Grazing management for healthy soils

by Christine Jones

Summary

The roots of grasses form a mirror image of the tops. This relationship provides a very useful guide to the health and productivity of grasslands. In general terms, the removal of leaf area through grazing results in root pruning, while resting from grazing enables root strengthening. Continuous root pruning (as happens to the most palatable components of a grassland when the grazing process is not controlled) reduces root biomass, slows nutrient cycling, exhausts plant reserves and ultimately causes plant death. However, grasses also degenerate if overrested. The grazing process therefore needs to be carefully managed, using intermittent grazing and resting to stimulate the growth of new leaves and to provide pruned roots as organic matter for soil biota.

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Fig. 1. A grass plant's roots are about the same size as its top.

Introduction

Healthy soils are the cornerstone of all agricultural productivity. The way we manage plants for healthy soils, through control of the grazing process, is the focus of this paper. An examination of excavated plant roots from many sites throughout temperate Australia, plus insights gained while working with landholders on the biological monitoring of their pastures, have made it abundantly clear that good grazing management requires:

1. understanding how to use grazing to stimulate grasses to grow vigorously and develop healthy root systems
2. using the grazing process to feed livestock AND soil biota
3. maintaining 100% soil cover (plants, litter) 100% of the time (NO exceptions)
4. rekindling natural soil forming processes
5. providing adequate rest from grazing without overresting

All five criteria are equally important. Conservatively stocked properties may appear healthy at a casual glance and are usually in better condition than land heavily overstocked for long periods. However, on closer inspection, it can be seen that damage is still occurring, albeit at a slower rate. Any land which is continually exposed to grazing animals will fail to meet the five criteria listed above. There are many indicators. Patch grazing, bare ground between plants, unhealthy root systems, little evidence of biological activity in soils, nutrient transfer to stock camps, low litter levels, weed invasion, tracking, damage to riparian zones, reduced moisture-holding capacity and fluctuations in water table levels affecting streamflow, spring flow and the incidence of dryland salinity. Continuous grazing represents zero grazing management. Graziers who do not proactively manage the grazing process unwittingly place themselves in an ongoing confrontation with nature.

Grasslands and grazers

The resource degradation associated with unmanaged grazing often leads to well-intentioned requests for permanent "grazing exclusion". However, grasslands and grazers have co-evolved over millions of years, and grasslands NEED grazers, be they kangaroos, elephants, termites or sheep, to facilitate energy flow and the recycling of nutrients. In medium to low rainfall areas, grasses which are not grazed become senescent and cease to grow productively (McNaughton 1979). If all herbivores are excluded, the health of the grassland declines over time.

The use of fire as an alternative method of biomass removal and growth stimulation may appear attractive, but results in atmospheric pollution, the loss of many nutrients which would be recycled in the grazing process, loss of surface litter, and, if used frequently, bare ground with a capped soil surface which inhibits the infiltration of rainfall (Savory 1988). Landholders may occasionally have valid reasons to use fire, such as woody weed control, or the enhancement of fire-dependent species. However, in view of the risks, fire is a tool which should be used cautiously and infrequently.

Managed grazing is arguably the only natural process by which grasslands can be "improved" on a sustainable basis. Unmanaged grazing, or complete exclusion from grazing, will inexorably (whether it be quickly or slowly) lead to desertification in all but the high rainfall areas (Savory 1988). To achieve healthy grasslands in medium to low rainfall areas, stock need to bunched into large mobs and moved frequently (Savory 1988). Grazing cells provide a convenient tool for stock control. In extensive areas with few fences, stock can be herded, as is now the practice on many large tracts of public land in the United States and Canada. However, there is far more to grazing management than putting stock together and manipulating the graze and rest periods. High density short duration grazing *per se* can also lead to resource degradation in the absence of ecological guidelines which ensure that all five criteria previously listed are satisfied. When all five criteria are met, grazing acts as a rejuvenating process.

The living soil

Our soils are the basis of all productivity, but what makes a healthy soil? To be truly healthy and working FOR you, rather than having to be "propped up" with costly inputs, soil needs to be living. Only the biological activity which accompanies plants can turn mineral soil (i.e. a collection of weathered rock minerals) into living soil. Maintaining permanent groundcover and using the grazing process to prune roots to feed soil organisms (soil biota), is of fundamental importance for the regeneration of grasslands.

An enormous number and variety of organisms live in healthy soils, and perform many functions. Large soil invertebrates, such as earthworms and dung beetles, are easy to see and more familiar to most of us than the microscopic components. They assist in the decomposition of plant litter and animal manure by making it more accessible to soil microbes. In turn, the activities of microbes (e.g. soil fungi and bacteria) can release up to twice the amount of plant nutrients (such as phosphorus) than are available from applied fertiliser.

How can we increase biological activity in soils? Like us, soil organisms cannot survive without water, food and shelter. That is, they require suitable habitat and a reliable food source. These requirements are met by organic matter in, and on the surface of, the soil.

Surface litter reduces temperature extremes (both hot and cold, like a roof on your house), and aids the infiltration of rainfall. It also reduces evaporation, so that the net effect of keeping soil permanently covered is that it stays moister for longer. Plant roots in the soil, both living and dead, provide substrate (food) for soil organisms, in a form which is most available when conditions are warm and moist. This is fortunate, because the nutrient cycling activities of soil organisms in turn make nutrients available to plants when the plants most need them, at a rate at which they can be utilised. This is one of the multiple benefits of working WITH nature. These nutrients would otherwise be leached below the root zone or adsorbed (fixed) onto soil particles in an unavailable form (Singer and Munns 1992).

Root pruning

Controlled grazing is the **management of the relationship between animals, plants and the soil.** When undertaken in such a way as to provide organic matter in the form needed for healthy, living soils, controlled grazing can regenerate grasslands and improve livestock production simultaneously.

Fig. 2. The biomass of the roots and the tops of grasses are roughly equal, forming a mirror image. Short grasses (left) have small root systems.

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In grasslands, grass plants and their litter form the primary interface between animals and the soil. The biomass of the tops and the roots of grasses are roughly equal, forming a mirror image (Fig. 2). The energy for root growth and metabolism can only come from sunlight captured by the plant top during photosynthesis. A small plant top cannot possibly support a large root system. Short grasses have short roots (Fig. 2, left). Vigorous grasses have dense, multi-branched roots (Fig. 2, right).

Deep, fibrous root systems provide a multiplicity of benefits including soil aeration, erosion control, enhanced nutrient cycling, soil building, increased water-holding capacity and reduced groundwater recharge. They also provide habitat and substrate for soil biota such as free-living nitrogen-fixing bacteria.

Fig. 3. Continual grazing pressure on the most palatable grasses provides a competitive advantage

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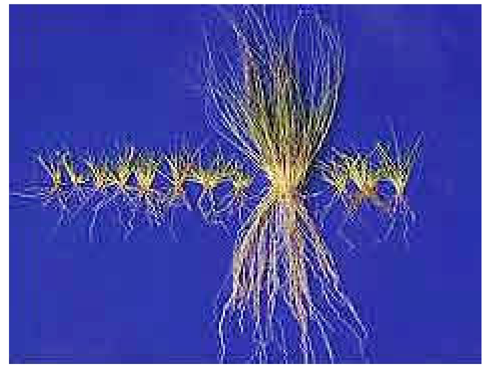
to the less palatable grasses for water and nutrients



Grass plants and their litter form the primary interface between animals and the soil. When livestock are left in the same paddock for long periods of time they place continual grazing pressure on the most palatable grasses and these are kept short (Fig. 3). The compromised root system of these overgrazed plants cannot function effectively. Nutrient availability may be reduced 80-90%, creating an ongoing requirement for fertiliser application. Short root systems also render plants extremely vulnerable during droughts.

Fig. 4. When desirable grasses are rested (right) and then rapidly defoliated through pulsed grazing (such as cell grazing), the roots are pruned within a few hours to equalise the biomass (left). This root pruning effect is regenerative rather than degenerative.

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If desirable grasses are rested from continuous grazing (Fig. 4, right) and then defoliated in a single grazing event (such as in cell or pulsed grazing), a large proportion of roots cease respiring and die within a few hours of the removal of the leaves, in order to equalise the biomass (Richards 1993). The root pruning effect (Fig. 4, left) is regenerative rather than degenerative. These "pruned roots" provide extremely valuable organic matter which improves the physical, chemical and biological attributes of the soil.

It is fundamentally important that grasses be rested prior to the next graze, to rebuild new root systems (Earl 1997). Leaf regrowth can begin within hours of grazing, provided conditions are favourable (Richards 1993). However, re-grazing at this sensitive stage will severely deplete plant reserves, resulting in either plant death or the formation of a steady-state type of equilibrium, where both tops and roots remain restricted in size, such as is found in mown turf and continuously grazed grassland (Richards 1993).

During the graze period (which is most commonly one, two or three days) approximately 20% of the available forage should be trampled to form surface litter and approximately 20% left standing (i.e. around 60% utilised for animal consumption). The percentages vary with circumstances but the importance of forming surface litter cannot be overemphasised. Finally, if the grassland is to be productive, it must not be overrested. Senescent plants are relatively nutrient poor and have low digestibility and inactive root systems. Overgrown grasses, in particular, can inhibit the growth of other herbaceous grassland species such as forbs, which contribute to both biodiversity and livestock production. For these reasons, the grasses which are desirable from an animal production perspective need to be grazed intermittently. Remember however, that a low percentage of relatively unpalatable, ungrazed bunch grasses is beneficial. These reduce wind-speed, improve humidity at ground level and provide habitat for small living things above and below ground. The result is higher overall productivity than can be obtained from short, uniform pastures.

Competitive interactions between species

What about the grassland components we don't want? The plants we call weeds? It is often said that for as long as we spray weeds there will be weeds to spray. This truism applies equally to the ploughing, burning or deliberate application of grazing pressure to unwanted plants. Attempting to manipulate a limited number of species, be they considered desirable or undesirable, with little consideration for the dynamics of the entire plant and animal community, can lead only to a deterioration in ecosystem processes and landscape function (Savory 1988).

When the grazing process is not managed, stock continually select the most palatable pasture components (Earl and Jones 1996). As already mentioned, if these plants are overgrazed they will have short roots. This prevents them from competing effectively with relatively unpalatable, ungrazed weeds, which will have deeper root systems (Fig. 5A). In this situation, the ungrazed weeds have an obvious advantage in obtaining water and nutrients, particularly during droughts. If the "softer" grasses are overgrazed to the point where they die, it is highly likely that the less palatable species, which have had the opportunity to seed, will take their place.

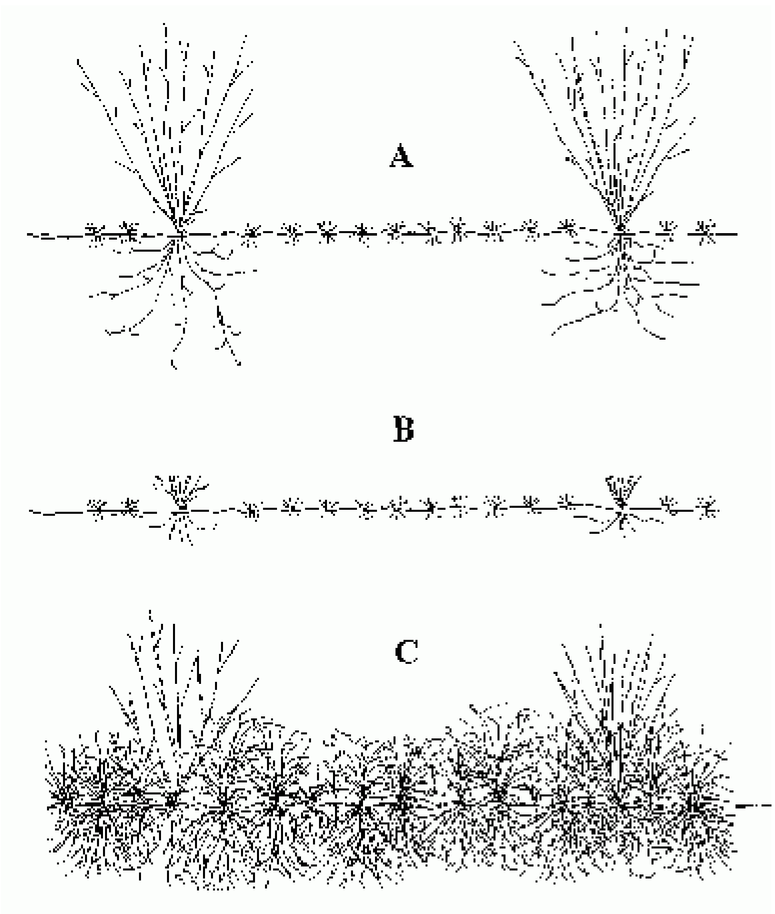

Fig. 5. Effect of grazing method on the competitive interactions between plants, particularly below ground. A: relatively unpalatable species gain an advantage for water and nutrients under continuous grazing. B: crash grazing, burning, herbicide or slashing reduce the biomass of all plants above and below ground. C: long rest periods and short, heavy graze periods enable desirable plants to form vigorous root systems and out-compete less desirable plants.

Considerable effort has been expended to find ways to "graze weeds into the ground" (Fig. 5B) using some form of crash grazing in otherwise set-stocked situations. Like ploughing, burning or spraying, short term results often appear promising, but in the longer term, the health of the grassland declines and the less desirable plants more often than not proliferate.

The use of high stock densities to apply grazing pressure to relatively unpalatable pasture components (Fig. 5B), can reduce ecosystem health to an even greater extent than selective grazing (Fig. 5A) if used repeatedly. In this scenario (Fig. 5B), the root biomass and root depth of all species will be reduced, as will litter cover, leading to greater fluctuations in soil temperature, reduced infiltration of rainfall, lower soil moisture levels, lower levels of soil biological activity and reduced capacity for nutrient cycling. Plant community dynamics, particularly competitive interactions below ground, will be almost non-existent (Fig. 5B). The use of high stock density in this way differs from the strategic use of animal impact as defined by Savory (1988).

Given the same starting point as before (Fig. 5A), let us ignore the weeds, and instead concentrate on what we want. In order for the more desirable pasture components to produce vigorous top growth, and therefore vigorous roots, we need to allow sufficient plant growth between graze periods. Plant community dynamics will do the rest (Fig. 5C). Competition BELOW ground is the most effective way to reduce the vigor of established weeds.

To reduce the germination of new weed seedlings, groundcover needs to be maintained at 100% (plants plus plant litter), for 100% of the time. This again depends on appropriate grazing management. Well-mulched soils provide excellent establishment conditions for the perennial grasses regarded as desirable for livestock production. These plants evolved in soils high in organic matter whereas weedy species usually colonize bare ground.

Conclusion

The way grasslands are managed affects not only their diversity and productivity, but also the extent to which they nourish soil organisms. The activities of these organisms are vitally important to both the cycling of nutrients and the maintenance of good soil structure, which in turn have positive feedback effects on plant growth and animal production.

When pastures are always short, natural nutrient cycles canÕt function. Degraded pastures can be supplemented with fertiliser, but this augmentation is unbalanced and usually only economical when commodity prices are high. In the current marketplace, the majority of livestock producers are faced with a negative cash flow situation and can little afford expensive off-the-shelf products. Furthermore, loss of groundcover as a result of unmanaged grazing leads to weed invasion and erosion, as well as off-site impacts such as sedimentation of dams and rivers.

Changes to conventional grazing practices which enhance ecosystem function have implications far beyond changes in botanical composition. Of particular importance from a rangeland health perspective, is the effect of appropriate grazing management on the infiltration of rainfall and the water-use efficiency of plants, drought survival, biodiversity, organic matter levels, soil biota, soil structure and the building of new topsoil.

Improvements in these factors can move us towards the restoration of hydrological balance on a catchment scale and most importantly, strengthen rural communities through their impact on farm profitability.

References

Earl, J.M. (1997). The benefits of increasing defoliation interval. *Proc. 12th Ann. Conf. Grassland Society of NSW,* Dubbo, pp. 143-145.

Earl, J.M. and Jones, C.E. (1996). The need for a new approach to grazing management - is cell grazing the answer? *The Rangeland Journal***18**: 327-350.

McNaughton, S.J. (1979). Grazing as an optimisation process: grass-ungulate relationships in the Serengeti. *American Naturalist* **113**: 691-703.

Richards, J.H. (1993). Physiology of plants recovering from defoliation. *Proc. XVII Int. Grasslands Congress,* Palmerston North, New Zealand, pp. 85Ò93.

Savory, A. (1998). *Holistic Resource Management.* Island Press, Washington, DC.

Singer M.J. and Munns, D.N. (1992). *Soils, An Introduction.* Second edition. McMillan, New York.

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