Solving the dryland salinity problems of the Murray Darling Basin with historical research, observation and logic

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Abstract

Historical records indicate that vast areas of the Murray-Darling Basin (MDB) were characterised by grasslands or grassy woodlands with low tree densities prior to European settlement. Furthermore, observations indicate that most of the roots of mature trees are concentrated in the top 50 cm of the soil and they do not have a defined tap root. The majority of grass roots are also concentrated in the top 50 cm of soil. It would therefore seem that much of the rainfall is retained in, and used from within this zone and is not accessible from depth. It was not tree removal that resulted in an increased incidence of salinity, but rather, the destruction of native grassland communities with an associated decline in soil organic matter and the water retention ability of the soil. The re-establishment and maintenance of permanent, perennial grassland communities provide a solution to the MDB dryland salinity problem.

Key words

Native grasses, tap roots, land management, salinity

Introduction

Most of the MDB with greater than 400 mm rainfall has been “cleared” for agriculture, predominantly for the production of annual crops and pastures (14). This closely corresponds to the areas that are threatened by dryland salinity.

There is a general consensus that the removal of the deep rooted vegetation of the pre-European environment and its replacement with shallow rooted crops and pastures has altered the water balance and an increased proportion of the rainfall has been allowed to infiltrate past the root zone. This has contributed to a rising water table and allowed dissolved salts to be brought to the land surface. The typical cross sectional *before clearing* model depicts a deep water table below a deep rooted, tree filled landscape. The *after clearing* model depicts a scene where the trees have been replaced with shallow rooted crops and pastures with a corresponding water table rise to the lands surface. It is logical to assume that by restoring or mimicking the conditions that existed previously in the environment, the incidence of salinity could be reduced or reversed.

Dryland salinity control is generally based on the above premise. Whilst there is some evidence that farming and revegetation practices can control water tables on a site-specific basis, there is no indication that these practices have altered the rising salinity trend across the basin (15). Walker et al. (16) concluded that significant areas of trees needed to be incorporated into the landscape to reduce leakage in the high rainfall parts of the MDB.

From a landholder’s point of view, the undeniable increase in aesthetic appeal and improved wildlife habitat from the large scale planting of trees hardly compensates for the loss of short-term productivity and doubtful long-term economic returns from tree related enterprises. It is unlikely that large-scale landscape redesign for salinity mitigation will ever be taken up with enthusiasm by landholders without substantial financial incentives.

What if the Murray-Darling Basin area currently threatened by salinity was not a tree covered landscape, but one that was grassland dominated? What if some of the now well recognised recharge areas of rocky hill-tops were in fact grasslands and saline outbreaks did not occur at the break-of-slope below them? What if trees, shrubs and pastures do not have deep roots and do not have the ability to extract water from deep in the soil? Based on these scenarios, can a hydrological balance be achieved that will be environmentally sound, control salinity, restore the landscape to its pre-existing condition and be financially rewarding?

Tree density in the MDB prior to European settlement

Goldney (6) estimated that 76% of the total land area of the Central Western region of New South Wales has been substantially cleared. The Central West Slopes were estimated to have lost 86% of the original tree cover, the Western Plains 83% and the relatively rugged Central Tablelands 50%. Goldney assumed that the original tree cover of the Central Tablelands was 100%.

Much of the writing for environmental purposes has focused on trees, particularly in relation to the increased incidence of eucalyptus dieback, habitat for endangered species and 'remnant vegetation'. The grasslands have been largely overlooked. Some sources are very explicit in their description and indicate that extensive areas of the MDB were dominated by a grassland community. Atkinson (1) reported that, treeless grasslands formed an uninterrupted chain from the Liverpool plains to Lake George (near present-day Canberra). Surveyor George Evans recorded large hills covered with grass, a ridge of pasture hills and 'stupendous green hills' close to present-day Bathurst (5).

The word 'plains' was consistently used to describe the grasslands. *The Macquarie river, Takes a winding course thro' the Plains which can be easily traced from the high banks adjoining, by the particular verdure of the trees on its banks, which are likewise the only trees throughout the extent of the* [Macquarie] *Plains* (10). These were one of four plains named by George Evans in 1813-14 as he surveyed the region. The observations made by explorer John Oxley are typical of the early descriptions of the vegetation of the Central West; *The timber is very open, and if the country had been divested of the numerous acacia bushes with which the face of it was covered, it would be impossible to wish for a land more lightly timbered: the grass Bromus was very luxuriant.*

Assumptions that the original tree cover in the Central West and Central Tablelands of New South Wales was up to 100% cannot be justified from original documents.

The root systems and water use of trees

Observation of tree root systems along pipeline excavations, cuttings for road re-alignment and trees that have been uprooted in storms do not exhibit evidence of a tap root or a deep root system, the vast majority of roots being close to the surface and lateral in direction.

It is surprising, given the perceived importance of tree roots in extracting ground water, that more information is not available on the exact nature of the root system of trees. Chilcott (2) observed in excavating tree roots that root architecture changed with the age of the trees. Beneath the smallest tree (18 cm diameter at breast height) five sinker roots were excavated to a depth of 1.7 metres. Observation of adjacent overturned trees suggested deep tap roots were common in smaller trees, but absent in larger trees. Chilcott (2) found small tree roots (2-5 cm diameter) were entwined with grass roots, with a majority of all roots found in the top 50 cm of the soil profile. It would seem that a search for water by roots deep into the soil profile would prove futile as all soil air, water and nutrient transactions took place in the 'action zone' of the A horizon.

Preliminary results from research in south west Victoria indicate that in summer a large eucalypt can use between 400 and 1000 litres of water a day. This is 20-30% of the water used by an area of well watered pasture; similar to the area covered by the crown of a tree (11). The mathematical conclusion to covering 50% of the landscape with trees, is that rainfall infiltration past the root zone could double.

The root system and water use of grasses

A study of the root structure of a range of ungrazed native grasses, including *Themeda australis* and *Elymus scaber* traced them down to 100 cm with most roots in the zone 0-60 cm (12). The biomass of the tops of grasses and their root system are roughly equal and form a mirror image. In general terms the removal of leaf material through grazing, reduces the biomass of the roots. Vigorously growing grasses have a vigorous root system and heavily grazed grasses have short roots (9)

A detailed botanical description of the grasslands as they appeared to the first settlers does not exist and it is almost impossible to form an accurate picture from the fragmentary contemporary reports that are available. It is likely that in areas of almost even rainfall distribution throughout the year, such as the central areas of the MDB, most of the grassland species were perennial in nature, a dynamic mix of legumes and a wide range of other forbs. This formed the community of warm season (C4 plants) and cool season (C3) plants that had the ability to fully utilise the available rainfall under most conditions. Data collected from LIGULE field trials indicated that pasture containing the best C3 and best C4 grasses could achieve better water use for recharge control than any of the species growing alone (12).

Table 1: The compatibility of C3 and C4 plants as part of a plant community.

Photosynthetic pathway	C3 plants	C4 plants
Sunlight requirements	Lower	Higher
Temperature requirements	0^0 C to 35^0C Optimum ~25^0C	15^0C to 45^0 C optimum ~35^0C
Moisture requirements	Higher	Lower
Nutrient requirements	Higher	Lower
Examples (genera)	Microlaena, Austrostipa, Austrodanthonia, Elymus	Themeda, Bothriochloa, Paspalidium.

Pre-European grassland communities had the ability to efficiently utilise available rainfall. The proportions of C3 and C4 plants in the community were determined by environmental conditions of rainfall and temperature. High temperatures and/or low rainfall resulted in a greater proportion of C4 plants while lower temperatures and/or high rainfall resulted in a higher proportion of C3 plants. Trees were not necessarily a part of the system and where they did exist, they were competing with the other organisms for their requirements in the “action zone” of the soil A horizon.

Applying water use efficiency principles to land management.

Traditional crop-pasture rotation necessitates perennial pasture destruction for the establishment of annual grain crops. This creates water use inefficiencies within each system and in the transition between systems. Despite the adoption of ‘more sustainable’ cropping practices an average loss of 7 kg of soil is incurred for the production of every kg of wheat produced. Soil organic matter levels and the water retention capability of the soil are unlikely to improve while these losses continue.(8)

A pasture, irrespective of its present composition, could be manipulated to be as efficient as the pre-European grasslands in water use. A wide range of native species are the most suitable to fill all environmental niches, and all niches must be eventually filled to allow for variations in seasonal conditions. Of particular importance is the balance between C3 and C4 plants to obtain the optimum water use efficiency for the situation. Addition and subtraction of plant species can be made by broadcasting seed or direct drilling, stock pressure and natural competition. Grazing management strategies need to be implemented that favour perennial plants over annual plants.

Annual winter grain crop production can be incorporated into the system by manipulating the species composition towards the C4 perennial plants and creating a niche for the C3 grain crop. Here the annual plant is performing its traditional role as a colonising species in the absence of perennial plants. For the production of annual summer grain crops, species manipulation would favour C3 pasture plants.

Conclusions

To obtain a good score on any assignment it is necessary to do some homework and the first requirement is to get the basics right. Any conclusions drawn from flawed basic information will be flawed. Clearly in assessing the salinity problem, the homework has not been done. It has relied upon the traditional salinity model that has remained unchallenged for decades.

In the pre-European salinity prone areas of the Murray-Darling Basin significant areas of the landscape were dominated by grassland. It was not totally covered in trees. The tops of hills were not necessarily the domain of trees and woody shrubs, the grasslands extended to these areas too. Assumptions that these are the major recharge areas and that the removal of the native vegetation has contributed to salinity discharge could be correct, but planting with trees may not be an effective solution.

Casual observation of trees uprooted in storms or by erosion indicate that the accepted descriptions of the root systems are inaccurate. Assumptions on the functioning of the water cycle and the ability of trees to access the water table based on these descriptions need immediate re-assessment. Some simple investigations by excavation through the radius of the root system would prove that trees have a very limited ability to tap into water reserves many metres below the surface.

Water balance in native grassland communities was sufficiently high to control dryland salinity in pre-European times. The plant community and the levels of organic matter in soils need to be considered in the water balance equation rather than individual species.

Radical land management changes for the higher utilisation of water may not be necessary for the control of dryland salinity. Small incremental changes across the landscape based on the reintroduction and/or enhancement of the native pastures and growing annual crops into a native pasture base may present a more financially attractive option to landholders than attempting commercial tree related enterprises.

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