Whatever happened to dryland salinity? A review of the Australian salinity agenda; management for sustainable productivity and climate change effects

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Abstract

In the not too distant past, dryland salinity in Australia was considered to be one of the nation's greatest environmental concerns. All States were involved, with significant amounts of public money being spent on the issue. Statements referring to it as an "awakening monster from the deep" and "the creeping white death", publicised on Federal websites such as the Australian Academy of Sciences and CSIRO, indicated the level of national concern. The causes have been attributed to an excess of water in the landscape, mobilising deep ancient salinity stores and bringing previously dormant salts to the surface. Dryland salinity is listed as being a 'threatening process' to biodiversity, killing native fauna and flora and apparently favouring exotic species, despite Australia being one of the naturally saltiest places on earth. The research reported here in upland catchments of NSW challenges these views, the generally accepted model of the processes driving secondary dryland salinity in most uplands of the Murray Darling Basin is at odds with field observations. Holistic biotic and abiotic measurements taken in grassy woodlands exhibiting various degrees of increased salinisation, to investigate the fundamental processes operating within and between the regolith and surface/subterranean biota, show that elevated salinity levels are a localised, soil surface process associated with vegetation/soil degradation and subsequent increased soil evaporation rates. No cause-effect relationship was established linking increased salinity levels to native fauna or flora mortality. Many native species flourish in such environments, as can be expected, having co-evolved with salty and sodic soils. The results have implications for appropriate salinity mapping, modelling and management activities. This includes the issue of a warming climate regime and the likelihood of increasing soil surface evaporation rates, hence, increased salinisation associated with soil and vegetation degradation.

Keywords

Transient salinity, groundwater, salt mobilisation, salt management.

Dryland salinity paradigms

Dryland salinity has been considered a major environmental concern across southern Australia for a number of decades, with most reports suggesting that the situation was going to get significantly worse in the future (e.g. NLWRA 2000; 2007). However, very little attention has been given to its effects on biodiversity, particularly terrestrial, nor the processes that induce it in upland landscapes. Some research performed in south-eastern (SE) Australia claims that elevated salinity levels cause many adverse impacts on terrestrial biota, including mortality, especially to endemic species, whilst favouring conditions for exotic species (weeds) (Taws 2003; Briggs and Taws 2003; Zeppel et al. 2003; Seddon et al. 2007). It is claimed that a hypothetical "feedback loop" based on hypothetical regional "rising groundwater" worsens things further, as toxic salty groundwater "rises" and kills the trees, allowing groundwater to rise further, killing more trees and so on. This is termed the rising groundwater model (RGM) (Bann and Field 2006a,b; 2007; 2010a,b; Bann 2014). Therefore, dryland salinity is classified as a threatening process to endemic biota (EA 2001). This is despite Australia being the naturally saltiest place on earth, with the greatest proportion of saline/sodic soils than any other country. Fauna and flora have therefore adapted to these conditions, particularly SE Australia where dryland salinity is a natural (primary) phenomenon. (Kreeb et al. 1995; Williams 1998; McEvoy and Goonan 2003; Bann and Field 2006a; 2007; 2010a; Bann 2014). In addition, Pannell and Roberts (2010) report that $1.4 billion of public funds spent on the National Action Plan for Salinity on 1700 projects over seven years was a waste of money and was "readily foreseeable". It is therefore clear that further investigation and clarification regarding causes and effects is warranted.

Invalid assumptions

There are many invalid assumptions and misinterpretations identified in previous research from SE Australia that investigates the effects of dryland salinity on terrestrial biota. The presumed cause of any elevated soil salinity levels is continually blamed on 'rising saline groundwater' (i.e. excess landscape water). However, this concept is unsupported in dryland landscapes from all southern states (e.g. W.A. - Conacher 1975; S.A.

– Thomas et al. 2009; Qld – Hughes 1983; N.S.W. – Murray 1996; Acworth and Jankowski 2001; Wagner 2001; Bann 2014; Victoria - Dahlhaus et al. 2008; Tasmania - Meadows 2008; and nationally; Rengasamy 2006; Fitzpatrick 2008; Bann and Field 2006b). The RGM is used to incorrectly link possible adverse effects with impacts to the biota (Taws 2003; Briggs and Taws 2003; Zeppel et al. 2003; Seddon et al. 2007). Some examples of the assumptions include; 1) All salinity is considered to be secondary (primary is ignored, despite primary salinity being a feature of SE Australia) and elevated salinity levels are considered to be new and unusual, and toxic (the recognition that landscapes were saline pre European settlement is ignored). 2) Any apparent adverse effect to biota (e.g. dieback) where salinity levels are elevated are due to the salinity levels (and conversely, any evidence for positive effects are linked to non-saline conditions), and thus cause-effect is inferred without evidence. 3) Endemic species are considered to be intolerant to elevated salinity levels and the high salinity levels are unusual and toxic. 4) Weed presence is due to elevated salinity levels and not something else (and weeds are always considered bad – despite their benefits at assisting reducing surface evaporation, hence evaporite deposition and salinity levels). 5) Salinity is always considered to be solely sodium chloride (a number of other important salts are also usually present and likely more toxic). 6) Spatial (scale) and temporal factors are rarely considered - salinity levels are treated as if they are homogenous across a site with insufficient soil sampling performed at each site (spatially variable and fluctuating soil EC levels, especially following rainfall, are not considered). There is therefore a need to further test these assumptions in order to make strategic monitoring and management recommendations for both biodiversity conservation and sustainable productivity. Furthermore, as the RGM is promoted as being the general cause of Australian secondary dryland salinity, it is also applied to salinity mapping, modelling, monitoring and management activities. The consequences include irrelevant management activities (Pannell and Roberts 2010) failing as they are designed to address invalid hypothetical concepts. This includes the assumption that climate change has not only halted the reported expansion of the saline sites, but appears to have eradicated it. This is reflected in the recent absence of salinity related talks at major national and international conferences that once considered the salinity agenda important enough to run whole sessions or indeed, whole conferences (e.g. 2nd International Salinity Forum held in Adelaide over 4 days in 2008).

Paradigm investigation

To investigate these issues, Bann (2014) looked at ten sites on the Southern Tablelands of NSW with various degrees of soil and vegetation degradation with associated salinity. A suite of holistic biotic and abiotic metrics were taken at stations along transects at each site, to obtain as much quantitative data to allow analyses and comparisons for objective conclusions of regolith and ecological processes to be made. Metrics collected included soil ($EC_{(1:5)}$, cations, anions, pH, N, P, K, C, compaction, slake and dispersion), biological (invertebrate, frog and reptile data, soil bulk respiration, SOM, vegetation attributes), hydrological (surface and deeper water) and geophysical (EM 38 and EM31 surveys performed at different times of the year with different moisture regimes).

No biological, hydrological, pedological or geophysical evidence was found to indicate that rising groundwater was a problem, or indeed that it was associated with any of the degraded areas. The predominant hydrological changes occur above the semi-permeable clay-rich B horizons (duplex soils), as interflow and seasonal saturation (i.e. 'transient salinity' – Rengasamy 2006). No evidence was found linking elevated salinity levels with significant adverse effects to endemic biota, or favouring exotic species over endemic. Indeed, many taxa flourish in the disturbed conditions, such as ants and spiders as well as endemic grasses, a number considered to be productive, and trees (Bann and Field 2006a; 2010a). Evidence indicates that in the uplands of SE Australia at least, dryland salinity is consequent to elevated surface evaporation levels from soil and vegetation degradation mainly due to cumulated unsustainable management practices, particularly those associated with intensive stock grazing. This concurs with other field research from eastern Australia (e.g. Hughes 1983; Murray 1996; Wagner 2001; Meadows 2008; Bann and Field 2010b; Bann 2012; 2014). Many other synergistic symptoms associated with the degradation are likely to adversely affect biota, such as toxic (alkaline) pH levels, a lack of SOM, and other essential nutrients, compacted dispersible soils, lack of plant available water, etc., more so than salinity levels *per se*. It is therefore a symptom of this process, not the cause. *In situ* soil and vegetation remediation is therefore essential for productivity and must be strategically managed. Many other sites in all states across southern Australia were visited and the same situation appears to be occurring at these, hence is likely to be more general, especially in uplands, than the rising groundwater model.

Implications for future research, management and climate change

Management activities that attempt to address the RGM focus on planting deep rooted perennials to suck up excess groundwater have generally failed (George 2006; Pannell and Roberts 2010). Surficial processes which reduce soil evaporation, as discussed by Bann (2012; 2014), need to be considered, such as *in situ* soil amelioration and nutrient and water retention, rather than groundwater. Salt tolerant endemic species capable of productivity should be considered rather than the exotic species and hybrids presently preferred for management activities (Bann and Field 2006a), especially in the endangered box/gum grassy woodlands of SE Australia. As increased surface evaporation increases soil salinity levels, increased temperatures coupled with high rainfall events associated with climate change will likely exacerbate dryland salinity problems, not reduce them as presently promoted (e.g. Campbell 2008). It is therefore suggested that soil salinity should be back on the political and academic agendas.

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