

Dryland salinity and terrestrial biodiversity in southeastern Australia: surviving comes naturally

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Introduction

Both dryland salinity and terrestrial biodiversity loss in southern Australia have both been high profile management issues for a number of years, and dryland salinity is listed as a threatening process to biodiversity (EA 2001). Despite this, research into the inter-relationships of increased salinity levels and native biota is scarce and the majority of this research focuses on aquatic systems. In many cases the evidence indicates that increased salinity levels adversely affects endemic biota and hence biodiversity. The same conclusions have been stated for the few terrestrial biodiversity reports focused on southeastern Australia (Taws 2003; Briggs and Taws 2003; Zeppell et al. 2003; Thompson and Briggs 2005), although the mechanisms and principals are poorly understood. Briggs and Taws (2003) generalise to suggest that increased salinity levels actually kill endemic vegetation and favour exotic species (weeds). Such results also require temporal context; increased salinity levels in southern Australia are not recent and are probably not presently extreme (De Deckker 1983; Crawley 1994). As a result, it is likely that native biota is relatively tolerant of high and fluctuating salt levels as suggested by Barnett (2000), Kreeb et al. (1995), Malcolm (2005) and Bann and Field (2005, 2006). This paper investigates the effects of increasing soil salinity on terrestrial biota in southeastern Australia.

Sites and methods

Following an extensive reconnaissance of sites in three states, ten sites with various degrees of apparent salinisation on the Southern Tablelands of NSW in the upper Murray Darling Basin were selected for research. Sites contained Yellow Box (*Eucalyptus melliodora*) and Blakelys Red Gum (*E. blakelyi*) Grassy Woodlands (YBRGGW). These woodlands dominate the more productive soils of the lower slopes and drainage lines, and hence, have been extensively cleared and modified for agriculture. As a result, they are listed as an Endangered Ecological Community in state and federal acts and as dryland salinity usually breaks out in this landscape position, it is listed as a threatening process (EA 2001). Elevation of the sites range from 450 to 650 m.a.s.l. with a regional mean annual rainfall of 550-700mm. Sites were selected that exhibited minimal levels of agricultural disturbance, particularly vegetation and soil degradation caused by domestic stock grazing (sheep). Pastoralism is

the main landuse across the region. Sites were restricted to those underlying lithologies of Ordovician, and Silurian metasediments and volcanics of the Lachlan Fold Belt.

A suite of biotic and abiotic measurements were performed over three years at the ten sites to investigate interactions between the regolith and biota. Metrics included ground macro-invertebrate (pitfall traps, log discs left on the soil for habitat and buried toilet roll termite baits) and vertebrate surveys, flora identification and leaf analyses, various field and laboratory soil and water analyses and the application of the Landscape Function Analysis assessment procedure (Tongway and Hindley 2004). Abiotic measurements performed included soil EC (1:5w), pH (1:5w), surface compaction, presence of organic material, carbonates and/or bicarbonates (reaction with HCl), aggregate stability and nutrient, cation and anion analyses. A number of piezometers were installed at three sites. EC was performed at various times during the three years to investigate temporal variation. Multivariate statistical analysis was performed using GenStat 10th Edition.

Results

The majority of sites inspected were relatively small, in particular, the salinised zones (areas

of apparent dryland salinity) that were generally less than 1 Ha in size. Sites appeared to be restricted to their current extent, showing no sign of expansion since 2004. All sites inspected appeared to have some degree of fragmentation and/or degradation and had at some time been grazed by sheep, thereby influencing soil conditions (Greenwood & McKenzie 2001). Sites that had been fenced off from recent domestic grazing appeared to be responding by stabilising.

Readings of 20.2 dS/m and 1.6 dS/m (EC 1:5w) were taken at the same location two days apart, after rainfall, indicating that soil EC levels fluctuate considerably and frequently, especially following rainfall. EC levels are generally highest at the soil surface. Soil pH (w) varied considerably temporally and geographically, from 3.8 to 10.6 in the top 5cm of soil. The alkaline conditions are generally associated with degraded scalded areas. A number of scalded areas had carbonates or bicarbonates present, although laboratory analyses indicated the reaction with HCl was not due to carbonates. These scalded areas are also lacking in organic matter and nutrients and rarely have an A1 horizon, exposing an A2 horizon that is generally sodic, bleached, dispersible and has a very poor structure. These soils are prone to erosion.

Brush-tailed possums, swamp wallabies and eastern grey kangaroos were common at all sites. Frogs, lizards and geckos also inhabit salinised areas. Many frogs were identified in the salinised zones. Results do not show any link between elevated salinity levels and adverse impacts on ground vertebrates. Anecdotal evidence suggests the contrary, that mortality from foxes is a far greater threat to vertebrates than salt toxicity. Foxes were present at all sites. Rabbits and hares were also common. Spiders, centipedes, mites, earthworms and 11 Order of insects were identified in the salinised zones. In particular, meat ants (*Iridomyrmex purpureus*) appear to favour salinised and degraded areas, often building their large nests within the actual scalded area (commonly referred to as 'discharge zones') where the most elevated salinity levels usually occur. Nests are occupied for long periods, usually many years, and extend to a depth of at least 50-75cms, well into the clay B horizon, suggesting that at no period does the groundwater inundate to this level. Many other endemic ant species (>15 spp.) also tolerate the elevated salinity levels. Other insects inhabiting the salinised areas include termites, wasps, beetles and cockroaches. Five termite species were identified and exotic earthworm species are the most common worms in YBRGGW, however, native species appear to be more abundant than exotic species when salinity levels increase, indicating likely superior salt tolerance.

No relationship was found between salinity levels (EC) and the number of animals caught in the pitfall traps (biomass), the number of taxa identified within the pitfall traps and beneath the log discs, nor the presence of termites, worms, ants, frogs and lizards.

The rate of photosynthesis (Photosystem II), a surrogate measure for plant health, of *E. melliodora* leaves measured with a Photosynthesis Efficiency Analyser (PEA meter) (Liu et al. 2001) indicates that there is no significant difference between plants growing in salinised areas and those in nonsalinised areas. This suggests that *E. melliodora* exhibits tolerance to increased salinity levels, which is not surprising, as all trees growing in the salinised areas, at all ages, appeared to be in a healthy state. *E. blakelyi* also germinate and grow in salinised areas and although they do suffer from dieback (widespread tree health decline), salinity cannot be directly implicated as suggested by Taws (2003), Briggs and Taws (2003) and Thompson and Briggs (2005), as dieback occurs across the entire landscape. Moreover, many of the dead trees that are still standing have been ringbarked. *E. cinerea*, *E. bridgesiana* and *E. rubida* were also observed growing in areas with increased soil salinity.

At least six endemic grass species that are also drought tolerant and relatively productive as fodder grow in or around the salinised areas, including the most saline scalds. These have been discussed by Bann and Field (2006). In particular, *Cynodon dactylon* (couch grass) grows on the most salinised and degraded sites. It has a mat forming growth habit (rhizomes and stolons), capable of growing onto and across the scalded areas, removing the need to

germinate within the most elevated soil salinities. This was observed at a number of sites, provided the area was excluded from stock. Interestingly, on sites that had not been recently grazed, the boundary between grasses and the bare scalded area was usually abrupt, with no apparent impact on the grasses. The boundary often corresponded with a huge variation in EC levels, usually within 10-20cm laterally. This suggests a sudden change in soil conditions, or simply erosion. At a number of sites, rainfall runoff from the areas of elevated salinity drained directly into YBRGGW, with no apparent adverse impacts on vegetation health.

Discussion

No evidence was found linking increasing salinity to dieback and/or dying trees as suggested by Taws (2003), Briggs and Taws (2003) and Thompson and Briggs (2005). Many trees persist in salinised areas and dieback occurs across the entire landscape, from numerous compounding and confounding factors (e.g. perennially raised water tables, drought, intensive stock grazing, past management practices, erosion, insect plagues). Blaming salinity for a trees poor health, that in many cases is only apparent as insect foliage attack, is unfounded.

No evidence was found linking increasing salinity with weed dominance as suggested by Taws (2003), Briggs and Taws (2003) and Thompson and Briggs (2005). This conclusion concurs with Coutts-Smith & Downey (2006). Numerous other factors are involved for the incursion of weeds, especially those relating to disturbance, which must be considered when investigating the causes responsible for the presence of weeds (Coutts-Smith & Downey 2006). Evidence from this current research indicates that increasing salinity favours endemic species; Australian flora and fauna have co-evolved with elevated and fluctuating salinity levels for millennia (Crawley 1994).

Although elevated soil salinity levels are periodically present at some of the more salinised sites, these levels do come and go, hence, biota need to be equipped to tolerate both elevated salinity levels and the large fluctuations. Although some mobile invertebrate predators do not appear to be adversely affected by increased salinity levels, the effects on other functional groups is not as clear. It is likely that the presence of the meat ants in particular would deter many animals. Areas with high salinity levels are also often bare, exposed, compacted and sometimes highly alkaline, in addition to having formidable predators (meat ants, wolf spiders and trapdoor spiders); a hostile, dangerous place for any ground dweller to reside. In addition, alkaline and acidic soil conditions are not only toxic to the biota, they can severely reduce nutrient availability for plants. As the toxic conditions are usually at the soil surface itself, such as increased salinity, compaction, exposure and desiccation, the 'long stem native tube-stock' method should be trialed in these situations, as initial trials suggest that this technique could be useful (Hicks 2003).

It appears other parameters such as soil pH, vegetation and soil degradation from stock grazing and landuse practices play a more significant role on terrestrial biota recruitment and survival than salinity *per se*. It also appears that many dryland salinity expressions are another symptom of land (or soil) degradation, rather than the actual cause, hence, salinity can not be a threatening process in these landscapes. The threatening process is the cause of the soil degradation.

Moreover, as little evidence was found that increasing salinity levels adversely affects biota, hence that the habitat associated with increased soil salinity and soil degradation may actually provide an additional opportunity (ecotone) within the YBRGGW ecosystem, allowing many native species, particularly colonisers, to thrive. Further work on this matter is required.

Conclusions

Many endemic flora and fauna species flourish within salinised areas in southeastern Australia. This is not surprising, as salt levels in Australian dryland soils are amongst the highest in the world, and have been for millennia. No evidence was found to indicate that flora and fauna species are prevented from healthy occupation of saline sites or by elevated salinity levels.

More emphasis needs to be directed towards various trials involving planting endemic grasses and trees, of local provenance, in addition to the current focus on exotic and or pseudo-exotic species (i.e. native and/or hybrid species from another state). Local provenance seed should be collected to match local habitat variation, such as soil salinity, pH, moisture and clay content. Predicting biodiversity loss and/or ecological change in response to secondary salinisation in southeastern Australia requires careful consideration of site disturbance. Sites that are fenced off from regular trampling and grazing by stock appear to respond well, in biomass and biodiversity.

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