Saltbush – a case for reintroduction

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Abstract. This paper reviews historical, philosophical and socio-cultural information as a means of explaining why saltbush in Australia has declined. That decline coincided with introduced hard hoofed animals overgrazing native pastures and was compounded by land clearing. Over time, losing ecosystem diversity degraded vegetation, soil and water resources; subsequently, watertables rose. A benefit of saltbush ecosystems has been keeping landscape function stable by controlling saline watertables. In suitable ecosystems, the reintroduction of saltbush would be potentially highly rewarding, but significant impediments block the way, none more so than a decision-making context overwhelmingly constrained by short-term production and financial considerations. The authors investigate those impediments and consider economic, environmental and social imperatives in devising a suggested long-term plan for reintroduction.

Keywords: saltbush, farm management, holistic planning

Introduction

The concept of sustainable development did not accompany the early Europeans settling in Australia. They lacked an understanding of the soil, vegetation and weather in their new environment. Their farming methods changed the landscape and led to degradation of the natural environment.

This paper reviews an important aspect of that degradation, the loss of saltbush ecosystems. It discusses why saltbush populations declined and the consequences. It establishes the need for reintroduction of saltbush and considers the impediments to that. Finally, it provides an action plan with a set of recommendations that are devised to address holistic needs at economic, environmental and social levels.

The changing landscape

The Australian continent was not a pristine, stable landscape prior to European settlement. At that time Australian Aborigines were hunter-gatherers who impacted on the landscape and vegetation by using fire extensively. The effects of fire were relatively rapid in moulding land surfaces through processes which were continual and often intensive (Hughes and Sullivan 1986).

'Fire-stick farming' was a widespread land management practice involving systematic burning of habitats to increase the availability of plant and animal food. Curr (1882, p.188), who travelled widely in northern Victoria, observed:

> *I refer to the* fire-stick*; for the blackfellow was constantly setting fire to the grass and trees, both accidentally, and systematically, for hunting purposes. Living principally on wild roots and animals, he tilled his land and cultivated his pastures with fire; and we shall not, perhaps, be far from the truth if we conclude that almost every part of New Holland was swept over by fierce fire, and on average, every five years.*

The impact of this practice, together with earlier soil development processes, induced many native Australian plants to develop attributes that enhanced survival in old and infertile soils which were largely undisturbed by soft-footed native animals. Due to their ability to withstand fire, low soil fertility and long periods of low rainfall, these genera thrived.

Early Europeans arrived to find species of the genera *Atriplex* (saltbush) and *Kochia* (bluebush) dominating the vegetation of large areas of the arid and semi-arid landscape (Osborn et al. 1932). Whereas the best-known *Atriplex* species in Australia is Old Man saltbush (*A. nummularia)*, all the approximately 100 species in this genus are known for their drought resistance (Gates 1968) and across the globe are most often found on saline soils.

Relatively little saltbush now remains in Australia's semi-arid zone or the wheat-sheep belt; the majority of populations now occur below the 300 mm rainfall isohyet. When domesticated hard-hoofed animals were introduced to these areas great changes occurred due to soil disturbance, compaction and plant damage (Penfold and Stevens 2005). When disturbance occurs opportunity is provided for ruderal plants, generally exotic annuals, to thrive. With their vigorous growth and large seed crops, even in drought, these tend to displace extant native perennials. Saltbush is unable to compete with fast growing annuals for nutrients and water, particularly during the cooler months when young plants are shaded or grazed out (Honeysett et al. 2004).

The change from subsistence farming to commercial agriculture occurred in the 1830s when the commercial possibilities of livestock triggered a rapid expansion in pastoral industries (Heathcote 1979). Saltbush country is relatively open and, with its understorey of native grasses, was eagerly settled in the days of pastoral expansion by graziers seeking to produce high quality strong wool (Leigh 1994). Pressure on the natural environment increased. These large adjustments associated with pastoral expansion provided less opportunity for continued fire-stick farming and the emergence of less favourable conditions for saltbush.

Frontier settlement coincided with a decline in saltbush and native grassland pastures, and increased occurrences of weeds, pests and diseases. The impact of these factors has been difficult to gauge. However overgrazing weakens ecosystems thereby triggering conditions favourable to weed (including deliberately introduced exotic spp.), pest and disease populations.

Curr (1882, p. 185) squatted near Tongala, northern Victoria in 1841, and his account reinforces how quickly environmental change occurred.

> *…the grass originally grew in large tussocks, standing from two to twenty feet apart, depending on circumstances. Gradually as the tussocks got fed down by sheep and cattle they stooled out; and the seed got trampled into the ground around them, and in the absence of bush fires grew…in conjunction with a little grass, large proportions of the continent were covered with salt-bush and pigs-face. In places, for instance around Mt Hope and the Terricks in Victoria, the salt-bushes occasionally attained the height of 12 feet, standing 20 or 30 feet apart; in other localities a dwarf variety of this plant prevailed, and grew so close as to almost crowd out the grass entirely.*
>
> *With this class of vegetation great changes have occurred, and at Mt Hope (as in country where generally it grew), stocking has almost entirely destroyed it… but in consequence of constant overstocking and scourging of the pastures, these, where not eradicated, have very much decreased, their places taken by inferior sorts and weeds introduced from Europe and Africa.*

Landscape degradation accelerated so quickly that just 70 years after the first inland settlement at Bathurst, New South Wales, a Royal Commission (1901) was called to evaluate the severe problems of overgrazing caused by domestic livestock and rabbits on Australia's arid and semi-arid rangelands (Noble and Tongway 1986).

Although current knowledge of pre-European climate is minimal, it appears that a major drought began in 1837–38, persisting until about 1842. Jones (1995) suggests that this drought was the driest period for 2000 years, and possibly 9000 years. The drought paralleled a surge in pastoral expansion and climate change, probably involving both a reduction in rainfall and an increase in temperature (Critchett 1990).

During this period of drought and pastoral expansion, grassland ecosystems altered before they could be accurately recorded with the damage due to overgrazing effectively masked by some recovery of the grasslands when weather conditions subsequently improved. Jones (1999) notes an account by Robertson from the late 1800s which describes a rapid alteration of grasslands in Victoria and the appearance of salinity and soil erosion due to grazing practices. Contemporary accounts such as this suggest European settlement during the 19th century had a swift and irreversible effect on native shrub and grass distributions.

Additional factors contributing to saltbush decline include introduced pest animals, like goats and rabbits, ringbarking saltbush seedlings and established stands during dry periods, and increased grazing pressure resulting from the proliferation of watering points in areas that once experienced only intermittent grazing after wet periods (Freudenberger and Landsberg 2000).

Early European explorers and settlers conceived of Australia as being 'untouched, empty, underdeveloped, pristine' (Reynolds 1980) and viewed the country as *terra sine scientia*—land with no knowledge (Dovers 1992). Whilst utilisation of the newfound land was well within acceptable socio-cultural values of the day, early European settlers lacked an understanding of the interrelationships between soil, vegetation and weather in their new environment. Barr and Cary (1992, p.1) suggested that they:

...applied English farming methods, which had been developed in a land of cool wet summers, to a land where summers were dry, hot and long. Farming methods had to be relearned in the brown land.

A powerful instrument of landscape change was the Closer Settlement Acts of the 1860s, rewritten intermittently until the 1970s. This legislation was based on the thought that agriculture could provide a living for a large number of small farmers, and that this would develop the countryside and stimulate wider economic development (Malcolm et al. 1996). Encouraged by various government concessions in place until the 1980s, farmers intensified production by clearing native vegetation and improving pastures using European-farming techniques. Those farming methods changed the Australian landscape with astonishing swiftness and on such an imposing scale that Campbell (1994) suggests our knowledge of the impact of these changes and associated ongoing degradation processes is still sketchy and superficial.

We realise now that biodiversity has been a casualty of the altered landscape. Studies indicate that over half of Australia's native vegetation has been cleared for agricultural and other purposes in what has been termed the *intensive land use zone* of the continent, which includes much of the Murray Darling Basin (MDB) (Graetz et al. 1995). It is claimed that clearing is the single greatest threat to terrestrial biodiversity since grazing industries completely altered native pastures (EPA 1997).

Understanding saltbush

Old Man saltbush (*A. nummularia*) is an indigenous plant of Australia, highly acclaimed and widely recognised for its stock feed value from the days of early pastoral expansion. Sippel (1993, p. 5) refers us to an extract from an agricultural gazette from prior to 1890 which extols its worth as a fodder plant:

...Oldman saltbush is one of the plants whose value as a fodder plant would not be easy to exaggerate. Its advantages are that it is nutritious, yields an enormous quantity of feed in a short time, it seeds enormously and may be propagated from cuttings. It has been so much appreciated that it is getting scarce. No one in Australia disputes its value but it is desirable occasionally to remind our people of the worth of our native vegetation. If we are not careful there are some native plants that we shall have to import from other countries.

Saltbush is a salt accumulator and perennial with significant environmental attributes, especially the ability to grow on saline soils with salt levels up to 50 000 ppm (Sippel 1993) and to lower watertables. Anecdotal evidence suggests that some salinity was obvious before European settlement, highlighted in 1829 when explorer Charles Sturt discovered the Darling River and found the water too salty to drink (Murray-Darling Basin Ministerial Council 1987).

Exploitative European settlement caused native saltbush and other flora and fauna to decline in many areas (Thompson et al. 1983), and the confluence of squatting and overgrazing, closer settlement and the advent of irrigation caused watertables to rise. Vial (2000, p. 1) reported that in the late 1800s,

...existing stands of gangland saltbush supported large numbers of sheep and cattle through severe drought... [however, the]*...effectiveness of this perennial reserve brought about its own demise, as it allowed continued set stocking to stop regeneration and exhaust the reserves of established plants.*

Overtime, populations of shallow-rooted annual crops and pastures replaced deep-rooted native perennials, which altered the hydrological balance of natural wetting and drying cycles (Eardley 1999), and accelerated the death of habitats that supported salt sensitive native flora and fauna. A further consequence of European farming systems has been increased salt levels in many rivers. A notable example is that virtually the entire water supply to the State of South Australia, which draws from the MDB, has become threatened (Weatherley 2002).

The potential for irrigation in Victoria's Kerang area was first recorded by Major Thomas Mitchell during his 1836 exploration. The natural vegetation in the region until the 1860s was salt-tolerant pigface and saltbush (*Dysphyna* spp. and *Atriplex* spp.), an indicator of high levels of natural salinity in the soil profile. At that time, the Kerang area had a watertable 8–10m below the soil surface, but following irrigation development by 1900 it rose to be only 2–3m below the soil surface. Weatherley (2002, p. 5) reported that

...the physical characteristics of the landscape were to be a minor consideration in the development of the region compared with the demands of local settlers for assistance to safeguard their livelihoods,

the political attractiveness of water supply development, the national inclination to 'develop' land and the drive of agricultural science to improve production...

By 1989, one-third of the land in this area could support only the most salt-tolerant plants such as saltbush (Weatherley 2002).

Management choices

The loss of perennial shrubs from semi-arid and arid communities to the point of complete removal by overgrazing has had long-term economic consequences which could have been avoided by grazing less intensively. For instance, in a study of merino sheep grazing on Riverina Plain bladder saltbush (*A. vesicaria*) and cotton-bush (*K. aphylla*) communities, Wilson et al. (1969) found that animal productivity was maintained at 0·6 sheep/ha with little decline in the *A. vesicaria* population. At 1·2 sheep/ha, grazing eliminated 98 per cent of *A. vesicaria* from the pasture which consequently proved incapable of maintaining sheep condition. Saltbush does not readily recover from overgrazing so when it declines so does the economic sustainability of the land. In areas where perennial grass pastures do not establish or erosion is liable to occur, the value of saltbush over grasslands is the better stabilising of sheep numbers and reducing fluctuations in production and income (Beadle 1948; Williams 1968; 1960). Grain and Graze (2005) researchers at Condobolin, New South Wales, are developing a saltbush-cropping system using *A. nummularia* to reduce profit variability between years on mixed farms. By incorporating alleys of Old Man saltbush into crop and pasture paddocks at 20 per cent, researchers hope to improve the quality and reliability of summer forage for stock. What this project reveals is that researchers can now link the economic cost of declining saltbush populations to financial rewards from reintroduction.

This research suggests a growing awareness of the importance of saltbush for sustainable systems, yet Australia may be lagging in appreciating the role saltbush can play with Freudenberger et al (1999) pointing to more Old Man saltbush now being grown overseas than in Australia.

Land managers need to be aware of the holistic impact their management choices have in the long term. It is then crucial that there is proper appreciation of the ability of saltbush's major environmental benefit to keep watertables low. Evidence of this benefit comes from Western Australia where measurements taken following heavy rainfall (85 mm) showed watertables rose 137 cm under annual pasture but only 6 cm under Old Man saltbush pasture (AWI 2004). Saltbush is also a very efficient converter of light rainfall events and Barrett-Lennard (2006) suggests that every farmer in the 300–400 mm rainfall areas should have at least some of it growing.

With good ground cover and grazing management, saltbush intercepts and retains more rainfall than do shrub-free areas because it reduces wind velocity and water evaporation from the topsoil. Honeysett et al. (2004) reported that the increase in net water intake at the soil surface did not mean a greater deep-drainage component; rather, water is better utilised by saltbush before it escapes down the profile. In the case of *A. nummularia*, this occurs because of its three-tier root system, comprising a shallow zone of fine roots, a deep taproot of 3–5 m, and laterals up to 10 m which seek out moisture and minerals at depths unavailable to other fodder plants (Nixon 1996). Whilst annual pasture species root systems follow a waterfront down the soil profile, a perennial like saltbush has roots deep in the profile ready to capture water. A further benefit is the fact there is no deep leakage of free nitrates because saltbush is a non-leguminous plant.

Saltbush has some other extraordinary properties. With the exception of *A. australasica*, all members of the genus *Atriplex* show the Kranz type of leaf anatomy typical of plants with a C_4 pathway of photosynthesis (Osmond 1973). A C_4 plant like *A. nummularia* photosynthesises faster than a C_3 plant under high temperatures and light intensity, making them efficient sequesters of large amounts of CO_2 by storing carbon at an early age, and longer, in the large root system and ungrazed branches.

The carbon-storing feature of C_4 plants like *Atriplex* have long-term environmental benefits, particularly if a carbon credit trading market develops in agriculture. Chris Mitchell, former CEO of CRC Greenhouse Accounting, suggests increasing the amount of carbon stored in the landscape is one way to offset some of agriculture's contribution to CO_2 emissions (2004, cited in Murdoch 2004a). Alan Lauder is a sheep breeder in Western Queensland whose work with CSIRO scientists has led to international recognition of his contribution to understanding how Australia's unique landscape works. He claims that we had all the tools [native plants] needed for long-term ecological sustainability, but removed them (pers. comm., 28 Apr 2006). The treatment of drought, greenhouse, water quality, biodiversity and salinity as separate issues, rather than one holistic issue, reflects what

Lauder suggests has really happened, that is; the carbon cycle has been mismanaged.

Management choices that use saltbush and perennials as feed sources can be the backbone of grazing systems. At Pyramid Hill, Victoria, Millsom (2002) reported stocking rates improved from 0.2 dse/ha to 2.0 dse/ha on saline soils after revegetation with saltbush. Other benefits accruing in this case were lower faecal parasite egg counts, increased land conservation works being undertaken arising from the improved carrying capacity, and more ready access to capital to allow enterprise diversification. Evidence from Pearce et al. (2003) found that grazing systems utilising saltbush could prevent the dehydration of lambs before slaughter, because ingesting high concentrations of sodium in saltbush helps increase the ionic concentration of extracellular fluid that stimulates a lamb's thirst. They also found saltbush-grazed sheep displayed a lower overall level of fat on the carcass, higher carcass yields and wool growth compared to animals grazing pasture-stubble.

Michael and Margaret Lloyd, farmers from Lake Grace in Western Australia, won the prestigious McKell Medal in 2003 for excellence in natural resource management. When the Lloyds began farming in the 1960s, salinity was not a significant issue in Western Australia's wheatbelt country. However, by the late 1970s, parts of their property were becoming waterlogged and saline. Today, 800 out of 2250 ha of previously arable land is affected, but the Lloyd's response to salinity

> *...changed what could have been a disaster into a blessing, as their pastures have helped them survive recent drought years. This investment in saltbush-based pastures is unique—few other Australian farming families have invested on a comparable scale* (DAFF 2003, n.p.).

In their economic analysis, the Lloyds calculated that their investment in saltbush-based pastures provided an additional financial benefit of A$154 per ha, a very powerful incentive for action.

Economic modelling validates the long-term financial benefits of saltbush. Some models have identified profitable strategies using saltbush as grazing stands at high sheep stocking rates for one or two months in autumn or early winter, when the additional feed fills the autumn feed gap. As a result of this strategy, the whole farm may be able to sustain a higher stocking density and reduce supplementary feed costs (Barrett-Lennard et al. 1990; Salerian et al. 1987). In Western Australia, whole farm bio-economic analysis modelling showed that saltbush pastures are likely to be profitable across a range of scenarios. O'Connell and Young (2002) showed income gains of A$30–40/ha were possible on a typical wheat-belt farm revegetating 50 hectare lots.

The financial and environmental effects of continuing to mismanage saltbush farming systems could be profound. The Cooperative Research Centre for Plant Based Management of Dryland Salinity estimates that if current agricultural practices are maintained in major MDB catchments, the area at risk of salinisation will increase by 300 per cent to more than half a million hectares by 2021 (National Land and Water Resources 2001).

Impediments to saltbush reintroduction

The foregoing indicates multiple advantages likely to arise from increasing the proportion of saltbush in the landscape; however barriers to reintroduction pose major threats to saltbush's future use.

Unsuitable conditions

Whilst different species of the genus *Atriplex* are suited to a broad region throughout Australia, a barrier to reintroduction is the perception that *dry zones* [below the 300 mm rainfall isohyet] and *cold zones* [above 350 m altitude] are not suitable for productive growth. Saltbush growth is predominantly driven by rainfall, but plants also respond to stored moisture and watertables, with systematic and steady growth recorded well into extended dry periods (Honeysett et al. 2004).

Landscape change may have rendered some other areas less suitable for reintroduction of saltbush. The MDB, known as the *food bowl* of Australia, is the largest river system in Australia, crossing several state boundaries and covering an area of 1.05 million square kilometres. Two million people live and work within the MDB, and depend on it for their water supply. Sitting in the lower MDB is the semi-arid pastoral country of the Riverina Plain, covering approximately six million hectares. This area, originally famous for its wool industry, saltbush and grass plains vegetation, has low and erratic rainfall with large areas of impermeable sodic clay soils. Saltbush grows on most soil types; however, some clays, acidic (pH<5, Ca Cl_2) and poorly aerated saline soils (EC_e >10 dS/m) form natural geographical barriers to reintroduction (Barson et al. 1994).

Population models and field measurements of births, growth and deaths have been used to investigate the long-term change in abundance of *Atriplex*. Following the saltbush (*A. vesicaria*) dieback on the Riverina Plain from 1977–1983, research by Clift et al. (1986) examined why 50 per cent of the *A. vesicaria* rangelands failed to regenerate.

Whereas the cause of dieback remained unknown, research found that declining distribution in many areas was attributed to selective grazing of female bushes and continuous heavy grazing of regenerating stands causing more damage post-dieback than the dieback phenomenon itself. Of particular interest to Hunt (2001) was whether *A. vesicaria* is at risk of being eliminated throughout grazed paddocks when the recommended practice of continuous grazing at conservative stocking rates is employed. Hunt's research found that decreases in adult survival and recruitment made the largest contributions to reductions in population growth rate. The research also found that the piosphere around watering points continued to expand over many years under set stocking, so the area devoid of *A. vesicaria* became larger.

Freudenberger and Landsberg (2000) found that the number of watering points in a rangeland influenced the spatial distribution of grazing. For the chenopod rangeland, 92 per cent of productive rangeland is within 10 kms of an artificial watering point—a sheep's grazing radius (Arnold and Dudzinski 1978). Whilst the proliferation of watering points with set stocking to increase production delivers short-term economic benefits, in the long-term it can be viewed as anathema to achieving sustainable production and natural resource systems.

Clarifying mixed messages from scientists

There are conflicting perspectives and understandings among both scientists and graziers regarding saltbush. Some take a narrow perspective focusing on one aspect of the plant as fodder while others, as has been the position throughout this paper, take the wider perspective that forage shrubs have a multi-functional environmental and economic role and their many positive attributes need to be carefully considered. By taking such a perspective the more holistic potential for saltbush can be discerned.

Historically, saltbush country was held in high esteem by pastoralists; however some research using saltbush grown on saline land has cast doubt on its value as a fodder plant. The current push to reintroduce saltbush challenges some scientific findings and myths about grazing saltbush, thereby creating a situation where mixed messages are sent or received.

Honeysett et al. (2004) suggests that disappointing experiences with saltbush usually stem from unrealistic expectations of production potential or else inappropriate management. Often, the poor management of grass cycles is transferred to saltbush, whose physiological slow growth cycle means that it is often subjected to continuous grazing which it cannot sustain.

Going back 40 years, Wilson (1965) acknowledged that many areas of Australian native vegetation were lost due to overgrazing, particularly during drought years, but said saltbush 'reintroduction should not be undertaken without prior study of the advantages to be gained and the relative merits of the various species available'. In contrast, from a perspective of conservation, Leigh and Mulham (1970) balanced this view when they suggested that until alternative species that are at least equal in drought tolerance, nutritional quality, and low in sodium, are proven capable of replacing *A. vesicaria,* it was vital that remaining saltbush vegetation be maintained. The lesson to be learned here is that from both a reintroduction and a conservation of saltbush perspective, an appropriate grazing system needs to be followed.

It has been commonly accepted that livestock will selectively graze plants with higher nutritional value and lower natural toxins; however, in Western Australia, Norman et al. (2004) found more complex variables influenced how sheep preferentially graze different *Atriplex* species. These preferences were not clearly associated with oxalates, tannins, sulphur or sodium — factors that reduce saltbush palatability — nor was it clear if these factors were even linked to animal productivity. Clearly more research is needed on these nutritional aspects.

Another mixed message is the amount of dry matter produced from *Atriplex* species compared to exotic perennials. Honeysett et al. (2004) claim that saltbush's dry matter production is only 4 kg of leaf and twig per mm/ha/year compared to lucerne's 7 kg/mm/ha/year, but Nixon (1996) claims saltbush only requires 304 L of stored water compared to 750 L for lucerne to produce 1 kg of dry matter. While these findings are not in contradiction with each other, the second is more significant where water is a limiting factor.

In order to obtain some clarity, the principal author recently conducted a series of interviews with saltbush landholders, research scientists, extension officers and marketers. The questions put, covered saltbush zones, revegetation targets, contingency plans, purposes and recovery timeframes. Three major points emerged: first, saltbush is productive outside of defined zones; second, a significant gap exists between saltbush revegetation targets and current reality; and third, there was general acceptance that native perennials are central to landscape sustainability. The survey also highlighted that the multi-faceted reasons for reintroducing saltbush ranged from stabilising landscape function and livestock income, to reclaiming saline areas, lowering watertables and improving financial and biodiversity outcomes. The majority of respondents also noted that 2-4 years elapsed before ecological or economic benefits were observed following reintroduction.

Financial considerations

There is limited information on financial performance because free-range saltbush ecosystems are relatively scarce as are full benefit:cost analyses based on saltbush plantations. Complicating any financial analysis is the fact that inappropriate management reduces lifespan and productivity from *A. nummularia*.

This is a constraint that needs to be considered when examining a financial study by NSW Agriculture (2000, cited in Honeysett et al. 2004) that evaluated saltbush plantations as a drought preparedness strategy for landholders in the central west of NSW. Proposals were assessed for the change in expected returns from the introduction of saltbush. Three establishment methods were used – direct seeding, bare-rooted, and speedlings – at 2500 plants/ha per treatment. No increase in carrying capacity was expected, but an increase in reliability of finishing animals and price gains was encompassed with the budgets. It found that landholders could potentially benefit from the introduction of a saltbush plantation using the bare rooted technique on two and a half per cent of the property, compared to the existing feed strategy. However, when the area of saltbush increased to five per cent, the existing tactical grain feeding strategy was economically desirable. In all cases, the study found that the existing tactical grain feeding strategy was economically preferable compared to the speedling and direct-seeding alternatives (Honeysett et al. 2004). Caution needs to be exercised in interpreting this particular financial analysis in that saltbush establishment costs can be amortised over 50–100 year life expectancy. Furthermore saltbush has low maintenance costs compared to other agricultural enterprises.

Whereas establishment costs have always been a barrier to saltbush reintroduction, recent technical innovations in direct seeding and establishment methodologies on heavy clay and saline soils has meant seed costs have reduced to approximately A$70 ha (Millsom 2002). This lower establishment cost compares favourably with sowing an exotic perennial like fescue (*Festuca*) at A$140 per ha, or the NSW Agriculture analysis noted above that costed speedlings at A$650-850 per ha.

Atriplex seedlings are poor competitors, and competition for water and nutrients from exotic weeds slows regeneration by reducing seed germination percentages, seedling vigour and increasing germination time (Waters 2001; Villiers 1994, cited in Penfold and Stevens 2005). These undoubtedly are factors mitigating against farmers investing in saltbush reintroduction as direct seeding saltbush has been a hit-and-miss process. However, Stevens (2006) has found that seed priming with the plant hormone gibberellic acid could cut germination time from 30 days to five, and increase germination rates from five to 99 per cent. This research is particularly encouraging and may lead to significant reductions in establishment costs. In turn, this could well lead to changes in grazing enterprises, something countenanced with caution by most Australian landholders.

With enterprise selection, many graziers believe that saltbush country is unsuitable for cattle production because of an inability to obtain the same forage intake and production as sheep. Wilson and Graetz (1980) found that the diet consumed by cattle in areas grazed by sheep was of poorer quality during dry times; however in terms of productivity and enterprise selection, results indicated that the weight gain of cattle on saltbush country was essentially the same as sheep. Tolerance to saline drinking water can be an enterprise production factor. Peirce (1968) suggests that non-pregnant and older sheep have more tolerance of saline water than ewes and lambs—these in turn have more tolerance than cattle (Weeth and Haverland 1961).

Pearce (2004) suggests that a dual potential now exists for farmers to utilise their saltbush to combat salinity and develop gourmet niche markets for sheep meat grown on saline land. French farmers have a sophisticated niche market for their lamb and mutton raised on the salt fields of Normandy and Haute–Provence; Welsh farmers raise saltmarsh lamb on tidal estuaries.

A 2003 case study in Western Australia showed that as saline areas increase, graingrowers became more interested in planting saltbush and salt tolerant grasses on saline discharge areas. It was shown in this case study that saltland pastures generated around A$7500 a year of additional profit from a typical 3750 ha property, with the consequence that the property's arable farm area can be increased by up to eight per cent (Murdoch 2004b).

According to Honeysett et al. (2004) many cropping areas are seen by some researchers as ideal for establishing saltbush plantations because they are free of weeds and stumps. It is suggested that a process of saltbush alley farming be introduced, a system that uses saltbush in alleys with annual crops or pastures. Researchers from a range of groups working on the National Dryland Salinity Program that encompasses alley-farming systems, suggest farmers would need to determine their own economic cut-off point, past which saltland pastures meant forgoing valuable cropping options (Murdoch 2004b). Enterprise selection should be based on perennial species (including leguminous trees), because they are at the heart of restoring metastable and diverse ecosystems.

Blott and Knight (1999) at Walpeup, Victoria, measured the changes in soil moisture and canola (*Brassica napus*) yields in an alley farming system using *Atriplex* spp. and *Acacia*. Their research found that 'recharge is therefore less likely to occur below the fodder belt', and 'the area of crop displaced by belts can be recovered by increased crop yields in the alleys'. It also highlighted several factors critical to decisions about integrating alleys into cropping systems. Acknowledging that recharge is an important issue to the MDB, the study found that unless rising watertables or wind blown sand damage to crops is directly affecting the farm, farmers perceived they would get little direct benefit from alley farming. The reasons, according to Blott and Knight (1999), were threefold – first, alley farming required modification in behaviour to manage the new system; second, the risk of unforeseen problems; and third, farmers could not make a short-term profit due to high establishment costs.

Millsom (2002) suggests that another obstacle to saltbush reintroduction is that the people who have had good results on their properties are the innovators rather than conventional farmers.

Procrastination

Dr John Williams, recently retired chief of CSIRO Land and Water, strongly supports saltbush research by farmers. He says that the level of change is too slow because of the rigidity of some scientific approaches, 'when what you want is a change of mind-set, traditional research—discipline by discipline—isn't necessarily very good' (Murdoch 2004a).

In Western Australia in 1968, after dryland salinity was identified as a problem, the Department of Agriculture began to screen forage species suitable for saline soils (Barson et al. 1994). Nearly 40 years later, researchers still do not have a definitive economic answer, let alone ecological answers about which species are more productive, palatable or salt tolerant.

The extract below indicates that time delays are not a modern phenomenon, because

> *...the plains of lower Riverina were covered with saltbush and cotton bush...and today these species are looked upon almost as curiosities. We have no doubt that plenty of roots and seeds are available on the back portions of the colony...and that, were small nurseries created here, it is likely that in a few years we would again have such valuable plants thriving vigorously on the local pastures. Is the experiment worth a trial?*
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> *The Pastoral Times*, 15 May 1886.

Time is a real barrier to reintroducing saltbush; the more saline soils become, the more difficult perennial species are to establish. Unfortunately, as Murray CMA Seedbank Coordinator and Revegetation Manager Martin Driver points out (pers. comm., 27 Nov 2006), saltbush is not magic in fixing environmental problems or poor grazing management.

Conclusion and recommendations

The NFF and ACF have estimated that at least A$65 billion is necessary over 10 years to deal with salinity and water quality issues in the MDB alone (Leigh 2001). Saltbush should not be seen as a remedy for salinised soils only, rather as a stepping-stone to improving economic and environmental sustainability; the decline in saltbush populations is symbolic of wider environmental degradation.

Pre-European vegetation was not a monoculture, as are many of today's agro-ecosystems. A single species in a landscape shaped by perenniality means a loss of diversity, less energy captured and impaired landscape function. The recommendation is to revegetate a high percentage of areas with saltbush, not as a monoculture but rather as an ecological system where chenopod layers will dominate.

A 30-year Saltbush Plan is offered here (in Appendix 1) and recognises a need to introduce a range of perennial plants to the landscape. It positions saltbush as a vital link to sustainability and restoring landscape function.

After investigating the use of saltbush at plot, paddock and catchment levels, it is apparent to the writers that if reintroduction is to be successful and not *ad hoc*, certain micro and macro-issues need answers. For the Strategic Plan to succeed, the human profile required for the reintroduction of saltbush to the environment will be on the shoulders of visionary governments, innovative communities, and the committed or young landholder.

The issues surrounding reintroduction are many, and prioritising, financing and undertaking actions for reintroduction will rely on landholders, communities, researchers and educators working as one in an adaptive management framework under the umbrella of the Council of Australian Governments.

The Saltbush Plan 2008–2038 empowers communities by allowing them to develop actions and set the finer details on implementation by treating reintroduction as a challenge, not as a problem. Time is of the essence — research will be holistic, some decisions will be best bet options.

The key ecological areas identified for financial investment and social engineering are the MDB and associated irrigation zones, and the sandplains cleared for agricultural production in South Australia and Western Australia. Within these zones, areas deemed most suitable for the Saltbush Plan would have several common factors:

- Saltbush was part of the original ecosystem
- Above saline watertables
- Capacity for enterprise diversification
- Food bowl areas.

Dillon (1979) wrote that farm management was too holistic and human a process for partial economic analyses to take agriculture very far. The writers concur and feel the single most important challenge about saltbush's reintroduction, regardless of by whom, how or when, is that decisions are holistic and not based solely on economic analysis.

The Saltbush Plan 2008–2038 suggested here is founded on a three-part vision associated with rebuilding an ecologically sustainable continent, research and development into commercially sustainable farming systems, and demonstrating best practice social engineering. It lists objectives, outlines key related goals and recommends actions to achieve these outcomes. A timeline for implementation is included.

The Saltbush Plan has a strong emphasis on land acquisitions with caveats on enterprise selection, fully compensated for from treasury. These new *publichold* titles will have lease back, culturally sensitive agreements, tied to land tenure which would allow land trading, generational transfer, and performance bonuses for meeting holistic outcomes.

The recommendations aim to be comprehensive and holistic. They also acknowledge two important constraints; first, the vast gap currently between saltbush dream targets and reality, and second, short-term socio-economic and political considerations mean land acquisitions and full funding could be difficult. For politicians, this should be no long-term excuse for procrastination, because the environmental issues are too serious, the social needs too great, and time too short. To do nothing will be socially and ecological irresponsible.

Acknowledgement

The authors are indebted to Peter Dowling and Catherine Ledger for their guidance and skilful assistance.

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-Vision 1-	Rebuild an Ecological Sustainable Continent		
Objective	**Goal**	**Proposed action**	**Timeline for implementation**
Reduce water and nutrient leakage	Reintroduce Chenopods	200% tax deductibility for revegetation with saltbush species	Commence from year one
	Reintroduce native grasses	*All areas planted to saltbush include native grass*	Parallel with saltbush reintroduction
	Prevent dryland salinity	*Wheat/sheep zone to grow a perennial species every 7 years*	Rotate with crops/pastures
	Prevent irrigation salinity	*200% tax deductibility for zero leakage infrastructure irrigation systems*	Commence from year one
Improve water quality	*Improve river flow and health*	*Target 30% of original flows to watercourse regeneration*	1% per year over life of plan
	Watercourse filter zones	*20 km wide riparian zone protection on rivers*	5 kms in 10 years, balance over 20 years
Repair and rebuild soil health	*Rebuild soil organic carbon levels*	*Eliminate all agricultural burning practices* *Stop all land clearing for the period of the strategic plan*	*Within 10 years* *Commence from year one*
	Optimise soil pH levels for perennial growth	*Eliminate all annual species fodder conservation activities*	3.3% reduction per year for plan life
Protect and increase native flora and fauna populations	*Buffer zone watercourses*	*Biological control exotic flora and fauna species*	*One species every 10 years*
	Buffer zone wetlands	*Create natural river reed filter weirs*	*Within 20 years*
	Exotic animal control	*100% elimination of domestic and wild feline populations* *100% elimination of rabbit and fox population*	*Within 20 years* *One species every 10 years*
	Exotic plant control	*100% phase out of exotic annual grazing species plantings*	*3·3% per year for plan life*
	Rebuild metastable ecosystems	*Target land acquisitions in buffer zones for publichold titles*	*Commence from year one*
-Vision 2	***RandD Commercially Sustainable Farming Systems***		
Improve financial benefits	Increase enterprise flexibility	*Macropod cooperative livestock systems developed*	*Developed 10 years, publichold by 30 years*
	Increase income	RandD perennial pasture cropping techniques	Within 10 years
	Lower expenditure	Evaluate GMO perennial crops	Invest Uni., Dept. and private RandD
Increase commercial opportunities	Increase capital flexibility	*Land tenure based on TBL production*	Within 15 years
	Develop flexible farming systems	*Model Desha farming systems*	Research/model low input farming asap
	Increase biological outcomes	*200% tax deductibility for no-till organic production processes*	*Commence from year one*
Develop strategic commercial benefits	Financial risk	*Agricultural globalisation access linked to TBL outcomes*	WTO lobbying/trade restrictions
	Establish carbon credit trading	*Link community carbon credits to bioregion revegetation* *Develop carbon credit root banks*	*Payments linked to revegetation targets* *Develop @ WTO/UN level 15 years*
	Alter climate change	*Develop indigenous RandD bush tucker food bowl ecosystems*	*One system within 15 years*
-Vision 3-	***Demonstrate Best Practice Social Engineering***		
Redefine Landcare	Deliver training in ecological sustainability	*Focus school/university education on ecological agricultural content*	Within 3 years
	Quality assured farming systems	*Conceptualise conservation farming as the next step up from Landcare*	Within 3 years
	Revegetate buffer zones	*100% revegetation of irrigation salinity and recharge zones*	3.3%reduction per year for plan life
Re-education by research and extension	Develop biological farming systems	Develop organic GMO to combat exotic pests and diseases	Within 15 years
	Communicate one message on saltbush	Develop agronomic well managed and commercial research plantations	Increased RandD to Dept. Ag. within 5 years
	Develop saltbush technology	Improve seed harvesting capacity	*Within 5 years*
Link land title to TBL guardianship	Develop Right-to-Farm training	Develop government buy/lease back and covenant agreements	*Ongoing and conditional*
	Develop intergenerational responsibility	Intergenerational transfers linked to an environmental dowry	Establish env. review boards asap
Commitment from governments and communities to TBL financial support	Develop industries based on saline water	Integrate financial investment with research/practical application	*Establish Gov/business RandD corporation*
	Develop native cropping system	Integrate native grass seed and root crop options with saltbush and grazing	*Invest in educational institutions*
	Develop native animal grazing system	Develop clean and green Macropodidae cooperative livestock enterprises	*Link bioregions/publichold-within 10 years*
	Develop zero leakage irrigation systems	Verify agronomical well managed and nil leakage zones with tax benefits	*Within 5 years*
	Profile population centres	Link declining population to increasing land acquisitions	*Commence from year one*