SUBMISSION TO
HOUSE OF REPRESENTATIVES

INQUIRY INTO CO-ORDINATION OF THE SCIENCE TO COMBAT SALINITY

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EXECUTIVE SUMMARY

Strategies to combat salinity have been dominated by hydrological modelling which emphasises differentiation of the landscape into 'recharge' and 'discharge' areas, models water flows and displays exaggerated vertical dimensions but does not examine the quantitative salt and water balance in salt affected areas especially under conditions of revegetation. As a consequence some people assume that whatever happens in saline areas is dominated by the arrival of water and salt from off-site in quantities which will prevent long term sustainable revegetation for productive use or biological conservation.

Return visits to old saltland revegetation research sites in Western Australia has revealed that a high proportion of the sites are long term sustainable for the growth of forage halophyte shrubs with an annual understorey. Sites revegetated up to 50 years ago and grazed each autumn since are still producing with the original shrub and understorey species. Other areas which have been destocked have revegetated naturally and are providing major environmental benefits and ecosystem services.

The old site evidence indicates that many revegetated salt-affected areas establish a salt and water balance without which long term survival would be an impossibility. Current policies on salinity research do not take account of these facts and as a result there is very inadequate funding of saltland revegetation relative to catchment treatment. Catchment treatment will not achieve as much as on-site revegetation where the primary cause of the problem is on-site recharge. It is misleading to describe these areas as 'discharge' areas.

There is an urgent need to change policies to give more priority to understanding and implimenting the revegetation of saline soils to reap the major benefits from grazing and environmental improvement that will result. The development of carbon credits as a means of paying for saltland revegetation offers an excellent chance for farmers, communities and the environment to benefit. There is an opportunity for Australia to lead the world in this field.

INTRODUCTION

The author has been involved in salinity research for nearly 50 years. The majority of the work has involved finding ways to make saltland productive with forage species. Although Western Australia has been the world leader in this field from as early as the 1970s recogition and funding within Australia has been limited. There are a number of reasons for this.

1 Policy making has been dominated by the belief that the major emphasis must be given to treatment of 'recharge' areas and that revegetation work done on 'discharge' areas is doomed to failure due to being overwhelmed by the arrival of water and salt from up-slope.

2 There has also been an impression that plants growing in saline land will not use significant amounts of water and will not therefore make a contribution to lowering watertables.

3 There has been a mistaken impression that halophyte forage is of little value on farms.

As result of these misconceptions the available funding has been stretched and many areas of work have not been adequately addressed or opportunities have been missed. These include:

1 Failure to recognise the potential for productive use of saline land.

2 Failure to have a nationally co-ordinated programme of research on productive use of saline land. Despite the best efforts of the workers involved with the National Committee on Productive Use and Rehabilitation of Saline Land it has never had its own funding.

3 Failure to research and quantify the salt and water balance of revegetated saline land.

4 Failure to adequately evaluate Australian halophyte forage germ plasm.

5 Failure to recognise that revegetation of some saline land can be long term sustainable.

6 Failure to evaluate the multiple benefits, economic, social and environmental, of revegetation of saline land.

7 Failure to capitalise on Australia's world leadership in the field of productive use of saline land.

8 Failure to recognise that short term funding strategies are totally inadequate for researching complex slowly changing systems.

9 Failure to recognise that plants growing on saline soils require attention to growth requirements such as fertility, acidity, compaction, waterlogging which if corrected can lead to major improvements in productivity

10 Failure to recognise the potential for selection for important agronomic characteristics within halophyte forage species.

11 Failure to recognise the economic significance of having high protein forage available to fill the autumn feed gap.

Some of these failures have been addressed in Western Australia (See the Proceedings of the 1996 PURSL Conference held in Albany) but due to inadequate support the research was abandonned and programmes of national and international significance were terminated.

For these problems to be addressed it is essential to counter the three misconceptions stated above.

THE DISCHARGE AREA BOGEY

There is a strong belief in some quarters that revegetation of 'discharge' areas is a waste of time. The proponents believe that water and salt flowing from higher in the catchment will accumulate in the 'discharge' areas and kill the species that are planted. This belief appears to be based on impressions given by flow tube modelling that there is a major movement of salt and water occurring **laterally** in the landscapes. The author has records and coloured slides of old research and demonmstration sites on saline land in WA going back over 50 years (some from deceased workers). The CRC for Salinity has arranged for the old research sites to be revisited to determine the long term outcomes of the research and provide answers to several questions. Of particular relevance to the 'discharge' area issue are the answers to the following:

1 Is revegetated saltland sustainable in the long term?

2 What site characteristics determine long term sustainability of revegetation?

I will deal with the answers in some detail.

Question 1 Is revegetated saltland sustainable in the long term?

In answering the question, sustainability was divided into three categories:

Remedial - sites whose capability has changed from the species originally planted to species of lesser salt and/or waterlogging tolerance.

Sustainable - sites on which the originally planted species are still surviving and may be recruiting, and where other species of comparable salt and/or waterlogging tolerance have invaded. Plants of lower tolerance may be finding niches created by the tolerant species.

Reversionary - sites whose capability has changed to plants of higher salt and/or waterlogging tolerance than the originally planted species.

In a few cases the whole of the old site has been cultivated and it is not possible to make a judgement. In a few cases there is an additional factor which may have influenced site condition, such as flooding or heavy grazing, see Footnotes.

The data in Table 1 indicate that in a majority of cases the revegetation initiated decades ago has proved to be sustainable according to the definition given. This does not indicate that on all of these sites there is a highly productive stand of halophyte forage shrubs because in many cases the original stand was sparse. But it does mean that the species have maintained themselves by survival or recruitment. Grazing does not appear to be a significant factor in the site rating. However, there are sites such as 103b East of Narembeen which would almost certainly have been worse if grazed.

Question 2 What site characteristics determine long term sustainability of revegetation?

This question needs to be answered by detailed study of landscape position, soil type, rainfall, and site hydrology. An attempt is made in Table 2 to classify the sites according to the part of the landscape in which they occur.

The data in Table 2 suggest that the issue of sustainability is not strongly related to the type of landscape in which the sites are situated. There was not time during this visit to study the soils and hydrology but soil data are available for a proportion of the sites (Malcolm and Swaan, 1989).

The site inspections reveal that a high proportion of saline sites in the WA wheatbelt can be revegetated for either forage production with halophyte shrubs and understorey or for biological conservation with the expectation of being long term sustainable. The application of the term 'discharge' to many of these sites is inappropriate. The use of the description 'discharge' for all saline areas is misleading and should be stopped. There is an urgent need to study in detail the old sites and determine the reasons for them being sustainable, reversionary or remedial.

WATER USE BY HALOPHYTES ON SALINE SITES

In answering the previous questions it was shown that many saline sites are in fact sustainable. This being the case it is important to know whether the species used for revegetation are capable of using the water which infiltrates on the sites otherwise it would add to the watertable and threaten sustainability. One of the questions addressed in the study of old sites was:

Question 3 What is the salt and water balance in sustainable revegetation?

For a site to be in balance there must be, averaged over time, equal amounts of salt and water arriving and departing. Arrivals may include salt and water in rainfall and run-on and in any recharge water arriving from up-catchment via subsurface routes. Departures may include evapotranspiration, groundwater flow downstream (below ground), run-off, wind blown soil and removal by animals. In the Atriplex spacing experiment conducted at site 141 (Malcolm, et al, 1988) (NOTE: Details of the site numbers are valable if required. In total there are about 270 sites) it was shown that in the period 1976-8 the chloride content of the root zone of shrubs increased by up to 21.7 t/ha as a result of use of groundwater by the shrubs which were calculated to have used 60-100 mm of water from the watertable over the two year period (Barrett-Lennard and Malcolm, 1999). The shrubs contained in the material harvested from the plots up to 0.66 t/ha of ash. The increase in salt in the root zone could have been due to a rearrangement of the salt in the soil profile due to the extracion of water from the watertable by the shrubs. If this water was replaced by underground flow of water (and salt) from up-catchment and the shrubs once again extracted the water and left the salt behind in the root zone, and if this process was repeated each year it would be expected that over time levels of salt in the root zone would prevent the shrubs from continuing to extract water. Continued water and salt movement into the site would cause a rise in the watertable and kill the shrubs. It is interesting to note that for the Belka Valley, Bettenay, Blackmore and Hingston (1962) concluded that the gradients and aquifer permeabilities were so low in the landscape that the primary cause of salinity on the valley floor was the clearing of the valley floor.

No further measurements have been made at this site but the 2003 visit revealed that a denser stand of Atriplex spp is on the site. Species composition has changed but not, as far as is known, towards higher salt or waterlogging tolerance. It can be stated that whatever changes have occurred have not resulted in the demise of the Atriplex stand. The persistance of the stand into 2003, 25 years after the end of the experiment, indicates that a salt and water balance must have been established. Whatever salt and water are arriving from up-catchment are within the capacity of the shrubs/site to balance by outputs. The hypothesis that can be developed from these observations is that the main arrivals of water at the site are from rainfall and run-on and that the shrubs use all of the water resulting in no rise in the watertable and recycle/redistribute whatever salt is involved.

A similar situation exists at site 105 where the author photographed a stand of Maireana brevifolia in 1960 (See Plates)and conducted detailed soil sampling (Malcolm, 1963) and observed that the stand had an understorey including Medicago polymorpha. Data on water holding capacity of the soil and its water content in autumn indicated that the water content of the soil had been drawn well below the 15 atmosphere percentage to a depth of 2.7 m. This had not occurred beneath the adjacent crop/pasture paddock. The stand was at that time at least five years old having been present when the author first visited the property in 1955. The 2003 visit, 48 years after the first photograph, revealed that there is still a stand of M.brevifolia with a vigorous understorey of grasses and legumes including M. polymorpha. Once again, a salt and water balance must have been established.

Evidence in support of this hypothesis comes from a report on the Lake Chinocup Catchment (Salama, et, al, 2000). They reported that in the catchment of 4000 square kilometres, 2000 sq km of which was stated to be the recharge area and the remaining 2000 sq km the discharge area, 'about 5.73 million m^3 of saline groundwater is discharged into the lake systems each year'. If this quantity of water is distributed over the 2000 km^2 of the discharge area it amounts to a depth of 2.86 mm which is well within the capacity of a halophyte shrub stand to utilise. The salt content of this water is not reported but if it is of the order of 9000 mg/L, the amount of salt arriving beneath each hectare is 250 kg. This is about half the salt in the tops of a stand of Atriplex shrubs and about five times what arrives in the rainfall each year. These data indicate that achievement of salt and water balance in comparable landscapes is practicable.

The number of sites on which there is sustainability of halophyte shrub stands indicates that establishment of salt and water balance on saline sites is a common phenomenon. There is a need for more research on the mechanisms establishing this balance.

ARE HALOPHYTE FORAGES VALUABLE

Halophyte forage shrubs are used as off-season feed in numerous countries by a wide variety of domestic animals. The shrubs tested in WA for use on saline land were included in grazing experiments to determine their ability to survive repeated autumn defoliation and estimates were made of the number of grazing days obtained from the bushes. Three experiments were conducted for 3, 6 and 5 years respectively. Reports were obtained from farmers of the use they were making of halophyte shrub pastures. The results were published in the Journal of the WA Dept of Agriculture and the establishment of halophyte shrub pastures was recommended to farmers (Malcolm and Pol, 1986). The need for shrub pastures to be grazed in conjunction with dry feed to dilute the salt content was advised to farmers as early as 1974 and the shrubs were recommended as an autumn feed.

Work at the Great Southern Agricultural Research Institute in the 1990s by Warren and Casson concluded that saltbushes could be used by sheep for maintenance. This was misinterpreted by some to mean that halophyte forage was of little value. The especial value of having maintenance feed available in the autumn was overlooked. The latest results of the WA 1 and WA 2 studies by the CRC for Salinity are confirming the earlier work and economic studies now emphasise the possibility of reducing autumn feeding costs by using shrub forages with understorey of other dry material. One of the questions posed in the old site study was:

Question 4 What is the long term productivity?

No yield measurements were made in the study. There are sites such as 98 (27 years) (See Plates), 105 (43 years) & 146 (27 years) where there has been long term autumn grazing and the stands are in good condition. It is likely that the grazing capacity of the M. brevifolia at site 146 (T. York, Tammin) compares more than favourably with the figures obtained in 1985 (Malcolm and Pol, 1986) because the photo records indicate a denser stand of shrubs (confirmed by Mr York). It is reasonable to assume that the long term yields on these sites are related to rainfall in some way. The author (Malcolm, 1963) measured the autumn yield of grazeable material from a Maireana brevifolia stand on the property of Bevan Parker (105) over five years (1955-9). The yields were found to be closely related to the total rainfall for the two years prior to the harvest in each case. The understorey species on site 105 included Medicago polymorpha in 1960 and it is still there in 2003.

ENVIRONMENTAL BENEFITS

Since much of the work in the old sites was commenced there has been an increased interest in the environmental implications of saltland revegetation. Observations on the old sites have included collection of higher plants, mosses and lichens and notes on evidence of animal occupation. An attempt to answer questions on the environmental implictions of revegetation was made as follows:

Question 6 What are the environmental benefits from revegetation of saline land?

There appear to be many environmental benefits from revegetation of saline land but few have been measured. Ferdowsian et al, 2002, documented the lowering of watertable levels beneath an extensive stand of halophyte shrub pasture. The evidence for use of groundwater by saltbush and bluebush in two old sites has been discussed in the answer to question 3. Logically this would result in reduced run-off and flooding, reduced erosion of soil by water and reduced nutrient flow to streams but these benefits have not been measured.

The control of wind erosion by revegetation was achieved at site 140 where the trans trains were being stopped because saline soil blown from an erosive paddock was shorting the signals. With funding help from Westrail the area was excluded from grazing and sown with halophyte shrubs. Poor results were obtained until ice plant, Mesembryanthemum nodiflorum, stabilised the soil. The sown species were then able to establish. The area is now grazed annually by about 600 sheep for a month and there is no erosion problem.

On site 140 the topsoil was largely in place. However, on sites 101 and 103b there are extensive areas where erosion has removed the topsoil and the subsoil has proved to be very difficult to revegetate. There is some evidence of succession enabling species diversity to increase. Some bushes of Halosarcia sp. have several young plants of Atriplex sp. establishing in their shelter. Other examples of succession occur in many sites with annuals colonising close to or beneath shrubs and lichens growing on the old wood of Atriplex spp or in one case on the trunks of Hakea.

Two examples of environmental improvement due to grazing exclusion are at sites 82 and 123. At site 82 the owner has an extensive sandy salt flat which includes a salt lake. Seed of Puccinellia cilliata was given to Mr Sudholtz in 1963 and over the years he spread it to 180 ha. His son has destocked the property for the last twelve years and a shallow drain has been provided to reduce waterlogging. Native pines and other species are now colonising the sandy banks on the flat.

Halosarcia and Casuarina have formed a dense cover around the salt lake which the owner says has become fresher. Swans and ducks were seen on the lake at the time of the visit and the farmer was obviously very proud of his achievement. Site 123 would have been cleared for agriculture early last century and cropped for many years before becoming saline. In 1970 a test plot of mainly Atriplex spp was established on the saltland. The person owning the site when the plot was established protected the land around the test plot and spread seeds from the plot resulting in the establishment of several hybrid bushes. Casuarina trees are now spreading in the area and at the time of the visit a plant of Roycea divaricata was observed at the entrance to the original test plot. This plant is uncommon.

There is evidence for the revegetated sites providing opportunity for the development of variation within species of plants. Somewhat differing forms of Didymanthus roei and Eragrostis dielsii have been observed. There are many examples of the revegetated areas becoming habitat for various biota including, spiders, ants, scorpion, birds and unseen burrowing animals. For the sites in the central wheatbelt it was possible to collect and have identified the mosses, see Table 5. There is also evidence for the sites providing harbour for weeds such as Cape tulip, Thread Iris and Guildford Grass and for rabbits and foxes. However, the benefits of revegetation greatly outweigh the disbenefits.

Question 7 How much carbon dioxide is sequestered?

No measurements of carbon dioxide sequestration were made. However, sites have been idenbtified where measurements could be made and contact has been made with Dr S. Mann at the Chemistry Centre to provide details.

The sale of carbon credits is a possible way to pay for the costs of saltland revegetation. Saltland vegetation is fire retardant and grazing only removes the leaves leaving the roots and branches as a carbon store.

CONCLUSION

It is concluded that there has been a serious misunderstanding of the detailed hydroology and ecophysiology of saline sites. A substantial proportion of sites in the WA wheatbelt can be revegetated for grazing or biological conservation with the expectation of long term sustainability. These areas establish a salt and water balance because the major contribution to the groundwater is from ON-SITE recharge. These areas should not be referred to as 'discharge' areas. Revegetation of many saline areas is profitable and of major benefit to the environment.

These conclusions differ from the principles which have been driving policies for reaearch and funding and should be used to modify the approach of governments and funding bodies.

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Table 1 Sustainability of revegetation of saltland

Criterion	Remedial	Sustainable	Reversionary	Unknown
No of sites	6	52	18	5
Duration[12] (mean and range in years)	36 (18-50)	30 (10-50)	28 (18-46)	
Grazing (no of sites)				
yes	2	23	9	
no	3	25	6	
uncertain	1	4	3	
Site CVM numbers	80[13], 85a, 95, 101a[1], 130, 132	79, 81, 82, 83, 84, 86, 87, 88[14] 89[2],90, 92, 93, 96, 98, 103, 103b, 105, 107, 114a, 122, 123, 125a, 128, 128b, 133, 134, 137, 140, 140a, 141, 144, 145, 146, 146a, 147, 149, 150b, 151, 151a, 154, 157, 165, 166, 171, 171b, 171c, 174, 176a[8], 177, 185, 208, 210	94[3], 101[10], 102, 124, 125, 128a[4], 136, 148, 150a, 160, 161[5], 162, 170, 172[6], 177a, 180a, 182, 208a[9]	127[11], 129[11], 131[11], 163[11], 175[7]

Table footnotes: 1 Tree plantings, 2 Solar pumps, 3 Flooding, 4 Juncus acutus invasion, 5&6 Halosarcia invasion, 7 Sprayed for cropping, 8 Heavy grazing, 9 Extra road run-off, 10 Wind erosion, 11 Cultivated, 12, No start date is available at present for sites 128a, 128b, 150b, 13, Dam and trees, 14 Drain.

Table 2 Classification of sites by landscape position.

Salt lake chains (Baandee type[1])			Tributary valleys ((Belka, Merredin, Mortlock, Avon types[1])			Hillside seepages			Upland salinity		
Rem[2]	Sus	Rev	Rem	Sus	Rev	Rem	Sus	Rev	Rem	Sus	Rev
-	86	94	130	81	102	80	79	88	95	90	-
	97	101	132	82	124	85a	154			174	
	105	128a		83	125	101a	157				
	125a	148		84	136						
	128	170		87	150a						
	128b	176a		89	160						
	144			92	161						
	147			93	162						
	149			96	172						
				98	177a						
				103	180a						
				103b	182						
				105	208a						
				114a							
				122							
				123							
				133							
				134							
				137							
				140							
				140a							
				141							
				145							
				146							
				146a							
				150b							
				151							
				151a							
				165							
				166							
				171							
				171b							
				171c							
				177							
				185							
				208							
				210							
Totals											
0	9	6	2	37	13	3	3	1	1	2	0

1 Described by Bettenay and Mulcahy, 1972.

Table 3 Planted or sown species, the numbers of sites on which they have survived and the maximum period of survival recorded.

Species	Number of sites on which surviving	Maximum survival recorded (years)
Atriplex amnicola	42	39
A. amnicola x A. nummularia	3	20
A. bunburyana	18	33
A. canescens	1	35
A. cinerea	8	27
A. halimus	4	35
A. lentiformis	6	21
A. linearis	2	34
A. nummularia	23	46
A. paludosa	13	26
A. undulata	14	26
A. vesicaria[1]	1	50
Maireana brevifolia	38	50
Puccinellia ciliata	20	45

1 The A. vesicaria is in a natural stand to the East of Jilakin Lake.

PLATES

Korbelka

Top Left
A germ plasm conservation plot of Atriplex amnicola planted with 1000 plants in 1976. The photo was taken in 1981 after the plot had been grazed by sheep.

Top Right
The same plot as at top left taken in 2001 being grazed by cattle.

Jilakin

Bottom left
An area on which the late Mr Bevan Parker encouraged Maireana brevifolia to colonise staring about 1950. I first saw the area in 1955 and the photo was taken in 1960 as part of my M. Sc. study.

Bottom right
The same area as at bottom left photographed in 2001. The fence has been replaced and some M. brevifolia has spread to the firenreak. The paddock on the left is still cropped.