SUBMISSION ON SUSTAINABILITY

by Clive V. Malcolm, Consultant in Land Rehabilitation

I submit that substantial areas of the salt-affected land in Western Australian farming areas can be revegetated for forage production or biological conservation and that the revegetated areas will be long term sustainable.

I further submit that the revegetation will result in many benefits for the farmers, the community and the environment.

I recommend that revegetation of saline land should be included in the State's sustainability policy.

The basis for these statements is as follows:

LONG TERM SUSTAINABILITY OF REVEGETATED SALTLAND

Starting in 1955, there was a specific research programme at the Western Australian Department of Agriculture on revegetation of saline land. References of relevance are in my publication list (Appendix 1) which includes a high proportion of the relevantliterature. Plants have been identified which are capable of growing on virtually all salt-affected land in the farming areas except salt lakes. Establishment techniques have been developed and innovative grazing management methods are in use.

In the course of this research a total of about 280 research sites, mainly on private land, were used and a database with details of these sites is currently being produced with funding assistance from the CRC for Plant Based Management of Dryland Salinity (See Appendix 2). In the preparation of the database old sites will be visited to determine what changes have occurred over the years. In many cases the sites have remained fenced for decades with some controlled grazing being permitted by the farmers. Although only a few sites have been visited to date it has become apparent that stands offorage shrubs or puccinellia on saline land have survived in good condition for periods of up to at least 41 years. There is also evidence of recruitment of native grasses and other native plants including fungi and lichens. Casual observation of the use of revegetated areas by white fronted chats, ants, lizards and kangaroos indicates that although in some cases the revegetation species are not endemic they provide habitat which benefits wildlife.

In Table 1 are details for three sites, representative of three different valley types, and on which saltland pastures are known to have been in use for decades.

Table 1 Long term sustainable saltland pastures in different valley types

Pasture	Farmer & town	Rainfall	Valley type*	GrazingUse	Years
Puccinellia	Samwell, Kulikup	>375	Mortlock	Spring & autumn	25
Bluebush	Parker/ Lucchesi, Kulin**	<375	Baandee	Autumn	>41
River saltbush	Willis/McGellin, Korbelka	<375	Belka	Autumn	26
Five saltbush species	McClelland/ Tiller, Kellerberrin**	<375	Belka	Autumn	26

* Bettenay and Mulcahy, (1972)
** These sites have changed ownership

Of particular significance is the condition of the sites at Kellerberrin and Jilakin for which soil and plant data were collected and photos taken in the past.

In 1955 I was taken by the late S. T. (Tom) Smith to the property of the late Bevan Parker (brother of the late Dr Lex Parker) East of Jilakin Lake and with extensive areas of salt-affected land. Bevan had encouraged the spread of bluebush (*Maireana brevifolia*) on his saline land and made regular use of it by grazing his sheep on it in conjunction with dry pasture and stubble. He also fed hay on the bare areas resulting in the establishment of more bluebush from trapped seeds. Bevan's sheep were the cause of complaint from his shearers because they were so large, he had peak cuts of wool per head and peak prices for his wool and he attributed these achievements to the use of bluebush. Locals referred to him as 'Bluebush Parker'.

In 1960 I conducted soil sampling to 2.7 metres depth in a stand of bluebush which Bevan had established on saline land on his farm and in the adjacent grass paddock. The results of this sampling were reported in my M.Sc Thesis in 1963. The area was used most years for grazing and I observed and photographed the annual understorey which included grass and *Medicago polymorpha*. Salt and water contents of the soil were determined in September 1960 and February 1961. Moisture release curves were determined for the soil and it was calculated that the bluebushes were removing water from the saline soil to significantly below the wilting point and to a much greater degree than occurred under the adjacent grass (Figure 1). The property is now owned by Mr Lucchesi who purchased it from Bevan and has continued to use the area for grazing in autumn. Inspection of the area in February 2001 revealed that the stand has become denser and comprises smaller bushes than were present in 1960 photographs. The stand still has an understorey of *M. polymorpha*. No analytical data have been obtained on the current condition of the soil but the plant indications are that on this site a stand of *M. brevifolia* grazed in autumn is a long term sustainable land use, in this case at least 41 years. The site is on soils grading from salmon gum to morrell and is representative of many wheatbelt situations.

On the site North of Kellerberrin (Table 1) five species of *Atriplex* were planted at five spacings in 1976. There were three replications and a total of 75 plots with 25 bushes per plot in five rows of five with the central nine being harvested after two years to determine the effect of plant spacing on biomass production. A two metre deep hole was augured in each plot with samples taken to represent twenty centimetre increments of the profile. Each hole was lined with downpipe and the watertable levels in all 75 test wells were monitored over two years and samples of the water taken for analysis. The results of detailed soil sampling have been reported elsewhere (Malcolm, et al, 1988 and Barrett-Lennard and Malcolm, 1999). Material was harvested from the bushes in 1978 and the soil was resampled. Between the two sampling dates the salt content of the root zone from 0.2 to 1.4 m increased significantly by up to 21.7 t/ha of chloride as a result of the bushes having used 60-100 mm of water from the watertable beneath the plot (Barrett-Lennard and Malcolm, 1999). The plot has remained fenced but the farmer has made some grazing use of the bushes since the experiment ended in 1978. The site was inspected in March 2002. There has been a change inthe species composition of the saltbush stand, *Atriplex vesicaria* and *A. undulata* having been greatly reduced and *A. bunburyana* having greatly increased. The overall result is that the stand is at least as dense 24 years later as it was after the increase in salt in the root zone was measured in 1978. No soil analytical data have been obtained since 1978 but the plant indications are that a stand of *Atriplex* spp on this site is a long term sustainable form of land use, in this case 26 years. The site appears to be typical of many saline areas in the central wheatbelt.

The stands of puccinellia, bluebush and saltbush discussed above are in Mortlock, Baandee and Belka valley types (Bettenay and Mulcahy, 1972) respectively, indicating that long term sustainable saltland pastures are possible in a range of landscapes and rainfall zones. What is not known is how this is achieved. In the cases of both saltbush at North Kellerberrin and bluebush East of Kulin, there is evidence for the shrubs drying out the soil profile to a degree where there would be no leakage below the root zone. Indeed, the reverse is the case, because the saltbushes used water from the watertable. It may be inferred that the biomass production of the shrub stands would be related to the incoming fresh water (rain plus run-on if any). In my thesis are data for bluebush biomass production being related to the two year total of rainfall prior to measurement. The difficult factor to quantify is the amount of water and salt arriving in theroot zone from up-catchment.

For the Lake Chinocup Catchment (Pingrup), calculations indicate that 5.73 million m^3 of water is flowing from the 'recharge' area to the 'discharge' area annually (Salama, et al, 2000) . If distributed over the extent of the 'discharge' area (2000 km^2) this amounts to a depth of 2.86 mm of water if evenly spread. No data are given for the salt content of the water. In Table 2 the salt load arriving in the valley floor is calculated based on assumptions of salt contents of 4500 or 9000 mg/L total dissolved solids in the moving water. The amount of salt arriving turns out to be of the same order of magnitude as the amount which falls in the rain each year.

Table 2 Perspectives on water and salt movement and storage in Western Australian wheatbelt landscapes.

WATER	Water or salt source	Water depth (mm/yr) OR salt (t/ha/yr)
	Arriving in Lake Chinocup discharge area by underground movement	2.86 a
	Rainfall at Lake Chinocup	
	Water use by *Atriplex* spp, N. Kellerberrin (rain + 30-50 mm)	239 to 300 b
	Water use by *M. brevifolia* at Jilakin	250-375 c
SALT		
Arriving in Lake Chinocup discharge area by underground movement	Groundwater 4500 mg/L TDS	0.125 (deduced from 'a')
	Groundwater 9000 mg/L TDS	0.250 (deduced from 'a')

	Rain at Quairading	0.070 d
	Atriplex tops at Kellerberrin	0.500 b
	Atriplex root zone increase, Kellerberrin	10.5 b
	In valley floor surface to bedrock	up to10,000 e

a Salama, et al b Malcolm, et al. c Malcolm, 1963, d Hingston, e Salinity, a situation statement for Western Australia, 1996.

These data indicate that the arrival of quantities of water and salt in valley floors comparable to that in the Lake Chinocup Catchment is unlikely to threaten halophyte vegetation. Lake Chinocup is similar to Lake Jilakin which adjoins the property of Bevan Parker and it is likely that there is an insignificant amount of salt and water arriving beneath the bluebush stand. The data focus attention on on-site recharge as the major contributor to rising watertables and revegetation of valley floors as the best way to lower watertables in at least some wheatbelt valley floor types. Similar conclusions were drawn by Bettenay et al. (1962) and Matta (1999) for the Belka Valley and the townsite of Merredin respectively. (Note the long term sustainability of the river saltbush in the Belka Valley in which Bettebay et al. did their research (SeeTable 1)). It is likely that these conclusions apply to a substantial proportion of the saline land in wheatbelt valley floors. The data challenge the claims made by some persons that plants above a saline watertable will salt themselves out. This will only be the case if the watertable is the only source of water for growth and there is no opportunity for flushing the root zone.

The salt balance of areas such as Samwell's puccinellia stand is also poorly understood. Mark has attested to the fact that there are flowing seepages growing *P. vaginatum* scattered through the puccinellia stand. It is likely that the watertable also intersects the surface in areas growing puccinellia during the winter. Presumably salt balance is achieved by salt from the puccinellia root zone flowing out of the soil anddown the stream. Once again there is a case for further research.

ENVIRONMENTAL BENEFITS

The most serious environmental consequences of salt encroachment are soil erosion, loss of biodiversity and habitat, decline in stream quality due to silt, salt and nutrients, increased flood risk and severity, lost aesthetics and raised watertables.

The most obvious effect of revegetation is to reduce soil erosion to a minimum. This is especially true of saltland pastures involving shrubs because even after heavy grazing there is always a stand of ungrazed branches to reduce surface wind velocity. Revegetation with perennial species has been shown to dry out the profile (Malcolm, 1963; Malcolm, et al, 1988) and to result in all incident water plus water from the watertable being used (Barrett-Lennard and Malcolm, 1999) on saline sites. This results in the landscape having the capacity to absorb more water. It also results in reduced watertable levels and improved annual plant cover (Barrett-Lennard and Galloway, 1996). The presence of vegetation, especially perennial species would be expected to increase the cracking of the soil and lead to more rapid infiltration. Data have not been obtained but it can be hypothesised that these changes would lead to reduced flood risk and reduced nutrient flow to streams.

Data have also not been obtained formally on the effects of revegetation on biodiversity and habitat. An expected result of lowered watertable levels and reduced flood risk is that it would be beneficial. I have observed species such as *Danthonia caespitosa, Enchylaena tomentosa*, *Wilsonia humilis, Sclerolaena* sp., *Didymanthus rowei*(?), and samphires volunteering in areas that have been fenced for the growth of saltland pastures. Those who have collected bluebush seeds and spread them on the floor to dry will attest that the sample is alive with insects and spiders. White fronted chats have often been observed to colonise shrub plantings on saline land. It is time to measure these benefits.

An additional benefit from revegetation is sequestration of atmospheric carbon in the woody branches and roots of forage shrubs and in improved soil organic matter. A rough estimate of the amount of carbon dioxide equivalent sequestered by a saltbush stand based on data from North Kellerberrin is 10 t/ha (Malcolm, 2001).

It must be recognised that there may also be some negative effects from revegetation. *Paspalum vaginatum* has been observed to cause raising of creek beds resulting in the diversion of surface flows and puccinellia has been observed to spread into some areas fenced for biological conservation.

A major benefit to the environment would result from revegetation of areas which are too saline for pasture production with native species for biological conservation.

ACHIEVING REVEGETATION

The Saltland Pastures Association (SPA), based on the experience of many of its members proposed to the State Salinity Council (SSC) a major project for revegetation of one million hectares of saltland on Western Australian farms. It was proposed that land suitable for forage production would be revegetated with forage halophtes and land that was too saline and waterlogged would be revegetated for biological conservation (Malcolm and Lloyd, 2001). The SSC provided funding for the preparation of a Business/Project Plan which is being written prepared at the WA Department of Agriculture with guidance from a Steering Committee with representation from four Natural Resource Management Groups, the Department of Agriculture and the SPA. The project named '1MPULS>' (one million hectares of productive use of land with salinity) will benefit from the new Land Water and Wool project for Sustainable Grazing from Saline Lands. The possibility of attracting carbon credits for the carbon sequestered by the revegetation is being discussed with potential partners and the passage of the Western Australian carbon rights legislation would be helpful. It is anticipated that the plan will be completed by the end of the financial year and that action will commence in earnest soon after.

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CURRICULUM VITAE

FULL NAME: Clive Vincent MALCOLM

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DATE OF BIRTH: 26 December 1933

PLACE OF BIRTH: Perth, Western Australia

MARITAL STATUS: Married with five children

EDUCATION: 1946 - 1950 Perth Modern School
1951 - 1954 B.Sc.(Agric) University of Western Australia
1952 - Associate Art of Speech Australia
1963 - M.Sc.(Agric) University of Western Australia.
Thesis: An Agronomic Study of *Kochia brevifolia* R.Br.
1975 - M.Sc. (Pollution and Environmental Control)
Manchester University, Dissertation: The processes
determining environmental quality standards with
reference to Greater Manchester.

CERTIFIED PRACTISING AGRICULTURALIST (CPAg) by the Australian Institute of Agricultural Science and Technology

CURRENT PROFESSIONAL ACTIVITIES

Member of the Technical Committee of the Islamic Development Bank concerning the development of the new international Biosaline Agriculture Centre currently being constructed in Dubai (May 1998).

Vice President of the Saltland Pastures Association.

Seeking funding for a training course for Pakistani and Australian farmers and advisers in the areas of saltland treatment and landcare.

Providing advice concerning the revision of the Salinity Action Plan and the Background Statement.

Providing advice concerning research programmes on saltland pastures to Agriculture WA and Muresk.

See also the most recent publications on the list in this cv.

CONSULTANCIES AND INVITED PAPERS

In 1968 I was invited to South Australia to advise on problems of foliar salt uptake during sprinkler irrigation.

In 1971 I was invited to present a review on problems of shrub establishment on saline soils at the International Shrub Symposium in Utah.

In 1982 I went as a consultant to the Governments of Iraq and Saudi Arabia to advise on problems of forage production on salt-affected soils.

Also in 1982 I was invited to present a paper on the effects of salinity on forage shrub growth to the Boden Conference of the Australian Society of Plant Physiologists at Thredbo.

In 1983 I undertook a UNESCO consultancy to Tunisia to advise on current and future research for the Institut Regions Arides at Medenine.

In 1985 I presented a paper by invitation to the FAO Expert consultation on the role of forestry in combatting desertification at Saltillo, Mexico.

In 1985 I was invited (funded by US/AID) to deliver a paper to the US/Pakistan Biosaline Research Workshop in Karachi.

In 1987 I delivered a paper by invitation at the International Botanical Congress in Berlin.

In 1987 I undertook a consultancy of one month for FAO to Iran to recommend a programme for rehabilitation of the salt affected rangelands of Iran.

In 1990 I delivered papers to conferences in Pakistan, India, Perth, Tatura and Adelaide.

In 1990 I undertook a consultancy to Iraq on rehabilitation of saline pseudo-sand dunes for FAO.

In 1991 I delivered an invited paper to the International Conference on Agricultural Management in Salt Affected areas in Agadir, Morocco.

Since my retirement in 1991 I led a training course in India on Community Involvement in Revegetation of Saline Land and acted as a consultant to the South Australian Department of Agriculture on productive use of saline land.

In 1992 I delivered an invited paper to the International Symposium on Strategies for Utilizing Salt Affected Lands in Bangkok, Thailand in February.

In November 1992 I participated in a UNEP expert consultation on the role of halophytes for livestock and for rehabilitation of degraded land. I was joint editor of the Guidelines produced by the consultation.

In December 1993 I was one of a panel of experts examining plans for the Islamic Development Bank for the establishment of a major salinity research centre in the United Arab Emirates.. I am currently (10/97)a member of the Technical Committee of the Biosaline Agriculture Centre construction of which will commence in 1997.

In September 1994 I delivered an invited paper at the Internatiuonal Conference on Land and Water Resources Management in the Mediterranean Region in Bari Italy.

I was Chairman of the Organising Committee for the 4th Australian Workshop on Rehabilitation and Productive Use of Saline Land to be held in W. Australia in March 1996.

FELLOWSHIPS

In 1966 I was awarded an FAO Andre Mayer Research Fellowship. This enabled me to conduct research at the University of California in Riverside and to discuss problems of irrigation salinity experienced at Carnarvon with workers at the U.S. Salinity Laboratory and other research establishments. Also I was enabled to visit many salt affected areas in U.S.A., North Africa and the Middle East to discuss salinity problems and to collect seeds of salt tolerant forage plants for testing in Western Australia.

In 1974 I was awarded a Robert Gleddin Overseas Fellowship to enable me to undertake the M.Sc. course at Manchester University in Pollution and Environmental Control. This was at a time when I was called upon to advise on many environmental issues.

In 1986 I made a lecture tour of U.S.A. including giving the Blankenbacker Lecture Series at Montana State University. I undertook two months research at Tucson, Arizona under the U.S./Australia Science and Technology Agreement in 1986 and under the Mexico/Australia Science and Technology Agreement made a two week visit to Mexico.

EXPERIENCE:

I joined the Soil Research and Survey Section of the Department of Agriclture in late 1954, and was in continuous employment in the Section (or its recent equivalent) until my retirement in September 1991. I was immediately given the task of studying thevalue of a salt tolerant shrub pasture and researching methods of returning salt affected land to production. This work led in 1963 to my M.Sc.(Agric.) Thesis.

During my employment I was also required to conduct soil surveys at Badgingarra, Wiluna, South Perth and Denmark, to develop equipment for studying soil structural problems and to conduct research into soil structure and plant water relations. I assistedin studies on salt movement in soil and groundwater in the 1950's and 1960's and in the early 1960's I investigated problems of irrigation with poor quality water at Carnarvon. Over several years I ledinvestigations which showed that sodium, salinity and boron were causing growth problems that could be alleviated by leaching.

In specialised extension exercises I have conducted backhoe pit studies of salt problems in the Morawa, Cadoux, Wongan Hills, Tammin and Quairading districts and have done detailed soil sampling in saline sites at 18 areas from north of Morawa to Ongerup,in south Western Australia.

I have made advisory visits to farmers throughout the farming districts and spoken at field days as a salinity specialist on numerous occasions.

In 1966-67 I spent 14 months overseas conducting research into the foliar uptake of chloride during sprinkler irrigation at the University of California at Riverside. Following that period I collected seeds of salt tolerant forage plants in U.S.A., Algeria, Tunisia, Turkey, Israel, Iraq and Iran. The seed collection was returned to Western Australia and has been augmented by overseas exchange and plant exploration trips which I have made in the Murchison, Gascoyne, Eastern Goldfields and Nullarbor regions of Western Australia. The collection of salt tolerant forage species totals 950 and has been subjected to a screening programme. It has resulted in the selection of forage species which are now being harvested and planted commercially on wheatbelt farms. Two selections of *Atriplex amnicola* have been released (1987).

My research on shrub establishment problems has led to the development of the new technique, 'niche seeding' and the Mallen Niche Seeding Machine. The machine was developed during an intensive nine year testing and research period and is now commercially manufactured and used for commercial contract seeding in Western Australia and South Australia.

The research on salt tolerant forage has attracted interest overseas and seeds have been sent to over 30 countries. In 1980 I presented a paper at a salinity symposium in India and visited research establishments in India and Pakistan. In 1984 I was Chairman of the Organising Committee for a Research for Development Seminar on "Forage and fuel production from salt-affected wastelands". The Seminar, held at Cunderdin 19-27 May 1984, was attended by scientists from 20 countries and supported by a grant of $80,000 from the Australian Development Assistance Bureau.

I was responsible for extending the principles of revegetation technology developed for wheatbelt saltland to other harsh environments including arid rangeland and mine dumps. This led to the formation of the Revegetation Technology Group. I was the Operational Group Manager of the Revegetation Technology Group studying the rehabilitation of salt affected farmland, degraded rangeland, recharge areas and mine dumps at the time of my retirement. The plant selection techniques, species and establishment methods developed for wheatbelt saltland are being applied with promising results to the other difficult environments.

I was co-leader in Australia from 1988 to 1992 of a cooperative research project with five research institutions in Pakistan on forage shrub production on saline and/or alkali soils funded by the Australian Centre for International Agricultural Research.

I was the leader of a training course on Community Involvement in Revegetation of Saline Land given jointly by the Department of Agriculture of Western Australia and myself in India in 1992/3.

Currently (1997) I am on the Technical Committee for the Islamic Development Bank's new Biosaline Agriculture Centre in Dubai.

COMMITTEES

I was Chairman of the National Committee on Productive Use and Rehabliitation of Saline Land from its inception in 1990 until 1992.

For many years I represented the Department of Agriculture on the Water Purity Committee and the Gascoyne River Advisory Committee.

SPECIAL PUBLICATIONS BY INVITATION

I wrote a chapter for the book "Shrub Biology and Utilisation" edited by Prof. C.M. McKell of Utah and published by Academic Press in 1989. My chapter is entitled "Forage shrub production on salt-affected soils".

In September 1993 I gave four lectures in an Advanced International Course on Halophyte Utilisation in Agriculture in Agadir Morocco and I am second of the three editors of the book published by Dekker of the lectures and author of four of the chapters. See publication number 69.

OTHER INTERESTS

In my private life I have accepted leadership responsibilities in many ways. For example, President, Australian Soil Science Society (2 years), Royal Society meeting secretary (several years), Secretary New Heart for Perth Society (several years), Warranted Scout Leader (8 years), Drama producer of Perth Gang Show (2 years).

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APPENDIX 9 Paper to National Conference on productive Use and Rehabilitation of Saline Land, Launceston, 2001.

Revegetation of one million hectares of wheatbelt saltland in Western Australia

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ABSTRACT

The area of secondary saline land in Western Australia is forecast to increase to 4-6 milllion hectares. Salinity causes a dramatic drop in production for farmers and is associated with erosion, flood generation, rising watertables, nutrient flow to streams, poor habitat and biodiversity loss.

Technology has been available in Western Australia for twenty years for obtaining profitable forage production from saline land using halophytic shrubs and grasses but farmer uptake has been slow. Revegetation for forage production not only provides an economic return, as attested by farmers who have done it on a broad scale, it also results in erosion control, mitigation of flooding, retention of nutrients, lowered watertables and improved habitat. The technology is especially relevant to the broad valleys of the wheatbelt where the major cause of salting is valley floor recharge.

Farmers need an incentive to revegetate saline land especially if it does not occupy a major area on their farm. The public benefits from having saline land revegetated justify the expenditure of public funds on mapping the areas to be revegetated, developing technology packages and providing training to facilitate having the job done.

Salinity threatens the biological diversity of the broad valley floors and it is proposed to establish biological conservation plantings on a proportion of the revegetated saline land. Farmers will receive assistance with this conservation work. An incentive which this strategy hopes to access is to obtain carbon credits for the carbon sequestered in the forage shrubs, improved ground cover and increased soil organic matter. Estimates indicate that the credits may cover the costs of establishment and fencing.

The project will require the establishment of new enterprises associated with seed harvesting, direct seeding, fencing and trading in carbon credits. There will be an opportunity for the development of new animal products based on clean green accreditation. The project will be responsible for the creation of employment in regional areas in a new industry which is likely to expand to additional saline areas in Western Australia as well as interstate and overseas.

PREAMBLE

Western Australia is predicted to have continuing increases in salt-affected land from the present 1.8 million hectares up to a total of the order of 4-6 million hectares despite efforts to use more water in the agricultural landscape (State Salinity Council, 2000a) . Secondary salt-affected land is the most erosive in the landscape, generates the most and fastest run-off, is the poorest habitat and worst eyesore and threatens other developments. When agricultural land becomes salt-affected its production drops dramatically, with serious economic implications for the farmers and their families.

The Government of Western Australia through the State Salinity Council has prepared 'The Salinity Strategy', outlining the nature of the problem and the approaches to be taken for its treatment. A second document, titled, 'Salinity Actions', indicates the actions to be taken (State Salinity Council, 2000b). One of those actions is for AgWest (Agriculture Western Australia), CALM (Department of Conservation and Land Management) and the Saltland Pastures Association (SPA) to focus on the productive use of saline land. Salinity Actions has included the Saltland Pastures Association's initiative for revegetation of one million hectares of saline land over ten years.

BACKGROUND

Research indicates that salt encroachment is caused by the movement of unused rainfall below the root zone of crops to join the watertable (George et al, 1997) . Lateral movement of water below ground is so slow that in many cases, such as the broad valleys of the wheatbelt, on-site recharge in the valleys is the major cause of the salinity problem (Bettenay et al, 1962). A practical and economical way to counteract the problem in these areas is to revegetate the saline valley floors. Research at Agriculture WA and development efforts by Western Australian farmers and companies has provided the technology to make salt-affected land productive using forage halophytes. There are in existance examples of shrub stands over forty years old and still in use for grazing (Malcolm, 2001).

The technology available now includes:

- a range of species selected for their ability to produce forage on salt-affected land;
- methods of harvesting and handling seeds;
- the niche technique for direct seeding;
- seedling planting methods;
- techniques such as fertiliser, ripping and plant partnerships for improving production; and,
- management strategies for utilising the forage material in farm programmes.

There are additional benefits. Revegetation controls erosion, mitigates flooding, reduces nutrient flow to streams, improves habitat and uses water thereby lowering the groundwater levels. Revegetation of saline land creates a new source of income, without competing with any other land use.

To extend the good results on some farms to the majority we need to use the skills and experience of the relatively small number of farmers who have availed themselves of the technology. The barriers to adoption include low wool prices, unfamiliar technology, need for different machinery which they do not have, need for new management knowledge and pre-occupation with other aspects of farming. There is also a need for improved ways to identify the best areas for revegetation to extend the good results on some farms to the majority. With the predictions of increasing salinity it is becoming increasingly important for action to be taken to revegetate salt-affected land for public as well as private benefits.

None of the factors which has hindered adoption of saltland revegetation in the past has changed significantly. It is unlikely that broadscale revegetation would be undertaken by farmers unless new factors are introduced into the decision making process. New factors which are the basis for this proposal are:

- the release of the new Salinity Strategy and Salinity Actions documents;
- recognition of the increased risk of downstream flooding and eutrophication due to increasing salinisation of land and degradation of watercourses;
- increased government commitment to take effective action on salinity;
- the possibility of attracting carbon credits to pay for establishment costs; and,
- recognition of a new urgency to ameliorate further loss of biological diversity from saline areas. (CALM surveys have shown that the risks of extinction are highest in valley floor habitats.)

Carbon credits

This proposal explores the possibility of obtaining carbon credits to help pay for the establishment of halophyte shrub pastures and thereby give farmers the incentive to participate. The State-Commonwealth arrangements which will be required do not yet exist, but they may come into being as the greenhouse issue develops.

When salt-affected land is planted to halophyte shrubs for grazing, the shrubs develop a woody framework of branches and a substantial root system. Grazing by sheep removes the leaves and the small sticks leaving the roots and branches. The root system and the branches are fully developed by about year three. There are in existance examples of shrub stands over twenty years old and still in use for grazing.

Carbon credits are needed by organisations such as Western Power, Woodside Petroleum and BHP as well as many overseas companies. Contracts would have to be drawn up for revegetation and for the farmer to maintain the integrity of the carbon bank so established. There would also have to be put in place a verification system, probably using satellite imagery, to ensure that the carbon bank was established and remained intact. It may be necessary for the monitoring function to be carried out by a third party. As there is a substantial public interest in having the revegetation done it should be possible to arrange that the public sector puts in place an adequate system of verification.

Biodiversity
Biodiversity conservation is identified as one of the aims of the Salinity Strategy. It is proposed that the conservation of biodiversity can be incorporated as one of the aims of the revegetation of saline land on farms. It has been observed that some birds and small mammals quickly return and some local plant species volunteer on relatively small revegetated saline areas grown solely for their pasture value. The potential biodiversity benefits must be far greater when such revegetation is established deliberately for diversitification and is managed for the buffering of remnant vegetation and with grazing protection.

Just as remnants of bush are set aside in special reserves on farms, a proportion of the revegetated land can be designated for biodiversity benefits and biological conservation as a reciprocal action by farmers for assistance with revegetation and fencing. Under Salinity Actions, CALM will have programmes for the survey of saline land for biodiversity and storage of seeds for revegetation.

WA technology for sustainability.
There is a further possible benefit from the proposal. There are many countries (and other States in Australia) where revegetation of degraded land is an urgent necessity. Many of these countries are poor, require bilateral projects and programmes and cannot afford to pay for it to be done. If the work can be done in exchange for carbon credits, the skills and experience developed in Western Australia will be able to be exported to achieve major revegetation projects elsewhere.

PROPOSAL
It is proposed to revegetate one million hectares of salt-affected land for forage production, carbon sequestration and environmental improvement in the Western Australian wheatbelt.

VISION
Revegetation of one million hectares of currently unproductive land will create employment, establish a new industry, provide major environmental benefits, yield grazing for millions of sheep and contribute substantial greenhouse benefits. The motivation for the project is the urgent need to revegetate saline land to provide a return for affected farmers and to ameliorate some of the more acutely degraded parts of the agricultural landscape. Belief that the value of the carbon credits earned per hectare by a stand of shrubby halophytes will help pay for the establishment cost is the added incentive. Farmers would contract to maintain the stand's integrity as a carbon sink. It is proposed that there is a sufficient public benefit in having the saline soils revegetated that the verification costs should be bourne by the public sector. Farmers would have the option of agreeing to allocate a section of the revegetated land for biological conservation in return for assistance with establishment and fencing costs. Farmers could include at their own expense the sowing of grasses such as Puccinellia and Tall Wheat Grass and annual species such as Balansa clover with the forage shrubs.

Saline land, a new resource - Farmers in Western Australia have shown that saline land is capable of providing off season forage which can be used to substantially increase the overall carrying capacity of their farms. This technology has been in use for up to twenty years on farms. Reported carrying capacities exceed those of non-saline pastures on the same farms in some cases.

The availability of halophyte shrub pastures on saline land enables farmers to adopt strategies such as deferring grazing on non-saline annual pastures after the break of the season and reducing the time spent on hand feeding during seeding. The halophyte shrubs are responsible for lowering groundwater levels and ameliorating the soil sufficiently to allow less salt tolerant species to grow and improve the quality of the mixture of forage available. The shrub-based systems now include the sowing of grasses such as Puccinellia and Tall Wheat Grass, and annuals such as Balansa clover with the forage shrubs. Managed appropriately, forage shrub stands have been observed to produce for over forty years (Malcolm, 2001).

Environmental benefits - Revegetation with halophytic forage shrubs and grasses provides many public and private benefits including increased water use, erosion control, flood mitigation, nutrient trapping, watertable lowering, remnant vegetation buffering and habitat creation. The environmental benefits can be increased further by designing revegetation for diversification in both structural and floristic terms with non-forage plants and local provenance species of importance for catchment and regional biodiversity benefits in the revegetation programmes and giving them special protection on a proportion of the revegetated land. Catchment planning for co-ordination of these areas across adjacent farms can define where corridors are most needed for biological conservation. Existing covenanting schemes could be invoked and developed for the long term protection of such areas.

Carbon dioxide sequestered by a halophyte stand - There are limited data on the amount of woody biomass produced by a stand of halophytes. In an experiment north of Kellerberrin stands of *Atriplex* spp yielded about 1.8 t/ha of ash free grazeable material (Malcolm et al, 1988). Measurements of the woody component were not made but could be expected to be at least equivalent to half of the grazeable matter making a total aerial component of the shrubs of up to 2.7 t/ha. Conservative estimates for carbon in the roots and the soil organic matter give an overall estimate of the carbon dioxide equivalent sequestered by the improvements associated with revegetation as about 9.9 t/ha (Malcolm, 2001). Prices from $8 to $30per tonne would yield the farmer from $79-$297 per ha gross which is a range from a reasonable incentive to an excellent incentive. These figures are only indicative and they must be confirmed to determine the actual carbon levels sequestered. However, there are several ways to promote the production of *Atriplex* spp biomass and none of them was used in the experiment at Kellerberrin. The methods are, fertiliser, soil ripping, selection of high yielding strains and selection of sites best suited to the growth of the species being planted. There is good reason to believe that the yields could be substantially increased at least on some sites.

Costs of verification - There is a need for the amount of carbon in the established stands to be verified in order that carbon credits may be paid. It is proposed that there is sufficient public interest to justify public expenditure on the development of a funding proposal for the implementation of the verification system needed.

Costs of establishment - Stands of halophyte forage shrubs are established for prices ranging from 3-15 cents per bush. It is common to plant about 1500 per hectare, equivalent to an establishment cost of $57-225 per ha, including machine hire. The price can vary depending on whether a farmer owns or hires the seeding equipment with or without an operator and whether the farmer harvests his own seeds.

REQUIREMENTS FOR SUCCESS

For the project to proceed the following factors would need to be in place:

1 **Improved land capability assessment**, at the scale required to identify suitable candidate areas throughout the south-west. Further assistance is required from Land Monitor and the NRM agencies. Contractors and landcare technicians will require assistance with implementation, design and works on the ground. Tools for planning and implementation design will require region-scale analysis and a good understanding of potentially suitable areas across whole catchments.

2 **Technology that is proven in practice**. There are a number of operators who have done revegetation on their own farms and/or have carried out contract revegetation on other properties. The experience of these persons would be invaluable for the project. These persons will also be seen to be practical farmers in whom other farmers can put their trust. It will be necessary to engage these persons to assist in training and advice for the implementation of the revegetation programme. It is vitally important to view the revegetated areas in the context of the whole farm enterprise in each case and the

current examples show how this can be done.

3 Technology that is based in sound research. Research programmes in WA led to the successful examples of revegetation of saline land on which this project is based. Extrapolation of the current successes to one million hectares of saline land will require:

- characterisation of saline areas in terms relevant for revegetation including, climate, soil, waterlogging, salinity and inundation;
- ongoing research to improve the range of revegetation options available, including, selection of species/varieties for particular situations, methods to improve production and methods of utilisation;

- accurate assessment of the carbon sequestration by representative stands of forage halophyte shrubs;
- development and implementation of the verification system for sequestered carbon; and,
- species identification and methods of establishment for species to be planted for biological conservaion.

4 Technology that is clearly defined. It will be necessary to provide the following technical back-up for the programme:

- identification of the areas to be revegetated. Contractors and landcare technicians will require assistance with this task and it will be sought from AgWest , CALM and Land Monitor ;
- appropriate assembly of revegetation information including, species selection, seed harvesting, cleaning and storage, germination requirements, establishment methods, methods of maximising production and methods of management. This task will include the development of new technology for selecting and sourcing species and provenances for biological conservation as well as forage production and has been assigned in Salinity Actions to AgWest , CALM and the SPA.
- information concerning revegetation of saline land will be included in the collaborative project between CSIRO and AgWest under Salinity Actions and made accessable via REX and AgFax and regional networks;

5 Wide acceptance of the technology by farmers, scientists and the community. The SPA has been responsible for a major change in perceptions of the value of saltland pastures in the last two or three years. This needs to be extended and reinforced.

6 Monitoring systems would need to be established. The effect of the revegetation project on groundwater levels and biological conservation will need to be monitored. The assistance of AgWest, CALM, DEP and the NLWRA in this task will be sought and would include co-operation with other systems currently in existance. There is a need for baseline studies and the development of methods for monitoring the plantings from the points of view of ensuring the validity of the carbon sinks, assessing the value of the forages to the farming systems and monitoring the environmental effects.

7 A favourable cost/benefit analysis comparing income from carbon credits with costs of establishment. There is a need for a full assessment of the likely carbon sequestration by halophyte forage shrubs and a detailed costing of the establishment options together with an assessment of the reaction of farmers to the availability of money for carbon credits. The project will be promoted to the Australian Greenhouse Office.

8 Quality assurance checks will be put in place. The project will develop GMO free, clean and green and environmentally audited brands for its outcomes. (c.f. Liebe group)

9 Further partnerships will need to be established with other groups involved in agriculture and improved grazing systems, greenhouse credits, river management, ecotourism, revegetation, seedbanks, protection of rare flora, biodiversity management, information networks and communication.

MAJOR TASKS

Implementation of the plan to have one million hectares of saline land revegetated in ten years is a major challenge requiring a Decade Action Plan. The tasks identified below are subject to change as the plan is developed and will require detailed development in the business/project plan with the partners and funding sources identified for each. The order in which they are discussed here is not necessarily chronological.

Co-ordination

The Decade Action Plan will cover an extensive geographic area, involve many people and groups and include many different aspects from site identification to monitoring. It will be essential to have a Steering Group to oversee the project and a co-ordinator. The Co-ordinator will co-operate with communities to establish other groups to be responsible for operations, promotion, communication, monitoring and research. The Co-ordinator will work with the Saltland Pastures Association, AgWest, CALM, DOLA (Land Monitor), CSIRO, DEP and others to co-ordinate those responsible for the tasks that follow.

Map areas for revegetation

It will be necessary for AgWest, CALM and DOLA (Land Monitor) to establish a project for mapping the areas to be revegetated. Initially the areas which have already been successfully revegetated must be identified and characterised and then similar areas mapped. CALM will provide advice on the mapping of areas suitable for biological conservation and these will be separately shown on the maps. The farmers who own mapped areas will be advised of the possibility that their land qualifies for inclusion in the Decade Action Plan and they will be given full details of the action necessary for them to attract the available assistance.

Technology and training for revegetation

Packages must be developed with details of the Decade Action Plan and the information on which it is based. Persons must be identified who will be involved in the implementation of the Plan and they must be given training in the following areas which will be covered in the packages:

- the Decade Action Plan, community links, co-ordination and management;
- characterisation of areas for revegetation and their pegging in consultation with owners;
- agronomy of species for revegetation;
- theory and practice of field establishment of halophyte forage shrubs, grasses and annuals on saline land;
- fencing, utilisation and management;
- assistance available to farmers, contractors and enterprises; and,
- monitoring.

Revegetation action

'Revegetation Action' packages must be prepared for advising farmers the details of the land which is eligable for inclusion in the Decade Action Plan, how it can be done, what their obligations are and what benefits they will enjoy. There will be public advertisements for persons wishing to be involved as well as personal approaches to those whose land has been mapped as suitable. The packages will be posted and personal visits will be available to clarify the issues and on site inspections will be essential for implementation.

Research

Research will be required in the following areas:

- research to improve methods for identifying the areas suitable for revegetation for forage production. The first criterion will be degree of similarity to areas previously successfully treated and the second criterion will be to identify areas for which on site recharge is important;
- methods will have to be developed to identify areas suitable for revegetation for biological conservation, the species to be used and methods of establishment and management;
- there are data which indicate that the production from saltland pastures can be improved by using measures such as soil ripping, fertiliser, selection of superior strains and use of species mixtures. Adaptive research will be required to extend these results to the areas being revegetated;
- research to determine the capacity of the revegetation systems in use to sequester carbon and attract carbon credits for the Decade Action Plan. This work must commence as soon as possible so that the results will be available early in the project; and,
- CSIRO has already initiated action to identify research directions for best utilising forage produced on saline land.

PARTNERS

The Decade Action Plan involves a wide diversity of groups and skills working towards a common objective. There will be actions relevant to all of the following, AgWest, CALM, Department of Land Administration, Water and Rivers Commission, Department of Environmental Protection, SPA, Western Australian Farmers' Federation, Pastoralists and Graziers Association , Australian Conservation Foundation, Greening Australia (WA), Co-operative Research Centre for Plant-Based Management of Dryland Salinity, CSIRO, Centre of Excellence for Natural Resource Managment, Regional Development Council and its Commissions, Great Southern Salinity Centre (pending), National Land and Water Resources Audit, Area Consultative Committees, Regional Natural Resource Management Groups, Green Corps, Green Skills, Shire Councils.

FUNDING SOURCES

Farmers will be expected to assist with the revegetation project on their properties by actions such as ground preparation, fenceline clearing and management. These actions will form the basis for matching funding from a wide variety of sources including the following: Greenhouse Gas Abatement Program, Water Corporation, Western Power, Regional Assistance Programme, Natural Heritage Trust, National Dryland Salinity Programme, State Salinity Council, Department of Commerce and Trade funding for Regional Development and Research and Development, Progress Rural, Collocation of Services,

ACTION

On 27 February 2001 a workshop of about 100 stakeholders was organised by a joint committee of AgWest and the SPA to provide directions for the preparation of the Decade Action Plan. A Steering Committee and a project officer will shortly be appointed.

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APPENDIX 7 List of old saltland agronomy research sites (details not yet completed)

CVM No	Town	Owner	Past action	Trip	Phone
82	Aldersyde	Sudholz, H.R.		HY	
9	Ambergate	Paterson, A.F.		SW	
10	Ambergate	Tomcala, J.		SW	
210	Arrino	Maley, C.E.	Old demo site, samphire seeding	GE	
202b	Badgingarra	Wilson, I.		GE	
204	Badgingarra	Badgingarra Research Station		GE	
204a	Badgingarra		Direct seeding Euc spp		
128a	Beacon, SW	Job, L.		NU	
31	Beaufort River	Thompson, R.	1976, 13 kg seed P. distans. Shrub primary test. Basic Mallen expt 1977.	AH	
2a	Bedford Harbour	Esperance Land Development	Niche seeding expt, Pucc selections.	ES	
101a	Belka, E./Merredin	Cummins, Rod (R.K. & M.J.) now Tomljanovich, Stan		HY	
128	Bencubbin	Maitland, M.	Basic Mallen 1977 expt, original collection of 'Meeberrie' line	NU	
128b	Bencubbin	Davies, S.	Seed plots of 971 & 949.	NU	
80	Beverley	Avondale Research Station	Pava	HY	
202a	Bibby Springs	Emery, Ted		GE	
185	Bindi Bindi /Gabalong	Crane, .V. (Bert & Norm Snr)	Atriplex variety test	MO	
57	Boddington	Tomlinson "Yarrandoo"	1974, Pucc PN72/1.	AH	
46	Bokal	Ness, A.C.	1974, Atriplex ecotype trial, UWA germ plasm	AH	
47	Bokal	Wharton, C.N.	1972, Pucc, PN72/5/6/7/8/9 + shrubs	AH	
48	Bokal	Johnston, A.C.	1971, Pucc accs PN71/7/8	AH	
49	Bokal	Holmes, Alec	1975, Pucc accs	AH	
193	Bolgart	Erickson, J.		MO	
194	Bolgart	Clarke, J.		MO	
195	Bolgart	House, Ed		MO	
123	Booralaming	Stout, R.K.	Wider test site. Atnu x Atam observed	NU	
212	Bootenal	Lieshman, B.		GE	
78	Borden	Sounness, Cliff	Pucc	PI	
55	Bowelling	Nuske, Mrs C.B.	1962, Pucc, Agel, Panic	AH	
172	Bowgada	Campbell, A./Starkey	Very old demo	MO	
173	Bowgada	Calver, R.P., McLean	Very old demo	MO	
40	Boyup Brook	Ritson, Phil	1976, Pucc distans	AH	
41	Boyup Brook	McLean, C.W.	1972, Pucc acc 412	AH	
42	Boyup Brook	McCallum, C.W.		AH	
32	Bridgetown	Stevens, S.B.	1972, Pucc, PN72/4/8. Trigonella. Pucc Acc 425	AH	
114	Brookton	Gartrell, T.		HY	
114a	Brookton	Eva, K.		HY	
114b	Brookton	Peck, Ed	Tamarix sp	HY	
58	Broomehill	Newby, J.K.	Atam Acc 582, 1975, UWA germ plasm	PI	
101	Bruce Rock	Shields, Ray may now be Buller, Les	Stabilisation of area blowing onto road	HY	
197	Bullsbrook	Steer, W.		GE	
83	Bulyee	Poultney, Leo	Old demo site	HY	
143	Bungulla	Gardner, W.R.	Germ plasm 585, 1976.	NU	
169a	Buntine	Ranger, Doug, West,	Wider test site	MO	

		B.			
177	Buntine	Fawkes, A	West, B., Ranger, D., Allen, A.	MO	
177b	Buntine	Wilson, D., Dodd, John	Mallen seeding.	MO	
10a	Busselton	Slade, W.		SW	
187	Calingiri	McGill, Frank		MO	
188	Calingiri	McGill, Ian		MO	
50	Capercup, nr Duranillin	Stanton, R & J	1971, Pucc, PN71/7	AH	
206	Carnamah	Heinrich, W.A.	Old demo site	GE	
207	Carnamah	Forrester, A.R.C.	Pucc and samphire planting	GE	
208	Carnamah	Waters, B./Leeming, G.V.	Wider test plot	GE	
3	Cartmeticup	Bessell-Browne, C.		South West	9822802
12	Chittinup via Boscabel	McFarlane, G.L.		Albany H'way	
43	Chowerup	Davidson, R.	1962, Pucc, Agel, Pava, Panic	AH	
66	Collanilling (Wagin, E.)	Smith, Andy West, Geoff.	UWA germ plasm	PI	
199	Coomberdale	Tonkin, Roger, Robert.	Old demo site	GE	
94	Corrigin	Trott, Jack (dec'd) Rendell, Lloyd.	Acc Atam 405, 1975. Many old expts	HY	
95	Corrigin	Larke, C. & K.	Old demo site	HY	
30	Cranbrook (Gordon R)	Pope, J.W. & E.B. RMB 215, De Toledo	1973, Pucc accs, Threlk	AH	
25	Cranbrook	Armstrong, Sam Tony & Warrick	1972 PN72/1, 1973 PN73/1, Pucc + P,N	AH	
26	Cranbrook	Sanders, D.G.	1972 Pucc Acc 143. Closed 1979	AH	
26a	Cranbrook	"Faye's strip"		AH	
26b	Cranbrook	Lehman, I.	Mixed shrub and grass planting	AH	
27	Cranbrook	Addiss, Mark: Tony Armstrong	1972, Pucc Accs 122, 136, 147, 477. Seed plot of 477 Pucc	AH	9826803 Tony 9826113
27b	Cranbrook	Sluiter, Ken	Contract seeder	AH	
27c	Cranbrook	Forward, Don	Niche seeding expt	AH	9825113
27d	Cranbrook	Williamson, Bill now Graham Jones	Direct seeding demo. Seed plot of 971 & 949 mix Nth Stirl SCD.	AH	9826100
27e	Cranbrook	Walsh, Ian & Joan	Seeding contractor,	AH	
27f	Cranbrook	Oliver, Glen	Seed plot of 971, 50% estab	AH	
28	Cranbrook, W	Williams, H.	1972 Pucc Acc 183	AH	9826803
27a	Cranbrook/N. Stirlings	Stevenson, C.	Wider test plot	AH/PI	
45	Culbin	English	1972, Pucc accs 122, 136, PN72/1	AH	
121	Culham (Toodyay, N.)	Syred, B.		NU	
147	Cunderdin	Cunderdin Agricultural College	Niche seeding expt 1983.	NU	
149	Cunderdin	Stokes, Jim	Pucc	NU	
150	Cunderdin	Roberts, I.		NU	
150a	Cunderdin	Lundy, H.	Wider test site	NU	
150b	Cunderdin	Dennis, N.	Northam office germ plasm plot.	NU	
151	Cunderdin	Lundy, Arnold	Wider test site	NU	
148	Cunderdin (Wyola)	Harris, John	Demo area by Grt E. H'way & wider test plot	NU	
115	Dale River	Blight, G.R. & J.M.(Ex J. Strange)	Pucc 165	HY	
116	Dale River	McCallum, A.D.		HY	
117	Dale River	Gartrell, K.	Acc 336 Pucc	HY	
118	Dale River	Schilling, C.		HY	
119	Dale River	Noonan, W.E.		HY	
118a	Dale river	Hutchinson	Acc 174 Pucc	HY	
178	Dalwallinu	District High School	Wider test plot	MO	
179	Dalwallinu	Wallis, J.R.		MO	

179a	Dalwallinu	Hyde, C.		MO	
202	Dandaragan	Fitzgerald, H.		GE	
86	Dangin	Clemens, Bruce (deceased), Lance	Initial test site, niche seeding expts, 1981,	HY	
87	Dangin /Carolling, S.	Hall, A.		HY	
88	Dangin	Johnston, Bruce	Testing of grasses, sprig planter test	HY	
89	Dangin	Keast, Dan	Broad scale niche seeding, 1982.	HY	
52	Darkan	Junior Farmers	1963, Pucc seed prod	AH	
53	Darkan	Davis, W.J. & Co	1962, Pucc, Agel, Panic. Pucc seed prod. 1971, PN71/7	AH	
54	Darkan	Gibbs, H.G., PO Box 28	1972, PN72/1, Pucc accs 122, 136 PN73/1	AH	
217	Derby	Savannah Systems			
34	Dinninup	Dewar, N., Maringee Farm Pty Ltd (Mountbatten's) Manager P. Lammonby	1972, Pucc 72/1/8. Pucc accs 122, 136,481.482.483	AH	
36	Dinninup, N.	Ullilson, A. "Arrinya"		AH	
37	Dinninup, N.	Wheeler, Geoff R. (Ex Hilder)		AH	
38	Dinninup, N.	Hilder, J.L.	May be same as 37.	AH	
39	Dinninup, N.	Harris, S.S.		AH	
35	Dinninup, N.	Rhodes, D., "Fairwinds" Mgr Wolfe	1972, Pucc PN72/1, accs 122, 136.	AH	
124	Dowerin	Hatwell, A.	Niche seeding expt	NU	
67	Dumbleyung	Richardson, John	Atam Acc 580, 1975. UWA germ plasm	PI	
51	Duranillin	Sieber, P.W., Box 7	1962, Pucc, Agel, Pava, Panic	AH	
125	Ejanding	Underwood, J. (L.C.B. and Sons)	(Joe) Borello Nominees. Crossing of Atnu & Atam.	NU	
125a	Ejanding	Jones, Norm	Grazing of bluebush	NU	
205	Eneabba	Cooper, C.J.		GE	
22	Frankland	Treasure, V	1972 PN72/5/6/8/9 + shrubs, 1973 more Pucc & shrubs	AH	
186	Gabalong	Waters, W. (Bill)	Germ plasm 592, 1976.	MO	
1b	Gibson's Soak	Campbell, J.		ES	
2	Gibson's Soak	Esperance Downs RS, WADA		ES	
198	Gillingarra	Johnston, F.L. & H.		GE	
153	Grass Valley	Dempster, P.	Germ plasm 585, 1975.	NU	
154	Grass Valley	Dempster, Vern (H.V.)	Germ plasm 578, 1975.	NU	
152	Grass valley	Spencer, M. (dec'd)	Pucc, sprig planting test	NU	
85a	Greenhills	Penny, H.	Demo corner	HY	
170	Gutha	Tubby, M. to R. Stevens	Niche seeding expt, source of 'Rivermor'	MO	
170a	Gutha	Stevens, J.		MO	
6	Harvey	Cappagreco		SW	
7	Harvey	Paravicini		SW	
113	Highbury	Gambrell, Arthur		HY	
113a	Highbury, E.	Styles, Basil (Whimbin Rock Rd)	Seed plot 971.	HY	
140	Hines Hill	Cahill, K.	probably same as 136a	NU	
102	Hyden	Buktenica, Gerald	Wider test site. Germ plasm 421, 1975	HY	
75a	Jerramungup	Mangan, Ian	Demo site	PI	
75b	Jerramungup	Crossman	Wider testing	PI	
105	Jilakin (Kulin, E.)	Parker, Bevan (dec'd) Lucchesi,		HY	

		Legio?			
83a	Jubuk	McMiles, Robert	Excavations in salland, also drains	HY	
179b	Kalannie	Worley		MO	
216	Kalgoorlie	South Chaffers dump	Niche seeding expt etc		
103	Karlgarin	James, B.	Saltbush variety test	HY	
59	Katanning	Hore		PI	
60	Katanning	Katanning Reserve		PI	
61	Katanning	Anderson, T.H.		PI	
61a	Katanning	Nicholls, W.A.		PI	
62	Katanning	Keast		PI	
62a	Katanning	ABRI	Saltbush grazing trials	PI	
85	Kauring (Greenhills)	Halbert, B.	Germ plasm plot, 742, 1976.	HY	
141	Kellerberrin	McClelland, Stan	Saltbush spacing expt, Mallen vs conventional, 1977.	NU	
142	Kellerberrin	Gardner, G.	Very old demo	NU	
23	Kendenup	Sandilands, C., Bill, Chauvel Rd, N end where Kalgan Rd crosses H'way, S of w'course nr Todd Rd	1971, PN71/3/5 Pucc spp, 1972, Agel, 1976 Pucc spp. Closed '79.	AH	
24	Kendenup	Sounness, I. T.	1962, Pucc, Agel, Panic, Pava	AH	
33	Kojonup	Jefferis, V.E.	1973, Pucc acc 165.	AH	
126	Kokardine (Cadoux, N.)	Clarke, K.L.		NU	
161	Kondut	Millsteed, Robin	6 year grazing experiment	MO	
173a	Koolanooka	Rogers, V.W.	Old drainage work	MO	
127	Koorda	Lodge, George (Dec'd)	Very old demo site	NU	
99	Korbel	Endersbee, Eric, may be Hooper, Chris	Old Atnu etc plantings	HY	
100	Korbel	Starcevich, J. now Fuschbichler, Kevin	S.T.Smith drilling site	HY	
100a	Korbel	Bazanich		HY	
98	Korbelka	Willis, Elwyn, now McGellin, Brian	Atam Acc 440, 1976.	HY	
93	Kunjin	Hewitt, Stan	Acc 99 Atgl, 464 Atpa, 1975.	HY	
135	Kunnunoppin	Kahl, Lionel	Norrish, Kevin and Neil	NU	
176	Latham	Taylor, F.		MO	
176a	Latham	Just, Trevor		MO	
215	Leonora	Hurst, Lance	Niche seeding expt		
75c	Mallee Road Sump	Slade, P.		PI	
177a	Maya	Diamond, Kim	5 years grazing expt, Niche seeding expt 1973, broad scale seeding, large plot grazing tests. Maya seed plot 971 & 949 mix.	MO	
44	Mayanup	Henderson, A.	1962, Pucc, Pava, Agel, Panic	AH	
151a	Meckering	Pearse, Stan	2 plots Atam seed incr 949, 1975	NU	
171c	Merkanooka	Milloy, P.	Saltbush variety	MO	
138	Merredin	Merredin Research Station		NU	
139	Merredin, S.	Willis, T.	Germ plasm 716 Atre, 1976.	NU	
183	Miling	Ralph, A.		MO	
184	Miling	Reynolds, T.		MO	
182	Miling/Pithara	McNeil, A.		MO	
211	Mingenew	Wells, R.		GE	
200	Moora	Hamilton, Fred		GE	
201	Moora	Topham, K.G.		GE	
171a	Morawa	North, Joe	Bluebush sowing	MO	
171b	Morawa	White, J.	Demo	MO	
68a	Moulyinning		road verge trial	PI	
68b	Moulyinning	Mott, J.		PI	
68	Moulyinning (Dumbleyung, E.)	Mott, O.	Niche seeding expt, wider test site	PI	
20	Mount Barker	Research Station		AH	

19	Mount Barker	High School	1970, Pucc acc & estab	AH	
81	Mt Hardie	Thompson, N.	Atcxi germ plasm plot, 524, 1976.	HY	
84	Mt Kokeby	Ridgway, T.		HY	
122	Nambling	Crute, Colin	Atpa germ plasm, 1976	NU	
136	Nangeenan (Nokaning)	Giles, Malcolm		NU	
136a	Nangeenan may be same as 140	Cahill, K.	Stabilisation of area blowing onto rail	NU	
103a	Narembeen	Huddleston		HY	
103b	Narembeen	Treloar	Revegetation of devastated area	HY	
104	Narembeen	Cook, Harvey Yandle, A.J. &S.J.	Old demo	HY	
104a	Narembeen, E./Holleton	Crosthwaite, B.		HY	
13	Narrikup	Tombleson, J.	1962 Pucc test plot, 1965 ab	AH	
14	Narrikup	Barton, R.	1971/2/3 Pucc + N & P n.s.	AH	
15	Narrikup	McMahon try Bruce, B.A. & D. at Mt Barker	1962 Pucc test plot, dense, 1965 ab	AH	
111	Narrogin	Dawes, V.	Atam Acc 586, 588. UWA germ plasm.	HY	
111a	Narrogin	Tucker, Phil		HY	
112	Narrogin Valley	Rhodes, T.	Atam Acc 601, 716 Atre, 1975. UWA germ plasm.	HY	
75d	Needilup			PI	
196	New Norcia	Halligan, D.		MO	
74	Newdegate	Orr Bros was Tod Kirwan	Wider test site	PI	
75	Newdegate	Duncan, Mrs, now Ian Chamberlain	Very old demo site	PI	
4	Noggerup	Honey, D.		SW	
109	Noman's Lake	White, A.	Atam Acc 577, 1975. UWA germ plasm's Lake	HY	
130	Nungarin	Herbert, R.L.	Old demo site	NU	
76	Ongerup	Trent, H./Weir, D.G.		PI	
77	Ongerup	Newbey, Ken	Acc 439 Atnu, 471 Atun, 1975.	PI	
96	Pantapin	Hughes, Claude		HY	
174	Perenjori	Hesford, R.		MO	
175	Perenjori	Spencer, O.P. & D.	Pucc selections	MO	
20a	Perillup	Riggall, J.		AH	
189	Piawaning	Smith, A.H. & Co		MO	
190	Piawaning	Robinson, G.		MO	
191	Piawaning	Sudholz, Rudy		MO	
69	Pingaring	Battison, George	Niche seeding expt	PI	
69b	Pingaring	Lloyd, Michael		PI	
70	Pingrup	Reed, M		PI	
71	Pingrup	Altham, Bruce	Saltbush variety trial. UWA germ plasm	PI	
72	Pingrup	Clark, Bruce; Holmes, Kelvin	Atam Acc 596, 1975. UWA germ plasm	PI	
73	Pingrup	Solly, Miss Claire /Wolfe, Steven	Wider test site	PI	98201 023
171	Pintharuka	North, A. & E.N. (Bill, dec'd)	Wider test site. Source of 'Pintharuka' saltbush	MO	
180	Pithara	Mills, G.		MO	
180a	Pithara	Coyle, J.	Broad scale seeding	MO	
181	Pithara	Monks, Noel		MO	
90	Quairading	Lyall, R. / Haythornthwaite, R.		HY	
92	Quairading	Hinkley, Alan		HY	
91	Quairading, S.	Holmes, G. /Potney, Henry	, Acc 119, 1975	HY	
21	Rocky Gully	Everix, G. "Green	1962, Pava, Panic & Agel, 1963	AH	

		Slopes"	Pucc		
110	Rushy Pool (Narrogin, E.)	Borthwick, G. (dec'd)		HY	
1a	Salmon Gums	Hanson, Mrs Jenny	8/83 seeded Mabr, Atam, Atle, Atun, N. Salmon gums on L. Field day 9/84.	ES	
1	Salmon gums	Salmon Gums RS, WADA	Bluebush plot sown.	ES	
11	Serpentine	Bongascia		SW	
97	Shackleton (Erikin)	Jones, R.M.		HY	
97a	Shackleton	Tippett, Greg	Lot feeding on shrub stands.	HY	
119a	Talbot Brook	Strange	Acc 165 Pucc	HY	
120	Talbot Brook	Ovens	Acc 122 pucc, died	HY	
120a	Talbot Brook	Cox	Acc 167 Pucc	HY	
120b	Talbot Brook	Wiseman	Acc 136 Pucc	HY	
29	Tambellup	Rayner, A.C., "Atunga"	1962, Pucc, Agel, Pava, Panic. 1964 P, N	AH	
144	Tammin	Stokes, Bernie	Germ plasm 405, 1976	NU	
146	Tammin	York, Peter and Tony	Atam Acc 440, niche seeding expt on Atam ecotypes 1977.	NU	
146a	Tammin	Crogan, C.	Germ plasm 949.	NU	
145	Tammin, S.	Hinsley, Miss Hilda	Wider test site, Niche seedng expt , initial testing	NU	
169	Tardun	Flynn, T.		MO	
56	Tarwonga	Chadwick, R. (115 mile peg on Albany H'way)	1972, PN72/1, 122, 136. PN73/1.	AH	
208a	Three Springs	Franklin, A.H.	Wider test site.	GE	
209	Three Springs	Frankland, E.L./ Mostyn		GE	
158	Toodyay	Chitty, A.H.		NU	
157	Toodyay (Hoddy's Well)	Pearce, Vern	Grasses	NU	
108	Toolibin	MacDonld, Grant		HY	
133	Trayning	Hulls, Don	Saltbush variety test	NU	
134	Trayning	Smeeton, Gordon		NU	
65	Wagin	Sprigg, D. & Sons	Atam Acc 572, 1975. UWA germ plasm	PI	
137	Walgoolan	Wahlsten, Peter and Brian	Wider test site. Mallen ridge vs chisel, 1977.	NU	
5	Waroona	Melvin, F.D.		SW	
203	Watheroo/ Arrawarra	Crombie, Richard		GE	
129	Welbungin	Probert, E.	Old demo site	NU	
107	Wickepin	Fleay, P.		HY	
56a	Williams	Tucker, P.	Seed prod plot 971.	AH	
159	Wongan Hills	Smeeton, John	Niche seeding	MO	
160	Wongan Hills	Sadler, C.A. & Co (Don)	Farmer borrowed niche seeder	MO	
162	Wongan Hills	Millsteed, Peter	Mallen detail expt, 1979	MO	
163	Wongan Hills	Griffiths, Neil	Niche seeding expt, UWA germ plasm 471, 1976. 471 seeded 1977.	MO	
164	Wongan Hills	Wongan Hills Research Station	Wider testing, Mallen coatings expt. Germ plasm 949, 1976. Seed plot sown 1977.	MO	
165	Wongan Hills	Booth, Victor	Niche seeding expt	MO	
166	Wongan Hills	Hyde, R & R (Rob and Rosemary)	Germ plasm 573, 1976. UWA germ plasm.	MO	
167	Wongan Hills	Hewitt, E.E. & Sons		MO	
168	Wongan Hills	Ackland, J.B.		MO	
64	Woodanilling	Whitham, Alec		PI	
63	Woodanilling, W.	Thompson, Russell		PI	

16	Woogenilup	Adams, Bil, now in Mt barker, try Colin	1966 Pucc test plot, 1972/3 N, n.s.	AH	9854102
17	Woogenilup	Enright,J.G. Christopher "Middle Creek"	1962 Pucc seed prod plot.	AH	9854101
18	Woogenilup, E.	Heffernan, N, 1973 (Derek Hill, old owner)	1972, Pucc N, 1975 N	AH	9854203
156	Woorooloo	Woorooloo Training centre		NU	
155	Wundowie	Grasby, J.C.	Samphire, Puci, Pava	NU	
127a	Wyalkatchem	Soil Conservation District demo	Niche seeding demo	NU	
106	Yealering	King, Norm Hodgson, Colin		HY	
106a	Yealering	Corke	Spvi	HY	
131	Yelbeni	McAndrew, Neil	Old demo site	NU	
132	Yelbeni	Diver, Barry		NU	
192	Yerecoin	Brennan, Tom	Early pucc testing and samphire	MO	
192a	Yerecoin	Field, Tom		MO	
8	Yoongarillup	Rossi & Myers		SW	
79	York	Morrell, F.G.		HY	
127b	Yorkrakine	Hutchinson, Ernie	SCD seed plot, 971	NU	
111a	Yornaning	Nottle, Ian	Yornaning SCD, seed plot 971.	HY	
111b	Yornaning	Herman, Lindsay	Yorning SCD, seed plot 971.	HY	
111c	Yornaning	Dixon, Bruce	Yornaning SCD, seed plot 949.	HY	
213	Yuna	Teakle, R.K.		GE	
214	Yuna	Stokes, R.S.		GE	