The Four Aces

Overcoming multiple natural resource management issues in Western Australia through the establishment of Greenhouse sinks

GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF Conservation AND LAND MANAGEMENT

Conserving the nature of WA

The Four Aces: Overcoming multiple natural resource management issues in Western Australia through the establishment of greenhouse sinks

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- reducing the greenhouse effect;
- protecting biodiversity;
- reducing salinity; and
- protecting agricultural land.

A consultancy for Griffin Energy

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1 Executive summary

Several major, large-scale environmental challenges currently confront south-western Australia. These include:

- Climate change as a result of increasing atmospheric greenhouse gas concentrations.
- Salinisation, following land development for agriculture, with resultant effects on water resources, biodiversity and agricultural land.
- Biodiversity decline, both as a result of salinity (and waterlogging), and as a consequence of the extensive clearing and degradation of native vegetation.
- Degradation of pastoral lands ("rangelands") following over-grazing.
- Land and water degradation in other forms such as wind erosion, soil acidification and eutrophication.

An additional challenge for Government is the decline in rural populations, leading to cumulative losses of services, including education, police and banking.

Griffin Energy provides coal to the Western Australian power-grid, and is thus interested in determining whether carbon sinks in soil and vegetation can be used to reduce net CO_2 emissions from coal to allow it to compete with gas. The amounts of extra carbon emitted from coal compared to natural gas are estimated to be in the range of 0.25 to 0.50 Mt CO_2-e/year for a 350 MW power station.

The Kyoto Protocol, an international agreement dealing with climate change, seeks to reduce net greenhouse gas emissions (Appendix B). Emissions from fossil fuel use can be counterbalanced through the use of "sinks" - the sequestration of carbon in plants and soils as a result of changes in land use. The Protocol allows a market-based approach to reducing greenhouse emissions through carbon trading.

A clear opportunity exists to use investment in revegetation to not only sequester carbon, but also to confront the major environmental challenges such as enhancing and protecting biodiversity, stabilizing or reversing salinity, maintaining the productivity of agricultural and pastoral systems, protecting rural infrastructure and increasing regional employment.

Previous sinks schemes have focussed on afforestation and reforestation using trees, under Article 3.3 of the Kyoto Protocol. Under Article 3.4 activities such as "cropland management", "grazing land management" and "revegetation" are also considered eligible activities, following the 2001 climate change meeting in Bonn. "Revegetation" under Article 3.4 is tree planting not considered to constitute a forest. The inclusion of Article 3.4 activities will allow a broader range of measures to be used as carbon sinks, such as use of a wider range of species for farmland revegetation, accumulation of soil carbon and the manipulation of rangeland grazing systems. Those Article 3.4 activities that are considered as part of Australia's emission profile will depend on Federal Government policy.

The biodiversity and salinity benefits of revegetation are considered to be greatest in the wheatbelt (<500 mm rainfall zone), where 450 plant species are threatened with extinction and internationally important wetlands are threatened with destruction.

The Western Australian Government has recently received a report from the Salinity Taskforce that recommends that the Government invests significant funds to reduce losses of infrastructure, water supplies and biodiversity from salinity impacts. The Government will act on these recommendations as well as commit Western Australia to the National Action Plan on salinity and water quality. The Government will certainly welcome funds for partnerships with the private sector for these investments.

The amount of revegetation required to sequester 0.25 to 0.50 Mt CO_2-e over a 20 year power-plant life cycle will vary with annual rainfall with estimates ranging between 27,000-54,000 ha in the 400 mm rainfall zone, to 4,500-9,000 ha in the 1,000 mm rainfall zone. With integration of this revegetation across farmland (e.g. 20-25% of land area planted) the total treated area could be four to five times higher. It is not known how large an area of rangelands would have to be considered for treatment.

This proposal recommends that prior to undertaking a large sequestration scheme, two Pilot studies be undertaken. These will examine different options for carbon sequestration in the WA wheatbelt and the southern rangelands and they will address the commercial imperatives of both the landowner and the fossil fuel based energy industry by:

1. Establishing the amounts of carbon sequestration that can be achieved through changed land management.
2. Determining the most cost effective means of achieving the multiple outcomes of carbon sequestration, biodiversity enhancement, salinity control and the maintenance of agricultural values in the treated areas.
3. Resolving the best land acquisition strategy.
4. Resolving an array of technical issues such as re-establishing native vegetation on farmland, predicting the amounts of carbon that can be sequestered in native plants and soils and adapting monitoring protocols to report on greenhouse, biodiversity and salinity outcomes.
5. Demonstrating the results to landholders, business and policy makers, with the pilots forming a template for the larger project and representing the best practice for sequestration schemes in dryland areas of Australia.

The two pilot projects are:

Pilot I Agricultural lands: Several catchments that are of particular importance for preserving biodiversity ("Natural Diversity Recovery Catchments") have been identified by the Conservation Commission and the State Salinity Council.

The pilot would entail a sub-catchment scale (5,000 ha) treatment in a Natural Diversity Recovery catchment, with 1,000 ha of revegetation being established over a three year period using best-practice guidelines, with localized pumping and evaporation. The revegetation would be integrated with agriculture across the catchment and comprise a range of native species and both expand and protect existing biodiversity values. Some of these native species, such as woodland eucalypts, may eventually produce timber products.

This Pilot represents an opportunity to establish a world-class experiment that will resolve the question as to whether salinity can be stabilised or reversed by the partial revegetation of dryland agricultural catchments.

The Lake Bryde Wetland Complex, 350 km south-east of Perth, is the recommended candidate area for this Pilot. As the farmland in this area is freehold, a land acquisition strategy (purchase vs lease) will have to be decided.

This pilot could result in the direct sequestration of approximately 157,000 t CO_2-e of carbon dioxide over a 20 year period, at an estimated cost of $11/t CO_2-e and specific protection of biodiversity in the treated catchment.

Although "environmental markets" for biodiversity and water quality have been advocated in eastern Australia, it is assumed for the purposes of this report, that they have no monetary value at present.

Pilot II Pastoral Lands (Rangelands): A three year investigation of the effects of changed grazing practice, feral animal control and treatment of degraded areas on the amounts of carbon that can be sequestered in rangeland systems (plants and soils). A particular emphasis will be on the feasibility of measuring small changes in carbon through on-ground measurement, modelling and remote sensing techniques.

These two pilot projects build on an array of existing Department of Conservation and Land Management collaborations including ones with the Cooperative Research Centres (CRC) for Greenhouse Accounting and Plant Based Management of Dryland Salinity. Any future collaboration with these organisations will require negotiation. Similarly, it may be feasible to lever additional R&D funding from Research and Development Corporations to expand the range of investigations in the pilots.

This report recommends that Griffin Energy takes this opportunity for significant carbon sequestration and environmental management and commences on-ground activities in early-2002.

2 Introduction

In early 2001 the WA Government opened the way for new coal contracts by indicating that future tenders would be received for up to 350 MW of new generating capacity from either coal or gas. Recent generation plants have been gas fired and to compete with natural gas, coal will have to be competitive both in terms of price and greenhouse emissions.

Griffin Energy provides coal to Western Power, and is thus keen to determine whether soil and vegetation based carbon sinks will allow coal to compete with gas in terms of net greenhouse emissions. The amounts of extra carbon emitted from coal compared to natural gas are estimated to be in the range of 0.25 to 0.5 Mt CO_2-e/year for a 350 MW plant

This proposal assumes that Australia will ratify the Kyoto Protocol and that greenhouse gas emissions limits will come into force, such that new power generation will require emissions permits. It also considers that as a consequence of this agreement that greenhouse sinks will be considered as a means of reducing net emissions, both by companies that emit greenhouse gases and those who wish to invest in carbon as a tradable commodity.

It is certain that revegetation, and appropriate changes in land management, sequester carbon[1]. Currently, economic circumstances and a range of environmental problems, including land degradation and loss of biodiversity, are encouraging changes in land management within the south-west agricultural region of WA. One of the strategies for addressing these problems is revegetation. Therefore, a clear opportunity exists to use investment in revegetation to not only sequester carbon, but also to tackle other major environmental challenges, such as enhancing and protecting biodiversity, stabilising or reversing salinity[2-5], maintaining the productivity of agricultural and pastoral systems, protecting rural infrastructure and increasing regional employment.

This proposal recommends that, before undertaking a large sequestration scheme, Griffin Energy undertakes a series of Pilot studies to explore different options for carbon sequestration. These studies will address the commercial imperatives of both the landowner and the fossil fuel based energy industry by:

1. Establishing the amounts of carbon sequestration that can be achieved through changed land management.
2. Determining the most cost effective means of sequestering carbon, enhancing biodiversity and maintaining agricultural values of the treated areas.
3. Resolving the best land acquisition or cost sharing strategy for a full project.
4. Resolving an array of technical issues such as re-establishing native vegetation on farmland, predicting the amounts of carbon that can be sequestered in native plants and soils and adapting monitoring protocols to report on greenhouse, biodiversity and salinity outcomes.
5. Demonstrating these results to landholders, business and policy makers, with the pilots forming templates for the larger project and representing best practice for sequestration schemes in dryland areas of Australia.

This proposal will briefly consider the amounts of carbon to be sequestered in a full project, and then propose two pilot projects.

3 Background

3.1 Environmental challenges

Several major, large-scale environmental challenges currently confront south-western Australia.

These include:

- Climate change as a result of increasing atmospheric greenhouse gas concentrations[6].
- Salinisation, following land development for agriculture[2], with resultant effects on water resources, biodiversity and agricultural land[7].
- Biodiversity decline, as a result of salinity and also due to poor representation of remnant biodiversity in integrated reserves, and other degrading processes such as weed incursion.
- Degradation of pastoral lands ("rangelands") following over-grazing[8].
- Land and water degradation in other forms such as wind erosion, soil acidification and eutrophication[9].

An additional challenge for Government is the decline in rural populations, leading to cumulative losses of services, including education, police and banking.

The Western Australian Government has recently received a report from the Salinity Taskforce[7] that recommends (p. 10) that the Government invests significant funds to reduce losses of infrastructure, water supplies and biodiversity from salinity impacts.

"The Taskforce is concerned at the substantial threat that salinity poses to public assets such as biodiversity on public and private lands, conservation reserves, public water supply catchments, rural towns and other infrastructure such as road and rail. The Taskforce considers that both State and Commonwealth Governments must invest significant resources in this area and the Taskforce has recommended increased investment and attention."

The Government will act on these recommendations as well as commit Western Australia to the National Action Plan on salinity and water quality. The Government will certainly welcome funds for partnerships with the private sector for these investments.

3.2 Climate change

There is increasing acceptance that climate change, as a result of increasing greenhouse gas concentrations, is a real phenomenon[6]. International negotiations to tackle climate change have resulted in the formulation of an international agreement, the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). This is subject to ongoing negotiation but may come into force in 2002, if ratified by enough countries. It is not certain if Australia will ratify the Kyoto Protocol.

The Kyoto Protocol includes a market-based approach to emissions reductions, by allowing emissions trading (Article 17). It also allows (Articles 3.3 and 3.4) for carbon that is taken from the atmosphere and sequestered in soils and plants ("greenhouse sinks") to be considered as allowable emissions reductions. Ratification of the Kyoto Protocol will result in individual countries having emission targets, with penalties for non-compliance. A background paper on greenhouse is included in Appendix B.

Previously, carbon sequestered in plantations (Article 3.3) was considered more likely to be allowed as eligible emissions reductions[10], however the recent CoP 6B meeting in Bonn decided that Article 3.4 activities such as "forest management", "cropland management", "grazing land management" and "revegetation" were also eligible activities. These will be eligible in the first accounting period 2008-2012. "Revegetation" under Article 3.4 is tree planting not considered to constitute a forest. The inclusion of Article 3.4 activities will allow a broader range of measures to be used as carbon sinks, such as use of a wider range of species for farmland revegetation, accumulation of soil carbon and the manipulation of rangeland grazing systems.

This decision thus allows carbon investment through changes in land-use such as:

- Farmland revegetation that does not fit within the definition of the establishment of "forests" in Article 3.3.
- Changing grazing management in the rangelands to change carbon storage.
- Soil management to change the amounts of carbon sequestered through revegetation, changed agricultural practice or rangelands de-stocking.

Importantly in relation to Article 3.4, each country will "fix its choice of eligible activities prior to the start of the first commitment period[11]." What is allowable in Australia will depend on the Commonwealth Government.

3.3 Salinity

Salinity threatens agricultural land, conservation reserves, water resources and infrastructure across south-western Australia[7]. This problem has been induced by the widespread removal of deep-rooted native vegetation for farming, and replacement with shallow-rooted annual plants. The reduced water-use has resulted in rising water tables that mobilise salt stored in the soil. Saline groundwaters enter plant root zones, or discharge on the ground surface. In Western Australia 1.8 Mha is currently salinised, with 6.1 Mha likely to be affected in the future; respective Australia-wide estimates are 2.5 and >15 Mha[12].

A key issue for the agricultural areas of Australia is whether salinisation can be stabilised or reversed either by revegetation, site engineering, or a combination of the two. Although it has been demonstrated that groundwater discharge can be overcome by the revegetation of small catchments[13], there is considerable current debate about the merits of different approaches in restoring the water balance across large catchments in low rainfall areas. In the absence of perfect knowledge about how to tackle salinity, and the imperative for almost immediate action, revegetation remains a promising option[14]. Estimates are that up to 3 Mha of land in Western Australia will have to be treated[15].

3.4 Biodiversity decline

In the wheatbelt much of the remaining natural biodiversity is in small reserves that are not only susceptible to salinity but also at risk from a range of threats including weed invasion, waterlogging, eutrophication, feral animals, and disease. The biota in many of these reserves is effectively isolated. Recent surveys in the wheatbelt indicate that up to 450 species of vascular plants are at risk of extinction[6], in addition to many other species of microflora and microfauna. Similarly, habitats for migratory birds are at risk, globalising a local problem.

Increasing the amounts of perennial vegetation in catchments will help restore their hydrology[14]. Strategic revegetation can meet several aims, including expanding remnant vegetation to buffer against weed invasion and salinity, providing additional habitat and also connecting isolated remnants to allow the movement of native animals.

3.5 Rangeland degradation

Across much of Australia's rangelands grazing has resulted in deterioration in the condition of the ecosystem. Noble et al.[8] summarise the results of several rangeland condition surveys in Western Australia. From 50 to 94% of the land is considered in a "deteriorating" or "degraded" condition. De-stocking of this land and removal of feral herbivores, will undoubtedly, result in an increase in biomass, particularly on the "deteriorating" land. "Degraded" land may require more active management intervention (re-seeding, cultivation) to help restore vegetation.

Changing stocking rates will change both plant and soil carbon pools. Walker and Steffen[17] suggest that Australian rangeland soils can be used as a sink for carbon. They suggest that the most carbon will be fixed in soil organic matter, with the move away from practices, which cause land degradation. For example, citing work by Williams, they suggest that pastoral activity has decreased soil carbon contents from 1.5 to 0.5%. Across Australia's rangelands they suggest that sequestration in the soil organic pool could be around 14 Mt (51 Mt CO_2-e). Ash et al.[18] measured the soil carbon contents in soils under rangeland pastures of different condition, in northeast Queensland and the Northern Territory. They estimate that up to 11.7t CO_2-e/ha of carbon could be added to the soils with optimal improvement in rangeland condition.

Simply de-stocking domestic animals may not be enough to increase carbon fixation. De Salis[19] suggests that the rate of biomass accretion could be increased by feral herbivore control, whereas the modelling of Moore et al.[20] indicates that fire suppression will also be important. Significant changes in carbon accretion may be possible by active management such as re-seeding, local cultivation and other restorative techniques developed for rangeland grazing systems[21].

De-stocking rangelands may thus result in the accumulation of carbon in biomass and soils, and this may be considered as a carbon sink. Similarly, the removal of livestock will result in avoided emissions of methane. The WA Greenhouse Council[22] suggests annual gains of 5.2 Mt CO_2. If this carbon is traded, it could be used to underwrite large-scale change in land-use, with benefits to the natural biota.

4 Establishing a greenhouse sequestration project for sustainability

4.1 Full project

It is assumed that the amounts of carbon that will need to be sequestered in soil and vegetation to reduce the net CO_2 emissions from coal to allow it to compete with gas for a full project are of the range of 250,000 to 500,000 t CO_2-e/year. This represents the difference in carbon emissions between a 350 MW power station fired by coal, rather than gas. It also takes into account the whole life cycle (source to power station) of both fuel sources. Thus, over 20 years the power station would require fixation of 5-10 Mt CO_2-e.

Estimates of the amounts of carbon that could be sequestered in vegetation in the Western Australian agriculture area are given in Table 1, along with estimates of methane emissions avoided by removing sheep. This information is based on likely timber harvest yields, expanded to whole-tree and stand values. These numbers are provided as a guide; more accurate, whole-tree sampling will be necessary to derive more reliable biomass and carbon values where a range of native species are planted.

The effects of revegetation on soil carbon are uncertain, with a recent review producing equivocal results[23]. However, unpublished data from five bluegum plantations in Esperance indicated a 4 t CO_2-e/ha increase after six years on conversion from cropping land[24]. Similarly, measurements of soil carbon contents under continuous pasture indicated an increase in soil carbon content of 2% (approx 110 t CO_2-e/ha), compared to continuous cultivation after 16 years in an area with 350 mm annual rainfall in WA[25]. Thus a small increment of carbon sequestration has been assumed following the revegetation of cropped soils. Higher rainfall areas are mainly pastured.

4.2 Economic returns

Key outputs for the project are the restoration of biodiversity and reversal of salinity - outputs for which there is no direct market value at present. It is clear from Table 1 that the direct cost of sequestered carbon will be greater in the lower rainfall areas without an income stream from timber sales or another commercial product.

Putting an economic value on the ecological benefits of revegetation and ensuring the sustainability of an agricultural system through "environmental credits" is currently being investigated in the Murray Darling Basin, where there are various downstream users of the water. There is no guarantee that such markets will come into existence in Western Australia.

Table 1. Estimated amounts of net carbon sequestration occurring in different rainfall zones of the agricultural region of Western Australia. An estimate is also made of the amount of revegetation required to sequester 10 Mt of CO2-e over a 20-year period.

Rainfall (mm/year)	**Carbon sequestered in 20 years (t CO_2-e/ha)**				**Area required to fix 10 Mt CO_2-e (ha)**
	Soil	Avoided emissions from sheep	Biomass	Total	
400	11	15	157	183	55,500
600	22	20	314	356	28,000
800	33	25	629	687	15,000
1000	0	40	1100	1140	9,000

Assumptions: Trees in strips, wood basic density 0.5 t/m³, harvest index (trunk/tops) 0.7, root/shoot ratio 0.2, carbon content 50%, establishment cost $1500/ha. Avoided emissions from sheep – 3 t CO2-e/animal over 20 years, with stocking rates varying with rainfall.

4.3 Land acquisition

Although large areas of land are potentially suitable for the establishment of greenhouse sinks, and there is widespread acceptance that revegetation is required to overcome land degradation, a key limitation to expansion will be acquiring land, as farmers often see revegetation as being competitive with economic crops such as wheat.

Developing a land acquisition strategy will be essential to the success of a large-scale sequestration project. A number of different strategies have been used to acquire land for revegetation, each with a range of advantages and disadvantages:

- Free or subsidized trees. This approach is generally least successful in achieving long term changes, as the amount of trees planted is usually quite small and is in areas that farmers see as unproductive.
- Sharefarming agreements with associated caveat on the property title to give a right to timber. The Department of Conservation and Land Management developed these agreements in association with the WA Farmer's Federation. A similar right to carbon is proposed in new Western Australian legislation. Sharefarming conditions can vary but often involve an up-front payment and either an annual lease or share of harvest proceeds.
- Land purchase. Land purchase for plantation establishment is the most secure form of ownership of greenhouse credits. However land purchase often causes antagonism with rural communities due to the displacement of farming families, perceived fire risk and reduced opportunities for local farmers to expand their holdings. Similarly, the agricultural component of these properties will need to be managed, after treatment.

A successful strategy used by the Water Authority of WA in the Wellington Dam catchment in the 1980's was to purchase properties, revegetate according to a plan, subdivide the treated areas on the property titles and then sell the farmed land.

4.4 Linkages

Although centred on Western Australia, this project will be of national and international significance, by defining and demonstrating multiple benefits from greenhouse sinks. The project also offers the potential to protect the flora and fauna of a world recognised area for biodiversity.

4.4.1 International treaties

This proposal will implement principles consistent with an array of international treaties, between Australia and other countries, that promote sustainable development and the protection of migratory wildlife including:

- The UN Framework Convention on Climate Change (UNFCCC). The recent Conference of Parties meeting in Bonn stressed the need for the implementation of land use, land-change and forestry (sinks) to contribute to the conservation of biodiversity and the sustainable use of natural resources[11].
- The UN Convention on Biological Diversity (UNCBD). This aims to preserve the biological diversity of the planet through the protection of species and ecosystems and encourage their sustainable use. Linkages are being developed between the UNCBD and the UNFCCC.
- The UN Convention to Combat Desertification.
- The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention). This requires parties to promote the conservation of listed wetlands (such as Toolibin Lake).
- The Convention for the Protection of the World Cultural and Natural Heritage.

4.4.2 State and Commonwealth initiatives

This proposal also fits in with a range of recent State and Commonwealth initiatives:

- Department of Conservation and Land Management Natural Diversity Recovery Program and related projects,
- State Salinity Strategy,
- Natural Heritage Trust (Bushcare, Farm Forestry Program, National Landcare Program),
- WA and National Greenhouse Strategies,
- Australian Greenhouse Office's "Bush For Greenhouse" Program,
- WA State Salinity Strategy, National Action Plan for Salinity,

- Gascoyne Murchison Strategy, and
- Greening Australia (WA) Living Landscapes Project.

In addition, it will produce significant benefits for the State by encouraging on-going private investment in revegetation with resultant enhanced regional employment opportunities.

4.4.3 Research institutions and centres

The Department of Conservation and Land Management is a partner in two Cooperative Research Centres (CRCs) undertaking research relevant to this proposal. It may be possible to develop partnerships between the projects proposed here and the CRCs, in return for research resources. The Centres are:

- CRC Greenhouse Accounting. This CRC was established in July 1999 and is based at the Australian National University. This CRC aims to develop methodologies to account for carbon in plants and soils.
- CRC Plant Based Management of Dryland Salinity. This CRC, established in 2001, has a focus on using profitable perennial plant systems to increase water use. This project fits within those objectives.

Other research centres undertaking work, that could feasibly be integrated with the project are:

- The CRC Landscape Environments and Mineral Exploration. This CRC has a program that is attempting to use new mineral exploration technology to determine the distribution of salinity.
- The National Airborne Geophysics Program – Federal and State financing, with a strong emphasis on salinity assessment. A catchment scale project could provide an attractive opportunity to focus resources.

Aspects of the research could be undertaken as research projects within Tertiary Institutions. This could be advanced by the strategic application of grants for Honour's or Master's level research.

4.5 Attracting additional funding

4.5.1 Greenhouse Gas Abatement Program

This project could also form the template for a broader Commonwealth Government Greenhouse Gas Abatement Program (GGAP)[1] project to sequester all emissions from the new power station. Several new GGAP projects will be funded in the next two years with these aiming to demonstrate means of reducing net greenhouse emissions from a number of sectors. Average Commonwealth funding is around $10m per funded project.

Although the guidelines include sinks schemes, and particularly those that deliver multiple environmental benefits, none have been funded to-date.

4.5.2 Matching funds from State and Commonwealth

The possibility exists for such a proposed initiative to enter into a cooperative agreement with the WA Government to build on investment in on-ground activities in salinity and greenhouse. Similarly, there are various Federal funds are also available to Natural Resource Management based Regional groups, as well as funds from the Commonwealth Government's proposed National Action Plan for Salinity.

4.5.3 Leverage of R&D funds

The potential exists to leverage Griffin's investment against a range of other grants, effectively doubling the investment. Examples include the Australian Research Council's "SPIRT" grants (industry/ universities) Land and Water Australia and the Rural Industries Research and Development Corporation. This research funding could be used to undertake specific studies across the catchment.

4.6 Greenhouse specific issues

Several issues that are specific to greenhouse sinks projects will need to be considered as part of these projects[26].

[1] www.greenhouse.gov.au/ggap/successfulprojects/index.html

- *Permanence*: If the revegetation is considered for carbon credits, they will need to be registered in some form. Any loss of carbon, through harvest and non-replacement, fire or pest attack will need to be reported.

- *Risks*. Questions that will need to be addressed include:

  Sinks: Determining the impact on revegetation of fire or drought.

  Financial: Estimating the effects of a fluctuating carbon price, exchange rates or interest rates on the project. Similarly, a large sinks scheme may result in a substantial increase in land prices, if land acquisition is through purchase.

  Political: Determination of what will happen to sink schemes in the absence of the Kyoto Protocol being ratified. Similarly, although Article 3.4 activities were allowed to be included in the first commitment period at the Bonn conference, it is essential to determine if the Australian government will take up this option.

- *Additionality*: Would the project occur without carbon investment?

- *Leakage*: These are unforeseen emissions outside the project boundaries, such as the revegetation of farmland resulting in new clearing elsewhere. This was raised in a recent Commonwealth inquiry into Greenhouse issues[27] but is considered unlikely with the almost complete cessation of land clearing in Western Australia.

4.7 Indigenous participation

There are opportunities for Indigenous participation, as many of the Indigenous communities in the wheatbelt have been involved in revegetation training and implementation schemes.

4.8 Communication strategy

A crucial component of this project will be the communication of project results to a wide range of audiences. Strategies that could be used include:

- Development of linkages with high school and university environmental studies courses such that education groups could visit the site. Such groups could participate by making measurements of various project components,

- Continual updates of project progress on the world wide web,

- Presentation of project overview and results to decision makers in government and the private sector at major greenhouse, energy, salinity and land conservation conferences (local, national and international),

- Media coverage in major city and country newspapers, national and international environmentally orientated television programs,

- Annual project seminar, with presentation of results of different component projects, with visiting speakers, and

- Development of "Icon" species that can be used in the media campaign and in Griffin's general media advertising.

5 Pilot Project 1: Catchment scale Treatment

5.1 Aim

In this proposal we suggest a 5,000 ha pilot project that will be concentrated in a single catchment and entail 1,000 ha of revegetation, or 25% of the total area, over a three-year period. This will form the basis for a broader revegetation scheme that sinks carbon at a rate of 0.25 to 0.50Mt CO_2-e/year, producing greenhouse, biodiversity, salinity and sustainable agriculture outcomes.

To enhance the process of tackling salinity, this proposal will also undertake an engineering study that investigates pumping, desalination and the local disposal of water.

It is expected that the results of this study will represent a best-practice template, suitable for greenhouse investment that could be extrapolated to other areas.

A detailed project plan is provided in Appendix A.

5.2 Outcomes

Outcomes will include:

- Direct sequestration of approx. 157,000 t CO_2-e over a 20 year period, at a cost of $11/t CO_2-e[2], using a range of vegetation including potentially commercial local woodland species and revegetation with local species for bio-diversity enhancement.
- Specific protection of threatened biodiversity in the catchment.
- Resolution of technical issues such as methods of measurement of carbon, prediction of carbon sequestration rates in plants and soils, responsiveness of carbon sequestration to management changes, best methods of reporting and verification.
- Development of best-practice reporting guidelines for greenhouse, biodiversity and salinity outcomes, with ongoing periodic reporting of each.
- Resolution of the best strategy to develop partnerships with local communities, a land acquisition strategy, long-term management of the sinks and fire and feral animal control.
- Determination of whether the environmental outcomes (biodiversity, salinity) coming from the project can be traded ("environmental credits").
- A catchment scale installation that will resolve in the longer term (15-30 years) the issues of whether revegetation will slow or reverse the onset of salinity and biodiversity decline.
- Comparison of a range of re-vegetation options (e.g. complete revegetation, perennial pastures, partial re-planting) in terms of biodiversity enhancement, hydrological effectiveness, carbon sequestration and bio-energy potential.
- Determine effects of desalination and revegetation on whole catchment greenhouse gas (CO_2, CH_4, NO_2) emissions and storage. Estimate how these will change in response to different management options.

5.3 Size and location of the pilot

It is recommended that this project be targeted in the Lake Bryde-East Lake Bryde Natural Diversity Recovery Catchment of the central wheatbelt (Figure 1). The Conservation Commission and the State Salinity Council, because of its very high biodiversity values, and threats from salinisation, have already targeted this for special consideration.

Considerable previous State investment has been made in this catchment, including broad studies of hydrology, soils and biodiversity. It is considered highly likely that up to 5,000 ha of land can be acquired for this scheme in the Lake Bryde Catchments.

Targeting higher rainfall Water Resource Recovery Catchments, or catchments with existing infrastructure, was considered. These include catchments such as the Kent River and the Wellington Catchment. Commercial investment in

[2] 20 year period, 7% discount rate, land purchase at $500/ha included. No direct value given for biodiversity, salinity or agricultural sustainability benefits.

revegetation is currently occurring within these catchments, and the challenges to biodiversity are less severe than in the wheatbelt, where there are large areas of un-cleared vegetation.

5.4 Land acquisition

For the pilot project land purchase offers some benefits – assuming that the right catchment is found – in that new experimental management schemes and techniques can be imposed. An issue for purchase, for the pilot, is that the location will be dependant on what land is on the market, and the land-holdings may not comprise a whole catchment.

It is highly likely that a catchment of around 5,000 ha will be available for purchase in the Lake Bryde catchment.

5.5 Revegetation strategy

The revegetation strategy would comprise both strips of trees (oil mallees and local eucalypts) arrayed across paddocks, plantings that interconnect between remnants and block plantings in various parts of the landscape. Salt tolerant species would be planted in lower landscape positions. This design would attempt to both optimise both the carbon sequestration, hydrologic and biodiversity values of the plantings. Recent best-practice guidelines will be used to design the revegetation[28].

Local native species would be used where possible. Replanted areas would be supplemented with logs and woody debris to enhance nesting[29].

5.6 Engineering and pumping

The accelerated dewatering of the Pilot catchment by pumping and local disposal in evaporation ponds is an option that can be considered. A similar approach has been advocated to save several rural towns under threat of salinisation[7] as well as Toolibin Lake.

Whether pumping will succeed in lowering groundwater tables and reducing salinity will depend on the catchment characteristics. These will be defined during the site investigation phase (§8.3). Costs of evaporation ponds vary with local conditions, with estimates in the Murray Darling Basin for 2 ha ponds ranging between $11,000-22,700/ha and for a 200 ha pond $4,700-11,700/ha[30].

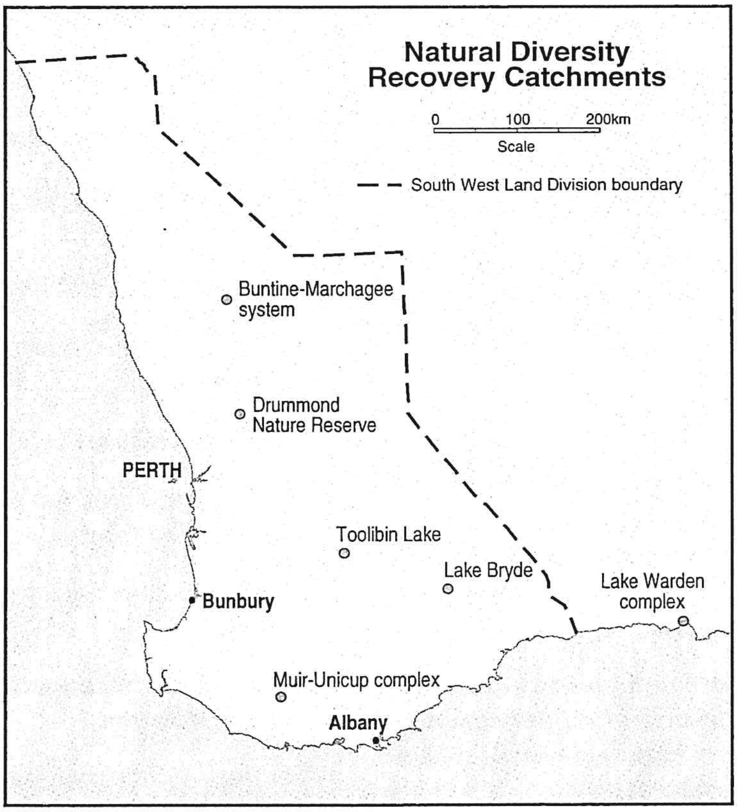

Figure 1 Natural diversity recovery catchments in south-west WA[16]

5.7 Research and development

A range of R&D is required for this project.

5.7.1 Greenhouse

- Determine the range of species that are can be successfully reestablished and how these might differ across the landscape,
- Investigate the carbon sequestered by local native species and develop predictive models of carbon sequestration,
- Develop growth curves for key species,
- Determine the amounts of carbon sequestered in the soil, and
- Develop management methods to optimize the amounts of carbon sequestered, while retaining the biodiversity values and long-term stability of the plantings.

5.7.2 Biodiversity and ecological restoration

- Develop/adapt low cost establishment systems for revegetation,
- Develop biodiversity targets – what is achievable?
- Determine the extent the revegetation has recovered biodiversity using key species,
- Attempt to reintroduce species of animals (e.g. lizards) that are poorly mobile, and
- Examine techniques developed in mine-site rehabilitation for the treatment of agricultural land.

5.7.3 Salinity

- As part of revegetation of catchment install neutron access tubes and piezometers to determine the effectiveness of revegetation in reducing stored soil water, recharge and groundwater levels, and
- Ongoing measurement of piezometer response to different treatments across catchment and whole of catchment response. Develop whole-of-catchment water budget.

5.7.4 Catchment engineering

Pumping into evaporation ponds represents an option for accelerating the dewatering of the groundwater systems.

- Determine from hydrological examination and modeling whether pumping and local disposal is a realistic option, and
- Investigate effects of pumping on groundwater levels in adjacent areas.

5.7.5 Integration

- Determine the best means of integrating revegetation within catchments,
- Determine best land acquisition strategy for a broader project, and
- Determine specific locations that might be suitable for the broader project.

5.8 Project resourcing

It is recommended that Project resourcing be considered as four parts:

1. Land acquisition, negotiation of land access agreements/arrangements.
2. Catchment investigation and planning.
3. Revegetation establishment.
4. R&D, monitoring and reporting.

5.8.1 Land acquisition and revegetation

The overall project cost will depend on the land acquisition strategy. Land acquisition options are:

1. Purchase the land and employ a farm-manager.
2. Purchase the land and lease the agricultural land to adjoining farmers.
3. Excise and purchase treated areas of land from farms.
4. Lease the areas treated with revegetation from the landholder.

The costs of revegetation are estimated in Tables 2 and 3 for 1,000 ha treated over years 2 and 3, for either land purchase or lease.

Costings here assume that the actual revegetation is put out to tender. An option that might be attractive is to use the technical officer attached to the project (§5.8.3) to supervise contractors undertaking the planting in years 2 and 3. The salary of this position has thus been split (50:50) between R&D duties and supervising revegetation in years 2-3. Lease-hold land will require extra liaison between the project team and the landholders.

Returns assume that the system can sequester 157 t CO_2-e/ha in 20 years (Table 1), and that only the carbon in the vegetation is sold at $12 t CO_2-e. There is no monetary value ascribed to biodiversity or agricultural sustainability benefits.

The costs of leasing land significantly increase the cost of sequestration – land purchase appearing most favourable. Purchase and excision (Option 3) above would avoid the need to continually manage the agricultural land.

Table 2. Partial budget for establishing 1,000 ha of vegetation across a 5,000 ha sub-catchment with land purchase. Agricultural component (purchase, costs and returns) is not considered. Costs over a 20 year period.

Item	Net Present Value ($)
Land purchase	500,000
Management	90,275
Operations (planting, weed control etc)	1,151,676
Monitoring and inventory	62,406
Total Costs	1,804,357
Carbon revenue	1,884,000
Net return	79,643
Carbon price for zero net return ($/t CO_2-e)	11

Assumptions: for treated area, farmland ignored; use of contractors, revenue from carbon at $12/t CO_2-e, no other revenue, 7% discount rate over 20 years. Carbon yield 157 t CO2-e.

Table 3. Partial budget for establishing 1,000 ha of vegetation across a 5,000 ha sub-catchment with annual lease. Agricultural component (purchase, costs and returns) is not considered.

Item	Net Present Value ($)
Lease ($100/ha/year)	1,159,401
Management	90,275
Operations (planting, weed control etc)	1,151,676
Monitoring and inventory	62,406
Total Costs	2,463,758
Carbon revenue	1,884,000
Net return	(579,758)
Carbon price for zero net return ($/t CO_2-e)	16

Assumptions: use of contractors, revenue from carbon at $12/t CO_2-e, no other revenue, 7% discount rate over 20 years. Carbon yield 157 t CO2-e.

5.8.2 Catchment characterisation

Estimated costs for characterising the catchment according to the outline given in Appendix A are summarized in Table 4.

Table 4. Estimated costs of characterizing a 5,000 ha sub-catchment

Item	Cost ($)
Soil survey	
Hydrological investigation	
Geophysical survey	
Biological survey	
Total	**100,000**

5.8.3 R&D investigations

It is recommended that the R&D investigations on the site be coordinated by a dedicated Research Scientist who would:

- Have responsibility for managing the project,
- Coordinate detailed site investigations using contractors (soils, hydrology, vegetation),
- Undertake specific investigations (carbon sequestration in various plant species and soils) individually and in cooperation with other scientists,
- Monitor response of catchment in terms of biodiversity, salinity and carbon,
- Promote the project through presentations at various fora and organise field-days,
- Report on key outcomes.

Item	2001/2	2002/3	2003/4	2004/5	2005/6
Research Scientist (L6)	32,000	64,000	64,000	64,000	32,000
Technical Officer (L3)	21,500	21,500	21,500	43,000	21,500
On-costs (35%)	18,725	29,925	29,925	37,450	18,725
Operating (drilling, laboratory analysis)	10,000	35,000	35,000	35,000	35,000
Travel	5,000	15,000	15,000	2,000	2,000
Total Cost	**87,225**	**165,425**	**165,425**	**181,450**	**109,225**

Notes:

1. *Projects could be undertaken in cooperation with the Cooperative Research Centres for Greenhouse Accounting and Plant Based Management of Dryland Salinity.*

2. *Additional R&D funding for specific projects could be obtained from competitive grants (e.g. Rural Research R&D corporations, Australian Research Council).*

5.9 GANTT chart

Commencement Date 01/01/02

Completion Date (final reporting date) 31/12/04

Task	Year 1				Year 2				Year 3				Prerequisite Tasks	Constraints/ Comments
1	■												Catchment selection & acquisition	Land available
2		■	■										Catchment characterization – soil, geology, hydrology, biology	Use of contractors
3		■	■										Development of revegetation plan	Integrate data sets with GIS
4			■	■									Seed collection of native species	
5					■	■			■	■			Nursery growth of native spp.	
6			■	■			■	■			■	■	Installation of monitoring network	
7							■				■		Planting 1,000 ha with local species	Use of contractors
8								■	■	■	■	■	Maintenance of planted areas	Inspect for insects, weeds
9													Measurement of key indicators	
10				■				■				■	Write up and reporting	Report on pilot at 3 years. Annual reports of progress.
11	■	■	■	■	■	■	■	■	■	■	■	■	Publicity	

6 Pilot Project 2: Defining the greenhouse impacts of changed rangeland management

6.1 Background

Changes in rangeland management activities fall within Kyoto Article 3.4, which appears to have been considered allowable following the 2001 Bonn CoP 6B meeting. It is feasible that changes in rangeland stocking practice will result in an increase in carbon stores in plants and soils (§3.5).

6.2 Issues related to rangeland sequestration

There are however some major unresolved issues related to rangeland sequestration:

1. Predicting the amounts of carbon that will be sequestered following changed stocking practice and feral animal control and where it accumulates (soils, plants?).
2. Determining the effects on carbon sequestration by actively managing degraded areas (e.g. reseeding, cultivating).
3. The long-term stability of any changes in carbon sequestration with respect to fire susceptibility (will an increase in biomass result in more intense fires that put currently stored carbon at risk? Is there any evidence of differences in fire frequency and intensity in systems with different management?).
4. Determining whether any changes in carbon can be measured in a cost-effective manner.
5. The legal implications of sequestering carbon on Pastoral Leases (is the sequestered carbon owned by the Lessee or by the Crown?).
6. Will carbon sequestered in rangeland systems be considered eligible to count against Australia's Kyoto assigned amount (§3.2)?

6.3 Defining a research project

Issues 1-4 can be resolved with a targeted research project; issue 5 requires a Legal opinion.

A research project could have the following components:

6.3.1 On-ground measurement

Several opportunities exist to quantify the effects of changed grazing practice. These include:

- Exclosures established by the WA Department of Agriculture (approx. 30) in the 1950's,
- Assorted rehabilitation trials may have been maintained to allow re-measurement,
- Fence-line contrasts between different grazing strategies,
- Use of Western Australian Rangeland Monitoring System plots indicating qualitative changes over time, and
- Re-measurement of condition assessment measurements and calibration of these with biomass and carbon.

6.3.2 Remote sensing

Several approaches to remote sensing of rangeland condition have been tried. These include recent work by the CSIRO CMS (Wallace et al. 1996).

- Calibration of these images with changes in biomass.

6.3.3 Feasibility in measuring carbon changes

A major part of both the ground-based and remote sensing studies will be to determine the feasibility of measuring carbon changes in rangeland systems, in terms of both costs and timeliness.

Research projects within the CRC Greenhouse Accounting (Dr Michael Hill, BRS) assessing the potential role of rangelands as carbon sinks include assessments of Aboriginal land management on carbon stores (in SA), and the use of modelling to assess carbon sequestration (ASSESS).

6.4 Resourcing

Item	2001/2	2002/3	2003/4	2004/5
Research Officer (L2/4)	23,500	47,000	47,000	23,500
On-costs (35%)	8,225	16,450	16,450	8,225
Operating (drilling, laboratory analysis)	10,000	25,000	25,000	25,000
Travel	5,000	15,000	15,000	2,000
Total	**46,725**	**103,450**	**103,450**	**58,725**

Notes:

1. *Project could be undertaken in cooperation with the Cooperative Research Centre for Greenhouse Accounting (Dr Michael Hill), CSIRO CMS (Jeremy Wallace) and Agriculture WA (Dr Ian Watson).*

6.5 GANTT chart

Commencement Date 01/01/02

Completion Date (final reporting date) 31/12/04

Task	Year 1				Year 2				Year 3				Prerequisite Tasks	Constraints/ Comments
1	■	■											Literature review	
2		■	■										Selection and inspection of historical trial plots (exclosures, treatments)	Plots have been maintained, historical records available
3		■	■										Identification of fence line contrasts	
4				■	■	■	■						Sampling and analysis of plots	Destructive sampling allowed
5							■	■					Laboratory measurements of carbon	
6								■	■				Relate ground measurements to remote sensed values	
7								■	■				Modelling of results	
8										■	■	■	Write up and reporting	Final report at 3 years. Annual reports of progress.

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8 Appendix A: Implementation Of Pilot Project I

Combining carbon sink re-vegetation and engineering to enhance and protect biodiversity, agricultural values and tackle salinity in a salinised catchment in the Western Australian wheatbelt.

8.1 Introduction

This pilot will resolve a range of technical issues that may develop as part of a larger revegetation program to sink up to 0.5 Mt of CO_2-e.

8.2 Catchment selection

It is recommended that a discrete sub-catchment, of 4,000-5,000 ha size, in the Lake Bryde. This catchment has the advantage of already being prioritised as a catchment of importance for the protection of biodiversity by the Western Australian Government.

The specific location of the catchment and costs of the project will depend on the land acquisition strategy for the pilot – leased or purchased.

8.3 Catchment characterisation

The first category requires the acquisition of knowledge about the distribution of materials in the landscape and the current hydrological status of groundwater and surface water systems. Detailed ground-based soil survey is expensive and time consuming. If the catchment has not already been surveyed in detail then it is recommended that digital elevation and gamma radiometric data be acquired initially to aid in determining what species to plant at specific locations within the catchment.

For ascertaining groundwater levels there is no alternative to the installation of piezometers. These need to be situated in specific locations in order to ascertain the direction of groundwater flow and the magnitude of the pressure heads that have developed in the catchment.

This stage will thus:

1. Characterise geology, soils, hydrology and biological features of the catchment,
2. Determine the areas that are contributing to the salinisation of the catchment and in particular the sources and flows of water and of salt, and
3. Indicate the best location of both revegetation and engineering interventions, using best current knowledge.

Parts of this stage could be undertaken through a series of short-term consultancies.

8.3.1 Soils/regolith

Describe nature of soils/regolith, with particular attention to:

(a) Soil texture (sand/loam/clay) – this should give an indication of the likely recharge rates across the catchment,

(b) Organic carbon and inorganic carbon (carbonate) contents of soils (surface 1 m), for greenhouse baseline accounting,

(c) Soil fertility,and

(d) Depth and nature of regolith (to bedrock) – using drill holes (including some coring) for hydrological investigation, sedimentology and for monitoring network.

8.3.2 Geology

Geophysical examination of catchment. Data sets to include gamma radiometrics, magnetics and electromagnetics. Ground survey (combined with soils) to confirm outcrops. This will define the geology of the area and in particular any structural controls of water flows and any sedimentation in the valley.

Gamma radiometrics is an indirect method capable of predicting soil properties and their distribution in the landscape. From these data, properties such as parent material and soil texture can be inferred. Most practitioners have an expectation that airborne geophysics in general and gamma radiometrics in particular will provide cost-effective aids to land managers interested in the pattern of materials in the landscape. In the wheatbelt of Western Australia, high thorium counts are related to the presence of lateritic material, high potassium to potassium feldspars of granite and granitic derived soils, low counts due to leached sands. The relationship with gamma and other environmental variables is complex since it will depend upon the environmental characteristics of the area such as parent material, the weathering environment, solubility and transport mechanisms of soil particles and isotopes (and daughter products).

For salinity assessment, the ability to map salt stores and to more precisely identify recharge and discharge areas are of particular interest when planning revegetation strategies using perennial vegetation. The effect of vegetation attenuating the gamma decay signals is minimal over the majority of Australian vegetation conditions due to low densities and dry canopies, so the airborne radiometric measurement essentially 'sees' the gamma emissions from the surface soil and regolith materials. Because water content can influence gamma emissions, it is usual to make measurements at a time of year when the soil is dry. Attenuation of the gamma signal means that waterlogged areas cannot be distinguished from sandplain areas and so it is usual to include data from digital terrain analysis in order to improve the interpretation.

For catchments in the size range of 50 to 10000 ha, the distribution of properties at a scale relevant for management are most efficiently ascertained by low flying systems with a line spacing of about 100 m and a flying height of about 25 m.

8.3.3 Topography

Produce 0.5 m digital elevation model of the catchment.

8.3.4 Hydrology

(e) Define hydrology of the area – and determine major causes of the salinity problem,

(f) Water table depths and pressures,

(g) Measure salt stores including current expressions of salinity, and

(h) Determine porosity of the different layers in the regolith to determine if there are any conductive layers.

8.3.5 Biological survey

Map and describe remnant vegetation in terms of species and condition.

8.3.6 Integration

Produce maps of various features including salt stores, regolith water holding capacity, current water content (including water tables), soil organic carbon contents.

Combine the above data sets via hydrologic modelling to produce an indication of sources of salt and water in catchment. Develop whole of catchment water estimates (e.g. how much water is in the valley floor? what is imbalance between rainfall and water use?).

Use best available model to predict likely effectiveness of different treatments and best location.

8.4 Treatment strategy

Develop a plan that divides the landscape into different zones, dependent on hydrology:

1. Areas that are currently salinised,
2. Areas that are likely to become salinised in 5-10 years, and
3. Areas that may become salinised in >10 years or not at all.

Different strategies will be used for each.

8.4.1 Areas that are currently salinised

These areas are often beset both by salinity and sheet erosion. Surface soil has been removed and subsoils have been exposed resulting in loss of fertility and exposure of clays with physical problems.

Actions:

1. Fence these areas.
2. Determine whether it is possible to de-water salinised valley floor aquifers. Dispose of water into sealed bottom evaporation ponds. Install pumps.
3. Determine if there are any surface drainage/ engineering works required to inhibit future sheet erosion or channel fresh run-off water.
4. Establish plants that are tolerant of hypersaline conditions. These will be selected from local flora on the basis of hydrological conditions – e.g. saltbush in centre, with fringing trees.

Questions:

Can dewatering by pumping be used as a short-term measure to lower the water table to allow plantings to be established for long term control?

8.4.2 Areas that are likely to become salinised within 5-10 years

These areas will have intact surface soil horizons and will be identified from hydrological mapping.

Actions:

Plant these areas with a range of deep-rooted plants (salt bush/trees/grasses) based on best advice.

Treat surface water problems.

Questions:

Test effectiveness of pumping vs permanent vs phased plantings of trees and shrubs in terms of using water.

Are there differences in water use of species? Is there an optimum rate/time for pumping to take place to assist/accelerate biological methods?

8.4.3 Areas that may become salinised in >10 years or not at all

These areas still have intact surface soil horizons and will be identified from hydrological mapping.

Actions:

Plant these areas with a range of deep-rooted plants (trees/pastures) based on best advice.

Several different revegetation strategies will be assessed in terms of likely products and in terms of mode of planting. This will be at the sub-catchment scale (100 ha), where different strategies can be compared in terms of their overall effectiveness.

Questions:

Test effectiveness of permanent vs phase plantings of trees and shrubs in terms of using water.

Are there differences in water use of species?

8.5 Implementation

8.5.1 Planting

A range of issues will need to be considered as part of the revegetation strategy:

- Local government regulations,
- Organizing contractors to undertake planting (ripping, spraying, planting),
- Insect monitoring and spraying, and
- Assessing growth of weeds and spraying.

8.5.2 Ongoing management

Ongoing management will be required on the vegetation. This will include the control of rabbits and control of fire.

8.5.3 Pumping and local disposal of water

An option to speed up the repair of the catchment will be accelerated dewatering with pumps, with subsequent evaporation in local ponds. Estimates have been made of the costs of protecting several rural towns in Western Australia with pumping – these range up to $7.6m over 30 years.

This component will require a separate feasibility study. The amounts of water that can be pumped will depend on the transmissivity of the local aquifers.

Mode of planting	**Purpose**				
	Timber	Water Control	Carbon credits	Bioenergy	Restoration
Strips	x	x	x	x	
Blocks	x	x	x	x	x
Phase		x		x	

8.6 Monitoring and reporting

An integral component of the project will be the monitoring and reporting of the project outcomes. This will involve the establishment of permanent inventory plots to measure tree growth and carbon sequestration, the establishment of ground and surface water monitoring networks and the key biodiversity indicators.

Where possible standardized sustainability indices will be used. Appropriate monitoring protocols will be developed in consultation with scientists from other institutions including the CRC for Greenhouse Accounting. Selected monitoring outcomes (e.g. salinity, carbon) will be reported on an annual basis; for other attributes longer time frames are likely to be adequate.

8.6.1 Carbon sequestration

Workbooks have been produced for setting up greenhouse accounting at a project scale[26,31].

Major issues include:

1. Establishing the project boundaries,
2. Estimating project emissions (fuels, fertilizers),
3. Resolving issues to do with permanence, additionality, risks and leakage (§4.6), and
4. Producing a baseline and establishing permanent sampling plots across the revegetated areas.

It is suggested that carbon be measured in trees, with a small study determining if the change in soil carbon with revegetation is significant.

Prepare a whole of catchment greenhouse budget.

Establish permanent sample plots within revegetated areas to measure growth and estimate carbon sequestration.

8.6.2 Biodiversity

Sample points established in remnant vegetation and in re-established vegetation to determine the abundance of selected species of insects and birds.

8.6.3 Salinity

Piezometers need to be monitored, but groundwater responses are notoriously slow. Changes to saturated areas, reduced waterlogging and wind erosion, enhanced biodiversity and carbon sequestration are all potential candidates for monitoring. Some of this monitoring can be undertaken using air photo interpretation and remote sensing techniques, but ground-based survey data will also be required. Similarly, different components can be measured at different time intervals.

It is well known that trees will dry out the soil profile to the depth of rooting. Detailed monitoring of soil water storage changes using for example, neutron access tubes may not be warranted. Establishing the depth of rooting using survey techniques such as monitoring soil water potential profiles with the filter paper method are simpler and easier to perform.

An untreated catchment of similar size will be located nearby to compare gross effects.

8.6.4 Agriculture

Monitor overall productivity of agriculture from farm records (wool clip, animals sold, gross tonnage of grain).

8.7 Timeframe

A Gantt Chart for the first 4 years of the project is provided in §5.9.

9 Appendix B: Background Paper: Greenhouse Governance and Emissions trading

9.1 Introduction

This brief paper describes the response of various levels of Government to climate change, emissions trading and describes the opportunities for those wishing to use revegetation to establish a carbon sink.

9.2 Governance

9.2.1 International governance

The increasing recognition that global climate is being changed due to the accumulation of greenhouse gases has resulted in a range of national and international activity.

The United Nations Framework Convention of Climate Change (UNFCCC)[3] was initiated in 1992, and ratified in 1994, with Australia as a signatory. This treaty recognised global warming as a problem, and set in process a series of steps to stabilise greenhouse gas emissions. A series of conferences of parties to the convention (CoP) meetings ensued, with the COP 3 meeting at Kyoto in 1997 resulting in the Kyoto Protocol[4]. The COP is the decision making body of the UNFCCC.

The Kyoto Protocol consists of a series of actions by 39 industrialised countries (listed in Annex I of the protocol and called "Annex I countries") to reduce global carbon dioxide emissions by 5.2% in the period 2008-12 ("the first commitment period") relative to 1990 ("the baseline"). There are no restrictions on non-Annex I countries. Unlike most industrialised countries Australia was able to argue for an increase in net emissions, to 108% of the 1990 base-line in 2008-2012. This is Australia's "assigned amount". Similarly, Australia successfully argued that emissions from land clearing had contributed to its 1990 baseline, thus changing net emissions from this sector was a valid means of reducing overall emissions. The Kyoto Protocol also opens the possibility of emissions trading, through a series of "flexibility mechanisms".

While carbon dioxide is the best known greenhouse gas Kyoto Article 3.1 identifies six greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride). The Global Warming Potentials of these gases are considered in terms of a carbon dioxide equivalent (CO_2-e), with methane and nitrous oxide respectively having 21 and 310 fold warming potential values, compared to carbon dioxide over a 100 year time period. Amongst other sources, methane is produced from ruminant livestock and landfills and nitrous oxides from agricultural soils and nitrogen fertilizer.

Articles relevant to the establishment of greenhouse sinks are:

Article 3.3 *Carbon sinks*

The counting of sinks within the land use, land use change and forestry (LULUCF) sector, from afforestation or reforestation of farmland. Only carbon sequestered in forests established after 1990 can be counted ("the Kyoto forests").

Article 3.4 *Additional activities*

This relates to other land-use activities, such as "forest management", "cropland management", "grazing land management" and "revegetation". The recent Bonn meeting (CoP 6B) deemed that these were also eligible for inclusion in the first commitment period. Australia decided not to include "forest management" activities against its assigned amount. It is this Article against which changes in carbon in agricultural soils and rangelands could be included. Farmland revegetation that doesn't meet the definitions of "forests" can also be included.

Article 6 *Joint implementation (JI)*

JI foreshadows the trading of carbon emission credits between Annex I countries.

[3] www.unfccc.de/resource/convkp.html

[4] www.unfccc.int/resource/protintr.html

Article 12 *Clean Development Mechanism (CDM)*

CDM allows Annex I countries to gain credits for certified emissions reductions from sustainable development activities in non-Annex 1 (i.e. developing) countries. Sinks from afforestation or reforestation are also included.

Article 17 *International emissions trading*

Establishes a market-based approach to emissions reduction by allowing Annex I countries to trade parts of their assigned emissions and certified emissions reductions.

Scientific input to this process has come from the Intergovernmental Panel on Climate Change (IPCC)[5], which is a body of the United Nations Environment Program (UNEP) and World Meteorological Organisation (WMO). The Subsidiary Body on Scientific and Technical Advice (SBSTA) undertakes policy and scientific advice to the CoP.

Specific details of implementing the Kyoto Protocol have been debated at subsequent CoP meetings. The COP 6 meetings in the Hague and Bonn provided some resolution of issues relating to emissions trading and activities eligible for this process, and in particular definitions for Article 3.3 and allowed activities under Article 3.4.

It should be stressed that the Kyoto Protocol has not been ratified. Ratification requires 55 nations, and nations that contribute 55% of global emissions, which has been assumed to mean that it has to be supported by the United States, however several Annex I countries are planning to ratify in 2002.

Emissions reduction activity may, however, still occur in the absence of Kyoto, driven by corporations and domestic incentives[6].

9.2.2 Australian governance

Within Australia, the Prime Minister's Greenhouse Statement in 1997[7], set up the Australian Greenhouse Office (AGO), which is within the Department of the Environment. This is responsible, along with the Department of Foreign Affairs and Trade (DFAT[8]) in negotiating Australia's international stance. International Greenhouse Partnerships, sits within the Department of Industry, Science and Resources.

Government policies and programs are outlined in the 1998 National Greenhouse Strategy. The AGO has a range of programmes that include attempts to manage greenhouse emissions from the residential, industrial, transport and energy sectors. The Bush for Greenhouse Program ($5.5m) is specifically related to revegetation. The Greenhouse Gas Abatement Program (GGAP, $400m) may include a sinks component.

A key feature of Australia's response is an attempt to tie the benefits of Greenhouse abatement programs with other regional issues, such as land degradation [2,10].

The Western Australia Greenhouse Council has members from across a range of agencies and stakeholder groups. The Department of Conservation and Land Management has representation on the Emissions Trading Technical Panel and has chaired the Sustainable Land Management Technical Panel. The emissions profile of the land-use, forestry and agricultural sector have been summarized for WA [22,12].

9.3 Emissions trading

As noted, the Kyoto Protocol has opened the way for emissions trading as a means of reducing greenhouse emissions. The philosophy behind emissions trading is that a market-based approach will be more effective in meeting compliance targets than governmental control and regulation. Market

[5] www.ipcc.ch

[6] http://ens.lycos.com/ens/nov99/1999L-11-15-03.html

[7] 20 November 1997 "Safeguarding the Future: Australia's Response to Climate Change" www.greenhouse.gov.au/ago/safeguarding.html

[8] www.dfat.gov.au/environment/climate/

[9] http://www.isr.gov.au/science/pmseic/greenhouse.pdf

[10] www.environ.wa.gov.au/publications/report.asp?id=7&catid=33&pubid=1062

trading has been successfully applied to the management of sulphur dioxide emissions in the US, this being managed by the US Environmental Protection Agency[11].

Emissions trading is a developing market, and details of how this market will run are still being resolved. The British Government has recently established an emissions trading scheme, however this specifically precludes the use of sinks. Other international markets are also developing, including the Chicago Board of Trade, New York Mercantile Exchange and the International Petroleum Exchange.

While details are being resolved, a likely scenario is that the market will work within a framework where "allowed emissions" are "capped" at a negotiated level. The allowed emissions will be divided into tradable units (tonnes of CO_2), and these units certified and traded. Critical in this process will be keeping transaction costs to a minimum.

Thus, revegetation will constitute a carbon sink, and credit for the stored carbon can be sold. Implicit in this however, is that if the vegetation is removed and not replaced the carbon will have to be re-purchased. There are also issues about the fate of carbon in wood products following harvest, and whether these should be considered to be a carbon store.

Although the international processes have not been finalised, and likely prices are not clear[12], there has been some early sinks activity. Examples include:

1. State Forests of New South Wales has signed a contract with the Tokyo Electric Power Company to establish up to 40,000 ha of plantations over 10 years.[13]

2. The Dutch Electricity Generating Board set up the FACE Foundation (Forests Absorbing Carbon dioxide Emissions) in 1990, which developed a series of forest sinks.[14]

3. BP-Amoco has instituted an internal emissions trading system between business units. The Forest Products Commission has an agreement to establish plantations with BP (Kwinana).

There is a strong likelihood that trading in emissions will become a reality. It should be stressed that an overriding feature of these developments is that emissions trading will be part of an international market, and treated in a similar manner to other financial instruments. The Australian market will have to be compatible to the international market. There will not be a Western Australian markets, setting its own rules.

[11] www.epa.gov/globalwarming/

[12] GO estimates range from A$10-50/tonne CO_2-e

[13] www.planetark.com.au/dailynewsstory.cfm?newsid=5715&newsdate=17-Feb-2000

[14] www.facefoundation.nl/

10 Terms of Reference for report

An investigation of the possible treatment of several salinised catchments with revegetation and engineering options to produce a range of environmental outcomes. Apart from sequestering carbon, outcomes also include re-instating the long-term biodiversity and agricultural stability in areas threatened or affected by salinisation.

The planning study (Stage Ia) (this document) will involve developing a detailed plan for the project (Stage Ib) with outcomes including:

- identification of locations across the agricultural region, each with different emphases on outcomes from which three catchments can be selected,
- production of a broad plan for the catchments including experimental and monitoring protocols,
- linking the project with existing projects and priorities within the Department of Conservation and Land Management, and in particular the Wheatbelt Region, and with other Agencies and other interest groups,
- identification of potential collaboration with other research groups (e.g. CRC Greenhouse Accounting, CRC Dryland Salinity) and prospects of leveraging external funding,
- production of a Project Agreement to cover issues such as intellectual property and publicity, and
- indicative costs of implementing Stage Ib.

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