THE NEW HYDROLOGY:

NEW CHALLENGES FOR LANDCARE AND TREE CROPS

JRBartle Manager Farm Forestry Unit Department of Conservation and Land Management
Paper presented to the WA State Landcare Conference Esperance September 1999

ABSTRACT

Recent reviews of Western Australian agricultural hydrology research have produced results of fundamental importance in the development of salinity control and landcare. This work indicates that water use by perennial plants might not be as large as earlier research had indicated and that a much greater proportion of perennial plant cover, up to 80% of the agricultural landscape, might be required to achieve salinity control. It reveals a far larger landcare task than previously contemplated. It will provoke farmers to question the feasibility of revegetation strategies to control salinity and starkly reveals the alternatives: living with the problem or incurring the cost of major engineering works.

This paper argues that living with the problem is not a credible option. The costs of land loss and downstream impacts, the national acceptability of such large-scale degradation and possible consequences for our agricultural trade, dictate that a serious attempt at developing solutions is obligatory. It re-asserts that perennial plant solutions, particularly commercial woody plants, remain a major component of the solution, although it is now clear that complementary engineering works at the discharge end of the system will be required.

The role of woody perennials is supported by strong fundamentals in world wood markets, with declining supply from native forests and the likely imposition of carbon emission limits tilting markets in favour of natural, renewable industrial products like wood and biomass fuels for bioenergy.

BACKGROUND

What is the 'new' hydrology?

A new consensus on the hydrology of agricultural salinity in WA emerged following the release of the first State Salinity Action Plan in 1996. The Plan was accompanied by a technical assessment (Anon, 1996) and a source paper (Ferdowsian et al 1996) that presented projections of the likely future extent of salinity. These projections indicated that land damage due to salinity would expand from the present 9% to over 32% of agricultural land within several decades. This was a dramatic increase over previous perceptions of the size of the problem and focused a wide range of attention on the Plan.

Many salinity research workers felt the published Plan was far too optimistic in its expectation of successful treatment of salinity and that it failed to realistically account for the considerable body of hydrological knowledge that had developed through the previous decade or so.

This was a factor in encouraging researchers to sharpen their technical positions and several key publications on salinity emerged since. The most prominent of these are George et al (1999), Hatton and Nulsen (in press) and Hatton and Salama (1999).

These publications make the following key points:

- reduction in water table depth by deep rooted perennials does not extend far beyond the boundary of the planted area
- control of recharge to groundwater will require a perennial plant leaf area similar to that which prevailed under native vegetation
- the proportion of perennial cover required is up to 80% of the landscape.
- tree cover on discharge areas will not be sustainable due to salt accumulation in the root zone.
- low gradients in the landscape dictate long time periods for response to reductions in recharge
- the long time response will see a large proportion of the projected maximum salinity damage expressed, even if rapid large scale implementation of treatments is achieved

This gloomy prognosis has been most strongly influenced by a survey of water table levels at some 80 revegetation trial sites across the south-west by George et al (1999). Their data for 33 recharge area plantings are presented in Fig 1. Note that water table reduction should be more readily achieved on upslope, generally less saline recharge land, in comparison with flat, saline discharge land. However, even on this land Fig 1 shows that reduction in water table level associated with trees was less than previous expectations would have led us to believe. It is especially notable that impact remained relatively small, on average, even for proportions of planting up to 60% of the landscape.

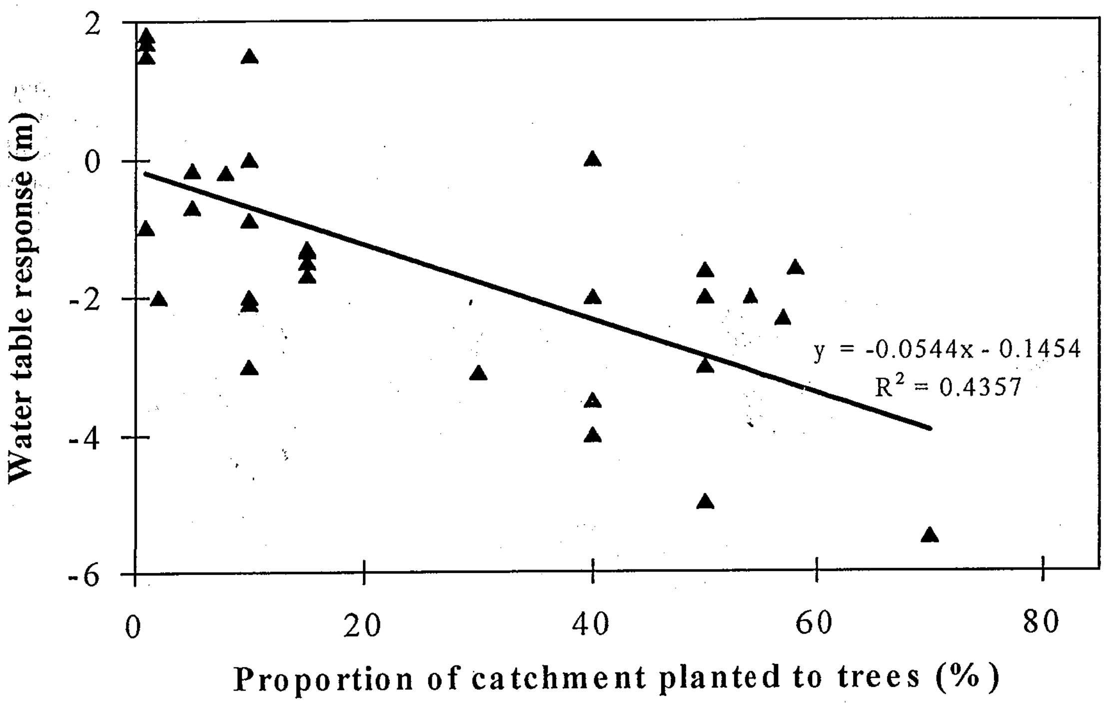

Fig 1: Relationship between the proportion of the catchment planted with trees (%) and the water table response (m) at recharge sites in Western Australia (From: George et al, 1999)

Why were we so optimistic in the past?

The early optimism was based on a large body of research on direct water use (evapotranspiration) by trees in small plots. In many cases this showed that trees consumed much more than just the rain that fell on the plot area (Raper, 1997). The inference was that tree root systems were able to deplete soil and ground water over sufficient depth to provide a gradient for inflow of water from adjacent areas. This engendered confidence that partial plantings of deep-rooted perennials could serve as pumps to mop up surplus water from adjacent annual plant crop and pasture areas. It is also implicit in this view that there is a sufficient proportion of the landscape where trees could perform this function i.e. where the groundwater is accessible, not too salty and aquifers are conductive enough to deliver water to tree root zones. Most of the sloping land of the wheatbelt (some 60 to 70% of the area), it was assumed, would fall into this category.

The conceptual model that emerges from the new hydrology is that perennials are only able to consume incoming rainfall on their area and prevent recharge to groundwater. However, it assumes that the conditions of groundwater accessibility, salinity and conductivity occur on 'a very limited fraction of the wheatbelt' (Hatton and Salama, 1999). Hence there can be little extraction from groundwater and limited lateral advantage from perennials. This model therefore says that to de-water the agricultural landscape we must 'take the trees to the water', i.e. we need perennials 'everywhere' or as George et al (1999) say, on as much as 70 to 80% of the landscape. In the alternative 'water comes to trees' model the trees can be dispersed in alley configuration, for example, and much more room is left for conventional agriculture.

The problem with the George et al (1999) evidence is that it is a survey of outcomes. It tells us little about how and why. They acknowledge this deficiency and to complement the survey they also present five case studies with more detailed information. Three of these five provide evidence that water can indeed come to the trees. The statement by Hatton and Salama (1999) that 'only a very limited fraction of the wheatbelt' has conditions that permit access to groundwater is not supported by any data. It appears to be a reasonable assumption for extensive flat regions such as Esperance sandplain, and broad wheatbelt valley floors, but not for the undulating land surfaces that make up more than 60% of the wheatbelt.

The problem is that there is little knowledge, and little research in progress, on the processes by which water becomes available to roots, either via natural flow paths, or by deliberate management design (Table 1). We need to understand such processes to be able to resolve the conflicting results of the new hydrology and the older work on direct water use. More importantly, until we have this knowledge we are not able to design systems that achieve a desirable level of recharge control with a minimum of perennials.

Table 1 outlines the questions about how management or natural processes might make water preferentially available in the root zones of perennial plants.

TABLE 1: CAN WATER COME TO TREES?

1. By use of surface drainage structures to collect and divert collected water to be infiltrated on perennial planted areas.

- over what soil types and area might it be feasible to collect surface water?
- what amounts could be collected?
- over what soil types and area might it be feasible to infiltrate collected water (what depth, storage capacity, infiltration properties and elevation in relation to collection area)?
- what type of structures are required to do this?

2. By preferential recharge of shallow subsurface perched flows into perennial planted areas

- what soil types and areas generate perched aquifers?
- what is their flow duration and volume?
- does perched flow preferentially infiltrate into the drier soil profiles beneath perennials?
- is it feasible for such flows to be deliberately intercepted and infiltrated under perennials?
- what type of structures is required to do this?

3. Through accessibility of deep profiles and permanent groundwater:

- what soils and areas permit deep water and root penetration (i.e. to deep groundwater depth)?
- what soils and areas have physical (hard pan) or chemical (acidity/salinity) barriers to root occupation?
- how deep do perennial roots penetrate?
- does deep root penetration vary with species?
- can deep root penetration be facilitated by lateral root ripping, planting density and layout?
- do deep roots tap groundwater?
- what volumes of water can be extracted from groundwater?
- how does groundwater salinity affect viability and water extraction potential of root systems?

We clearly do not have the knowledge to accurately predict the proportion of cover and distribution of perennials required to achieve particular salinity control results. It is premature to conclude that perennials cannot use more than rainfall and therefore that partial cover is not effective. However, it seems likely that the desirable proportion of perennials will be more than the open ended 'at least 20%' in the Salinity Action Plan (1996) but less than the 'as much as 80%' indicated by George et al (1999).

It is clear that complete salinity management systems will need treatments for extensive flat areas where highly saline groundwater is at or close to the surface and plants can make no useful contribution to water use. These areas will require engineering works such as evaporation basins that provide for safe disposal of the final increment of water and salt that cannot be consumed or retained in stable storage within the agricultural landscape. The amount of saline water to be disposed, and therefore the size and cost of engineering structures, will be determined by the level of water use that can be achieved by agriculture.

LEARN TO MANAGE SALINITY OR 'TAKE IT ON THE CHIN': DO WE HAVE A CHOICE?

An understandable reaction to the new hydrology is to conclude that: *to bring salinity under control is going to be so hard, it's not worth the fight'.* This proposition presents a major challenge for wheatbelt farmers and the landcare movement. This section presents the case to say that we can't withdraw from the fight. It is a blunt overview of the costs and the complications of accepting salinity as unavoidable. The costs are not confined to the farm. Farmers might be inclined to tolerate salinity on their own land. However, they will also have to take account of the external costs – the downstream or off-farm costs. What are these costs, who has to pay them, and if these costs continue to escalate what will be the local, national or international repercussions for farmers?

Costs and risks in choosing to live with salinity:

- **on-farm costs:** it is not a pretty picture to contemplate the direct cost to the average farm of the area of saline land increasing from 9% to 32%. Firstly, this is an average – some properties will have more and some less. The area of saline, saturated land will continue to branch out across the farm in patterns that will ignore the presence of farm infrastructure and the convenience of farm operations. Some farms will have a disproportionate share of their infrastructure (homes, sheds, dams, roads, fences) on such land. Many farm homesteads are located on land that is going to become saline. In winter, or at least during wet periods, water logging will make machinery movement across this land more difficult. Better quality tracks and creek crossings will be necessary. This effect will extend beyond the margins of permanently saturated land, where shallow groundwater will increase the frequency of temporary waterlogging and the risk of bogging farm vehicles. The first rigorous analysis of these costs is now underway in a major collaborative Commonwealth funded project called 'Salt Scenarios 2020' (Pannell, pers comm). The costs of salinity are to some degree off-set by the potential to make productive use of saline land. Since it is inevitable that we will have considerable expansion in salinity, productive halophytic species and practices such as ridge cropping warrant development.

- **off-farm costs:** agricultural salinity will dramatically change the character of the entire drainage network of the south-west. All the flat land on the floor of every valley is projected to become permanently saline and saturated over the next several decades. This will inundate and kill even large areas of remnant native vegetation (George et al, 1994). The natural habitat of hundreds of species of plants and animals that occur only on valley sites will severely contract and many species will be endangered. The big rivers emanating from the wheatbelt have already been written off as sources of drinking or irrigation water, but others such as the Collie, Kent and Warren are at risk. The state has a vast investment in infrastructure along the river valleys, virtually all of which was designed for a hydrologic regime which has now changed radically and will change more in the future. The destructive impact of soil saturation on the stability and durability of foundations of buildings, structures, roads and utilities is becoming more evident. Saturation of such a large proportion of the land also means greatly enhanced run-off. In peak rainfall events this will be reflected in greatly increased flood frequency and height and will pose unprecedented risk to property. There has been little work done to estimate these costs but Pannell (pers comm) considers that they will be at least as large as on-farm costs.

- **community acceptance and politics:** the enormous public good will that farmers enjoy in the fight against salinity is a valuable asset. The Landcare movement has a high public profile and is the major vehicle for the nation's continuing large investment in salinity control. However, it's a safe bet that the community will be expecting a dividend from this investment. The new hydrology sounds a warning to farmers. It implies that typical current landcare works can not be effective. If farmers don't improve the effectiveness of their fight against salinity they risk eroding community good will and provoking political demand for remedies to be imposed by regulation. An agriculture that is ecologically unsustainable is also likely to be politically unsustainable. Farmers must value the present good will and use the funds it can generate to develop effective solutions.

- **international risks:** the international community, most commonly through the United Nations, is rapidly building major programs for protection of the global environment. The 1992 Rio Conference (UN Conference on Environment and Development or UNCED) marked a quickening of this process. It reinforced the charter of various UN agencies and programs and stimulated development of new, strong and pervasive conventions to protect the environment. Australia is invariably a signatory to these conventions. These bodies and conventions include the UN Commission on Sustainable Development (CSD), the Intergovernmental Panel on Forests (IPF), the Framework Convention on Climate Change (FCCC) which has given rise to the Kyoto Protocols for limits on greenhouse gas emissions, the Convention on Biological Diversity (CBD), the Convention to Combat Desertification (UNCCD). The issue of sustainable forest management has captured much of the attention of these programs to date. However, the issue of sustainable agriculture could in future come in for more attention in these and other international programs. Trade restrictions can emerge as a measure to give these programs teeth. Against this background it seems bad policy to be seen to be inactive in the fight against salinity.

The case for accepting salinity without a fight seems weak. There seems to be too much to lose. What then is the attraction of the alternative option – to develop the capability to control salinity?

POTENTIAL FOR COMMERCIAL WOODY PERENNIAL CROPS

If it will be intolerable to live with salinity, what can we do to make control feasible?

I am not going to try to answer this big, all encompassing question – that's the business of the current review of the State Salinity Action Plan. However, it is clear that significant recharge control will only be achieved by extensive adoption of perennial plants – this means a fundamental change to the suite of plants and range of practices used in agriculture.

The aim in this section is to overview perennial plant options and then to focus on the opportunity to develop new commercial woody plant crops and industries that might be commercially viable on a scale that is relevant for salinity management.

Perennial plant types

Perennial plants come in many forms. Table 2 gives an overview of the range of types and some examples in current use. The major division used in this table is between grazing plants and non-grazing plants. This is a convenient separation because it indicates very different management and product options. Within the grazing category there are well known herbs and grasses and some newer woody fodder shrubs. Within the non-grazing category the separation is between trees (with conventional timber producing options) and shrubs with a wide range of as yet little developed product options. The listing of farm trees and understorey reflects the landcare and Natural Heritage Trust commitment to non-commercial revegetation. Non-grazing shrubs are divided into sprouters and seeders indicating a major management difference where sprouters can regenerate from the stump but seeders must be replanted after harvest. Both of these may be harvested on cycles as short as 2 years and are therefore called short rotation tree crops. Short rotation sprouters such as willow and poplar are now well established as bioenergy crops in agriculture in Europe. The Australian flora is especially rich in sprouting species such as mallee.

TABLE 2: OVERVIEW OF PERENNIAL PLANTS TYPES

PERENNIALS				
GRAZING		NON-GRAZING		
HERBS/GRASSES	SHRUB	TREE	SHRUB	
			Sprouters	Seeders
lucerne	tagasaste	bluegum	oil mallee	Acacia
phalaris	Acacia saligna	maritime pine	melaleuca	understorey
	saltbush	farm trees	understorey	

Commercial or non-commercial perennials?

The required scale of planting of perennials is in the order of millions of hectares and the cost of establishment will be measured in billions of dollars. To occupy land on this scale, to build new industry infrastructure and to attract the necessary capital investment, perennials will have to pay their way as well as improve water use. Furthermore, to achieve the necessary rate of adoption perennials will need to be very competitive with other options available to farmers. As Barr (1999) said, 'reliance on stewardship will only go so far'. The major perennial plants will need to achieve the status of wheat or sub-clover!

Hence the answer to the question of whether perennials should be commercial or not seems quite clear. However, the Landcare movement and the Natural Heritage Trust (NHT) have had considerable difficulty reconciling their conservation ethic with this commercial reality. There has been an inclination to sideline support for commercial revegetation in spite of steeply increasing pressure from farmers for 'profitable landcare options'. Now, with the added pressure from the new hydrological predictions, this has become the Landcare movement's major current challenge. It must rise to this challenge for three reasons:

- the important and admirable nature conservation objectives inherent in landcare cannot be achieved separate from the much bigger issue of bringing salinity under control.
- the Landcare movement is being relied on as the major channel for public investment in the treatment of land degradation, including salinity.
- farmers are ultimately accountable for the success of public investment in landcare – they will be left exposed if the claimed or implied gains in salinity control are not realized.

Current commercial perennial options

Perennials that already have a commercial track record are an obvious choice for inclusion in current revegetation activities. Table 3 gives an overview of the current commercial perennials and the limits of their range.

TABLE 3: CURRENT COMMERCIAL PERENNIAL OPTIONS

Perennial species	Plant form	Rainfall zone	Soil preference	Products	Development status
Bluegum	tree	>600 mm	deep fertile	pulpwood, saw logs	new industry, expanding rapidly
Pinus radiata	tree	>600 mm	deep fertile	chipwood, saw logs	old stable industry.
Pinus pinaster	tree	>400 mm	light infertile	chipwood, saw logs	old, major new expansion in 400 to 600 mm zone
Lucerne	herb legume	>400 mm	deep freely drained, not too acid	grazing, fodder	old established, expanding to drier areas
Tagasaste	woody shrub legume	400 to 600 mm	light infertile	grazing	new, expanding rapidly
Oil mallee (many species)	woody shrub	< 600 mm	full range	eucalyptus oil, wood, bioenergy	commercially unproven

Perennial grazing plants feed into the already established sheep and cattle industries. Since these industries are large and currently rely predominantly on annuals there is scope for rapid conversion to perennials. However, lucerne and perennial grasses have been available for decades and have never achieved high levels of adoption. One reason is that the soil and rainfall preferences of existing options are too narrow. Considerable work is underway to adapt lucerne to a wider range of soils. Perhaps the major constraint to expansion of perennial grazing species is the long-term cost/price squeeze afflicting the grazing industries. New investment in these industries is not attractive at this stage. The imperative to develop new perennials could therefore also provide an opportunity to diversify the economic options available to farmers (Bartle et al, 1996). The woody perennials (trees and shrubs) offer entry for wheatbelt farmers to large markets in wood and non-wood products.

Table 3 includes three timber producing tree crops. These offer opportunity for entry into existing timber industries and provide economic diversification. Of these only *Pinus pinaster* (maritime pine) extends into the wheatbelt, out to a limit of 400mm rainfall/year, where it could make a substantial contribution to salinity control. It is a long rotation (more than 30 years) timber crop but the large, long term investment is financed by the Government through sharefarming arrangements managed by CALM (Shea, 1998). As the pine resource comes on stream in a decade or so, initially as thinnings for panel board manufacture, there will need to be substantial investment in processing plant, much of which will need to be located in country towns.

Table 3 also indicates that there are no commercially proven woody perennial options available for extensive use in the drier wheatbelt although oil mallee is under development.

This quick overview of perennial options shows that the choices are too thin. If we are to have an extensive presence of perennial plants in agriculture we need at least several new species and several new industries that are commercially viable and able to operate on a large scale. It would also be desirable to have dozens of smaller scale industries based on niche crops to fill in the gaps and take in every minor variation of soil type, situation and grower preference.

This is not a small job.

But before we change our mind and decide that living with salinity might be preferable, we should do some simple evaluation of the prospects. What sort of things might work and what are the chances of successful development? Since woody plants will grow wood, the obvious place to start is the market outlook for wood and related non-wood products.

How favourable is the global market outlook for wood products?

Woody perennials offer potential for entry to world wood markets. These are bulk commodity markets with a traded value of US$114 billion in 1994 (FAO, 1997). They are similar in size to world food commodity trade, but very different in one important respect. Wood commodities feed into industrial markets and consumption is related to the level of economic activity, whereas food commodity consumption is related to population. Global economic activity is growing at nearly double the rate of population. Furthermore, food commodity demand grows most strongly in those parts of the world least able to pay. These fundamentals may partly explain the long-term decline in the real net value of farm production that has put Australian farmers under such pressure over the past several decades (Chisholm, 1992).

Like food only a small proportion of wood production is traded. The region with the highest volume of imports is Asia, and Western Australia has a transport advantage over most suppliers to these markets. Another feature of wood markets has been the rapid expansion in the technology, range of product types and consumption of panel board and paper products, and the increasing proportion and types of residue and recycled material being used (FAO, 1997). Flexibility on feedstocks is vital because our potential wheatbelt short-rotation woody crops will produce quite different feedstocks to the conventional forestry residue sources.

There are two long-term changes underway in global wood markets that should reinforce the strong economic fundamentals of new woody plant crops.

The first is the diminishing supply of wood from the native forests around the world. There are four major forces at work here:

- forests are being cleared for agriculture in developing countries. During the period 1990 to 1995, clearing occurred at a rate of 13 million ha/year or 0.7%/year of total forest area in developing nations. (FAO, 1999). This was offset by forest establishment on farmland in developed nations of 1.7 million ha/year or an increase of 0.1%/year.
- forest condition is declining. The direct conversion of forest to agriculture in developing nations is less than half the area being converted by attrition of forest cover under pressure from subsistence farmer/forest communities FAO (1996). The low level of management input to tropical forests has also left them vulnerable to illicit logging, overharvesting, fire, pests and disease.
- forests are being put into reserves that exclude logging. Some 9% of world forests now have some form of formal exclusion of wood supply (FAO, 1999). Many developing nations have placed forest in reserves for biodiversity conservation or protection of native communities.
- imposition of sustainable management practices. The International Tropical Forestry Organization which accounts for more than 80% of the worlds tropical forests and 95% of tropical timber trade aims to have all exports (logs and products) coming from sustainably managed forests by 2000 (FAO, 1999). Certification schemes are being developed to supervise these commitments.

The second change is reduced costs of production and increased competitiveness by wood that may emerge from the global endeavour to limit greenhouse gas emissions.

Over the past 100 years the carbon dioxide concentration of the atmosphere has increased by some 20% after having been stable for more than 1000 years. This is a result of population increase and industrialization driving forest conversion to agriculture, and increased consumption of fossil fuels. It is known that increases of carbon dioxide concentration of this order will enhance the 'greenhouse effect' of the atmosphere and it will more efficiently retain solar energy. There is concern that the resulting atmospheric heating will cause climate change. Although hard evidence of climate change or its consequences has not yet become apparent there has been sufficient concern for the majority of developed nations to agree to the Kyoto protocols. These protocols set out the principles by which nations might limit their net emissions of carbon (and related greenhouse gases). The principles are yet to be transformed into workable accounting rules at the national or international level.

One of the major Kyoto principles concerns 'storage management' i.e. emissions of carbon can be offset by carbon taken up and stored in forests (or tree crops) and products. This is effectively a reversal of one of the major sources of carbon emissions, the conversion of forests to agriculture. Another principle concerns 'substitution management' i.e. renewable fuels like wood (or biomass) do not have emissions limits because they effectively avoid emissions that would otherwise be required from fossil fuels.

These two principles could generate considerable advantage for woody plant crops in the market place. Carbon storage entitlements (carbon credits) could be sold thereby reducing cost of production. Biomass fuels or bioenergy will come closer to being economically viable. These are direct effects. At the same time, the gains for wood products become losses for competitor products such as metals, masonry and plastics that have high fossil fuel inputs. This would further tilt markets in favour of wood.

In spite of the uncertainty about the detail of Kyoto accounting many large producers of carbon emissions are seriously looking at major investment in forestry.

It seems fair to conclude that the outlook in wood markets is attractive enough to justify further investigation.

How might we select best prospects for developing new industries?

There are several logical steps that can be followed in a 'greenfields' development. CALM evolved such a procedure, presented in Appendix 1, as background for development of the oil mallee industry.

The first two steps, search and pre-feasibility, enable a priority ranking of any prospect as follows:

- Search: a process to objectively select species/products that warrant further investigation.

- Pre-feasibility assessment: a coarse evaluation of search selections for the fundamentals of economic success i.e. cost of production, yield/quality, costs and value added in processing, and market prices.

In the search process species/product candidates are assessed for key attributes that should predispose to successful commercial development. Bartle (1999) conducted such an evaluation for oil mallee. CALM and AGWEST have recently been awarded a grant under the Natural Heritage Trust to do extensive search and prefeasibility work on native species. The attributes assessed under 'search' along with a brief rationale is as follows:

1. Market size

The extent of revegetation required to have an impact on salinity can be measured in millions of hectares. This inevitably means large volume markets to minimize risk of oversupply. This does not exclude development of dozens of small industries based on tree crops producing products like specialty timber, essences, flowers, fruits and nuts. However, it does indicate that we must also create some several substantial new industries producing large volume commodities at world competitive prices to provide the base load for revegetation. This means we must aim at very large wood and related non-wood products markets. Table 4 lists potential categories of large volume products.

TABLE 4: CATEGORIES OF LARGE VOLUME PRODUCTS FROM WOODY PERENNIALS

CATEGORY	PRODUCT
Reconstituted wood products	**panel board (oriented strand board and fibre board)**
Extractive products	**oils, resins, gums, tannins**
Carbon products	**charcoal, activated carbon**
Energy	**• liquid fuels (ethanol, methanol) • solid fuel for electricity**
Chemicals	**• gasification (ammonia, methanol) • fractionation (cellulose/lignin)**

2. Amenable to extensive production systems

Wheatbelt farmers have highly mechanized, low labour input businesses. They are world leaders in applying new technology and generating economies of scale. They compete successfully in highly competitive world markets. These farmers will be keen to apply their comparative advantage in large-scale commodity production systems to new perennial crops. They are unlikely to be interested in the unfamiliar production systems needed for products like flowers, fruits and nuts. They will be more attracted to perennial crops that are obviously compatible with their existing knowledge and production systems - high volume harvest, mechanised materials handling systems and bulk transport.

3. Transport horizon or local processing to improve value

Annual crops have products with values in the range $200 to $400/tonne. A 300 km trip to a coastal port represents less than 15% of product value and is not a serious constraint on the viability of the crop. In contrast, many raw wood feedstocks will have values as low as $30/tonne, which for the same proportion of transport cost limits their local transport horizon to 50 km.

4. Short rotation

The establishment cost and alternative annual revenue foregone on land occupied by tree crops imposes an economic constraint on the rate of adoption by farmers. In the higher rainfall forestry tree crop industries this constraint is overcome by 'sharefarming' arrangements where an off-farm investor shares the costs and the harvest revenue with the landowner. Another way to facilitate adoption of woody crops is to select short rotation types where harvest revenue starts early and comes regularly thereby maintaining farm cash flow and helping the farmer finance his own investment in the crop. On a whole industry level the investment required for short rotation woody plant crops will be less than long rotation crops and therefore a short rotation industry should be more readily developed.

5. Residue use options

Most woody perennial crops will generate some form of residue or lower value fraction. Especially where whole plant harvest and transport to a local processing point is necessary, some economic use for residues will be essential. Once centralized, residues can have a negative value that reflects disposal cost. The possible emergence of restrictions on greenhouse gas emissions will increase the prospects for commercial use of uniform quality, large volume, centralized biomass residues as renewable biomass fuels or bioenergy.

6. Compatibility with present agricultural practice

Any woody plant crop would be developed to be complementary to traditional agriculture, in particular to provide a high water use option to help control salinity. To be effective in achieving high water use it will be necessary for the crop to be widely dispersed across the farm. It is likely that dispersal will be most easily achieved in the form of perennial plant belts. Belts will permit efficient harvest for both the perennial and annual plant components while also achieving the objective of providing efficient access for the perennial to surplus water from the adjacent annual areas. The focus on belts gives rise to the frequent reference to alley farming systems and to the extent of planting being measured in kilometers instead of hectares.

Two particular problems of compatibility emerge with belt or alley planting systems.

In belts there is a large degree of exposure of the adjacent annual crop or pasture to competition from the perennial crop. Shading is not likely to be a problem where the perennial is harvested on a short rotation and never likely to exceed a height of 3 m. However root competition will occur.

Ideally the perennial crop would have only deep roots exploiting water surplus to that required by the annual plants. While this ideal will not be achieved there is potential to perennial crop species that have strong deep rooting ability. There is also the quite simple management option of ripping adjacent to mallee belts every few years to trim lateral root development and reduce competition. On the other hand, if the perennial crop is economically competitive, the farmer can be indifferent as to whether revenue comes from perennial or the annual components.

The second problem with any perennial crop arranged in belts is palatability or toxicity. Fencing long narrow belts in alley farming systems to protect perennials from grazing would not be viable. It will therefore be imperative to select unpalatable and non-toxic species. Young seedlings are likely to need protection and they would generally established in conjunction with a crop.

7. The advantage of natives species

If we use exotic species as the source of new commercial crops probably hundreds of species would need to be screened to locate several that may have commercial value. In such a process some of those tested may have potential to become weeds and may escape from cultivation to express their weed habit. For example, the desirable attributes of low palatability and rapid regeneration could be the makings of a successful weed. Weeds can cause economic loss through the need to impose controls or suffer the loss of use of land. Woody weeds also present a risk to the nature conservation value and biodiversity of our native bush. Weed risk would be greatly reduced if new woody crop development first considers the potential value of native species. There is little risk of native species becoming weeds because they have evolved within the checks and balances of local ecology.

There are also some strong commercial advantages in giving priority to native species.

We can be much more confident of the tolerance to the native environment by native species and that natives will not fail abruptly after some extreme climatic event or when they reach an advanced stage of growth. Also we are seeking perennial species specifically to do an unusually difficult job – to develop deep root systems in what is clearly a harsh subsoil environment. It is therefore sensible to consider native species because they might be well adapted to these conditions.

There has historically been free trade in genetic resources. Australia with few native food crop plants has been a major beneficiary of this trade. However, with the emergence of plant variety rights access to genetic resources has tightened. We have the opportunity to take a strong commercial position in native plant product industries through development and exclusive control of our vast native plant genetic resources.

Oil mallee – a model for wheatbelt woody perennial crop development

The oil mallee project is the first new woody perennial crop development for the wheatbelt of Western Australia. It was initiated by CALM in 1993 and is now well advanced in the various aspects of industry exploration outlined in Appendix 1. A full review of the project was recently presented in a seminar conducted by the Oil Mallee Association (Oil Mallee Association, 1999).

Some 12 million oil mallee seedlings have been planted over the past 6 years. The rate of planting is rapidly escalating with 8 million seedlings projected to be planted in winter 2000. There are now more than 500 growers and a solid base of establishment and management knowledge has been built up.

CALM provided finance for seedlings in the first 3 years but since then growers have financed all planting. The project has attracted strong support the Rural Industries R&D Corporation, the Commonwealth Natural Heritage Trust (and preceding programs) and the State Government Regional Enterprise Scheme.

The industry recently commenced its first commercial feasibility investigation in partnership with RIRDC and Western Power. This project is evaluating a plant designed to combine the production of eucalyptus oil, activated carbon and electricity (Stucley 1999, Harrison 1999). The investigation looks promising and the partners have commenced assembling funds to construct a 20% scale pilot plant at an estimated cost of $5 million.

Harvest of mallee can commence at age 4 and be repeated on a cycle or rotation of 2 or 3 years - a typical short rotation tree crop. Each new crop resprouts or coppices back from the lignotuber or mallee root. There are many potentially commercial coppicing species that could be managed in the same way as oil mallee. For this reason CALM and the industry operators, the Oil Mallee Association and the Oil Mallee Company, have taken every opportunity to build into oil mallee development the capability to also handle other short rotation crops that may be developed in future. For example, harvest and materials handling systems have been designed for general application to short rotation crops (Giles, 1999), and the development of the products, activated carbon and electricity, also has wider application.

The oil mallee project is not yet a proven commercial success. However, it is an example where the development process discussed in this paper has been applied and validated. It provides a model for the 'several more' woody perennial crop developments yet to come.

REFERENCES

Anonymous 1996. Salinity: a situation statement for Western Australia. A report to the Minister for Primary Industry and the Minister for the Environment.

Barr N (1999). Social aspects of rural resource management. Outlook 99. ABARE

Bartle JR, Campbell C and White G. 1996. Can trees reverse land degradation? Proceedings, Australian Forest Growers Biennial Conference Mt Gambier.

Bartle JR, 1999. Why oil mallee? Proceedings of Oil Mallee Profitable Landcare Seminar. Oil Mallee Association.

Chisholm AH, 1992. Australian agriculture: a sustainability story. Australian Journal of Agricultural Economics, vol 36 (1): 1-29.

Ferdowsian R, George RJ, Lewis F, McFarlane DJ, Short R and Speed R, 1996. The extent of dryland salinity in Western Australia. In Proceedings, Fourth National Conference on the Productive Use and Rehabilitation of Saline Lands. Promoco Conventions, WA.

Food and Agriculture Organisation (1996). Forest Resource Assessment 1990: Survey of tropical forest cover and study of change processes. Forestry Paper 130. FAO Rome.

Food and Agriculture Organisation (1997). State of the World's Forests 1997. FAO Rome.

Food and Agriculture Organisation (1999). State of the World's Forests 1997. FAO Rome.

George RJ, Nulsen RA, Ferdowsian R and Raper GP (1999). Interactions between trees and groundwaters in recharge and discharge areas – a survey of Western Australian sites. Agric Water Management 39, 91 – 113.

George, R. J., McFarlane, D. J., and Speed, R. J. (1994). The consequences of a changing hydrologic environment for native vegetation in south-western Australia. In 'Nature Conservation - The Role of Networks.' (D. A. Saunders, J. L. Craig, and E. M. Mattiske Eds), pp. 1-28. (Surrey-Beatty: Sydney.)

Giles RG, (1999). Mallee harvesting and materials handling. Proceedings of Oil Mallee Profitable Landcare Seminar. Oil Mallee Association.

Hatton TJ and Salama RB, (1999). Is it Feasible to Restore the Salinity-Affected Rivers of the Western Australian Wheatbelt? Second Australian Stream Management Conference, Adelaide South Australia.

Hatton TJ and Nulsen RA (in press), Towards achieving functional ecosystem mimicry with respect to water cycling in southern Australian agriculture.

Harrison D (1999). Integrated timber processing. Proceedings of Oil Mallee Profitable Landcare Seminar. Oil Mallee Association.

Raper GP (1997). The water use of trees and shrubs in mediterranean climates in southern Australia. Report to RIRDC Project DAW – 35A.

Shea SR (1998). Western Australia's development and future prospects for tree crop industries. A paper presented to the Australian Paper and Forestry Forum, Melbourne 1998.

Stucley C (1999). Integrated processing of oil mallee for activated carbon, eucalyptus oil and renewable energy. Proceedings of Oil Mallee Profitable Landcare Seminar. Oil Mallee Association.

Western Australian Salinity Action Plan (1996). State Salinity Council.

Western Australian Salinity Action Plan (1998). State Salinity Council.

APPENDIX 1: DEVELOPMENT PROCESS FOR PERENNIAL WOODY PLANT CROP INDUSTRIES

1. SEARCH

Screen plant and product attributes to identify species with best chance of success

2. PREFEASIBILITY ASSESSMENT

Confirm search indications by more rigorous evaluation of key performance parameters i.e. cost of production, yield/quality, markets/prices, economies of scale, biodiversity/landcare/ social values, initial economic analysis. Select best bets.

3. INDUSTRY EXPLORATION

Commence building industry foundation with R&D in the following areas:

3a Technical

- taxonomy
- breeding/propagation
- seed production
- establishment
- silviculture/hydrology
- harvest/process
- product science
- residue utilisation

3b Environmental

- integrated design inc land, water, biodiversity
- carbon sequestration
- species mixtures
- economics of environ-mental values
- green products

3c Commercial

- form grower group
- establish a resource
- demonstration sites
- farm business plans
- market research
- attract buyer interest
- attract investors
- industry analysis

4. FULL FEASIBILITY INVESTIGATION

Assemble committed parties. Conduct feasibility investigation, design industry structure, legal arrangements and capital sources. Generate bankable industry business plan.

5. PROMOTION AND ADOPTION

Expand the extension, education and publicity activities commenced in stage 3.