Fitting Perennials into an Annual World

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ABSTRACT

Widespread planting of deep-rooted perennial plants offers the most realistic option for the ongoing utilisation of the excess water that is causing salinity in wheatbelt valleys. There are many types of perennial plants, including those with salt-tolerance, which could form the basis of future high water-use agricultural systems. However to be effective in controlling salinity they must be planted on a large proportion of the landscape (over 30%, perhaps up to 80% in some areas). Over two thirds of the wheatbelt landscape is being managed by farm families as private enterprises based on annual plants. These individual farmers are the people who will make the decision to grow perennials. Establishing large areas of perennials will not be financially possible unless the perennial plants form part of a profitable, practical, affordable enterprise. Two realistic scenarios are described where farmers plant 40% of their land to unprofitable perennial options. Farmers on average sized farms would have to either invest $1 million once off, or lose $30,000 per year in perpetuity. An alternative solution of governments subsidising the entire farming community for the same scenarios would involve the once-off investment of $2 billion of public funds or ongoing subsidies costing $60 million per year.

Currently there are no perennial based systems that are understood and developed to the extent that large areas (more than 10% of a farm) could be established with confidence by farmers in areas with less than 500 mm annual rainfall. It is not a simple question of extension and education for land managers. The options either do not exist or require further development. Hence it is recommended that well targeted research and industry development is implemented. This should be undertaken in a way that land managers and other interest groups are participants in the research and build confidence in the new industries. This model has been operated by CALM in partnership with the Oil Mallee Company, and the Department of Agriculture in partnership with the Evergreen Group in the West Midlands. The new Cooperative Research Centre for Plant-based Management of Dryland Salinity offers an opportunity to apply a wealth of expertise to development of new industries.

THE "ANNUAL WORLD"

The focus of this conference is on salinity - a major negative environmental impact resulting from an agricultural system based on annual plants. Before addressing the question of replacing annuals with perennials, it is worth making sure we have an understanding of the annual system. This analysis will not deal with the impact of the system on salinity – those are adequately covered elsewhere in the conference. The aim is to consider the production systems currently in place and their economic and social aspects.

The annual world from a state perspective

Annual plants form the basis of the agricultural systems in the wheatbelt of Western Australia. These annual systems continue to contribute substantially to the community and the economy. The component with the highest value is annual crops, (particularly wheat) which represent over 60% of WA's gross value of agricultural production (Table 1). The wealth generated from the wheatbelt supports directly the population of over 100,000 people located in the region, and provides the basis for economic activity in urban areas worth many times this value. The only perennial plants currently generating revenue in the wheatbelt are lucerne (mainly on high pH soils in the southern wheatbelt) and tagasaste (mainly on deep sands in the western wheatbelt). Total revenues attributable to these species is insignificant. Salinity threatens both agriculture and the natural resources and infrastructure of wheatbelt valleys. On the other hand, the management of salinity has its own risks. The potential treatments for salinity have large development and implementation costs and will diminish the revenues from the annual plant industries.

Table 1. The gross value of Western Australia's agricultural production 1998/99[1]

Product	Value		Contribution from the wheatbelt
	$m	%	
Crops (excluding pastures and grasses)	**$2,703**	**63**	
Cereals for grain	$1,836	43	***
Crops for hay	$55	1	**
Legumes for grain	$212	5	***
Oilseeds	$231	5	***
Fruit and nuts	$132	3	-
Grapes	$35	1	-
Vegetables	$202	5	-
Pastures and grasses	**$69**	**2**	
Cut for hay	$63	1	**
Harvested for seed	$3	0	**
Livestock slaughterings and other disposals	**$764**	**18**	
Cattle & calves	$351	8	*
Sheep & lambs	$237	6	*
Livestock products	**$636**	**15**	
Wool (b)	$441	10	*
Milk	$157	4	-
Total agriculture	**$4,270**	**100**	

[1] Australian Bureau of Statistics 2001a

The annual world at the farm scale

Western Australian farms rely heavily on annual crops. For the three year period from 1996/97 to 1998/99 more than 40% of farm areas were sown to annual crops in all four major wheatbelt regions (Table 2). The remainder of farms is predominantly annual pasture species grazed by sheep and, to a lesser extent, by cattle. Over the three year period of the ABARE statistics, there was wide variation in the performance of wheatbelt farm businesses. In all regions the farm business profit was negative for the 'bottom 25%' of farms (in terms of rate of return on capital), and on average was relatively low for all farms (Table 2).

For a farmer to replace a large area of annuals with perennials he or she will require access to finance. The capacity to invest varies greatly between individual wheatbelt farms. The level of equity of a farm business gives an indication of the capacity of that business to borrow further funds for expansion into new enterprises (such as perennials). A rule of thumb often used by the banks is that if equity drops below 70% then the farm business is considered a questionable lending risk (R. Kingwell, pers. comm.). Over the three years from 1996/7 to 1998/9 the equity averaged 81% and varied from 52% (in the bottom 25% of the South Coast Wheatbelt) to 98% (in the top 25% of the Eastern Wheatbelt) (Table 2). In June 30, 1999 the average equity of WA grain businesses was 74%, close to the bank's cut-off level, however a reasonable proportion of farm businesses were well-positioned with relatively little debt (Table 3). About 36% of grain farms in WA had total farm debts less than $100,000 and almost 20% of farms had less than $50,000 debt. However, this was prior to the dry season in 2000, and the record dry start to the season in 2001. It is likely that these two seasons will see most farms increase their indebtedness; and suffer a reduction in the value of farmland, further eroding their equity.

Two common perceptions of wheatbelt farms are that they are continually growing in area and that the terms of trade (the ratio of prices received for outputs to prices paid for inputs) are continually declining. Over the 1990s these trends were not as evident as in previous periods. In the south coast region it does appear to be the case that farm size is increasing (Table 4). However, in other regions there is no clear evidence that average farm size is steadily increasing. Over the past decade the period of high grain prices in the mid-1990s has meant that the often-quoted declining terms of trade for farmers has not been as evident or as strong in the 1990s as observed in preceding decades (Figure 1).

In summary the picture is one of an agriculture that does not have the capacity to finance large scale change. However there are also indications that some past downward trends in the wheatbelt economy may be stabilizing, reinforcing the region's ongoing role as a major contributor to the economy and community of Western Australia.

Table 2: Farm business performance for four WA wheatbelt regions (average for the three years 1996/7 to 1998/9)[1]

	Unit	Average[2]	Top25%[2]	Bottom 25%[2]
a. Eastern Wheatbelt				
No of farms	no.	578	144	144
Farm size	ha	3397	6336	1825
Cropping intensity	%	51	49	72
Equity[3]	%	84	98	63
Age of owner	yrs	43	53	38
Farm cash income[4]	$'000	132	277	42
Disposable family income	$'000	82	141	-3
Farm business profit[5]	$'000	39	181	-61
Rate of return[6]	%	5.3	10.3	-3.8
b. Northern Wheatbelt				
No of farms	no.	875	219	219
Farm size	ha	3108	2939	3675
Cropping intensity	%	50	64	37
Equity[3]	%	82	72	70
Age of owner	yrs	43	53	38
Farm cash income[4]	$'000	161	292	17
Disposable family income	$'000	97	272	0
Farm business profit[5]	$'000	65	245	-107
Rate of return[6]	%	4.7	12.7	-2.9
c. Central Wheatbelt				
No of farms	no.	3920	980	980
Farm size	ha	1871	2863	700
Cropping intensity	%	45	55	30
Equity[3]	%	83	82	94
Age of owner	yrs	50	47	57
Farm cash income[4]	$'000	93	197	23
Disposable family income	$'000	57	106	33
Farm business profit[5]	$'000	22	127	-45
Rate of return[6]	%	2.9	8.3	-3.7
d. South Coast Wheatbelt				
No of farms	no.	461	115	115
Farm size	ha	2508	2553	3185
Cropping intensity	%	43	61	33
Equity[3]	%	58	58	52
Age of owner	yrs	41	35	33
Farm cash income[4]	$'000	68	212	-39
Disposable family income	$'000	50	145	35
Farm business profit[5]	$'000	4	101	-91
Rate of return[6]	%	4.0	8.5	-0.7

1. ABARE 1999, 2000
2. Farms were ranked by their rate of return to capital.
3. Equity =((owned farm capital - liabilities)/owned farm capital) x 100
4. Farm cash income = total cash receipts - total cash costs
5. Farm business profit = farm cash income + changes in trading stocks - depreciation - imputed cost of family labour
6. Rate of return = (profit at full equity / total opening capital) x 100 (where profit at full equity = farm business profit + rent + interest and finace lease payments - depreciation on leased items (i.e. profit at full equity considers the case where the farmer fully owned all the capital used in his/her farm business).

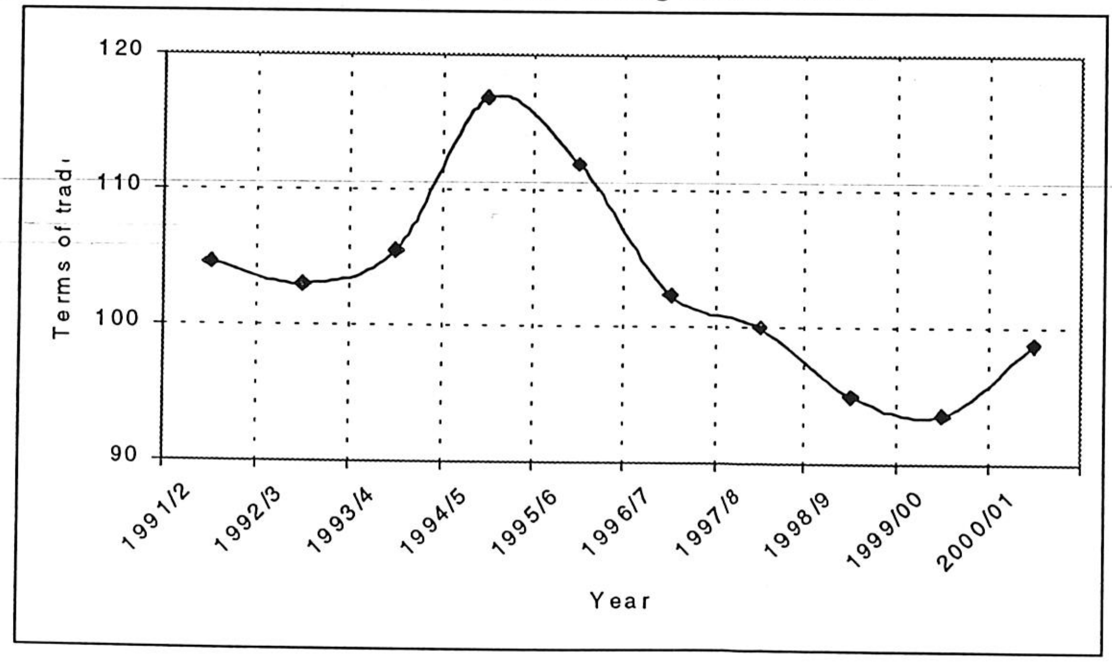
Table 3: Distribution of farm debt among WA grain farms as at 30 June, 1999.

Debt	% of all farms
No debt	5
Less than $20,000	7
$20,000 to $50,000	7
$50,000 to $100,000	17
$100,000 to $150,000	4
$150,000 to $250,000	16
$250,000 to $500,000	27
$500,000 to $1,000,000	11
More than $1,000,000	7
Total	**100**

Table 4. Change in size of WA grain farms during the 1990s.

Region	Average size of WA grain farms (ha)		Change in farm size (ha)
	1992/3 to 1996/7	1996/7 to 1998/9	
Eastern	3697	3397	-300
Northern	3119	3108	-11
Central	2029	1871	-158
South-coast	2078	2553	475

Figure 1. Terms of trade for WA grain farms during the last decade.



WHY PERENNIALS?

Perennial plants invest a large proportion of their resources to develop deep root systems and so get access to deeply infiltrating water. Access to deep moisture permits a longer active growing season and greater water use than can be achieved by annual plants. Salinity researchers agree that perennials will eliminate recharge over the area on which they stand where annual rainfall is less than 600mm. There is however debate about whether relatively small areas of perennial plants might intercept significant surface and subsurface flows of water from adjacent annual crops or pastures. Hatton and George (2001) review the circumstances where this will occur. The extent to which water will move to trees is favoured by sloping land, less saline groundwater, thinner regolith (<10 m) and transmissive aquifers. In such a situation White et al (2001) estimated that belts of trees occupying 16% of the landscape would reduce annual recharge generated under upslope annual crops and pastures from 35 to 5 mm. Furthermore, if the pasture phase is lucerne the proportion of trees required to limit recharge to 5 mm was 8%.

It is not clear what proportion of the wheatbelt might have suitable conditions for perennials in belts or alleys to provide significant reduction in recharge. Such conditions certainly do not prevail on the extensive flat floors of valleys of the medium to low rainfall wheatbelt. It is likely that there will be need both for species suited to belts and for species able to occupy annual crop land as a short, de-watering phase in the rotation. The large and growing area of land affected by high water tables will also require commercial perennial cover. In all cases the extent of perennial use will demand that they are commercially viable before they will be adopted on the scale necessary to control salinity or make productive use of saline land.

However, there are many attractions to commercial perennials other than their impact on the spread of salinity. Perennials will convert surplus water into valuable production. They have great diversity with a wide range of growth habit, soil and climate preference, management regimes and products. They offer diversification into large new industries. There is scope to select perennials that can be efficiently integrated into existing annual plant based agricultural systems. Perennials can be tall and robust and provide shelter and wind erosion control all year round.

Perennials alone will not be adequate to achieve the desirable level of control of salinity. However, they will complement engineering treatments on discharge areas that will be required. The viability of engineering treatments will depend on the volume of saline water to be managed. Extensive use of commercial perennials could reduce that volume by a substantial factor.

Finally, it is too risky to just accept salinity as inevitable – the external/community/non-farm costs are substantial and will always generate conflict and uncertainty for agriculture. If a strategy of passive acceptance of salinity is adopted there is unacceptable risk of national political/environmental regulation and international trade sanction. It is environmentally responsible and commercially prudent for agriculture to be seen to be making every effort to achieve sustainability. Hence we should proceed with development of commercial perennial options. The nation is prepared to invest considerable funds in this endeavour.

WHICH PERENNIALS?

There are currently no perennial species grown commercially on a large scale in the WA wheatbelt. However, there are a few with a small presence and there are many prospective perennials. Table 5 provides a classification of types of perennials based on plant form, use and site preference. Given the scale of perennial cover required it will be desirable to examine options in all categories.

Table 5: A classification of perennial plants based on form, use and site preference

Plant type and form		Grazing		Direct-harvest	
		Recharge	Discharge	Recharge	Discharge
Woody	Tree				
	Coppice				
	Seeder				
Herbaceous	Non-legume				
	Legume				

Trees can produce non-grazing or 'direct harvest' products and there are potential species for both recharge and discharge parts of the landscape, e.g. *Eucalyptus astringins* (mallet) a native wheatbelt species that prefers recharge parts of the landscape and has a small current use for the manufacture of tool handles, while *Eucalyptus occidentalis* is a potentially commercial timber species for recharge areas. There are dozens of tree species that could be developed for commercial use including local natives, Australian natives and exotics like *Pinus*. Sawn wood markets volumes are large.

Woody plants with the ability to coppice (grow back from the cut stump) can be used as short rotation crops that do not need to be replanted after harvest. The native flora is rich in coppicing species. Mallee is an example now under active development as a large scale biomass feedstock crop. Biomass feedstocks show promise for multiple products including extractives, wood chip and bioenergy. Coppicing species appear generally to be poorly adapted to discharge areas but some mallees and *Melaleuca* species have good tolerance of salinity and waterlogging and have commercial potential. In all some 40 species of mallee eucalypts and *Melaleuca* are currently being investigated for their commercial potential.

Obligate seeding (non-coppicing) woody plants have potential as phase crops where they can produce biomass feedstocks in rotation with conventional annual crops. The genus *Acacia*, a major native legume group, shows most promise for this type of crop. It is large seeded and can potentially be mechanically sown thus reducing establishment cost – an imperative for a short-rotation seeder crop.

There are woody grazing shrubs for both recharge areas (tagasaste) and discharge areas (saltbushes).

The herbaceous perennials will most commonly be grazing plants like the legume lucerne or non-legume grasses. As with grazing shrubs, this category has the significant advantage that they supply already existing industries. They therefore do not face the considerable development costs of direct harvest species where all harvest, transport, processing and marketing operations must be built from scratch.

Lucerne is the herbaceous perennial at the most advanced stage of development as a component of WA farming systems. There are many herbaceous perennials other than lucerne. G. Moore (unpubl. data) listed over 100 genotypes as potential subjects for investigation of their suitability for the WA wheatbelt. A range of sub tropical perennial legumes could also be used. Ten-year old stands of *Siratro* and *Lotononis* in the West Midlands have survived the driest summers on record (T. Wiley pers. comm.).

The Cooperative Research Centre for Plant-based Management of Dryland Salinity has established a sub-program to identify and evaluate potential species.

While most of the focus of this paper is on perennial plants capable of growing in recharge areas in the landscape, the recharge areas form a significant and growing part of the wheatbelt. Land affected by high watertables varies in its potential to support plant growth. Barrett-Lennard et al. (1999) divided such land into three broad classes – land of 'high', 'moderate' and 'low' productivity on the basis of position in the landscape, soil texture, and the severity of salinity, waterlogging and inundation. Barrett-Lennard (2001) speculates that saltland rated as 'high' productivity (shallow brackish groundwater – about 20% of WA's saltland) may be recognised as the most profitable land on the farm. He suggests it could be used for the growth of high value wood and horticultural crops. Land of 'moderate' productivity (duplex moderately saline and waterlogged land – about 40% of WA's saltland) may be used for the growth of mixtures of halophytic forage shrubs with annual understorey species. These pastures could be used for the grazing of sheep and perhaps cattle. Land of 'low' potential (highly saline, waterlogged – about 40% of WA's saltland) will be mostly only suitable for the growth of samphire species. Together with aquaculture and other more intensive land uses, these industries have been referred to as the PURSL (Productive Use and Rehabilitation of Saline Land) options. The range of these options is still developing. Yensen (2000, cited by E. Barrett-Lennard, pers. comm.) estimated that there are 10,000 salt tolerant plant species capable of producing 250 potential halophyte crops (Yensen, 2000, cited by Barrett-Lennard, pers. comm.).

PRODUCTIVITY OF PERENNIALS

To be useful, a perennial plant needs to be able to produce enough harvestable product or yield to compete economically with current alternative enterprises. The Western Australian wheatbelt encompasses a wide range of environments (soil types and rainfall). Any one commercial species is unlikely to be adapted equally to them all. The lack of information on the adaptation of perennials to the WA soils and climates makes it difficult to predict their potential for production.

Recent research and farmer experience has demonstrated that lucerne in rotation with crops on hospitable soils during good seasonal conditions will use significantly more water, produce similar or more biomass and support higher subsequent grain yields than an annual pasture (Latta et al. 2001a, b; Latta and Blacklow 2001). However, lucerne may not be as productive as the conventional annual alternatives on sandier or heavier soils with low soil water holding capacity and/or high bulk density in the absence of reliable summer rains, especially when soils are also acidic (R. Latta, pers. comm.). Approximately two thirds of the wheatbelt soils are acidic, and there is little summer rain, so lucerne is likely to be limited in the extent to which it can be planted.

Several perennial woody crops have been found to be more productive on some problem soils than the annual plant alternatives. Tagasaste has demonstrated this ability on deep sands (Oldham, 1991). Similarly some mallee species perform well on acid wodgil sands in the central wheatbelt. Mallee appears to be able to produce at full yield potential on such soils whereas annual crops and pastures can be very poor.

Perennials appear to be better than annuals in tolerating or achieving production under unusual weather conditions such as drought, frost and summer rain. This is perhaps because of their ability to tap into moisture over a greater depth of soil and grow in summer. This broader biological capability may reduce the variability in production of wheatbelt farms reliant on annual crops.

Perennials with a long time to harvest bring different risks to the level of production. Major risks are loss from fire or damage by drought or pests. Regularly grazed herbaceous perennials have a risk profile similar to annual systems because they are harvested regularly over time. The short rotation woody phase crop has greater risk because it leaves the accumulated growth of several years exposed to risk. Coppice crops have a much larger up-front cost but regular harvest and fire resistant coppicing root-stocks limit the risk. Long-rotation sawlog crops are the most exposed but many of the prospective species are not vulnerable to fire. These risks will require extra costs to manage or insure for risk of loss. It will require some experience to develop cost-effective management techniques for these risks.

Considerable attention has been given to optimising the location of tree plantings from the perspective of salinity control or shelter (Hatton and George, 2001). Now that it is generally agreed that a large proportion of perennial cover is required to control salinity, different factors must be optimised in planning perennial distribution. Shelter objectives will not need much attention because they are likely to be well met by any extensive planting configuration that exceeds 20%. Maximising the production of woody perennials becomes an important reason to adjust their planting distribution in the landscape.

PERENNIALS AND FARMING SYSTEMS

Perennials can be established either as a long term cover on selected areas or as a phase of limited duration in rotation with annual plants. Long term cover would include trees, coppicing shrubs or herbaceous perennials. These might be block plantings (plantations or pastures) or belts across cropping land. Blocks could be used to target areas with preferred access to subsurface water, sites prone to wind erosion or soils suited to the species (eg. tagasaste on deep sands). Belts might be preferred for shelter or extensive recharge control on slopes. Phase crops would be used widely across cropland to deplete deep stored water, to provide a break in the annual crop sequence (for weed or disease control) or, if using legumes, to improve soil nutrient status.

It is apparent that the integration of perennials into management systems will be complex. Salinity control will rarely be the sole objective. Optimised systems incorporating perennials are not yet well developed. Good analyses of some aspects of systems are available, for example, for shelter or salinity control (RIRDC). Since salinity control will require quite large proportions of land under perennial cover at any one time their impact on the operations of annual cropping systems will be a strong determinant of perennial distribution and management.

While salinity control objective might be best served by planting blocks of woody perennials based on hydrological criteria, economics and compatibility with annual crops are likely to require other layouts. The experience with large scale planting of mallee suggests that belt/alley layouts will be preferred. There are some useful observations from the development of mallee layouts (Ian Stanley and Anthony Jack, pers. comm.), including:

- belt planting with alley widths down to 100 m do not compromise large scale annual crop operations
- mallee yields appear very good in 2 to 4 row belts
- herbicide drift and grazing do not compromise yield
- design for efficient entry, exit and turning large machinery around at the paddock boundary is essential
- the alley area (the compartment between adjacent belts) can provide a useful planning and operational management unit

- contour belts require more careful design, especially in maintaining alley width as whole multiple of machine passes – this requires a 'keyline' contour with adjacent belts off contour as dictated by the slope of the land and set alley width.
- the zone of competition between the mallee belt and the adjacent annual crop or pasture is quite narrow (up to mallee age 5 years without harvest)

The operational evolution of belt designs has made good progress but there is now a need for it to be complemented by careful experimentation.

There are significant gaps in knowledge and farmer-confidence that need to be addressed before lucerne can be adopted at a significant scale. When 35 farmers from five districts were asked what the issues were that inhibited their adoption of lucerne on a broad scale (Olive et al. 2001), they raised 200 specific points, many of which related to fitting lucerne into farming systems.

- Can lucerne be established with an annual cover crop (e.g barley), so reducing the net cost of that first year?
- Is it possible to crop an annual over of established lucerne stand, and increase the flexibility of the lucerne rotation?
- What options are there for weed management within the lucerne phase of the rotation, so reducing the week burden on subsequent annual crops?
- Are more flexible ways of grazing lucerne to maintain animal production than a strict rotational grazing system?
- What are the impacts of lucerne on the pests and diseases of other parts of the farming system (e.g. the carryover of virus diseases affecting pulse crops in a subsequent season)?

One of the significant changes for farmers introducing perennial pastures will be in their grazing practices. Perennial pastures will not perform (and many will not persist) under traditional 'set stocking'. Whole farm, planned rotational grazing is required for optimum productivity. This will require investments in farm infrastructure and farmer training (T. Wiley, pers. comm.).

ECONOMICS OF PERENNIALS

The on-farm economics of perennials will be the major driver of their adoption by farmers. 'Mainstream' professional agriculturalists predict only small increases in the areas of perennials over the coming decades (McConnell 2000). This reflects a perception that production systems based on perennials are not economically viable. Other stakeholders will support the development of perennials for alternative objectives, in particular to control salinity and protect biodiversity. Both the on-farm economics and the salinity control and biodiversity protection motivation for perennials have been well canvassed elsewhere (State Salinity Council 2000).

The following sections examine the cost of attempting to establish non-profitable perennials as a solution to salinity - the cost to individual farmers and the cost to the broader community - then examines the current understanding of the economics of some of the perennial options under development.

The cost of non-profitable systems to farmers and the state

For the purposes of thinking through the implications of promoting the adoption of non-profitable perennial systems consider the following two scenarios. The scenarios are based on two different perennial systems that might be available to use water and limit the spread of salinity. Then the cost of implementing those options at a farm-scale or at a regional scale are considered.

Scenario 1: A tree system that costs $1000/ha to establish, then returns enough on an annual basis to break even with the alternative annual system

Scenario 2: A perennial pasture system that costs about the same as the annual system to establish, but then returns $30/ha less each year than the alternative annual system.

Other assumptions common to both scenarios are:

- A target of 40% of the landscape covered with perennials is believed to be required to address salinity;
- An average farm size of 2,500 ha;
- A region the size of the central agricultural region is being targeted (say about 5m ha in extent – so 40% plantings of perennials would cover two million hectares).

The simple calculation reveals the following implications:

Scenario 1: The additional costs involved in adopting the non-profitable tree system over 40% of the landscape would be:

- $1 million in 'start up' capital for each average sized farm;
- $2 billion in 'start up' capital for the region;

with no additional annual net costs over and above the annual system it replaces.

Scenario 2: The additional costs involved in adopting the non-profitable 'perennial pasture' system over 40% of the landscape would require no additional initial investment to establish the system, but would result in the following ongoing impacts:

- $30,000 per year net loss in perpetuity for an average sized farm;
- $60 million per year net cost to the region.

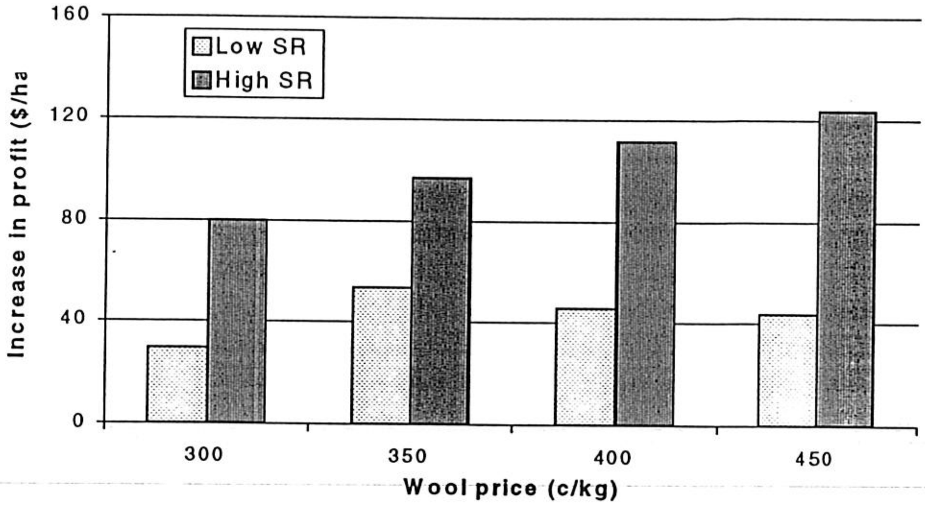
Clearly the amount of money required under these scenarios for farms ($1m initial investment or $30,000 per year) is outside the budget of individual landholders. At a whole region level, the amounts ($2b initial investment or $60m per year) are greater than the level of funding that governments have been willing or able to commit to salinity in one region in the past. The cost of Scenario 1 is more than the $1.5b spent Australia-wide on the Natural Heritage Trust. And the ongoing cost of Scenario 2 is equivalent to half the WA Department of Agriculture's annual allocation from the government for the entire state.

The following sections reinforce the view that there is a critical need for investment to improve the economics of perennial systems. Whether changes in land management are driven by private investment for profit, public investment, or through regulation, the economics will determine their level of success.

Economics of lucerne

Given the short history of serious efforts to introduce perennials into the wheatbelt it is not surprising that there have been few economic analyses of lucerne's benefits to the farming system. Bathgate et al. (2000) undertook a study of the contribution of lucerne to the profitability of farming systems in three regions in the medium to high rainfall areas of WA. The results of the analysis showed that the value of lucerne to a farm system depends very much on the extent to which its profit is able to compete with that of crops on the same land. Where continuous cropping was an option, a system based on lucerne could not compete. Where animal enterprises were part of the farming system it was profitable to establish lucerne on up to 20% of the land, depending on the favorability of production and price factors towards the lucerne (Figure 2).

Figure 2: Contribution of lucerne to farm profit at different wool prices stocking rates for the medium rainfall area of the Fitzgerald region (450mm). A low stocking rate (SR) implies grazing pressure was not increased after the introduction of lucerne.



The main profit drivers of a farming system including lucerne revolved around the animal components of the system (Table 6). The authors concluded that the amount of lucerne growth in summer is one of the most important factors. The summer growth can be used more efficiently by reducing grain feeding, increasing stocking rate (Figure 2) and altering flock structure from a wool flock to a wool and prime land flock, thereby further increasing the returns to lucerne.

Table 6: Relative contribution of factors that influence the benefits of lucerne to profit (from Bathgate et al. 2000).

	Increase in $/ha of rotation	Change	Relative Importance	Region
Wool price	4-5	50 c/kg greasy	3	South Coast
Summer growth	4-12	700 kg DM/ha	2	South Coast
Stocking rate	16	2 to 3 dse/ha	2	South Coast
Flock Structure	17-18	wool to prime lambs	1	Great Southern
Soil Structure	N/A		5	NA
Nitrogen fixation	1-2	30 kg/ha	4	Both
Grain protein	3	1.5pp	4	Both
Grain yield	6	10%	3	Both

These analyses were based on little data. Bathgate et al. (2000) pointed out that the lucerne production data they used came from a small number of recent experiments that were conducted over seasons that were atypically wet. Young (2000), who analysed the economics of lucerne systems in the Kojonup area highlighted the lack of experimental data for animal performance and lucerne growth on which to base economic analyses.

Economics of mallee

Mallee is not yet in commercial production. Some 900 farmers have planted 8000 ha since 1994. This high level of commitment by growers was the basis for a feasibility investigation undertaken in 1999 by a consortium of the Oil Mallee Company, Western Power Corp, Enecon and CALM. It will soon be published (RIRDC, 2001). This investigation showed that mallee delivered as chipped green biomass for approx $30/tonne would make integrated processing commercially viable. Integrated processing is the concurrent production of activated carbon, eucalyptus oil and electricity. The study was based on a plant of 100 000 tonnes/year processing capacity and a haulage radius of 70 km. On the strength of this investigation Western Power Corp will proceed with construction of a $5 million demonstration scale plant at Narrogin during 2001/2002.

This study used harvest and transport cost estimate of $15/green tonne and a payment to the grower of $15/green tonne. The payment to the grower was calculated to provide a return competitive with other crop options. Mallee biomass yield varies over the range 12.5 to 25 green tonnes/ha/year from belt plantings. Harvest is conducted on a 2 to 3 year cycle. The major costs of mallee production are presented in Table 7 (coppice column). The only published farm scale economic analysis is by Herbert (1999).

There is good potential to improve the economics of mallee production. Some of this will come from genetic improvement of mallee (Bartle et al 1999). Further gain will come from better crop management and better integration into the farm.

For example, the opportunity cost of annual crop or pasture on wodgil soils can be as low as $10/ha (O'Connell, unpublished). Yet these soils give mallee yields at the high end of the range. There are large areas of such soils available and they appear to be an attractive prospect for mallee coppice crop development.

Perennials and cash flow

Costs and revenues for perennials can be very unevenly distributed over time. Herbaceous grazing perennials (e.g. lucerne) is the least affected by this issue, though the loss of revenue from land being established to lucerne is seen as one of the major impediments to its adoption (Olive et al. 2001). A sawlog crop requires substantial investment in the year of establishment but generates no return for 25 or more years. Long delayed revenues can impose significant problems in financing the investment. Many perennial crops incur the risk that the initial expenditure must be made up-front while the revenue extends over some years.

The implications of this at a regional level can be seen by calculating the cash flow related to planting one million hectares of wheatbelt farmland planted to each of the major perennial types (Figure 3). The perennial types represented are:

- Phase: typically herbaceous pastures such as lucerne, but also may be woody perennial phase crops;
- Coppice: such as oil mallees; and
- Long-term: such as timber trees.

In these analyses it is assumed that each perennial type has the same net present value (NPV). Their costs and revenues are realistic but have been manipulated so that they can be presented here as being equally competitive as an investment (Table 7).

Figure 3. Cash flow for 1 million hectares of three perennial types over 25 years.

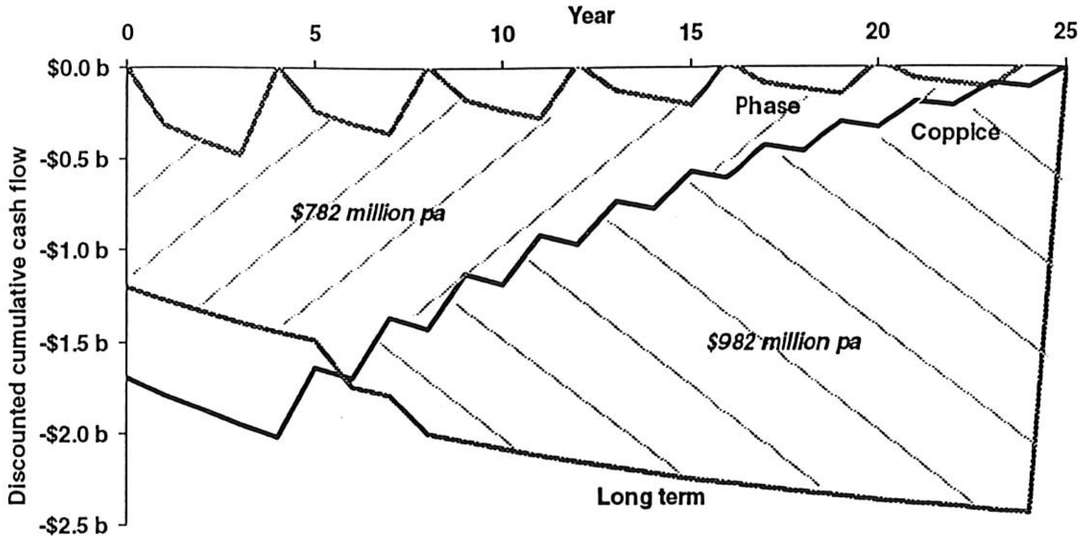


Table 7. Assumptions used in analysing cash-flow for three perennial options (shown in Figure 3)

	Units	Coppice	Phase	Long Term
Establishment Cost	$/ha	1700	240	1200
Annual Costs	$/ha	30	30	20
Opportunity cost	$/ha	65	65	52
First harvest	t/ha	42.2	60	90
Coppice harvest	t/ha	42.2	-	-
First harvest	Years	5	4	25
Coppice interval	Years	2	-	-
Density	per ha	1778	1600	500/100
Price	$/t	30	30	70
Adjusted price[1]	$/t	29.64	29.81	131.4

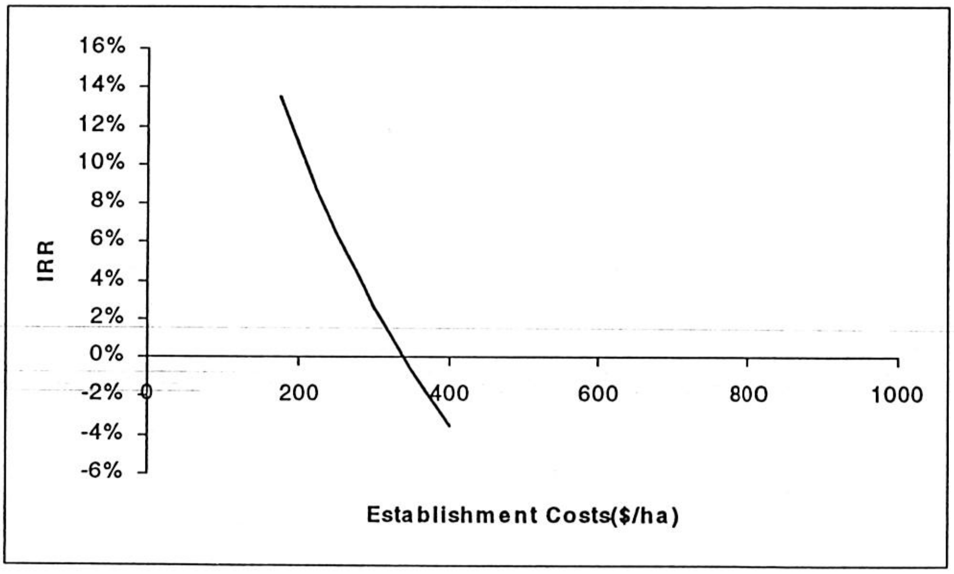
[1] Adjusted price is the change in the current best guess price required to give equivalent NPV in Figure 3

The phase option (lucerne and the woody perennial phase crop) have cash flows that present no particular difficulty to finance (Figure 3). The short rotation coppice crop has high initial establishment cost but its regular harvest revenue steadily depletes the outstanding balance to give an average annual debt over the 25-year period of $782/ha. The long rotation sawlog crop generates no revenue until harvest at year 25 and has an average debt load of $1764/ha. While lucerne of woody phase crops might be accommodated readily into the farm business without borrowed finance the coppice and long-rotation tree crops are likely to require financing schemes such as the 'sharefarm' arrangements developed for bluegums. The Government has announced that it will legislate to smooth the legal process relating to tree crop sharefarming.

Woody phase crops

A woody phase-crop is a tree species that is established to be completely harvested a few years later (say 3 to 5) and replaced by a different crop (eg. an annual cropping rotation). Woody phase crops appear to be very attractive because they have a low establishment cost, favourable cash flow and offer diverse biomass production opportunities. Table 7 shows the assumptions behind the phase crop cash flows shown in Figure 3. A cost of $240/ha is included for establishment. This implies that the crop can be established by direct seeding instead of by way of expensive seedling stock. Clearly woody phase crops would have little prospect if they have to carry the establishment costs of coppice crops. Figure 4 shows the sensitivity of phase crop IRR to establishment cost. Techniques by which direct seeding could be done reliably on a large scale are not yet developed. Initial work on such techniques is now underway. The large native plant group *Acacia* appears to offer considerable promise as a source of phase crop species. *Acacia* species are large-seeded and could be readily adapted to direct large scale direct seeding. They are legumes and could provide a nitrogen fixing phase in cereal crop rotations.

Figure 4 Sensitivity of Internal Rate of Return (IRR) to establishment cost from a woody phase crop



PERENNIALS' PRODUCTS AND MARKETS

Direct harvest perennial crops offer potential for radical diversification of the farm business (Bartle, 1999). They could reduce the present reliance on a narrow range of food and fibre products. They might produce a range of non-food products that are not as exposed to the progressive decline in terms of trade that characterises agricultural commodities. They will have different cycles and seasons of operations that will provide opportunity to plan more even flow of activities across seasons.

There are a host of large volume products that can be made from woody biomass feedstocks. They include extractive products (like eucalyptus oil), reconstituted wood products (like fibre and chip board), industrial paper, charcoal and carbon products, bioenergy (including biomass fuel for electricity and biomass for conversion to transport fuels like ethanol and methanol) and chemicals.

The most pessimistic estimate of the proportion of perennial plant cover required to gain control of salinity is up to 80% (George et al, 1999). If half of this was to be achieved with woody perennials and typical mallee biomass yields were obtained (15 green tonnes/ha/year) the WA wheatbelt (15 million ha) would generate an annual yield of some 90 million tonnes. This is several times larger than all current agricultural production. Bartle (2001) shows that if commercial uses are to be found for all this material it would require some 10% of national and Asian region reconstituted wood and industrial fibre markets, most of the State's electricity market and more than half of transport fuels markets. This is indeed a tall order. It suggests that the building new woody perennial based industries is likely to take a generation or more, that it should focus on the large scale markets and that success will be critically dependent on bioenergy becoming commercially viable.

Biomass feedstocks from direct harvest perennial crops will commonly produce multiple products. The combination of products makes the crop as a whole commercially viable where any one product might not be viable alone. This is the case for mallee where integrated processing for three products, eucalyptus oil, activated carbon and electricity, appears commercially viable (RIRDC, 2001). There is an inherent stability in a crop and an industry that can spread its revenue base across several co-products. There is a parallel with livestock industries where all parts of the animal are utilised to produce a range of products. The significance of this can be indicated using the mallee example. Raw mallee feedstock consists of several components that generate different products, i.e. leaf for oil, wood for activated carbon and twig and other residue for electricity. Each product can be nominally allocated a share of the biomass feedstock price and operating costs. Conceptually each product can pay according to its means and its nominal share of the cost burden can be varied to cater for market cycles or new market development. Electricity generation is a vital component of integrated processing because it uses the lowest value biomass fraction, avoids residue disposal costs and can use waste heat generated in the processing the other products. Hence the other products can afford to carry a greater share of operating costs. This helps mallee fuel compete in current markets with low cost coal and gas.

It is an appropriate time to be launching infant bioenergy industries. Biomass is a renewable fuel and qualifies for 'renewable energy certificates' under the new Renewable Energy Act. Also the recent international agreement to uphold the Kyoto protocols could see the carbon sink potential of woody perennial crops having a value. Bioenergy consumption appears likely to increase rapidly.

On the other hand, perennial pastures offer the opportunity to expand existing industries, though probably with changes. A recent study was conducted into the potential expansion of beef production in the wheatbelt, initiated in part because of the potential for expanded perennial pasture options (Peggs 2000). The study concluded tat the wheatbelt region has the potential for greater cattle production, with the ability to expand cattle numbers by some 384 000 head over the next decade. Peggs (2000) warns that expanding the beef and cattle industry into the Wheatbelt needs to proceed with caution because of the current high entry costs. He also said that expanding beef production into the Wheatbelt would require substantial support from the Department of Agriculture by providing information to potential and existing beef producers. Three fundamental issues growers need support include the economics of the enterprise, markets and production systems. Similarly Wiley (pers comm) highlights that markets already exist for animal products and a current problem for WA meat industries is a shortage of supply; and that animal husbandry and marketing skills of wheatbelt farmers and consultants will have to be upgraded.

Multi-product crops

Biomass feedstocks from direct harvest perennial crops will commonly produce multiple products. The combination of products makes the crop as a whole commercially viable where any one product might not be viable alone. This is the case for mallee where integrated processing for three products, eucalyptus oil, activated carbon and electricity, appears commercially viable (RIRDC 2001). There is an inherent stability in a crop and an industry that can spread its revenue base across several co-products. There is an obvious parallel with the livestock industries where all parts of the animal are utilised to produce a range of products.

The significance of this for the purchaser of the harvested oil mallees is illustrated with data from RIRDC, 2001. The raw mallee feedstock consists of several components that generate different products. Each product can be nominally allocated a share of the biomass feedstock price of $30/tonne. This cost sharing is flexible. Conceptually each product can pay according to its means and its nominal share of the cost burden can be varied to cater for market cycles or new market development. In the case of biomass as fuel or 'bioenergy' there is huge potential for large volume consumption of residues if the price is low and the supply is large. The effective fuel cost of mallee residue for electricity generation in integrated processing is only $6/tonne. This is cheaper than coal on a contained energy basis but the centralised supply of coal means vast generating plant can be built adjacent to coalfields thus providing huge economies of scale. However, biomass is a renewable fuel and if the world decides to limit fossil fuel carbon emissions under Kyoto type rules then bioenergy consumption could increase rapidly.

SOCIAL IMPACTS OF PERENNIAL SYSTEMS

A fear associated with the introduction of new large-scale enterprises is that it will impact negatively on rural communities, similar to the effects of Blue gum plantations in the high-rainfall zones of WA. However, none of the perennial options being considered currently appear likely to replace existing production systems with ones that require substantially less labour. In fact the opposite appears likely - the direct harvest products of many woody perennial crops are likely to be biomass feedstocks for a range of extractive, reconstituted wood, charcoal/carbon and bioenergy products. These will commonly be too low in value to be transported out of rural centres, thus locking in local processing and diversification of the regional economy, and providing employment.

In the case of perennial pasture options, on saline or non-saline land, expanded animal industries are likely to result. These will probably have similar labour requirements to current systems, and will continue to require the support of existing agribusinesses and other rural organisations.

Having productive perennial systems covering a significant proportion of the landscape (particularly the saline areas) will have a more intangible social benefit – improved amenity value of the landscape.

AN INDUSTRY DEVELOPMENT MODEL FOR NEW SPECIES, PRODUCTS AND MARKETS

The new perennial crops required to better manage agricultural systems will need to be a fully integrated and functional part of the farm business. It will also be desirable to implement large scale planting of these new perennial crops as rapidly as possible. To achieve these goals it will be crucial for farmers to rapidly build their knowledge and confidence in the new crops and industries.

For the crops which are new, the early industry development stage will not be attractive to entrepreneurs and venture capital. The lead times are too long and the risks too high. A partnership between Governments and organised farmer groups appears to be the best development model for the pre-commercial stage of industry development. This will be best achieved by on a whole industry (not regional) basis. During this stage the farmer group should be encouraged to build a strong equity position in the industry. This will sustain farmer confidence in the later stages of commercial development.

This is the development model that is behind the emerging mallee industry (Figure 5. Bartle, 2001).

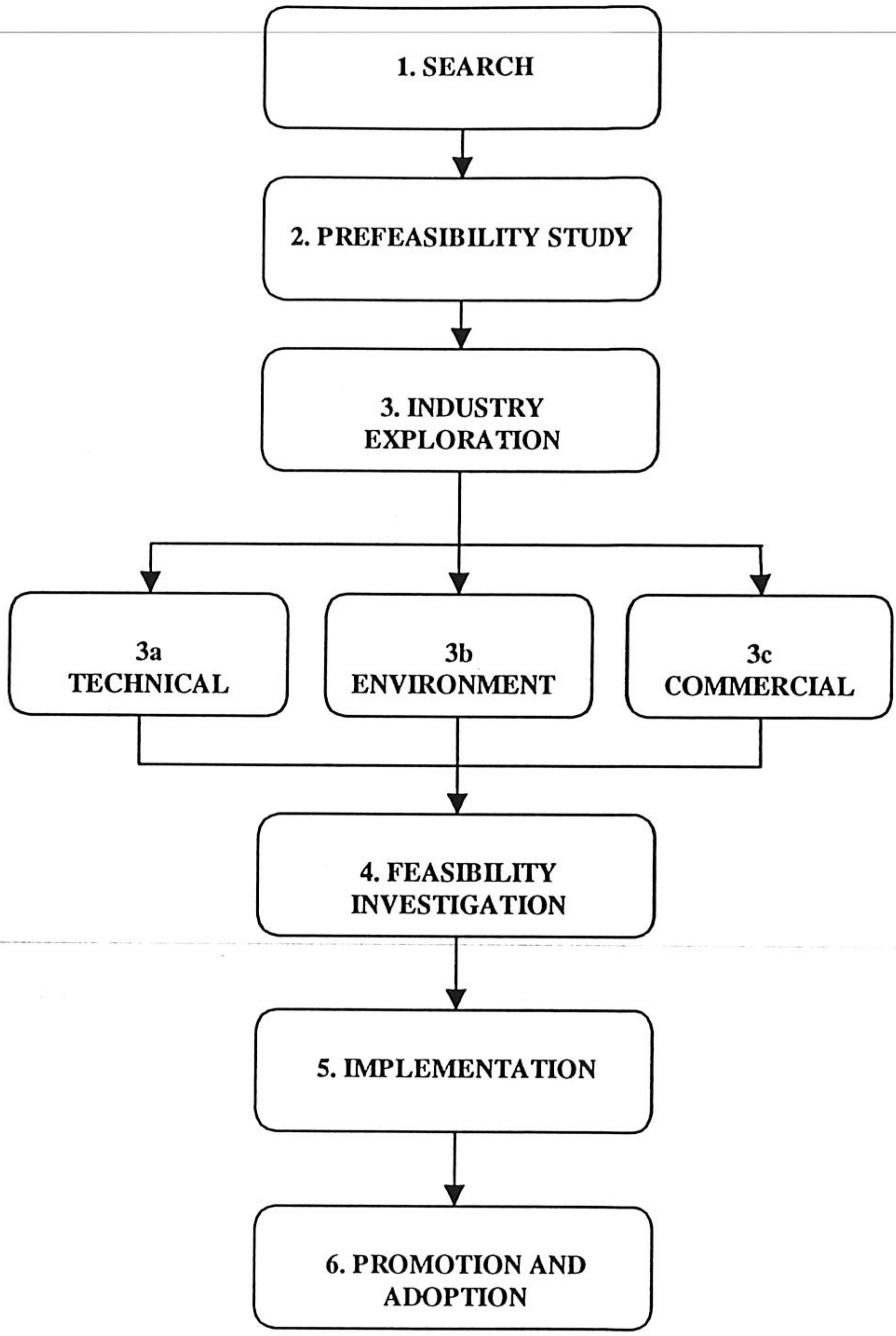
The first two stages in Figure 5 (Search and Pre-feasibility study) involve objective selection of best prospects for development based on biological attributes and product potential. CALM consolidated the initial work of this type for mallee in the early 1990s. The extension of this type of work to other species and products is now the focus of major national R&D projects supported through the farm Forestry Program, the Rural Industries R&D Corporation and the Salinity CRC.

The third stage called industry exploration consists of three sub-sections (technical, environmental and commercial) and is the stage where direct farmer participation is vital. During this stage public and farmer investment can build the foundation of a new industry. In particular, farmer investment in large scale planting and development of an initial resource base and in pooling this within a commercial structure can provide the springboard for farmer equity in the industry. This stage will take several years before the next stage, commercial feasibility investigation, is warranted. This then leads into commercial investment and large-scale implementation.

Although our mediterranean climate is well suited to annuals, perhaps the major reason why we have so few commercially viable perennials is that we have not made sufficient investment in R&D to have developed them. Furthermore, where we have invested in perennials R&D, the range of targets have been mostly confined to plants that can be accommodated in current industries like lucerne. The potential for completely new industries based on woody perennial species has been discussed by Bartle (1999, 2000) and is indicated by the emerging mallee industry (Enecon. 2001).

If the development model used for oil mallees and other woody perennials is applied to perennial herbaceous pastures, it appears that lucerne is past the feasibility investigation phase. However, the range of factors affecting the adoption of a relatively well understood option such as lucerne as described in this paper demonstrates the complexity of introducing a new enterprise. Simply growing a new species of plant is a relatively easy task. Developing a production and marketing system that takes into account the intricacies of the biophysical, economic and management issues is a much larger task. Not only are the data sparse, but ideas about how the farming, processing and marketing systems might be optimised are in their infancy.

Figure 5. The development model behind the emerging mallee industry (Bartle, 2001).



Historically the length of time to develop a new farming system and introduce it on a large scale can be expected to be at least 20 years. An example of rapid adoption of an agricultural innovation is the development of the lupin industry in Western Australia. The first domestic lupin variety was released in 1967 and by 1987 an area was established equivalent to approximately 5% of the WA agricultural area (Marsh et al, 1996). The lupin production system, based on an annual crop plant, is not as radically different to conventional systems as one involving perennials.

Managing the development of perennial-based industries

It is one thing to demonstrate the need for research and development, it is another thing to undertake it successfully. There are few involved in Western Australian agriculture who would question the contribution of scientific research to the development of the sector. The partnership between agricultural scientists with specialist knowledge and farmers with a willingness to integrate new knowledge into their farming system is well understood. However, despite this, there is not a shared vision about the place of specialists in the future of salinity management. A simplistic representation of a common view developed over the past decade sees a polarisation of approaches to salinity management into two broad groups – the "researchers" and the "on-ground-workers":

- The "researchers" are sometimes seen by "on-ground-workers" as spending funds on research that is at best directed at the wrong questions or at worst totally unnecessary. One recent quote is: "'Experts' have been a barrier to change as they have said things can't be done";
- The "on-ground-workers" are seen by "researchers" as wasting resources by pushing ahead with strategies that are popularly held to be useful, but which at best are unproven and at worst have been found to be ineffective.

R&D investors and interested parties (e.g. everyone at the conference) need to have confidence that the research is addressing the right questions and is being conducted in a way that has the best chance of success. Establishing a mechanism for investors to have that confidence is a priority. Over recent years in some quarters there has been a growing trend to farmers participating in setting priorities and undertaking research. Examples of groups that have taken an active role in significant areas of research are the Oil Mallee Association, the Oil Mallee Company, the Evergreen Group (West Midlands), Liebe Group (Northern wheatbelt), Irwin Mingenew Group (Northern wheatbelt), the WA Lucerne Growers Association and the primary farmers of the Low recharge cropping systems project.

Wiley (pers. comm.) points out that Northern wheatbelt farmers are adopting lucerne on a broad scale with very little research done in their areas: "Adoption is driven by farmers, not researchers. We need to find out what are the factors which are inhibiting and encouraging farmers to adopt first, and then focus research on these issues. The biggest challenges for farmers when changing to perennial based farming will be the 'systems' changes, rather than simple technical changes. Traditional reductionist R&D is not appropriate for addressing these issues. Farmers will have to do the bulk of the systems development with support from R&D people. This will require a change in thinking for many researchers and farmers."

In addition to a process that allows farmers to be part of the R&D team, it is important that we develop and maintain the capacity of our specialists. We need to ensure that we are supporting people who can undertake quality research and development. The Cooperative Research Centre (CRC) for Plant-based management of dryland salinity is a body that can help support that development.

CONCLUSIONS

- Large areas of perennial plants will not be established in the wheatbelt unless they are part of profitable enterprises;
- Profitable enterprises based on perennial plants that can be established over large areas do not exist apart from a small number that are under development;
- Developing new agricultural enterprises based on perennial plants involves a complex range of research and development activities covering topics as broad as plant

agronomy, farming system development , harvest engineering, product and market development, and management and funding structures.

- There is a need to invest significantly more in relevant R&D than in the past.
- Developing realistic viable perennial options will require a shared appreciation of the needs and direction of R&D through the participation of farmers, scientists and bureaucrats in the entire process.
- There are some successful examples of partnerships between farmers and scientists that provide a basis for developing future R&D teams.

ACKNOWLEDGEMENTS

Our thanks go to Mike Ewing, Diana Fedorenko, Richard George, Alan Herbert, Ross Kingwell, Roy Latta, Dave Pannell and Tim Wiley, for their contributions of information and discussion.

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