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Balancing off-site impacts of agriculture, community aspirations and economic reality

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Abstract. Rural and urban communities are increasingly concerned about environmental degradation caused by agriculture. In future, agricultural systems will be expected to optimise yields within an economic, environmental and social context, not just maximise profit. This paper outlines the economic, environmental and social outcomes of current agricultural systems, canvasses some solutions and uses a case study to illustrate the complexities faced by communities to develop sustainable land use. Off-site agricultural impacts include salinisation, acidification, erosion, declining water quality, fragmentation of remnant ecosystems and decline in landscape aesthetics and cultural value through the loss of individual remnant trees. Poor profitability, particularly in the grazing industries, imposes limits on the ability of individual farmers to minimise these off-site impacts. Some communities are well informed and are developing a long-term vision for more sustainable land management. However, these groups will not be able to achieve their goals without large, long-term commitments by government. Politically difficult issues, such as regulation of land use, pollution from agricultural land and land retirement should not be excluded from serious policy debate, as has occurred in the past. Education of urban and rural communities is needed to enable Australians to decide on priorities for ecologically sustainable agriculture and rural development.

Many people know that agriculture has degraded land, vegetation and water and that this is increasingly unacceptable. The reasons for problems include a lack of understanding of climate and natural ecosystems, inappropriate government policy on land use and reliance on world markets. Science and farmer innovation have delivered an efficient system based on minimising inputs and maximising profit. The problem is that the time scales for pay back periods are short. Profitability is measured by direct costs and benefits without considering off-site costs accruing in areas remote from the enterprise or in the future.

Agricultural sustainability and ecologically sustainable development have many definitions. We use these terms to mean, '*the use of farming practices and systems which maintain or enhance the economic viability of agricultural production, the natural resource base and other ecosystems influenced by agriculture*' (Anon. 1998a). Some of the major issues in developing more sustainable agricultural systems are:

- Community participation, education and ownership of decisions on land use is essential.
- Land should be used within capability and land use should be in terms of impact on the total catchment.
- Communities need a clear vision of what they want landscapes to look like in the long-term (100 year+).
- Development of Local Action Plans are useful for targeting local action and to address cost sharing.
- Agricultural systems must optimise yields within an economic, environmental and social context and not just maximise profit. Regional development, not just agriculture, needs to be considered holistically.
- Where there are benefits to the wider community resulting from changed land use or management, compensation to individuals is needed.
- Conservation of natural ecosystems within agricultural lands must be urgently addressed.
- Australian landscapes are important for aesthetic and cultural reasons. Such aspects are often not considered in everyday life, but are important for our underlying sense of place.

Table 1. On-site and off-site impacts of land and vegetation degradation from agriculture.

Form of degradation	On-site impact	Off-site impact
	Land degradation	
Salinisation	Only if recharge and discharge localised within a farm boundary.	Salinisation of land where discharge is located off-farm from recharge areas. Stream salinity - reduced water quality and reduced life of roads, bridges, houses, gardens and water using appliances. Stream salinity - decline in habitat quality for aquatic species.
Soil acidification.	Product removal and organic matter accumulation. Reduced ability to grow acid sensitive species (lucerne, phalaris), legume nodulation problems. Reduced groundcover and increased susceptibility to erosion. Changes in soil biota.	Reduced ability to grow acid sensitive species (lucerne, phalaris) reduces options to control recharge. Nitrate contamination of streams and/or groundwater. Reduced groundcover, increased erosion risk and potential for stream turbidity, siltation and eutrophication. Decreased stream pH.
Soil erosion.	Loss of organic matter and structure. Decline in soil fertility. Sheet, gully or tunnel erosion.	Stream turbidity and sediment problems. Eutrophication - algal blooms. Decline in habitat for aquatic species.
Nutrients loss from plants 'mining' soil.	Decline in soil fertility, reduced on-farm productivity and ability to grow some species.	Reduced ability to grow species which require good fertility (lucerne, phalaris) reduces options for recharge control.
Soil structural decline	Decline in water holding capacity and potential for growth.	Only if soil erosion occurs.
Organic matter loss.	Decline in soil fertility and structure.	Dissolved organic matter in water reduces water quality.
Chemical degradation of soil.	Herbicide resistance. Plant uptake of toxic substances. Changes in soil biota. Effects on plant root diseases.	Reduced water quality if chemical is mobile. Decline in habitat for aquatic species
	Degradation of vegetation	
Fragmentation	Changed microclimate (increased wind, temperature and light, decreased humidity), effects on flora and fauna. Reduced hydrologic status. Influx of nutrients, chemicals, weeds and/or biota from agricultural land.	Decline in habitat quality for flora and fauna. Loss of biodiversity. Reduced hydrologic status, water quality and increased salinity.
Loss of individual remnant trees.	Reduced shade and shelter for stock. Reduced habitat for native flora and fauna.	As for fragmentation, but to a lesser extent Landscape aesthetics, unique 'Australian' character of landscapes lost.

We consider factors needed to balance agricultural production and conservation of natural resources. We also outline major consequences of current systems, address solutions and use a case study (Boorowa River Catchment) to illustrate complexities in developing sustainable land use in our economically driven system.

Impacts of current systems

Agriculture can have 'on-site' and 'off-site' impacts. On-site impacts only affect the paddock or farm, whereas off-site impacts affect the wider ecosystem and community. Land managers have control of on-site impacts, economics notwithstanding. Off-site impacts are also within the land manager's control, but are more difficult to manage, as the impact is felt by someone who is remote from the farm. Major degradation problems caused by agriculture and impacts are shown in Table 1. In this paper, we concentrate on the off-site impacts, as these affect the wider community, not just farmers.

Off-site environmental impacts of agriculture

Degradation of land, water and vegetation

Degradation has occurred because extensive clearing and the replacement of deep-rooted native vegetation with more shallow-rooted annual crop and pasture species has changed the water balance. Water can be lost as surface runoff, subsurface flow (in duplex soils) and deep drainage. Recharge rates vary considerably across landscapes and between climatic zones, but have generally increased substantially under agriculture compared with native vegetation (Hatton *et al.* 1996).

Dryland salinity

This is the most politically sensitive and publicised impact of increased recharge. Salinity requires three things to occur - a store of salt, a supply of water to mobilise salt (altered water balance) and a mechanism by which salt is redistributed where it can cause damage (Williamson 1998). In NSW, 120,000 ha of land are currently affected, whilst 5 million ha could be at risk (Lovering *et al.* 1998). The NSW river basins most susceptible are the Lachlan and Murrumbidgee rivers and the northern rivers Macquarie, Namoi and Gwydir. Within these broad areas, local conditions control the distribution of salinity, and both the outbreak of land salinisation and the increase in salt load is seemingly randomly spread. Of concern are areas around Wagga and further to the north and east, in the Yass-Boorowa and Wellington-Dubbo areas.

Contamination of waterways

Water quality is reduced through increased salt or nutrient content, or turbidity and sedimentation (erosion of stream banks). In the Murray, Lachlan and Murrumbidgee rivers, there are very low native fish populations and high European carp densities. Regulation of water flows and the effects of agriculture may be major causes (Anon. 1998a; Harris and Gehrke 1997). Stream salinity trends provide an early warning sign of impending dryland salinity and indicate general catchment health.

Large areas within the 500-800 mm/yr rainfall zone of the southern and eastern Murray Darling Basin (MDB) show increasing stream salinity in addition to rising groundwater (Walker *et al.* 1998).

Nutrient loss from agricultural land, particularly nitrogen (N) and phosphorus (P), is a major issue. Nutrient concentrations in streams are often higher than acceptable for aquatic ecosystem health (Anon. 1997b; Anon. 1998b). Land use and pathways of water loss (surface, subsurface or deep drainage) also determine the likelihood of loss. Where groundcover is poor, or when fertiliser P usage is high, surface water can contain high concentrations of P (Nash and Halliwell 1998). Water lost from soils as subsurface flow or deep drainage can contain high N concentrations, particularly under legume pastures or high stocking rates (White *et al.* 1997). Off-site impacts of N and P loss are eutrophication (algal blooms), turbidity, declining health of aquatic ecosystems and loss of biodiversity (Anon. 1998b; Chartres and Webb 1998).

Soil acidity

It is now well established that agriculture makes soils more acid (Helyar and Porter 1989). Causes include removal of agricultural produce, increased organic matter and nitrate leaching. Soil acidification can have both on-site and off-site impacts (Table 1). Acid soils severely limit the opportunity to grow some plant species and can thus have a major impact on water use of agricultural systems and salinity.

Groundwater contamination

Contamination of groundwater by nitrate-N from agriculture is a major environmental problem in Europe (Addiscott 1988). Excess nitrate concentrations render water unfit for human consumption (Anon. 1992). Australian evidence also shows that nitrate-N concentrations under agriculture could cause groundwater contamination (Anon. 1997b; Pakrou 1997; Schmidt *et al.* 1998; White *et al.* 1997). Intensive enterprises (viticulture, cropping, dairy) are likely to have higher nitrate losses than grazing, with low losses from forests (Schmidt *et al.* 1998).

Degradation of native vegetation

Fragmentation and loss of isolated trees can both have off-site impacts (Table 1). Fragmentation is the restriction of natural or remnant ecosystems to small areas. The major problem is that native ecosystems commonly exist in areas which are too small to support healthy ecosystem functioning (Hobbs and Saunders 1993). Loss of habitat and reduced biodiversity result. In the wheat-sheep belt, commonly only 5-15% of temperate woodlands remain, and many plant and animal species are threatened or extinct (Robinson and Traill 1996).

Decline of isolated remnant trees is caused by many factors, including increased soil fertility, soil compaction, lack of regeneration and lack of habitat for beneficial birds and insects (Landsberg 1988). This loss has on-site and off-site impacts (Table 1). The loss of what is considered to be 'the Australian landscape' through the loss of isolated trees will constitute a major loss of aesthetics and cultural identity (Cary 1999; Martin 1999) in the next 20-100 years (Table 1).

Socio-economic impacts of current systems and structural change issues

Agriculture, particularly the broadacre grazing industries, faces large challenges in the coming decades. A continuing feature has been the long-term decline in farmers' terms of trade - prices farmers receive increase more slowly than input costs. Farmers must continually adjust operations to remain profitable, and the dairy and cropping industries have been able to achieve consistent increases in productivity over recent decades. Grazing industries have not performed nearly so well, with wool in particular achieving one quarter the growth of crop industries over the past decade (Wool Industry Task Force 1996). One step to productivity improvement is in farm consolidation. Farm numbers have been declining since the 1920s but, in recent years, consolidation has not been a strategy commonly used by the majority of broadacre farmers. Currently, 25% of farmers contribute 75-90% of the value of production (Watson and Hall 1999). This minority of large farms also achieves most of the productivity gains made in broadacre agriculture (Knopke, 1995). On the other hand, the majority of farms are economically small, are making few productivity gains, and farm families are now highly dependent upon off-farm work. It is unrealistic to expect such farms to generate sufficient surpluses for resource protection.

A farm financial sustainability indicator has been defined by the FAST farmer group. They suggest that disposable family farm income needs to be over $45,000/yr to maintain investment in both the farm business and environmental protection. Disposable family farm income is the total money a family has after farm operating costs, machinery has been maintained (depreciation) and interest and lease commitments have been met. It is the annual profit made from both the farm and non-farm gross income, or profit the farm family has to meet living expenses, invest on and off-farm, pay off debt and pay tax (Clarke *et al.* 1998). In much of the MDB, fewer than one third of farms achieve this benchmark (Barr and Ridges 1998).

With the poor profitability of grazing enterprises, traditional economic theory suggests that operators of poorly performing farm businesses would sell out to operators of larger businesses. An increased exit rate from agriculture would result and allow opportunities for better performing businesses to expand. However, recent analysis has shown that farm turnover in the broadacre cropping and grazing industries is low. There has been a shift to off-farm income as the major income source. Fewer younger persons are entering farming. Older farmers are deferring the decision to leave farming, particularly in the MDB uplands. With the average age of farmers commonly over 55 years, this trend cannot continue indefinitely (Barr and Ridges 1998). There may be dramatic changes in the social structure of catchments as the current generation of older farmers eventually dispose of farms.

The implications of the changing patterns of structural adjustment have not been considered in catchment management plans. Catchment plans assume that farm businesses will have sufficient surplus to support investment in resource protection. Implicitly, they assume that structural adjustment will create businesses capable of making such investments. Perhaps more importantly, these catchment plans assume that the social structure of catchments will remain unchanged. This latter assumption is ironic, given the economic analysis used in many catchment plans extends to a 25 or 30 year horizon, and the modelling of biophysical processes may use a horizon of 50-100 years (Barr and Ridges 1998). The grim truth may be that some catchments are unlikely to be economically, ecologically or socially sustainable (Watson and Hall 1999).

Environmental solutions

Environmentally sustainable land use needs to have an acceptable water balance, and preservation of soil, vegetation and water resources measured at the landscape scale, in which trade offs between off-site costs (measured over the long-term) and farm production benefits are optimised.

High rainfall areas

To control groundwater levels and discharge in upland areas (rainfall 600-800 mm/yr) where groundwater systems are localised (commonly recharge and discharge areas are only 1-3 km apart), a minimum of 30% of the landscape may need to be re-forested (Hatton *et al.* 1996). Recent predictions suggest 50-70% re-forestation may be required in some areas (Hatton *et al.* 1996; Hatton and Nulsen 1999). These figures are likely to be both impractical and depressing for catchment communities. Decisions about how to tackle such problems will involve considerations of the magnitude of the hydrologic imbalance and associated land and water degradation, and the flow of costs resulting from this imbalance. Social issues and the ability of sections of the community to cope with change will be very important in making decisions about environmental management.

Forestry is one option to reduce recharge whilst maintaining or increasing profitability. However, there are also social considerations. Some communities believe that there are negative impacts such as rural de-population (Race and Curtis 1996). Economic considerations such as proximity of plantings to processing plants and land tenure issues can also detract. Legislation in Victoria, but not yet in NSW, recognises legal separation of tree plantation ownership from that of the land, which allows independent sale of either the land or the trees. Most profitable commercial forestry is likely to occur on prime agricultural land receiving 600 mm rainfall/yr (preferably 800+ mm/yr), and on fertile soils and low to moderate terrain (Booth and Jovanovic 1991). Whilst an important tool to restore the hydrologic imbalance in the high rainfall zone, forestry is therefore not a panacea. It will often not be suitable for the pieces of land which are causing proportionally high land and water degradation, and are economically unviable under current management. In such areas, re-vegetation with indigenous perennials and land retirement is likely to be the best option.

Where control of salinity is paramount, revegetation of high recharge areas and 'break of slope' agroforestry plantings is of high priority. This land use should protect lower areas more suited to agriculture. Deep-rooted perennials such as trees and lucerne have greater potential to use water and reduce recharge than perennial grasses, which are better than annual crops and pastures. However, soil acidity and/or waterlogging commonly prevent lucerne from being an option in high rainfall grazing areas. Soil acidity can also limit phalaris persistence on strongly acid soils where aluminium concentrations are high (Ridley 1995). Good manage- ment is essential for high water use and persistence of perennial pastures, with greater management skills being needed than for annual species.

Cropping areas

In low relief areas of the MDB, cropping is commonly the dominant enterprise. Rainfall is often 600 mm/yr or less and groundwater systems tend to be regional (recharge and discharge areas can be located over 10 km apart). Soils are commonly not strongly acidic, at least in the subsoil. Increasing the perenniality of cropping systems is currently limited to alternating perennial pastures with annual crops (using the perennial to dry out the soil and then allowing progressive re-filling under successive crops), retaining remnant vegetation, re-vegetating non-productive parts of the farm with trees and alley cropping. Short rotations of lucerne (three years) and crops (two to four crops depending on soil type, annual rainfall and distribution) offer most promise for restoring the water balance (Passioura and Ridley 1998). Management is more complex than for current systems, and short rotations of lucerne are sometimes impractical due to reduced profitability compared with more conventional annual pasture-crop rotations.

Other complications

An additional problem of designing farming systems to reduce recharge is that the planting of perennials may reduce runoff to unacceptable levels. Thought needs to be given for particular areas as to whether control of recharge is the primary concern, or whether optimisation of recharge control whilst maintaining supply of runoff water is important. This is likely to be increasingly important where rainfall exceeds 700 mm/yr. There may be a case for landholders in parts of upland catchments to supply water rather than agricultural or forestry products. However, appropriate incentives or a dryland water market would be needed.

Remnant vegetation

Protection and enhancement of remnant vegetation should be high priorities, to reduce land and water degradation and protect species diversity and cultural values of landscapes. Fencing remnants off from heavily grazed land is the first essential step, but this alone is not enough. Grazing management, vegetation dynamics and fire control are needed, in addition to managing the surrounding area (nutrient inputs, weed control, feral animals) and connecting interdependent natural ecosystems (Hobbs and Saunders 1993). Seeking advice from biologists and ornithologists is essential to protect and enhance remnant ecosystems.

Unfortunately it appears that little can be done to prevent continued decline of isolated remnant trees. Regeneration is possible by stock exclusion and weed control. Colleagues in natural ecosystem management refer to such trees as 'the living dead', a sad but pragmatic reality of current agricultural systems.

Boorowa River Catchment case study

The Boorowa River Catchment in brief

The Boorowa River Catchment is within the upper-Lachlan River region, southern tablelands of NSW. The watershed area is 182,242 ha, extending from south of Cowra to north of Yass. Approximately 167,000 ha are covered by the Boorowa Regional Catchment Committee (BRCC), an umbrella group comprising seven Landcare groups (approximately 300 farmers) and local council.

Businesses deemed 'agriculture, forestry or fishing' in the Boorowa Local Government Area comprised 78% of the total in 1997. The median farm family income for 1996 was $31,000, with 26% of farm families earning less than $25,000 and 23% earning more than $50,000. Clearly the majority of farm families are not achieving the sustainability benchmark of $45,000/yr. The prevalence of low business incomes is due to the large number of economically small farm units. In 1995/96 over half of the farm businesses generated less than $80,000 in farm receipts. Boorowa is clearly part of the 'small farm problem' discussed at the recent Agricultural Outlook conference (Beare 1999) and is typical of many broadacre farming communities.

Rainfall ranges from 600 mm/yr on the western edge of the catchment to over 700 mm/yr in the east, with slight winter dominance. The Boorowa township is in the centre of a large, broad open relief landscape about 15 km across, surrounded by low hills. Mixed cropping/grazing occurs in the arable land around the town. Fine wool is grown in the south-eastern and northern parts of the upper catchment, with cattle enterprises also in the eastern portion. Soil Conservation land classes commonly range from II to IV on the arable land, and IV to VI for grazing land. Many soils are deficient in N, P, K and S, with trace element deficiencies of Mo, B and Se known on some soil types. Soils are commonly moderately to strongly acidic (Hird 1991). On grazing country, soil fertility is usually very low.

Mixed cropping comprises 12% of the catchment area, unsown-degraded pasture 59%, woody vegetation 7% and improved pasture 10% (J. Jenkins, *pers. comm.*). In the arable areas woody vegetation is as low as 3%. There is highly visible evidence of dryland salinity in many areas. The BRCC has been highly active in community education and lobbying politicians and government. This group works collectively with the aim of achieving a catchment approach to controlling degradation of natural resources and promoting environmentally sustainable systems which are economically viable.

Addressing environmental issues

Dryland salinity is the greatest environmental problem, with soil acidity, tree decline, soil nutrient depletion, soil organic matter loss and declining surface water quality also important (Hayman 1996). There are likely to be off-site impacts (Table 1) by not addressing a number of degradation issues simultaneously.

Salinity - the big environmental issue. In the Boorowa River catchment , a survey of Landcare properties (80% of the catchment area) mapped salinity. Over 1% (approximately 2,000 ha) is already affected (of this 2,000 ha, 4% is severely affected, 17% moderately affected, 60% slightly affected and 19% is at risk). Salinity hazard mapping has shown that high risk areas cover much of the southern catchment centred on the arable land and also south east into the Pudmans Creek sub-catchment. High risk areas are also around Breakfast Creek. Salinity, however, also occurs in many areas outside these regions. Most salt is mobilised from the headwaters of the Boorowa River and Pudmans Creek -electrical conductivity (EC) levels are as high as 2300 μS/cm. These areas are contributing on average, about 500 kg/ha/yr of salt. In an average year, the Boorowa River is estimated to be exporting about 100,000 tonnes of salt, while in a dry year (such as 1994) it exports about 35,000 tonnes of salt. The Boorowa River catchment is currently exporting about 15 times the salt inputs to the catchment. The catchment has an extremely large salt store, and it is estimated that it will take 150-200 years before equilibrium (salt inputs = salt exports) is reached.

The catchment comprises many localised groundwater systems. Recharge and discharge areas are 1-5 km apart and commonly span only two to four properties. Groundwater systems usually comprise a deeper fractured rock aquifer capped in the mid to lower parts of the hillslopes by transported and weathered material, including an upper soil layer. Salt is mainly stored in the upper weathered layer. Where streams intercept the upper layer directly, stream salinities are highest - where streams have incised below this upper layer, stream salinities reflect the salinity of the deeper groundwater. During dry periods, such as the drought of 1994/95, this upper layer can dry up, with resultant large decreases in stream salinity.

Groundwater levels respond swiftly to rainfall. The main recharge event occurs following winter rains, when deeper groundwater levels rise significantly for a two or three month period. In spring, groundwater levels stabilise and then fall, reaching an annual minimum in late autumn. The groundwater response of the shallow aquifer is similar but simpler. With winter rains, the shallow system fills to near ground level where it stays until spring, when it slowly dries out. Once the summer arrives the shallow system is more or less unsaturated.

Measurements of groundwater level change within the deep aquifer over many years has shown that this system has risen considerably over much of the catchment. Around Boorowa, groundwater levels in the deep aquifer are mostly at the ground surface, including sites reasonably high up the hillslopes. Rates of rise are about 0.5 m/yr. Other areas show similar high proportions of groundwater levels at or near the surface. Shallow water levels in these regions are still responding according to their seasonal pattern, implying that most of the catchment is not yet at equilibrium and that salinity outbreaks will continue.

Remnant vegetation. Death of isolated remnant trees is also highly visible. Tree decline is approximately 2% per year, with Blakely's redgum (*Eucalyptus blakelyi*) most affected. Yellow box (*E. melliodora*) and stringybark (*E. macrorhyncha*) are also susceptible. The catchment is a habitat area of endangered bird species (Superb parrot, Regent honey-eater).

Forestry *versus* non-commercial tree planting. Farm forestry is not very attractive because soils in high recharge areas are often infertile or shallow, and rainfall is relatively low and unreliable. Forest industries are most interested in purchasing wood if farmers can guarantee a regular supply of specified quality at competitive prices. This is only possible on the deeper soils at the eastern edge of the region (Powell 1996). Benefit:cost (B:C) economic analysis has indicated that non-commercial tree planting and establishment of perennial pastures appears economically viable (B:C ratio 1.38 without including benefits to be gained from a reduction in catchment salt loads). In addition, other environmental rewards would occur primarily through a reduction in salt load to streams and rivers and the impact of salinity on town water infrastructure (Hill 1996).

Incentives offered for trees and perennial pastures. The BRCC applies for Natural Heritage Trust (NHT) funds. Funding permitting, the BRCC then offers incentives to landholders to plant perennial vegetation on recharge areas for mapped saline discharge areas. Either trees (direct seeded or tubestock) or pasture can be established and managed within specified guidelines aimed at maximising chances of successful establishment and persistence. Fencing incentives are also available. Over the past 5 years, establishment covered by NHT incentives has been approximately 150 ha trees/yr and

1500 ha pasture/yr. Additional pastures (1500-2000 ha) are also established (J. Jenkins, *pers. comm.*)

Reasons for optimism

Vision. The BRCC has some visionary landholders who are thinking about the future of agriculture and the rural community. As landholder Michael Carmody puts it, "The visionaries gave the tree a shake and woke the community from a slumber of ignoring the degradation and unsustainability of our land. All the rest of us had to do was to step from the platform onto the train". The BRCCs vision is to attain at least 15% tree cover over 30 years. Although only half of the 30% 'Hatton' figure, it is a more realistic community target.

Pasture establishment. The high level of pasture establishment shows that community education of catchment processes, water use of agricultural systems, soil acidity and management are broadly acceptable even in hard times. At current rates of pasture establishment (3000-3500 ha/yr) for 10 years at 80% success rate, a further 24,000-28,000 ha (13-15% catchment area) could be established. This is in addition to existing pastures (10% catchment area). Thus, 23-25% of the catchment could be under perennial pastures in the next 10 years. Grazing management and maintenance of soil fertility for persistence and water use is necessary, and will require increased complexity of management and costs.

Rainfall distribution. The average rainfall of 600-700 mm/yr, and its relatively even distribution, mean that designing a hydrologically acceptable agricultural system may be achievable with current species options.

Localised salinity. Salinity is highly visible, but the localised groundwater system and the fact that many properties have small areas affected mean that community awareness is high. Other communities which have less visible problems (such as soil acidification) have much lower environmental awareness.

Soil acidity is not too severe. Approximately 200 soil profiles analysed by DLWC show that the topsoil pH (1:5 soil:water) is commonly in the range 5.0-6.0 and subsoil pH is usually over 6.5. There are some known exceptions of light acidic soils where cocksfoot persists better than phalaris. Generally with liming, adequate soil fertility and management, it is likely that acid sensitive species for recharge control (lucerne and phalaris) or profitability (canola) can be grown.

Remnant vegetation. Despite poor tree health and a low amount of remnant vegetation, tree planting has had large impacts on bird numbers and species. Direct seeding techniques are very successful, with a mixture of tree and shrub species being used (15 acacias, 18 eucalypts and 7 understorey species). Direct seeding and electric fencing, have dramatically reduced costs and increased success. On 'Allendale', increasing tree cover from 3 to 8% has shown a large increase in bird numbers. Ninety species including large flocks of Superb parrots are present. Bird populations can remove 50-70% of insects from trees (Francis 1997).

The more difficult issues

Recharge control needed in relation to community vision. Recharge areas are extensive and often comprise all the areas upslope from discharge areas. To prevent discharge, much of this area would probably need to be planted. Community monitoring will be needed to determine the minimum area required to give a net positive benefit. The target of 15% tree cover developed by the BRCC could well be too low to prevent the spread of salinity, but suggesting a higher percentage is likely to be soul destroying for farming families.

Current tree planting is less than 0.1% of the catchment area per year, and will need to be markedly increased if 15% tree cover is to be achieved in 30 years. Without NHT funds, tree planting would largely cease. Whilst tree planting is crucial, the success or failure to reduce recharge will occur due largely to perennial pastures. Management skill and equity of farming families will have a major influence on the outcome. However, the fact that only 23% earned sufficient for business investment is a major concern.

Cropping systems. Despite the largest increases in salinity risk occurring in the arable areas, little emphasis has been put on changing current cropping systems. Farmers feel they have no option but to increase cropping to maintain economic viability, and current management is likely to further increase salinity. The Boorowa township is suffering from high water tables, although many town residents are unaware of problems as yet.

The optimal solution in arable areas appears to be the use of lucerne in the pasture phase of crop rotations. Although this management may reduce profitability in some years compared with annual pasture based systems or long crop rotations, the BRCC could consider either changing the incentive guidelines for arable land and/or developing a Local Action Plan. Incentives are currently available to sow lucerne or phalaris, but only for a pasture phase of six years minimum. Reducing the requirement to three years perennial followed by a maximum number of crops (perhaps two after phalaris, three after lucerne) before re-sowing to perennials would help redress the water imbalance problem in cropping systems. Local Action Planning would help develop cost-sharing arrangements between farmers, the community and government, and would allow benefits of reduced salinity to be borne by beneficiaries. Some farmers are also very concerned about other effects of increased cropping. A major perceived issue is chemical soil degradation (Table

1), which would not be addressed by the above suggested action.

Structural adjustment issues and land retirement

Financial viability is a major problem preventing environmental management. Despite incentives for establishment of perennials on recharge areas, many farmers cannot afford the specified individual contributions. Catchment management plans which assume that farm businesses have the ability to undertake such investments are unlikely to succeed where profitability is poor (Barr and Ridges 1998).

Watson and Hall (1999) suggest that farms can be classified into four categories; economically viable-ecologically sustainable, economically viable-ecologically unsustainable, economically unviable-ecologically sustainable and economically unviable-ecologically unsustainable. The two groups which are ecologically sustainable require only good information and the general welfare net. Those regions which are economically viable-ecologically unsustainable provide a challenge to the community as a whole. Will the wider community accept the unsustainability of farming systems? The likelihood is that as Australia becomes increasingly urbanised, the probability of legislative controls will increase. The rice and cotton industries have experienced this pressure in the current debate about the environment. To pre-empt such measures, the grains and livestock industries are currently thinking about developing voluntary environmental management systems.

The final case of economically unviable-ecologically unsustainable regions also provides a major challenge. One strategy is to hope that regions change over time in a manner which solves the problems of unsustainable land use and unsustainable incomes. The current evidence is that the rate of adjustment in broadacre industry is much slower than would be required to solve the unsustainable income problem. The rate of farm aggregation is between 1-2% per year for much of the MDB uplands. However, this rate of change may increase dramatically in the next 10-20 years as the current generation of farmers retire. While the Boorowa district may only be capable of aiming for a target of 15% landscape tree cover under current conditions, higher cover may be achievable in another generation if the agricultural and social structure of the district changes significantly.

Governments may choose to intervene to hasten change. In the Tambo Valley, East Gippsland, Victoria, farmers have been recently been affected by a record five year drought, record floods and prolonged low commodity prices. In response to the high and regular costs of disaster relief and on-going economic viability problems, the Victorian government has established the Land Aggregation Program. This provides a mechanism for some farmers to voluntarily leave agriculture through government purchase of farms - 4 properties have been bought with a further 10 under consideration. These farms will be collectively assessed according to specified land capability criteria. The government will make decisions as to future land use. Options include (1) re-selling consolidated holdings where land capability is high, (2) establishing forestry enterprises or, (3) land retirement/crown land resumption.

The Tambo Valley example should be viewed as a policy experiment in operation. The program has short timelines and there is potential for community opposition, despite the parlous financial position of many farms. If it succeeds, this approach may be considered more widely for other areas where land is generating large off-site environmental impacts. In following these policies, governments will need to pay close attention to the capacity of communities to accept change. The current opposition to pine plantations in Western Victoria is a pointer to potential opposition if change is imposed too fast upon rural communities.

The best strategy for rural communities may be to involve themselves in debates now. Communities should perhaps attempt to define not only the direction of change required, but the rate of change which they can accept, and the role of government in catalysing change. Given the visibility of salinity problems, strong community action and (cynically) the proximity of Boorowa to Canberra and Sydney, the BRCC may have a strong case for lobbying to support and achieve land retirement in some areas if the community is willing. Raising this issue is likely to generate considerable debate and emotional pain amongst long established rural communities with strong ties to the land. However, the alternative to no pro-active action, may generate a similar outcome of land retirement or abandonment, as has occurred on marginal land in southern Europe, but with less compensation.

Conclusions

Future decisions by communities and governments about trade-offs between off-site impacts of agriculture and the environment will be made knowingly. A major mindset change is needed by some parts of the community. Difficult options, such as regulation of land use, runoff from agricultural land and land retirement have usually been excluded from policy debate (Fisher 1995), but attitudes are changing.

Managing agricultural and natural ecosystems to optimise environmental, social and economic goals is complex. Farmers need to have skills currently used by leading and/or visionary landholders. Over the next 10-20 years there will be large opportunities for appropriate land use change if there is political will and community resolve. For farmers who are economically unviable and ecologically unsustainable, appropriate incentives are needed to facilitate land use change. Subsidies should be consistent with the value of off-farm benefits. Land retirement using a 'voluntary redundancy' arrangement, where farmers are paid to retire land and manage it to certain requirements whilst retaining ownership, can be a viable and cost-effective option on some land (Fisher 1995), whilst recognising the importance of cultural connections of farmers to the land.

The Boorowa River Catchment community provides an interesting case study of how natural resource degradation is being addressed. The dedication of employed project officers and visionary landholders is of major importance in generating awareness and maintaining enthusiasm within an economic environment which does not favour sustainable land management. There is continued and increased need for government funding. Education of urban and rural people is needed so Australians can decide what priority should be put on ecologically sustainable agriculture and rural regional development.

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