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A case study of farm-based solutions to water logging and secondary salinity in southwestern Australia

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Abstract

The 'Ucarro' farm is located in the upper catchment (33°S117°E) of the Carrolup River, a tributary of the Blackwood River in southwestern Australia. When the present owners of the farm took over the property in 1975, the stream running through the farm was becoming saline and access to the lower portions of the farm was frequently hindered by water logging in the wet winter months. The paper describes the decision made by the present owners to develop a whole farm plan to ameliorate water logging and prevent the development of secondary salinity. The plan included the grading of interceptor drains with a fall of 1:300 along the contour 150–200 m apart down the slope and the locating of dams along the drains to hold water for the dry summer months. Belts of three or four species of trees were planted on the down-slope side of the drains after leveling the spoil from the drain and deep-ripping the soil. The benefits of this plan included reduced water logging, salinity and wind erosion, and increased yields, stocking rates and lambing percentages. While the costs of the drains, trees and fencing were about US\$ 2760 (US\$ 1 = AU\$ 1.7, June 2000) per km, gross margins have increased by about US\$ 2.70 ha^{-1} per year as a result of increases in cereal yields from 2.2 to 3.2 t ha^{-1}, increased carrying capacity of the pastures from 8.5 to 11.0 dry sheep equivalents (DSE) ha^{-1}, increased lambing percentages from 77 to 86% and increased income from aquaculture (fresh-water crustaceans) produced in the farm dams.

Keywords: Drains; Economic benefits; Wind erosion; Aquaculture; Frost risk; Whole farm plan

1. Introduction

The farm, 'Ucarro', is located at 33°S117°E high in the catchment of the Blackwood River (McFarlane and Williamson, 2002). The property was purchased by the Rundle family in 1975. After an initial period of 4–5 years of upgrading fences, pastures and

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buildings, it became apparent that water logging was making timely access to areas lower in the landscape difficult and that the watercourses throughout the property were becoming saline. Grazing by sheep made, the saline areas bare and these bare areas were gradually creeping up-slope from the base of the streams into good grazing and cropping land.

In order to restrict the spread of the saline areas, a variety of *Eucalyptus* species, particularly *E. camaldulensis* (river red gum) and *E. sargentii* (salt river gum), were planted near the stream lines and the areas fenced-off to prevent access to sheep and to prevent the development of bare areas denuded of pasture species. In 1981, the decision was made to also plant *Pinus radiata* (radiata pine) on the boundaries of the property to act as windbreaks and among the *Eucalyptus* species near the stream lines. The *P. radiata*, and an adjacent row of *Schinus areira* (pepper trees) (Woodall and Ward, 2002) have proved to be good windbreaks, but few survived when planted in the saline areas near the drainage lines.

The farm is the location of several papers reported in this special issue. See, particularly papers by Hatton et al. (2002), Hodgson et al. (2002), Ward et al. (2002), White et al. (2002), and Woodall and Ward (2002).

2. Whole farm plan

In the mid-1980s, it became clear that the trees planted along the drainage lines were not controlling the incidence of water logging lower in the landscape and were not reversing the development of secondary salinity. A whole farm approach was needed for water and salinity management.

Several options were available:

2.1. Do nothing

This would have been an easy option and while inexpensive at the time would not have been inexpensive in the long term with land degradation, rising water tables, wind erosion and water logging of crops and pastures reducing land values and profitability.

2.2. WISALTS banks

This was a deep drainage system that was popular at the time (McFarlane and Cox, 1992), in which level drains to a depth of 1.2 m are dug along the contours. They gather water and reduce water logging in some situations, but are expensive at approximately US$ 3000 per km, do not prevent wind erosion or salinity (McFarlane et al., 1990) and can be unsightly.

2.3. Farm by soil type combined with alley farming

This method involves the identification of soil types and then adoption of a farming practice to suit the particular soil type. Additionally, belts of trees are planted as close as possible to a north–south direction to minimize shading of the adjacent crops or pastures. While this option would have addressed the problems of wind erosion and some of the problems of salinity, it was rejected because of the large variability of soil types on the farm and it did not address the issue of drainage.

2.4. Whole farm plan

This plan entails the following elements:

- identification of sites for major dams;
- ignoring soil types and current fence lines;
- surveying for drains on a slight fall spaced approximately 200 m apart down the slope; and
- identifying locations for new dams of 2000–2500 m^3 on the drainage lines.

Planting three or four rows of trees immediately down-slope of the drains in the cool wet winter months.

This plan was adopted for ‘Ucarro’.

3. Implementation of the whole farm plan

The farm is located in the upper portion of the Carrolup River (McFarlane and Williamson, 2002). The total area is 885 ha of which 80% is arable and 11% is suitable only for permanent pasture (Table 1). The remaining 9% is taken up by access roads, fenced-off remnant vegetation, dams, drains and boundary trees that are also fenced-off (Table 1). The majority of the farm is shaped like a dish with the farm boundary approximately coinciding with the boundary of the catchment (Fig. 1). As a result there is little water coming on to the farm from neighboring properties. Water leaves the property through a tributary of the Carrolup River (Hodgson et al., 2002).

Between 1988 and 2000 the entire farm was surveyed, drains and belts of trees established and dams dug. Dams existing in 1988 were incorporated into the plan. The drains were located along the contours with a 1:300 slope approximately 150–200 m apart (Fig. 1). Dams were located along the drains, but excess water ultimately reaches

Table 1
The area and percentage area in various land-use categories in 2000 at the ‘Ucarro’ farm in western Australia

Land use	Amount of land (ha)	Percentage
Arable land	706	79.8
Permanent pasture	98	11.1
Drains (27 km × 13 m)	34	3.8
Fenced remnant vegetation	33	3.7
Trees fenced on boundary	3	0.3
Laneways	11	1.2
Total	885	100.0

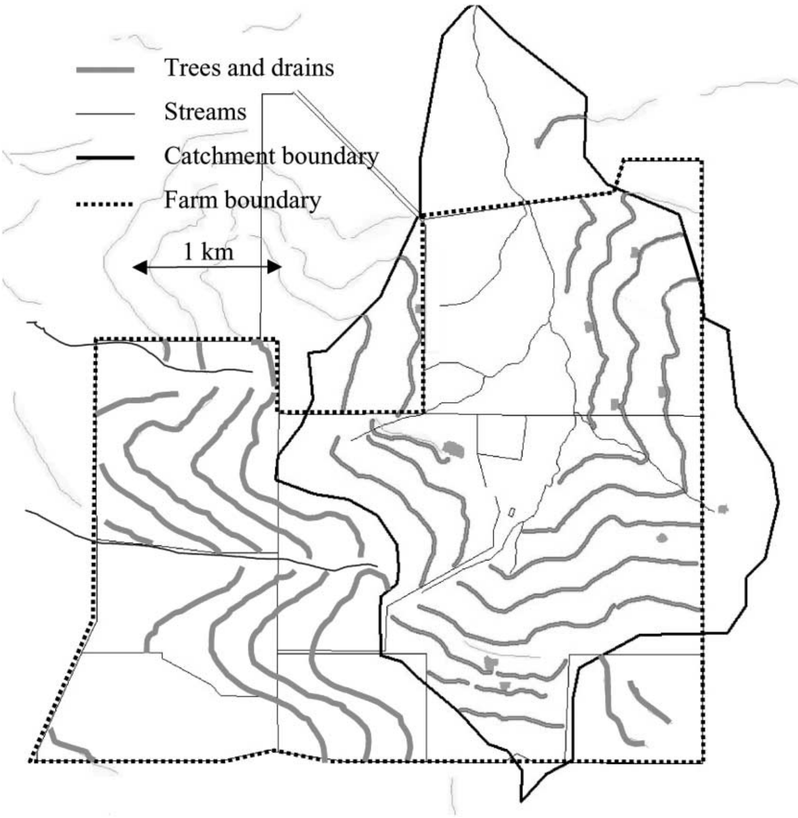

Fig. 1. Layout of dams, drains and tree belts on the 'Ucarro' farm in western Australia in 1999. The Carrolup River and streams flowing into it are shown. For its location in the river catchment, see McFarlane and Williamson (2002) and for further details, see Hodgson et al. (2002).

the stream in the valley floor. The drains and dams are estimated to reduce the water flowing into the river by 30–75%, depending on rainfall. Some water travels up to 5 km before reaching the river, whereas prior to the installation of the interceptor drains the water may have flowed only 400 m. The dams are used for aquaculture. Fresh-water crustaceans (*Cherax destructor*) are harvested annually for the local and export market.

Initially, the shallow surface drains were established with a bulldozer that removed the sandy surface soil down to the clay subsoil at a depth of about 0.35 m. More recently, an excavator has been used in addition to the bulldozer. The soil from the drains was then spread on the down-slope side of the drain. An integral part of the farm plan was the deep-ripping of the down-slope side of the drain and the establishment of three to four rows of trees 2.5 m apart and 5 m between trees in the ripped and leveled soil from the drain. Initially, five species of *Eucalyptus* were used: *E. platypus* (coastal moort), *E. camaldulensis* (river red gum), *E. leucoxylon* (red flowering gum), *E. globulus* spp. *globulus* (Tasmanian blue gum), *E. saligna* (Sydney blue gum). A considerable number of the latter two species died in summers with no rainfall and a large number of *E. platypus* split and were blown over in winter storms. Subsequently only *Corymbia maculata* (spotted gum) was planted as a tall species planted near the drain and *E. leucoxylon* planted as a multi-stemmed windbreak in the rows away from the drain. For the past few years, the trees have been planted in five rows 3 m apart and 6 m between trees. Both sides of the belts of trees were electrically fenced-off to prevent grazing and damage by sheep. As a result of the cost of the drains, trees and fencing, only 5 km were established in any 1 year. Prior to establishing the drains and trees, the section of the farm to be next established was planted to crops so that the trees could be planted and fenced-off prior to harvesting of the crop and prior to the grazing of the cereal stubbles by sheep.

4. Costs of establishing the farm plan

Since the commencement of the program in 1988, 27 km of drains and seven dams have been established. The total cost for the 27 km of drains incurred between 1988 and 2000 was US$ 74,250 and the cost of the seven dams at US$ 1500 per dam is US$ 10,500 giving a total cost of US$ 84,750 or US$ 96 ha^{-1} and US$ 7060 per year over the 12-year period (Table 2). The costs of labor for tree planting and fencing are not included.

5. Benefits of establishing the farm plan

The benefits of establishing the whole farm plan can be summarized as follows, and are discussed in greater detail:

1. reduced salinity creeping out from the drainage lines;
2. reduced water and wind erosion;
3. reduced water logging;
4. increased crop yields;
5. improved pastures;
6. increased flexibility in the cropping program;
7. improved lambing percentages and sheep comfort;
8. improved bird life and a reduction in the need for insecticides;
9. increased number of bees, and therefore, pollination of insect-pollinated crops; and
10. increased spraying window due to protection from trees.

Table 2
Costs (US$ per km) of establishing drains, trees and fences at the 'Ucarro' farm in western Australia

	Cost	Percentage
Planning	4	0.2
Banks	1200	43.5
Trees and planting	200	7.0
Electric fence	1356	49.3
Total	2760	100.0

5.1. Reduced salinity

One of the key benefits of the establishment of the drains and trees has been a reduction in secondary salinity. The area showing signs of poor plant growth due to salinity has disappeared and salinity levels in the stream have been reduced.

5.2. Reduced water logging, water erosion and wind erosion

The drains have reduced water leaving the property by 30–75%, depending on rainfall and its distribution, and the trees and drains have reduced water logging in the lower part of the farm. While the drains and trees have reduced surface water flows and lower the risk of water erosion, the trees also reduced the subsurface water flows (White et al., 2002; Hatton et al., 2002). The reduction in water logging has allowed timely access to the fields for planting, fertilizing and spraying the crops and pastures. Fields that previously could only support pasture are now dry enough to produce good crops.

The trees also provide a windbreak for crops, pastures and sheep. The reduced wind strength and reduced water logging have promoted pasture growth at critical times of the year, allowing better rotation of sheep around the farm. This has increased the carrying capacity from 8.5 to 11.0 DSE ha^{-1}. The trees provide a shelter for the sheep that has reduced sheep losses and increased the lambing percentage from 76 to 88% over the past 10 years.

The trees also protect the soil from the strong prevailing northerly and westerly winds, thereby reducing soil erosion and loss of topsoil containing organic matter and nutrients. The shelter allows more timely spraying of herbicides and insecticides and reduces shedding of seed, particularly of canola, near harvest. Losses from the inability to spray crops at the optimum time can be as great as 0.25 t ha^{-1} and losses from shedding can be as great as 0.15 t ha^{-1}.

The more timely application of sprays and fertilizers and the reduction in water logging has resulted in average cereal yields increasing from 2.2 to 3.2 t ha^{-1} over the past 10 years. While it is difficult to separate the causes for the increases in crop yields, pasture carrying capacity and lambing percentage arising from the establishment of the drains and trees from the general improvements in management, the drains and trees have certainly had a significant impact on the profitability of the farm.

An additional benefit that has arisen from holding more water on the farm is the increased income from aquaculture. Over the past 12 years, not only have the number of dams been increased by seven, but the water retained in each dam over the year has increased. This has resulted in the income from yabbies (*Cherax destructor*), a freshwater crustacean, for local and export consumption increasing from US$ 30 to 135 per dam per year.

5.3. Other benefits

Other benefits that are difficult to quantify are the increased bird population and reduced need for insecticides because of the trees. Also the flowering gums attract native bees and the increased population may have benefited the pollination of cross-fertilized crops such as canola and faba bean and eliminated the need to bring in hives of domesticated bees at flowering.

5.4. Frost risk

One cost that is difficult to assess financially is the increased frost risk from the presence of the trees. With belts of trees on the eastern side of a field, shading from the early morning sun increases the incidence of frost damage. This caused significant crop losses in 1998 in some parts of the farm with fields oriented along a north–south axis (Ward et al., 2002).

6. Conclusions

Seventy hectares of the farm has been sacrificed to drains, trees and remnant vegetation (Table 1) to manage water logging and secondary salinity. This is about 8% of the farm. Despite the loss of this arable land, it is concluded that the benefits outweigh the costs. The benefits in terms of increased crop, wool and lamb production has been documented. Gross margins have increased at approximately US\$ 2.70 ha^{-1} per year. This is after taking into account a US\$ 30,000 increase in capital costs associated with implementing no-till cropping. Finally, apart from the aesthetic benefits of the trees and the reduction in land degradation and scars from salinity, the increased land values from the whole farm plan help to compensate for losses of arable land.

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