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1. Introduction

The Toolibin catchinent lies at the head of the Blackwood/Arthur River drainage system in the central wheatbelt of Western Australia. Like much of the region it has been extensively cleared for agriculture over the past eighty years and now faces serious problems with secondary salinity. An imbalance between incoming rainfall and the water-use by current farming systems has brought about substantial rises in watertables and widespread salt encroachment. The cumulative effects of dryland cropping and grazing in a Mediterranean climate are also taking their toll and today waterlogging, erosion and soil structure decline are posing serious threats to agricultural productivity.

Lake Toolibin, situated at the southern end of the catchment remains one of the few relatively fresh inland wetlands in the southwest of Western Australia and an important breeding habitat for native waterfowl. Its deterioration in recent years has resulted in an inter-departmental investigation aimed at saving the lake (NARWC, 1987). What has become very clear from this work is that any management plan for the lake must take into account land degradation, management and landuse within its catchinent.

This report describes some of the background to the salinity problems and discusses how conservation farm planning and management changes might counter the ongoing land degradation. It sets out to stress that efforts to solve degradation and salinity on this scale must be approached on a whole catchment basis and involve all landholders. Although it is based on the Toolibin catchinent the report is relevant to similar catchinents in the region which share many of the problems. There is also a summary of the Toolibin Flats Rehabilitation Project for the individuals involved and for any groups considering similar undertakings.

2. Background Information

2.1 Location

The Toolibin catchinent is centred about 50 kin east of Narrogin and covers an area of about 440 km^2. Across its longest axis it stretches about 40 km from near Wickepin in the west to Harrismith in the east. Apart from a very small area north-west of Lake Toolibin it falls within the boundaries of the Wickepin Shire and therefore the Wickepin Soil Conservation District (SCD).

2.2 Climate

The region has a Mediterranean climate with very dry summers and most of its rain falling in the winter growing season. The average annual rainfall ranges from about 379 mm at Toolibin near the centre of the catchinent up to 421 mm at Wickepin in the west and 417 mm at Dudinin in the east.

2.3 Topography and natural drainage

The landscape of the area is essentially carved out of the Tertiary land surface which once covered the region. In more recent times poor external drainage from the region and a more arid climate have tended to inf ill the ancient valleys and drainage lines and further reduce what limited relief previously existed. Thus today much of the area consists of broad flat valleys surrounded by gently sloping uplands.

The land surface ranges from about 300 m above sea level at Lake Toolibin up to over 400 m where the divides rise in the east and west (Figure 1). Elevations remain relatively low through the central parts with the extensive Toolibin flats covering a large area north-east of the Lake. The approximate extent of these areas can be taken as that below the 320 m contour which accounts for about 130 km^2 or 30% of the catchinent area. The flats then spread out into long flat-bottomed valleys, with very slight grades averaging only about 0.1% to 0.2%. Near the centre of the catchment the flats are often bounded by very sharply defined slopes rising at between 2 and 4%. The most striking feature of many of these slopes is the sharp break of slope at their base. Elsewhere the valleys tend to rise more gradually from the flats to give broad gentle slopes of 1 to 2%. In the upper catchinent, where slopes usually increase either toward breakaways or, as in the western part, into more sharply dissected valleys, grades can be as high as 6 to 8%.

The catchinent divides naturally into several sub-catchments with drainage entering Lake Toolibin in two places. North-west Creek drains an area of about 40 km^2 and flows directly into the lake as a clearly defined watercourse. From the other sub-catchments creeks drain onto the flats where the water then tends to meander and in some cases spread out again before finally entering the lake through the North Arthur River. The movement of water on these flats is relatively slow and slight obstacles such as roadways, fences, debris and banks can easily impede or divert the flow.

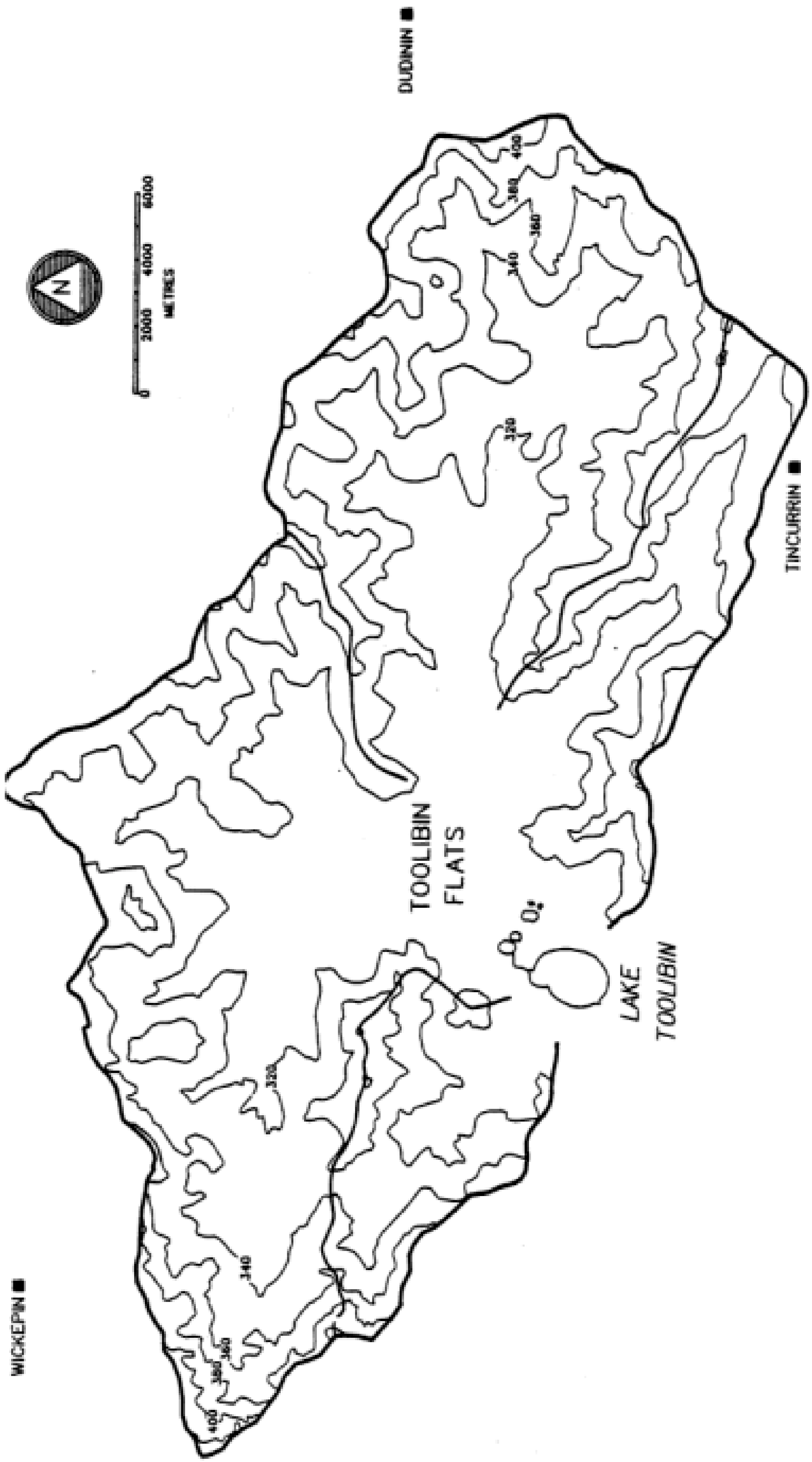


FIGURE 1: TOOLIBIN CATCHMENT - RELIEF

2.4 Existing soil. and landscape surveys

Mulcahy and Hingston (1961) made a detailed survey of the soils and landscape in the York-Quairading area. This together with a similar survey of the Merredin area (Bettenay and Hingston, 1964) gives a background to the land classes and soil types of the region.

Mulcahy (1967) identified several zones in south-western Australia based on the extent to which the ancient drainage lines were rejuvenated and the Tertiary land surface stripped. At areas such as Toolibin the rejuvenation has not been a major factor and soils are formed largely on the preweathered parent materials of the old laterite surface. In the flat valleys the soils formed mostly on the mixed colluvial and alluvial materials deposited over the extensive pallid zone clays of the region. Soils in the upper catchinent formed mainly on residual and reworked laterite or on the intermediate horizons of the truncated Tertiary profile. Those formed on fresh rock are not widespread.

In the Atlas of Australian Soils Sheet 5 (Northcote ~ ~ 1967) soil-landscape units were mapped for the south-west of Western Australia and published at a scale of 1:2,000,000. That part of the m~.p covering the Toolibin catchment is shown in Figure 2 and gives the approximate extent of various units. It should be noted, however, that the degree to which soil types and their boundaries can be accurately interpreted is limited by the scale at which this map was drawn.

2.5 Native vegetation

Before clearing, most of the catchment supported Eucalypt woodland of York gum (Eucalyptus loxophleba), Salmon gum (E. salmonophloia) and White gum (E. wandoo). Red morrel (E. longicornis), Rock sheoak (Allocasuarina heugeliana) and Jam (Acicia acuminata) also occurred in various associations over large areas. On breakaways the Blue mallet (E. gardneri) and Brown mallet (E. astringens) were dominant species. The distribution of thesewoodland species within the catchment is closely tied with the soil types and is referred to in a later section on soils and land management units.

Areas of heath-type vegetation occurred over quite large areas, particularly in the upper catchinent. Genera well represented in these areas include Dryandra, Leptospermum, Hpkea, Grevjllep, Adenanthos, Daviesia, Banksia and Acacia.

For greater detail on the plant species found in the area and the four recognized vegetation systems present in the catchment a more comprehensive description is given by Beard (1980) in the Vegetation Survey of Western Australia - Corrigin Area.

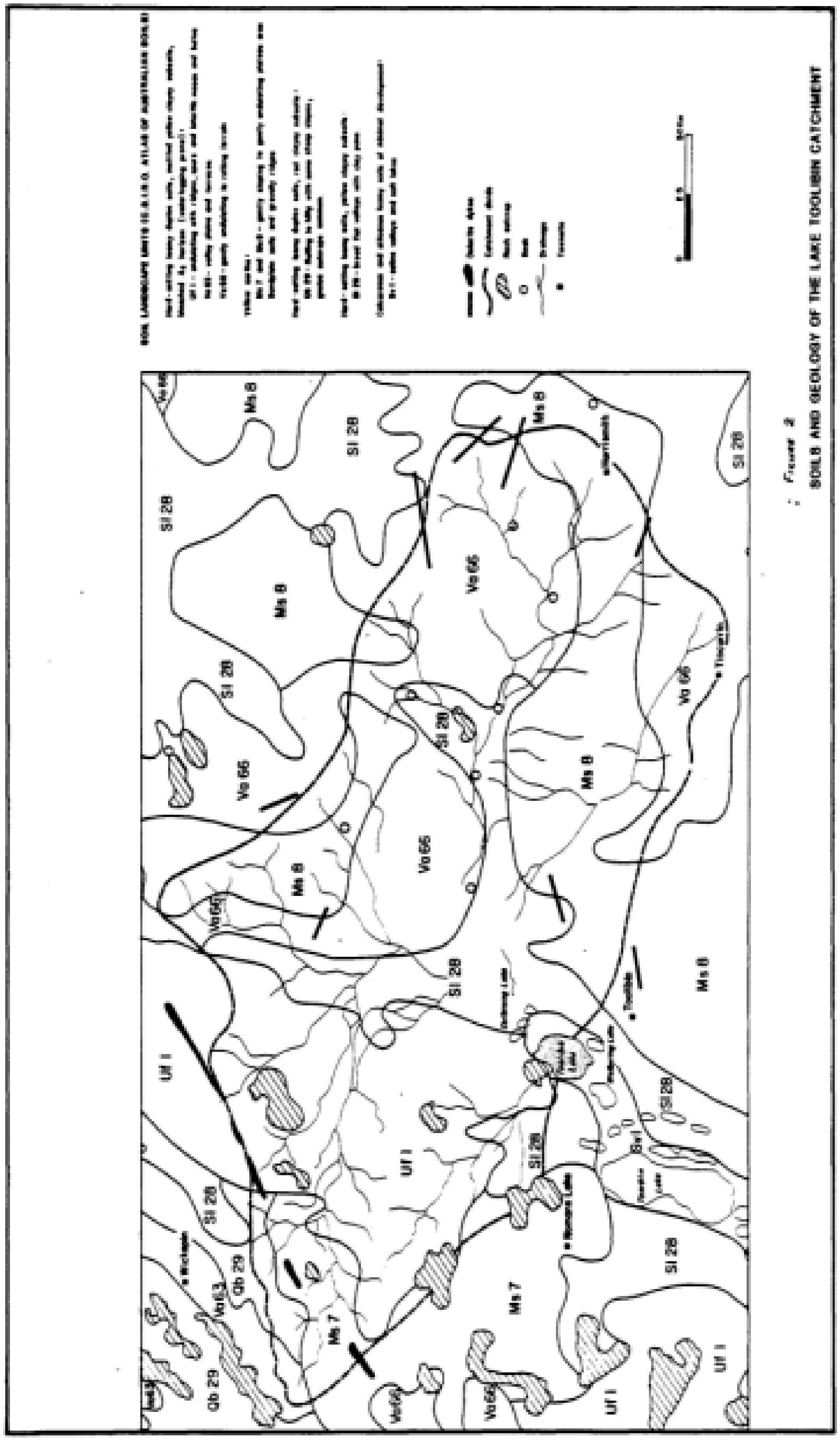


Figure 2
SOILS AND GEOLOGY OF THE LAKE TOOLIBIN CATCHMENT

2.6 Clearing history

Land was first taken up for farming in the late l890s but little clearing was reported to have taken place before 1905 (Watson, 1978). Large scale clearing commenced after World War I mainly on the better class Salmon gum, York gum and Morrel country and by 1933 most of this heavy land had been cleared for cropping. This expansion of farmland stopped with the 1930s depression and development of the lighter White gum-Jam country did not take place until into the late l940s and early 1950s.

By 1960 an estimated 85% of the catchinent had been cleared. This has increased to about 95% at present. Clearing of the remaining land is unlikely in the foreseeable future.

2.7 Groundwater levels and secondary salinization

Watson (1978) reported a survey of 46 bores and wells sunk in the Toolibin catchment between 1907 and 1913. The majority of the bores were 20 to 35 m deep and down to bedrock. Seven encountered very salty water, eight were brackish, four fresh and twenty seven were dry.

At Dingerlin Well 2 km due north of Lake Toolibin the free standing water level is known to have risen about 7.8 m between 1912 and 1977. Recent monitoring of this and other wells suggest that the initial rapid rises in watertables have slowed considerably. Instead significant discharge is now occurring from the catchinent by way of evaporation from salt scalds. The system could still be far from a new equilibrium however, and further rises may continue for some time yet.

During 1987 about 40 shallow observation wells (2 to 3 m deep) were drilled over large areas of the Toolibin flats for farmers to monitor, (Figure 3). Around or near salt scalds, watertables were generally found at depths of 1.5 m or less. In non-saline areas watertables were encountered in most bores greater than 2.5 m deep although the shallower bores often remained dry throughout the season. These measurements and records from other sources (McFarlane ~ ~. 1987; Martin 1986) indicate that watertables are now at relatively shallow depths under much of the flats.

The earliest reports of secondary salinity in the Toolibin catchinent date back to the l930s when, within a period of only a few years, an area just north of Reserve 27286 went from productive cropping land to saltland. This pattern has been repeated at successive sites further up the catchinent, presumably as the watertable has risen beneath an ever-increasing area of the flats. The severe scalds near the north of the flats are some of the most recent and can be shown from aerial photographs to have developed rapidly between 1962 and 1973. Recent estimates are that 3% of the total catchment is now severely salt affected and a further 2.6% is moderately salt affected (Stokes and Martin, 1986).

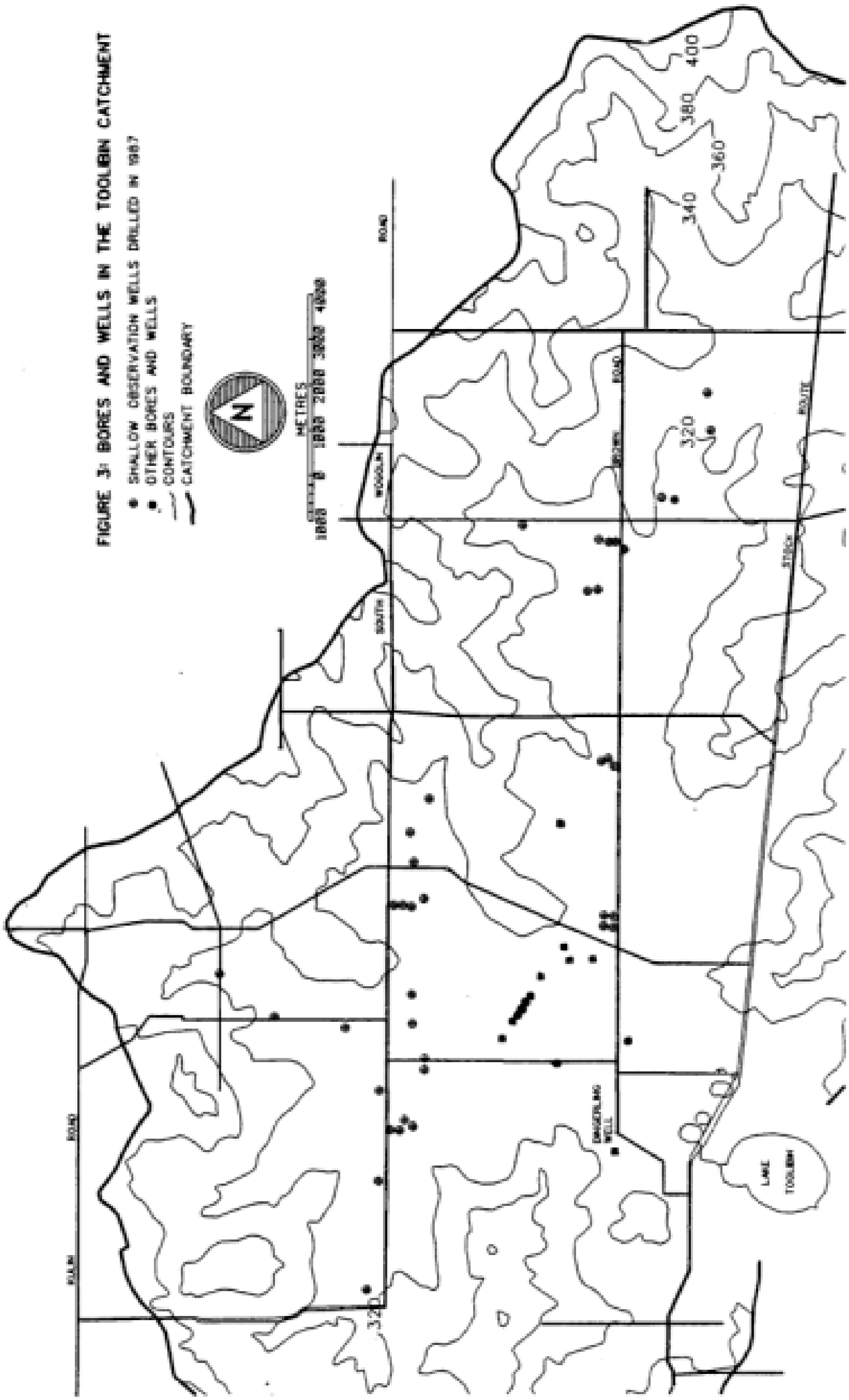


FIGURE 3: BORES AND WELLS IN THE TOOLIBIN CATCHMENT

2.8 Lake Toolibin

Lake Toolibin is a breeding ground for more species of waterbird than any other wetland surveyed in south-western Australia (Jaensch, unpublished). It also supports the second highest number of species of any inland wetland and is possibly the last stronghold of the Freckled duck (Stictonetta naevosa). Hence the lake is considered a valuable wildlife sanctuary by the Department of Conservation and Land Management (CALM) and worthy of preservation (Halse 1987).

One of the factors which make the lake so suitable for breeding is the relative freshness of the water during spring (NARWC, 1987). While salinity levels vary considerably over an annual filling and drying cycle the salinity during the critical spring breeding months is usually below an acceptable 3000 mg/L. The other important feature of the lake is the emergent lakebed vegetation of Swamp sheoak (Casuarina obesa) and Paperbarks (Melaleuca spp.). These trees survive seasonal inundation and provide safe nesting sites for the breeding water birds. The ongoing decline of the trees, especially on the western side of the lake, is therefore of major concern.

Since 1977 the North Arthur River Wetlands Rehabilitation Committee (NARWC) has been investigating Lake Toolibin and current threats to the lake’s role as a wildlife sanctuary. The main threats identif led are the salt load entering the lake in surface flow and the rising watertables beneath the lake. CALM[8]s planned tree planting to the west of the lake and possible pumping of groundwater from beneath the lakebed will hopefully address the latter problem in the short-term. The problem of incoming salt will require substantial efforts and co-operation from those involved$_4$, and possibly some control over water movement. A series of interceptor drains has already been modified to prevent them from discharging saline water into the western side of the lake. The major rehabilitation project on the salt affected land upstream and immediately adjacent the lake should also decrease the salt load by reducing the amount of surface salt that can be mobilized and transported by seasonal runoff.

3. Land Management and Farm Planning in the Northern Sub-Catchment

An area to the north of Lake Toolibin comprising some 5300 ha and involving seven landholders, was selected to:

(a) survey landuse and current farming practices;

(b) broadly describe the land management units present and their associated degradation hazards;

(c) assess the need and potential for conservation farm planning.

While the three farms and numerous blocks do not correspond strictly to a complete sub-catchment they will be collectively referred to as the northern sub-catchment. The area can be taken as representative of much of the Toolibin catchment with the exception of the most westerly upper catchinent where slopes and soils are more like those in the Narrogin Shire (i.e. west of the “Meckering line”).

3.1 General landuse

The landuse of the sub-catchinent is based on a mixed grazing and dryland cropping system of agriculture. Sheep are raised for wool and meat production and wheat is grown as the main crop. Barley, oats and lupins are also sown on a smaller scale. At present, commodity prices are tending to favour an expansion in wool production at the expense of cropping although this does not necessarily represent a long term change in landuse, There has also been a marked fall in barley sowings in recent years and a general trend to increased lupin production. In the surrounding district other minor landuses include the raising of cattle and angora goats, and the conservation of flora and fauna. Representative landuse statistics can be taken as those of the Wickepin Shire shown below in Table 1.

Table 1. Agricultural Production Statistics in the Wickepin Shire (Australian Bureau of Statistics, 1987 and 1988)

Number of farming establishments	**130 (approximately)**	
Cropping	**area cropped (ha) 1986/87**	**mean yield (t/ha) 1982-87**
- wheat	49,500	1.39
- barley	1,000	1.18
- oats	7,500	1.09
- lupins	5,300	0.89
Livestock		
- number of cattle*		1,300
- number of sheep		375,100
- total woolclip†		2,084,900 kg
- average weight of wool shorn per sheep (excluding lambs) †		5.27 kg

* At 31 March 1987
† For year to 31 March 1987

3.2 Land management units

Land capability is the ability of the land to sustain a landuse, in the long term, without being degraded. In the Wickepin district the various soil types differ greatly in their capabilities and therefore in the management they require to avoid degradation. This section describes how areas having similar soil types and capability, or requiring similar management can be classed into recognizable land management units and then farmed accordingly.

Most of the land area in the northern sub-catchment falls into the seven main land management units listed below. There are also several soil types and management units represented elsewhere in the catchment or not covering large areas which are described briefly.

3.2.1 Saltland

Within the sub-catchment large areas of the flats have become saline, ranging from marginally affected land to severe scalds with crusted salt. Where the watertables have come within about 1.5 m of ground level, capillary rise and evaporation have resulted in saline groundwater being drawn upwards and the accumulation of salt at the surface. So far the areas most affected and potentially at risk appear to be those at the edge of the flats at the base of sharp slopes. At several sites this also corresponds to where the ground level is lowest, being 50 to 100 cm below the surrounding flats and therefore the first affected by rising watertables (McFarlane ~ ~.1., 1987). Another factor possibly influencing where the scalds are developing is soil texture. The reddish loam soils, typically found at the base of the slopes are likely to be subject to considerable capillary rise and rapid salt accumulation at the surface. In contrast the highly impervious grey clays may be hindering the development of scalds over large areas of the flats, despite their potentially higher capillary rise.

Although not found in the northern sub-catchinent smaller areas of salinity and saline seeps occur in surrounding areas of the upper catchinent, probably associated with breaks of slope, dolerite dykes and localized highs in the underlying basement rocks. In these areas the most important effects of the salinity are often in spoiling of water supplies and causing water erosion rather than the large scale loss of productive land.

Management and problems

Fencing the saltland off from stock is essential. Further management options depend largely on the extent and severity of the salt affected site and on economics.

On bare salt, especially where water ponds in winter, the best that is likely to be achieved is a ground-cover of Samphire (Halosarcia spp.). This is easily propogated and if already growing in the immediate vicinity should volunteer itself once the area is protected from stock. Samphire provides valuable emergency feed or can be carefully grazed each autumn (Malcolm and Cooper, 1982).

On moderately affected sites it should be possible to return the land to production through the establishment of salt-tolerant forage shrubs or grasses. Suitable species include Wavyleaf saltbush (Atriplex undulata), River saitbush (A. amnicola), Grey saltbush (A. cineria), Bluebush (Maireana brevifolia), Tall wheatgrass (Agropyron elongatum) and Puccinellia (Puccinellia ciliata) (Malcolm, 1986). Self-regenerating varieties of River saltbush have been identified and should be available in the near future. Established pastures of these plants can be crash-grazed during the autumn feed gap at stocking rates up to the annual equivalent of 4 dry sheep equivalents per hectare.

Where salinity develops along creeklines or as confined seepage areas, high water-using salt tolerant trees can be planted to dry out the scalds. In many cases the areas affected below the seepages are much larger than the seeps themselves and trees may only be needed on relatively small areas. The planting of trees may also offer the best chance of economically reclaiming marginally affected saltland. Rows spaces 25 to 30 m apart with overall densities of 80-100 trees/ha can lower immediate watertables by 70-100 cm and in some cases have enabled the re-establishment of subclover pastures between the trees (Negus and Engel, unpublished). Department of Agriculture advisers are available to assist planning this kind of work and can give estimates of the numbers and types of trees needed.

Deep drainage has been used at a number of sites in Western Australia to reclaim saltland and in some cases has been very successful. Unfortunately there are several drawbacks and careful consideration must be taken of these drawbacks at potential sites. Apart from the very high installation costs and difficulty in making it a cost effective alternative, a major problem is usually the disposal of the saline water collected by the drains. There is very little grade on the flats and broad valleys to get the effluent away and legal constraints prevent it from being discharged onto neighbouring properties, natural watercourses, roads and Crown reserves. Therefore, as a way of tackling saline scalds, deep drainage is unlikely to have much use within the Toolibin catchment or surrounding districts.

The use of mechanical pumping to lower watertables has similar problems of saline effluent disposal and high installation costs as well as considerable running costs. It has been successfully used at sites where saline seeps are causing the salting of valuable irrigation dams. However even in these cases it is often seen as a short term measure until strategically planted trees can effectively lower the watertable. A major limitation of pumping is often the low hydraulic conductivity of the subsoils and the resulting localized drawdown at the bore. Hence on broad areas underlain by kaolinitic clays (pipeclay) such as the Toolibin flats, large numbers of bores would be needed making the whole exercise prohibitively expensive.

3.2.2 Heavy valley soils

These soils cover large areas of the flats and up into the valleys. They range from the hardsetting grey clays usually associated with Salmon gums to the redder, more workable loams and clay-barns found with York gums and Morrels. On wetter depressions the native vegetation becomes dominated by Swamp sheoaks and Paperbarks.

A typical profile consists of a shallow sandy-loam to clay-loam topsoil passing into a sandy-clay subsoil, often with mottling. At depths of 1 to 2 m the whole profile is usually underlain by white kaolinitic pallid zone clays which can extend for considerable depths to fresh rock.

Profile 1. On the clay-flats north of Lake Toolibin among Salmon gums

0 to 13 cm	brown/dark brown	(10 YR 4/3)	sandy loam	pH 6
13 to 18 cm	brown	(10 YR 5/3)	sandy clay	pH 6
	with strong brown	(7.5 YR 5/6)	mottles	
18 to > 50 cm	pale brown	(10 YR 6/3)	sandy clay	pH 9

Management and problems

In general the hardsetting grey clays are suited to pasture and should be sown to Circle Valley medic. Due to difficulties in the control of broadleaf weeds in medic pastures periodic cropping every four to five years may be necessary. Successful crop establishment can best be achieved using chemical weed control, reduced tillage and sowing as early as possible. On the more easily cultivated soils a shorter rotation (eg. 1

in 3) of crop and pasture may be preferable and help use more of the water stored in the profile. Field peas can be grown in the rotation as a grain or fodder crop provided the site is safe from waterlogging.

Soil structure decline is often not seen as a major problem by farmers and these heavy valley soils, particularly the grey clays are usually assumed to have always had poor structural properties. Contrary to this one farmer in the northern sub-catchment reported that land which had probably suffered from excessive cultivation by a previous owner responded very well to minimum tillage with noticeable improvements in soil structure. This is consistent with the numerous trials demonstrating the damage caused by excessive tillage on heavy soils contrasting with the benefit of reduced cultivation. The use of chemical weed control can also avoid yield losses through delayed seeding or alternatively the damage caused by cultivation in adverse conditions. Cultivation in too wet or too dry conditions is both difficult and damaging to soil structure. A single application of gypsum may be useful in the first year of reduced tillage, after which minimum tillage alone should be sufficient to improve soil structure.

Wind erosion is probably underrated as a form of land degradation on the heavy soils. The accumulation of clover and medic burr on fence lines is common throughout the region in summer and is probably more cause for concern than the unsightly sandblasting on unproductive Banksia sands. The reduction in pasture seedling density and removal of nutrients, particularly nitrogen, from these agronomically useful soils may be causing significant losses to productivity and reducing the long-term potential of the soils.

Waterlogging and flooding adversely affect crop and pasture production and compound other forms of degradation such as salinity and soil structure decline. Investigations conducted within the Toolibin catchinent indicate that significant groundwater recharge can occur on the flats immediately after heavy rain or flooding (McFarlane ~ ~., 1987). Recent studies have also shown that while crops can tolerate short periods of waterlogging with very little damage, longer periods of flooding and the combination of very low salt levels with waterlogging can reduce yields greatly (Barrett-Lennard, personal communication). For these reasons it is desirable to get excess water off low-lying areas quickly. Unfortunately this is made difficult by the lack of grades both along the valleys and further downstream along the North Arthur River. Several of the farmers affected by flooding have recently sought to deepen natural watercourses or to confine them with levee banks. While offering some protection from flooding it is unlikely that these structures will be able to greatly improve the flow of water away from the flats partly because of the inherent flatness of the landscape but also a lack of connecting drains. Solutions to the problem are presently under investigation by officers of the Departments of Agriculture and CALM, the Wickepin SCD and farmers. Future work is likely to be aimed at integrating existing structures and removing obstructions to surface flow.

Because the valleys and flats are the areas most prone to salt encroachment they should be monitored for the appearance of Barley grass or patchy crops.

If identified, salt-affected land should be fenced out as soon as possible to prevent stock from camping on the area and before its severity makes revegetation more difficult.

3.2.3 Sand over clay soils

These duplex (texture contrast) soils cover very large areas both on the flats and on the gently sloping valley sides. They are associated mainly with White gum and Jam, and also Salmon gums where the clay is quite shallow. White gum usually predominates where the sandy topsoil is deepest and where shallow sand seams occur on the flats. In some areas of upper catchment pisolitic gravel is present in the subsoil and the vegetation becomes dominated by Mallees.

Normally these duplex soils consist of dark grey or brown sandy A horizons passing sharply into pale brown sandy-clay subsoils at depths of up to 60 cm. In some profiles in low lying areas bright orange mottles and soft concretions at the top of the B horizon indicate the presence of a seasonal perched watertable. Occasionally the sandy topsoil directly overlies white pipeclay.

Profile 2. On a gentle valley slope among Salmon gums and White gums

0 to 20 cm	greyish brown	(10 YR 5/2)	loamy sand	pH 6.5
20 to 40 cm	pale brown	(10 YR 6/3)	sandy clay	pH 9

Management and problems

Generally these soils are well suited to both cropping and grazing. The traditional 1 in 3 rotation of cereal crop and clover pasture has proven itself well on this land class. Lupins can also be grown in the rotation particularly on the deeper soils and where waterlogging is not a problem.

Where these soils are found on slopes (often 2 or 3%), or below high runoff areas such as mallet hills, water erosion can be a problem. Aerial photographs taken of the region in December 1983 after an exceptionally wet early winter indicate that rill erosion and sheet erosion on cultivated paddocks can be considerable. It is recommended that where known erosion hazards exist grade banks at grades of 0.4 to 0.5% should be used in conjunction with cultivation on the contour. If no safe disposal point for the runoff is available, absorption banks or structures for spreading the water can be used.

Waterlogging can occur in the shallower duplex profiles where the problem takes the form of restricted internal drainage rather than surface ponding. Root growth in crops can be seriously stunted, both through the direct effects of waterlogging and from root rot diseases. Where appropriate reverse-bank seepage interceptors (Negus, 1983) and grade banks upslope are recommended.

At high stocking rates and after poor seasons, wind erosion can be a major form of degradation. One of the disturbing aspects of the problem is that the fertile dust and fine clay materials are capable of being removed at wind speeds much lower than those required to produce visible erosion events. On cropped paddocks it is essential that sufficient standing stubble be retained to roughen the surface and reduce wind speeds over the soil to safe levels. It is also critical that farmers remove stock from pastures before overgrazing occurs which may lead to wind and/or water erosion. In the longer term well placed windbreaks offer increased protection but can still not be relied upon to prevent erosion when overgrazing is practised.

3.2.4 Brown loamy soils on moderate slopes

On several prominent slopes rising sharply from the flats rich brown soils occur associated with Morrel woodland and sometimes York gums. The presence of lime in the subsoil and their position in the landscape suggest these soils may have formed quite recently on wind blown lake parna or possibly in-situ on basic parent materials. They are typically gradational with increasing soil pH trends and strong colours throughout. At the top of the slope they can contain a high proportion of pisolitic gravel, presumably of lateritic origin.

Profile 3. On a moderate slope under pasture

0 to 14 cm	dark brown	(7.5 YR 3/2)	light sandy clay loam	pH 6.5
14 to 25 cm	strong brown	(7.5 YR 4/6)	sandy clay loam	pH 7.5
25 to 50 cm	strong brown	(7.5 YR 4/6)	sandy clay	pH9.0
	with lime nodules at 25 to 30 cm			

Management and problems

These soils are the best agricultural soils in the district being relatively fertile, well structured and free from waterlogging and high runoff. Water erosion is generally not considered a problem by farmers and cultivation on the contour may give sufficient protection without the need for banks.

Of the soils in the district these seem particularly suited to ‘agronomic manipulation’ or high water-using options to counter rising watertables. On the morrel slopes rainfall infiltrates readily and is preferably made use of rather than being left to percolate beyond the root zone to the groundwater below. The quantity of water involved each season is not large and is measured in terms of millimetres but the cumulative amount year after year over vast areas is substantial. In experiments conducted over two years at Cunderdin and Kondut, water-use was measured for cereal and lupin crops and found to range between 50 and 90% of growing season rainfall (Nulsen and Baxter, 1982). In the same experiments the sub clover pastures only made use of between 20 and 40% of this rainfall. Thus the choice of rotations can clearly make a major difference to water-use. Similarly nitrogen applications can bring about large increases in the leaf area of a crop and therefore its water use. Considering that these slopes are often found immediately above salt scalds, shorter rotations of crop and pasture may be the preferred management.

3.2.5 Infertile grey sands

Bleached grey sands, often referred to as Banksia sands, 'gutless' sands or spillway sands, are common on the higher catchment divides. When .incleared they are associated with the Western Australian Christmas tree (Nuytsia floribunda), Slender banksia (Banksip pttenuata) and heath species. Generally profiles consist of sand overlying mottled concretions and gravel at depths varying from 50 cm up to several metres.

Profile 4. On a gentle slope behind a breakaway

0 to 10 cm	light brownish grey	(10 YR 6/2)	sand	pH 6
10 to 70 cm	very pale brown	(10 YR 7/3)	sand	pH 6
	concretions at 70 cm			

Management and problems

These areas are best left uncleared. Where already cleared they are difficult to maintain with an adequate ground cover and are highly susceptible to wind erosion. They do not grow very good pastures and are often dominated by weed species such as Geranium (Erodium spp.) and Silver grass (Vulpia spp.).

Several potential uses for these areas have been suggested. On sufficiently large sites Western Australian blue lupins may be considered as a grazing crop, Given that they are poor agricultural soils and almost certainly act as recharge sites for catchment groundwater, another option is the establishment of deep-rooted perennial plants to transpire as much water as possible from the system. Tagasaste or tree lucerne (Cytisus proliferus) is one species currently being investigated for use as a fodder plant. It has already been successfully planted on several sites within the Toolibin catchment. The establishment of suitable pines is also being attempted in the district, although indications are that growth rates will make commercial harvesting uneconomic. It should be noted that Pinus radiata, while relatively easy to establish, is not suited to the area and that the less easily established Pinus pinaster has a better chance of growing to a healthy mature tree. At a site 10 km east of Wickepin several other tree and shrub species are being tested which may prove suitable for on-farm timber, marketable wildflowers or fodder.

3.2.6 Rocky ironstone surfaces and gravels

Rocky ironstone surfaces occur in the upper catchment, often associated with large areas of grey sands or the backslopes of breakaways. The grey or pale brown sandy surface contains ironstone concretions and rocks up to 30 cm or more in diameter. This usually passes into dense gravel or clay at shallow depths. In some areas dense pisolitic gravel is present at the surface. The native vegetation is often of the heath form including Kerosene bush (Dryandra spp.) and Ti tree (L.eptospermum spp.) or sometimes White gum, Rock sheoak and Mallees.

Management and problems

While not the best soils in the district these areas often grow reasonable clover pastures given sufficient phosphorus fertilizers. Depending on the size of the ironstone, cultivation may be possible but can cause serious wear and tear on machinery. In some instances rock-rollers have been useful for reducing the size of the boulders.

3.5.7 Breakaways and mallet bills

These steep slopes are common in the upper catchment associated with Brown mallet, Blue mallet and White gum. At the top of the hill there is often an ironstone cap giving way down the slope to exposed pallid zone clays or shallow profiles developed on this material. The surface is water-repellent and often overlies subsoils with distinct pink colouring.

Management and problems

These areas have very high rates of runoff and should not be cleared. Where the native vegetation has deteriorated the fencing of these hills is recommended to allow natural regeneration. In such cases it may be necessary to break up the surface soil to some extent to catch seed and rainfall. Alternatively the planting of seedlings can be attempted.

Grade banks may be used to control water erosion downslope, provided a safe disposal point can be found for the excessive runoff. In the absence of a safe waterway absorption banks are needed.

3.2.8 Other units

Although large areas of yellow sandplain do not occur until further east of the Toolibin catchment, areas of pale yellow, light-textured gravelly soils do occur toward Dudinin. While they are not found in the northern sub-catchment they would probably represent a significant management unit further east.

Pockets of non-wetting sands are reported to exist at some sites and may likewise need to be considered as a separate unit.

Small areas of strongly coloured yellow sand occur on the flats associated with riverine deposits. These soils are probably more fertile than the grey sands but generally not sufficient in area to be treated as a separate land class.

Similarly areas of very red and often rocky soils occur associated with dolerite dykes but only as small patches. Apart from their tendency to fix large amounts of applied superphosphate these soils are quite fertile.

3.3 Conservation farm planning

Planning the management and layout of farms with regard to soil conservation has been practised in the region for several decades. In recent years it has become increasingly important for the following reasons:

(a) The severity and rate of land degradation in the region is now seriously threatening agricultural productivity. These problems must be addressed urgently but need to be tackled within a long term framework. For instance the planting of windbreaks and the construction of drains and flood control banks all need to be fitted into a well considered, overall plan and not treated in isolation. Similarly where grade banks and contour cultivation are needed, suitable paddock boundaries should be planned and possibly surveyed now, even if refencing is not done until later.

(b) There is greater need in current farming systems to base paddocks on similar soil types or areas requiring the same management, i.e. land management units. As management options have become greater in number, increasingly they have become soil type dependent. The various crops and pasture species grown today can be suited to or tolerant of very different soil conditions. Greater efficiency can often be achieved by separating the land management units present. If areas in a paddock not suited to cropping are fenced with other non-arable land they can be grazed and managed separately rather than continually growing poor crops that lower the average yield and net returns. Fencing to soil type can also avoid degradation problems such as the wind erosion experienced on poor soils when a paddock is stocked to its average carrying capacity. Similarly, paddock boundaries can be used in steeper country to separate areas safe for cropping from those which are not.

In the northern sub-catchment much of the scope for conservation farm planning is in realigning fences and paddocks to fit the lay of the land more closely. At present a lot of the fencing is still based on the rectangular lines on which the land was first surveyed at the time of release and does not take into account ridges, breaks of slope, creeklines and waterways etc.

Fencing to soil type or management units has been carried out to some extent. The fencing of saltland has generally been completed and these areas are now being managed separately. Infertile sands have also been fenced at a number of sites and planted to trees or tagasaste. However deliberate attempts to plan fencing around the other land management units has generally not been attempted.

There is also a need on most farms to plan for small, well timbered paddocks surrounded by effective windbreaks. Such areas are necessary for sheltering stock after shearing and in severe weather. Officers of the Department of Agriculture recommend that they can also be used for holding stock during our unavoidable droughts when pastures are beyond the safe limits of grazing and feedlotting is needed.

Several factors tend to limit the potential for paddock reorganization, in particular the lines of native trees along fencelines, the locations of existing water supplies and the numerous separately owned and comparatively small blocks in the area. Tree lines need not prevent fences from being repositioned and several farmers have already been prepared to separate the two where needed. Problems with dams and small blocks may not be as easily worked around but should not stop various possibilities from being explored.

Within the full Toolibin catchment about half of the 50 landholders have now had conservation farm plans drawn up on large aerial photographs with the assistance of Department of Agriculture staff. This is expected to increase over the next year or so. Their implementation will probably take place over a 10 to 15 year time span as fences need replacing and finances allow. It is important that after this current run of farm planning is completed farmers be made aware of the need for their plans to be revised and updated regularly as management practices, landuse and problems continue to change.

4. Tooliban Flats Rehabilitation Project

In the long run the fate of Lake Toolibin will depend heavily on the success or failure of the Toolibin Flats Rehabilitation Project. While inflows to the lake are desirable to maintain downward heads on the lakebed, salt washed in from the saline land upstream poses one of its most serious threats. The possibility of selectively diverting the most saline flows is currently being considered and may eventually improve the situation. In the mean time rehabilitation of the affected land is an immediate course of action in the best interests of both farmers and the lake.

4.1 Aims

Since its formation the Wickepin SCD committee and the Department of Agriculture, Narrogin have been organizing the project in co-operation with Greening Australia (W.A.) and eight of the farmers most seriously affected. The main goals for the project include:

- bringing badly salt-affected land back into production;
- reducing surface salt accumulation by maximizing vegetative ground cover;
- establishing high water-using salt-tolerant trees on moderately affected land to lower watertables and reduce ongoing encroachment;
- using the project as a large scale demonstration.

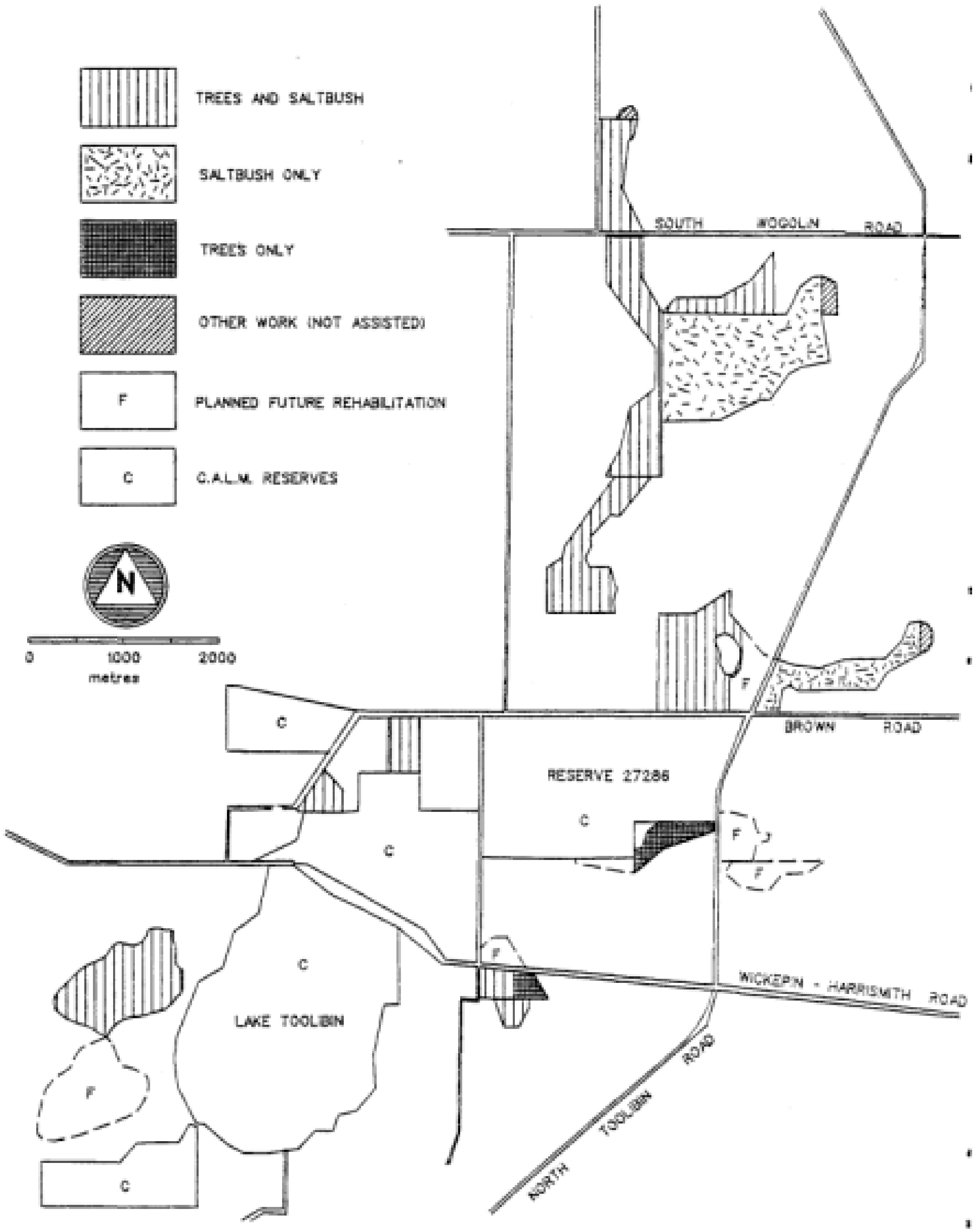
4.2 Approaches taken

The approach advocated by the Narrogin Department of Agriculture and most widely implemented has been the planting of salt-tolerant trees in north-south rows 20 to 25 m apart with saltbush sown between the tree rows. Within the rows trees have been planted about 5 to 6 m apart to give a density of roughly 80 to 100 trees/ha.

On two large sites, together comprising some 190 ha, the farmers involved opted to plant only salt-tolerant forage shrubs. This was largely because of the scale and severity of the scalds and difficulties already being experienced in tree establishment. On the northernmost site samphire has already become well established and covers a large area of previously bare surface.

A third approach chosen by one of the farmers for two of his sites was the planting of solid stands of trees at densities of about 200 trees/ha. This was only attempted where there was no intention of returning the land to production. Because of the higher numbers of trees required this could only be done over limited areas.

FIGURE 4 TOOLIBIN FLATS REHABILITATION PROJECT



4.3 Saltbush seeding

The main species sown so far is Wavyleaf saltbush (Atriplex undulata) largely because of seed availability. Small amounts of River saltbush (A. amnicola), Old man saltbush (A. nummularia), Grey saltbush (A. cinerea), Silver saltbush (A. bunburypnp), Quailbrush (A. lentifprmis) and A. halimus have also been tried either separately or in 'shotgun' mixtures with Wavyleaf saltbush. In 1987 an attempt was made to facilitate the spread of Bluebush (Maireana brevifolia) by placing several handfuls of seed in each drum of vermiculite mulch used during saltbush seeding.

To date about 520 ha of salt affected land have been sown to saltbush. The results have so far been very inconsistent and highlight the difficulties still faced with the niche seeding technique. One of the main problems is clearly our dependence on favourable seasonal conditions. While the 1985 sowings were quite successful, the much larger areas sown in 1986 were very disappointing due mostly to the dry spring in that year or possibly poor quality seed. In 1987, the dry July and August allowed seeding to be done earlier than normal when the areas would usually be unworkable and boggy. This and good follow-up rains appear to have favoured germination and helped the large areas sown to become established.

A second main factor affecting results has been soil type. Establishment has been most successful on the loamy soils but attempts at niche seeding on the hardsetting grey clays have tended to fail until 1987. Possible explanations for this include: (1) poor leaching of salt from the grey clays, (2) the clay's rapid crusting after light rains, (3) the clay's high bulk density hindering penetration by emerging radicles (Malcolm, personal communication).

Insects and mites have probably also caused significant damage. The redlegged earth mite (Halolydeus destructor) and lucerne flea (Sminthurus viridis) may account for much of what was apparently failed germination. In 1987 lucerne flea was observed on the grey clays feeding on the germinating saltbush seedlings four weeks after sowing. At a nearby site in the district one farmer reported about a dozen different pests among emerging seedlings. It was also reported by another farmer's wife that in a germination test in the garden emerging saltbush seedlings were being eaten as quickly as they came up without any sign of the pests responsible.

4.4 Tree planting

Tree planting commenced in 1985 with some 24,000 seedlings being planted by local school children and interested parties. A further 24,000 trees were planted in 1986 and 9000 in 1987.

Numerous problems have been experienced in establishment and overall losses in the three years have been considerable. In 1985 heavy losses occurred due to the extremely dry season and in some cases the fact that the most severe sites were tackled first. Deaths also occurred in 1986 and 1987 but to a smaller extent. As a result between a third and half of the total 57,000 trees must be considered as replants.

Problems were also experienced with the waterlogging of seedlings mechanically planted in furrows. Conversely drought stress was a problem where planting was on the top of high mounds. A technique which seems to be quite successful is the planting of seedlings in 15 cm furrows on top of 20-30 cm mounds. This not only gives protection from ponded water but facilitates leaching as in the niche seeding of saltbush.

The species used are ranked below roughly from most to least successful.

Species	**Number planted**
Flat-topped Yate (Eucalyptus occidentialis)	19,300
Swamp Sheoak (Casuarina obesa)	21,500
River Red Gum (E. camaldulensis)	900
Swamp Mallet (E. spathulata)	200
York Gum (E. loxopheleba)	2,600
Kondinin Blackbutt (E. kondininensis)	700
Coastal Moort (E. platypus var. heterophylla)	150
Tasmanian Bluegum (E. globulis)	250
Tamarisk (Tamarix spp.)	5,800
Wattles (Acacia baileyana, A. podalyriifolia)	5,800

The Flat-topped yate has been the most successful of the eucalypts and accounts for much of the 1986 and 1987 plantings. Two year old trees at some sites are already well over 2 m high with thick healthy foliage. When mature these trees have a high flattened canopy and a form considered ideal for their intended role (Negus, personal communication). Unfortunately a potential insect problem exists in a defoliating lerp (Cardiaspina sp.), which has recently devastated native stands of this tree in southern regions. To date no trouble has been experienced in the Toolibin area but CALM advisers have suggested that planting mono-cultures of Flat-topped yate may be unwise.

Swamp sheoaks have been the most salt tolerant of the species. Unfortunately continual pruning by rabbits and kangaroos has retarded their growth in many cases. Doubts about their low water-using potential have been raised but some benefit must be expected from whatever transpiration does occur. In addition their eff3cts in shading, mulching and reducing wind speeds may help reduce surface salt accumulation on severe sites.

The York gum and Kondinin blackbutt were first planted in 1987. As yet it is too early to assess their survival but both are native to the general region and could be useful in the future.

The Tamarisk cuttings and Wattles were planted in 1985 and were a complete failure. This was possibly due to the dry season and shortcomings in the planting technqiues used. No further attempts to establish these species have been made.

4.5 Outlook

Tree planting will hopefully continue for as long as possible with up to 150 ha of salt affected land planned for future rehabilitation. Unfortunately it is likely that some farmers will find it necessary to reintroduce stock to treated areas before new sites are attempted thus limiting further replantings or delaying new work.

The saltbush plantings will have to be persevered with until satisfactory grazing pastures are achieved. Because establishment has been so unreliable with niche seeding techniques and because of the make-or-break nature of seasonal conditions, saltbush plantings have been tending toward a low cost approach. The use of black paint and high vermiculite rates have been impractical on 50 to 100 ha sites due to cost. In the future the use of sure but more expensive techniqes may be attempted instead. For instance the planting of saltbush seedlings may prove a better technique on the areas of hard-setting grey clays. If a reliable method can ensure establishment and immediate grazing potential it may be more economical in the long run than attempting partially successful niche seeding over two or three years.

The planned setting up of seed nurseries in the district with the best known species and strains of saltbush should provide for greater availability of River and Grey saltbush and allow major cost savings. Already the collection of over 100 kg of Wavyleaf saltbush seed from one of the small 1985 sown sites has led to considerable savings for the project.

The project has already received recognition for its commitment and community involvement in being awarded the 1986 Countrywide Tree Care Award from the ABC. It is intended that as plantings mature and become more visually impressive it will be widely used as a demonstration of this approach to saltland management.

4.6 Assistance

The main financial support to the project has been from State Assistance to Soil Conservation. Funds were provided for 50% cost sharing of fence erection and the full costs of transporting seedlings, grading ridges and several minor expenses. Additional funding was received from Greening Australia (W.A.) and the Australian Bicentennial Authority for the purchase of seed and tree seedlings. The National Soil Conservation Programme provided funding for the purchase of a saltbush seeder for use throughout the Wickepin SCD.

Alcoa of Australia Ltd donated some 35,000 trees or about 65% of those used through their Greening Australia Support Scheme. Contributions have been received in one form or another from the Wickepin Shire, the Department of Conservation and Land Management, the Agriculture Protection Board, Terra Trading Co. Pty Ltd, Hoechst

Australia Ltd, I.C.I. Australia Operations Pty Ltd, and Langley Chemicals. There has also been substantial input by way of planning, supervising and labour from Mrs Tern Lloyd (Greening Australia W.A.), Mrs Lyn Chadwick (Secretary of the Wickepin SCD) and officers of the Narrogin Department of Agriculture.

5. Recommendations

Landuse, management and treatments within the study area need to be considered on a catchment basis if the causes of the land degradation problems are to be addressed. This must include the integration of any attempts to confine flood waters and the linking of drainage structures to existing culverts and roadside drains. For long-term productivity at the farm scale soil conservation measures and management options must also be integrated but, more importantly, landuse and management must take account of the varying capability of the different land types present.

It is recommended that:

(i) The land must always be used and managed within its capability.

(ii) Higher water-use crops and management options should be used where practical. In particular the use of wheat-lupin rotations on poor to medium quality light land is desirable.

(iii) Contour cultivation between well-built grade banks should be used wherever water erosion is a problem.

(iv) Minimum tillage should be used on the heavy valley soils and on soils with a water or wind erosion hazard.

(v) Degraded land should be rehabilitated, preferably with a view to future production.

(vi) As far as possible the establishment of deep rooted trees and perennials should be attempted on land not suited for agriculture.

To be successfully adopted these recommendations need continued extension to both the farming community and, where necessary, to local authorities. Some degree of co-ordination is also essential in future work.

6. Acknowledgements

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