High water use plant options for the Fitzgerald River catchment: a case study

P L. Hill
Nadene Schiller

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HIGH WATER USE
PLANT OPTIONS
FOR THE
FITZGERALD RIVER
CATCHMENT

Patricia Hill and Nadene Schiller

February 2003

High water use plant options for the Fitzgerald River Catchment

A case study

Compiled by Patricia Hill and Nadene Schiller

February 2003

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Summary

The Fitzgerald River Catchment is facing similar sustainability issues to other south coastal catchments. In particular, a priority concern for land managers is the lack of information about available options and where they can be applied to assist in managing salinity.

This report summarises the key outcomes of a new GIS-based methodology for undertaking catchment-scale land capability analyses. The results are then applied to a high water use farming systems land capability analysis.

The project was instigated in order to capture and tabulate existing options for optimising water use on farms. These options were limited to the use of high water use plants relative to existing annual plant-based farming systems. The objective was to develop methodology for identifying feasible high water use plant options, and identify areas of the landscape that are capable of sustaining them. This was achieved through tabulating available options and performing land capability analysis in a spatial framework using environmental limitations of each option.

Various water use options are available to land managers in the Fitzgerald River Catchment. However, only a few are suited to the environment and/or management systems. The most suitable options included 18 plants suited to the soils and other environmental and management factors. These plants could be integrated into existing systems with minimal risk. Land capability analysis demonstrated that small changes to current farming practices were required to increase the water use of some areas while minimising (though not eliminating) the risk of failure.

High water use plant options found to be suited to most of the Fitzgerald River Catchment include various native grasses, kikuyu, puccinellia, lucerne, oil mallees and tall wheat grass. Several other options were identified for smaller areas, and need to be considered by individual land managers as filling a particular niche in suitable environments.

The case study proved invaluable in highlighting some of the deficiencies that inhibit the development of high water use farming systems. In particular, the limited availability of environmental data at catchment or farm scale was difficult to extrapolate to local situations. For this reason, integration of the plant options into the current system by land managers will be enhanced by local demonstrations.

One of the key characteristics of this study was that it berepeatable, efficient and applicable to similar catchments. While the maps are specifically related to high water use plant options for the Fitzgerald River Catchment, many plants are described in terms of their environmental and management requirements. This summary will enable individual land managers (regardless of geographic location throughout Western Australia) to consider whether to integrate them into their systems. Furthermore, the land capability analysis methodology framework will enable groups to undertake similar analyses to assess their regions in terms of suitability for various high water use plant options. This research provides exciting opportunities for salinity management throughout the agricultural regions of Australia.
1. Introduction

Patricia Hill

The South Coast Regional Initiative Planning Team (SCRIPT) recognised in 1996 that salinity management is a necessary activity on farms in the South Coast of WA, with an estimated million hectares of land at risk from salinity and reduced agricultural production. Increased salinity will also result in the loss of valuable water resources, wetlands and riparian vegetation, causing significant damage to adjacent nature reserves and the Fitzgerald River National Park.

During planning, a number of sustainability issues including soil acidity, rising groundwater tables and salinity, and the economic sustainability of current farming systems were identified in the Fitzgerald River Catchment.

To address the salinity issue, a project was initiated to examine the potential to integrate high water use plant options into existing farming systems to combat rising water tables and reduce salinity.

1.1 Project objectives and aims

In order to address salinity, it is imperative that farming systems are developed that have the highest water use possible. Land managers may develop systems with relatively high water use by integrating plants that use more water into existing systems. The feasibility of each proposed plant option is determined by:

1. Ability of the environment to sustain the option;
2. Capacity of the current farming system to integrate the option;
3. Profitability of integrating the option; and
4. Likelihood that the land manager will adopt the option.

The aim was to develop a methodology for quantifying these factors, with the first two being the central focus. This report summarises the first step: quantifying the environment’s ability to sustain the proposed high water use options. Specifically, it provides details of the application of developed methodology to a case study region, the Fitzgerald River Catchment, in order to verify the validity and usefulness of the methodology.

1.2 Approach taken

The basis of the project is a farming systems land capability analysis which, with interaction with land managers, assists in ascertaining the suitability of various high water use options. In addition, emphasis was placed on increasing land managers’ awareness of sustainable farming systems.

This analysis serves as a case study for integrating high water use farming options into future catchment planning processes. It therefore needs to be repeatable, accurate and feasible so that it may be applied readily.
1.2.1 Project plan

The perceived salinity management issues within the catchment were identified and prioritised with the catchment group. An action plan was then developed for the project. The action plan tasks were:
1. Development of project;
2. Establish dataset collection procedure and collect datasets;
3. Soil analysis for prescribed nutrients;
4. Analysis of datasets resulting in high water use farming system options;
5. Land capability analysis of the Fitzgerald River Catchment; and
6. Extension of results to catchment group.

This report deals with steps 1 to 5.

1.2.2 High water use farming systems

Salinity can be managed by reducing recharge to groundwater, increasing groundwater discharge and productive use of salt-affected land (Bowyer 2001).

It is well documented that annual plants and pastures do not use as much water as perennial native vegetation. Much of our landscape has been altered for agriculture, and consequently many land degradation issues have arisen, including salinity.

It is important that a sustainable balance is reached between agriculture and the environment, and one way of achieving this balance is through high water use systems. These take up more water than annual systems, and as a consequence less water is recharged to the groundwater.

1.2.3 General outline of methods

Land capability analyses are used to determine the capability of land systems to adequately support a particular activity or land use. The activity or land use is described in terms of its environmental requirements, and the land system is analysed with regard to its capability to meet these requirements. However, it is a feature of these analyses that areas are only capable of supporting a particular activity or land use if no permanent damage is caused by its integration into the existing system.

The requirements for successful implementation of the activity can depend on whether it is:
- physical e.g. climate or soil type;
- social e.g. inclination of land manager to adopt change or the level of support available; and/or
- economic e.g. profit margin, distance to market for the new activity or capital required to integrate activity into existing system.
It is therefore possible to assess each part of the landscape and theoretically determine whether it is capable of supporting a particular land use without causing permanent damage to the existing resource.

Historically, land capability analyses have been performed using a set methodology as described in ‘Land Capability Assessment and Methodology’ (Wells and King, 1989). This relies on three key steps:

- Identifying the requirements of a particular land use in order for it to be successful;
- Analysing the existing environment and deriving land mapping units; and
- Matching the proposed land use with units that are capable of supporting them.

The land systems of the Fitzgerald area have been classified and mapped using a hierarchical mapping unit system (see section 3.4). This enables soil-landscape units to be classified according to their environmental features, and grouping of areas with similar characteristics. For example, within the Upper Fitzgerald System (which includes moderately incised valleys and moderately inclined slopes), soils can be expected to be mostly Alkaline grey sandy and/or loamy duplexes. This unit is therefore associated with a suite of environmental limitations, and may or may not be capable of supporting a particular land use. For example, it would be incapable of supporting the integration of a land use that required acid soil.

This methodology provides benefits for land capability analysis where the landscape is predictable (i.e. where a robust catena exists), because a region can be readily assessed using broad predetermined mapping units. However, many land managers have observed that the Fitzgerald landscape varies within very small distances, and broad mapping units may not be precise enough in determining whether a particular area is capable of supporting a particular land use. For example, within any particular paddock there may be five different soil types, only one of which would be capable of supporting a proposed land use.

To overcome this problem, an innovative methodology was proposed. This allows every sampled point on the landscape to be assessed independently of the surrounding locale, so that even very small areas could be identified as capable of supporting a proposed use. This is particularly relevant to high water use plant options because in some cases it is desirable to grow the new plant in small areas. For example, a 5 ha parcel of land that is moderately saline (within a paddock in which there is no other salinity) may be better suited to growing tall wheat grass, while the rest of the paddock may still be used for lucerne.

The proposed methodology is possible using geographic information systems (GIS). GIS allows each environmental property to be assessed independently, accepting or rejecting each point of the landscape as being either capable or incapable of supporting any proposed land use. Each of the requirements for a land use (e.g. soil texture, pH and salinity) can be assessed across the landscape, resulting in maps of areas capable of meeting all of the requirements. Land managers can then use these maps to identify the plant options that are best suited to the environment. The approach does require additional data collection outside that already held in the hierarchical mapping unit system, and this approach was used here.
2. Fitzgerald River Catchment

Nadene Schiller

2.1 Background information

2.1.1 Location

The Fitzgerald River Catchment is about 20 kilometres east of Jerramungup townsite and about 400 kilometres south-east of Perth (see Figure 1). It encompasses 104,000 hectares of which 35% is cleared of vegetation. The largest area of vegetation is within the Fitzgerald River National Park.

![Figure 1: Location of Fitzgerald River Catchment](image)

2.1.2 Land use

There are 34 individual land owners, with most managers owning and managing more than one parcel of land. The main use of cleared land is broad-scale agriculture, primarily winter cropping and livestock. The cropping rotations and production mix vary due to soil type, capital structure and individual preference, which all determine the range of crop and livestock enterprises on each property.
Existing land use significantly influences the suitability of high water use plant options if it is desirable to maintain existing systems. For example, winter cropping is highly compatible with oil mallee alleys but not necessarily with tagasaste if the land manager does not run cattle.

In addition to crops and stock, 35% is within private bush remnants, nature reserves, Crown land and National Park. Other minor land-uses include tourism and recreation.

2.1.3 Climate

The catchment experiences a Mediterranean climate with cool wet winters and dry hot summers. Temperatures can range from 0°C in winter to 45°C in summer. Average annual rainfall is between 400 and 450 mm (Jacup records 448 mm) but can vary by more than 100 mm. Approximately two-thirds falls in the six months between May and October. Significant summer rain may be experienced.

Figure 2: Annual rainfall in and out of growing season (May to October) from Data Drill

Figure 3: Average monthly rainfall and evaporation (a) and average temperatures for South Fitzgerald River (b). The highest recorded temperature, average maximum and minimum daily temperatures, and lowest recorded temperature (since 1957)* are shown.
2.1.4 Geology

The Fitzgerald River is underlain almost entirely by the Yilgarn Craton with the lower riverine reaches underlain by the Albany-Fraser Orogen. The Yilgarn Craton comprises mainly Archaean granitoid rocks with cross-cutting dolerite dykes associated with the Gnowangerup Dyke Suite (Dodson 1999).

The Fitzgerald is a rejuvenated river that drains south-east, having etched away the weathered granitoid profile and sandplain, exposing granite along the bottom of drainage lines and leaving remnant Tertiary sedimentary rock with laterite profiles exposed on the flanks of low hills (Dodson 1999). This impacts on rooting depth, as plants that require deep soils will not reach full potential on shallow soils over exposed granite. Sandplain covers much of the sediments, and terraces of alluvium line the course of the southerly flowing rivers. These sediments consist of up to 12 m of unconsolidated, poorly sorted gravel, sand, silt and clay derived from erosion of the Tertiary duricrust and basement rocks (Dodson 1999).

2.1.5 Hydrogeology

The catchment has regional aquifers in the Tertiary sandplain with the watertable 10 to 20 metres below the surface. Local aquifers are found in the more dissected granitic landscapes where groundwater occurs in spaces created by joints, fractures and faults, or within pore spaces of the weathered profile. As such, the depth to the watertable over shallow basement areas is variable. Generally, within broad flat valleys where basement is shallow the watertable is within 1 to 2 m of the surface, whereas on top of hills it is much deeper or absent. In the north, valleys are 5 km wide, and contain many small lakes connected by high watertable (Dodson 1999).

Fresh (non-saline) water is associated with two systems:

- Small areas of fresh water near sand dunes where high recharge has resulted in formation of both perched watertables on top of the kaolinitic clay layer and fresher groundwater mounds over saline regional groundwater.

- Near broad ridges consisting of coarse-grained soil profiles derived from granite. These profiles have experienced a high degree of recharge, resulting in profiles that are highly leached. As groundwater tables rise, small volumes of fresh water may be detected.

Neither system can be considered as containing sustainable water resources as they have limited yield capacity, and the supply of fresh water can be exhausted.

2.1.6 Soils

Soils generally comprise Grey shallow (gritty) sandy duplex and Duplex sandy gravels, Grey non-cracking clays, Pale deep sands and Semi-wet soils (Overheu 1996, 2002 and in prep.). Narrow bands of heavy reddish clays, derived from dolerite dykes are also common. Small areas of rich reddish brown colluvial loams are isolated to drainage lines. Pedogenesis is aeolian and colluvial with subsoil clays developing on deeply weathered granitic bedrock (mostly felsic granites) intersected by occasional dolerite dykes.
The (coarse) sandy-surfaced soils are susceptible to wind erosion, topsoil acidification and nutrient leaching. The high hydraulic conductivity of the topsoils, low landscape relief and sodic subsoil clays increase susceptibility to waterlogging. In combination with high evaporation this increases risk of secondary saline enrichment for many soils. The subsoil structure is mostly poor, presenting high susceptibility to structural decline, increasing the risk of traffic pans and poor rooting conditions. The most significant feature is the prevalence of highly acid topsoils.

Soil groups described are shown in Table 1 (Schoknecht 2002). Eight groups comprise over 70% of the study area. The most common is the Grey shallow sandy duplex. Duplex soils cover 40% of the catchment.

Using existing soil-landscape mapping and comprehensive soil analyses, soil-landscape systems and sub-systems have been identified. Five systems have been identified, which are further divided into 15 subsystems (Table 2).

Table 1: Dominant soil groups in the Fitzgerald River Catchment

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Area (ha)</th>
<th>% of catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey shallow sandy duplex</td>
<td>15,062</td>
<td>15</td>
</tr>
<tr>
<td>Grey shallow loamy duplex</td>
<td>13,053</td>
<td>13</td>
</tr>
<tr>
<td>Grey deep sandy duplex</td>
<td>12,049</td>
<td>12</td>
</tr>
<tr>
<td>Shallow gravel</td>
<td>10,041</td>
<td>10</td>
</tr>
<tr>
<td>Semi-wet soil</td>
<td>8,033</td>
<td>8</td>
</tr>
<tr>
<td>Grey non-cracking clay</td>
<td>5,021</td>
<td>5</td>
</tr>
<tr>
<td>Saline wet soil</td>
<td>5,021</td>
<td>5</td>
</tr>
<tr>
<td>Duplex sandy gravel</td>
<td>5,021</td>
<td>5</td>
</tr>
<tr>
<td>Other soils (29 groups)</td>
<td>27,110</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>100,411</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2: Soil-landscape units with soil groups and land degradation risk within the Fitzgerald River Catchment

<table>
<thead>
<tr>
<th>Soil-landscape system</th>
<th>Description</th>
<th>Dominant soil group</th>
<th>% soil group</th>
<th>Degree of land management risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jerramungup System</td>
<td>The long, southerly slope adjacent to the Stirling/Avon Province divide. Level to gently undulating, dissected plateau with relatively low elevation. Dissected by many small tributaries of the upper catchments to large river systems that flow to the coast. Some parts are severely salt-affected and nestings of dolerite dykes are common.</td>
<td>Grey shallow sandy duplex&lt;br&gt;Alkaline grey shallow loamy duplex&lt;br&gt;Grey deep sandy duplex&lt;br&gt;Grey non-cracking clay&lt;br&gt;Saline wet soil&lt;br&gt;Alkaline red shallow loamy duplex</td>
<td>35&lt;br&gt;20&lt;br&gt;15&lt;br&gt;8&lt;br&gt;10&lt;br&gt;5</td>
<td>Moderate soil acidity&lt;br&gt;Moderate to high salinity&lt;br&gt;Moderate structure decline&lt;br&gt;Moderate water erosion&lt;br&gt;Low waterlogging&lt;br&gt;Moderate wind erosion</td>
</tr>
</tbody>
</table>

Subsystems

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jm (6,000 ha)</td>
<td>Undifferentiated system level unit occurring only within the Magenta Reserve. May represent all subsystem units from Jm1 to Jm6</td>
</tr>
<tr>
<td>Jm1 (6,603 ha)</td>
<td>Level to only very gently inclined, often poorly drained, plain. Grey deep sandy duplex with Grey shallow sandy duplex.</td>
</tr>
<tr>
<td>Jm2 (20,194 ha)</td>
<td>Gently undulating to undulating dissected plain with hill slopes and hillcrests. Grey shallow sandy duplex is dominant with Duplex sandy gravel and Shallow gravel</td>
</tr>
<tr>
<td>Jm3 (1,760 ha)</td>
<td>Gently undulating to undulating landscape with occasional low rises with deep sand sheet pockets or linear sand dunes. Pale deep sand is dominant with Grey deep sandy duplex also common</td>
</tr>
<tr>
<td>Jm5 (5,370 ha)</td>
<td>Gently undulating to undulating rises and hillcrests on catchment divides. Grey deep and shallow sandy duplex soils, associated Yellow/brown deep and Shallow sandy duplex soils and minor Alkaline grey sandy duplex soils</td>
</tr>
</tbody>
</table>
Table 2: continued

<table>
<thead>
<tr>
<th>Soil-landscape unit</th>
<th>Description</th>
<th>Dominant soil group</th>
<th>% soil group</th>
<th>Degree of land management risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newdegate System</td>
<td></td>
<td>Grey deep sandy duplex</td>
<td>13</td>
<td>Moderate soil acidity</td>
</tr>
<tr>
<td>250Nw (690 ha)</td>
<td></td>
<td>Alkaline grey shallow sandy duplex</td>
<td>12</td>
<td>Moderate to high salinity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey shallow sandy duplex</td>
<td>7</td>
<td>Moderate structure decline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkaline grey shallow loamy duplex</td>
<td>7</td>
<td>Moderate water erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low waterlogging</td>
<td></td>
<td>Moderate wind erosion</td>
</tr>
<tr>
<td></td>
<td>Internal relief is low, and slopes rarely exceed 9%. On the most elevated areas, sheet rock outcrops and laterite or duricrust breakaways, and extensive salt scalds at the base of the break are a common feature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Newdegate System 250Nw (690 ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Internal relief is low, and slopes rarely exceed 9%. On the most elevated areas, sheet rock outcrops and laterite or duricrust breakaways, and extensive salt scalds at the base of the break are a common feature</td>
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<td>13</td>
<td>Moderate soil acidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkaline grey shallow sandy duplex</td>
<td>12</td>
<td>Moderate to high salinity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey shallow sandy duplex</td>
<td>7</td>
<td>Moderate structure decline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkaline grey shallow loamy duplex</td>
<td>7</td>
<td>Moderate water erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low waterlogging</td>
<td></td>
<td>Moderate wind erosion</td>
</tr>
<tr>
<td></td>
<td>Newdegate System 250Nw (690 ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Newdegate System 250Nw (690 ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Fitzgerald</td>
<td>Moderately incised valleys and gently to moderately inclined slopes with 3-15% gradients. System Formed where the Fitzgerald, West and Phillips Rivers and their tributaries have dissected the Jerramungup System</td>
<td>Alkaline grey shallow loamy duplex</td>
<td>25</td>
<td>Moderate soil acidity</td>
</tr>
<tr>
<td>System 243Uf</td>
<td></td>
<td>Alkaline grey shallow sandy duplex</td>
<td>20</td>
<td>Moderate salinity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey sandy duplex</td>
<td>15</td>
<td>High structure decline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey brown shallow loamy duplex</td>
<td>10</td>
<td>Moderate water erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkaline grey sandy duplex</td>
<td>8</td>
<td>Low waterlogging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bare rock</td>
<td>5</td>
<td>Moderate wind erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stony soil</td>
<td>5</td>
<td>Moderate wind erosion</td>
</tr>
<tr>
<td></td>
<td>Upper Fitzgerald System 243Uf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Fitzgerald System 243Uf</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Subsystems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uf1 (4,161 ha)</td>
<td>Narrow saline valley flats and major saline drainage lines. Dominant soils are Shallow gravels and Semi-wet soils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uf2 (5,802 ha)</td>
<td>Valley flats, low lying waterlogged and salt-affected areas including narrow alluvial plains</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uf3 (929 ha)</td>
<td>Deeply dissected river valleys. Stony soil, Shallow gravel and Saline wet soil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uf4 (3,883 ha)</td>
<td>Footslopes and lower slopes with Grey shallow sandy duplex soils, many with neutral to acidic subsoils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uf7 (4,102 ha)</td>
<td>Very gently undulating upland plain. Grey shallow sandy duplex and Alkaline grey shallow loamy duplex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uf8 (2,288 ha)</td>
<td>Small areas of sandy gravels capping rises. Duplex sandy gravel</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2: continued

<table>
<thead>
<tr>
<th>Soil-landscape unit</th>
<th>Description</th>
<th>Dominant soil group</th>
<th>% soil group</th>
<th>Degree of land management risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lf</td>
<td>Moderately incised valleys and gently to moderately inclined slopes with gradients of 3 to 15%. Lower Fitzgerald System has formed where the Fitzgerald, West, and Phillips Rivers and their tributaries have dissected the Jerramungup and Hamersley Systems</td>
<td>Alkaline grey shallow loamy duplex</td>
<td>25</td>
<td>Moderate soil acidity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkaline grey shallow sandy duplex</td>
<td>20</td>
<td>Moderate salinity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey sandy duplex</td>
<td>15</td>
<td>High structural decline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey brown shallow loamy duplex</td>
<td>10</td>
<td>Moderate water erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkaline grey sandy duplex</td>
<td>8</td>
<td>Low waterlogging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bare rock</td>
<td>5</td>
<td>Moderate wind erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stony soil</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Lf1 (2,885 ha)</td>
<td>Narrow saline valley flats and major saline drainage lines; Dominant soils are Shallow gravels and Semi-wet soils.</td>
<td>Gravelly pale deep sand</td>
<td>18</td>
<td>Moderate soil acidity</td>
</tr>
<tr>
<td>Lf3 (18,097 ha)</td>
<td>Deeply dissected river valleys. Stony soil, Shallow gravel and Saline wet soil.</td>
<td>Grey deep sandy duplex</td>
<td>15</td>
<td>Moderate structure decline</td>
</tr>
<tr>
<td>Lf4 (1,140 ha)</td>
<td>Footslopes and lower slopes with Grey shallow sandy duplex soils, many with neutral to acidic subsoils.</td>
<td>Pale deep sand</td>
<td>10</td>
<td>High water erosion</td>
</tr>
<tr>
<td>Lf5 (1,747 ha)</td>
<td>Gently undulating rises and some upland plains with mainly Grey shallow sandy and loamy duplex soils</td>
<td>Grey shallow sandy duplex</td>
<td>10</td>
<td>Low waterlogging</td>
</tr>
<tr>
<td>Lf6 (963 ha)</td>
<td>Valley slopes and hill crests, with granitic rock outcrops or breakaways. Rock exposures/outcrops include granite, gneiss and dolerite. Dominant soils are Grey shallow sandy duplexes.</td>
<td>Other soils</td>
<td>47</td>
<td>Moderate wind erosion</td>
</tr>
<tr>
<td>Su</td>
<td>Bench and escarpment on the southern edge of the Jerramungup Sandplain with Grey shallow duplex (shallow and deep), Grey non-cracking clay and Pale shallow sand</td>
<td>Gravelly pale deep sand</td>
<td>18</td>
<td>Moderate soil acidity</td>
</tr>
<tr>
<td>Su (985 ha)</td>
<td></td>
<td>Grey deep sandy duplex</td>
<td>15</td>
<td>Moderate structure decline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pale deep sand</td>
<td>10</td>
<td>High water erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey shallow sandy duplex</td>
<td>10</td>
<td>Low waterlogging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other soils</td>
<td>47</td>
<td>Moderate wind erosion</td>
</tr>
</tbody>
</table>
2.1.7 Native vegetation

Native vegetation persists in the Lake Magenta Nature Reserve, Fitzgerald River National Park and numerous small government reserves, road reserves, along watercourses and on private land. Vegetation communities vary with mallee and banksia scrub on the deep sand in the north, moort woodland on clay soils, and yate woodlands on the riverine reaches of the Fitzgerald River.

The dominant vegetation communities include:

- Mallee heath: Dense vegetation, dominant trees *Eucalyptus* spp. with diverse shrubs in understorey
- Mallee shrubland: Dominated by *Eucalyptus* spp.; real middle layer, the understorey is <0.5 m
- Yate woodland: Tall trees (*Eucalyptus occidentalis*), open woodland structure, predominantly sedge understorey; adjacent to watercourses and seasonally damp areas; good examples on Fitzgerald River south of South Coast Highway
- Casuarina woodland: Located near granite outcrops and adjacent to rivers; closed thickets, basically lacking shrub and ground layers
- Moort woodland: Always on clay in closed thicket structure; dominant species moort (*Eucalyptus platypus var. platypus*); good example on Location 1628 near Lake Magenta Road
- Riverine: Incorporates a number of other communities, mainly Yate Woodland, Casuarina Woodland and Mallee Heath, growing along main watercourses, i.e. Fitzgerald River and Twertup Creek.

2.1.8 Waterways

The Fitzgerald River is one of six large river systems within the Fitzgerald Biosphere sub-region of the South Coast. It is approximately 80 kilometres long, draining in a south-easterly direction from the Lake Magenta Nature Reserve to the Fitzgerald Inlet. The major tributaries are the Susetta River and Twertup Creek, which meet at the Fitzgerald River within the National Park. The river is seasonal and flows after heavy rains, with all but a few pools remaining for the rest of the year.
2.2 Methods

2.2.1 Site selection

Lisa Crossing

Soil sampling was carried out at 10 sites on each property - see Appendix Map 1. Site selection was based on the hydrological systems defined by Ruhi Ferdowsian (Department of Agriculture, Albany) - see Appendix Map 2. A hydrological system describes the hydrology and geology of the landscape based on the available surface and drilling information. These systems are associated with the distribution of soils within the landscape. Sites were selected that provided good coverage of the property and represented the hydrological systems present.

2.2.2 Soil sampling procedure and analysis

Nadene Schiller

The project required a soil sampling methodology for detailed statistical analysis, interpretation and mapping.

The minimum dataset requirement for comprehensive analysis was 10 soil sites per farm, which equated to 420 sites over the whole catchment. At each site a topsoil sample was collected with a subsoil sample if the subsoil layer was reached within 25 cm of the surface. A 200 g sample was collected and labelled from zero to 10 to that particular location number.

A soil sampling sheet assisted in providing ancillary information including exact location (GPS reading), land use i.e. pasture, cropping etc., position in the landscape, slope type and percentage, evidence of surface rock and degradation.

CSBP analysed each individual soil sample in the Perth soil laboratories. Each soil sample was tested for:

- Texture and gravel content
- Colour
- Nitrate nitrogen
- Ammonium nitrogen
- Phosphorus
- Potassium
- Sulphur
- Organic carbon
- Reactive iron
- Conductivity
- pH Level (CaCl$_2$)
- pH Level (H$_2$O)
- Aluminum CaCl$_2$

Details of soil analysis methodology can be obtained from CSBP.
2.2.3 Data and geostatistical analysis

Nick Middleton

Modelling to estimate soil properties at unsampled locations was performed in a Geographical Information System (GIS), which is a set of computer software and hardware used to capture, manage, analyse and visualise any information that can be spatially referenced. In this case, the soil analyses from the chemical assays performed by CSBP could be referenced using coordinates captured by GPS and used in conjunction with previously spatially referenced information such as soil-landscape mapping.

The application of GIS to this project used four main procedures:

- Entry and validation of soil chemical analyses with their corresponding spatial coordinates to a digital database;
- Analysis of the spatial patterns in the distribution of assay values of the various chemical analyses performed, using the geostatistical method of semi-variography;
- Estimation of chemical values at unsampled points using the geostatistical interpolation method of inverse distance weighting;
- Integration of the estimated soil properties with other spatially referenced datasets to provide capability maps for the high water use farming systems promoted in this report.

The software products used to undertake the analysis were:

- Microsoft Access 97 to store all information relating to chemical analyses and the coordinates of their related sampling points;
- Geostatistical Library 2 (Deutsch and Journal 1992) to examine the presence or absence of spatial structure in the distribution of the chemical properties of the analysed soil samples based sampling point separation distance; and
- ArcView 3.2a desktop GIS with Spatial Analyst (Environmental Systems Research Institute 1999) raster add on to provide a data visualisation and interpolation capabilities and perform capability analysis.

In order to create continuous maps of each of the soil properties, inverse distance weighted (IDW) estimation was applied to generate the pH surface used in the later capability assessment for applicable high water use farming systems. The IDW interpolation method uses known values and applies weighting inversely proportional to their distance from the point being estimated. For more detailed description of this methodology see Isaaks and Srivastava (1989, pp 257-259).

The estimation of unknown values was limited to the use of the five closest points as an approximate means of limiting the influence of sampling points beyond the range of spatial dependence. In other words, only the five closest sample points were used to estimate the value of the soil properties at unsampled sites. In addition, samples closer to the point being estimated were assigned a larger proportional weight than
those at greater distance, because closer sample points are more likely to have a closer value for any particular soil property than a point further away.

The resulting product of this estimation process is expressed in the map in Figure 4, with the colour shading of estimated values at significant thresholds used to identify areas of low pH. The dataset will provide one of three inputs for assessing the capability of soils to support the high water use plant options suggested in section 3.5. The other criteria against which capability is measured are soil texture and a combination of salinity (EC) and inundation/waterlogging as interpreted from the hydrological systems (Ferdowsian 1999). Once the maps of limiting factors (soil texture, pH, salinity and waterlogging) were developed, it was possible to identify areas that were capable of supporting the establishment and growth of each plant option using the methods described below.

Figure 4: pH variation interpolated across a paddock using values from four sample points. Dark areas are higher pH (to 5) while light areas are lower (to pH 4)

Both the interpolated pH in CaCl₂ and the hydrological systems were divided into three classes to represent the varying level of sensitivity of the suggested plants, corresponding to the ratings shown in Table 3. It is considered that salinity and risk of inundation/waterlogging are closely correlated and areas with the three levels of tolerance could easily be identified within the landscapes identified by Ferdowsian (1999). Appendix Map 3 identifies the hydrological systems and the map legend indicates the salinity/waterlogging tolerance for each system.

Soil textures were interpreted using a combination of sample texture information collected as part of this study and previous soil mapping. The distribution of the interpreted textures can be seen in Appendix Map 4 and their appropriateness for the suggested high water use plant options in Table 4.

Using the three data sources in combination, areas that meet the suggested requirements for pH sensitivity, salinity/waterlogging sensitivity and appropriate soil textures can be identified by the means of the following logic:
\[ C = (S_1 \text{ or } S_2 \text{ or } ... S_n) \text{ and } H \text{ and } W \]

Where:
- \( C \) is the area capable of growing the plant option of interest;
- \( S_1 \) to \( S_n \) are the soil textures appropriate for growing the plant;
- \( H \) is the pH tolerance of the plant; and
- \( W \) is its salinity/waterlogging tolerance.

The result of the application of this logic can be seen in Appendix Map 5. An example of the implementation of the logic for the commercial tree option of oil mallees would be:

\[ C_{\text{oil mallees}} = (S = 2 \text{ or } S = 3 \text{ or } S = 4 \text{ or } S = 5) \text{ and } H \leq 2 \text{ and } W \leq 2 \]

Translation of this logic using the legends for the soil texture classes, pH and salinity/waterlogging tolerances can be that oil mallees are best suited to areas of:

- Sand to sandy loams, loamy sand to sandy loam, loam or clay loam;
- pH >5.0 in CaCl₂ (moderately tolerant of soil acidity); and
- Moderate salinity/waterlogging.

The logical statements for how capability areas were derived are printed with the associated maps for each plant option in Appendix Map 5 and Table 4.

The process for identifying the geographical confines to which each plant option is suited is summarised in Figure 5.

This series of questions is repeated for every location using the GIS, resulting in areas of land that are capable of supporting the establishment and growth of the plant in question, and areas that are not suitable for that particular plant.

The climatic limitations for each plant option (also noted in Table 4) were not incorporated into the capability assessment because options were rejected prior to analysis if they required greater annual rainfall than experienced in the catchment. The mean annual rainfall distribution for the study area, as generated by the Bureau of Meteorology, can be seen in Figures 3 and 4. This data can provide a guide but should be used in conjunction with other information sources such as the Bureau of Meteorology and Department of Agriculture, in addition to the RCA and Silo websites.
Figure 5: Flow chart to determine whether a particular location meets the environmental requirements of the proposed high water use plant.
2.2.4 Soil and landscape interpretation

Tim Overheu

Soil-landscape mapping is a survey of land resources which delineates repeating patterns of landscapes and associated soils. A soil-landscape mapping unit reflects soil and landscape processes. In addition to the key parameters of soil and landscape, geology plays a part at broad levels through the influence of tectonics on landform, and at more detailed levels through the influence of lithology on soil parent material. Other environmental factors such as climate and native vegetation also contribute to distribution of soil and landscapes and are incorporated into the mapping units.

The categories of information provided by soil-landscape mapping include:

- Text descriptions of the map unit, including general landscape information;
- Proportions of unmapped soil types (soil groups);
- Proportions of land units (soil and landform);
- Land qualities assigned to land units and/or soil types;
- Site and soil profile descriptions at known points;
- Some soil profile descriptions with associated soil chemistry or physics data at known points.

2.2.5 High water use plant option requirements

Patricia Hill

Numerous plants potentially have higher water use than conventional or currently grown plants e.g. sub. clover. These plants fall into one of the following categories:

- Commercial tree options;
- Perennials;
- Fodder shrubs;
- Annual crops and pastures;
- Native grasses;
- Summer crops; and
- Revegetation species.

The environmental requirements of species in each of these categories were identified and tabulated in Table 4.
2.3 Results

2.3.1 Soil nutrient assessment and maps

*Patricia Hill*

Most samples had a low to very low topsoil pH (Figure 6a), whereas most subsoil samples were in the moderate range (Figure 6b). This indicates topsoil acidification. In correlation with the low soil pH, aluminium levels in topsoil samples were generally very high, whereas in subsoil samples aluminium levels were low to very low (Figure 7). In general, most soil samples had low to moderate levels of sulphur, potassium, salinity and nitrogen, with little variation down the profile. Phosphorus levels in topsoil samples were moderate to high, whereas most subsoil samples had low to very low levels of phosphorus (Figure 8).

*Figure 6: pH for surface soils (a) and subsoils (b); scale varies between graphs*

*Figure 7: Aluminium levels for surface soils (a) and subsoils (b); scale varies between graphs*

*Figure 8: Phosphorus levels for surface soils (a) and subsoils (b); scale varies between graphs*
The reactive iron levels of the topsoils were generally low, however most subsoil samples contained very high levels (Figure 9), probably correlated to the low phosphorus.

![Figure 9: Iron levels for surface soils (a) and subsoils (b); scale varies between graphs](image)

Spatial representation of the key soil nutrients allows ready identification of distinct areas of nutrient sufficiency and deficiency. Refer to Appendix Map 6 of soil pH in CaCl₂ as an example.

### 2.3.2 Soil texture map

**Tim Overheu**

Soil texture refers to particle size distribution of sand, silt and clay. It is based on field or ‘hand’ texture analysis, which is measured from the behaviour of a small handful of soil moistened and kneaded into a ball and then pressed between the thumb and forefinger to form a ribbon.

Appendix Map 4 illustrates the soil texture across the catchment. The texture classes were interpreted using a combination of sample texture information collected as part of this study and previous soil mapping (Overheu unpublished).

Soil texture measurement was undertaken on surface (0-10 cm) and sub-surface (10-25 cm) samples at 238 of the 420 observation sites. Therefore the map generally only reports on the surface (even though the sub-surface texture where available was used to infer a soil classification). Aerial photograph interpretation and additional field reconnaissance assisted in mapping.

The data were grouped into six rating classes, which with other data (pH, salinity and waterlogging), were used to discriminate land use options based on suitability. These included:

- Weak sands;
- Sands to sandy loams;
- Loamy sands to sandy loams;
- Loams;
- Clay loams; and
- Heavy clays.
It is important to note that the texture class map (Appendix Map 4) is an inferred diagram illustrating distribution of soils with unique surface characteristics. It does not map soil types.

2.3.3 Land capability assessment for high water use plant options

2.3.3.4 High water use plant options

Patricia Hill

The requirements for successful establishment of high water use plant options are given in Table 4. There are several perennial and annual options, each with specific environmental and management requirements detailed in the key (Table 3).

Sensitive plants will grow at lower levels of pH or other factors than suggested, but it is likely they will not achieve full potential. See table of pH ranges for crops in ‘Australian soil Fertility Manual’ by J.S. Glendinning but note that values are measured in water not calcium chloride as used in this project.

Table 3: Key to land capability classes

<table>
<thead>
<tr>
<th>pH</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sensitive plants - pH &gt;6.0 (in CaCl₂)</td>
</tr>
<tr>
<td>2.</td>
<td>Moderately tolerant plants – pH &gt;5.0</td>
</tr>
<tr>
<td>3.</td>
<td>Tolerant plants – pH &gt;4.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrical Conductivity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Salt-sensitive – EC &lt;230 mS/m</td>
</tr>
<tr>
<td>2.</td>
<td>Moderately salt-tolerant – EC &lt;550 mS/m</td>
</tr>
<tr>
<td>3.</td>
<td>Salt-tolerant – EC &lt;2000 mS/m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Waterlogging</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sensitive to waterlogging</td>
</tr>
<tr>
<td>2.</td>
<td>Moderately tolerant of waterlogging</td>
</tr>
<tr>
<td>3.</td>
<td>Tolerant of waterlogging</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rooting depth</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Achieves optimum growth if root-permeable soil is deep</td>
</tr>
<tr>
<td>2.</td>
<td>Achieves optimum growth if root-permeable soil is medium</td>
</tr>
<tr>
<td>3.</td>
<td>Achieves optimum growth if root-permeable soil is shallow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rainfall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Requires 450 mm or more (high rainfall)</td>
</tr>
<tr>
<td>2.</td>
<td>Requires 325 mm or more (medium rainfall)</td>
</tr>
<tr>
<td>3.</td>
<td>Requires 325 mm or less (low rainfall)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Very sensitive to temperature extremes</td>
</tr>
<tr>
<td>2.</td>
<td>Sensitive to temperature extremes</td>
</tr>
<tr>
<td>3.</td>
<td>Tolerant of temperature extremes</td>
</tr>
</tbody>
</table>
## Table 4: Environmental requirements of farming system options

1. Commercial tree options


<table>
<thead>
<tr>
<th>Plant</th>
<th>Soil Texture</th>
<th>pH</th>
<th>EC</th>
<th>Texture pH</th>
<th>Water-logging</th>
<th>Rooting depth</th>
<th>Rain</th>
<th>Temperature</th>
<th>Reference</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue gums</td>
<td>Medium-deep sands/gravels/clays</td>
<td>Moderately tolerant</td>
<td>Moderately tolerant</td>
<td>Sensitve</td>
<td>Deep</td>
<td>High</td>
<td>Sensitve</td>
<td>13, 14, 24, 25, 32</td>
<td>Requires large production base to ensure commercial viability. Distance to market/port/mill. Windbreaks; alley farming – crop yield penalties; best in blocks. Suited to retiring land managers.</td>
<td></td>
</tr>
<tr>
<td>Pine trees</td>
<td>Sands</td>
<td>Tolerant</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td>Deep</td>
<td>Medium</td>
<td>34</td>
<td></td>
<td>Best suited to least productive areas as alleys and blocks. Requires large production base to ensure commercial viability. Distance to market/port/mill.</td>
<td></td>
</tr>
<tr>
<td>Oil mallees</td>
<td>Loams, clays, heavy duplexes</td>
<td>Moderately tolerant</td>
<td>Moderately tolerant</td>
<td>Moderately tolerant</td>
<td>Deep</td>
<td>Medium</td>
<td>17</td>
<td></td>
<td>Low input. Habitat for wildlife. Need strategies for long-term management (e.g. burning). Requires large production base to ensure commercial viability. Need to work in cooperatives. Medium/long-term investment. Distance to market/port/mill.</td>
<td></td>
</tr>
<tr>
<td>Olives</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td>Deep</td>
<td></td>
<td></td>
<td></td>
<td>Long-term investment. Distance to market.</td>
<td></td>
</tr>
<tr>
<td>Jojoba</td>
<td>Free-draining</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td></td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandalwood</td>
<td>Derived from light granite</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td>Sensitve</td>
<td></td>
<td>Medium</td>
<td></td>
<td></td>
<td>Not suited to heavy clays. May take 23-100 years to reach harvest size. Cost of establishing ~$1500/ha. May be used for remnant vegetation. Need hosts.</td>
<td></td>
</tr>
</tbody>
</table>
Table 4: continued

### 2. Perennials

<table>
<thead>
<tr>
<th>Plant</th>
<th>Texture</th>
<th>pH</th>
<th>EC</th>
<th>Water logging</th>
<th>Rooting depth</th>
<th>Climate</th>
<th>Reference</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucerne</td>
<td>Most well drained soils</td>
<td>Sensitive</td>
<td>Sensitive</td>
<td>Moderately sensitive</td>
<td>Medium</td>
<td>Tolerant</td>
<td>29</td>
<td>Improved weed control. Requires optimum areas to persist and achieve maximum water use. Difficult to remove. Requires specific grazing rotation. Paddock scale. Possible benefits for filling feed gaps for sheep.</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>Sands, loams, sands/clay-gravels</td>
<td>Tolerant</td>
<td>Moderately tolerant</td>
<td>Tolerant</td>
<td>Shallow</td>
<td>High</td>
<td>Sensitive</td>
<td>7</td>
</tr>
<tr>
<td>Phalaris</td>
<td>Clays, loams, sands/clay</td>
<td>Sensitive</td>
<td>Moderately tolerant</td>
<td>Tolerant</td>
<td>Medium/shallow (root depth &lt;1.8 m)</td>
<td>Medium</td>
<td>Sensitive</td>
<td>11, 16</td>
</tr>
<tr>
<td>Tall wheat grass</td>
<td>Sand/clay, loams, sands/clay</td>
<td>Tolerant</td>
<td>Tolerant</td>
<td>Tolerant</td>
<td>Medium</td>
<td>Tolerates frost</td>
<td>16</td>
<td>Very useful on salt-affected land. Similar to phalaris in coping with winter waterlogging on shallow duplex soils. Less sensitive to temperature extremes than kikuyu. Requires rotational grazing.</td>
</tr>
<tr>
<td>Veldt</td>
<td>Deep sand</td>
<td>Tolerant</td>
<td>Sensitive</td>
<td>Sensitive</td>
<td>Medium</td>
<td>Very sensitive</td>
<td></td>
<td>Should be grazed at flowering to avoid becoming an invasive weed in native bushland, along roadsides and in crops. Requires rotational grazing.</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>Sand, loam</td>
<td>Sensitive</td>
<td>Moderately tolerant</td>
<td>Moderately tolerant</td>
<td>&lt;1.8 m</td>
<td>High</td>
<td>Tolerant</td>
<td>11, 21, 28, 29</td>
</tr>
<tr>
<td>Cocksfoot</td>
<td>sand/clay gravel, loam</td>
<td>Tolerant</td>
<td>Sensitive</td>
<td>Sensitive</td>
<td>Shallow</td>
<td>High</td>
<td>Tolerant</td>
<td>4, 11, 20</td>
</tr>
<tr>
<td>Puccinellia</td>
<td>Sand, loam or clay</td>
<td>Sensitive</td>
<td>Tolerant</td>
<td>Tolerant*</td>
<td>Medium</td>
<td>Tolerant</td>
<td>1, 2, 10, 15, 16, 29</td>
<td>* not tolerant of waterlogging over summer.</td>
</tr>
<tr>
<td>Rhodes</td>
<td>Light-medium</td>
<td>Moderately tolerant</td>
<td>Tolerant</td>
<td>Sensitive</td>
<td>Medium</td>
<td>Tolerant</td>
<td>1, 7, 12, 18</td>
<td>Able to increase stocking rates</td>
</tr>
</tbody>
</table>
### Table 4: continued

<table>
<thead>
<tr>
<th>Plant</th>
<th>Texture</th>
<th>Soil logging</th>
<th>Rooting depth</th>
<th>Climate</th>
<th>Reference</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3. Fodder shrubs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tagasaste</td>
<td>Deep sand</td>
<td>Moderately tolerant</td>
<td>Sensitive</td>
<td>Deep</td>
<td>Medium</td>
<td>31 High management requirement. Water use is dependent on grazing regime. Suited to alley farming, cattle fodder, areas prone to wind erosion, inter-row pastures and crops. Virtually permanent – need to have long-term management plan.</td>
</tr>
<tr>
<td>Saltbush</td>
<td>Clay, deep sand/ clay</td>
<td>Tolerant</td>
<td>Moderately tolerant</td>
<td>Low</td>
<td>9, 16, 22</td>
<td>Does not supply a balanced diet for stock. Requires grazing management &amp; monitoring. Excellent for highly saline areas and alleys. Allows growth of better pasture spp. in inter-rows on saline soils. May induce deficiencies in stock.</td>
</tr>
<tr>
<td>Acacia saligna</td>
<td>Sands, loams</td>
<td>Moderately tolerant</td>
<td>Tolerant</td>
<td>Medium</td>
<td>27, 33</td>
<td></td>
</tr>
</tbody>
</table>

| **4. Annual crop or pasture** |                 |              |               |         |           |                                                                                 |
| Serradella                 | Deep sand       | Tolerant     | Sensitive     | Deep    | Medium    | 5, 6, 8, 19, 26, 30 High protein value.                                          |

| **5. Native grasses e.g. wallaby, kangaroo windmill, weeping rice, spear, and brush wire-grass** |                 |              |               |         |           |                                                                                 |
| Grasses                     | Moderately tolerant | Low        |               | 11, 23   |           | High protein value.                                                             |
**Table 4: continued**

6. Revegetation species

Can be chosen according to site requirements – flat-topped yate for saline, waterlogged soils, or sandplain mallee for acid soils etc. Best suited to unproductive areas, for windbreaks, recharge areas, alleys, contours, blocks and corridors. See the websites below for more information.

2.3.2.1  High water use plant option capability maps

*Patricia Hill and Nick Middleton*

Plant capability maps were developed for the options considered suitable in terms of environment and existing land use using Table 4. Areas considered capable of sustaining these options are shown in Appendix Map 5.

The most extensive options (in terms of land capability) include pines, oil mallees, lucerne, kikuyu, puccinellia, native grasses, tall wheat grass and Rhodes grass. Other options are suited to smaller areas and may prove to be locally significant.
2.4 Discussion

*Patricia Hill*

The project aimed to perform a land capability analysis for the Fitzgerald River Catchment based on plant options with higher water use than existing crops and pastures, to reduce waterlogging and salinity.

A soil survey was undertaken as part of the analysis and revealed that most soils had a low to very low topsoil pH, whereas most subsoils had moderate pH. This indicates topsoil acidification. Aluminium levels in topsoil samples were generally very high, but low to very low in the subsoil. Topsoil acidification has been observed in neighbouring catchments and is likely to be occurring here. Many of the currently acid soils were probably acid prior to clearing of native vegetation and will respond to lime application.

Phosphorus levels in topsoils were mostly moderate to high, whereas most subsoil samples contained low to very low levels. The reactive iron levels of the topsoil were generally low, but most subsoil samples very high and probably correlated to the low phosphorus. Most soil samples contained low to moderate levels of sulphur, potassium, salinity and nitrogen, with little variation down the profile. Most nutrient limitations can be overcome by applying fertilisers.

Assessing the catchment for water use plant options has enabled land managers to identify plants that are theoretically suited to different parts of the landscape. Having assessed the land's physical (environmental) characteristics, and matched it with plant options, it was found that several could be readily incorporated into existing farming systems.

High water use options included trees such as pines and oil mallees, physically suited to most of the catchment. Exceptions include areas of particular soil texture and high salinity. For example, the heavy clay soils which limit the growth of pine trees are not suited to this option, and creek-lines which are characterised by sands are not ideal for oil mallees (particularly if grown commercially). These two options may be used in alley farming systems, windbreaks or as blocks in the landscape. They may also be used as an income source if planted extensively.

The perennial options suited to large areas include lucerne, kikuyu, puccinellia, native grasses, tall wheat grass and Rhodes grass. Lucerne has grown very successfully – its distribution primarily restricted by drainage (not suited to creek-lines), low soil pH and high salinity.

Veldt grass grows very well but can become invasive, so this needs to be considered.

Kikuyu suitability is mainly influenced by soil texture – in most cases it does not achieve optimum growth in very heavy soils. If incorporated into the system it should be realised that it provides poor winter feed, and should be grown with a winter-active pasture. Kikuyu is also better suited to areas that are not cropped frequently, as it tends to spread and can be difficult to control.
Puccinellia is excellent for moderately saline areas, as it is salt-tolerant. However, extent may be restricted due to intolerance of waterlogging. It is acid-sensitive, and will not tolerate low pH.

The grasses are suited to most of the catchment due to ability to grow in a wide range of soil types. Rhodes grass is intolerant of salinity and will not achieve optimum results on heavy soils. The native grasses provide good feed quality, though may require specific management. Most perennial options provide benefits over annual pasture species in terms of filling feed gaps for sheep and cattle. In addition, the perennial options provide surface cover on fragile soils, which is important in wind erosion control.

Other options, including Acacia saligna, saltbush and serradella, are suited to smaller areas. They provide opportunities on soils not suitable for other plants. For example, the high salt tolerance of Acacia saligna and saltbush gives niche status for saline and otherwise unproductive soils.

The plant option suitability maps allow land managers to appreciate the geographical extent of various options. They are not prescriptive, but indicate potential distribution of that particular plant. They may be used alone, with another of option, or incorporated into the pasture or cropping system. It is not suggested that they replace another plant that is already productive and using substantial water.

In addition to the capability maps, this report contains a summary of many high water use plants in terms of their environmental and management requirements. Land managers may also consider these options, provided that the increased level of risk (in terms of failure) associated with their incorporation is acknowledged.

The maps show areas that are ideally suited to plants – that is, only areas that present an ideal environment. Land managers may decide that they are willing to tolerate less than optimum growth and choose an option that, while not ideally suited, will still establish and grow in a particular area. On the other hand, areas may appear to meet the three key requirements (soil texture, pH and salinity) but be unsuitable for other reasons. For example, a small area of shallow rock that does not appear on the maps because it was overlooked during sample collection may be shown as being suitable where in reality it restricts growth of deep-rooted plants. Factors such as soil nutrient status were not included in the GIS analysis because there is insufficient data on specific requirements for the high water use plant options.

Suitability can vary over time. For example, nutrient levels can be adjusted readily using fertiliser, and their levels are highly temporally and spatially variable. Also, if an option is not suited to an area due to low soil pH, applying lime can increase its suitability. Similarly, some poorly drained soils may be treated with gypsum to better suit plants that are intolerant of waterlogging, and deep ripping can alter rooting depth if it is a limiting factor.

The sampling procedure should be taken into account. Samples were not taken from rocky outcrops, saline areas or remnant bush. This imposes some limitations on the representation of these features in the maps, and may give false indications of soil properties. However, this is unlikely to significantly affect the capability maps, as
these features are generally small in dimension and the intended use of the maps is at sub-catchment rather than paddock scale.

Variability of rainfall is an important consideration. In general, the north of the catchment receives less than the south, and this may affect the suitability of some options. While this study assumed that the rainfall was uniform across the catchment and eliminated it from the capability analysis, it is worth noting that most of the catchment experiences annual rainfall of less than 400 mm in many years. In order to minimise the risk of failure of plant options, it is important to consider the annual rainfall and use Table 4 to identify whether a proposed option is suited to the area.

The process and methodology to complete the Fitzgerald River High Water Use Project is repeatable and efficient. Based on the lessons from this project, the method can be applied to other catchments and other problems with a great degree of efficiency. In addition, there is a high degree of flexibility in the methodology in terms of mapping scale, environmental factors considered, complexity or simplicity of the issue in question, and purpose of the study. GIS has significant utility in land capability analyses and potential to explore an extensive range of applications.

The ability to reliably estimate the chemical values of soils at unsampled locations offers potential benefits, including costs, time and the use of data in other ways. This offers savings over a more extensive sampling program without significantly affecting the accuracy of estimations of soil properties. This is provided that soil properties can be reliably estimated using interpolation techniques.

The publication scale of 1:250,000 for the soil-landscape mapping imposes some limitation on the application of the information. For example, the scale is not suitable for paddock identification of soil types or boundaries. It is suitable for:

- Broad land capability analysis for major land uses;
- Strategic planning for broad dry land agricultural uses;
- Regional plans, planning for rural shires; and
- An overview of management issues and solutions for large catchment areas.

The maps are intended for identification of specific regions for which plant options are suited, but cannot identify very small features that will affect the suitability.

Another limitation is that the interpolation technique requires a spatial relationship between points, which makes it possible to estimate the value of various properties at unsampled locations. However, without the presence of a structure such as that identified for pH, the values generated by interpolation techniques cannot be assumed to be a reliable estimate of values at unsampled locations. Inverse distance may reduce this problem, however results obtained using this process also have inherent limitations. Specifically, this method does not consider the effect of geographical barriers on soil properties. An example is where land use changes can cause marked barriers between soil properties such as pH, and therefore the true value of the property is not represented. The map will show a gradual change in the property where in reality a sharp difference can be observed on either side of the barrier.
The high water use land capability analysis highlighted some key deficiencies in availability of data. Specifically, the environmental requirements of many high water use plants are not defined. The development of novel GIS-based methodology for land capability analyses showed that the process could be applied to other case study areas. It is an efficient method for which accuracy can be defined.
2.5 Conclusion

Patricia Hill and Nadene Schiller

Land managers in the Fitzgerald River Catchment have identified the need to address some sustainability issues. These include soil acidity, rising groundwater tables and salinity, high water use farming systems and economic sustainability of current farming systems.

As part of the planning process, a farming systems land capability analysis was undertaken. The outcomes included:

- comprehensive soil analyses over the whole catchment;
- maps relating to soil fertility over the whole catchment;
- land capability analysis to identify possible high water use farming system options;
- tabulation of existing options for optimising water use on-farm;
- baseline dataset for further research;
- increased awareness of the key deficiencies of the soil types in the catchment.

The project identified possible high water use plant options including pines, oil mallees, lucerne, kikuya, puccinellia, Rhodes grass and to a lesser extent *Acacia saligna*, saltbush and serradella. It is likely that one or more of the options could be incorporated into existing management strategies. This will result in higher water use provided that the introduced plant uses more water than the existing plant.

One of the requirements of this study was that it be repeatable, efficient and applicable to similar catchments in the region. While the maps are specifically related to the Fitzgerald River Catchment, this report summarises the environmental and management requirements of many high water use plants. This will enable individual land managers (regardless of geographic location throughout Western Australia) to consider whether to integrate any of them into their system.

A wealth of topsoil analysis information has been collected and requires more interpretation. Results from the detailed soil analysis will be useful beyond Fitzgerald River. The project highlighted the need for an active catchment group to initiate such a project and to obtain full support of the land managers.

A land capability analysis methodology framework has been developed that will enable groups to undertake similar analyses to assess their region in terms of its suitability to various high water use plant options. This research provides exciting opportunities for salinity management throughout the agricultural regions of Australia.
3. Future research

One of the key areas for future research is the social and economic issues as limiting factors to the suitability of plant options. By comparing the economics of the existing options with proposed options, it will be possible to determine whether it is economically viable to incorporate those options into the existing system.

Economic comparisons may be done in workshops with the group as part of the ongoing extension of the results. Integration of the plant options into the current system by land managers will be enhanced by local demonstrations. Trial and demonstration sites would augment incorporation of plant options into the existing system.

In addition to the range of plant options available to create high water use farming systems, consideration should also be paid to non-plant options. For example, similar data could be compiled for options such as deep drainage and surface water management. This should outline the necessary environmental requirements, and whether the proposed option will affect the existing environment in a negative way, including off-site effects.

Most soil samples from the Fitzgerald River Catchment had low to very low topsoil pH, and most subsoil samples had moderate pH (Figure 6). This indicates topsoil acidification. In correlation, aluminium levels in topsoil samples were generally very high, whereas subsoil aluminium levels were mostly low to very low (Figure 7). This is a very important land degradation issue, as topsoil acidification can reduce yields and crop and pasture options. The collected dataset could readily be used for identifying soils at risk of further acidification and for targeting areas that require lime application in order to prevent subsoil acidification.
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Environmental requirements of farming system options


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