An assessment of the impact of Ophthalmia Dam on the floodplains of the Fortescue River on Ethel Creek and Roy Hill Stations

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An Assessment of the Impact of Ophthalmia Dam on the Floodplains of the Fortescue River on Ethel Creek and Roy Hill Stations

A.L. Payne and A.A. Mitchell

Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

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Table of Contents

1. Summary and recommendations ................................................................. 1

2. Introduction and background .................................................................... 4
   2.1 The Ophthalmia dam .............................................................................. 4
   2.2 Terms of reference ............................................................................... 4
   2.3 Hydrological aspects of the dam environment .................................... 8
   2.4 Stocking history of Roy Hill and Ethel Creek stations ...................... 11
   2.5 Literature review ............................................................................... 11

3. Methods ................................................................................................. 14
   3.1 The land system approach .................................................................. 14
   3.2 Preliminary environmental mapping and pre-selection of traverse routes
       and sampling sites .............................................................................. 14
   3.3 Selection of Carramulla Creek as a control area .................................. 16
   3.4 Field traverses and assessment of soil erosion and pasture/vegetation
       condition ........................................................................................... 16
   3.5 Inventory sites .................................................................................. 17
   3.6 Tree condition ................................................................................... 17
       3.6.1 Tree condition sampling sites ...................................................... 17
       3.6.2 Tree condition assessment sites ................................................. 17
   3.7 Photographic sites ............................................................................ 18

4. Results .................................................................................................... 19
   4.1 Land systems comprising the area ...................................................... 19
   4.2 Soil and vegetation degradation on the Fortescue River .................... 39
       4.2.1 Ethel Creek station ..................................................................... 43
       4.2.2 Roy Hill station .......................................................................... 46
   4.3 Soil and vegetation degradation on Carramulla Creek ....................... 48
   4.4 Evidence of recent grazing and flooding and their impact on vegetation... 49
   4.5 Analysis of dam impact on individual flood events ......................... 50
5. Conclusions ................................................................. 53

5.1 Causes of tree stress and death ......................................... 53
  5.1.1 Lack of flooding ....................................................... 53
  5.1.2 Direct and indirect effects of overgrazing ..................... 56
  5.1.3 Disease and insects .................................................. 56

5.2 Causes of lost production and death of perennial grasses ........ 56

5.3 Management implications .................................................. 59
  5.3.1 Ethel Creek station ................................................... 59
  5.3.2 Roy Hill station ....................................................... 59

6. Photographs ........................................................................... 61

7. References ............................................................................... 71

8. Appendices ............................................................................. 73
   Appendix 1. Criteria for traverse assessment......................... 73
1. **Summary and recommendations**

(a) The area surveyed covered all of the floodplains of the Fortescue River, and Jigalong, Jimblebar and Carramulla Creeks which fall within Ethel Creek and Roy Hill stations. Some country adjacent to the floodplains was also surveyed.

(b) Six land systems, Bullina, Coolibah, Fortescue, Jigalong, Marsh and Washplain occur on the floodplains and are described. All these systems are developed on river alluvium and rely largely on regular flooding every two or three years for the maintenance of their vegetative cover. One of the major vegetation communities of the area - the grassy coolibah woodland - is distinctive in this riverine environment and is not well represented elsewhere.

(c) Two serious, distinct and largely unrelated environmental problems are evident on the area surveyed. The extent and severity of both problems are greatest on Ethel Creek station but are also significant on Roy Hill station.

(d) The first problem is longstanding, severe landscape degradation in the form of almost complete loss of perennial vegetative cover and soil erosion (mainly scalding) due to historical overgrazing.

   - On Ethel Creek station the areas of severe degradation as a result of historical overgrazing total about 214 sq km. The areas have been mapped.
   - A rehabilitation programme is required on Ethel Creek as a matter of some urgency. Such a programme will require paddocking of the frontage into manageable units, destocking, and cultivation and reseeding works. Some parts of this programme have already been commenced.
   - On Roy Hill station the areas of severe degradation because of historical overgrazing on the Coolibah land system is about 17.5 sq km. Elsewhere the perennial grass pastures of the Coolibah land system are degraded and patchy but there is generally little soil erosion. The parts of the Edenholme system seen during the survey have almost completely lost their perennial grass cover but, because of the flat topography and clayey soils, there is very little soil erosion. About 9 sq km of this system, which is not subject to flooding from the Fortescue River, has been mapped as severely degraded.
   - In order to improve pasture condition on Roy Hill station a programme of more controlled stocking (including destocking severely degraded areas) involving additional fencing and water points needs to be developed. Some cultivation works and reseeding on parts of the Edenholme system may be worthwhile. Some parts of such a programme have already been commenced.

(e) The second environmental problem within the survey area is serious, recent (since about 1987 or 1988), widespread stress and death of trees (mainly *Eucalyptus coolabah*) and loss of perennial grasses because of a lack of regular flooding caused largely by the Ophthalmia dam. This problem sometimes overlaps with areas which have been identified as being severely degraded and eroded due to past overgrazing but also frequently occurs on areas which are not eroded or severely degraded.
The study by Ng et al. (1991) shows that the reductions in flooding since the Ophthalmia dam was constructed are partly due to climatic variation and partly due to the dam. Reductions caused by climatic variations have not occurred in every year since dam construction (i.e. not in years with above average flows). Reductions due to the dam have occurred in every year since the dam was constructed - that is, the effect is continuous. The effect of the dam is also cumulative on any effect caused by climate and exacerbates that effect.

Ng et al. show that although the average river flow since the dam was constructed is less than the long term average (due to the lack of large cyclonic events post dam) there would still have been, in the absence of the dam, numerous moderate flows in the 10 years since dam construction. These are flows with up to about a five year recurrence interval and are considered to be sufficient to maintain the floodplain vegetation.

The reductions in flooding caused by climatic variations, since the dam was constructed, are not sufficiently large or continuous to be a significant contributing factor to the vegetation decline problem now seen on the floodplain. This conclusion is borne out by the observation that there is negligible vegetation problem evident along Carramulla Creek which has been subject to the same rainfall regimes but which is not dammed upstream.

The effects of the dam in terms of reducing flood volumes, flooding frequency and flood width are substantial on many parts of the Fortescue River floodplains.

The presence of the Ophthalmia dam is considered to be the major cause of the recent vegetation decline problem on the floodplains of the Fortescue River.

Overgrazing in the mid 1980s is likely to have contributed to the loss of perennial grasses on some parts of the Fortescue River frontages (particularly on Ethel Creek station) but is not currently a contributing factor.

The direct effect of grazing on eucalypt and other trees in the past, or recently, is not considered to be a significant contributing factor to the recent dramatic and widespread decline of trees.

Soil erosion as an indirect effect of overgrazing in the past or present is considered to be only a minor contributing factor to the recent decline of trees.

This survey showed that the effect on the vegetation commences on the levees and upper banks of the Fortescue River on Ethel Creek station near Horse Camp bore, which is about 34 km downstream from the Ophthalmia dam. The effect extends for about 39 km northwards along the river past Ethel Creek homestead and then for about another 24 km into Roy Hill station.

The areas already affected or likely to be affected to a greater or lesser extent by the reduced flooding are 400 sq km on Ethel Creek station and 177 sq km

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1 Kennedy et al. (1991) contend that the effect commences from immediately below the dam wall. The first 14 km below the dam was not inspected during this survey.
on Roy Hill station. This does not include the Marsh land system on Roy Hill station which may be affected to some extent in the future.

- The damage on Ethel Creek station is already quite severe. The potential for the problem caused by the dam to become worse and more widespread is considered to be very high on Ethel Creek station and moderately high on Roy Hill station.

- Without a return to unimpeded flooding, the vegetation already under stress will probably continue to die until either a lower population of the current species is reached, which is supportable under the decreased water regime, or the present species will become dominated or be replaced by others with lower water requirements.

- Restoration of the affected areas would require a return to an undisturbed natural flooding regime coupled with manipulation of grazing pressure.

- Strategies for restoration or rehabilitation need to be developed and implemented as a matter of urgency. Programmes which involve only the manipulation of grazing pressure may not be able to fully restore the eucalypt woodlands or the perennial grasses.

(f) A comprehensive vegetation and hydrological monitoring programme is required on both stations. It is recommended that such a programme be jointly developed between the Department of Agriculture, the Department of Conservation and Land Management, the Western Australian Water Authority, Mt Newman Mining Ply Ltd and the station lessees.
2. Introduction and background

This text and the accompanying maps form a report on the condition of the floodplains of the Fortescue River and some of its tributaries on Ethel Creek and Roy Hill stations in the Pilbara region of Western Australia (see Figure 1). The report summarizes the findings of a field survey undertaken by the Rangeland Management Branch of the Department of Agriculture over the period April 1-9, 1990. Some additional observations were made during the period October 27 to November 8, 1990.

The inspection and report was requested by the Department of Resources Development (now Department of State Development) after local pastoralists claimed that the Ophthalmia dam on the Fortescue River was having an adverse effect on vegetation downstream from the dam.

2.1 The Ophthalmia dam

The Ophthalmia dam was constructed in 1981 by Mt Newman Mining Company Ply Ltd on the Fortescue River just upstream of Ethel Gorge near the town of Newman (see Figure 1). The dam supplies water for an artificial recharge system into a nearby aquifer with a borefield for town and mining water supply. The location of the dam in relation to the various subcatchments of the Fortescue River and to Ethel Creek and Roy Hill stations are shown in Figure 2. The main areas concerning this survey lie along the river in subcatchments G, J and M.

The project to construct the dam was outlined in a Notice of Intent (1981). Among other things the Notice indicated that monitoring of natural vegetation in the immediate vicinity of the reservoir area and the dam would be carried out and this has been done (Walker 1988).

An appendix (prepared by the Environmental Praxis Group, Murdoch University) in the Notice of Intent indicated ‘.... a matter that should perhaps be addressed is any possible consequences further downstream as a result of damming these sections of the Fortescue River. It is considered that this is largely a matter for the hydrological consultants’. This suggestion was not pursued and environmental monitoring on pastoral properties downstream of the dam was not undertaken.

2.2 Terms of reference

The terms of reference for the survey were as follows:

(a) map and describe the land systems (landforms, soil and vegetation) which comprise the floodplains of the Fortescue River and associated tributaries between the Ophthalmia dam and the Roy Hill marsh. The survey to be confined to parts of the Ethel Creek and Roy Hill pastoral leases;
Figure 1. Location Map
(b) assess the condition of the vegetation and soils of the systems defined in (a) above. The condition assessment sites will be located at varying horizontal distances from flow lines in an attempt to detect any effects of reduced river flows;

(c) where possible, assess the contribution of grazing and altered water flows to the condition of the floodplain by:

- comparison with similar areas which have not been subjected to altered flow but have been grazed;
- comparison with areas subject to altered water flow but which have experienced a different grazing regime;

(d) attempt to define any impacts on the ecosystem by means of LAND SAT albedo change imagery based on data acquired before and after dam construction;

(e) assess the carrying capacity of the surveyed areas;

(f)\(^2\) assess the changes in the water table in bores and wells in flowlines below the dam and in flowlines not affected by the dam if possible. This will include such information as details of new bores, bores sunk deeper and bores gone dry.

\(^2\) This term of reference was not examined or met. The necessary expertise to undertake such an investigation lies with the Water Authority of Western Australia and/or the Geological Surveys Section, Mines Department, rather than with the Department of Agriculture.
Figure 2. Upper Fortescue River Sub Catchments
2.3 Hydrological aspects of the dam environment

The dam has been the subject of a number of published and unpublished reports on hydrological aspects associated with the design and construction phases of the project and later with assessment of impact on the downstream floodplains. Those reports which are most pertinent to this investigation are the Notice of Intent (1981) and the studies by Australian Groundwater Consultants Ply Ltd (1989) and Ng et al. (1991).

The dam’s maximum storage capacity is 30.6 million cubic metres (Australian Groundwater Consultants Ply Ltd 1989) which is more than the long term (1907-1989) average annual flow at Ophthalmia dam of 29.9 million cubic metres (Ng et al. 1991). Estimated annual flows at the dam site since 1907 are extremely variable ranging from zero to occasionally more than 150 million cubic metres in years with large cyclone events.

Since the dam was constructed in 1981, annual flows have varied from considerably below to a little above the long term average (Table 1 and Figure 10). The dam has spilled three times but only very briefly on each occasion and, in effect, there has been negligible downstream contribution from the dam’s catchment since 1981.

Table 1. Estimated annual flows at Ophthalmia dam since dam construction in 1981 (ex Ng et al.,1991)

<table>
<thead>
<tr>
<th>Years</th>
<th>Estimated flow (mcm)* at Ophthalmia dam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>44.215</td>
</tr>
<tr>
<td>1983</td>
<td>5.059</td>
</tr>
<tr>
<td>1984</td>
<td>11.062</td>
</tr>
<tr>
<td>1985</td>
<td>47.083</td>
</tr>
<tr>
<td>1986</td>
<td>43.056</td>
</tr>
<tr>
<td>1987</td>
<td>27.531</td>
</tr>
<tr>
<td>1988</td>
<td>30.935</td>
</tr>
<tr>
<td>1989</td>
<td>0.080</td>
</tr>
<tr>
<td>Mean 1982-1989</td>
<td>26.127</td>
</tr>
<tr>
<td>Long term (1907 - 1989) mean</td>
<td>29.894</td>
</tr>
</tbody>
</table>

* mcm = millions of cubic metres.
A review of the effects of the dam on the Fortescue River streamflow downstream of the dam was prepared by Australian Groundwater Consultants Pty Ltd in 1989. The review concluded that the dam decreased peak flow and volume at the southern boundary of Roy Hill station for events with a recurrence interval of >2 years and that the magnitude of the effect was dependent on rainfall distribution throughout the catchment.

Rainfall records and climatic variability in the area have been examined by Waugh (personal communication) and Ng et al. (1991). Waugh examined the rainfall data at Ethel Creek station, Roy Hill station and Newman Post Office for an eight year period since the dam was completed in December 1981. The mean annual rainfall for the three sites since the dam was constructed was about one to two per cent below average. There were a number of years with above average rainfall but no large cyclonic events during the period.

Analysis of rainfall data by Ng et al. (1991) indicated that, although post-dam average annual rainfall totals were not significantly different from pre-dam annual averages, average stream flow volumes were about 13 per cent less in the post-dam period because of the lack of large storms. No events with greater than about a 5 year recurrence interval have occurred since dam construction. However, there have been numerous events with two or three year recurrence intervals and, in the absence of the dam, there would have been substantial flooding on various parts of the Fortescue River frontages.

Ng et al. (1991) described the relative impact from the dam and climatic variations on streamflow volume reductions on the floodplains downstream of Ophthalmia dam. This was done by comparing the post-dam (1982-1990) event average with the long term (1907-1990) event average.

Ng et al. (1991) showed that the Ophthalmia dam has an impact, in terms of markedly reducing flow volumes, peak flows, flooded width and frequency of flooding on the downstream floodplain. The dam shows these effects at a number of cross-sections on the Fortescue River, the locations of which are shown in Figure 3.

In general terms the greatest impact of the dam was on the more frequent floods, i.e. the smaller floods with an average recurrence interval of less than five years. The dam showed a relatively smaller impact on the larger events.

For flood events with an average recurrence interval of 2-5 years the dam reduced flow volume by an average of about 52 per cent at cross-sections 5, 7 & 8 and by about 23 per cent at cross-sections 10, 11 & 12. The effect was more marked on smaller events with less than a two year recurrence interval being about a 73 per cent reduction at cross-sections 5, 7 & 8 and 40 per cent reduction at cross-sections 10, 11 & 12.

The impact of the dam decreased with distance towards Roy Hill but the effect was still marked at a number of cross-sections on Roy Hill station. The effects of the dam on individual post-dam events (1982-1990) at a number of cross-sections on the river are described in more detail later in this report (see 4.5).
Figure 3. Fortescue River flood plain showing cross-sections referred to by Ng et al (1991)
2.4 **Stocking history of Roy Hill and Ethel Creek stations**

Because impacts due to Ophthalmia dam may be masked or exacerbated by the effects of stocking, it is necessary to consider the stocking history of Ethel Creek and Roy Hill stations.

The history of early settlement in the Pilbara and other pastoral areas is one of rapid build up of stock numbers (with maximum numbers in the mid 1930s), often on very few permanent waters to levels now known to be excessive and non-sustainable, followed by substantial decline in numbers to present day levels (Anon 1979). Degradation, known to have commenced many years ago (Fyfe 1940), was the frequent result of overgrazing.

Stock numbers on Roy Hill station (Figure 4) have followed the general pattern with very high numbers in the 1930s gradually declining by about two thirds to present day numbers. No data are available for the period 1959-1969 and there is no information about the spatial distribution of stock. although it is reasonable to assume that substantial numbers were depastured on river floodplain country. Records for Ethel Creek station are incomplete (Figure 4) but numbers were very high in the 30s and 40s, in 1959 and again for a short period in the mid 80s. Many of these are likely to have been run on floodplain country of the Fortescue River and its tributaries.

2.5 **Literature review**

Ng *et al.* (1991) conducted a literature review of the effects of altered hydrological regimes on riparian forests. He states as follows:

Potential sources of moisture for riparian forests include (Reily and Johnson 1982):

- overbank flooding;
- groundwater;
- and precipitation.

The relative importance of these sources is poorly known. In dry climates, overbank flooding may assist forest abundance and tree growth by saturating the rooting zone and raising the water levels of shallow, unconfined aquifers. The timing, frequency and size of these floods can be crucial in preventing drought stress and promoting regeneration.’

‘A number of researchers have described the decline of riparian forests downstream from dams (e.g. Reily and Johnson 1982; Harris *et al.* 1987; Bren 1988; Rood and Heinze-Milne 1989; Rood and Mahoney 1990). The decline may be the result of altered seasonal stream flow patterns (high- and low-flow regimes), changes in channel morphology and pattern, and the retention of suspended silt, sediment, and nutrients behind the dam wall. Potential impacts include:

- reduced forest abundance;
- reduced plant vigour;
- reduced seedling abundance;
Ethel Creek

Stocking history 1990 - 1991

No data: 1948-58; 1960-72
(Totals do not include young stock)

Roy Hill

Stocking history 1990 - 1991

No data: 1959-69
(Totals do not include young stock)
- absence of seedlings;
- fewer saplings; and
- changes in species composition and diversity.’

‘Harris et al. (1987) state that these impacts are poorly understood and that Government agencies have little scientific information on which to base their decisions. Furthermore, the development of a general model for predicting the impacts of dams on downstream riparian forests has proved elusive owing to the differences in species composition, geomorphic setting and hydrologic setting from site to site (Kondolf et al. 1987), as well as the dynamic response of vegetation to natural and artificial events such as droughts and dam releases’.

Dexter et al. (1986) described how river red gum (*Eucalyptus camaldulensis*) forests on the Murray River have evolved in an environment characterised by natural flooding in the winter/spring months of most years alternating with dry conditions during summer/autumn months. He also described how, as a result of construction of dams and intensive river regulation for domestic and irrigation water supplies, the extent and duration of flooding of the red gum forests has been substantially changed with adverse effects on the health of the forest.
3. Methods

3.1 The land system approach

For the sake of uniformity with other surveys in rangelands (e.g. Mitchell et al. 1979; Payne et al., 1982, 1987) and for mapping convenience this survey adopted the land system approach to resource description and evaluation. Christian and Stewart (1953, 1968) define a land system as 'an area or group of areas throughout which there is a recurring pattern of topography, soils and vegetation'. Each land system has a characteristics pattern able to be seen on aerial photographs and generally occurs over an area greater than 5 sq km and is therefore of a scale suitable for mapping at 1:250,000 or 1:100,000 scale. Land systems consist of smaller land units or elements, each of which has a distinctive photographic pattern. The relative proportion of the component units and their arrangement one to another gives the broader photographic pattern that characterizes the particular land system.

3.2 Preliminary environmental mapping and pre-selection of traverse routes and sampling sites

The areas of major concern along the Fortescue River were mostly covered by colour aerial photography taken in 1989 at 1:40,000 scale and in 1983 at 1:25,000 scale. Land systems and degraded areas were interpreted in the office and boundaries verified or amended as necessary after field inspection.

Where recent photographic coverage was not available, boundaries were interpreted on LANDSAT imagery (at 1:50,000 scale) taken in June 1989. This imagery and the colour aerial photographs were also used for pre selecting field sampling sites and for navigating in the field.

In addition LANDSAT data were obtained for August 1981 (prior to Ophthalmia dam being filled for the first time) and August 1987. An albedo (land surface reflectance) change image between the two times was obtained. This indicated areas that had become more reflective, less reflective or for which there was no change in reflectiveness between 1981 and 1987. Areas that had become more highly reflective were visited in the field and sampled in order to attempt to determine the reason for the increased reflectiveness.

Field traverses to give maximum coverage of the areas of interest in the time available were designed in the office. Occasionally it was necessary to amend the traverse route in the field.
Figure 5. Fortescue River flood plain
*Showing extent of flood plain and traverse routes*
3.3 Selection of Carramulla Creek as a control area

The floodplains associated with Carramulla Creek were selected as suitable control areas to compare with the floodplains of the Fortescue River. An important prerequisite for selection was that the two areas appeared from photo interpretation to be comprised of the same land system. (This subsequently proved to be the case and the system was named Fortescue.) Both areas had presumably been subject to the same or similar rainfall regimes and both had been grazed in the past. The significant difference was that Carramulla Creek had not be subjected to altered flows (i.e. was not dammed).

Traverses were planned for the floodplains associated with Jigalong Creek, but these floodplains were not selected as control areas because they were comprised of different land systems (and often different vegetation communities) to those found along the Fortescue river.

3.4 Field traverses and assessment of soil erosion and pasture/vegetation condition

A total of 26 traverses were undertaken in the field (Figure 5). Ten of these were made during the April 1990 survey and the remainder during the October-November 1990 survey. Fourteen traverses (totalling 550 kilometres) were on Ethel Creek station and twelve (totalling 510 km) on Roy Hill station. At each kilometre the land system and unit of the system was identified and assessed for soil erosion and vegetation condition. Additional brief notes on vegetation were also made.

The criteria used for assessing whilst traversing are presented in Appendix 1, and the actual assessments have been recorded on the 1:100,000 scale station maps (not presented here).

In addition to traverse assessments a number of other samplings were done whilst traversing. These were as follows:

(a) inventory sites (105);
(b) tree condition sampling sites (21);
(c) tree condition assessment sites (30); and
(d) photographic sites (12); (additional to photos taken at (a) and (b)).

All these sites are indicated on the station maps (not presented here).
3.5 *Inventory sites*

These sites were pre-selected on the aerial photographs to cover as many of the photo patterns, within each land system, as possible. Detailed description of the landform, soil and vegetation were made at each of these points. A colour photograph and 35 mm slide were taken at each site. Examination of these data enabled the formal land system descriptions to be compiled.

3.6 *Tree condition*

3.6.1 *Tree condition sampling sites*

These sites were preselected on the aerial photographs or on LANDSAT albedo change images. LANDSAT albedo change imagery indicate that some areas within the Fortescue River floodplain and river fan deposits on Ethel Creek and Roy Hill stations have become considerably more reflective since the Ophthalmia dam was constructed. The inference from this is that the ground vegetative cover had declined to expose more of the red, more highly reflective soil surface. A number of areas identified as having become more reflective were visited on the ground and sampled.

Transects with an area of 2000 m² (100 m x 20 m) were laid out at each site and trees and shrubs identified and counted. Trees were assessed as being either alive, unhealthy (with obvious signs of recent stress, e.g. loss of leaves, death of small branches, coppicing) or dead. Basal cover of perennial grasses was estimated by eye or by a 'step point' method (Evans and Love 1957). A colour photograph and 35 mm slide was taken at each site.

3.6.2 *Tree condition assessment sites*

These sites were preselected on the aerial photographs on the levees or upper banks close to the main channels of the Fortescue River and Carramulla Creek and on the floodplains of the Fortescue River. At each of these sites the trees in an area 100 m x 10 m (50 m either side of the point) were assessed for health and the site then allocated to one of the following categories:-

<table>
<thead>
<tr>
<th>Category</th>
<th>% Trees dead or unhealthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>1</td>
<td>2-10%</td>
</tr>
<tr>
<td>2</td>
<td>11-25%</td>
</tr>
<tr>
<td>3</td>
<td>26-50%</td>
</tr>
<tr>
<td>4</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>
The trees most commonly encountered at sampling sites were coolibah (*Eucalyptus coolabah*), and variable barked bloodwood (*E. dichromophloia*). Other trees frequently encountered were corkwood (*Hakea suberea*), whitewood (*Atalaya hemiglauca*), *Acacia citrinoviridis* and, less commonly, mulga (*A. aneura*) *A. coriacea* and river red gum (*Eucalyptus camaldulensis*).

### 3.7 Photographic sites

Twelve photographs (additional to those taken at inventory sites and tree condition sampling sites) were taken whilst on traverse with positions identified and marked on aerial photographs and maps. Some of these photo sites were also tree condition assessment sites.
4. Results

4.1 Land systems comprising the area

During the April 1990 survey six alluvial land systems, associated with the Fortescue River and its tributaries, were identified and mapped. A number of additional systems were also identified, however field sampling was incomplete.

A second survey in October-November 1990 enabled all land systems on Ethel Creek and Roy Hill stations to be described and assessed. Descriptions of these systems are not presented in this report, although they are shown on 1:100,000 scale station maps.

The systems on Ethel Creek and Roy Hill stations can be placed into five broad groups as indicated below. However, only the alluvial plain and marsh systems which are relevant to the terms of reference and areas of concern of this study are further detailed:

- alluvial plain and marsh deposits;
- grooved sheet wash plains;
- sandy plains;
- stony plains;
- hills and ridges.

The alluvial plain and marsh deposits are Bullina (Bua), Coolibah (Cob), Fortescue (For), Jigalong (Jig), Marsh (Mar) and Washplain (Wsp). These systems have developed under a regime of regular flooding and many of the vegetative communities that they support depend on flooding for their maintenance.

The Bullina system occurs only as a very small area in the north of Ethel Creek station and the south-east of Roy Hill station. It forms a discrete part of the lower reaches of the Jigalong Creek and consists of floodplains and broad swampy depressions with grassy woodlands in good condition.

The Coolibah system occurs immediately downstream from the Fortescue system, from just north of the Ethel Creek homestead to Roy Hill homestead. It consists of floodplains with weakly glazed clay soils supporting a distinctive riverine woodland of coolibah (Eucalyptus coolabah) and patchy perennial grasses. The grass pastures are generally degraded but the system is still highly productive after flooding.

The Fortescue system flanks the Fortescue River from where it emerges from the Hamersley ranges northwards to about the Ethel Creek homestead. It also occurs as smaller areas flanking parts of Jimblebar and Carramulla Creeks in the south of the survey area. It consists of scalded alluvial plains with scattered woodlands and shrublands with patchy perennial grass understorey. Pastoral potential was high but is now much reduced as there are serious problems of vegetation and soil degradation on the system.
The Jigalong system flanks the Jigalong Creek in the east of the survey area. It is a complex alluvial system with a number of different land units supporting various tall and low shrublands generally based on mulga (*Acacia aneura*). It is of moderate to high pastoral potential. There are a number of areas of serious vegetation degradation and soil erosion.

The Marsh system to the west of Roy Hill homestead is a large area subject to regular inundation as a result of natural obstruction of the Fortescue River further downstream. It supports diverse halophytic vegetation of samphires, saltwater couch, false lignum and saltbush with distinct donations depending on such factors as flood heights, duration of flooding and soil salinity. Some of the lowest lake bed areas support very little vegetation although such areas are only a small proportion of the total system. Pastoral potential is generally high.

The Washplain land system occurs mostly in the east of the survey area on both stations and receives less frequent river flooding than the other systems. It supports dense, groved mulga shrublands on clayey soils. Pastoral potential is moderate to high.

Figure 6 shows the extent and location of these alluvial systems. It also shows the areas supporting eucalypt trees and woodlands (mainly coolibah, *Eucalyptus coolabah*).

Detailed descriptions of the above systems are presented in the following section.
Figure 6. Fortescue River flood plain
Showing extent of alluvial land system and location of Eucalypt woodlands
Bullina land system*

Flood plains, broad swampy depressions and drainage foci with grassy woodlands and tall shrublands.

**Geology:** Quaternary alluvium.

**Geomorphology:** Depositional surfaces flood plains and broad terminal drainage foci associated with the lower reaches of Jigalong Creek.

**Pastoral use:** High pastoral value with productive perennial grass pastures subject to fairly regular flooding, low susceptibility to erosion.

**Estimated carrying capacity:**

* Traversed but not sampled in field.
Coolibah land system

Floodplains with weakly glazed clay soils supporting eucalypt grassy woodlands.

Geology: Quaternary alluvium.

Geomorphology: Depositional surfaces - active floodplains and alluvial plains with shallow meandering and anastomizing central channels of the Fortescue River.

Pastoral use: High pastoral value when in good condition but the perennial grass pastures are widely degraded; the system still produces useful forage, including abundant annuals, after episodic flooding but has limited durability in dry seasons; generally minor susceptibility to erosion.

Estimated carrying capacity: 35 ha/cattle unit when in good range condition.
Coolibah land system

<table>
<thead>
<tr>
<th>Landform and soils</th>
<th>Vegetation: formations and major species</th>
<th>Comments and condition indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost flat alluvial plains up to 4 or 5 km wide with central channels, subject to fairly regular flooding; soils are dark red, self mulching, weakly gilgaied clays &gt; 1 m deep sometimes with a sparse mantle of calcrete pebbles and rocks or ironstone gravel.</td>
<td>Unit 1  Flood plains (70%) Woodlands of <em>Eucalyptus coolabah</em> with occasional undershrubs and patchy perennial tussock grasses. Trees (4-8 m): <em>Eucalyptus coolabah</em>, <em>Atalaya hemiglauca</em>, <em>Capparis umbonata</em>. Shrubs (mostly &lt; 1.5 m): <em>Acacia farnesiana</em>, <em>A. victoriae</em>, <em>A. tetragonophylla</em>, <em>Capparis lasiantha</em>, <em>Cassia spp.</em>, <em>Sclerolaena bicorns</em>, <em>Neptunia monosperma</em>, <em>Chenopodium auricorum</em>. Perennial grasses: <em>Eragrostis xerophila</em>, <em>E. setifolia</em>, <em>Eriachne gardneri</em>, <em>Chrysopogon fallax</em>.</td>
<td>Pasture type: Roebourne Plains Tussock Grass. Perennials augmented by annual grasses and forbs after flooding. Desirable perennials include: <em>Eragrostis xerophila</em>, <em>E. setifolia</em>, <em>Eriachne gardneri</em>, <em>Chrysopogon fallax</em>. Pastoral use limitations: Low to moderate susceptibility to erosion.</td>
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<tr>
<td>Almost flat plains up to 3 or 4 km in extent and mostly on outer margins of system, frequently with numerous small claypans, sandy banks and scalded tracts; soils are dark red clay loams and light clays &gt; 1 m deep</td>
<td>Unit 2  Alluvial plains (15%) Very patchy tall and low shrublands dominated by <em>Acacia aneura</em>, <em>A. victoriae</em>, <em>C. desolata</em>, <em>C. oligophylla</em> with scattered <em>Eragrostis xerophila</em> and <em>Chrysopogon fallax</em>; spinifex (<em>Triodia</em> spp.) on small sandy banks.</td>
<td>Pasture type: Tussock Grass but frequently degraded to annual herbfields. Desirable perennials include: <em>Eragrostis xerophila</em>, <em>Chrysopogon fallax</em>. Pastoral use limitations: High susceptibility to erosion.</td>
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<tr>
<td>Almost flat plains up to 2 km in extent subject to less regular flooding than units 1 and 2; soils are dark red, self mulching gilgaied clays &gt; 1 m deep. Principal profile form: Ug 5.38.</td>
<td>Unit 3  Gilgai back plains (5%) Tussock grassland with very scattered shrubs. Mid shrubs (1-2 m): <em>Acacia farnesiana</em>, <em>A. victoriae</em>. Low shrubs (&lt; 1 m): <em>Neptunia monosperma</em>, <em>Sida coronata</em>. Perennial grasses: <em>Astrebla elymoides</em>, <em>A. pectinata</em>, <em>Eriachne gardneri</em>, <em>Eragrostis setifolia</em>, <em>E. xerophila</em>.</td>
<td>Pasture type: Tussock Grass. Desirable perennials include: <em>Astrebla elymoides</em>, <em>A. pectinata</em>, <em>Eragrostis setifolia</em>. Pastoral use limitations: None with controlled stocking.</td>
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</tbody>
</table>
**Coolibah land system**  continued

<table>
<thead>
<tr>
<th>Landform and soils</th>
<th>Vegetation: formations and major species</th>
<th>Comments and condition indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 4</strong> Stony plains (2 %)</td>
<td>Usually no perennial vegetation.</td>
<td>Sparse annual grasses and forbs in season.</td>
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<tr>
<td>Occasional stony plains up to 1 km in extent and marginally higher than adjacent units 1 and 2, very dense mantles of ironstone gravel and pebbles; soils red clays &gt; 1 m deep.</td>
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</table>

| **Unit 5** Depressions and drainage foci (3 %) | Close woodlands of *Eucalyptus coolabah* or *Acacia aneura* (6-10 m) with scattered undershrubs and perennial grasses such as *Chrysopogon fallax* and *Eriachne gardneri.* | Pasture type: Tussock Grass. Desirable perennials include: *Chrysopogon fallax.* Pastoral use limitations: None with controlled stocking. |
| Low lying depressions and foci up to 1.5 km in extent but usually smaller within units 1 and 2. Soils probably light to medium clays > 1 m deep. | | |

| **Unit 6** Channels, banks and minor river terraces (5 %) | Fringing woodlands (5-8 m) of *Eucalyptus coolabah* with fairly dense tussock grasses dominated by *Eriachne gardneri,* other grasses include *Eragrostis setifolia,* *Chrysopogon fallax.* | Pasture type: Tussock Grass. Desirable perennials include: *Eriachne gardneri,* *Eragrostis setifolia,* *Chrysopogon fallax.* Pastoral use limitations: None with controlled stocking. |
| Meandering, braided channels 2-50 m wide and shallowly incised 1-4 m passing more or less centrally through unit 1; larger channels flanked by narrow, poorly developed terraces and banks; bedloads of silty sand; dark red clayey soils on banks and terraces. | | |
Fortescue land system

Scalded alluvial plains with patchy grassy woodlands and shrublands.

**Geology:** Quaternary alluvium.

**Geomorphology:** Depositional surfaces - alluvial plains, flood plains and depressions with minor levees and channels of the Fortescue River.

**Pastoral use:** High pastoral value when in good condition, now widely degraded and eroded; parts of the system are still moderately productive after episodic flooding but overall pasture durability is low; unit 1 highly susceptible to erosion.

**Estimated carrying capacity:** 40ha/cattle unit when in good range condition.
Fortescue land system

<table>
<thead>
<tr>
<th>Landform and soils</th>
<th>Vegetation: formations and major species</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 1</strong> Alluvial plains (60 %)</td>
<td>Patchy, very scattered, tall, mid or low shrublands with sparse perennial grasses; some extensive bare degraded areas with no perennial vegetation. Trees (occasional 3-5 m): <em>Hakea suberea</em>. Tall and mid shrubs (1-2 m+): <em>Acacia citrinoviridis</em>, <em>A. victoriae</em>, <em>A. aneura</em>, <em>A. tetragonophylla</em>, <em>Eremophila longifolia</em>. Low shrubs (&lt; 1 m): <em>Cassia oligophylla</em>, <em>C. helmsii</em>, <em>C. desolata</em>, <em>Rhagodia eremaea</em>, <em>Ptilotis obovatus</em>. Perennial grasses: <em>Eragrostis xerophila</em>, <em>E. setifolia</em>, <em>Chrysopogon fallax</em>.</td>
<td>Pasture type: Tussock Grass but frequently degraded and eroded. Perennials augmented by annual grasses and forbs in season or after flooding. Desirable perennials include: <em>Rhagodia eremaea</em>, <em>Eragrostis xerophila</em>, <em>E. setifolia</em>, <em>Chrysopogon fallax</em>. Undesirable perennials include: <em>Cassia helmsii</em>, <em>C. desolata</em>. Pastoral use limitations: Moderate susceptibility to erosion, some sites susceptible to shrub invasion.</td>
</tr>
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</table>

| **Unit 2** Flood plains, outwash river fans and Depressions (20 %) | Woodlands dominated by *Eucalyptus coolabah* with scattered undershrubs and dense patches of perennial grasses or tall, moderately close tall shrublands dominated by *Acacia aneura*, *A. citrinoviridis* with dense undershrubs and perennial grasses. Trees (4-10 m): *Eucalyptus coolabah*, *E. dichromophloia*, *Acacia aneura*, *Hakea suberea*, *Atalaya hemiglaucu*. Tall and mid shrubs (1-4 m+): *Acacia aneura*, *A. citrinoviridis*, *A. tetragonophylla*, *Eremophila longifolia*. Low shrubs (< 1 m): *Cassia* spp., *Rhagodia eremaea*, *Indigofera* sp. Perennial grasses: *Chrysopogon fallax*, *Eragrostis xerophila*, *Dichanthium* sp., *Eriachne gardneri*. | Pasture type: Tussock Grass. Desirable perennials include: *Chrysopogon fallax*, *Dichanthium* sp. Pastoral use limitations: None under controlled stocking. |

Almost flat plains up to 5 km wide on either side of major river channels, subject to occasional flooding; surfaces are often extensively scalded and hummocked. Soils are dark reddish-brown clays or clay loams over clay > 1 m deep, pH 6.0-8.5. Principal profile forms: Uf6.12, 6.21, 6.53.

Almost flat plains, fans and depressions marginally lower than unit 1 and receiving more regular flooding; soils are dark reddish brown light clays or clay loams over clay > 1 m deep. Principal profile form: Uf6.71, Ug5.38.
### Fortescue land system  continued

<table>
<thead>
<tr>
<th>Landform and soils</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 3</strong> Plains with groved vegetation (12 %)</td>
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<tr>
<td>Almost flat alluvial plains with groved vegetation, occurs on outer margins of system; soils are probably clay loams over clays similar to unit 1.</td>
<td>Intergroves: Vegetation similar to unit 1. Groves: See unit 4.</td>
<td>Pasture type: Tussock Grass but frequently degraded. Pastoral use limitations: Susceptible to erosion.</td>
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<tr>
<td><strong>Unit 4</strong> Groves (1 %)</td>
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<tr>
<td>Groves and bands of dense vegetation occurring within unit 3, up to 200 m long x 50 m wide but commonly less, soils are &gt; 1 m deep, dark reddish brown loams or clay loams becoming more clayey with depth. Principal profile form: Gn2.12.</td>
<td>Closed tall shrublands or woodlands dominated by <em>Acacia aneura</em>. Trees (4-6 m): <em>A. aneura</em>. Tall and mid shrubs (1-4 m): <em>A. aneura</em>, <em>A. tetragonophylla</em>, <em>Eremophila forrestii</em>. Low shrubs (&lt; 1 m): <em>Eremophila sp.</em>, <em>Maireana planifolia</em>, <em>Sida sp.</em> Perennial grasses: <em>Chrysopogon fallax</em>.</td>
<td>Pasture type: Mulga Grove. Desirable perennials include: <em>Chrysopogon fallax</em>, <em>Eremophila forrestii</em>, <em>Maireana planifolia</em>. Pastoral use limitations: None under controlled stocking.</td>
</tr>
<tr>
<td><strong>Unit 5</strong> Sandy banks and sheets (3 %)</td>
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<tr>
<td>Irregular sandy banks and patches on unit 1, up to 2 km in extent, moundy surfaces; soils are dark reddish brown or dark red sandy loams or loamy sands &gt; 1 m deep, pH 6.0-7.5. Principal profile forms Uc5.21.</td>
<td>Hummock grasslands or grassy shrublands. Trees (occasional): <em>Eucalyptus aspera</em>, <em>Hakea suberea</em>. Tall and mid shrubs (1-2 m+): <em>Hakea suberea</em>, <em>Acacia tetragonophylla</em>, <em>A. retivenia</em>, <em>A. pachyacra</em>, <em>Cassia helmi</em>. Low shrubs (&lt; 1 m): <em>Cassia helmi</em>, <em>C. oligophylla</em>, <em>Ragodia eremaea</em>, <em>Eremophila forrestii</em>. Grasses: <em>Triodia pungens</em>, <em>T. basedowii</em>, <em>Eragrostis eriopoda</em>, <em>Chrysopogon fallax</em>, <em>Paraneurachne meulleri</em>.</td>
<td>Pasture type: Soft Spinifex or Tussock Grass. Desirable perennials include: <em>Eremophila forrestii</em>, <em>Triodia pungens</em>, <em>Chrysopogon fallax</em>, <em>Paraneurachne meulleri</em>. Pastoral use limitations: None under controlled stocking.</td>
</tr>
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</table>
### Fortescue land system continued

<table>
<thead>
<tr>
<th>Landform and soils</th>
<th>Vegetation: formations and major species</th>
<th>Comments and condition indicators</th>
</tr>
</thead>
</table>

Ill defined levees 25-150 m wide flanking major channels and raised 1-2 m above adjacent unit 1, mounding surfaces; soils are dark reddish brown silty loams and clay loams > 1 m deep. Principal profile form: Gn2.12.

| **Unit 7  Channels (3 %)** | Channel beds unvegetated. Eucalypt woodlands fringing banks and channels. Trees (6-15m): *Eucalyptus camaldulensis*, *E. coolabah*, *Acacia coriacea*, *A. citrinoviridis*, *A. aneura*. Tall shrubs (2-6m): *Acacia citrinoviridis*, *A. tetragonophylla*, *Melaleuca* sp. Other shrubs: *Cassia* spp., *Indigofera* sp. Grasses: *Chrysopogon fallax*, *Cenchrus ciliaris*. | Pasture type: No pastures in riverbeds, Tussock Grass pastures on banks. Desirable perennials include: *Chrysopogon fallax*, *Cenchrus ciliaris*. |

Major and minor river channels up to 200 m wide incised 2-5 m, sand and gravel bedloads, banks with reddish brown silty loam and clay loam soils.
Jigalong land system

Flood plains and slightly higher alluvial plains with mixed shrublands and grassy shrublands.

Geology: Quaternary alluvium and colluvium.

Geomorphology: Depositional surfaces - flood plains, alluvial plains and fringing gravelly plains with central anatomizing channels and creeklines.

Pastoral use: Moderate to high pastoral value tussock grass, chenopod and mulga shrub pastures when in good condition; some units susceptible to erosion and are now degraded.

Estimated carrying capacity: 60ha/cattle unit when in good range condition.
### Jigalong land system

<table>
<thead>
<tr>
<th>Landform and soils</th>
<th>Vegetation: formations and major species</th>
<th>Comments and condition indicators</th>
</tr>
</thead>
</table>

Almost flat plains up to 5 km in extent subject to periodic floodings; surfaces often scalded, hummocked and rilled with variable density mantles of ironstone gravel and pebbles. Soils are dark reddish brown clays or duplex types > 1 m deep. Principal profile form: Uf 6.21, Dr 2.12, Dr 2.53. 

| **Unit 2** Alluvial plains (60 %) | Patchy, very scattered or scattered tall shrublands dominated by prickly acacia or mulga with halophytic and non-halophytic under shrubs. Trees (occasional): *Acacia aneura*. Tall shrubs (> 2 m): *Acacia victoriae*, *A. aneura*. Mid shrubs (1-2 m): *A. victoriae*, *A. tetragonophylla*. Low shrubs (< 1 m): *Cassia spp.*, *Eremophila pterocarpa*, *E. maculata*, *Maireana aphylla*, *Enchylaena tomentosa*, *Rhagodia eremaea*, *Sclerolaena spp.*. Perennial grasses (occasional): *Eragrostis xerophila*. | Pasture type: Mixed halophyte but frequently degraded. Desirable perennials include: *Rhagodia eremaea*, *Maireana aphylla*, *Enchylaena tomentosa*. Undesirable perennials include: *Cassia spp.*, *Eremophila pterocarpa*, *Acacia victoriae*. Pastoral use limitations: Areas with duplex soils are highly susceptible to erosion if vegetation depleted, some parts likely to become shrub invaded. |
### Jigalong land system continued

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<thead>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 4 Gilgai plains (5 %)</strong></td>
<td>Patchy tussock grassland of Roebourne Plains grass (<em>Eragrostis xerophila</em>). Mid and low shrubs (occasional &lt; 1.5 m): <em>Cassia oligophylla, C. hamersleyensis, Eremophila pterocarpa, Acacia victoriae, Enchylaena tomentosa</em>. Perennial grasses: <em>Eragrostis xerophila, E. setifolia</em>.</td>
<td>Pasture type: Roebourne Plains Tussock Grass. Desirable perennials include: <em>Eragrostis xerophila, E. setifolia, Cassia hamersleyensis</em>. Pastoral use limitations: Some susceptibility to soil degradation and erosion if perennial grass cover lost.</td>
</tr>
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</table>

Gently inclined plains on outer margins of system, slightly elevated above and not flooded as frequently as units 1 and 2, surfaces may be mounded with dense mantle of ironstone grit, gravel and pebbles. Soils are sandy clay loams over incipient hardpan or gravel. Principal profile form: Um 5.31.

Flat plains up to 1 km in extent with weakly gilgaied microrelief and variable density mantle of ironstone gravel. Soils are dark reddish brown, cracking clays > 1 m deep. Principal profile form: Ug 5.38.
### Jigalong land system  continued

<table>
<thead>
<tr>
<th>Landform and soils</th>
<th>Vegetation: formations and major species</th>
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</tr>
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<tbody>
<tr>
<td><strong>Unit 5  Drainage foci (&lt; 1 %)</strong></td>
<td>Small foci may have grassy or bare central areas ringed by mulga and other shrubs, larger foci support moderately close tall shrublands with grassy understorey. Trees (4-6 m):  <em>Hakea suberea, Acacia aneura</em>. Tall shrubs (4-6 m):  <em>A. aneura</em>. Mid and low shrubs (1-2 m):  <em>Acacia victoriae, Eremophila forrestii, Cassia oligophylla, Rhagodia aremaea, Enchylaena tomentosa, Solanum lasiophyllum</em>. Perennial grasses:  <em>Chrysopogon fallax, Eragrostis xerophila, Eriachne gardneri</em>.</td>
<td>Pasture type: Tussock Grass. Desirable perennials include:  <em>Rhagodia eremaeae, Enchylaena tomentosa, Chrysopogon fallax, Eriachne gardneri</em>. Pastoral use limitations: None under controlled stocking.</td>
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<tr>
<td>Discrete drainage foci and pans mostly &lt; 250 m in extent (occasionally larger) within unit 2. Soils are clays occasionally weakly gilgaied. Principal profile form: Uf 6.21.</td>
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<tr>
<td><strong>Unit 6  Major and minor channels (4 %)</strong></td>
<td>Close fringing woodlands and tall shrublands on banks and terraces often dominated by  <em>Acacia citrinoviridis</em>. Trees (4-10 m):  <em>Acacia citrinoviridis, A. aneura, A. distans(?), A. coriaceae, Eucalyptus camaldulensis, E. coolabah</em>. Tall shrubs (2-6 m):  <em>A. citrinoviridis, A. farnesiana, A. victoriae, A. aneura</em>. Perennial grasses:  <em>Chrysopogon fallax, Eriachne gardneri, Cenchrus ciliaris</em>.</td>
<td>Pasture type: Tussock Grass. Desirable perennials include:  <em>Chrysopogon fallax, Eriachne gardneri</em>. Pastoral use limitations: None under controlled stocking.</td>
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<tr>
<td>Meandering and anastomizing channels up to 100 m wide with associated narrow river terraces and banks to 4 m, channel bedloads of sand and silt, juvenile clayey alluvial soil on banks.</td>
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</table>
Marsh land system

Lake beds and floodplains with samphire and other low shrublands and grasslands, subject to regular inundation.

Geology: Quaternary alluvium and lacustrine deposits.

Geomorphology: Depositional surfaces - lake beds and saline peripheral flood plains forming a termination basin for the upper reaches of the Fortescue River.

Pastoral use: Perennial grass and chenopod shrub pastures of high to very high pastoral value and samphire pastures of low pastoral value; the system has low susceptibility to degradation and erosion except for some marginal outer plains which are moderately susceptible.

Estimated carrying capacity: 60/ha/cattle unit when in good range condition.
Marsh land system

<table>
<thead>
<tr>
<th>Landform and soils</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 1  Stony plains (5 %)</strong></td>
<td>Patchy low shrublands of samphire (<em>Halosarcia</em> sp.) and <em>Eremophila</em> sp. nova.</td>
<td>Pasture type: Samphire or Mixed Halophyte. Desirable perennials include:</td>
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<td>Low shrubs (&lt; 1 m): <em>Halosarcia</em> sp., <em>Eremophila</em> sp. nova, <em>E. pterocarpa</em>,</td>
<td><em>Frankenia</em> sp., <em>Atriplex bunburyana</em>. Pastoral use limitations: Slight</td>
</tr>
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<td></td>
<td><em>Fransenkenia</em> sp., <em>Atriplex bunburyana</em>, <em>Solanum lasiophyllum</em>. Perennial</td>
<td>susceptibility to erosion where mantle is sparse.</td>
</tr>
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<td></td>
<td>grasses (Occasional): <em>Enteropogon acicularis</em>, <em>Cenchrus ciliaris</em>.</td>
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<tr>
<td><strong>Unit 2  Alluvial fans and drainage floors (5 %)</strong></td>
<td>Scattered to close tall shrublands with halophytic under shrubs and perennial grasses. Trees (occasional): <em>Eucalyptus coolabah</em>. Tall shrubs (2-4 m): <em>Acacia coriacea</em>, <em>A. farnesiana</em>, <em>A. sclerosperma</em>, <em>Melaleuca</em> sp. Mid shrubs (1-2 m): <em>Muehlenbecka cunninghamii</em>, <em>Rhagodia eremaea</em>. Low shrubs (&lt; 1 m): <em>Atriplex bunburyana</em>, <em>A. amnicola</em>, <em>Maireana pyramidata</em>. Perennial grasses: <em>Cenchrus ciliaris</em>.</td>
<td>Pasture type: Saltbush. Desirable perennials include: <em>Atriplex bunburyana</em>, <em>A. amnicola</em>, <em>Cenchrus ciliaris</em>. Pastoral use limitations: Fans have moderate to high susceptibility to water erosion, floors with denser vegetation and clay soils are more stable.</td>
</tr>
<tr>
<td><strong>Unit 3  Gilgai plains (5 %)</strong></td>
<td>Very scattered low halophytic shrublands with occasional melaleuca thickets. Tall</td>
<td>Pasture type: Saltbush. Desirable perennials include: <em>Atriplex spp.</em>,</td>
</tr>
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<td></td>
<td>shrubs (2-4 m): <em>Melaleuca</em> sp. Low shrubs (&lt; 1 m): <em>Atriplex bunburyana</em>, *A.</td>
<td><em>Maireana pyramidata</em>. Pastoral use limitations: None under controlled</td>
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## Marsh land system continued

<table>
<thead>
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<th>Landform and soils</th>
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<tbody>
<tr>
<td><strong>Unit 4</strong> Flood plains (30 %)</td>
<td>Shrubby grasslands of saltwater couch in patches or as more or less continuous sward, also shrublands without perennial grasses. Shrubs (&lt; 1.5 m): <em>Meullerolimon salicornaceum</em>, <em>Muehlenbeckia cunninghamii</em>, <em>Halosarcia</em> spp. Perennial grasses: <em>Sporobolus virginicus</em>.</td>
<td>Pasture type: Perennial Grass. Desirable perennials include: <em>Sporobolus virginicus</em>. Pastoral use limitations: No grazing when inundated.</td>
</tr>
<tr>
<td>Almost flat plains extending up to 4 or 5 km, subject to periodic inundation. Soils are clays over gypsum at variable depth. Principal profile form: Uf 6.53, 6.21.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Unit 5** Saline flood plains (55 %) | Very scattered to moderately close shrublands of samphire often with distinct zonation of species, also some extensive areas with no perennial vegetation. Mid shrubs (1-2 m): *Halosarcia auriculata*. Low shrubs (> 1 m): *Halosarcia indica(?)*, subsp. *bidens*, *H*. sp. nov. Perennial grasses: *Eragrostis* sp. | Pasture type: Samphire. Pastoral use limitations: Low palatability of most samphires although useful annuals after flooding, no grazing when inundated. |
| Almost flat saline plains and broad drainage corridors subject to regular inundation. Soils are probably alkaline, highly gypsiferous clays. | | |

| **Unit 6** Kopi banks (< 1 %) | Not sampled. | |
| Intermittent channels up to 100 m wide usually with bare clayey surfaces; large waterholes 100 m wide and up to 3 km long. | Fringing tall shrublands and scattered trees around waterholes. Trees (4-10 m): *Eucalyptus camaldulensis*, *E. coolabah*. Tall shrubs (> 2 m) *Acacia ampliceps*, *A. farnesiana*. Mid shrubs (1-2 m): *Rhagodia eremaea*, *Muehlenbeckia cunninghamii*. | Pasture type: Mostly no pastures. |
Washplain land system

Almost level alluvial washplains with groved mulga shrublands.

**Geology:** Quaternary alluvium.

**Geomorphology:** Depositional surfaces - alluvial plains subject to sheetwash from adjacent higher systems and from river floodouts.

**Pastoral use:** Moderate pastoral value mulga shrub hardpan and mulga grove pastures, moderately susceptible to erosion.

**Estimated carrying capacity:** 100ha/cattle unit when in good range condition.
Washplain land system

<table>
<thead>
<tr>
<th>Landform and soils</th>
<th>Vegetation: formations and major species</th>
<th>Comments and condition indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat or very gently inclined alluvial plains subject to sheet flow, surfaces often with dense mantels of ironstone and other gravel and pebbles. Soils are duplex or gradational types generally &gt; 1 m deep. Principal profile form: Dr 2.32, 2.53.</td>
<td>Very scattered to scattered shrublands dominated by mulga, cassias and eremophilas. Tall shrubs (&gt; 2 m): Acacia aneura. Low shrubs (&lt; 1 m): Cassia desolata, C. helmsii, Eremophila cuneifolia, E. af. punicea, Enchylaena tomentosa, Maireana georgei, M. villosa, M. planifolia, Solanum lasiophyllum. Perennial grasses (occasional): Eragrostis xerophila.</td>
<td>Pasture type: Mulga Shrub Hardpan. Desirable perennials include: Enchylaena tomentosa, Maireana spp. Undesirable perennials include: Cassia spp. Pastoral use limitations: Slight to moderate susceptibility to erosion.</td>
</tr>
<tr>
<td>Dense patches and bands of vegetation 10-50m wide by up to 500m long arranged transverse to the direction of sheet flow on unit 1. Soils are probably clayey gradational types and clays.</td>
<td>Moderately close to closed mulga woodlands or tall shrublands with numerous undershrubs. Trees (2-6 m): Acacia aneura, Hakea suberea. Tall shrubs (2-4 m): Acacia aneura. A. victoriae. Mid shrubs (1-2 m): Cassia desolata, Eremophila forrestii. Low shrubs (&lt; 1 m): Eremophila sp., Cassia helmsii, C. luerssenii, Rhagodia eremaea, Enchylaena tomentosa, Sida spp., Solanum lasiophyllum. Perennial grasses: Chrysopogon fallax, Digitaria coenicola, Enneapogon sp.</td>
<td>Pasture type: Mulga Grove. Desirable perennials include: Eremophila forrestii, Rhagodia eremaea, Enchylaena tomentosa, Chrysopogon fallax. Pastoral use limitations: None under controlled stocking.</td>
</tr>
<tr>
<td>Unchannelled tracts receiving more concentrated sheet flow than unit 1. Soils are probably clayey gradational types and clays.</td>
<td>Moderately close to closed mulga woodlands or tall shrublands as for unit 2.</td>
<td>Pasture type: Mulga Grove. Desirable perennials include: As for unit 2. Pastoral use limitations: None under controlled stocking.</td>
</tr>
</tbody>
</table>
4.2 Soil and vegetation degradation on the Fortescue River

Information collected whilst traversing and at sampling sites indicated that degradation of soil and vegetation was widespread on parts of the floodplains of the Fortescue River and some of its tributaries.

Severely degraded areas as shown in Figure 7 are areas which show considerable loss of perennial grasses and palatable shrubs and moderate or severe soil erosion. They may or may not support patchy woodlands or scattered trees such as coolibah (*Eucalyptus coolabah*) or corkwood (*Hakea suberea*). A good proportion of the degraded areas as mapped have never supported woodlands. Erosion was mostly in the form of widespread surface stripping, scalding and hummocking by wind and water. Occasional ruing and active gullying occurred but was not common.

Tables 3 and 5 indicate that minor erosion (and occasional moderate and severe erosion) in the form of surface stripping and root exposure is quite common on the Coolibah land system. The tables also indicate that there is serious and more widespread erosion on the Fortescue land system.

The mapping accuracy of all the individual patches of degradation is not meant to be absolute, however, as a whole, Figure 7 and the 1:100,000 scale station maps (not presented here) clearly indicate the major areas of concern.

Figure 8 indicates those sites adjacent to major channels and elsewhere on the floodplains where the tree layer is clearly showing signs of recent serious stress (as ill thrift and death).

**Table 2.** Tree health and erosion on the Fortescue and Coolibah land systems, Ethel Creek and Roy Hill stations*

<table>
<thead>
<tr>
<th>Trees dead or unhealthy (%)</th>
<th>No. of sites</th>
<th>No. of sites showing soil erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>2-10</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>11-25</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>26-50</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>&gt;50</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>7</td>
</tr>
</tbody>
</table>

* Assessed at 51 sites (20 tree condition sampling sites, 26 tree condition assessment sites and five permanent photo sites).
Soil erosion and root exposure of trees in the arid zone may contribute to tree stress and death. On some eroded parts of the Fortescue and Jigalong land systems on Ethel Creek station there are remains of very large, but long dead, eucalypt and mulga trees. However, the recent (since about 1987) widespread and dramatic decline in tree health as indicated by this survey is unlikely to be largely as a result of soil erosion. This contention is supported by the information provided in Table 2.

Some erosion was evident on five of the 24 most severely affected sites (i.e. those sites showing 26-50 per cent or >50 per cent trees dead or unhealthy). The remaining 19 severely affected sites exhibited no erosion or root exposure. This suggests that erosion is not a major contributing factor to the current problem of tree stress and death.

An isolated area of active gully erosion occurs on the Fortescue land system a few kilometres east of Ethel Creek homestead. The erosion appears to have been exacerbated by the presence of a station track and coolibahs and acacias are dead or showing stress throughout the area. In this instance the decline of the woodlands is due to a change in water regime caused by the gullying. However, the area affected is only a small proportion (probably <5 per cent) of the whole Ethel Creek floodout plain system on which the trees are currently showing widespread stress.

Jigalong Creek was only sampled for tree health at one site which showed > 50% of trees dead. These were long dead mulga on an area of severe degradation and erosion caused by historical overgrazing.

LANDSAT albedo (reflectance) change imagery indicated that numerous areas within the Fortescue floodplain and river fan deposits on Ethel Creek station had become considerably more reflective since the Ophthalmia dam was constructed. The inference from this is that ground vegetative cover had declined to expose more of the red, more highly reflective, soil surface.

Nearly all of the extensive areas showing severe scalding and degradation due to past overuse showed no change in reflectance between 1981 and 1987; i.e. they were highly reflective (bare) in 1981 before the dam was constructed and still highly reflective in 1987. The areas of increased reflectance were generally on the margins of previously degraded areas or on broad, uneroded clay plains.

Four sites on Ethel Creek station (CS, 8 and 10 and 110) showing increased reflectance on the albedo change image were visited and sampled on the ground. Two sites (CS and C10, see Figure 8) supported what were previously good stands of the perennial weeping grass (*Chrysopogon fallax*). Fifty to 90 per cent of grass butts were dead or moribund. More than 50 per cent of coolibah trees on both sites were dead or unhealthy. The increase in reflectance appears to be due to the loss of perennial grass cover occurring between 1981 and 1987 i.e. since Ophthalmia dam was constructed. The other two sites (C8 and 110) supported practically no perennial grasses either dead or alive. The change in reflectance is probably due to changes in the annual herbage (such as roly poly (*Salsola kali*) and *Sclerolaena bicornis*) because of grazing or seasonal effects.
Figure 7  Fortescue River flood plain
Showing extent of severely degraded areas due to past overgrazing
Figure 8  Fortescue River flood plain  
Showing extent of flood plain and tree health indicators
The albedo change imagery could not be used to detect any changed reflectance on the narrow levees and upper banks of the Fortescue River where substantial death and unthriftyness of trees occurred. This is probably due to the inherent limitations of resolution (30 m pixel size) of the imagery.

The albedo imagery did not generally indicate any change in reflectance on the floodplains of the Coolibah land system on Roy Hill station except for a diffuse area towards the north western end of the plain. This area became more reflective between 1981 and 1987 probably due to reduction in ground cover afforded by perennial grasses and/or annual herbage.

4.2.1 Ethel Creek station

There are two serious environmental problems on Ethel Creek station.

The first is severe landscape degradation in the form of the loss of perennial vegetative cover and extensive soil erosion (scalding, sheeting and gullying).

The second is widespread recent deaths and ill health of trees (mainly *Eucalyptus coolabah*) and some perennial grasses.

The condition of the area surveyed on Ethel Creek station is summarized in Table 3 which shows that nearly all the degradation is confined to the floodplains associated with the Coolibah, Fortescue, Jigalong and Washplain land systems. On the Fortescue system 36 per cent of the traverse records indicated moderate or severe soil erosion, mainly in the form of scalding and thin sheeting.

Thirty three per cent of traverse records indicated very poor pasture condition. On the Coolibah system there was less but still significant erosion (13 per cent of traverse records indicated moderate or severe erosion) and 39 per cent of traverse records indicated very poor pasture condition. On the Jigalong system 12 per cent of the traverse records indicated moderate or severe erosion and 25 per cent of records indicated very poor pasture condition. The Washplain system was also significantly eroded and degraded.

Very poor pasture condition is indicated by the almost complete loss of desirable perennial grasses such as weeping grass (*Chrysopogon fallax*), Roebourne Plains grass (*Eragrostis xerophila*), never fail (*E. setifolia*), and swamp grass (*Eriachne gardneri*). The degraded areas support annual grasses and herbs in season but for much of the remainder of the year are bare and exposed to the action of wind and water. Because of the general loss of desirable perennial pasture plants the pastures on the Fortescue frontages on Ethel Creek station have much reduced durability in dry times.

The total area of severe degradation on those parts of Ethel Creek station covered by this survey is estimated to be 214 sq km. This is composed of about 167 sq km on the Fortescue land system (36.3 per cent of the system), 4.3 sq km on the Coolibah system (4.6 per cent), 33.5 sq km on the Jigalong system (6.5 per cent) and 9.2 sq km on the Washplain system (9.1 per cent).
Table 3. Condition statements derived from traverse records (550 recordings on 21 land systems) - Ethel Creek station

<table>
<thead>
<tr>
<th>Land System</th>
<th>No. of recordings</th>
<th>Erosion (%)</th>
<th>Pasture condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nil</td>
<td>Minor</td>
</tr>
<tr>
<td>Balfour</td>
<td>42</td>
<td>88</td>
<td>5</td>
</tr>
<tr>
<td>Boolgeeda</td>
<td>11</td>
<td>73</td>
<td>27</td>
</tr>
<tr>
<td>Bullina</td>
<td>7</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Clasp</td>
<td>5</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>*Coolibah</td>
<td>31</td>
<td>61</td>
<td>26</td>
</tr>
<tr>
<td>Divide</td>
<td>97</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Edenholme</td>
<td>9</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Egerton</td>
<td>1</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Elimunna</td>
<td>13</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Fan</td>
<td>9</td>
<td>89</td>
<td>11</td>
</tr>
<tr>
<td>*Fortescue</td>
<td>128</td>
<td>39</td>
<td>25</td>
</tr>
<tr>
<td>*Jigalong</td>
<td>55</td>
<td>61</td>
<td>27</td>
</tr>
<tr>
<td>Lag</td>
<td>3</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>Noomingnin</td>
<td>16</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Prairie</td>
<td>13</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>River</td>
<td>32</td>
<td>97</td>
<td>3</td>
</tr>
<tr>
<td>Rocklea</td>
<td>7</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Spearhole</td>
<td>15</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Valentine</td>
<td>12</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Warn</td>
<td>2</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>*Washplain</td>
<td>42</td>
<td>67</td>
<td>17</td>
</tr>
<tr>
<td>Total – all</td>
<td></td>
<td>74</td>
<td>13</td>
</tr>
</tbody>
</table>

* Floodplain systems which are the major concern of this report.
The area of ailing and dead trees was first observed near Horse Camp bore on the Fortescue River and extended for about 39 km northwards along the river past Ethel Creek homestead to the boundary fence with Roy Hill station. The sampling indicated that the effect was generally quite severe with over 60 per cent of the sites showing greater than 25 per cent death or ill health and 36 per cent of the sites showing greater than 50 per cent death or ill health (see Table 4).

For the first 19 km northwards from Horse Camp bore the effect was largely confined to the levees and upper banks adjacent to the channel of the Fortescue River where the majority of trees are concentrated (the adjacent floodplains support patchy tall and low shrublands rather than woodlands). Trees on the lower banks and in the channels of the river were mostly healthy.

Table 4. Tree health on the Fortescue and Coolibah land systems, Fortescue River frontage, Ethel Creek station (assessed at 19 tree condition assessment sites and nine tree condition sampling sites)

<table>
<thead>
<tr>
<th>Trees dead or unhealthy (%)</th>
<th>No. of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2</td>
<td>2</td>
</tr>
<tr>
<td>2-10</td>
<td>4</td>
</tr>
<tr>
<td>11-25</td>
<td>5</td>
</tr>
<tr>
<td>26-50</td>
<td>7</td>
</tr>
<tr>
<td>&gt;50</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
</tr>
</tbody>
</table>

At about 19 km north of Horse Camp bore the Fortescue River splits into a number of channels forming a broad alluvial fan and floodplain which extends for about 20 km past the Ethel Creek homestead northwards to the boundary with Roy Hill station. Coolibah (Eucalyptus coolabah) woodlands flank the channels and extend outward in patches across the floodplain. These woodlands are in very poor condition with a high percentage of trees being unhealthy or recently dead. Large patches of dead or moribund weeping grass (Chrysopogon fallax) butts are common as the ground cover (e.g. at sites CS and ClO, see Figure 8). Perennial grass regrowth is restricted to the lowest parts of the landscape in channels, drainage tracts and drainage foci which have received extra run-on water from localized incident rainfall or from river flows.

Elsewhere on the floodplain there were numerous signs of past overuse in the form of scalded and eroded patches from which perennial grass cover has long since disappeared. However, it was clear that the remaining patches of better vegetation

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3 Kennedy et al (1991) contend that the effect commences from immediately below the dam wall. The first 14km below the dam wall was not inspected during this survey.
were being severely stressed.

4.2.2 Roy Hill station

The same two environmental problems (a) the loss of perennial ground cover and erosion caused by historical overuse and (b) recent stress and death of trees and grasses as described for Ethel Creek station also occur on Roy Hill station but are not as severe.

The condition of the area surveyed on Roy Hill station is summarized in Table 5. The majority of the degradation seen now is likely to have occurred in the early years after settlement when stock numbers were substantially higher than they have been in the last few decades. Grazing effects are discussed further in section 5.1.2.

Table 5 shows that the system with the most degraded pastures is Edenholme (54 per cent of records show very poor pasture condition) followed by Coolibah (46 per cent of records show very poor pasture condition). There is little erosion on the Edenholme system but eleven per cent of the traverse records on the Coolibah system indicated moderate or severe erosion.

Historical overuse on the Edenholme system has resulted in extensive loss of perennial grasses such as Roebourne Plains grass (*Eragrostis xerophila*) and never fail (*E. setifolia*). The system is still moderately productive as it supports numerous annuals in season but it now has negligible durability in dry seasons. Fortunately, due to its almost flat topography and clayey soils, the system is not highly susceptible to erosion. Although the pastures on the system are much degraded, only about 9 sq km are seriously eroded and have been mapped as severely degraded. The Edenholme system is not subject to flooding by the Fortescue River.

Degradation on the Coolibah system has resulted in considerable loss of perennial grasses. The ground layer consists of patches of sparse to moderately dense tussock grasses interspersed among larger areas supporting only annuals in season. The common perennial grasses are Roebourne Plains grass, never fail, swamp grass (*Eriachne gardneri*) and weeping grass (*Chrysopogon fallax*). The system is inherently fairly resistant to erosion but there are some areas of soil erosion in the form of sheeting, scouring and scalding. About 17.5 sq km of the Coolibah system (8.9 per cent) is severely degraded and eroded.

Other land systems seen during the survey showed some pasture degradation but little erosion and were generally in fair condition. There was some erosion on the outer margins of the Marsh land system but pastures on this system are nearly all in good or very good condition.

Traversing and sampling the coolibah (*Eucalyptus coolabah*) woodlands of the Coolibah land system revealed that there are quite frequently patches where trees are unthrifty or dead. Eleven of 42 traverse observations within the coolibah woodlands noted some degree of tree stress or death. Five of the 10 condition sampling sites indicated > 10 per cent trees dead or unhealthy (see Table 6).

Table 5. Condition statements derived from traverse records (510 recordings on 21 land systems) - Roy Hill station
<table>
<thead>
<tr>
<th>Land System</th>
<th>No. of recordings</th>
<th>Erosion (%)</th>
<th>Pasture condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nil</td>
<td>Minor</td>
</tr>
<tr>
<td>Adrian</td>
<td>1</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Boolgeeda</td>
<td>1</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Calcrete</td>
<td>39</td>
<td>94</td>
<td>3</td>
</tr>
<tr>
<td>Christmas</td>
<td>64</td>
<td>90</td>
<td>8</td>
</tr>
<tr>
<td>*Coolibah</td>
<td>63</td>
<td>72</td>
<td>17</td>
</tr>
<tr>
<td>Divide</td>
<td>16</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Edenholme</td>
<td>56</td>
<td>91</td>
<td>7</td>
</tr>
<tr>
<td>Egerton</td>
<td>3</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Elimunna</td>
<td>31</td>
<td>97</td>
<td>3</td>
</tr>
<tr>
<td>Fan</td>
<td>81</td>
<td>93</td>
<td>7</td>
</tr>
<tr>
<td>Jamindie</td>
<td>42</td>
<td>88</td>
<td>7</td>
</tr>
<tr>
<td>Lag</td>
<td>4</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Lewin</td>
<td>5</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>*Marsh</td>
<td>38</td>
<td>89</td>
<td>3</td>
</tr>
<tr>
<td>McKay</td>
<td>13</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Narbung</td>
<td>27</td>
<td>85</td>
<td>11</td>
</tr>
<tr>
<td>Perkililly</td>
<td>5</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Prairie</td>
<td>3</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Spearhole</td>
<td>2</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Warri</td>
<td>11</td>
<td>91</td>
<td>9</td>
</tr>
<tr>
<td>*Washplain</td>
<td>5</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total – all</strong></td>
<td><strong>510</strong></td>
<td><strong>89</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

* Floodplain systems which are the major concern of this report.
The effect is not as uniform or as marked as on Ethel Creek station but was encountered over a 24 km distance along the Fortescue River from the southern boundary with Ethel Creek station to a few kilometres west of Yundera Pool. The effect appears to be more pronounced towards the southern end.

The recent nature of the effect is indicated by the presence of numerous fine dead twigs and small branches. Evidence of water stress in the recent past is shown by coppicing (straggly bunching regrowth) from dead branchlets, branches and trunks.

Table 6. Tree health on the Coolibah land system Fortescue River frontage, Roy Hill station (assessed at 10 tree condition sampling sites)

<table>
<thead>
<tr>
<th>Trees dead or unhealthy</th>
<th>No. of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>4</td>
</tr>
<tr>
<td>2-10</td>
<td>1</td>
</tr>
<tr>
<td>11-25</td>
<td>2</td>
</tr>
<tr>
<td>26-50</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
</tr>
</tbody>
</table>

**4.3 Soil and vegetation degradation on Carramulla Creek**

About 40 km of frontage to Carramulla Creek from the old Great Northern Highway in the south to Big Mulga bore in the north was traversed and examined. Tree health was assessed at levee or upper bank sites preselected on the aerial photographs in the same manner as along the Fortescue River. Pasture degradation and patchy sheet erosion and scalding was encountered as elsewhere on the Fortescue land system. However the condition of the trees flanking the creek was much better than the condition of the trees flanking the Fortescue River (see Table 7).

Table 7. Tree health on the Fortescue land system on Fortescue River and Carramulla Creek frontages, Ethel Creek station

<table>
<thead>
<tr>
<th>Trees dead or unhealthy (%)</th>
<th>On Fortescue River (dammed) frontage (No. of sites)</th>
<th>On Carramulla Creek (not dammed) frontage (No. of sites)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2–10</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11-25</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>26-50</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>9</td>
</tr>
</tbody>
</table>
4.4 Evidence of recent grazing and flooding and their impact on vegetation

In April 1990 the grazing utilization levels on the pastures of the river floodplain country on Ethel Creek station were generally moderate.

In April 1990 the grazing utilization levels on perennial grasses on floodplain country on Roy Hill station were generally low. Country near an important Roy Hill watering point on Jigalong Creek (Meecadagunna pool and McAgnors bore) showed fair grass cover and growth. Cattle were grazing the area but levels of use on the grasses were not excessive. Further downstream along the Jigalong floodout there were good grass stands showing response to a small flood event (see photo 18). Grazing utilization levels were low.

On the other extensive areas of river frontage on Roy Hill, particularly along the Fortescue River, conditions were much drier and poorer than on those parts of the frontage subject to floodout from the Jigalong Creek.

The extent of recent flooding was very limited, being confined to channels, channel edges and terraces and other low spots in the landscape. In these restricted areas there was plentiful active leafy growth of perennial grasses with an abrupt cut off at the limit of the flood extent. There was no evidence of recent overgrazing. Away from the channels perennial grasses existed as clumpy patches with much bare ground. They occurred as dry, leafless, dormant or dead tussocks. It was obvious that they had not been flooded for many months.

![Graph showing the effect of Ophthalmia dam on maximum flood width at cross-section 8](ex Ng a al, 1991)

Figure 9. The effect of Ophthalmia dam on maximum flood width at cross-section 8 (ex Ng a al, 1991)
4.5 Analysis of dam impact on individual flood events

Ng et al. (1991) has described the negative impact of the dam on hydrologic parameters downstream of Ophthalmia dam (his Figures 30-35 and 42). The effects were examined for a number of individual post-dam (1982-1990) events at six cross-sections (see Figure 3) on the river. As an example, Figure 9 shows the effects of the dam on maximum flood width for 16 post-dam events at one cross-section. Clearly, as a result of the dam, the outer margins of the floodplain have not been nearly as regularly flooded as they would have been in the absence of the dam. The following further analysis of the effects of the dam on the frequency of flooding in various flood width zones is based on Ng’s modelled data.

Cross-section 5 (Double channel one)

The model shows that, with the dam present, there would have been no overbank flow since the dam was constructed. Bank full capacity was nearly reached only once in the nine years.

In the absence of the dam, overbank flooding would have occurred three times in the nine years and bank full capacity very nearly reached on another three occasions. These events would have enabled soil moisture stores to be replenished on upper banks and levees where trees are currently under stress or dying.

Cross-section 7 (Seven Mile bore)

The model shows that there would have been no overbank flow during the post-dam period with or without the dam. All flows were contained in the channel. Average maximum flood widths were about 54 m and 83 m with and without the dam respectively. In the absence of the dam, bank full capacity (105 m) would have almost been reached on numerous occasions thereby recharging the upper banks, levees and river terraces where trees are currently under stress or dying.

Cross-section 8 (Ethel Creek)

Table 8. Frequency and extent of post-dam flooding (1982-1990) at CS8

<table>
<thead>
<tr>
<th>Flood width zones (kin)</th>
<th>Frequency of flooding (No. of occurrences in nine years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with dam</td>
</tr>
<tr>
<td>0-0.5</td>
<td>16</td>
</tr>
<tr>
<td>0.5-1.0</td>
<td>10</td>
</tr>
<tr>
<td>1.0-1.5</td>
<td>7</td>
</tr>
<tr>
<td>1.5-2.0</td>
<td>4</td>
</tr>
<tr>
<td>2.0-2.5</td>
<td>1</td>
</tr>
<tr>
<td>2.5-3.0</td>
<td>0</td>
</tr>
<tr>
<td>3.0-3.5</td>
<td>0</td>
</tr>
</tbody>
</table>
The modelled results show that the dam has had a significant effect in terms of reducing peak flows, flow volumes, maximum flood width and 12 and 24 hour flood widths at this cross-section.

The effect of the dam on the frequency and extent of post-dam flooding are highlighted in Table 8.

The model results indicate that the presence of the dam had almost eliminated flooding in the 1.8-3.5 km flood width range (one event) during the nine year period. Without the dam the 1.8-3.5 km zone would have been partly or wholly flooded on eleven occasions.

The model results show that the 2.4-3.5 km zone had not been flooded in nine years due to the effect of the dam. Without the dam it would have been partly or wholly flooded on six occasions.

**Cross-section 10 (Irwin’s well)**

Table 9. Frequency and extent of post-dam flooding (1982-1990) at CS10

<table>
<thead>
<tr>
<th>Flood width zones (km)</th>
<th>Frequency of flooding (No. of occurrences in nine years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with dam</td>
</tr>
<tr>
<td>0-0.5</td>
<td>16</td>
</tr>
<tr>
<td>0.5-1.0</td>
<td>12</td>
</tr>
<tr>
<td>1.0-1.5</td>
<td>9</td>
</tr>
<tr>
<td>1.5-2.0</td>
<td>1</td>
</tr>
<tr>
<td>2.0-2.5</td>
<td>0</td>
</tr>
<tr>
<td>2.5-3.0</td>
<td>0</td>
</tr>
</tbody>
</table>

At this cross section the 1.5-2.0 km flood zone has been partly flooded, with the dam in place, once in nine years. Without the dam, this zone would have been wholly flooded four times and partly flooded on two other occasions in nine years.

There has been no flooding in the 2-2.5 km flood zone in nine years since the dam was constructed. Without the dam this zone would have been wholly flooded twice and partly flooded on another two occasions during the nine years.

**Cross-section 11 (Battle hill)**

Table 10. Frequency and extent of post-dam flooding (1982-1990) at CS11 (Battle hilt)

<table>
<thead>
<tr>
<th>Flood width zones (m)</th>
<th>Frequency of flooding (No. of occurrences in nine years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with dam</td>
</tr>
<tr>
<td>60-500</td>
<td>11</td>
</tr>
<tr>
<td>500-1000</td>
<td>5</td>
</tr>
<tr>
<td>1000-1500</td>
<td>1</td>
</tr>
</tbody>
</table>
At this cross-section the 0.5-1.0 km zone has been wholly flooded once and partly flooded four times post-dam. In the absence of the dam it would have been wholly flooded six times and partly flooded another three times in the same period.

The 1.1-1.5 km zone has not been flooded post-dam. In the absence of the dam it would have been partly flooded four times in the nine years.

*Cross-section 12 (Five Mile bore)*

The effects of the dam are not as significant at this cross-section due to flow inputs from Jigalong Creek. The average reduction in flooded width because of the effects of the dam is about 200 m for the post-dam modelled events. However, in 1987 and 1988 there were two events that, in the presence of the dam, were contained within the river channel whereas without the dam they would have flooded to about 850 m and 650 m respectively.
5. Conclusions

The alluvial land systems associated with the Fortescue River have evolved in an environment characterised by natural flooding in the late summer, autumn or winter months. Many of the plant communities that they support rely on these fairly regular flood events for their maintenance and production. Any significant continuing decreases in the frequency, extent and duration of flooding are likely to have detrimental effects on the vegetation in the fairly short term.

Widespread ill health and death of trees has been reported on parts of the Fortescue and Coolibah land systems since the Ophthalmia dam has been constructed. This survey confirmed that there is widespread decline and death of trees and that the effect is recent, probably commencing about 1987. The recent nature of the occurrence is indicated by the presence of still attached dead leaves and of numerous dead twigs and fine and medium branches. Evidence of water stress in the recent past is shown by coppicing (straggly regrowth) from dead branchlets, branches and trunks.

This survey also identified that severe landscape degradation in the form of soil erosion (mainly as sheeting and scalding) and loss of perennial grasses was extensive, particularly on Ethel Creek station.

The quality of 1957 black and white aerial photography is poor but an examination of it suggests that scalding and degradation was widespread at that time on Ethel Creek station. LANDSAT albedo change imagery clearly shows that this type of degradation was widespread before the Ophthalmia dam was built in 1981. For these reasons, and because of historical grazing pressures as outlined in 2.4, the degradation is considered to be longstanding damage due to historical overgrazing. Overgrazing on Ethel Creek station in the mid 1980s may have exacerbated the problem.

The survey showed that the two identified environmental problems sometimes overlap but are mostly spatially separate. Tree stress and death is usually not associated with soil erosion.

5.1 Causes of tree stress and death

5.1.1 Lack of flooding

The evidence from this survey strongly suggests that the major cause of tree stress and death is a lack of regular flooding in recent years, largely as a result of the Ophthalmia dam.

Reductions in flood frequencies, caused by the dam, of the magnitudes described in 4.5 are considered to be highly likely to result in water stress effects on the floodplain vegetation (particularly at cross-sections 8, 10 and 11).

As outlined in 2.3, Ng et al. (1991) showed that since dam construction there have been no flood events with greater then about a five year recurrence interval. However, there have been numerous smaller events, and, in the absence of the dam, there would have been substantial flooding on various parts of the Fortescue River.
frontages. These smaller more frequent events, rather than the occasional cyclone induced very large floods, are considered to be the most important for maintenance of the grassy woodlands of the floodplains. Ng et al. (1991) described the relative impact due to the dam and climatic variation by comparing the post-dam (1982-1990) event average with the long term (1907-1990) event average. Summary interpretations based on comparing the average flow over the eight post-dam years with the long term average need to be treated with caution.

An assessment of the relative impact of the dam and climatic variations on stream flow volumes is best made by looking at individual events rather than an eight year average. This approach shows that shifts resulting from climate can be either negative (for below average events) or positive for (above average events) and that both negative and positive shifts have occurred post-dam.

In the future the variations in average stream flow caused by climate will be both positive and negative. In contrast, the effect of the dam is continuously negative each year and exacerbates any reduced flooding event due to climate should there be one for the particular period or event under consideration.

The continuous and cumulative nature of the effect of the dam is highly significant, especially if superimposed on below average flow events which may have been only marginal for replenishment of floodplain vegetation.

Figure 10 shows annual river flows at Ophthalmia dam and average annual rainfall in the catchment above the dam calculated by Ng et al. (1991). The annual average flow at the dam is about 31 million cubic metres and there have been a number of above and below average yearly flows since the dam was constructed.

The run-off reductions as a result of post-dam climatic variations are not regarded as being excessive or unusually low. They do not approach the low flow periods 1961-64 or 1974-77.

There is no visible or anecdotal evidence of the present phenomenon of widespread tree stress occurring downstream in the past as might be expected for the periods 1961-64 and 1974-77. The effect of the dam is that there has now been a very low flow period for ten years, and this is having a substantial effect on the vegetation for many kilometres downstream of the dam.

The post-dam rainfall regime is not regarded as being a significant contributing factor to the widespread damage to trees currently evident on the floodplains of Ethel Creek and Roy Hill stations.

The most compelling evidence to support the conclusion that the unusually high level of tree death and ill health along the Fortescue River is caused by the lack of regular flooding caused by the Ophthalmia dam and not to variations in post-dam rainfall regimes is provided in Table 7 which compares the dammed catchment (Fortescue River) with an undammed catchment (Carramulla Creek).
Figure 10. (ex Ng et al. 1991) FORTESCUE RIVER, OPHTHALMIA DAM ANNUAL FLOW AND RAINFALL FACTORED BY AREAS FROM NEWMAN BRIDGE SIMULATED & ACTUAL FLOWS

Catchment Average (232 mm)

Dam constructed

CATCHMENT RAIN

WAWA FLOW
On Ethel Creek station the area of Fortescue River floodplain already affected, to a
greater or lesser extent by reduced recent flooding, is about 400 sq km (Figure 11).
This is nearly all of the Fortescue and Coolibah land systems. Tree populations occur
on about 20 per cent of this area and many are showing the problems previously
described. Trees and grasses will be further affected if the lack of flooding continues
in the future.

On Roy Hill station the area of the Fortescue River floodplain affected to a greater or
lesser extent by reduced recent flooding is about 177 sq km (Figure 11). This is most
of the Coolibah land system. Vegetation on the system will be further adversely
affected if the lack of flooding continues in the future.

Possible long term effects on the Marsh land system further downstream (west of
Roy Hill homestead) are unknown. The survey team saw no clear cut evidence of an
effect on this system at this stage, although there appears to be some areas of the
system that have not been flooded for a few years.

5.1.2 Direct and indirect effects of overgrazing

Direct grazing as such is not considered to be a contributing factor to the stress
problems currently seen on coolibah trees. Coolibah foliage is unattractive to and
rarely grazed by cattle and most leaves are out of grazing reach.

Where overgrazing has resulted in widespread soil erosion there can be an indirect
effect on trees in the form of decreased water infiltration, root exposure and
consequent stress and ultimately death. This effect is seen as occasional large, long
dead eucalypt and mulga trees on grazing induced degradation on parts of the
Fortescue and Jigalong land systems on Ethel Creek station. It is not seen to any
extent on the Coolibah land system on Ethel Creek or Roy Hill stations. However, the
current tree stress problem occurs much more widely on other parts of the two
stations (such as levees and upper banks of the Fortescue land system and
floodplains of the Coolibah system) where there is no erosion. This general
observation is supported by the observations previously presented in Table 2. For the
above reasons indirect grazing effects (soil erosion) are not considered to be a
significant factor contributing to the problem of recent tree deaths and stress on Ethel
Creek and Roy Hill stations.

5.1.3 Disease and insects

This survey did not attempt to determine whether disease or insects might be causes
of tree decline. However, if they were a major primary cause of decline, it would be
highly coincidental that they were confined only to the floodplains below Ophthalmia
dam. They are more likely to be secondary agents affecting trees already stressed by
lack of water.
Figure 11. Fortescue River flood plain:
Showing extent of flood plains affected or likely to be affected by reduced flooding caused by Ophthalmia dam
5.2 Causes of lost production and death of perennial grasses

Historically, overgrazing has degraded a large proportion of the perennial grasslands in the survey area. Since 1981, the relative importance of the effects of grazing and lack of flooding on reduced production and death of perennial grasses is more difficult to assess.

Stock numbers on Ethel Creek station were very high from 1982-1985 and grazing pressure on the river frontages may have been excessive. In addition there is no information about stock numbers between 1946-58 and 1960-72 although numbers are known to be very high in 1959. Any overgrazing effects have now been compounded by reductions in flooding due to the Ophthalmia dam.

Total stock numbers on Roy Hill station have generally been low to moderate for many years except for a period in 1984 and 1985 when they were fairly high (no records for 1959-69). Grazing pressure may or may not have been excessive on the frontage during this time but alone is unlikely to be responsible for the widespread deaths of perennial grasses now seen. Grazing utilization levels on the restricted areas of actively growing perennial grasses seen at the time of survey were low.

Observations on the Coolibah land system on Roy Hill station showed that flooding for the past few seasons had been restricted to the channels and low flood terraces adjacent to the channels (see 4.4).

In addition, observations by a number of local pastoralists (Messrs Sheehy, Lang, Ericson, R. Kennedy and M. Kennedy, personal communication) suggest that there has been no overbank flooding from the Fortescue channels onto the adjacent floodplains on Ethel Creek or Roy Hill stations since the dam first filled in 1982. This conflicts with the modelled findings of Ng et al. (1991).

The problem of loss of production from perennial grasses and death of tussocks on the Coolibah land system on Roy Hill station is more likely to be a result of reduced flooding caused by Ophthalmia dam rather than overgrazing. If the problem gets worse in the future it will be entirely a consequence of reduced flooding due to the dam (assuming no profound negative climatic variations) because the whole frontage is now destocked.

Impacts caused by the dam as described in 4.5 (particularly at cross-sections 8, 10 & 11) are considered to be highly likely to result in water stress effects on perennial grasses. This effect is already showing on the remaining perennial grass vegetation (and trees) on the Coolibah land system and parts of the Fortescue land system.

If reductions in flood frequencies and durations of the order of those outlined in 4.5 continue the problem is likely to become worse with continuing loss of production and death of perennial grasses.

As previously noted the hydrologic model findings of Ng et al. (1991), showing that there have been a number of reasonably wide floods at cross-sections 8, 10, 11 and 12 since the dam was constructed, are at odds with local observations. Attempts to obtain LANDSAT images to verify the extent of flooding along the Fortescue River
after large rainfall events were unsuccessful. Imagery was either not available for the exact dates of the events or was obscured by cloud.

5.3 Management implications

5.3.1 Ethel Creek station

About 36 per cent (167 sq km) of the Fortescue land system is so severely degraded that it needs to be withdrawn from grazing. Because the severely degraded areas form a mosaic with better parts of the system, this effectively means that most of the system would be involved. Withdrawal from grazing can only be effectively carried out by the provision of additional paddocks on the frontage (fenced according to country type into management units for use in the future) and by the closure of watering points.

The balance of the system along Carramulla Creek has the capacity to carry about 200 cattle units4 on a year long basis.

The Coolibah land system in the north of the station is degraded but some parts of it could continue to be grazed provided that severely degraded areas are excluded, stocking rates are conservative and wet season spelling can be arranged. The area suitable for use is about 92 sq km and it could carry about 180 cattle units on a year-long basis.

An area of severe degradation exists near Cross bore in the east of the station. This totals about 43 sq km (34 sq km on the Jigalong system and 9 sq km on the Washplain system). The area needs to be destocked to allow recovery of the vegetation.

A detailed, whole station management plan needs to be developed in order to address the land degradation problems on the station. This will include the development of special rehabilitation strategies involving cultivation works such as water-ponding and seeding. It is difficult to specify a time period in which reasonable recovery may occur but it is likely to be an extended period, especially if flooding continues to be affected by the presence of the Ophthalmia dam. In the absence of flooding, the treatments imposed are unlikely to promote the recovery or establishment of eucalypt trees although they should enhance the establishment of perennial grasses and shrubs.

The plan may also include reduction in overall stock numbers and better distribution of livestock. Such a programme has commenced with partial destocking of the Fortescue River frontage and the proposed redevelopment of the south western and south eastern parts of the station.

An essential part of the management plan is the development of a comprehensive vegetation and hydrological monitoring programme.

5.3.2 Roy Hill station

About 8 per cent of the Coolibah land system is severely degraded and eroded. The balance of the system is mostly degraded (but not eroded) having lost much of its

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4 A cattle unit (c.u.) is defined as an adult animal such as a steer over two years of age or a dry cow.
perennial grass pasture due to historical overuse. It now has limited durability in dry
times. However, it still produces abundant annual feed and useful perennial grass
feed in season or after flooding.

Perennial grasses still occur on about 20-25 per cent of the system, mainly in lower
areas associated with numerous small river channels but also as patches further out
on the floodplains. In the south-east of the station the lack of significant flooding from
the Fortescue River in recent years has resulted in lack of growth and death of some
perennial grass tussocks on the floodplains away from the channels.

At the time of survey (April 1990) the carrying capacity of the whole Coolibah land
system (about 215 sq km) on Roy Hill was only about 60 cattle units on a year long
basis. This is based on the 10 per cent of the system which was supporting
reasonable growth of perennial grasses. The balance of the system supported no
pasture growth. In good seasons or after flooding the potential of the Coolibah
system is estimated at about 480 cattle units on a year-long basis. This is based on
25 per cent of the area supporting perennial grass pastures rated at 1 c.u./35ha and
75 per cent of the area supporting growth of annuals rated at 1 c.u./50 ha.

The Edenholme land system immediately to the north of the Fortescue River has
severely degraded pastures but little erosion. Perennial grasses are absent or very
sparse over large areas and the system is useful only for opportunistic grazing of
annuals in season. This system is not sustained by flooding from the Fortescue
River.

A whole-station management plan needs to be developed in order to address the
land degradation problems on the station. In order to promote recovery of perennial
grases, the severely degraded parts of the Coolibah land system (and parts of the
Edenholme system) need to be protected from grazing. This has already commenced
with the destocking of Battle Hill paddock and the smaller paddock on the Fortescue
frontage south-east of the homestead.

Rehabilitation methods involving cultivation works are untested on the Coolibah and
Edenholme land systems. The systems do not lend themselves to water-ponding, but
furrowing or strip cultivation and seeding may be effective. It is difficult to specify a
time period (under protection from grazing and treatment) for reasonable recovery.
However, it is likely to be an extended period, especially if flooding continues to be
reduced. In the absence of regular flooding the treatments alone will not promote the
recovery or establishment of eucalypt trees. The recovery of grasses with relatively
high water requirements such as swamp grass (*Eriachne gardnerii*), and weeping
grasse (*Chrysopogon fallax*) is also likely to be slow and patchy but others such as
Roebourne Plains grass (*Eragrostis xerophila*) and never-fail (*E. setifolia*) may
respond more rapidly.

The whole station management plan will need to consider such things as additional
permanent watering points and better distribution of livestock. An essential part of the
plan is the development of a comprehensive vegetation and hydrological monitoring
programme.