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Rangeland Reference Areas

**Summary of a cooperative project between the
West Australian Department of Agriculture and the
Environmental Protection Authority**

David Blood

Resource Management Technical Report 141

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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1. Project Background

The rangeland survey program conducted jointly by the Departments of Agriculture (WADA) and Land Administration (DOLA) since 1970 provides resource information about landforms, soils and vegetation and their condition status in pastoral areas. About 60% of the pastoral areas have been surveyed and mapped to date (Table 1) but final reports have not been published for all areas.

Table 1: Range condition and inventory surveys for W.A rangelands.

Region surveyed and year field work commenced	No. of Leases	Area (sq km)	Range condition classes (percent of traverse observations)			Area sd&e* -sq km
			Good	Fair	Poor	
1. Gascoyne, 1970	32	63,400	32	53	15	950 (est)
2. West Kimberley, 1972	52	89,600	20	50	30	2,000 (est)
3. Nullarbor, 1974	7	47,400	50	10	20	-
4. Ashburton, 1976	30	61,200	64	27	9	534
5. Carnarvon Basin, 1980	53	74,000	45	32	23	647
6. Murchison, 1985	65	85,717	21	37	42	1,560
7. Roebourne Plains, 1987	6	10,200	51	27	22	233
8. N.E Goldfields, 1988	51	100,000	47	29	24	400 (est)
All areas	296	531,517	40	34	26	6,324

* sd&e = severely degraded and eroded.

A major use of the survey information is to assist the pastoral industry to develop sustainable grazing management practices. One aspect of sustainable management which WADA intends to further promote is the inclusion of areas of rangeland in excellent condition as references for grazing and conservation management in pastoral areas. Small areas of rangelands protected from grazing (such as exclosures and benchmark sites) are important tools in providing reference data for rangeland managers, researchers and administrators. Because of the lack of areas in true reference condition, additional sites are required.

In order to identify such key areas from existing survey information, this study was initiated. Also WADA wishes to promote the concept of cooperative management of these reference areas with station managers, Land Conservation District Committees (LCDC's) and the Department of Conservation and Land Management.

Although the approach may partly satisfy generally accepted practices for selecting conservation reserves, it is emphasised that the study is not an attempt to select a regionally or even locally representative conservation estate. The project proponents considered that the involvement of an extension organisation such as the WADA in an excision or reservation exercise would be undesirable because of the potential for conflict with long term pastoral clients.

The concept essentially involves encouraging collaboration between station managers and research and administrative organisations on management of ecologically valuable land and the extension to the industry of possible benefits. The most immediate benefit to pastoral managers is assist them to evaluate the effects of their management practices on different classes of country.

Reference areas may also have other significant benefits, both to managers and ecologists, for example;

- The protection of genetic resources that may decline under pressure from grazing animals.
- As a source of representative and unmodified natural environments on which to base investigations of arid zone ecological processes.
- Provision of future options for multiple land use such as tourism in areas of exceptional natural features or as a destination for educational scientific excursions.
- At a local and practical level, reference areas provide an ideal source of native seed stocks for use in regeneration of degraded land.

2. Objectives of the study

The objective of the study was to identify, describe and map areas of country in as near to original range condition as possible within the Murchison River catchment area. This was to be achieved by examination and sorting of the data collected during the Murchison rangeland survey undertaken between 1985 and 1988.

3. The study area

The chosen study area is that covered by the recently completed Murchison River catchment survey, which covers an area of about 86,000 square kilometres and is located between latitudes 25°,30' and 28°,1 and longitudes 115° and 119°. Although the final report still awaits publication, a complete set of detailed resource information is available in the form of resource maps and tabulated site and traverse data in an easily accessible databases.

The region is characterised by a long history of pastoral use, the first leases being occupied from the late 1860's. Favoured lands for grazing were generally those marginal to major watercourses where the availability of water was usually good (a key determinant of grazing and settlement patterns). As a consequence of intensive grazing, much of the vegetation has been degraded to poor condition and about 1.8% of the total area is considered to be severely degraded and eroded. Table 2 summarises the condition of the survey area.

Table 2: Summary of erosion and vegetation condition of the Murchison survey area (13,621 observations on 65 stations).

Total erosion				Vegetation condition		
Nil	Minor	moderate	severe	good	fair	poor
85%	10%	5%	<1%	21%	37%	42%

4. Methods

The basic mapping unit for the rangeland survey is the land system, which is defined as an area or group of areas throughout which there is a recurring pattern of topography, soils and vegetation (Christian and Stewart, 1953). Each land system has a characteristic pattern on aerial photographs. During the survey 73 land systems were identified and sampled and will be described in the survey report (Curry *et al*, in press). For ease of mapping and description, land systems with biophysical similarities were arranged into groups. Nineteen groups of broad land types were defined.

A traverse method of assessing soil and pasture condition was used to sample the nineteen land types. The method involved being accurately positioned on the aerial photographs and visually assessing erosion and pasture condition from the vehicle while in motion. Vehicle speed was generally 40 km/hr or less. At this speed, erosion assessments and plant species identification can be made with a high degree of confidence by experienced observers.

At each kilometre the country was given a numerical rating for wind erosion (4 levels), water erosion (4 levels) and vegetation condition (5 levels). The ratings refer to a piece of country seen about 100 m either side of the kilometre point. A total of 13,621 traverse observations on the nineteen land types were made during the course of the Murchison survey. The areas of each land type and sampling details on each are summarised in Table 4.

A rating of 001 indicates that no erosion of either type is present and the vegetation is in near original condition, whereas a rating of 335 indicates severe wind and water erosion and very poor vegetation condition. The definitions of erosion and vegetation condition ratings used during traversing are explained in Table 3. Traverse data for each land type are available in computer database form and on published maps.

Table 3: Definitions of traverse erosion and vegetation ratings.

a. Wind erosion

Rating	Severity	Description
0	nil	no erosion.
1	minor	Litter build up and small scalds. Small isolated scalds on which the surface shows some degree of polishing. Redistribution of soil to the margins of the scald, or minor buildup of soil material around obstacles..
2	moderate	Large isolated scalds and hummocks. Stripping of the soil surface and buildup against obstacles associated with large but generally discontinuous scalds; or, numerous small scalds scattered throughout the site.
3	severe	Major deflation of soil surface. Active stripping resulting in large continuous scalds with polished and sealed surfaces. Frequent large hummocks against obstacles. In sandy systems major dune drift. Plant cover very sparse to absent.

b. Water erosion

Rating	Severity	Description
0	nil	no erosion.
1	minor	Rilling or thin sheeting Patchy rilling and small gullies affecting small areas or thin sheeting (1-2 cm) and breaking the surface seal on parts of the site. Some redistribution of soil and litter downslope.
2	moderate	Gullies and/or sheeting on lower slopes. Gullies on the lower slopes or more susceptible parts of the site, these being capable of extension to less susceptible areas. The gullies may be associated with extensive but discontinuous disturbance of the soil surface by sheet erosion and redistribution of soil material.
3	severe	Terracing or extensive gullies. Severe sheeting or terracing affecting nearly all of the site. Redistribution of soil and exposure of the sub-soil or rock material. The sheeting may be associated with or replaced by very extensive gullying over most of the site.

c. Vegetation condition

Rating	Condition	Description
1	very good	The site's cover and composition of shrubs, perennial herbs and grasses is near optimal, free of obvious reductions in palatable species or increases in unpalatable species.
2	good	Perennials present include all or most of the palatable species expected; less palatable species may be conspicuous, but total perennial cover is not very different from the optimal.
3	fair	Moderate loss of palatable perennials and/or increases in unpalatable shrubs or grasses, but most palatable species and stability desirables still present; foliar cover is less than on comparable sites rated 1 or 2 unless unpalatable species have increased.
4	poor	Conspicuous losses of palatable perennials; foliar cover is either decreased through a general loss of perennials or is increased by invasion of unpalatable species.
5	very poor	Few palatable perennials remain; cover is greatly reduced, with much bare ground arising from loss of stability desirables, or has become dominated by a proliferation of unpalatable species.

The typical length of a traverse was about 80 km, with stops at pre-determined points along the route to record detailed inventory and condition information. Three or more traverses were required to give reasonable coverage of an average size station. Traverse routes taken by vehicle are dictated to a large extent by the nature of the

terrain, thus the most comprehensive sampling tends to be on the most accessible plains and the least comprehensive on the rugged uplands, ranges and hills. A typical sampling density for land types of accessible topography may be in the order of 4-6 sq km per observation but in more difficult terrain, this may be more than 10 sq km per observation. (refer Table 4).

The selection process was essentially a matter of extracting from the main traverse database, those sections of traverse where a minimum of three consecutive 001 ratings were recorded. A simple sorting procedure that arranged the recordings according to the traverse number, kilometre number, station and land type enabled this to be done.

It was decided arbitrarily that a sequence of three or more 001 ratings could incorporate an area large enough to be representative of a vegetation community or land unit within a land type, yet small enough not to be an inconvenience to normal station management. (Three sequential ratings equate to an area of 300 hectares.)

On some land types, none or very few reference sites could be identified using the above criteria. In order to identify some additional areas on these land types, criteria of 2 consecutive 001 ratings or a combination of 001 and 002 ratings were used.

5. Findings and discussion

Table 4 below presents a summary of area, sampling intensity and condition status of each of the 19 land types that occur in the area.

Table 4. Summary of traverse ratings by land type for condition class 001.

Land type	Total Area (sq km)	Percent of total area	Total no. of ratings	% of total	No. of 001 ratings	Percent of 001 ratings**	Sampling Intensity*
1. Rough hills	4,724	5.5%	344	2.5%	16	4.6%	14
2. Stony hills and plains	1,927	2.2%	310	2.3%	9	2.9%	6
3. Quartz plains and low hills	10,050	11.7%	1,222	9.0%	16	1.3%	8
4. Breakaways and granitic plains	12,584	14.7%	1,897	13.9%	53	2.8%	7
5. Complex stony and alluvial plains	1,722	2.0%	294	2.2%	9	3.1%	6
6. Permian stony plains	987	1.2%	152	1.1%	5	3.3%	6
7. Plains of laterite and parent rock	3,013	3.5%	580	4.3%	19	3.3%	5
8. Saline stony plains	471	0.5%	118	0.9%	2	1.7%	4
9. Spinifex sandplain	67	0.1%	21	0.2%	5	23.8%	3
10. Bowgada sandplain	9,076	10.6%	929	6.8%	109	11.7%	10
11. Mallee sandplain	290	0.3%	17	0.1%	2	11.8%	17
12. Sandplain with drainage floors	1,087	1.3%	143	1.0%	4	2.8%	8
13. Hardpan plains & Wanderrie banks	6,875	8.0%	1,067	7.8%	31	2.9%	6
14. Wash plains on hardpan	23,284	27.2%	4,220	31.0%	78	1.8%	6
15. Calcreted river plains	2,091	2.4%	535	3.9%	27	5.0%	4
16. Alluvial river plains	5,689	6.6%	1,557	11.4%	38	2.4%	4
17. Salt lakes with alluvial plains	1,649	1.9%	185	1.4%	33	17.8%	9
18. Clay plains	76	0.1%	19	0.1%	2	10.5%	4
19. Partly saline lake beds	55	0.1%	11	0.1%	0	0%	5
Totals:	85,717	100.0%	13,621	100%	458	3.4%	6.4

* Sampling intensity = the number of sq km per traverse rating.

** Percent of 001 ratings per land type= number of 001 ratings/total number of ratings.

The table indicates that poorly accessible land types were less intensively sampled than the survey average, whereas the more accessible washplains were sampled at

the same intensity as the survey average. The more productive alluvial river plains were sampled more intensively than the mean.

The table also shows the uneven distribution of 001 traverse ratings that occur in the survey. Less pastorally valuable land types such as extensive sandplain have a much higher proportion of 001 ratings than do more productive land types. The very low proportion of 001 ratings on some land types suggests that locating reference areas on these types may be difficult.

Eighty three potential reference areas were identified. Of these 42 satisfied the criteria of having three or more sequential 001 ratings, 14 satisfied the criteria of two consecutive 001 ratings and 27 satisfied less rigorous criteria as described in Appendix 1.

On six of the land types, no reference areas satisfying the major criteria of having three or more 001 ratings were found. In some instances this was because of the land types' small size and lack of sampling, but in other cases, it reflects the overall poor condition of the land type. In order to locate some potential reference sites, it was necessary to adopt the lesser criteria as previously described.

Additional information is available from detailed inventory and condition sampling sites adjacent to the possible reference areas. The site numbers are listed in Appendix 1 against the relevant reference area and may be useful for providing objective information for further assessing the reference areas' potential.

6. References

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8. Appendices

Appendix 1. The Open Country Reserve - an example reference area

In the course of the Murchison survey, an unused portion of Boolardy station was visited by the survey team. The "Open Country" paddock, although containing pastorally valuable chenopod vegetation, had been little used owing to localised occurrences of Kiteleaf poison (*Gastrolobium laytonii*). The near pristine condition of the block was immediately apparent to the survey team, who approached the station owners to inform them of the significance of the area.

The block, some 15,000 ha in area, was subsequently vested with the Department of Conservation and Land Management as a special conservation reserve following negotiation with the station owners. The Open Country reserve represents the largest ungrazed area of land (within a station) within the survey area and contains 7 of the regions most common land systems.

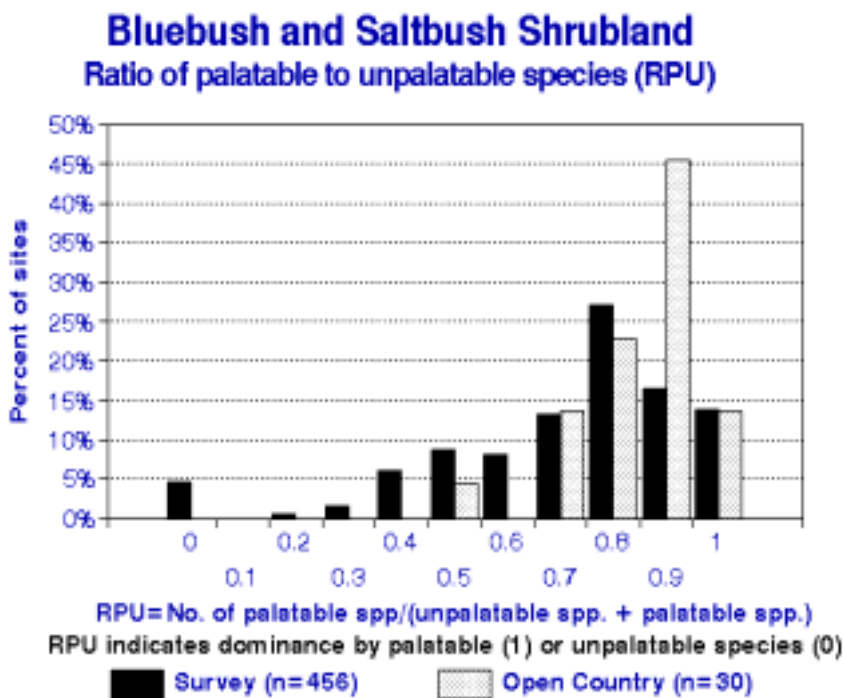
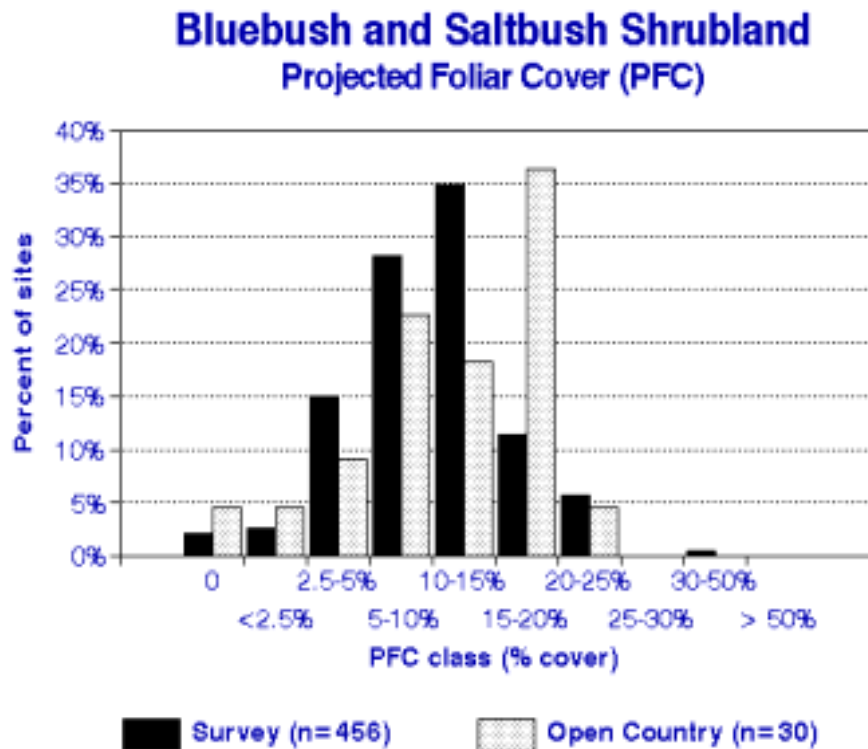
Subsequent to completion of the survey, Curry and Pringle (*pers. comm*), undertook intensive sampling of the Open Country to highlight the disparity in condition between an ungrazed area and the whole of the survey area. Two of the pastorally most important vegetation communities of the region are well represented in the 7 land systems of the Open Country. Other types are present but are mostly of minor occurrences.

A number of measures that describe community characteristics were selected for numerical comparisons between sites and among groups. These included *projected foliar cover* (percent perennial cover), *total perennial density* (number of plants per area - usually 1000 m²), *number of perennial species*, *diversity of perennial species* (Shannon-Weiner index, a logarithmic expression of diversity: the natural logarithm of [number of species times density of each species]) and the *ratio of palatable to unpalatable species* (a reflection of dominance by either palatable or unpalatable species class).

Chenopod shrubland (Bluebush and Saltbush)

Less widespread but pastorally more important are the Bluebush (*Maireana spp*) and Saltbush (*Atriplex spp*) Shrublands (usually classed as two distinct 'types' but data have been pooled for this exercise). These two types are characterised by the dominance of the given name of the association and quite often a variable assortment of halophytic low shrubs (*Cratystylis*, *Enchylaena*, *Ptilotus* and *Rhagodia spp*) with a mostly sparse tree or tall shrub layer of *Eucalyptus*, *Acacia*, *Hakea* and *Eremophila spp*. Occasional sites may contain some perennial grasses.

Figure 1: Vegetation attributes for the Murchison region and Open Country - Chenopod vegetation groups (Bluebush and Saltbush).



Hardpan Mulga Shrubland

The Hardpan Mulga Shrubland vegetation type is the most widespread community associated with the region. It occurs on level plains that receive run-on water from adjacent, more elevated land systems, such as low hills, breakaways and stony plains. The vegetation is characterised predominantly by a tree or tall shrub layer dominated by *Acacia aneura* with an understorey of mid and low shrubs including *Cassia*, *Eremophila*, *Rhagodia* and *Ptilotus spp.*

All measures for the Hardpan Mulga Shrubland were compared using t-tests, from which all comparisons showed significant differences (at $<.001$). A tabulated comparison of the contrasting values is given below in Table A1.

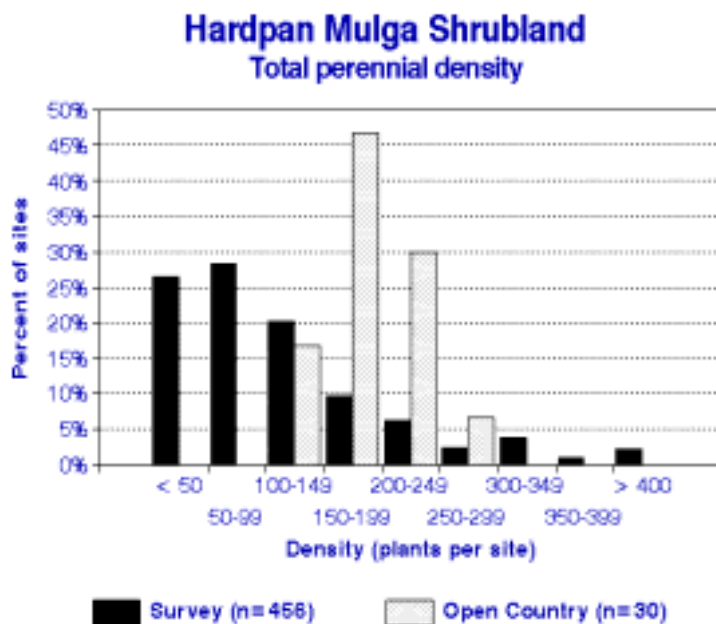
Table A1. Vegetation statistics for the whole survey vs Open Country - Hardpan Mulga Shrubland.

Hardpan shrubland Attribute	Whole survey; n=456		Open Country; n=30	
	mean	s.d	mean	s.d
perennial density	116	94.2	186	39.7
number of species	11.2	3.9	15.8	2.3
Shannon diversity	1.52	0.44	2.17	0.26

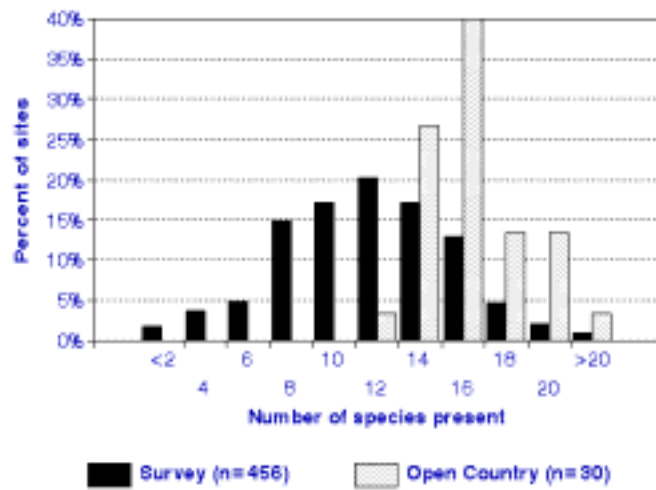
*s.d - standard deviation

Figures 3 and 4 reflect graphically the large variation between the ungrazed Open Country and the whole of the survey region.

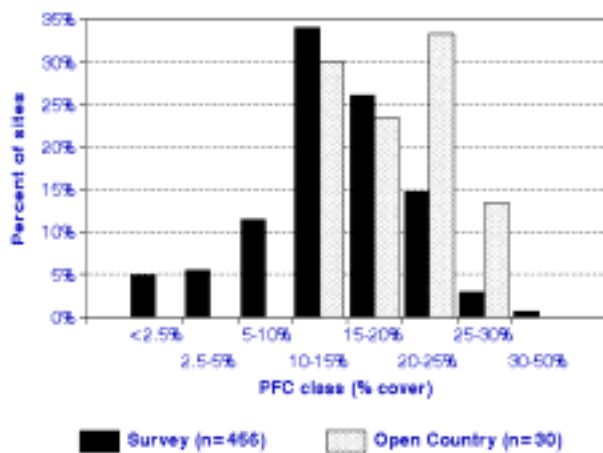
Figure 3: Vegetation attributes for the Murchison region and Open Country - Hardpan Mulga vegetation groups.



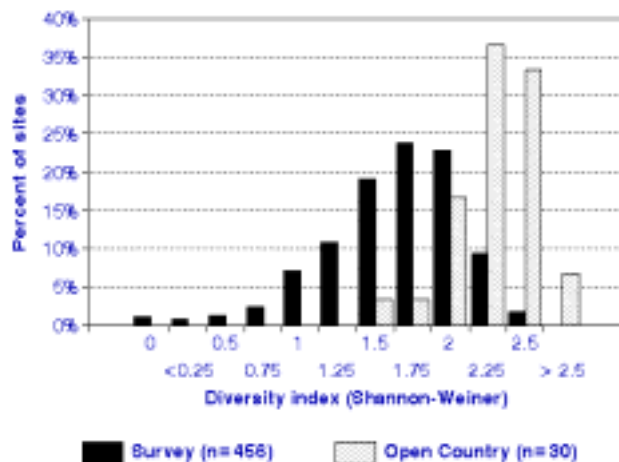
Hardpan Mulga Shrubland Total number of perennial species



Hardpan Mulga Shrubland Projected Foliar Cover (PFC)



Hardpan Mulga Shrubland Diversity of perennial species



Appendix 2. Descriptive key to Murchison land types.

(groups of land systems based on landform and vegetation)

Land type 1 (4,724 sq km) - Rough hills with scattered acacia shrublands.

Land system name	Area	Pastoral Value	Description of geomorphological features and major vegetation associations.
Agamemnon	423	Very low	Rugged hills and ridges of schist, gneiss, granite and quartz; tall acacia shrublands.
Augustus	83	Very low	Rugged hills, ridges and plateaux of sandstone, quartzite and shale; tall acacia shrublands.
Farmer	81	Very low	Hills and ranges of gabbro; tall acacia shrublands.
Gabanintha	962	Low	Ridges and rounded hills of basalt, dolerite, jaspilite and greenstone; acacia and isolated saltbush shrublands.
Moogooloo	20	Very low	Dissected plateaux, mesas, hills and steep footslopes of sandstone, greywacke and siltstone; acacia shrublands.
Norie	1328	Low	Hills of exfoliating granite domes and tor fields; variable acacia shrublands.
Peak Hill	503	Very low	Rugged sinuous ranges and hills of banded ironstone and hematitic shale; sparse acacia shrublands.
Thomas	458	Low	Hills with lateritised mesas, crests and stony slopes based on granite and gneiss; acacia and chenopod shrublands.
Weld	350	Very low	Rugged ranges of hematitic jaspilite, greenstone and whitestone; acacia shrublands.
Woodrarrung	371	Very low	Sandstone ranges with rocky slopes and boulder strewn valleys; tall acacia shrublands.
Yagahong	141	Very low	Rugged ridges and hills of basalt and greenstone; tall acacia shrublands.

Land type 2 (1,927 sq km) - Stony hills and plains with mulga-snakewood-halophyte shrublands.

Badgeradda	124	Low	Sandstone and siltstone hills and ridges with benched slopes and stony plains; snakewood-bluebush shrublands.
Beasley	138	Low	Low hills, ridges and lateritised summits with lower stony plains; sparse mulga-snakewood-bluebush shrublands.
Naluthanna	26	Low	Rough gabbro hills and short stony plains with gilgaied drainage floors; acacia and bluebush shrublands.
Sandiman	347	Moderate	Low sandstone and siltstone ridges, breakaways, stony slopes and lower plains; snakewood and bluebush/saltbush shrublands.
Wiluna	1294	Moderate	Low lateritised greenstone hills with extensive lower slopes and stony plains; mulga and isolated bluebush shrublands.

Land type 3 (10,050 sq km) - Low hills and quartz strewn plains with mulga shrublands.

Koonmarra	5335	Low	Stony plains and low rises with quartz mantles over granite, gneiss and red-brown hardpan; sparse mixed acacia shrublands.
Millrose	535	Low	Plains and sandy banks over granite and gneiss; mulga shrublands and sparse wanderrie grasslands.
Mindura	3661	Low	Low hills and outcrops of granite, gneiss and quartz with stony interfluves and lower plains; mulga shrublands.
Yarrameedie	519	Low	Stony hill spurs, slopes and pediment plains below ranges; sparse mulga shrublands.

Land type 4 (12,584 sq km) - Breakaways, sandy granitic plains, stony footslopes and plains with mulga-halophyte shrublands.

Land system name	Area	Pastoral Value	Description of geomorphological features and major vegetation associations.
Challenge	5235	Moderate	Sandy surfaced plains with granite outcrops and minor breakaways; mulga and patchy bluebush/saltbush shrublands.
Narryer	2510	Low	Stony plains, slopes and lateritised breakaways on granite and gneiss; sparse mulga shrublands.
Sherwood	4839	Moderate	Lateritised breakaways, kaolinised footslopes and plains on granite and gneiss; sparse mulga and bluebush shrublands.

Land type 5 (1,722 sq km) - Complex stony and alluvial plains with mulga-snakewood-halophyte shrublands.

Byro	497	Moderate	Stony and alluvial plains based on sedimentary rocks, partly saline; snakewood and bluebush/saltbush shrublands.
Holmwood	355	High	Saline plains below minor breakaways and short footslopes; bluebush and saltbush shrublands.
Horseshoe	204	Moderate	Undulating stony plains with low hills; mulga shrublands with patchy halophytes.
Jimba	36	Moderate	Alluvial plains with shale and siltstone mantles, low ridges and sandy banks; bluebush and saltbush shrublands.
Millex	500	Moderate	Partly saline plains over granite, occasional low sandy banks; mulga shrublands with bluebush and saltbush.
Trillbar	131	Moderate	Saline stony plains with low rises and gilgaied drainage foci; snakewood-halophyte shrublands and tussock grasslands.

Land type 6 (987 sq km) - Stony plains with patchy acacia-halophyte shrubland.

Boulder	832	Moderate	Gently undulating stony plains and occasional silcrete rises; mulga-snakewood, saltbush and bluebush shrublands.
Mantle	155	Low	Undulating stony plains and low rises with saline drainage tracts; snakewood and bluebush shrublands.

Land type 7 (3,013 sq km) - Irregular plains on laterite and parent rock with mulga, bowgada and halophytic shrublands.

Mongolia	456	Moderate	Plains with laterite and ironstone gravels, partly saline; mulga and patchy bluebush shrublands.
Nerramyne	726	Low	Plains and low rises on weathered granite above sandy drainage plains; mixed acacia shrublands.
Violet	1078	Moderate	Gravelly plains on greenstones, laterite and hardpan; sparse mulga shrublands with some groves.
Waguin	753	Low	Undulating sandy plains and stripped surfaces on laterite and granite; bowgada-mulga shrublands.

Land type 8 (471 sq km) - Saline stony plains with halophytic shrublands.

Austin	155	High	Mostly flat saline stony plains with low rises on granite or greenstone; bluebush shrublands.
Wongong	317	High	Saline stony plains on sandstone and siltstone with sluggish drainage tracts; Bluebush and saltbush shrublands.

Land type 9 (67 sq km) -Sand plains with acacia-mallee shrublands and hard spinifex.

Land system name	Area	Pastoral Value	Description of geomorphological features and major vegetation associations.
Bullimore	67	Very low	Sand plains with occasional linear dunes; tall acacia shrublands and spinifex grasslands.

Land type 10 (9,076 sq km) - Sand plains with grassy shrubland

Kalli	6065	Moderate	Plains of red sand over laterite; tall acacia shrublands with wanderrie grasslands.
Sandplain	2884	Moderate	Extensive red sand plains; bowgada shrublands.
Yalbalgo	127	Low	Sand plains with linear and reticulate dunes; bowgada shrublands.

Land type 11 (290 sq km) -Sand plains with acacia-mallee shrublands.

Eurardy	180	Very low	Red sand plains with S.W Botanical Province shrublands.
Nerren	110	Low	Red sand plains; mallee or bowgada shrublands.

Land type 12 (1,087 sq km) - Sandplain and drainage floors with grasslands and halophytic shrublands

Bidgemia	221	Moderate	Drainage plains with linear dunes and sandy banks; bluebush, saltbush and tall acacia shrublands.
Breberle	115	Moderate	Sand sheets, low dunes, narrow alluvial plains, lakes and claypans; halophyte and wanderrie grassy shrublands.
Liver	752	Moderate	Sand sheets, low dunes, sandy banks and saline flats with claypans and drainage foci; halophyte and tall acacia shrublands.

Land type 13 (6,875 sq km) - Hardpan plains and sandy banks with mulga-wanderrie shrubland

Belele	4701	Moderate	Hardpan plains with broad sandy banks; sparse mulga shrublands and wanderrie grasslands.
Bunny	485	Moderate	Hardpan plains with broad sandy banks, thin sheets of sand and channelled drainage zones; mulga shrublands.
Cole	1196	Moderate	Hardpan wash plains with reticulate sandy banks, groves and drainage tracts; mulga shrublands.
Flood	439	Moderate	Hardpan drainage plains with broad sandy banks; mulga shrublands and wanderrie grasslands.
Wooramel	56	Moderate	Sandy surfaced hardpan plains with sandy banks and sand sheets; tall acacia shrublands.

Land type 14 (23,284 sq km) -Wash plains on hardpan with mulga shrublands.

Channel	94	Moderate	Sharply dissected hardpan plains with narrow fringing slopes; mulga shrublands.
Frederick	36	Moderate	Hardpan wash plains with sandy banks and mulga groves; mulga and wanderrie shrublands.
Jundee	1338	Moderate	Hardpan plains mantled by ironstone grit and gravel with sandy banks; sparse mulga shrublands.
Tindalarra	3048	Moderate	Hardpan plains with saline drainage floors; mulga, bluebush and saltbush shrublands.
Woodline	2932	Low	Sandy surfaced plains over hardpan; groved mulga shrublands.
Yandil	3402	Moderate	Uniform drainage plains with occasional sandy banks and groves; sparse mulga shrublands.
Yanganoo	12433	Moderate	Extensive hardpan plains with numerous sandy banks and groves; mulga and wanderrie shrublands.

Land type 15 (2,091 sq km) - Calcreted river plains with grassy shrublands.

Land system name	Area	Pastoral Value	Description of geomorphological features and major vegetation associations.
Cunyu	1083	High	Drainage zones on hardpan with river channels and raised calcrete platforms; mulga and chenopod shrublands.
Mileura	1007	High	Saline and non-saline flood plains with river channels and raised calcrete platforms; halophyte shrublands.

Land type 16 (5,689 sq km) - River plains with saltbush, bluebush and other shrublands.

Bayou	491	High	Saline meander plains and flood plains with anastomosing channels; saltbush and bluebush shrublands.
Beringarra	2629	High	Alluvial flood plains and major river channels; saltbush and bluebush shrublands, eucalypt woodlands and tussock grasslands.
Coolabulla	50	High	Alluvial flood plains with veneers of calcrete or ironstone gravels, major channels; saltbush and bluebush shrublands.
Ero	1579	High	Tributary flood plains on red-brown hardpan, partly saline; mulga, saltbush and bluebush shrublands.
Outcamp	44	Moderate	Saline alluvial plains with clay soils; mulga and saltbush shrublands.
Roderick	407	High	Broad saline flood plains with many prominent small drainage foci and claypans; saltbush and bluebush shrublands.
Siberia	43	High	Saline alluvial plains, minor low sand dunes and fringing stony plains; bluebush shrublands.
Weenyung	153	High	Sandy alluvial plains and broad unchannelled drainage tracts; bluebush and saltbush shrublands.
Yewin	293	High	Broad saline flood plains with low kopi dunes, drainage foci and claypans; bluebush, saltbush and samphire shrublands.

Land type 17 (1,649 sq km) - Alluvial plains and salt lakes with halophytic shrublands.

Carnegie	1281	High	Salt lakes with fringing saline plains, dunes and sandy banks; saltbush and samphire shrublands.
Wolarry	368	High	Salt pans and swamps with fringing saline flats, dunes and sandy banks; bluebush, saltbush and samphire shrublands.

Land type 18 (76 sq km) - Clay plains with bluebush-saltbush shrublands and grasslands.

Merbla	76	High	Clayey alluvial plains with gilgai micro-relief; bluebush and saltbush shrublands with tussock grasslands.
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Land type 19 (55 sq km)

Wooleen	55	High	Lake beds with halophytic shrubland and grasslands. Lake beds with fringing saline plains and sandy banks; mixed halophyte shrublands and tussock grasslands..
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Appendix 3. Possible reference areas within the Murchison survey area

(based on 3 or more consecutive kilometres of traverse being rated as very good vegetation condition and having no erosion)

Land type 1

Site ¹	Station	Paddock	Land system	Land Unit(s)	Traverse ²	Map reference ³	C sites ⁴	I sites ⁵	Comments
M1	Mt Hale	Mt Matthew	Weld	Hills, valley, creek	71; 6-13	Belele: 527'113	-	237	Protected area in Jack Hills not used by sheep, (some goats)

Land type 2

M2+	Muggon	Mongolia	Badgeradda	Saline stony plain	92;23-24	Byro: 364'027	606	305	
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Land type 3

M3	Karbar	Unnamed pdk	Koonmarra, Mindura	Stony plain	98; 166-168	Belele: 595'040	-	-	Isolated sequence of sites in little used paddock corner.
M4+	Milly Milly	Open country	Koonmarra	Stony plain	38;7-8	Byro: 440'120	-	-	
M5+	Mt Padbury	Molly	Koonmarra	Stony plain	55;3-4	Rob Ra: 635'130	308,307	-	
M6+	Mt Padbury	Sleepy Hollow	Yarrameedie	Stony plain	55;80-81	Rob Ra: 636'132	-	188	
M7+	Mt Padbury	Martins	Yarrameedie	Foot slope	55;91-92	Rob Ra: 630'162	312	-	

Land type 4

M8	Kalli	Boorie	Sherwood	Footslope, stony plain	73;24-26	Belele: 525'041	443	-	
M9	Annean	Far	Sherwood	Granitic plain, breakaway	98;118-120	Belele: 562'037	659	340	Sparsely used paddock at western extremity of station
M10	Meka	Open Country	Sherwood	Granitic plain, footslope	171;16-19	Murgoo: 487'975	-	570	Little used by stock because of poison; same as Open Country
M10a-	Wynyangoo	East	Sherwood	Footslope, stony granitic plain	141	Cue: 655'945	-	-	3 * 002
M11	Boolarly	Open Country Reserve	Challenge	Stony granitic plain, footslope	83;37-42	Murgoo: 479'008	-	-	See Appendix 1 for description of Open Country Reserve
M11a	Boolarly	Open Country Reserve	Challenge	Hardpan and stony plain	83;54-56	Murgoo: 481'010	-	-	See Appendix One.

Land type 5

Site ¹	Station	Paddock	Land system	Land Unit(s)	Traverse ²	Map reference ³	C sites ⁴	I sites ⁵	Comments
M12	Boogardie	Malawanah	Millex	Saline and hardpan plain	153;7-9	Cue: 570'931	941,942	570	
M13-	Wynyangoo	Tom	Millex	Stony saline plain and drainage	143; 29-31	Cue: 570'930	901,902	485,486	3 * 002.
M14-	Ballythanna	Byro Plains	Byro	Drainage foci, sandy bank and channel	14;51-53	Glenburgh: 360'136	-	55	3 consecutive 002 ratings - (best recorded on Byro Plains)
M14b	Ballythanna, Innouendy	Byro Plains, West End	Sandiman, Jimba	Breakaways, plateaux, footslopes and stony alluvial plains	Not traversed	Glenburgh: 385'157	-	-	Unique area of relict Permian geology adjacent to Wooramel River.
M15-	Yallalong	Erong	Holmwood	Saline and alluvial plain	202;125-130	Murgoo: 340'002	1260	657,658	2 * 001, 4 * 002.
M16-	Yallalong	Meebree	Holmwood	Stony and stony plain	203;65-68	Murgoo: 337'966	-	-	3 * 002's.

Land type 6

M17	Muggon	Govt. Well	Boulder	Stony plain	92;163-165	Murgoo: 361'098	-	-	3 pdks on far north have had little use since development
M18-	Meeberrie	Bluebush	Boulder	Complex stony plain	86;44-46	Murgoo: 385'038	-	277	3 * 002's.
M19-	Byro	Bullock	Boulder	Stony plain.	21;65-67	Byro: 372'115	-	-	

Land type 7

M20	Karbar	Behring	Violet	Stony and laterite plain	101;36-38	Cue: 576'995	-	-	Disused pdk on far S.W corner of lease; ?unwatered.
M21	New Forest	Coolawalthy	Mongolia	Stony laterite plain and grove	200;44-46	Murgoo: 361'008	1236	645	Small pdk in far NW corner of lease; little used; poor access.

Land type 8

M22-	Meeberrie	Bluebush	Wongong	Complex stony plains	86;31-35	Byro: 382'040	543,544	274,275	1 * 001, 4 * 002.
M23-	Polele	Dry	Austin	Stony plain	93;34-36	Belele: 653'043	-	319	3 * 002's.
M24-	Wanarie	Jean's	Austin	Stony plain	155;4-6	Cue: 588'936	-	514	3 * 002's.

Land type 9

Site ¹	Station	Paddock	Land system	Land Unit(s)	Traverse ²	Map reference ³	C sites ⁴	I sites ⁵	Comments
M25	Wynyangoo	Charlie	Bullimore	Sandplain	141;5-8	Cue: 653'930	881	476	Minor system in Murchison - extensive areas to the east

Land type 10

M26	Curbur	Maori	Sandplain	Sandplain	4;39-42	Byro: 380'076	24,25	19	Very extensive systems to west of survey area.
M27	Muggon	Marloo	Sandplain	Sandplain	90;48-52	Byro: 372'028	-	296	"
M28	Muggon	Dink's	Sandplain	Sandplain	92;1-8	Byro: 361'037	-	-	"
M29	Muggon	Sth Corktree	Sandplain	Sandplain	92;76-82	Byro: 343'050	-	-	"
M30	Boogardie	Munigarra	Kalli	Sandplain	151;13-15	Cue: 555'909	-	-	"
M31	Mt Farmer	Wandarrie	Kalli	Sandplain	157;46-51	Cue: 537'913	-	524	"
M32	Mt Farmer	Junga, Keego	Kalli	Sandplain	158;11-17	Cue: 545'922	962	525,526	"
M33	Jingemarra	Carrabadgie	Kalli	Sandplain	164;23-25	Murgoo: 480'921	992	547	"
M34	Jingemarra	Milgoo	Kalli	Sandplain	165;35-37	Murgoo: 459'915	1002	-	"
M35	Woolgorong	Bubble	Kalli	Sandplain	180;118-121	Murgoo: 369,931	-	598	"
M36	New Forest	White Well	Sandplain	Sandplain	200;18-25	Murgoo: 369'998	-	641	"
M37	New Forest	Bin Bin	Yalbalgo	Sandplain,swale	200;33-38	Murgoo: 361'003	-	642,643	Same paddock as M21.

Land type 11

M38-	Pinegrove	Paradise	Eurardy	Sandplain	186;9-13	Murgoo: 341'925	-	613,614	Small areas within survey area, but very extensive to the west.
M39-	Bullardoo	Pindarri	Eurardy	Sandplain	186;19-23	Murgoo: 340'918	-	616,617	"

Land type 12

M40-	Curbur	Weendong	Liver	Saline plain, sandy bank	6;95-97	Byro: 374'070	-	28,29	Complex systems with mosaic topography. 3 * 002.
M41-	Byro	Moolumber	Liver, Bidgemia	Saline alluvial plain, sandy bank	21;55-59	Byro: 380'115	129,130	-	" 5 * 002.

M42-	Mt Narryer	Tilly	Liver	Saline plain	89;21-23	Byro: 376'049	567,56 8	288	"	3 * 002.
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Land type 13

Site ¹	Station	Paddock	Land system	Land Unit(s)	Traverse ²	Map reference ³	C sites ⁴	I sites ⁵	Comments
M43	Innouendy	Callyou	Flood	Hardpan plain	10;24-27	Glenburgh: 417'146	61,62,63	38	
M44	Innouendy	West End	Belele	Hardpan plain, sandy bank	10;74-76	Glenburgh: 399'141	65	40,41	Largely unused western portion of lease with patches of relict country.
M45	New Forest	Bin Bin	Bunny	Groves, Hardpan & sandy plains	200;39-43	Murgoo: 359'007	-	644	Same paddock as M21 and M37.

Land type 14

M46	Belele	Oilba	Yanganoo	Hardpan plain	58;44-47	Belele: 590'060	-	-	
M47	Belele	Yalgaroo	Yanganoo	Hardpan plain and sand plain	58;59-63	Belele: 574'050	-	199,20 0, 201	
M48	Cue Common	Common	Yanganoo	Hardpan plain	110;8-10	Cue: 590'959	-	-	
M49	Coodardy	12 Mile, Poison	Yanganoo	Hardpan and granitic plain	111;30-32	Cue: 549'985	717,71 8	382	
M50	Wynyangoo	East	Woodline	Hardpan plain	141;18-22	Cue: 939'658	882	-	

Land type 15

M51	Belele	Wombada	Cunyu	Drainage zone	59;65-68	Belele: 610'072	-	210,21 1	
M52+	Edah	Unknown	Cunyu	Hardpan plain, swamp	162;55-58	Cue: 519'910	-	-	
M53	Madoonga	Phillips	Mileura	Alluvial and saline plain	134;75-76	Belele: 558'025	-	446	
M54+	Wondinong	White Shepherd	Mileura	Alluvial plain, calcrete platform	139;29-33	Cue: 630'935	867	464	3 * 001, 2 * 002 ratings.
M55+	Wondinong	Burrajinni	Mileura	Alluvial plain, calcrete platform, drainage line	142;97-101	Cue: 633'919	864,86 5	-	2 * 001, 3 * 002 ratings.

Land type 16

Site ¹	Station	Paddock	Land system	Land Unit(s)	Traverse ²	Map reference ³	C sites ⁴	I sites ⁵	Comments
M56+	Wooleen	Wandarrie	Bayou	Alluvial and saline plain	87;18-26	Murgoo: 396'018	547	279	4 * 001, 5 * 002 ratings.
M57-	Billabalong	Five Mile	Bayou	Saline and alluvial flood plain, sandy bank, drainages	209;26-34	Murgoo: 383'973	1289	674,675	1 * 001, 7 * 002 ratings.
M58-	Billabalong	Jiggernoo	Bayou	Saline plain, drainage lines	198;39-41	Murgoo: 395'987	-	635	1 001, 2 * 002 ratings.
M59+	Moorarie	Belaire	Beringarra	Aluvial and saline plain	61;35-40	Rob Ra: 555'130	354	214	2 * 001, 4 * 002
M60+	Boolarly	House, Holding, Mt Dugal, Werragibin	Beringarra	Flood plain	80;83-88	Murgoo: 451'075	497	257	3 * 001, 3 * 002.
M61-	Murgoo	Brier	Beringarra	Alluvial plain	195;23-26	Murgoo: 429'677	1194,1195	-	1 * 001, 2 * 002.
M62-	Wooleen	Yewlands	Beringarra	Alluvial flood plain	88;8-10	Murgoo: 421'998	-	283	3 * 002.
M63	Boolarly	Open Country Reserve	Ero	Hardpan and alluvial plains	83;46-57	Murgoo: 473'006	-	-	Refer to Appendix 1 for detailed description of Open Country Reserve
M64-	Boogardie	Mulletah	Ero	Alluvial and hardpan plain, sandy bank	144;61-63	Cue: 466'939	-	-	3 * 002.
M65-	Meka	Bootra	Ero	Saline alluvial and hardpan plains	173;12-14	Murgoo: 499'966	-	-	3 * 002.
M66-	Yallalong	Sutt's	Siberia	Saline, alluvial and stony plains	202;72-77	Byro: 364'015	-	652,653	1 * 001, 5 * 002
M67	Muggon	Govt. Well	Weenyung	Alluvial plain, drainage zone	92;160-162	Byro: 361'098	-	-	
M68	Muggon	Pat's, Neegulburrie	Weenyung	Alluvial plain with sedim. Rocks	92;129-131	Byro: 347'075	-	-	
M69-	Twin Peaks	Curburtarra, Yarloo	Yewin	Alluvial and saline plain, swamp	205;19-25	Murgoo: 406'967	1279	677,678	Highly saline stock water. 3 * 001, 4 * 002.
M70-	Twin Peaks	Salt Well	Yewin	Saline plain.	205;37-39	Murgoo: 400'966	1281	-	Highly saline stock water. 3 * 002.
M71+	Murgoo	Golbung, Natherie	Yewin	Saline, alluvial and flood plain	195;45-52	Murgoo: 413'973	1196	628	Highly saline stock water. 3 * 001, 5 * 002.

Land type 17

Site ¹	Station	Paddock	Land system	Land Unit(s)	Traverse ²	Map reference ³	C sites ⁴	I sites ⁵	Comments
M72	Annean	Bitter Well	Carnegie	Saline alluvial plain, kopi dune	97;68-71	Belele: 625'017	645,646	-	
M73	Polele	Lake	Carnegie	Saline alluvial plain, sand dune	102;20-21	Belele: 635'020	648	354,355, 356	
M74	Boogardie	Two Wells	Carnegie	Alluvial & stony plain, calcrete platform	155;21-26	Cue: 575'940	-	509	About 50% of paddock is lake bed.
M75	Lakeside	Austin	Carnegie	Saline plain, sand bank & dune	161;2-9	Cue: 572'950	-	536,537	
M76-	Muggon	Big Wolarry	Wolarry	Stony saline plain, drainage foci	92;30-31	Byro: 347'030	-	308	3 * 002.
M77+	Muggon	S & N Corktree	Wolarry	Alluvial and saline stony plain	92;83-85	Byro: 345'055	-	312	2 * 001, 1 * 002.
M78-	Muggon	N. Corktree, Spinifex	Wolarry	Saline and alluvial plain	92;92-96	Byro: 349'059	614	313	1 * 001, 4 * 002.

Land type 18

M79+	Wynyangoo	South	Merbla	Stony and alluvial plain, footslope	142;30-32	Cue: 631'890	891	-	1 * 001, 2 * 002.
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Land type 19

M80-	Wooleen	Yewlands	Wooleen	Saline plain	88;2-5	Murgoo: 420'000	-	281,282	4 * 002.
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Key to types of reference sites

- ¹Site**
- M75** Sites in **bold** indicate that **at least** three consecutive observations of 001 occur.
 - M79+** Sites appended with a **+** indicate that **at least** two consecutive 001 observations and any combination of 002 occurs.
 - M80-** Sites appended with a **-** indicate that, because of the scarcity of this land type in good condition, any combination of 001 and 002 observations can occur.

	001.	represents a traverse observation where the optimal vegetation community exists and no erosion is present.
	002.	represents a traverse observation where the vegetation community shows a slight reduction in density and /or diversity among perennial species and no erosion is evident
²Traverse	92;92-96.	Indicates the traverse route number and the kilometre points at which the observations were made.
³Map reference	Cue: 631'890.	Map reference refers to 1:250 000 map sheet and the Easting and Northing coordinates (to 1,000 m) from the land system maps for the Murchison survey region.
⁴C' site	1196	Condition assessment sites, where vegetation attributes are collected for objectively classifying range condition.
⁵I' site	628	Inventory sites, where geological, soils and vegetation data is collected from which to describe the land systems.

