







LEGEND

-  Species of Interest
-  Study Area
-  Disturbance Footprint
-  Wanjarri Nature Reserve
-  Tenements
-  Surface Water

Mount Keith Satellite
Olearia xerophila sens. lat.
(G. Cockerton & P. Goodman WB38116)
 Author: Western Botanical Date: December 2017

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ December 2017 ~ A4 ~ Rev: B ~ CAD Ref g2414_R02_04_SOI_OX.dgn ~ Imagery: Landgtg (2011)

6980000mN

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6960000mN

260000mE

270000mE

Goldfields Highway

Wanjarri Nature Reserve

Mt Keith Operations

Mt Keith TSF



**Western
Botanical**

Addendum to Flora and Vegetation Assessment of the
Mt Keith Satellite Study Area, March 2017

Appendix 4: Vegetation Community Descriptions
and Quadrat Data

BHP Billiton, Nickel West Pty Ltd
Report Ref: WB867



Appendix 4a: Vegetation Community Descriptions for the Mt Keith Satellite (MKS) Study Area.

Addendum to Western Botanical (2017) *Flora and Vegetation Assessment of the Mt Keith Satellite Proposal Study Area March 2017*. Consultants report to BHP Billiton, Nickel West. Report reference WB867.

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Definitions

Sclerophyll Shrublands are those which are dominated or characterised by plants with hard, drought tolerant, non-succulent foliage. They include common genera such as *Acacia*, *Senna*, *Sida* and *Eremophila* varieties that make up the bulk of the flora and vegetation of the Yakabindie tenements. These species are generally not salt tolerant, however may demonstrate tolerances to a wide variety of soil types with corresponding range of inferred geochemistry.

Chenopod Shrublands are those that are characterised or have significant proportions of succulent perennial shrubs, soft-foliaged species in the family Chenopodiaceae. Dominant genera are *Atriplex*, *Maireana* and *Sclerolaena*. These species are generally salt tolerant.

Grasslands are those habitats containing a significant proportion of perennial or large annual grasses in the lower stratum, usually to 0.5m in height. Trees and other shrubs, usually sclerophylls, may also be present in upper strata. These habitats are usually on sandy or clayey sand substrates. The presence of significant grass component is a major factor in determining habitat relationships as a high grass component usually means a propensity to more frequent fire events. Frequency of fire is a major determining factor in affecting species composition.

Vegetation Associations associated with Limonitic Landforms are those associated with the mid to upper slopes of the Bevon land System where minor occurrences of banded ironstone formation (BIF), chert and tertiary laterite are present at the surface or at shallow depth.

Vegetation Associations associated with Landforms of Basalt (fresh rock) geology are those associated with subcropping or outcropping largely unaltered basalt geology of the Mt Keith – Perseverance fault line, encapsulated within primarily the Bevon Land System.

Vegetation Associations associated with Carbonate soils derived from Weathered Basalt are those which have a dominance of alkaline calcium and magnesium carbonates as fine silty sands, usually with some outcropping or subcropping unweathered basalt. These are associated with the Bevon, NuBev and Windarra Land Systems.

Vegetation Associations associated with Archaean Granite Geology are those associated with the Archaean granite breakaway systems of the Sherwood Land System.

Vegetation Associations associated with Sandplain Landforms are those associated with extensive orange sandplains of the Bullimore Land System where sand profiles can extend for many metres in depth usually with a semi-impeding hard pan present, which may present at the surface in some situations.

Vegetation Associations associated with Colluvial and Alluvial landforms are those that represent the lower slopes, colluvial and alluvial fans derived from a range of upper slope geologies, often demonstrating 0.5 to 1.5m of Wiluna hard pan conglomerates at the surface.

Shallow sandy mantles may be present. Areas of concentrated drainage, dominated by either Mulga or eucalypts are included in this group.

Vegetation Associations of Playa Complexes are those associated with shallow playa lakes where an impeding layer of silt is present in shallow depressions, usually surrounded by low rises of sand or calcrete. The playa lakes normally are inundated for short periods following seasonal rainfall and the narrow range of species dominating these are tolerant of both periods of inundation (waterlogging) as well as extensive periods of drought. These are associated with the Melaleuca, Carnegie, and Cunyu Land Systems.

Note: No assessment of the surface geology of the MKSO Study Area has been referenced, other than the Land System assessments of Pingle *et. al.* (1994), and observations made by botanists while conducting studies in the field.

Section 1. Vegetation Community Descriptions

1.1. Vegetation Associations associated with Basalt Geology (fresh rock)

1.1.1. BaMAS Complex Basalt, mixed *Acacia* species Shrubland Complex

To the south of Jones Creek, within the Bevon Land System, extensive areas of basalt rock in the form of rounded to subrounded boulders and scattered occurrences of shale is present. This region forms a series of low rounded hills supporting a complex of three vegetation associations and has largely been mapped as a Vegetation Complex.

The Basalt mixed *Acacia* species Shrubland (BaMAS) Vegetation Complex is a mosaic of three vegetation communities with indistinct boundaries and numerous intergrades between them. It covers an area of 182.9 hectares within the MKS survey area and occurs across mostly low hills and undulations of basaltic origin in association with the Violet Ranges landform system. This vegetation complex and its component vegetation communities forms an important part of the Violet Ranges PEC, which totally encompasses the BaMAS Vegetation Complex within the MKS Study Area.

Components of the BaMAS complex are

- Basalt *Acacia* aff. *doreta* Shrubland (BaAdS),
- Basalt *Acacia xanthocarpa* Shrubland (BaAxS); and
- interspersing Mulga woodland communities in colluvial depressions between the basalt hills.

Each component of the BaMAS Vegetation Complex, other than the Mulga Shrublands in colluvial depressions, is described below.

1.1.1.1. BaAdS Basalt, *Acacia* aff. *doreta* Shrubland

The Basalt *Acacia* aff. *doreta* Shrubland (BaAdS) is characterized by the upper stratum of *Acacia* aff. *doreta* (G. Cockerton & S. Cockerton WB38633) open shrubland with a PFC 10-20% on low hills and rises of Basaltic origin. The mid stratum typically includes *Senna* sp. Meekatharra (E. Bailey 1-26), *Ptilotus helipteroides*, *Ptilotus obovatus*, *Solanum lasiophyllum*, *Santalum spicatum* and *Scaevola spinescens* (5-10%PFC). The lower stratum is primarily made up of *Aristida contorta* grasses (3-8% PFC) with *Salsola australis*, Plate 1.

Within the MKS Study Area. 19.4 hectares BaAdS vegetation community has been mapped separately. This was done where it was possible to identify and map the boundaries of that community with confidence. However, this excludes the BaAdS component within the BaMAS vegetation complex, where it is a co-dominant vegetation type. The total area of the BaAdS community, a component of the BMAS Complex, within the MKS Study Area is therefore underestimated.



Plate 1. Basalt *Acacia* aff. *doreta* Shrubland (BaAdS)

The taxonomy of the *Acacia* aff. *doreta* is being reviewed in 2017 by Geoff Cockerton and Bruce Maslin.

1.1.1.2. BaAxS Basalt, *Acacia xanthocarpa* Shrubland

The Basalt, *Acacia xanthocarpa* Shrubland (BaAxS) community is characterized by the upper stratum dominated by *Acacia xanthocarpa* open shrubland, PFC usually 4-12%. The mid stratum contains scattered *Senna* sp. Meekatharra (E.Bailey 1-26), *Ptilotus obovatus*, *Acacia tetragonophylla*, *Eremophila forrestii* subsp. *forrestii* (1-3%), over a low herb and grass stratum of primarily *Aristida contorta* (PFC 10-20%), with *Ptilotus helipteroides*, *Enneapogon caerulescens*, *Ptilotus roei*, *Solanum lasiophyllum*, *Maireana georgei*, *Eriachne pulchella*, *M. triptera* and *Sclerolaena eriacantha*, Plate 2. BaAxS occurs on undulating slopes and low hills within the Violet Ranges landform in association with the basaltic geology of the area. It forms an important and dominant component of the Violet Ranges PEC.

Within the MKS Study Area. 83.2 hectares BaAxS vegetation community has been mapped separately. This was done where it was possible to identify and map the boundaries of that community with confidence. However, this excludes the BaAxS component within the BaMAS vegetation complex, where it is a co-dominant vegetation type. The total area of the BaAxS community, a component of the BMAS Complex, within the MKS Study Area is therefore underestimated.

The taxonomy of *Acacia xanthocarpa* is being reviewed in 2017-18 by Geoff Cockerton and Bruce Maslin.



Plate 2. Basalt *Acacia xanthocarpa* Shrubland (BaAxS)

Other Vegetation Associations of the basalt geology

1.1.2. BaAbS Basalt, *Acacia burkittii* Shrubland

The Basalt *Acacia burkittii* Shrubland (BaAbS) community is characterized as an upper stratum of open shrubland of *A. burkittii*, with a PFC of 8-15%, with scattered tall shrubs of *Grevillea berryana*. The mid stratum consists of scattered low to mid shrubs of *Senna artemisioides* subsp. *filifolia*, *A. tetragonophylla*, *Ptilotus obovatus*, *Ptilotus helipteroides* and *Solanum lasiophyllum* (combined 2-5 % PFC). The lower stratum forms a herb and grass layer with *Aristida contorta* and *Maireana georgei* (5-10% PFC), Plate 3. *Acacia macraneura* and *A. incurvaneura* occasionally join the upper stratum and *Enneapogon caerulescens* and *Sclerolaena eriacantha* often form a minor component of the lower stratum. Note, in the north-eastern Goldfields, *Acacia burkittii* and *Senna artemisioides* subsp. *filifolia* are almost exclusively found on alkaline soils with expressions of groundwater calcretes.

The BaAbS community occurs on low basaltic rises with fine sandy loam and significant evidence of groundwater calcrete deposition at the surface. It is often associated with and adjacent to drainage lines. BaAbS may be present as a minor component of the BaMAS vegetation complex. The BaAbS community, when not as a component of BaMAS vegetation complex, occupies 11.9 hectares within the MKS Study Area.



Plate 3. Basalt *Acacia burkittii* Shrubland (BaAbS)

1.1.3. BaCdS Basalt, *Calytrix desolata* Shrubland

The Basalt *Calytrix desolata* Shrubland (BaCdS) community is a low very open shrubland of *Calytrix desolata* occurring in small semi homogenous patches in association with the greenstone basaltic landforms of the Violet Ranges, with expressions of shale and calcrete underlying a pebbly ironstone mantle. The BaCdS community covers an area of 22.7 hectares within the MKS survey area and may occur adjacent to the BaAxS community. The upper stratum is usually absent or limited to an occasional *Acacia xanthocarpa*. The mid stratum consists of a low open shrubland of *Calytrix desolata* (10-20% PFC) with scattered *Grevillea inconspicua* P4, *Hemigenia exilis* P4 and /or *Eremophila forrestii* subsp. *forrestii* individuals to 1m high. The lower stratum comprises scattered *Aristida contorta*, *Eriachne pulchella*, *Ptilotus helipteroides* and other sundry annuals (PFC 1-5%), Plate 4.



Plate 4. BaCdS with *Calytrix desolata* dominant and occasional *Grevillea inconspicua* P4 within this habitat.

The BaCdS habitat is dominant on the footslopes of the Violet Ranges, south-west of the MKS Study Area, outside the area where habitat level mapping has been conducted to date. Here, both *Hemigenia exilis* P4 and *Grevillea inconspicua* P4 are present in significant numbers.

1.2. Vegetation Associations of Carbonate Soils derived from Weathered Basalt

1.2.1. GHPS Greenstone *Hakea leucoptera* subsp. *sericipes* – *Eremophila pantonii* Shrublands

The Greenstone *Hakea leucoptera* subsp. *sericipes* – *Eremophila pantonii* Shrublands (GHPS) vegetation unit occurs on slopes and plains of greenstone hills that have some shale and calcrete underlying a minor ironstone mantle. Smectite clays are also present in the lower slopes and valleys within this habitat. The GHPS habitat covers an area of 223.2 hectares mapped within the MKS Study Area.

The upper stratum is usually absent or limited to very scattered emergent *Hakea preissii*, *Casuarina pauper*, *Acacia oswaldii* and isolated Mulga species trees 4 to 6 m high (PFC <1%). The mid story is dominated by *Eremophila pantonii* and either *Hakea preissii* or *H. leucoptera* subsp. *sericipes* (but very rarely both), with presences of *Senna* sp. Meekatharra (E. Bailey 1-26), *Ptilotus obovatus* and *Acacia tetragonophylla* (PFC 10-25%). The lower stratum of GHPS is dominated by chenopods including *Maireana georgei* and *M. triptera*, *Sclerolaena eriacantha*, with *Solanum lasiophyllum*, *Ptilotus nobilis*, *Aristida contorta* and *Enneapogon caerulescens* (PFC 4-10%) also commonly present, Plate 5. The ground surface is soft and easily penetrated and has silty carbonate soil with a surface largely bare with a rocky ironstone and quartz mantle.



Plate 5. GHPS area which shows *Hakea leucoptera* ssp. *sericipes* and *Eremophila pantonii* as co-dominant species.

Areas of GHPS are relatively small, readily identified and not widely distributed within the project area. The presence of *Eremophila pantonii* as a dominant component of the vegetation indicates carbonates and alkaline soil conditions.

Eremophila pantonii is also a dominant shrub in association with *Eucalyptus gypsophila* in the EGPW habitat unit near the Six Mile Well deposit, reflecting the alkaline soils strongly influenced by calcrete and dolomite.

1.2.2. SSS Stony Senna Shrublands

The SSS vegetation unit occurs on Hills and slopes of saprolitic shale with a stony ironstone mantle and supports sclerophyllous shrublands. The SSS habitat covers an area of 127.7 hectares mapped within the MKSO Study Area and has a low species richness. The dominant stratum is the mid stratum with *Senna* sp. Meekatharra (E. Bailey 1-26).

The upper stratum is characteristically very scattered *Hakea preissii* (PFC <1%) and occasional *H. leucoptera* subsp. *sericipes* emerging from a mid shrub stratum dominated by *Senna* sp. Meekatharra (E. Bailey 1-26), with *Ptilotus obovatus*, *Scaevola spinescens*, *Acacia tetragonophylla*, *Rhagodia drummondii* and *Solanum lasiophyllum* (PFC 10-15%). The lower stratum is dominated by chenopods *Maireana georgei*, *M. triptera*, *Sclerolaena eriacantha*, with *Aristida contorta*, *Sclerolaena lanicuspis*, *Ptilotus nobilis* and *Enneapogon caeruleus* (5-20% PFC). Annuals present on the SSS habitat include *Ptilotus helipteroides* and *Zygophyllum iodocarpum* (PFC <1%), Plate 6.



Plate 6. Area of SSS which shows *Senna* sp. Meekatharra (E. Bailey 1-26) as the dominant species.

1.2.3. EGPW *Eucalyptus gypsophila* – *Eremophila pantonii* Woodland

The *Eucalyptus gypsophila* – *Eremophila pantonii* Woodland (EGPW) vegetation unit occurs on eroded calcrete outcrops with a minor ironstone and quartz pebbly mantle. The EGPW habitat covers an area of 11.9 hectares mapped within the MKSO Study Area. This is a discrete habitat unit within the region and occurs north, east and south-east of the Six Mile Well orebody. A large area of EGPW occurs west of the proposed haul road to Mt Keith and north of the Six Mile Orebody.

The upper stratum is characteristically open woodland of *Eucalyptus gypsophila* with a PFC of 10-30%, over a mid stratum dominated by *Eremophila pantonii* (PFC 10-20%). Other commonly occurring mid stratum species include *Acacia burkittii*, *Ptilotus obovatus*, *A. pruinocarpa*, *A. oswaldii*, *A. aptaneura*, *Exocarpos aphyllus*, *Scaevola spinescens* and *Senna artemisioides* subsp. *filifolia*. The lower stratum of EGPW consists of scattered herbs and grasses, *Sclerolaena diacantha*, *Maireana triptera*, *Ptilotus nobilis*, *Maireana georgei*, *Eriochiton sclerolaenoides*, *Aristida contorta* and *Sclerolaena eriacantha* (<2% PFC), Plate 7.



Plate 7. Highly eroded area of EGPW showing *Eucalyptus gypsophila* and *Eremophila pantonii* as co-dominant species with calcrete and dolomite rocks.

This habitat unit also supports other locally restricted species (in the areas assessed to date between Leinster and Wiluna) such as the calcrete-endemic *Cratystylis centralis* P3 (outside the MKSO Study Area) and the halophytic *Sclerostegia disarticulata*.

1.3. Vegetation Associations of Limonitic Landforms

1.3.1. SIMS Stony Ironstone Mulga Shrublands

The Stony Ironstone Mulga Shrublands (SIMS) vegetation unit is generally located on hill crests and associated upper slopes and consist of outcropping ironstone associated stony slopes. SIMS habitat covers a total area of 412.3 hectares mapped.

The SIMS upper stratum tends to be dominated by the Mulga group, *Acacia incurvaneura*, *A. fuscaneura* and *A. ayersiana* (% PFC) with infrequently scattered *Acacia quadrimarginea sens. str.* and *Acacia pruinocarpa*. The mid shrub stratum in the SIMS habitats is characterised by an open shrubland of *Eremophila latrobei*, *E. galeata*, *Senna* sp. Meekatharra (E. Bailey 1-26), *Sida ectogama* and *Solanum lasiophyllum* and has a PFC in the range of 1 to 5%. The lower stratum consists mainly of annual species with few perennials *Ptilotus schwartzii*, *Cheilanthes sieberi*, *Solanum lasiophyllum*, *Monachather paradoxus*, *Maireana georgei*, *Sclerolaena eriacantha* and *Sida* sp. dark green fruits (S. van Leeuwin 2260) (0-2% PFC), Plate 8. Annuals are common, particularly in areas where soil and moisture accumulate, however, their abundance and cover are very much related to seasonal rainfall.



Plate 8. SIMS habitat showing erosional landscape position, a dominance of Mulga species and a lack of shrubs and annual vegetation in lower strata.

1.3.2. SILS Stony Ironstone Low Shrublands

The SILS vegetation unit is characterised by low open sclerophyllous shrublands on low rises or hill tops dominated by *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3 and is often found in small discrete patches within the landscape. The sites often exhibit weathered duricrust and saprolitic rocks at or near the surface but may have a stony ironstone and quartz mantle. The SILS habitat covers an area of 27.2 hectares mapped in the MKS Study Area.

The upper stratum is characteristically very scattered *Acacia quadrimarginea* sens. str., *Acacia incurvaneura* (PFC 1 to 2%) with a dominant shrub stratum including *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3, *Eremophila jucunda* subsp. *jucunda*, *E. latrobei* and *Sida ectogama* with occasional *Eremophila* sp. Leinster (RJ Cranfield 6767) P3, (PFC 8 - 14%). The lower stratum consists of scattered *Ptilotus schwartzii*, *Sida* sp. golden calyces glabrous (H.N. Foote 32), *Eriachne pulchella* and *Aristida contorta* (< 2% PFC). Annuals include *Dysphania kalpari*, *Ptilotus helipteroides* and other sundry annuals (PFC 1%), Plate 9.



Plate 9. Area of SILS with an ironstone mantle over saprolite and a dominant shrub stratum of *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3 in the foreground.

Outside but adjacent to the MKS Study Area, the SILS habitat supports a range of conservation-significant and taxonomically-significant species including *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4632) P3, *Hemigenia exilis* P4, *Hibbertia* sp. Sherwood Breakaways (G Cockerton & G. O'Keefe 11911), *Stackhousia* sp. Mt Keith (G. Cockerton & G. O'Keefe 11017).

1.3.3. USBS Upland Small Bluebush Shrubland

The USBS vegetation unit occurs on sandy clays on upper slope and plains high in the landscape that have a heavy stony quartz that may occasionally contain some ironstone. USBS supports chenopod shrublands and covers an area of 92.9 hectares mapped within the MKS Study Area. A total of 14 species were recorded.

The upper stratum is characteristically very scattered *Hakea preissii* and *Acacia oswaldii* (PFC <1%), a sparse mid story including scattered shrubs of *Ptilotus obovatus*, *Eremophila pantonii*, *Acacia tetragonophylla* and *Senna* sp. Meekatharra (E. Bailey 1-16) (PFC 1-4%). The lower stratum of USBS is the dominant stratum and consists of predominantly *Maireana georgei*, *M. triptera*, *M. tomentosa*, *Sclerolaena eriacantha* and *Aristida contorta* (PFC 5%) with *Enneapogon caerulescens*, *Ptilotus nobilis* and other sundry annuals also regularly occurring, Plate 10.

In small patches, *Cratystylis subspinescens* can form the dominant mid shrub stratum as a low open shrubland and would be mapped as a separate unit if the area of occurrence was greater.



Plate 10. USBS showing the lack of upper story species and sparseness of other vegetation.

1.4. Archaean granite geology

1.4.1. BrCP Complex Breakaway Chenopod Plain Complex

BrCP occurs on Lower slopes of Breakaways and their associated down-slope plains that consist of kaolin soils and clay, a minor quartz mantle may form over these sandy clays. These plains support chenopod shrublands. BrCP habitat covers an area of 21.3 hectares within the MKSO Study Area, inclusive of the BrCP-TectS and BrCP-Fran sub-communities. Much of the BrCP complex is a mosaic or intergrade between these two communities. For descriptions, see below.

The upper tree stratum is characteristically absent (PFC 0%) while the mid story of low shrubs is dominated by a number of *Maireana*, *Tecticornia* and *Frankenia* species, Plate 11.



Plate 11. BrCP in foreground area showing the lack of upper story and the dominance of chenopods.

1.4.1.1. BrCP-TectS Breakaway Chenopod Plain Complex – Tecticornia Shrubland

The Breakaway Chenopod Plain Tecticornia Shrubland (BrCP-TectS) community is characterised by the lack of mid and upper stratum vegetation where the lower stratum heath is dominated by Tecticornia species. It occurs in association with the kaolin clay and weathered granite coarse fragmented soils deposited in the plains associated with the archaean granite breakaway systems. These areas are subject to brief seasonal inundation as part of the outwash plains from the breakaway system. BrCP-TectS covers an area of 0.6 hectares within the MKS survey area.

The upper stratum is typically absent and the mid stratum is limited to isolated shrubs of *Senna* sp. Meekatharra (E. Bailey 1-26) or occasionally *Hakea preissii* or *H. leucoptera* subsp. *sericipes* (PFC <1%). The low stratum is dominated by an open heath of *Tecticornia disarticulata* (PFC 5-20%). Other commonly found species include *Frankenia setosa*, *Gunniopsis propinqua* P3, *Aristida contorta*, *Atriplex quinii*, *Sclerolaena eriacantha* and *S. fusiformis*, Plate 12.

This vegetation community supports a small annual, a priority species, *Gunniopsis propinqua* P3.



Plate 12. Breakaway Chenopod Plain *Tecticornia* Shrubland (BrCP-TectS)

1.4.1.2. BrCP-Fran Breakaway Chenopod Plain Complex – Frankenia Shrubland

The Breakaway Chenopod Plain Frankenia Shrubland (BrCP-Fran) community is an open low *Frankenia* species heath occurring in association with the flats and plains at the base of breakaway landform features. BrCP-Fran occurs in flat depositional areas of kaolinised soils, which may be water ponding areas following rainfall events. BrCP-Fran covers an area of 8.5 hectares within the MKS survey area.

The upper stratum of BrCP-Fran is usually absent and the mid stratum is limited to isolated *Hakea preissii* and *Senna* sp. Meekatharra (E. Bailey 1-26) shrubs (PFC <1%). The low stratum is the dominant stratum, with a low open heath consisting of primarily *Frankenia setosa*, *F. laxiflora*, *Maireana tomentosa*, *M. georgei* and *M. triptera* (PFC 10-30%). Other commonly occurring species include *Aristida contorta*, *Sclerolaena eriacantha*, *Maireana glomerifolia*, *M. carnos*a, *Ptilotus obovatus*, *Atriplex quinii*, *A. codonocarpa* and *Solanum lasiophyllum*, Plate 13.



Plate 13. Breakaway Chenopod Plain Complex - *Frankenia* Shrubland (BrCP-Fran)

1.4.2. BrGP Breakaway Grassy Plain

The Breakaway Grassy Plain (BrGP) occurs in areas of alluvial depositional areas at the base of weathered granite breakaways associated with non-saline plains down-slope of the BrX Complex communities. It typically has coarse silty sands with numerous large fragments and granitic geology close beneath the surface, supporting Mulga shrublands with very little beneath except *Aristida contorta* grasslands. Statistically, this community shows a high degree of similarity with the HPMS community but differs in the coarse gritty siliceous sandy soil, low silt and clay content and markedly different understorey component.

The upper stratum consists of open Mulga shrubland with *Acacia incurvaneura*, *A. pteraneura* and *A. caesaneura* (15-25%) over a mid stratum of scattered shrubs *Eremophila latrobei*, *Ptilotus obovatus* and *Acacia tetragonophylla* (1-3% PFC), over a dense lower stratum of predominantly *Aristida contorta* grasses (15-50% PFC) with scattered *Solanum lasiophyllum*, *Sclerolaena gardneri*, *Abutilon cryptopetalum*, *Enchylaena lanata* and *Eragrostis eriopoda* herbs and grasses, Plate 14.



Plate 14. Breakaway Grassy Plain (BrGP)

1.4.3. BrX Complex Archaean Granite Breakaways

The Archaean Granite Breakaways BrX Complex represents Archaean granite breakaways and their associated kaolinised upper slopes. This vegetation complex incorporates plateaux (BrX-P) and the footslopes (BrX-FOL) communities, forming a complex between the two around the borders of the breakaway landscape features.

The breakaways themselves consist of the edge of the elevated plateaux of weathered Archaean granite while the slopes are primarily kaolinised, unstable sandy clay soils which rely on the presence of significant rock fragments, vegetation and cryptogams to minimise the effects of erosion (Plate 15).

BrX Complex occupies an area of 7.1 hectares within the MKS Study Area. Inclusive of the BrX-P and BrX-FOL communities. Mapping at a finer scale would be required to separate the component communities.



Plate 15. BrX Complex habitats in both the foreground and background of the photo with interspersing Breakaway Chenopod Plain (BrCP).

The BrX Complex supports a range of Priority Species and Species of Interest and as such, is considered a vegetation unit with high conservation significance;

Anacampseros sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) P1;

Eremophila pungens (including *Eremophila* sp. Leinster RJ Cranfield 6767) P4;

Hibbertia sp. Sherwood Breakaways aff. *H. exasperata* (G Cockerton & G O'Keefe 11911);

Olearia sp. Sherwood Breakaways (A. Taylor 25552);

Sida picklesiana P3;

Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3;

Verticordia jamiesonii P3;

1.4.4. BrX-P Archaean Granite Breakaway Plateaux

The upper stratum is generally limited to scattered *Acacia quadrimarginea sens. str.*, isolated patches of *Callitris columellaris* open tall shrubland and scattered *Eucalyptus carnei* along the plateau margins in some areas (PFC <5%). The mid story is often dominated by *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3 and *Calytrix uncinata*. (PFC 5-15%) with regular occurrences of *Acacia kempeana*, *Micromyrtus sulphurea*, *Eremophila glutinosa*, *Dodonaea petiolaris*, *Hakea recurva* subsp. *recurva* and *Ptilotus obovatus*, Plate 16.

The lower stratum on BrX-P consists of *Eriachne mucronata*, *Neurachne minor*, *Olearia* sp. Sherwood Breakaways (A. Taylor 25552), *Eragrostis eriopoda*, *Stackhousia* sp. Mt Keith (G. Cockerton & G. O'Keefe 11017), *Thyridolepis multiculmis* and sundry annuals (PFC <2%). It may also support *Hibbertia* sp. Sherwood Breakaways (aff. *H. exasperata*) G Cockerton & G. O'Keefe 11911).

The BrX-P community occurs on mostly exposed weathered granite rock, with very shallow soil regolith in small depressions of the rock surface. Most of the species present rely on cracks within the rocks to anchor their root systems. The landform characteristically consists of a flat-topped plateau surrounded by eroding cliff faces or breakaways.



Plate 16. BrX-P showing exposed rocky surfaces and open mid shrublands.

Note: *Hibbertia* sp. Sherwood Breakaways (aff. *H. exasperata*) G Cockerton & G. O'Keefe 11911) is not as yet an accepted Phrase name and does not occur as a separate entity on the Census of Vascular Flora in Western Australia. The taxonomy of this group is under review in 2017 by Geoff Cockerton and Dr. Kevin Thiele.

1.4.5. BrX-FOL Archaean Granite Breakaway Footslope

The Archaean Granite Breakaway Footslope (BrX-FOL) is a variable community associated with the breakaway communities. It forms a part of the BrX Complex and covers a total area of 15.7 hectares within the MKS survey area. It features largely erosional steep slopes, breakaway faces, depositional slopes and mounds with kaolinised soils and a high percentage of coarse fragments. The BrX-FOL community supports numerous caves and is a highly important fauna habitat, Plate 17.

The upper stratum typically features scattered patches of *Callitris columellaris* and Mulga shrublands with *Acacia incurvaneura*, *A. aptaneura*, *A. aneura*, *A. caesaneura* and *A. craspedocarpa* (PFC 3-25%) In restricted areas, *Eucalyptus carnei* can occur as scattered mallees. The mid shrub stratum includes *Senna* sp. Meekatharra (E. Bailey 1-26), *Scaevola spinescens*, *Eremophila oppositifolia* subsp. *angustifolia*, *Dodonaea petiolaris* and *Ptilotus obovatus* (PFC 5-30%). The lower stratum is highly variable, due to the variety in soil profiles or lack there-of. It usually interzones with the communities BrCP, BrCP-Fran, BrGP, BrCP-TectS or GrMS and can include the species *Maireana georgei*, *M. triptera*, *Sclerolaena eriacantha*, *S. fusiformis*, *Frankenia setosa*, *F. laxiflora*, *Tecticornia disarticulata*, *Atriplex quinii* and *Aristida contorta* (PFC 2-10%).



Plate 17. BrX-FOL community showing highly variable soil profiles and slopes.

1.4.6. GrEx Granite, Exfoliating granite outcrops

The Granite, exfoliating granite outcrops (GrEx) vegetation unit consists of large, rounded granite outcrops and boulders and are associated with the Barr-Smith Range (**Error! Reference source not found.**). The nature of the rock provides limited habitat for vegetation to establish and it can only do so in areas where soil has been trapped and where large rock crevices occur. The GrEx habitat covers an area of 62.4 hectares mapped within the MKS Study Area, and the regional occurrence is extensive.

The upper stratum is characteristically very scattered and contains *Acacia quadrimarginea sens. str.* and *Acacia incurvaneura* (PFC 10 - 20%). The mid story contains scattered *Senna* sp. Meekatharra (E. Bailey 1-26) and *Eremophila exilifolia* (PFC 1-2%). The lower stratum of GrEx characteristically supports substantial perennial Lemon Scented Grass (*Cymbopogon ambiguus*) and other sundry annuals (PFC 2%). The Priority 1 species *Anacampteros* sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) may be present within this vegetation unit.



Plate 18. Granite, exfoliating granite outcrops (GrEx) habitat in the background with SGRS habitat in the foreground.

1.4.7. GrMS Granitic Mulga Shrubland

Granitic Mulga Shrubland (GrMS) occurs where the underlying highly weathered Archaean granite geology either rises close to the surface, or forms low hills and rises. This community exists with outcropping granite and large granite cobble to boulders on the soil surface. It can grade up into the BrX complex of communities. The GrMS habitat covers an area of 990 hectares within the MKSO Study Area.

The upper stratum is characteristically open shrubland to scattered tall shrubs of *Acacia quadrimarginea sens. str.*, *A. incurvaneura*, *A. aneura* and *A. mulganeura* (PFC 5-20%) and a mid story consisting of very scattered shrubs of *Sida ectogama*, *Ptilotus obovatus*, *Acacia tetragonophylla* and *Scaevola spinescens* (PFC 1-6%). The lower stratum is mostly absent, with a few scattered *Sclerolaena eriacantha*, *Cheilanthes sieberi* and *Sida* sp. dark green fruits (*S. van Leeuwin* 2260) herbs (<1% PFC) (Plate 19). In some areas, *Eremophila exilifolia* or *Eremophila glutinosa* can form a dominant part of the mid shrub stratum with PFC to 25%.

GrMS – BrX Complex

The GrMS community and the BrX Complex of communities form a mosaic and broad ecotonal intergrade into the BrX Complex where the granitic hills and rises have infrequent breakaway features or represent an uplifted geological feature. It is predominant west of the Study Area.



Plate 19. Granitic Mulga Shrubland (GrMS)

1.4.8. SAES Stony *Acacia* - *Eremophila* Shrubland

The Stony *Acacia aneura* - *Eremophila galeata* Shrublands (SAES) vegetation unit occurs on colluvial plains and low rises and has a stony ironstone mantle with a minor amount of quartz, gritty clayey sandy soils, and supports very scattered sclerophyllous shrublands. It is often underlain by Wiluna hardpan conglomerate or Archaean granite sheet in the north-eastern Goldfields. Within the MKS Study Area, SAES may also be underlain by meta-basalt or basalt geology. Where this occurs, it may support scattered *Grevillea inconspicua* P4. The SAES habitat covers an area of 484.3 hectares within the MKS Study Area.

The upper stratum is characteristically isolated to scattered Mulga shrubs of *Acacia mulganeura*, *A. caesaneura*, *A. aneura*, *A. craspedocarpa*, *A. macraneura* and *A. pteraneura* (PFC <1%), over a mid story dominated by *Eremophila galeata* (PFC 5 –10%) with regular occurrences of *Senna* sp. Meekatharra (E. Bailey 1-26), *Ptilotus obovatus*, *Sida ectogama* and *Acacia tetragonophylla*. The lower stratum is usually sparse, consisting of *Maireana georgei*, *M. triptera*, *Ptilotus helipteroides*, *P. schwartzii*, *Sclerolaena eriacantha*, *Monachather paradoxus*, and *Solanum lasiophyllum* (<4% PFC), Plate 20.

Given the stony mantle, SAES areas generally have limited annuals however if an annual herbage lower stratum is present it consists of *Helipterum craspedioides*, *Rhodanthe charsleyae* and other sundry species.

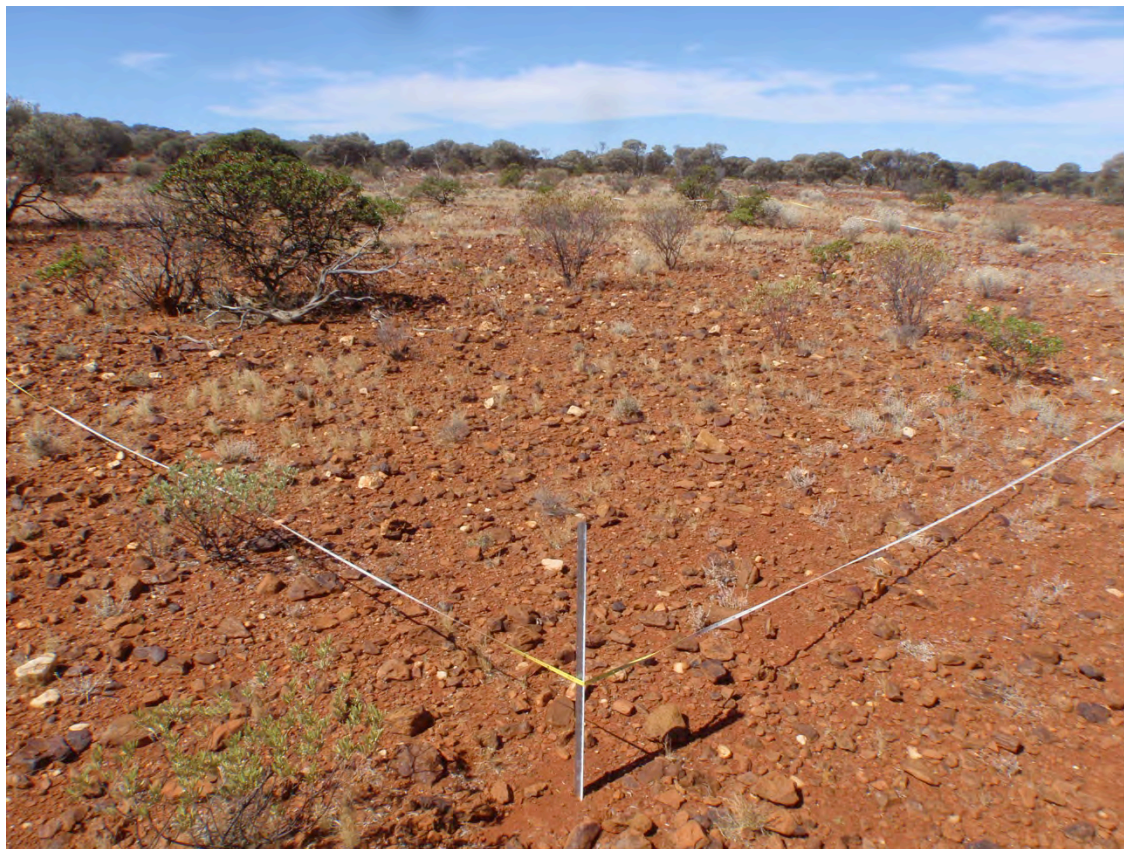


Plate 20. Stony *Acacia* - *Eremophila* Shrubland (SAES)

1.4.9. SGRS Sandy Granitic Acacia Shrublands

SGRS occurs on undulating plains of gritty sandy loams that have a quartz and granite rocky mantle. It occurs at the base of exfoliating Granite outcrops (GrEx habitat unit) and contains annual grasses rather than chenopods common elsewhere indicating non-saline conditions. SGRS habitat covers an area of 5.4 hectares within the MKS Study Area and is abundant in the region.

The upper stratum is characteristically scattered *Acacia aneura* and *Acacia quadrimarginea sens. str.* (PFC 5-20%) and a very scattered shrub layer consisting of *Eremophila platycalyx* subsp. Neds Creek, *Scaevola spinescens*, *Rhagodia drummondii*, *Senna* sp. Meekatharra (E. Bailey 1-26) and *Sida ectogama* (PFC 2%). The understorey may be dominated by *Eremophila exilifolia* or *E. glutinosa* where low rises of outcropping granite occur (PFC 10-15%). The lower stratum of SGRS consists of *Cymbopogon ambiguus*, *Helipterum craspedioides*, *Aristida contorta* and other sundry annuals (PFC 5-30%), Plate 21.



Plate 21. SGRS showing sparse vegetation.

1.5. Sandplain Landforms

1.5.1. MUWA Mulga Wanderrie Grassy Shrubland

Mulga Wanderrie Grassy Shrublands represent gently inclined plains of loamy soils interspersed with hardpans and is subject to sheet flow. Only 2.8 ha of MUWA occurs in the MKS Study Area as a single polygon.

The upper stratum consists of tall Mulga shrublands with *Acacia incurvaneura*, *A. aneura* and *A. caesaneura* (10-15% PFC). The mid stratum is a well-developed shrub stratum consisting of *Eremophila galeata*, *E. spectabilis* subsp. *brevis*, *E. latrobei* (various subspecies) and occasional *A. tetragonophylla* with a PFC of 5%. A well-developed perennial grass dominated stratum including *Monachather paradoxus* and *Eragrostis eriopoda* (2-10% PFC) is a key indicator of MUWA community, Plate 22.



Plate 22. Mulga Wanderrie Grassy Shrubland (MUWA)

1.5.2. SAMU Sandplain Mulga Spinifex Shrubland

Sandplain Mulga Spinifex Shrubland (SAMU) occurs on sandy soils to around 30 centimetres in depth over hardpan. SAMU supports hummock grasslands with emergent Mulga and occupies an area of 172 hectares within the MKSO Study Area.

The upper stratum is characteristically dominated by tall open Mulga shrublands (10-20% PFC) of *Acacia caesaneura*, *A. aptaneura* and *A. aneura*. On occasion, there may be scattered other Mulgas, including *A. fuscaneura* and *A. mulganeura*. The mid story is an open mid shrubland including *Eremophila spectabilis*, *E. forrestii* subsp. *forrestii*, *Acacia ramulosa* subsp. *linophylla*, *A. tetragonophylla*, *Psydrax rigidula*, *Maireana planifolia* and *Solanum lasiophyllum* (PFC 2-10%). The lower stratum of SAMU is dominated by the spinifex *Triodia basedowii*, with regular presences of *Monachather paradoxus* and *Eragrostis eriopoda* (PFC 10-25%), Plate 23. Annuals include *Helipterum craspedioides* and *Rhodanthe charsleyae*.



Plate 23. Sandplain Mulga Spinifex Shrubland (SAMU)

1.5.3. WABS Wanderrie Bank Grassy Shrublands

The Wanderrie Bank Grassy Shrublands (WABS) vegetation unit occurs on skeletal soils that usually consist of a hardpan with small discrete sand rises where plants are able to establish. WABS may contain a very scattered stony mantle which if present generally consists of ironstone and/or quartz pebbles. A crust usually forms in the bare areas of hardpan. The small discrete soil mounds usually support perennial grasses with occasional sclerophyll shrub species. WABS typically also contains a large number of long-dead mulga and regeneration is scarcely observed. WABS habitat covers an area of 182.2 hectares within the MKSO Study Area.

The upper stratum is characteristically very scattered Mulga species, variously *Acacia aneura*, *A. incurvaneura*, *A. pteraneura*, *A. aptaneura* and *A. macraneura* (PFC 5%) with a presence of *A. pruinocarpa*. A mid stratum of shrub species is characterised by *Sida ectogama*, *Eremophila latrobei* (various subspecies), *Eremophila spectabilis* subsp. *brevis*, *Ptilotus obovatus*, *Maireana planifolia*, *Psydrax suaveolens* and *Solanum lasiophyllum* (PFC 3-8%). The lower stratum of the WABS community consists of the perennial grass species *Eragrostis eriopoda* and *Monachather paradoxus* (PFC 8-15%) with some *Ptilotus schwartzii*, *Eriachne mucronata* and *Thyridolepis multiculmis* co-occurring, Plate 24. May include a suite of annuals where adequate runoff is received.

WABS-SAMU Complex

As the soil strata grades into deeper sandier soils, WABS forms a mosaic or complex with the SAMU and occasionally the SAMA vegetation communities.



Plate 24. WABS – notice the long-dead mulga that is characteristic of WABS areas.

1.5.4. SAMA Sandplain Mallee *Acacia* Spinifex shrubland

The SAMA vegetation community occurs on deeper sandy soils and is characterised by the Mulga, mallee and spinifex composition. It may represent an ecotone between the SAMU and SAWS communities. These areas are occasionally subject to fire and regeneration from seed as well as lignotuber is a common feature of the vegetation. Within the MKS study area, 13.3 hectares was recorded.

The SAMA community upper story consists of the mallee *Eucalyptus leptopoda* subsp. *elevata*, *E. kingsmillii*, occasional *E. lucasii* to 6m, *Acacia effusifolia* 1.5 to 3m, and Mulga species including *A. incurvaneura*, *A. caesaneura* and *A. aneura* (6-15% PFC). The mid stratum is usually sparse, consisting of scattered *Acacia ramulosa* subsp. *linophylla*, *Eremophila latrobei* (various subsp.) and *E. forrestii* subsp. *forrestii* (0-2% PFC). The lower stratum is dominated by the spinifex *Triodia basedowii* (15-25% PFC).



Plate 25. Sandplain Mallee *Acacia* Spinifex Shrubland (SAMA)

SAWS Sandplain, *Acacia* species Spinifex Shrubland

The Sandplain *Acacia* species Spinifex Shrubland (SAWS) covers 11.9 hectares of the survey area and represents *Acacia* species other than the Mulga group, over Spinifex. These areas are often subject to frequent fire and regeneration from seed as well as lignotuber is a common feature of the vegetation. *Acacia effusifolia* and *A. rhodophloia* are common in the mid shrub stratum and the lower stratum *Triodia basedowii* PFC is variable, depending on the time since the last fire, Plate 26.



Plate 26. SAWS community with *Eucalyptus kingsmillii* emergent mallee (image from 2004 survey event).

1.6. Colluvial and Alluvial landforms

1.6.1. DRES Drainage Line Eucalyptus Woodland

DRES are narrow to broad incised ephemeral watercourse that usually have a sandy bottom over the exposed bedrock that support *Eucalyptus camaldulensis* as a major feature. DRES habitat covers an area of 50.5 hectares within the MKSO Study Area.

The upper stratum is characteristically scattered *Eucalyptus camaldulensis* subsp. *obtusata* trees which occur along the incised channel (PFC 5-20%). The mid story of mid to tall shrubs occur primarily along the banks of the incised drainage lines, including *Acacia burkittii*, *A. tetragonophylla*, *A. aptaneura*, *Pimelea microcephala* subsp. *microcephala* and (PFC 1%). The lower stratum of DRES is limited to the raised sandbanks within the drainage lines and the banks, where it is dominated by the grass species *Themeda triandra*, *Cymbopogon ambiguus*, *Aristida contorta* and occasional *Aristida jerichoensis* var. *subspinulifera* P3 (10-25% PFC), Plate 27. The mobile coarse sandy beds of the deeply incised drainage channels are usually bare of vegetation.

Other commonly occurring species include *Duperreya commixta*, *Senna artemisioides* subsp. *x artemisioides*, *Acacia quadrimarginea* sens. str., *Ptilotus obovatus*, *Sida ectogama*, *Abutilon cryptopetalum*, *Eremophila exilifolia* and *Pluchea dentex*.

The priority species *Hemigenia exilis* (P4) has been recorded within this vegetation community, along with the weed species *Bidens bipinnata*.



Plate 27. Typical DRES with an incised channel and *Eucalyptus camaldulensis*.

1.6.2. DRMS Drainage line Mulga Shrubland

DRMS are poorly defined narrow to broad drainage tracts on clay loam soils with minor incised water flow channels. The change in relief between these drainage tracts and the surrounding plains is subtle at 0.5 meters. They often have an extensive algal and Liverwort crust which prevents extensive erosion as surface water flows move during peak flood periods. The DRMS habitat covers an area of 381.5 hectares within the MKS Study Area.

The upper stratum is characteristically Mulga Shrubland combination of usually *Acacia incurvaneura*, *A. aptaneura*, *A. craspedocarpa* and *A. caesaneura* (PFC 20-40%) with occasional *A. quadrimarginea sens. str.* involvement (see below). The mid story consists of a shrub strata comprising *A. tetragonophylla*, *Sida ectogama*, *Senna artemisioides* (various subspecies) and *Eremophila latrobei* (PFC 5-15%). The lower stratum of DRMS consists of low herbs *Ptilotus obovatus*, *Hibiscus burtonii*, *Solanum lasiophyllum* and the grass species *Cymbopogon ambiguus* (PFC 1-5%), Plate 28. Other commonly occurring species include *Santalum spicatum*, *Cheilanthes sieberi*, *Marsdenia australis*, *Duperreya commixta*, *Eremophila galeata*, *E. granitica*, *Abutilon cryptopetalum* and *Acacia burkittii*.

Where underlying, incised geology is granitic, *Acacia quadrimarginea sens. str.* joins the upper story and a dominant species and the understory can approach the Granitic Mulga Shrubland (GrMS) vegetation community in composition.



Plate 28. Drainage line Mulga Shrubland (DRMS)

1.6.3. GRMU Mulga Groves on Hardpan Plains

The Mulga Groves on Hardpan Plains (GRMU) occur on plains to gently inclined areas that maintain internal drainage at most periods however form connections between drainage lines during high rainfall events to create broad drainage areas. GRMU generally do not support a mantle of stones or pebbles or if they do, they are generally very scattered, however they often have a crust formed during extended periods of minimal rainfall.

GRMU generally supports a wide range of sclerophyllous species and are particularly rich in annuals following rainfall. GRMU habitat covers an area of 65.2 hectares within the MKS Study Area. The upper stratum is characteristically restricted nodes of tall shrubland to tall closed shrubland of Mulga species, primarily *Acacia incurvaneura*, *A. caesaneura* and *A. pteraneura* (PFC 25-50%) and a mid story of *A. ramulosa* subsp. *linophylla*, *Eremophila spectabilis* subsp. *brevis*, *Psyrax rigidula* and *Sida ectogama* (PFC 10-25%). The lower stratum of GRMU is a mixed herb and grass layer characterised by *Monachather paradoxus*, *Thyridolepis multiculmis*, *Maireana planifolia*, *Sida fibulifera*, *Eragrostis eriopoda*, *Sida calyxhymenia*, *Sida* sp. dark green fruits (PFC 5-10%), Plate 29.

Grove mulga woodlands are important refugia for flora and fauna and often retain moisture long into the otherwise dry periods of the year. Vegetation is therefore usually more dense than in surrounding similar habitats such as DRMS which often act as conduits for runoff rather than retaining moisture for long periods.



Plate 29. GRMU, A dense Mulga Grove with intergrove (HPMS) in the foreground.

1.6.4. HMCS Mulga Shrubland with scattered low Chenopod Shrubs

The upper stratum is characteristically scattered and patchy tall Mulga shrublands, with *Acacia aneura*, *A. incurvaneura*, *A. mulganeura*, *A. aptaneura* and *A. craspedocarpa* with occasional *Hakea preissii* and *A. tetragonophylla* (PFC 2-10%). The mid story is dominated by *Maireana pyramidata* (PFC 5-15%) with some *Ptilotus obovatus*. The lower stratum varies considerably in density and consists of *Sclerolaena lanicuspis*, *Maireana georgei*, *Sida fibulifera*, *Abutilon oxycarpum* subsp. Prostrate (A.A. Mitchell PRP 1266), *Aristida contorta*, *Tripogon loliiformis* and other sundry annuals (PFC 5-20%), Plate 30. HMCS occurs on gently inclined plains with sandy clay-loam soils underlain by weathered granite sheet and subject to extensive sheet flow derived from Archaean granite breakaways.

The HMCS described here is comparable to the Loamy Mulga Chenopod Plains (LMCP) recorded in the 2012 Yakabindie Borefields vegetation mapping by Western Botanical.



Plate 30. HMCS with an upper strata of Mulgas and a shrub layer dominated by *Maireana pyramidata*.

MpS *Maireana pyramidata* Shrubland

The MpS *Maireana pyramidata* Shrubland is affiliated with HMCS, but distinct due to an absence of upper story Mulga species. It is dominated by a shrub stratum of *Maireana pyramidata*. Areas of MpS are commonly encountered in the NE Goldfields on shallow soils over hardpan or granite sheet, downslope of breakaways systems.

1.6.5. HPMS Hardpan Mulga Shrublands

The Hardpan Mulga Shrublands (HPMS) vegetation unit occurs on level to gently inclined plains with a well developed hardpan and may contain a very scattered stony mantle which if present generally consists of ironstone and/or quartz pebbles. A crust usually forms in the bare areas of hardpan. These zones usually represent washplains or un-incised drainage channels featuring sheet flow water movement following rainfall events. HPMS supports an *Acacia* shrubland with very scattered sclerophyllous shrubs, Plate 31. HPMS habitat covers an area of 330 hectares within the MKS Study Area.

The upper stratum is characteristically an open high shrubland to mulga woodland of Mulga species, usually *Acacia incurvaneura* and *A. pteraneura*, occasionally *A. caesaneura* and *A. craspedocarpa* (PFC 10- 20%) and a scattered mid stratum of *Acacia tetragonophylla*, *A. ramulosa* var. *linophylla*, *Senna* sp. Meekatharra (E. Bailey 1-26)) and *Eremophila spectabilis* subsp. *brevis* (PFC 2-5%). The low stratum is characterised by scattered *Ptilotus obovatus*, *Solanum lasiophyllum*, *Aristida contorta*, *Eragrostis eriopoda* and *Monachather paradoxus* herbs and grasses (1-2%). The HPMS community is regarded as sheet flow dependent. Annuals include *Helipterum craspedioides*, *Rhodanthe charsleyae* and other sundry annuals (PFC <1%).



Plate 31. HPMS notice the extent of bare ground with minimal lower story vegetation that reflects the hardpan nature.

HPMS Thoma Hardpan Mulga Shrublands with *Acacia thoma*.

In some areas, *Acacia thoma* joins the upper story and forms co-dominance with the Mulga group. In these areas, the vegetation community is referable to HPMS-Thoma, Plate 32. There is an area of 3 hectares represented by a single polygon within the MKS survey area. *Acacia thoma* is more widespread in the Pilbara region and small, isolated occurrences are known between Leinster and Wiluna.



Plate 32. *Acacia thoma* community, NW corner of Wanjarri Nature Reserve, adjacent to the MKS Transport Corridor.

1.6.6. MMS Mulga over *Maireana triptera* Shrubland

The Mulga on *Maireana triptera* Shrubland (MMS) occurs on undulating plains and gentle slopes of stony clay loam soils with a shallow mantle that supports Mulga and chenopod vegetation. The soil profile is fairly homogenous, formed from glacial era alluvial sedimentary deposits. The MMS habitat occupies an area of 330 hectares within the MKS Study Area.

The upper stratum is characteristically open tall shrubland of Mulgas *Acacia incurvaneura*, *A. pteraneura* and *A. aneura* (PFC 15-20%), occasionally with scattered *Hakea preissii*. The mid story is quite variable, but usually characterized by scattered mid shrubs of *Scaevola spinescens*, *Acacia tetragonophylla*, *Ptilotus obovatus*, *Senna* sp. Meekatharra (E. Bailey 1-26), *Rhagodia drummondii*, *Enchylaena lanata* (PFC 5-15%), Plate 33.

The lower stratum of MMS is dominated by chenopod species, *Maireana georgei*, *M. triptera*, *Sclerolaena eriacantha*, *Aristida contorta* and *Enneapogon caerulescens* (PFC 5-30%), with regular presences of *Ptilotus nobilis*, *P. helipteroides*, *Cheilanthes sieberi*, *Sida* sp. dark green fruits (S. van Leeuwen 2260), *Solanum lasiophyllum* and *Maireana tomentosa*.

The MMS vegetation possibly represents a broad ecotone between the SIMS and the USBS vegetation communities.



Plate 33. Mulga on *Maireana triptera* Shrubland (MMS), chenopods inconspicuous as herb stratum.

1.6.7. SMS Stony Mulga Shrublands

SMS occurs on alluvial plains characterised by shallow loamy soils over gravely conglomerate hardpan (Wiluna hardpan) and represents the lower colluvial slopes downslope of the SIMS landscapes. The SMS habitat has a prominent stony mantle (quartz and ironstone rocks to 10 cm diameter) and supports a scattered Mulga tree stratum to 4m with a narrow range of sclerophyllous shrubs representing the understory Plate 34. SMS habitat covers an area of 763.8 hectares within the MKS Study Area.

The upper stratum is characteristically open Mulga shrubland of *Acacia incurvaneura* (PFC 10-15%) with occasional *A. pruinocarpa*. This can be replaced by other forms of Mulga in areas. The mid story is a scattered shrubland including *Sida ectogama*, *Senna* sp. Meekatharra (E. Bailey 1-26), *Eremophila galeata*, *E. latrobei* (various subspecies) and *Acacia tetragonophylla* (PFC 2-8%). The lower stratum consists of scattered herbs and grasses, *Aristida contorta*, *Ptilotus schwartzii*, *Solanum lasiophyllum*, *Sida* sp. dark green fruits, *Eragrostis eriopoda*, *Monachather paradoxus* and *Maireana triptera* (<2% PFC).



Plate 34. SMS habitat with stony mantle over loam showing the very scattered vegetation.

Appendix 4b. Quadrat & Releve Site Summaries

Note:

- Coordinates of sites presented a both UTM (MGA94) and decimal degrees, representing the north-western corner of each quadrat.
- Cover presented as % Projected Foliar Cover (PFC)
- Height presented as metres
- “Out” refers to plants occurring outside quadrat
- “+” refers to species present but PFC under 1%

BHP - NW - MKS

Site DP003 Unit: SIMS

Date 5/11/2016 **Type** Quadrat
MGA Zone 51 261446 **mE** 6964237 **mN** 120.586878 **E** -27.424355 **S**
Habitat Crest, possibly laterite capping, top third of landform.
Soil Orange clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|--|-------|---------|
| Acacia craspedocarpa | OUT | 3-4 |
| Acacia fuscaneura | + | 0.2 |
| Acacia fuscaneura | 10 | 3-4 |
| Acacia fuscaneura | + | 1 |
| Acacia quadrimarginea | OUT | 3-4 |
| Acacia tetragonophylla | 1 | 1.5 |
| Aristida contorta | + | 0.1 |
| Casuarina pauper | 1 | 4 |
| Cheilanthes sieberi subsp. sieberi | + | 0.1 |
| Duperreya commixta | OUT | 0.6 |
| Enchylaena lanata | + | 0.2 |
| Enneapogon caeruleus | + | 0.2 |
| Eremophila jucunda subsp. jucunda | + | 0.6 |
| Eremophila oppositifolia subsp. angustifolia | OUT | 2-3 |
| Eriachne helmsii | + | 0.2 |
| Marsdenia australis | + | 0.1 |
| Monachather paradoxus | + | 0.2 |
| Ptilotus obovatus (typical Goldfields form) | + | 0.3 |
| Ptilotus schwartzii | + | 0.4 |
| Scaevola spinescens (narrow leaf, spiny form) | 1 | 1.8 |
| Senna artemisioides subsp. filifolia | + | 0.4 |
| Sida ectogama | + | 0.2-0.6 |
| Sida ectogama | 0.5 | 1 |
| Sida sp. dark green fruits (S. van Leeuwen 2260) | + | 0.2 |
| Solanum lasiophyllum | + | 0.2 |
| Spartothamnella teucriflora | OUT | 0.3 |

Site Photo

BHP - NW - MKS**Site** DP004**Unit:** SIMS

Date 5/11/2016 **Type** Quadrat
MGA Zone 51 261464 **mE** 6964283 **mN** 120.587069E -27.423943S
Habitat Upper slope, ironstone, top third of landform.
Soil Orange clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|---|--------------|---------------|
| Acacia ayersiana (narrow phyllode form) | + | 4 |
| Acacia burkittii | + | 4 |
| Acacia craspedocarpa | + | 1.8 |
| Acacia fuscaneura | 2 | 3-5 |
| Acacia pruinocarpa | + | 0.1 |
| Acacia pruinocarpa | 2 | 4-5 |
| Acacia tetragonophylla | 1 | 0.8 |
| Amyema gibberula var. gibberula | + | 0.3 |
| Aristida contorta | + | 0.1 |
| Enchylaena lanata | + | 0.4 |
| Eremophila oppositifolia subsp. angustifolia | 1 | 3 |
| Eremophila oppositifolia subsp. angustifolia | + | 0.8 |
| Grevillea berryana | + | 6 |
| Maireana georgei | + | 0.2 |
| Ptilotus nobilis | + | 0.2 |
| Ptilotus obovatus (typical Goldfields form) | + | 0.4 |
| Scaevola spinescens (narrow leaf, spiny form) | + | 0.6 |
| Sclerolaena densiflora | + | 0.1 |
| Sclerolaena eriacantha | + | 0.1 |
| Sclerolaena fusiformis | + | 0.1 |
| Senna charlesiana | + | 0.6 |
| Senna sp. Austin (A. Strid 20210) | + | 0.5 |
| Sida ectogama | + | 1.4 |
| Solanum lasiophyllum | + | 0.3 |

Site Photo

BHP - NW - MKS

Site DP006

Unit: SMS / SIMS ecotone

Date 4/11/2016 **Type** Quadrat
MGA Zone 51 260910 **mE** 6962847 **mN** 120.581187 **E** -27.436799 **S**
Habitat Mid-upper slope, middle third of landform, colluvium at surface.
Soil Orange clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|--|--------------|---------------|
| Abutilon cryptopetalum | + | 0.2 |
| Acacia fuscaneura | 1 | 0.6-1.8 |
| Acacia fuscaneura | + | 0.1 |
| Acacia fuscaneura | 4 | 4-5 |
| Acacia oswaldii | .5 | 2.2 |
| Acacia pruinocarpa | + | 0.1 |
| Acacia pruinocarpa | 8 | 7 |
| Acacia pruinocarpa | + | 0.6 |
| Acacia tetragonophylla | .5 | 4 |
| Acacia tetragonophylla | .5 | 1.2 |
| Aristida contorta | + | 0.1 |
| Cymbopogon ambiguus | + | 0.1 |
| Enchylaena lanata | + | 0.6 |
| Eremophila oldfieldii subsp. angustifolia | .5 | 3 |
| Hakea preissii | .25 | 0.5-2.5 |
| Hakea preissii | + | 0.6 |
| Maireana georgei | 2 | 0.3 |
| Pimelea microcephala subsp. microcephala | OUT | 0.7 |
| Ptilotus nobilis | + | 0.2 |
| Ptilotus obovatus (typical Goldfields form) | 1 | 0.6 |
| Ptilotus obovatus (upright form) | .5 | 0.7 |
| Rhagodia drummondii | 1 | 0.8 |
| Santalum spicatum | OUT | 2.5 |
| Scaevola spinescens (narrow leaf, spiny form) | + | 1.6 |
| Sclerolaena densiflora | + | 0.1 |
| Sclerolaena eriacantha | + | 0.1 |
| Senna artemisioides subsp. x artemisioides | OUT | 0.2 |
| Senna sp. Meekatharra (E. Bailey 1-26) | + | 0.2 |
| Sida ectogama | OUT | 0.8 |
| Sida sp. dark green fruits (S. van Leeuwen 2260) | + | 0.15 |
| Solanum cleistogamum | + | 0.15 |
| Solanum lasiophyllum | + | 0.2 |

Site Photo

BHP - NW - MKS**Site** DP007**Unit:** SIMS

Date 5/11/2016 **Type** Quadrat
MGA Zone 51 261513 **mE** 6961483 **mN** 120.587015 **E** -27.449207 **S**
Habitat Upper slope, top third of landform, quartz and laterite at surface.
Soil Orange clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|--|--------------|---------------|
| Acacia ayersiana (narrow phyllode form) | 0.5 | 1 |
| Acacia ayersiana (narrow phyllode form) | 2 | 5-6 |
| Acacia fuscaneura | 2 | 1 |
| Acacia fuscaneura | 3 | 4-5 |
| Acacia fuscaneura | + | 0.1 |
| Acacia fuscaneura | + | 0.1 |
| Acacia quadrimarginea | 5 | 5-6 |
| Acacia tetragonophylla | 1 | 2 |
| Aristida contorta | + | 0.1 |
| Cheilanthes sieberi subsp. sieberi | + | 0.2 |
| Eremophila galeata | + | 0.1 |
| Eremophila latrobei var. tuberculosa | + | 0.2 |
| Eremophila latrobei var. tuberculosa | 1 | 0.7 |
| Harnieria kempeana subsp. muelleri | + | 0.6 |
| Harnieria kempeana subsp. muelleri | + | 0.1 |
| Hibiscus burtonii | + | 0.15 |
| Maireana georgei | + | 0.2 |
| Marsdenia australis | + | 0.05 |
| Psyrax suaveolens | + | 0.3 |
| Ptilotus helipteroides | + | 0.1 |
| Ptilotus nobilis | + | 0.2 |
| Ptilotus obovatus (typical Goldfields form) | + | 0.4 |
| Ptilotus obovatus (upright form) | + | 0.6 |
| Ptilotus roei | + | 0.15 |
| Ptilotus schwartzii | + | 0.4 |
| Santalum lanceolatum | OUT | 2.5 |
| Scaevola spinescens (narrow leaf, spiny form) | + | 0.7 |
| Sclerolaena densiflora | + | 0.1 |
| Sclerolaena eriacantha | + | 0.1 |
| Senna sp. Meekatharra (E. Bailey 1-26) | 1 | 1.8 |
| Senna sp. Meekatharra (E. Bailey 1-26) | + | 0.1 |
| Sida ectogama | + | 0.7 |
| Sida sp. dark green fruits (S. van Leeuwen 2260) | + | 0.1 |
| Solanum lasiophyllum | + | 0.3 |

Site Photo



BHP - NW - MKS**Site** DP008**Unit:** SIMS

Date 5/11/2016 **Type** Quadrat
MGA Zone 51 261648 **mE** 6961508**mN** 120.588385 **E** -27.449006 **S**
Habitat Crest, gentle sloping hill, top third of landform.
Soil Orange clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|--|--------------|---------------|
| Abutilon cryptopetalum | + | 0.1 |
| Acacia aff. doreta (G. Cockerton & S. Cockerton WB38633) | OUT | 3 |
| Acacia ayersiana (narrow phyllode form) | 6 | 4-5 |
| Acacia ayersiana (narrow phyllode form) | + | 0.2 |
| Acacia fuscaneura | 4 | 4-5 |
| Acacia quadrimarginea | OUT | 4-5 |
| Cheilanthes sieberi subsp. sieberi | + | 0.1 |
| Enneapogon caeruleus | + | 0.1 |
| Eremophila latrobei var. tuberculosa | + | 0.1 |
| Eremophila latrobei var. tuberculosa | 3 | 1.2 |
| Maireana georgei | + | 0.2 |
| Marsdenia australis | + | |
| Monachather paradoxus | + | 0.1 |
| Psyrax suaveolens | + | 0.3 |
| Psyrax suaveolens | + | 3 |
| Ptilotus obovatus (upright form) | OUT (1) | 0.8 |
| Ptilotus schwartzii | + | 0.4 |
| Santalum lanceolatum | + | 1.2 |
| Santalum lanceolatum | + | 0.2 |
| Sclerolaena densiflora | + | 0.1 |
| Sclerolaena eriacantha | + | 0.1 |
| Senna sp. Meekatharra (E. Bailey 1-26) | OUT | 1.2 |
| Sida ectogama | + | 0.8 |
| Sida sp. dark green fruits (S. van Leeuwen 2260) | + | 0.2 |
| Sida sp. Golden calyces glabrous (H.N. Foote 32) | + | 0.2 |
| Solanum lasiophyllum | + | 0.2 |

Site Photo

BHP - NW - MKS**Site** DP048 **Unit:** SIMS

Date 4/11/2016 **Type** Quadrat
MGA Zone 51 260504 **mE** 6963583 **mN** 120.577227 **E** -27.430089 **S**
Habitat Outcropping ridge, top third of landform.
Soil Clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|--|--------------|---------------|
| Abutilon cryptopetalum | + | 0.3 |
| Abutilon oxycarpum subsp. Prostrate (A.A. Mitchell PRP 1266) | + | 0.2 |
| Acacia ayersiana (narrow phyllode form) | + | 4 |
| Acacia craspedocarpa | OUT | 4-5 |
| Acacia craspedocarpa (hybrid) | + | 2 |
| Acacia fuscaneura | + | 0.2 |
| Acacia incurvaneura | 5 | 4-5 |
| Acacia tetragonophylla | OUT | 2 |
| Aristida contorta | 1 | 0.1 |
| Cheilanthes sieberi subsp. sieberi | + | 0.1 |
| Cymbopogon ambiguus | 1 | 0.3 |
| Dysphania rhadinostachya subsp. rhadinostachya | + | 0.1 |
| Enchylaena lanata | + | 0.2-0.6 |
| Enneapogon caeruleus | + | 0.2 |
| Eremophila granitica | + | 0.6 |
| Eremophila latrobei var. tuberculosa | + | 0.1 |
| Eremophila latrobei var. tuberculosa | 2 | 1.5 |
| Eriachne helmsii | 0.25 | 0.2 |
| Eriachne pulchella subsp. dominii | + | 0.05 |
| Euphorbia sp. | + | 0.05 |
| Hibiscus burtonii | + | 0.2 |
| Maireana tomentosa | 0.25 | 0.2 |
| Marsdenia australis | + | 0.3 |
| Monachather paradoxus | + | 0.2 |
| Paspalidium constrictum | + | 0.2 |
| Psydrax latifolia | 1 | 4 |
| Ptilotus nobilis | + | 0.2 |
| Ptilotus obovatus (typical Goldfields form) | 0.5 | 0.4-0.6 |
| Ptilotus roei | + | 0.1 |
| Ptilotus schwartzii | + | 0.3 |
| Rhagodia drummondii | + | 1.2 |
| Santalum lanceolatum | + | 0.6 |
| Santalum spicatum | 2 | 2-3 |
| Sclerolaena eriacantha | OUT | 0.1 |
| Senna artemisioides subsp. x artemisioides | + | 0.4 |
| Senna sp. Meekatharra (E. Bailey 1-26) | OUT | 1.5 |
| Sida ectogama | + | 1.3 |
| Sida sp. dark green fruits (S. van Leeuwen 2260) | + | 0.2 |
| Sida sp. Golden calyces glabrous (H.N. Foote 32) | 1 | 0.2 |
| Solanum cleistogamum | + | 0.2 |
| Solanum lasiophyllum | + | 0.3 |
| Wahlenbergia tumidifruca | + | 0.1 |

Site Photo



BHP - NW - MKS**Site** DP049 **Unit:** SIMS

Date 4/11/2016 **Type** Quadrat
MGA Zone 51 261177 **mE** 6962473 **mN** 120.583812 **E** -27.440219 **S**
Habitat Mid-upper slope, top third of landform.
Soil Orange clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|--|--------------|---------------|
| Abutilon cryptopetalum | + | 0.2 |
| Acacia fuscaneura | + | 0.05 |
| Acacia fuscaneura | 4 | 4-5 |
| Acacia pruinocarpa | 0.5 | 2.5 |
| Acacia tetragonophylla | 0.25 | 2.5 |
| Aristida contorta | + | 0.1 |
| Cheilanthes sieberi subsp. sieberi | + | 0.1 |
| Dodonaea rigida | OUT | 0.8 |
| Enchylaena lanata | + | 0.2 |
| Eremophila granitica | OUT | 0.6 |
| Eremophila latrobei subsp. glabra | OUT | 1.0 |
| Eremophila latrobei var. tuberculosa | + | 1.2 |
| Maireana georgei | + | 0.3 |
| Maireana triptera | + | 0.2 |
| Marsdenia australis | + | 0.1 |
| Monachather paradoxus | + | 0.2 |
| Ptilotus helipteroides | + | 0.2 |
| Ptilotus nobilis | + | 0.4 |
| Ptilotus obovatus (typical Goldfields form) | + | 0.3 |
| Ptilotus obovatus (upright form) | .5 | 0.8 |
| Ptilotus schwartzii | OUT | 0.3 |
| Scaevola spinescens (narrow leaf, spiny form) | 1 | 1.2 |
| Sclerolaena eriacantha | + | 0.1 |
| Senna artemisioides subsp. helmsii | + | 1.0 |
| Senna artemisioides subsp. x artemisioides | + | 0.6 |
| Senna sp. Meekatharra (E. Bailey 1-26) | 1 | 1.2 |
| Sida ectogama | OUT | 0.8 |
| Sida sp. dark green fruits (S. van Leeuwen 2260) | + | 0.2 |
| Sida sp. Golden calyces glabrous (H.N. Foote 32) | + | 0.1 |
| Solanum lasiophyllum | + | 0.6 |

Site Photo

BHP - NW - MKS**Site** DP050**Unit:** SIMS

Date 5/11/2016 **Type** Quadrat
MGA Zone 51 261084 **mE** 6962443 **mN** 120.582866 **E** -27.440473 **S**
Habitat Crest of hill, top third of landform.
Soil Orange clay loam, firm, surface crust.
Veg Condition Pristine

SPECIES LIST:

| Name | Cover | Height |
|--|--------------|---------------|
| Abutilon cryptopetalum | + | 0.1 |
| Acacia ayersiana (narrow phyllode form) | 4 | 4-5 |
| Acacia ayersiana (narrow phyllode form) | + | 0.7 |
| Acacia fuscaneura | 0.5 | 2-3 |
| Acacia fuscaneura | + | 0.4 |
| Acacia pruinocarpa | + | 0.4 |
| Acacia pruinocarpa | OUT | 8-10 |
| Aristida contorta | + | 0.1 |
| Cheilanthes sieberi subsp. sieberi | + | 0.1 |
| Enchylaena lanata | OUT | 0.4 |
| Enneapogon caeruleus | + | 0.2 |
| Eremophila galeata | + | 0.1 |
| Eremophila latrobei var. tuberculosa | 1 | 0.6 |
| Eriachne helmsii | OUT | 0.3 |
| Maireana georgei | + | 0.1 |
| Marsdenia australis | + | 0.1 |
| Monachather paradoxus | + | 0.1 |
| Ptilotus nobilis | OUT | 0.1 |
| Ptilotus obovatus (upright form) | + | 0.8 |
| Ptilotus roei | + | 0.05 |
| Ptilotus schwartzii | + | 0.4 |
| Rhagodia drummondii | OUT | 0.6 |
| Salsola australis | OUT | 0.1 |
| Scaevola spinescens (narrow leaf, spiny form) | OUT | 0.2 |
| Sclerolaena densiflora | + | 0.1 |
| Sclerolaena eriacantha | + | 0.1 |
| Senna artemisioides subsp. x artemisioides | + | 0.1 |
| Senna artemisioides subsp. x artemisioides | + | 0.6 |
| Senna artemisioides subsp. x artemisioides | OUT | 0.5 |
| Senna sp. Meekatharra (E. Bailey 1-26) | OUT | 0.6 |
| Sida sp. dark green fruits (S. van Leeuwen 2260) | + | 0.1 |
| Solanum cleistogamum | OUT | 0.1 |
| Solanum lasiophyllum | + | 0.3 |
| Spartothamnella teucriflora | + | 0.5 |