Jack Hills Iron Ore Project Area:
Auditing of the Conflicting Vegetation Classifications and Vegetation Mapping of Plant Communities in Reports by Mattiske Consulting (2006) and *ecologia* Environment (2009)

Prepared by

Professor Ladislav Mucina
Department of Environmental and Aquatic Sciences
School of Agriculture & Environment
Curtin University of Technology, GPO BoxU1987
Perth, WA 6845, Australia

Prepared for

Crosslands Resources Ltd
P.O. Box 1454, West Perth, WA 6872, Australia

FINAL VERSION
Perth, 18 September 2009

Table of Contents

Appendix 1: Comparative analysis of the procedures and results of the vegetation survey, vegetation classification, and vegetation mapping in reports by Mattiske Consulting (2006) and *ecologia* Environment (2009).

1. Motivation & Terms of Reference

The aim of this document is to review two consultancy reports on flora and vegetation assessment in the locality Jack Hills (140 km WNW of Meekatharra) in relation to the proposal of Crosslands Resources Ltd (CRL) to develop the Stage 2 Jack Hills Mine Expansion.

The problem (Dr Lara Jeffeson, pers. comm.) pertains to two conflicting vegetation classifications and vegetation maps of the area prepared by Mattiske Consulting (2006) and by *ecologia* Environment (2009).

This document features my expert opinion about the validity of procedures, plausibility of analyses and conclusions of these two, largely independent reports on the vegetation patterns (survey, classification, and mapping) of the planned Stage 2 Jack Hills Mine Expansion.

The Mattiske Consulting (2006) and *ecologia* Environment (2009) report also present the results of flora surveys (list of collected species and issues related to their geographic distribution, rarity and conservation status). This review is not primarily intended to scrutinize the flora-related parts of the reports.

2. Available Documents

The following documents and data have been provided to me by Dr. L. Jefferson:

i) Report by Mattiske Consulting Pty Ltd (Perth) entitled “Flora and vegetation of the Jack Hills Project Area”, issued in December 2005 for Murchison Metals Ltd. This report is part of an Environmental Protection Statement entitled “Jack Hills Iron Ore Project, Murchinson Region, Western Australia. Volume 3: Supporting Documentation”, prepared by Martinick Bosch Sell Pty Ltd (MBS) in May 2006 for Murchinson Metals Ltd.

ii) Report by *ecologia* Environment (Perth) entitled “Jack Hills Stage 2. Flora and vegetation assessment”, issued in April 2009 for Crossland Resources Ltd. The version of this report in my hands carries the status of “Draft”.

iii) PDF file of the paper: Meissner, R. & Caruso, Y. 2008. Flora and vegetation of banded iron formations of the Yilgarn Craton: Jack Hills. *Conservation Science Western Australia* 7(1): 89-103.

I have not had access to the report or data generated by MBS (2005). I have also not seen the original raw data generated by Mattiske Consulting (2006).

3. Auditing Report

3.1 Auditing Procedures

I have undertaken the following steps to approach the problem:

1) Studied and compared (see Appendix 1 for comparative summary), in detail the procedures, presented results and recommendations of both reports (Mattiske Consulting 2006 and *ecologia* Environment 2009).

2) Studied the paper by Meissner & Caruso (2008) and related sources (Section 5: References) pertaining to the flora and vegetation of the Eremean Region of Australia.

3) Compared the procedures pertaining to (a) vegetation survey methods and data quality, (b) vegetation classification procedures and results, and (c) construction of vegetation maps in the light of the compliance of the reports to the recommendations of the Environmental Protection Authority Guidance No. 51 (EPA 2004) as well as to the current level of theory and methodology of vegetation survey, classification and mapping. These three items are handled in detail (Section 5.2).

4) Analysed and discussed the reports in a synoptic way (Section 3.2).

5) Made recommendations to resolve the problem (Section 4).

3.2 Auditing Analysis

3.2.1 Vegetation Survey Methods and Data Quality

Three potential sources of problems relating to the collected (vegetation) data, which cannot really be blamed on either consultancy group, are:

(1) the failure to collect information on vegetation layering;
(2) the collection of data on occurrence of annual species; and
(3) the collection of presence/absence data instead of (semi)quantitative abundance or cover estimates.

Ad 1): EPA Guidance Statement No. 51 does not require use of vertical layering of vegetation samples (meaning: record of each species in a plot in particular, a priori defined vegetation layers; see Mucina et al. 2000 for the common standards for vegetation sampling used in Europe). The vegetation layering is an important source of information (adding new parameters to a vegetation data set) especially in regions having low alpha-diversity (number of species per plot or per habitat-level-defined vegetation patch).

Ad 2): There is a common belief among vegetation scientists that in highly dynamic environments the patterns of occurrence and associated quantitative phenomena such as "unpredictable" appearance and very variable abundance, in annual species are variables which cannot be used to classify and/or characterise vegetation types. In fact, we can view the temporarily occurring *synusia* (*sensu* Barkman 1973) as communities of their own right or a characteristic/typical component of more complex plant communities. These synusial communities carry important ecological and biogeographical message. They are as important as the perennial synusia within complex plant communities. There is, therefore no plausible reason to leave them out of the sampling or the analyses. Disregarding annual species at the data analytical stage of the project can be, however, justified when for instance two data sets (one with annuals and one without) are to be jointly analysed. In this instance the EPA Guidance Statement No. 51 (Section 3.3.2) is too permitting.

Ad 3): Robustness of vegetation data analyses depends on many factors, but those related to sampling are of particular importance. Specifically, the decision is crucial if to sample using presence/absence scale or to use some conventional semi-quantitative cover and/or abundance estimates (see van der Maarel 1979, Knapp 1984, Londo 1984 for details and handling of those sampling scales) or to use quantitative sampling (usually limited to counting of plant individuals, estimating biomass and/or measuring some parameters such as DBH and basal area). In species-poor data sets (representing regions characterised by low gamma diversity), the data analyses (especially classification/clustering) would perform in a suboptimal way due to general lack of variables and differentiation power carried by those variables. In other words: species-poor communities in arid lands will be difficult to differentiate on the basis of species presence or absence alone. A good example is documented by Table 1 in Meissner & Caruso (2008): one were very few species (mainly from Species Group H) show exclusive link to a community type (it appears that the Community Type 6 is the best defined one). Dominance plays a major role in community structuring and functioning and plays an equally important role in differentiating communities in any vegetation classification system featuring species-poor vegetation.

In summary: Using presence/absence sampling would probably do in communities scoring high species richness (such as kwongan shrublands), but sampling in species-poor arid environments requires at least semi-quantitative sampling.

3.2.2 Vegetation Classification Procedures and Results

Mattiske Consulting (2006) Report

The authors of the Mattiske Consulting (2006) report not only failed to explain the choice of the resemblance and the clustering technique. They failed also to interpret the dendrogram plausibly.

In particular:

(1) They present two dendrograms (both using Bray-Curtis/WPGMA) showing slightly different patterns, but do not explain why they use these two dendrograms and why they are different despite the same analytical parameters.

(2) Neither of the two dendrograms "recovered" or supported the classification of the sampled vegetation in 18 communities. In order to be able to identify clusters, one has to translate the hierarchical structure of a dendrogram into a non-hierarchical one. In some special cases some clusters appear to be clearly defined (without having implementing a formalised dendrogram-splitting analysis; see Popma et al. 1981). If the 18 communities would be recovered by the clustering, then one would expect compact clusters (identifiable by the community codes) in the dendrogram. There is no single community (of all 18) which would form such a compact cluster. The level of "mix-up" is very high – a fact which can be tested (and proved) readily by a formalised technique developed for this purpose (e.g. Feoli & Lagonegro 1979, Feoli & Ganis 1985).

(3) The statement that those communities *"…that are scattered through the dendrogram…are in part a reflection of the lower sampling regimes*" (possibly meaning: low number of plots per community) is groundless since ALL the communities are actually scattered through the dendrogram! Further, the authors do not offer any quantitative proof for this assumption.

The authors of the Mattiske Consulting (2006) report did not demonstrate why they would prefer to choose a particular multivariate technique and in particular – choose Bray-Curtis resemblance and WPGMA as the clustering technique. I appreciate that such choices (accompanied by lack of information to justify them) have been appearing even in some scientific papers, however it still remains to be considered a bad practice. There are hundreds of resemblance and a great number of clustering techniques available (see for instance Ludwig & Reynolds 1988, Legendre & Legendre 1998, McCune & Mefford 1999, Podani 2000, 2001, Podani & Miklós 2002, Lepš & Šmilauer 2003 etc.). The choice of resemblance and the classification (clustering) technique is not trivial; it is critical since any combination of these can produce very different classification results. This choice should be lead by the knowledge of the nature of the variable involved, heterogeneity of the data set, intrinsic transformation and space-distorting properties of particular clustering techniques and many other non-trivial considerations. A combination of Bray-Curtin/WPGMA is NOT a universal data-analytical strategy. If it proved to be informative (successful) for one analytical problem, it can fail for another.

I suggest that the source of these inconsistencies, such as missing information on reasons of choice of a particular numerical analysis or way of interpreting the dendrograms, also reflect the lack of specificity of the EPA Guidance Statement

No. 51. The Guidance suggests (Section 3.3.2 of the Guidance Statement) use of “a form of multivariate analysis” and sets the use of “presence/absence data and perennial species” minimum data standards. These statements are not useful and in cases can even be contra-productive, especially in cases where there sampled vegetation shows low species diversity or the use of presence/absence data is not appropriate for powerful multivariate analysis (be it classification or ordination).

Ecologia Environment (2009) Report

The communities are named and characterised obviously following the recommendations of National Vegetation Information System (NVIS) framework (Executive Steering Committee for Australian Vegetation Information 2003). This standard form is basically fine for structurally-derived vegetation units, however does not provide much latitude for clear floristic differentiation of the units (i.e. information on how Community A is different from Community B). The descriptions of the communities (see Table 4.6) are extensive, but not helpful in identification (and differentiation) of the units, especially in absence of ordered sites x species table. (The sites x species table in Appendix F is not structured, except for species being ordered alphabetically.) The ordered site x species table is a wide-spread tool of presenting vegetation classification (see for instance widely used textbooks by Mueller-Dombois 1974, Kent & Coker 1992) and series of well-known software packages were developed to serve the purpose of the table-sorting (e.g. TWINSPAN by Hill 1973 and Lepš & Šmilauer 2003; JUICE by Tichý 2002).
In summary: The presented data and the descriptions of the communities and sub-communities do not assist in a unequivocal and informative decision about the identity of the communities and sub-communities.

The dendrogram on page 21 obviously serves only for decorative purposes. From the caption it is not clear which clustering technique was used (SYSTAT is a software package) and which resemblance was used. The use of colours should emphasize continuous character of the data (the colour fuse into each other in a gradual way) which actually does not match the philosophy of this kind of clustering which produces crisp (not fuzzy!) clusters. It is likely that the authors did not know how to present the classification (how to decide on which cluster is which and what they mean). Small script used in designating the identity of each plot involved in the clustering is virtually unreadable, hence does not help the reader either. The authors mentioned in the text (page ix) that the *“data matrix detailing the presence/absence of species and their abundance in the quadrates was analysed using multivariate statistical methods”*. Why then is only one result (one analysis) presented? It is also not clear if the data were used to create the dendrogram (page 21).
In summary: After having inspected the dendrogram the reader cannot make a call on how the clusters in the dendrogram fit the classification into the communities and sub-communities.

3.2.3 Construction of Vegetation Maps

There are two major objections (pertaining to both reports) which are very serious and basically invalidate the use of the mapping products:

1. The link between the results of vegetation classification (scheme of vegetation units – communities and sub-communities) and mapping these (showing their spatial position and extent) was not made by either of the reports. The statement made by *ecologia* Environment (2009) on page ix that *"Mapping to sub-community level was not always possible as the distinctions in vegetation composition visible at ground level and produced by the multivariate analysis could not be reliably discriminated on the aerial photography."* is quite fair, but it is also a clear witness to the failure to establish this vital link and translate the vegetation units defined by vegetation classification (clustering or otherwise) to the vegetation mapping unit.

2. There is a large gap in our vegetation analytical toolbox: the **absence of clear vegetation mapping procedures and evaluation criteria**. EPA Guidance No. 51 is very silent about the preferred or standard vegetation mapping methodology. It appears, therefore, as more than appropriate to be more explicit about the steps involved in definition of mapping units and their recognition using available remote-sensed or geographic proxy data. Both reports failed to provide convincing detail which would allow judgement about the plausibility of the vegetation mapping process. Vague statements such as "*The interpretation of the key mapping units was also based on the proportion of different species in different communities and the interpretation of the aerial photographs.*" (Mattiske Consulting 2006, p. 10) or "*To delineate plant community associations in the study area, a combination of ground-truthing and cluster analysis was employed.*" (*ecologia* Environment 2009, p. 18) are not helpful.

4. Summary of Recommendations

4.1. Vegetation Sampling Quality

Semi-quantitative sampling using estimation scales of % cover should be the preferred practise especially in species-poor vegetation samples. All species (perennial and annual) should be recorded. Modifications to these standards produce data sets which are not readily commensurable. If there are various data sets that are to be used in one analysis, then the absolutely minimum standard (presence/absence of perennial species, without any split into vertical layers – one could call them "absolutely flattened data") is often a very poor reflection of the vegetation texture and structure.

The authors of both reports followed the comfortable minimum sampling standards of the EPA Guidance Statement No. 51. However the nature of the sampled Jack Hill area (low species diversity, multilayer structure) is asking for more profound judgement about the level of sampling detail. It is unfortunate that the vegetation layering is hardly considered in vegetation sampling and if it was, then this information has not been used in the data-analyses.

In summary, however, the vegetation data sampled are of acceptable quality and when all data are combined is also of reasonable extent.

4.2. Vegetation Classification & Community Description

Both reports failed to convince me that the classification of the vegetation and the definition of their vegetation types (communities) are trustworthy. They do contain an element of plausibility (link between vegetation type and habitat), however the differentiation on the sub-community level in particular (Mattiske Consulting 2006 report) is not justified convincingly. It is therefore impossible to state if the Community T3 is an ecologically (and/or biogeographically) recognizable vegetation type. Perhaps the most convincing community classification of data from the project area is presented by Meissner & Caruso (2008) albeit based only on presence/absence data, but using formalised INDVAL analysis (Dufrene & Legendre 1997) of species/site relationships. This paper suggests existence of only one (reasonable well-defined) *Triodia* community. A disadvantage of the latter paper is the limited data set (50 plots) while other plots were available for more convincing analysis.

Suggestion: According to the Guidance Statement No. 51 (Section 3.2.6) the consultants were supposed to take into consideration "information on adjacent areas, including herbarium records and previous surveys". It is unfortunate that *ecologia* Environment did not consider Mattiske Consulting's and Meissner & Caruso's data. Such analysis should include ALL available data sets (counting in fact 367 plots!), use presence/absence data (since some sets were collected only in this scale), and carefully select numerical-classification tools (incl. post-analysis evaluation of species/community relationships using INDVAL) in order to (1) present a new, robust classification, and (2) to clarify the status of the contentious Mattiske's T3 Community.

4.3 Vegetation Mapping

I do not find the other statement made by *ecologia* Environment (2009) on this topic (p. 18, par. 1) that a "combination of ground-truthing and cluster analysis was employed" satisfactory or trustworthy. Firstly a question arises how the cluster analysis was supposed to be used when there was no decision made on the identity of the clusters in hierarchic manner presented in the dendrogram on page 18). Secondly, how that "combination" was actually executed was not specified.

Suggestion: The re-analysis of the field data will produce a new classification scheme into communities (and sub-communities if found appropriate). This new scheme can be quite close to one of the existing classifications, however, revisiting the identity of mapped patches on the available maps is imperative. This review must follow clear (be it only ad hoc) criteria clearly guiding the process of the *translation of the new vegetation classification onto a new map*.

5. References

Barkman, J.J. 1973. Synusial approaches to classification. In: Whittaker, R.H. (ed.), *Ordination and classification of communities.* pp. 435-491. Dr. W. Junk, The Hague.

Dufrene, M. & Legendre, P. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* 67: 345-367.

***ecologia* Environment 2009.** *Jack Hills Stage 2. Flora and vegetation assessment.* Draft report prepared for Crossland Resources Ltd.

EPA (Environmental Protection Authority) 2004. *Guidance of the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986). Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. No. 51.* The Government of Western Australia, Perth.

Feoli, E. & Ganis, P. 1985. Comparison of floristic vegetation types by multiway contingency tables. *Abstracta Botanica* 9: 1-15.

Feoli, E. & Lagonegro, M. 1979. Intersection analysis in phytosociology: computer program and application. *Vegetatio* 40: 55-59.

Hill, M. O. 1979. *TWINSPAN - A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of individuals and attributes.* Ecology & Systematics, Cornell University, Ithaca, NY.

Kent, M. & Coker, P. 1992. Vegetation description: A practical approach. J. Wiley & Sons, Chichester.

Knapp, R. 1984. Sample (relevé) areas (distribution, homogeneity, size, shape) and plot-less sampling. In: Knapp, R. (ed.), *Sampling methods and taxon analysis in vegetation science*. pp. 101-119. Dr. W. Junk, The Hague.

Legendre, P. & Legendre, L. 1998. *Numerical ecology.* 2nd ed. Elsevier, Amsterdam.

Lepš, J. & Šmilauer, P. 2003. *Multivariate analysis of ecological data using CANOCO.* Cambridge Univ. Press, Cambridge.

Londo, G. 1984. The decimal scale for relevés of permanent quadrats. In: Knapp, R. (ed.), *Sampling methods and taxon analysis in vegetation science*. pp. 45-49. Dr. W. Junk, The Hague.

Ludwig, J.A. & Reynolds, J.F. 1988. *Statistical ecology.* Wiley Interscience, New York.

Mattiske Consulting 2006. *Flora and vegetation of the Jack Hills Project Area. In: MBS Environmental 2006: Environmental Protection Statement Jack Hills Iron Ore Project, Murchinson Region, Western Australia. Volume 3: Supporting Documentation.* Report prepared for Murchinson Metals Ltd.

MBS Environmental 2005. *Jack Hills Iron Ore Project. Murchison Region, Western Australia: Vegetation and Fauna Assessment.* Report prepared for Murchison Metals Ltd.

McCune, B. & Mefford, M.J. 1999. *PC-ORD. Multivariate analysis of ecological data. Version 4.0.* MjM Software Design, Gleneden Beach, OR.

Meissner, R. & Caruso, Y. 2008. Flora and vegetation of banded iron formations of the Yilgarn Craton: Jack Hills. *Conservation Science Western Australia* 7(1): 89-103.

Mucina, L., Schaminée, J.H.J. & Rodwell, J.S. 2000. Common data standards for recording relevés in field survey for vegetation classification. *Journal of Vegetation Science* 11: 769-772.

Mueller-Dombois, D. & Ellenberg, H. 1974. *Aims and methods of vegetation ecology.* J. Wiley & Sons, New York.

Podani, J. 2000. *Introduction to the exploration of multivariate biological data.* Backhuys, Leiden.

Podani, J. 2001. *SYN-TAX 2000. Computer programs for data analysis in ecology and systematics. User's manual.* Scientia Publishing, Budapest.

Podani, J. & Miklós, I. 2002. Resemblance coefficients and the horseshoe effect in principal coordinate analysis. *Ecology* 83: 3331-3343.

Popma, J., Mucina, L., van Tongeren, O. & van der Maarel, E. 1983. On the determination of optimal levels in phytosociological classification. *Vegetatio* 52: 65-75.

Tichý, L. 2002. JUICE, software for vegetation classification. *Journal of Vegetation Science* 13: 451-453.

van der Maarel, E. 1979. Transformation of cover-abundance values in phytosociology and its effects on community similarity. *Vegetatio* 39: 97-114.

Appendix 1: Comparative analysis of the procedures and results of the vegetation survey, vegetation classification, and vegetation mapping in reports by Mattiske Consulting (2006) and *ecologia* Environment (2009). The text highlighted in red are the reviewer's comments.

	Mattiske Consulting	*ecologia* Environment
A. VEGETATION SAMPLING		
1. Sampling campaigns	October 2004 (MBS), June 2005 (MBS), October 2005 (Mattiske Consulting)	Two-phase sampling (winter: June 2006 & spring: September 2007)
2. Mode of plot selection	"Representative areas" selected for sampling. It is a major omission not to present information on the criteria of representativeness.	Sites selected from aerial photography; sites assessed based on their representation on different landforms (see tab. S1.1). "Number of sites established was determined by the heterogeneity of the area." Ecosystem diversity was assessed using species area curves (see Section 4.6.3). The use of the rarefaction for judging the sampling adequacy of flora is quite acceptable however this method does not necessarily reflect the complexity of vegetation.
3. Number of plots	122 (geo-referenced and mapped) including: 18 (MBS) and 100 Jack Hills and 2 & 2 Mt Gould & Robinson, resp. (Mattiske); "additional sites were established on Mt Gould in December 2005" (p. 13, par. 3)	195 own plots (104 plots in Phase 1, 91 new sites + 59 repeat sites in Phase 2)
4. Size of plots	This information was not explicitly given in the report. I consider this a major omission since the plot size determines if the data can be used in further analyses, and because of the well-known link between the plot size and species diversity.	20 x 20 m; quadrat size was selected to allow comparison of the data previously collected by DEC (report by Meissner & Caruso 2008, later published).

5. Sampling scale (+/-, quantitative)	Presence-absence data were collected due to time constraints (see p. 7, last par.); It was not mentioned which sampling scale was used in the MBS 2004 and 2005 collections.	The authors failed to provide explicit information (in the body of the report) on the nature of the sampling scale. The data in Appendix F (sites x species matrix) make it clear that a (semi)quantitative scale was used in sampling. However it is not clear (has not been reported by the authors) which scale was used.
6. Vegetation layering	No vegetation layers (tree, shrub, herb layers) recognised in the course of vegetation sampling	Life-form strata were recognised following the procedures of the National Vegetation Information System.
7. Floristic completeness	Annual plants were collected on each sampling trip.	Annual plants obviously collected (the site x species matrix contains some).
8. Plant identification effort	Plants identified by comparison with herbarium material; specialists consulted; according to own information, the historical collections were not confirmed by Mattiske Consulting;	Voucher specimens were identified using current literature and WA Herbarium collections.
9. Geographic position (documentation)	Data provided	Data provided
10. Topographic data	Data on several of environmental parameters were collected (see page 7).	Data on several of environmental parameters were collected (see page 17).
11. Soil sampling & analyses	Only a few parameters were sampled: soil ratio (not clear what is meant by this term), outcropping rocks and their type, pebble type and size	Information on p. 17 states that *soil* was recorded as parameter, however it is not clear which particular soil characteristics were recorded.
12. Climate data	No microclimate data were collected	No microclimate data were collected
13. Vegetation status & condition	Informally discussed (pages 12-13);	vegetation status was ascertained in each of the plots, but nature (or agent) of disturbance not listed
14. Additional sampling in neighbourhood areas	Mt Gould & Robinson ranges (4 plots)	Not done
B. VEGETATION DATA ANALYSIS		

1. Incorporation of existing data-sets from the same (or close) area	Spring-months data by MBS incorporated (see p. 5, par. 1) into analyses; It is not clear if June 2005 (MBS) data were incorporated.	DEC surveys carried out at a number of BIF ranges of the Yilgarn Craton were available to the authors (see Tab. S.1). If the plot size was adjusted according to Meissner & Caruso (2008), then it is not clear why the Meissner & Caruso's data were not used in their analyses. Further it is not clear how the DEC's (2005) data were "compared" (see p. 18, par. 2).
2. Data collation (transformations, data masking etc.)	No information available (not clear if the earlier MBS data were quantitative and then "flattened" into presence-absence scale); it is not clear if the annuals were used in the analyses.	It is not clear what role was played by the 59 repeated samples (Phase 2) in the analysis. If they were not used, then why had they been collected? Since we do not know which sampling scale was used the information given in the electronic Appendix F ("For the purposes of statistical analysis, plant cover of N = 0.1" remains unclear (we do not know what N means.)
3. Incorporation of non-vegetation (topography, substrate, disturbance) data in numerical analyses	It does not appear that data on topography, % litter, soil ratio, % bare ground, outcropping rocks and their type, pebble type and size, ground disturbance were incorporated into numerical analyses of the data.	There were some environmental parameters (for the list see p. 17) recorded, but it does not appear that they were used in formal numerical analyses. Many of them were also not used in characterization and differentiation of the vegetation units.
4. Choice of resemblance in classification	Bray-Curtis resemblance; Reasons for this choice were not explained.	Not explicitly stated, but the notion of "Pearson complete linkage analysis (p. 18, par. 4) indicates that it might have been Pearson's correlations coefficient. Reasons for this choice were not explained.
5. Choice of clustering (or divisive) technique in classification	WPGMA; Reasons for this choice were not explained.	Complete linkage clustering to analyse own data; Reasons for this choice were not explained.
6. Choice of type of ordination (gradient) analyses	Not performed	Not performed
7. Choice of resemblance in ordinations (or gradient analyses)	Not performed	Not performed
8. Numerical analysis of species importance	Not performed	Not performed
9. Analysis of clusters (comparisons with existing classifications)	Not performed	Not performed

10. Numerical corroboration of vegetation-environmental patterns	Not performed	Not performed
C. VEGETATION CLASSIFICATION		
1. Nature of classification variables	Presence-absence data; However not explicitly informed if annual taxa had been used in the analyses.	Presence/absence data as well as "abundance"; The meaning of "abundance' is not clear as it refers to counts of individuals which were not done.
2. Presentation of classification results: dendrogram	Dendrograms are presented in Appendix D1 and D2; It is not clear why two dendrograms are presented (when text is mentioning only one) and why they differ when in both cases they are the result of WPGMA with Bray-Curtis; the interpretation of the numerical classification patterns (see p. 10, section 5.5, par. 2) does not reflect the patterns showed by the dendrogram. When considering (for instance) the dendrogram in Appendix D1, there is no notable match between the identity of the 18 communities and the potential clusters. In other words: the clustering did NOT recover the classification into 18 communities which allows a question to arise: on which basis were these 18 communities actually derived? The abbreviations in the first identification column (AB, CP, WDU etc.) are not explained.	Dendrogram is presented on p. 21 (Fig. 3.2) without much information in caption. The dendrogram in this shape is useless as it does not offer any insight into how the hierarchical structure was translated into crisp clusters (cutting levels and reasons for them). The use of colour grading into each other is indicative of the fact that the authors did not know what to do with the dendrogram (in particular how to interpret it). The format of the figure makes it impossible to match the classification pattern with the descriptions of the communities (sub-communities).
3. Presentation of classification results: structured species x site table	Not performed or presented	Not performed or presented
4. Number of communities/sub-communities recognised	18 communities	6 main communities, incorporating 18 sub-communities; The difference between community and sub-community is not defined here (no criteria of delimitation of sub-communities were cited).

5. Interpretation of vegetation patterns: floristic differentiation	The floristic differentiation is not supported either by dendrogram or structured site x species table (missing). The statement that "spinifex communities on the Robinson range are different from those on the Jack Hills and Mt Gould ironstone areas" is hardly tenable since the sampling on Robinson Range was only tentative (2 plots).	The floristic differentiation is not supported either by the dendrogram or structured site x species table (missing). I wonder why sub-community D2 has not been joined into one community together with S1 and S2 as all 3 units have *A. citrinoviridis* as the dominating species.
5. Interpretation of vegetation patterns: ecological differentiation	The (groups of) communities match major habitats; However for some groups of communities (C1 & C3 – both in major flow-lines; (M1, M2 & A1 – all on plains & flats; A3 & A5 – both on quartz and gravel flats; T1-T4 – all on upper slopes; P1-P2 – both on shallow gravelly slopes the ecological differentiation was not clearly articulated; this practice is hardly acceptable.	The authors claim (see Table 2.3), that there are 11 landform units found in the survey area. However, only 6 main communities (18 sub-communities) were recognised which suggests that there is no direct match between the number of landforms and vegetation units. This is fine, but no attempt was made to differentiate the communities in ecological terms (be it in relation to landforms, or soils, or other environmental parameters – for a list of those see p. 17).
6. Conservation issues	None of the communities listed as TEC, however the community T3 seems to be limited to Jack Hills while T1 and T2 were also found on Mt Gould. It is not clear, however, how T3 differs floristically and ecologically from T1 & T2; the statement "T3 community differs from T1 and T2 in the proportion of the species present in the respective communities" is not specific enough. The authors of this report are more specific on page 14 (section 6.4, par. 1), however it remains unclear what do the discussed floristic differences between T3 and the other T communities mean in an ecological and/or phytogeographic sense.	Database searches did not reveal any of the communities occurring at Jack Hills to be listed as threatened (see p. xi).
7. Large-scale comparisons	Small data sets from Mt Gould & Robinson Range were considered.	Authors were aware of previous surveys in the region (see Section 2.4, page 14).

D. VEGETATION MAPPING TOOLS		
1. Choice of mapping scale	Not discussed	1:15 000 (see p. ix)
2. Choice of mapping precision	Not discussed	Not discussed
3. Linking classification patterns and mapping	It is not clear how 18 communities and the mapping units (see Fig. 9 – VEGETATION) were matched.	On basis of the statement on p. ix (par. 1 in the section Vegetation) the match between the classification and the mapping units was not fully established.
4. Use of remote-sensing tools	Aerial photography was used; However it does not explain what the nature (and resolution) of photography was used. It equally did not explain in any detail how this tool was used in the mapping procedure.	Aerial photography was used; However it does not explain what the nature (and resolution) of photography was used. It equally did not explain in any detail how this tool was used in the mapping procedure.
5. Use of ground-truthing tools	No information was given whether any ground-truthing was performed *a posteriori* (after having constructed the preliminary versions of the vegetation map)	Ground-thruthing is mentioned (p. 18)
6. Methods of vegetation patch definition	Not discussed	Not discussed
7. Methods of land-unit definition	Land-systems of Currie et al. (1994) as well as previous work of MBS (2005) defining "landscape units" are mentioned; It is not clear how this information has not been used in mapping.	Landforms and land systems of the area are discussed; It is not clear how this information was derived.
8. Linking land-unit and vegetation patch patterns	Not attempted	Not attempted