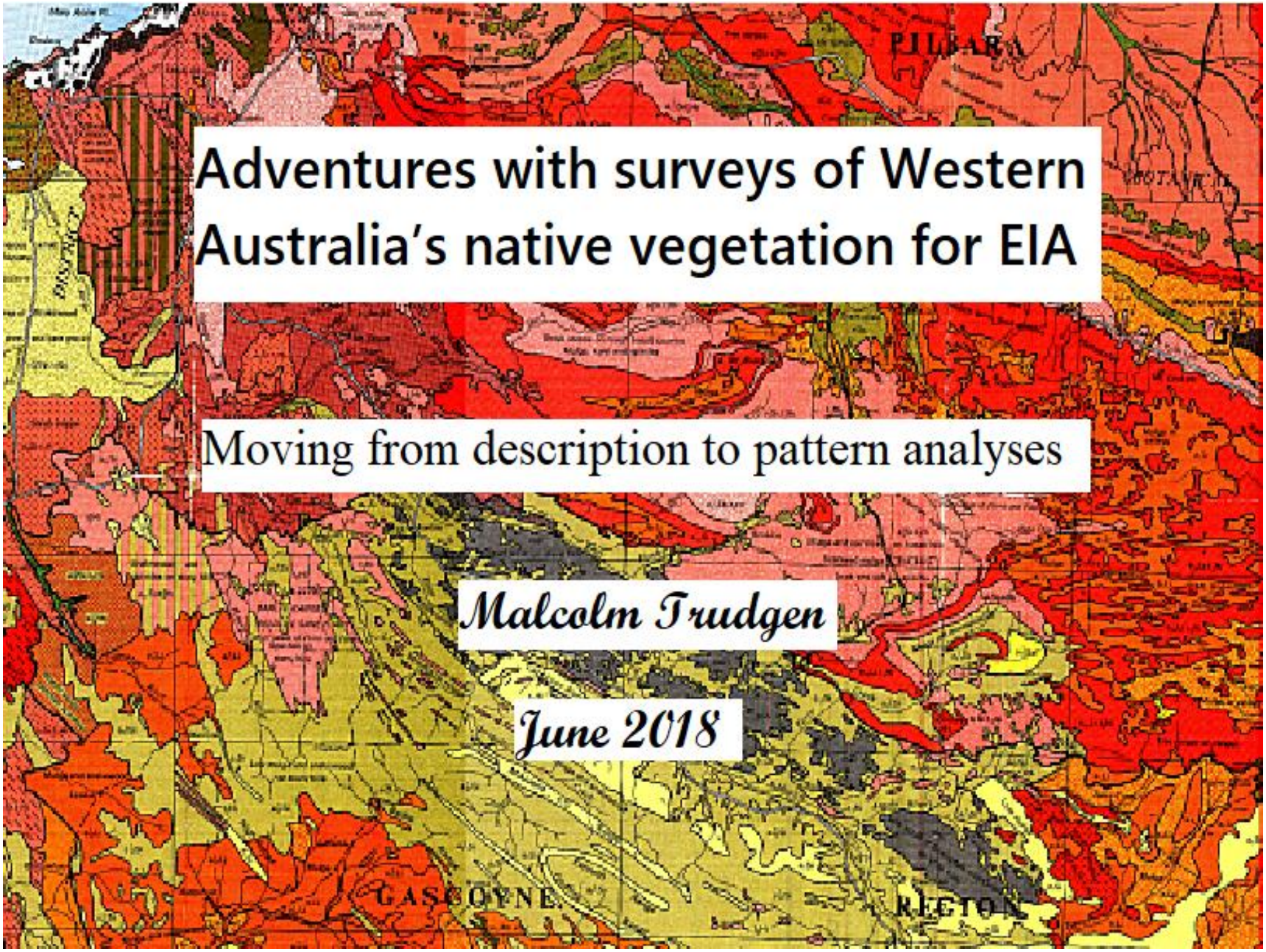
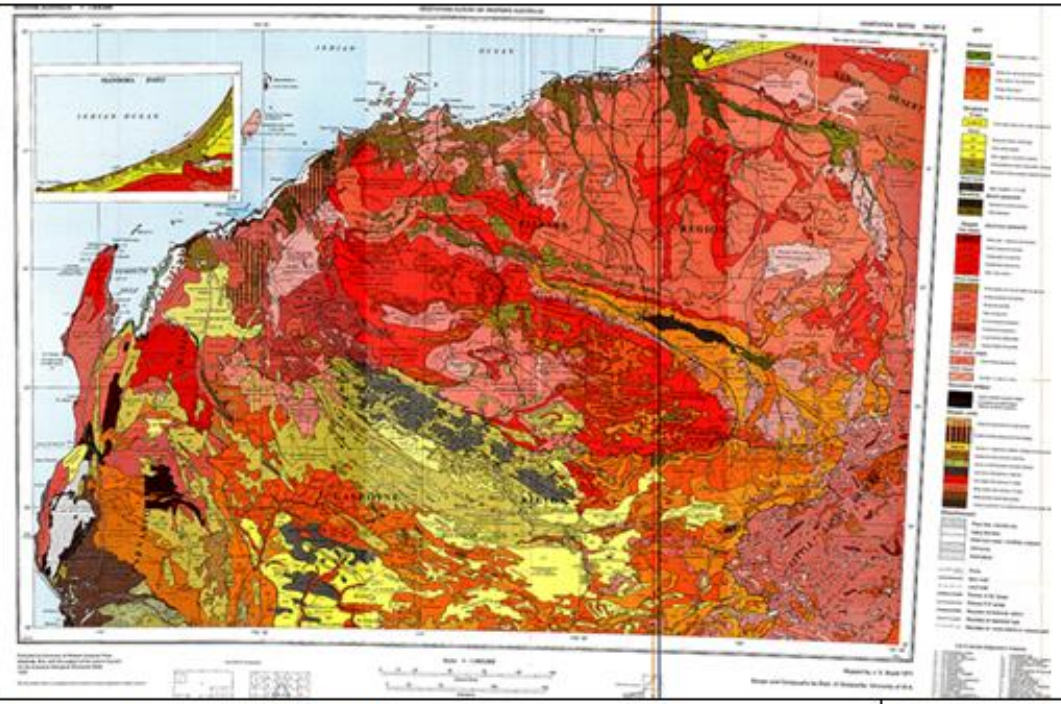


Adventures with surveys of Western Australia's native vegetation for EIA

Moving from description to pattern analyses

Malcolm Trudgen

June 2018



Coverage: context.

Coverage: it exists

Misuse, it is used for things it was never suitable for:

- EIA (except context)
- Land clearing assessments.

Why Beard's Pilbara map as the backdrop for the title slide?	It's an important overview, for some purposes. Adventure?

So, what is the issue? What level are his units? What do they measure?

They are vegetation complexes, with simplified descriptions, with frequently out of date or other broad taxonomy.

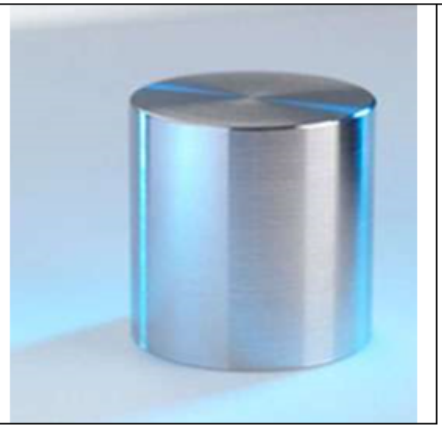
Using Beard's maps or land systems, you can go through a process, but it is not likely to mean much. So, our problem is what is a real process?

So, we have a measurement issue:

Measure:

1. Ascertain the size, amount, or degree of (something) by using an instrument or device marked in standard units.

2. Assess the importance, effect, or value of (something). [Dictionary.com]



Measurement can get pretty obsessive: "Le Grand K" or "Big K"), a cylinder of platinum-iridium alloy is the standard for the kilogram. Australia has a replica to standardize what we mean by a kilogram. They look like this, and people worry about them losing weight if they are used.

Physicists measure things to picometres (1 x 10^{-12} m). They measure the weight of neutrons to amzing precision. They detect gravity waves using interference patterns of light.

Geneticists measure DNA variation by recording the sequence of DNA bases by passing single DNA strands through tiny pores (amongst other ways).

They all have it easy. We are fudging it! **WHY??**

Partly, because, vegetation is a complex phenomenon and there is no simple measurement unit and no simple scale.

Well, there might be a too simple scale).

Why is vegetation a complex phenomenon? Because it varies in:

Layers: one to many layers of herbs, shrubs (small to large) and trees (small to large).

Dominance: one species to many species sharing dominance

Floristic diversity: few to many species in a stand

With each of these factors affecting the biodiversity or conservation value of: a stand, a plant community, a vegetation association or whatever unit you choose.

To attempt to deal with this complexity several approaches have been used in W.A., including:

1. Description on combinations of structure, dominance and floristics.

This at least has a series of ranks with some criteria for defining them:

Unit	Based on	Fuzziness index
Vegetation formation	Groups alliances. Structure of the upper layer only. E.g. Tall open forest.	Off the scale
Vegetation alliance	Groups vegetation associations that have the same upper layer dominant species.	High
Vegetation association	Groups plant communities with quite similar structure, dominance and floristics.	Moderate
Plant community	Groups stand with very similar structure, dominance and floristics. Has criteria for descriptions such as: Corymbia hamersleyana low open woodland over… with percentage cover ranges for groupings	Low
[stand]		

Sort of logarithmic. Except for the upper units very difficult to produce for large areas.

Demands significant skill for any degree of reproducibility.

2. Vegetation complexes

Based on describing the range of vegetation found in areas (polygons) of a map of another feature, such as geology or geomorphology/soils.

So complexes may have:

- Different ranges and proportions of plant communities in different polygons;
- Different ranges of plant communities in different complexes;
- Some plant communities in common with other complexes;
- Depending on the sampling density and descriptions may not describe all or even much of the variation present.

Unless the base maps used are part of a hierarchy, the units will be unrelated.

Three of the complex mapping publications that have been used in W.A. are:

Publication	**Fuzziness index**
Beard's vegetation mapping	Moderate to high
Darling System Atlas (Heddle *et al)*	Moderate to high
Pilbara Land System/Land Unit mapping	Moderate for land units

3. Floristic analysis

Based on pattern analysis* of the lists of species recorded at vegetation recording sites.

[*Mathematical wizardry beyond the understanding of most mere mortals.]

On the one hand offers some mathematical precision in group (unit) formation, but that depends on both the data quality and the robustness of the mathematics.

So issue are:

- The units for any study are at a level chosen during the analysis, there is not formula for producing a particular level of units; say equivalent to vegetation association;
- The number of units that can be defined for a study depend to a significant degree on the number of sites recorded;
- Recording sites, identifying specimens and entering the data are time consuming;
- Without a regional data set to compare new data to, the conservation value of an analysis is limited.

You can roughly compare the level of synthesis of examples of these different approaches:

Vegetation divided on structure only at the two upper level(s) and on structure and dominant genera or species at the lower levels	**Vegetation divided on broad geomorphological boundaries (+/- land system) with some subdivision on structure and dominant species into ecologically associated groups of types**	**Vegetation divided on less broad geomorphological boundaries (+/- land unit) with subdivision on structure and dominant species into ecologically associated groups of types**	**Floristic analysis: vegetation divided on the basis of the presence or absence of flora species. Sometimes extended to include structure (dominance)**
Biome: A concept that is partly distinguished on structure and partly on being a geographical entity. For example, the tropical rainforests of the Amazon Basin are a biome. Obviously, such as a large entity would not be entirely one formation but would have inclusions of others that would occur in a related fashion. This concept therefore straddles the conceptual boundary between the units in this column and the next			[Uses a concept that divides flora records for sites into a number of groups of sites on the basis of species presence and absence using programs such as PATN. The number of groups used being selected by the person doing the analysis. That is, level of units (floristic community types) varies from study to study.]
Vegetation Formation: A concept that covers vegetation of the same structure of the upper layer without reference to dominant species. While stands referred to a particular formation may have similar structure, they may have different dominant and associated species. For example a Banksia woodland with two shrub layers and a herb layer and a Casuarina woodland with virtually no understorey are both simply woodlands at the formation level. Aplin's (1979) modification of Specht provides a list of 29 formations	**Vegetation complex on the Swan Coastal Plain** A concept that covers a range of structural types that occur in a related pattern with borders defined by major geomorphological units with some subdivision on floristics between southern and northern parts of the geomorphological units. As mapped, fairly similar to CSIRO/ AGWA use of land systems with some subdivision. Co-incidentally, Heddle *et al* (1980) describe 29 vegetation complexes for the Swan CP, this would include vegetation from many of the formations listed by Aplin (1979)	**Vegetation complex on the Darling Plateau** A concept that covers a range of vegetation that occurs on one part of the range of geomorphology of the Plateau and the valleys incised into it, with subdivisions based on changes in vegetation related to broad climatic para meters. (Note: this reflects the fact that the Plateau/ Scarp complex has a higher range of topography and is older than the coastal plain, meaning that more diverse ecological situations have *developed. The result (with exceptions) is that there is less structural diversity in P/S vegetation complexes (Heddle *et al* 1980 gives 30 veg complexes for the Northern Jarrah Forest) (Variable? Possibly to sub-formation.)	**Swan Coastal Plain Survey (Gibson *et al* 1994) floristic community types)** 36 Floristic community types for the southern Swan Coastal Plain (Variable? Individual floristic community types possibly to sub-formation or even alliance level.)

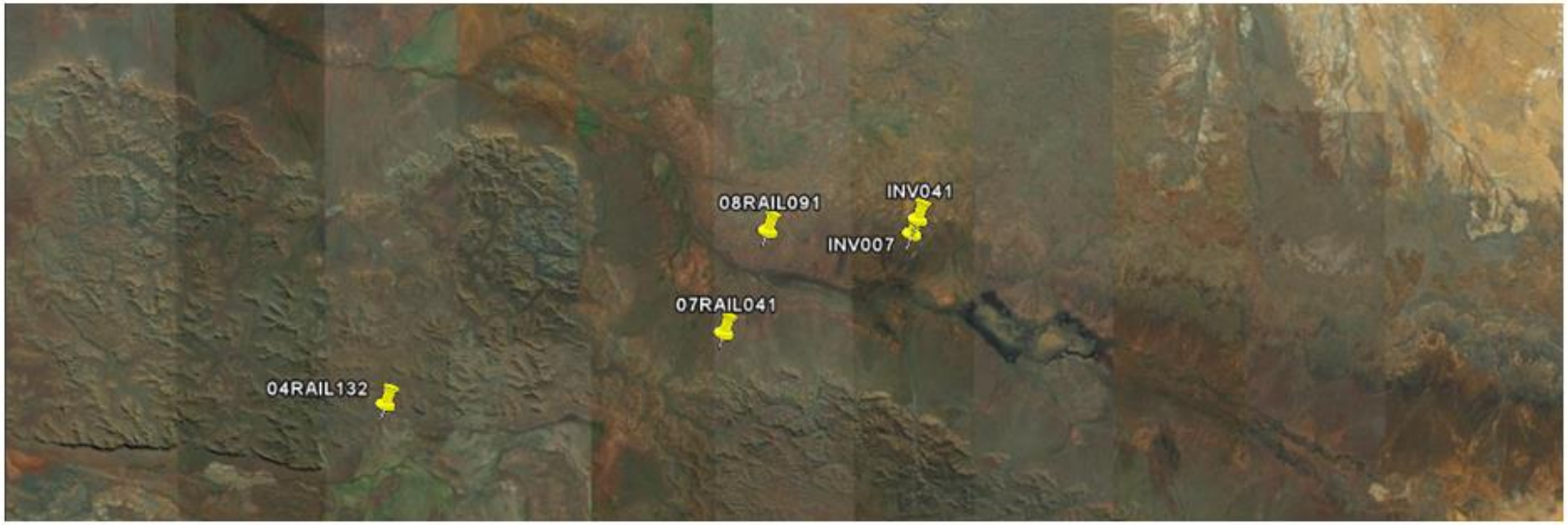
Vegetation Sub-formation: At the sub-formation level, the genus of the dominant of the upper layer is included to group examples of the same formation with related species as the dominant(s). For example, *Eucalyptus* woodland.		**Mapping by McArthur and Mattiske** (1985) of the Bassendean Dunes of the Gnangara Mound. (Variable? Possibly to alliance (individual types).)	**Whicher Scarp Survey (Keighery *et al* 2008) level floristic community types**. Variable? At least some at vegetation alliance level. Those with one quadrat lower? (It depends on whether you look at how different they are from each other or how much variation they include: those with one site are very different from most others, but obviously don't have much variation in them)
Vegetation Alliance: This level groups vegetation associations that have the same dominant species. For example, *Eucalyptus marginata* (Jarrah) forest and may have the same or related species important in the understorey			↓
Vegetation Association: A concept that covers two or more plant communities with similar structure and dominant species. May vary significantly in associated species, but all stands referred to it will have some visual similarity. Some definitions require similar species lists.			
Society: A series of plant communities with the same structure and the same species dominant in the different strata			
Plant Community: The basic unit of vegetation classification. Standing at one place looking at a stand of vegetation one is looking at a physical example of a plant community. Extending this to several very similar stands introduces some variation and it becomes a plant community concept.			
Stand: A particular example of a plant community			

So, can some these different approaches be rationalised? Can we find some equivalence?

It seems to be a matter of data density. The blues are two divisions of drainage size. The colours in the other column are dominant tree species. That is, floristics converging on structure in a PATN analysis of 2,883 Pilbara sites into 600 groups.

WPI	CP021	Acacia synchronicia scattered tall shrubs over A. bivenosa and Senna	Alluvial flood plain	-2
WPI	CP019	Acacia bivenosa open scrub over Triodia wiseana very open hummock	Slight rise to the southwest of a riverbed in undulating country	-2
WPI	CP022	Corymbia hamersleyana scattered low trees over Grevillea pyramidalis subsp.	Low flat rise between two dissected drainages	-2
WPI	CP053	Acacia xiphophylla high open shrubland over Triodia wiseana open	Broad pediment with open shrubland between low hills on alluvial plain with	-2
WPI	CP054	Acacia bivenosa high shrubland over Triodia wiseana open hummock	Pediment drainage between snakewood community sites	-2
WPI	CP055	Acacia aneura var. intermedia low woodland over Eremophila forrestii ssp.	Drainage line coming down from a hogback/old mesa through pediment	-2
308	2MATC09	Corymbia hamersleyana scattered low trees over Stylobasium spathulatum	Floodplain adjacent to a drainage line with River Gums (Eucalyptus	-2
378	BUN66	Corymbia hamersleyana scattered low trees to low open woodland over Acacia	Very gentle north facing slope of a very low rise on floodplain	-2
301A	BUN11	Corymbia hamersleyana scattered low trees over Acacia pyrifolia, Grevillea	Very shallow flow line with low rocky ridges in between	-2
378	BUN64	Corymbia hamersleyana low open woodland over Acacia sclerosperma subsp.	Flat floodplain on valley floor	-2
301A	BUN20	Acacia pyrifolia scattered shrubs over Tephrosia rosea var. glabrior low	Wide, mildly undulating, seasonally flowing cobbly drainage line	-2
378	BUN50	Corymbia hamersleyana scattered low trees over Acacia inaequilatera,	Flat floodplain on valley floor near broad river bed	-2
WPI	TC002	Acacia pyrifolia var. pyrifolia open shrubland over Grevillea pyramidalis ssp.	Alluvial plain. Flat and on the bottom third of the landform element	-2
WPI	TC004	Acacia pyrifolia var. pyrifolia high shrubland over Grevillea pyramidalis	Flat Alluvial plain. Bottom third of the landform element	-2
WPI	TC003	Eucalyptus victrix open woodland over Acacia trachycarpa, A. pyrifolia var.	Riverbed, floodplain	-2
308	MEAS01	Euclalyptus vitrix scattered low trees over Gossipium australe, Acacia	Creek flood banks, with shallow stony flow lines	-2
308	MEAS04	Scattered Eucalyptus vitrix tall open woodland over Acacia trachycarpa tall	Flow line, 1-1.5m deep, 30m wide	-2
308	MEAS02	Eucalyptus vitrix scattered low trees over Acacia pyrifolia, Acacia	Flood banks of stony creek	-2
WPI	ASN020	Eucalyptus camaldulensis/victrix XXX, Corymbia hamersleyana and Acacia	Major drainage line	-2
WPI	BOR102	Corymbia hamersleyana low woodland over Malvastrum americanum, Sida	Drainage line between rolling hills	-2
WPI	CR016	Corymbia hamersleyana low open woodland over Acacia ancistrocarpa, A.	Large drainage line on flat alluvial plain	-2
215	MI01	Corymbia candida subsp. candida low open forest over Stylobasium	Flowline	-2
378	BUN-MZ	Corymbia hamersleyana low open woodland over Acacia pyrifolia, A.	Minor flowline on southern baseslope from large hill	-2
WPI	CP036	Acacia spp., Hakea lorea ssp. lorea and Grevillea pyramidalis ssp.	Wide drainage line on an alluvial plain	-2
WPI	TC001	Corymbia hamersleyana low open woodland over Acacia pyrifolia var.	Minor drainage line on plain	-2
WPI	TC005	Corymbia hamersleyana low open woodland over Acacia pyrifolia var.	Minor drainage area	-2
WPI	KBW006	Corymbia hamersleyana low open woodland over Acacia ancistrocarpa, A.	Alluvial plain	-2
WPI	KBW007	Corymbia hamersleyana low open woodland over Acacia ancistrocarpa and	Creek line on plain	-2
WPI	CP042	Eucalyptus camaldulensis var. obtusa open woodland over Corymbia	Woodland in drainage line	-2
WPI	CR030	Eucalyptus leucophloia ssp. leucophloia and Corymbia hamersleyana low	Creek line	-2
WPI	CW013	Corymbia hamersleyana low open woodland over Acacia tumida var.	Flat valley floor in upper section of valley within mesa	-2
WPI	CW014	Eucalyptus leucophloia ssp. leucophloia low open woodland over Acacia	Gully (dissected drainage) approximately 5-10 m wide and 6 m deep	-2
WPI	CW019	Corymbia hamersleyana low open woodland over Acacia ancistrocarpa and	A drainage line on valley floor between two sections of the mesa	-2
WPI	CW030	Corymbia hamersleyana low open woodland over Acacia ancistrocarpa closed	Drainage line, on the plain	-2
WPI	CW034	Corymbia hamersleyana low open forest over Acacia tumida var. pilbarensis	A wide dissected drainage or gully on the flat	-2
WPI	TC013	Acacia pyrifolia var. pyrifolia and A. citrinoviridis open shrubland over	Floodplain, river bed	-2
WPI	TC014	Acacia citrinoviridis high shrubland over Acacia bivenosa, Stylobasium	Minor drainage line	-2
WPI	CWW051	Acacia citrinoviridis high shrubland over Gossypium robinsonii shrubland	Incised drainage line	-2
550AA	07RAIL04	Tall Open Shrubland of Acacia pruinocarpa, Acacia pyrifolia var. pyrifolia,	Valley floor, relatively flat	-2
WPI	CP094	Corymbia candida ssp. candida low woodland over Acacia colei var. colei high	Large river in alluvial plain	-2
WPI	CP162	Corymbia candida ssp.candida scattered low trees over Acacia trachycarpa, A.	Broad open area on an alluvial plain	-2
WPI	CP531	Eucalyptus camaldulensis open forest over Corymbia candida ssp. candida low	Drainage line	-2
WPI	CP158	Eucalyptus camaldulensis var. obtusa low woodland over Acacia trachycarpa	River drainage line	-2
WPI	CP160	Acacia trachycarpa high shrubland over Triodia epactia very open hummock	Alluvial plain	-2
WPI	HR066	Eucalyptus camaldulensis var. obtusa scattered low trees over Acacia pyrifolia		-2
WPI	KB025	Acacia trachycarpa and Grevillea wickhamii ssp. hispidula high shrubland	Adjacent to a river bed, on a gentle slope, running away from the river	-2
WPI	CP265	Eucalyptus camaldulensis var. obtusa open woodland over Corymbia	Drainage line	-2
WPI	CP271	Eucalyptus camaldulensis var. obtusa scattered trees over Corymbia candida	Drainage line, north bank of the Robe River	-2
WPI	CP465	Acacia synchronicia open scrub over A. pyrifolia var. pyrifolia scattered	River edge leading out onto flat plain	-2
WPI	BOR095	Eucalyptus victrix XXXX, Eucalyptus camaldulensis var. obtusa XXXX and	Creekbed	-2
WPI	TC033	Eucalyptus victrix over Acacia citrinoviridis and Acacia synchronicia over	River bank	-2

Examples of the distribution of groups from the 2,883 site classification.



200-gp: 105, 600-gp: 313

200-gp: 141, 600-gp: 423, 426

The next issue is:

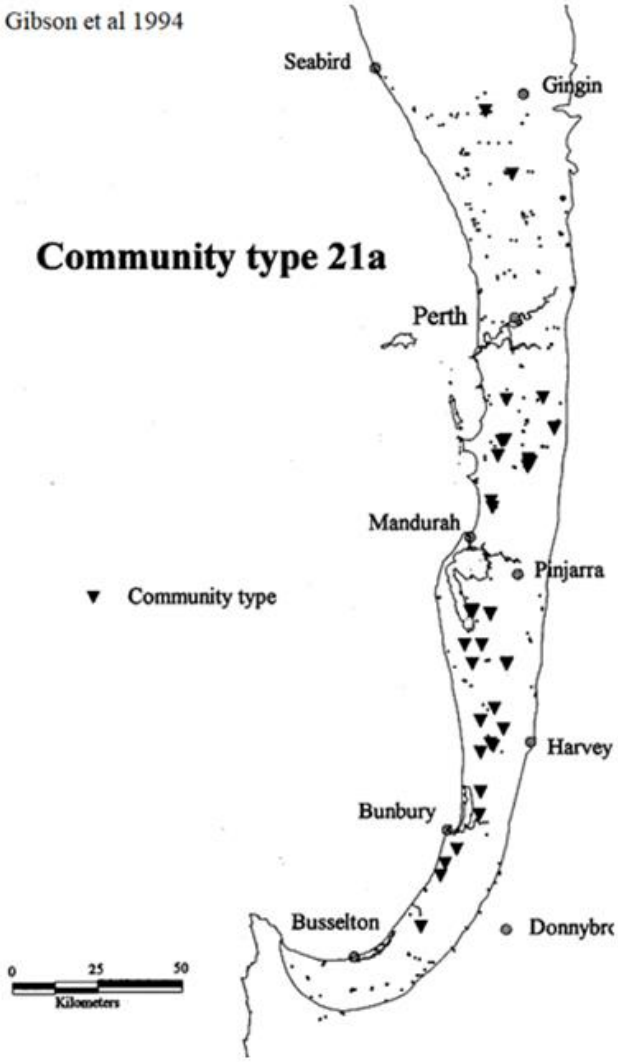
Is it possible to decide on the number of groups for a floristic classification so that it has a rank (level of synthesis) suitable for EIA? Or is it possible to test the suitability of a classification for EIA?

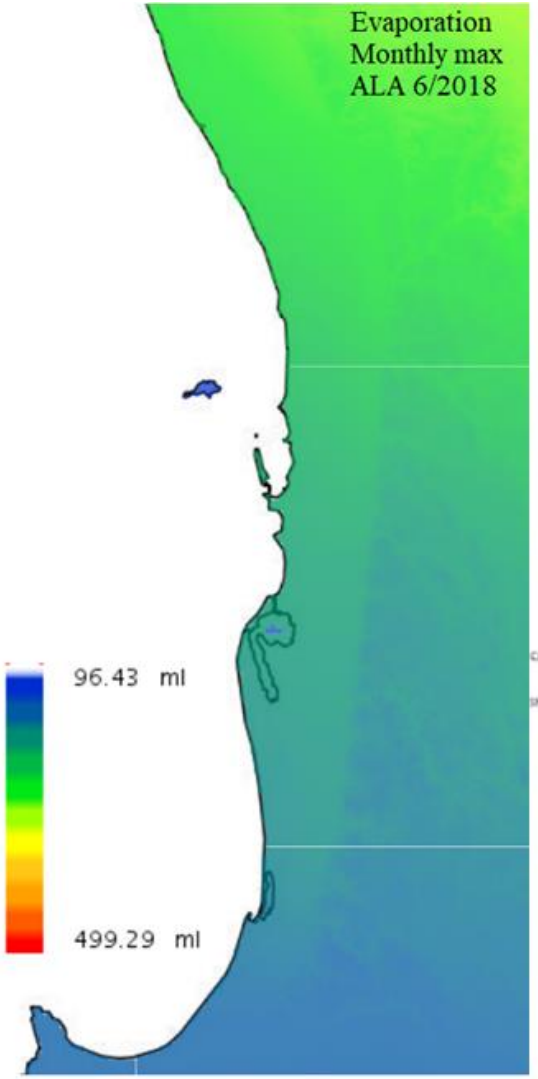
Firstly, we need to know what rank EPA makes decisions at. In Guidance 54, the EPA tell us "below the Alliance level". A bit vague, but they need some flexibility to deal with different situations. Unless they mean sub-alliance, that means around the vegetation association level.

Secondly, we are talking about vegetation units for EIA, so we should look at how vegetation types are likely to be distributed in an area we are considering. Then we should look at different numbers of groups and the diversity of structure, dominance and species diversity they have in the sites in the groups.

The Swan Coastal Plain is a good test case, because it has soil/geomorphology units that extend south to north and climate factors that change from south to north. So, if a unit extends a long way south-north it is a soil/geomorphology driven complex. Let's look at Community type 21a as such an example.

Gibson et al 1994





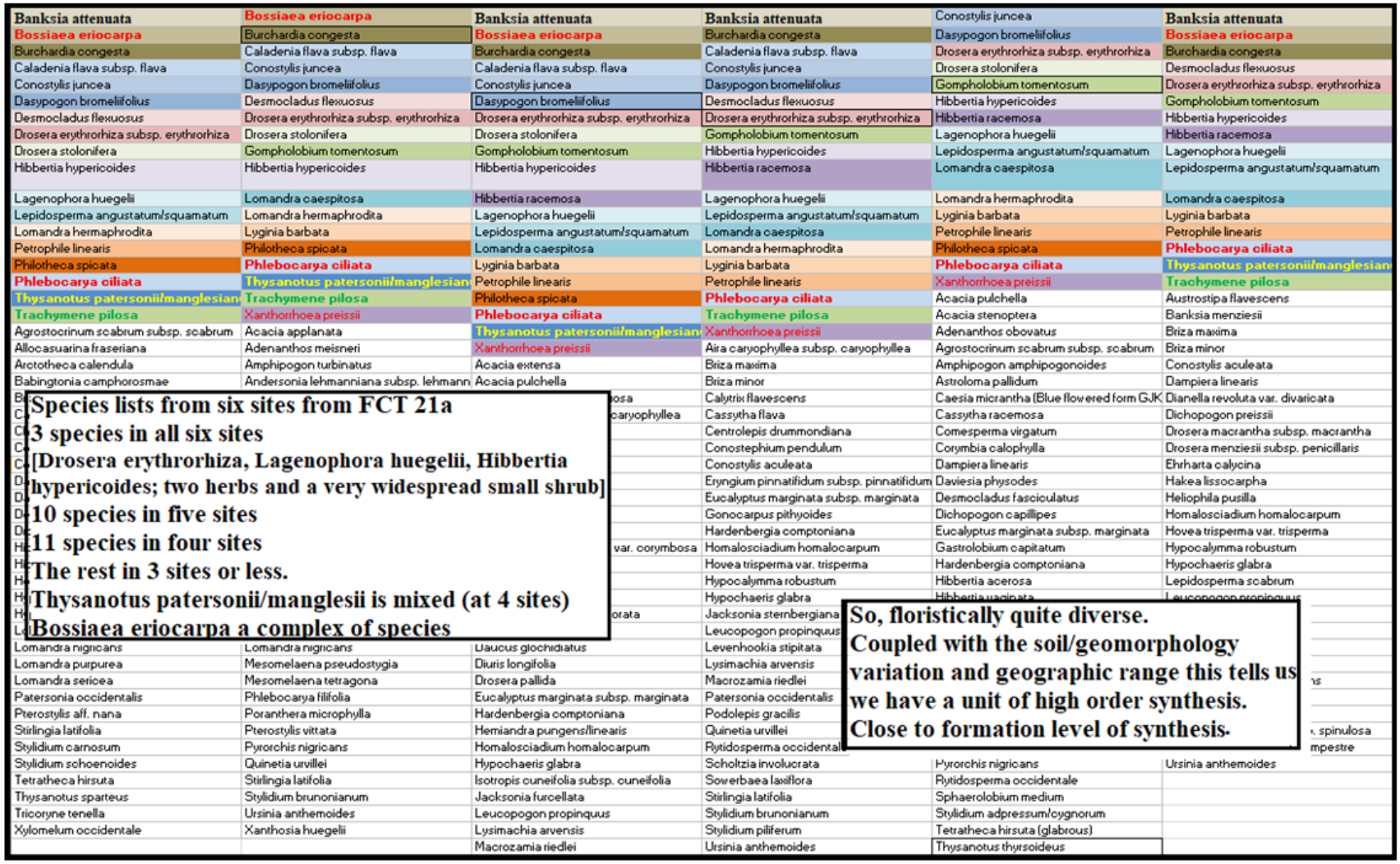
(a) Based on the 30 year period 1961–1990
Source: Bureau of Meteorology

Floristic community type 21a of Gibson *et al* (1994):

- Extends for ca. 230 km south to north, with the occurrences separated by several rivers. Most occurrences are from "Perth to Capel" (Gibson *et al.* p. 43).
- Occurs on a range of soil/geomorphology: "Just on half of sites in this group occur on Bassendean Dunes, another third occur on Spearwood system and the rest on alluvial soils." (Gibson *et al.* p. 43). [I.e. also has some W-E range.]
- The sites assigned to the floristic community type are from eight structural types of formation or near formation level (dense forest; forest; low forest A; woodland; low woodland A; open woodland; open low woodland A; low heath C (Gibson *et al.* 19940)).

The authors (p. 51) state of their units "these communities appear to be primarily determined by seasonal water regimes and geomorphology".

On range (geographic extent) FCT 21a is a moderate to high order unit. On soil/geomorphology it is a high order unit. On the range of vegetation structural units the sites placed in FCT 21a were recorded from it is a very high order unit. For this not to be the case, structure, dominance and floristics would have to have only a low level of correlation and floristics would have to have low correlation with soil/geomorphology.



Banksia attenuata	Bossiaea eriocarpa	Banksia attenuata	Banksia attenuata	Conostylis juncea	Banksia attenuata
Bossiaea eriocarpa	Burchardia congesta	Bossiaea eriocarpa	Burchardia congesta	Dasypogon bromeliifolius	Bossiaea eriocarpa
Burchardia congesta	Caladenia flava subsp. flava	Burchardia congesta	Caladenia flava subsp. flava	Drosera erythrorhiza subsp. erythrorhiza	Burchardia congesta
Caladenia flava subsp. flava	Conostylis juncea	Caladenia flava subsp. flava	Conostylis juncea	Drosera stolonifera	Desmocladus flexuosus
Conostylis juncea	Dasypogon bromeliifolius	Conostylis juncea	Dasypogon bromeliifolius	Gompholobium tomentosum	Drosera erythrorhiza subsp. erythrorhiza
Dasypogon bromeliifolius	Desmocladus flexuosus	Dasypogon bromeliifolius	Desmocladus flexuosus	Hibbertia hypericoides	Gompholobium tomentosum
Desmocladus flexuosus	Drosera erythrorhiza subsp. erythrorhiza	Drosera erythrorhiza subsp. erythrorhiza	Drosera erythrorhiza subsp. erythrorhiza	Hibbertia racemosa	Hibbertia hypericoides
Drosera erythrorhiza subsp. erythrorhiza	Drosera stolonifera	Drosera stolonifera	Gompholobium tomentosum	Lagenophora huegelii	Hibbertia racemosa
Drosera stolonifera	Gompholobium tomentosum	Gompholobium tomentosum	Hibbertia hypericoides	Lepidosperma angustatum/squamatum	Lagenophora huegelii
Hibbertia hypericoides	Hibbertia hypericoides	Hibbertia hypericoides	Hibbertia racemosa	Lomandra caespitosa	Lepidosperma angustatum/squamatum
Lagenophora huegelii	Lomandra caespitosa	Hibbertia racemosa	Lagenophora huegelii	Lomandra hermaphrodita	Lomandra caespitosa
Lepidosperma angustatum/squamatum	Lomandra hermaphrodita	Lagenophora huegelii	Lepidosperma angustatum/squamatum	Lyginia barbata	Lyginia barbata
Lomandra hermaphrodita	Lyginia barbata	Lepidosperma angustatum/squamatum	Lomandra caespitosa	Petrophile linearis	Petrophile linearis
Petrophile linearis	Philotheca spicata	Lomandra caespitosa	Lomandra hermaphrodita	Philotheca spicata	Phlebocarya ciliata
Philotheca spicata	Phlebocarya ciliata	Lyginia barbata	Lyginia barbata	Phlebocarya ciliata	Thysanotus patersonii/manglesian
Phlebocarya ciliata	Thysanotus patersonii/manglesian	Petrophile linearis	Petrophile linearis	Xanthorrhoea preissii	Trachymene pilosa
Thysanotus patersonii/manglesian	Trachymene pilosa	Philotheca spicata	Phlebocarya ciliata	Acacia pulchella	Austrostipa flavescens
Trachymene pilosa	Xanthorrhoea preissii	Phlebocarya ciliata	Trachymene pilosa	Acacia stenoptera	Banksia menziesii
Agrostocrinum scabrum subsp. scabrum	Acacia applanata	Thysanotus patersonii/manglesian	Xanthorrhoea preissii	Adenanthos obovatus	Briza maxima
Allocasuarina fraseriana	Adenanthos meisneri	Xanthorrhoea preissii	Aira caryophyllea subsp. caryophyllea	Agrostocrinum scabrum subsp. scabrum	Briza minor
Arctotheca calendula	Amphipogon turbinatus	Acacia extensa	Briza maxima	Amphipogon amphipogonoides	Conostylis aculeata
Babingtonia camphorosmae	Andersonia lehmanniana subsp. lehmann	Acacia pulchella	Briza minor	Astroloma pallidum	Dampiera linearis
B		osa	Calytrix flavescens	Caesia micrantha (Blue flowered form GJK	Dianella revoluta var. divaricata
C		caryophyllea	Cassytha flava	Cassytha racemosa	Dichopogon preissii
C			Centrolepis drummondiana	Comesperma virgatum	Drosera macrantha subsp. macrantha
C			Conostephium pendulum	Corymbia calophylla	Drosera menziesii subsp. penicillaris
C			Conostylis aculeata	Dampiera linearis	Ehrharta calycina
D			Eryngium pinnatifidum subsp. pinnatifidum	Daviesia physodes	Hakea lissocarpha
D			Eucalyptus marginata subsp. marginata	Desmocladus fasciculatus	Heliophila pusilla
D			Gonocarpus pithyoides	Dichopogon capillipes	Homalosciadium homalocarpum
D			Hardenbergia comptoniana	Eucalyptus marginata subsp. marginata	Hovea trisperma var. trisperma
H		var. corymbosa	Homalosciadium homalocarpum	Gastrolobium capitatum	Hypocalymma robustum
H			Hovea trisperma var. trisperma	Hardenbergia comptoniana	Hypochaeris glabra
H			Hypocalymma robustum	Hibbertia acerosa	Lepidosperma scabrum
H			Hypochaeris glabra	Hibbertia vaginata	Leucopogon propinquus
H		orata	Jacksonia sternbergiana	Hypocalymma robustum	
L			Leucopogon propinquus	Jacksonia sternbergiana	
Lomandra nigricans	Lomandra nigricans	Daucus glochidiatus	Levenhookia stipitata	Leucopogon propinquus	
Lomandra purpurea	Mesomelaena pseudostygia	Diuris longifolia	Lysimachia arvensis	Levenhookia stipitata	
Lomandra sericea	Mesomelaena tetragona	Drosera pallida	Macrozamia riedlei	Lysimachia arvensis	ns
Patersonia occidentalis	Phlebocarya filifolia	Eucalyptus marginata subsp. marginata	Patersonia occidentalis	Macrozamia riedlei	
Pterostylis aff. nana	Poranthera microphylla	Hardenbergia comptoniana	Podolepis gracilis	Patersonia occidentalis	
Stirlingia latifolia	Pterostylis vittata	Hemiandra pungens/linearis	Quinetia urvillei	Podolepis gracilis	
Stylidium carnosum	Pyrorchis nigricans	Homalosciadium homalocarpum	Rytidosperma occidentale	Quinetia urvillei	. spinulosa
Stylidium schoenoides	Quinetia urvillei	Hypochaeris glabra	Scholtzia involucrata	Pyrorchis nigricans	mpestre
Tetratheca hirsuta	Stirlingia latifolia	Isotropis cuneifolia subsp. cuneifolia	Sowerbaea laxiflora	Rytidosperma occidentale	Ursinia anthemoides
Thysanotus sparteus	Stylidium brunonianum	Jacksonia furcellata	Stirlingia latifolia	Sphaerolobium medium	
Tricoryne tenella	Ursinia anthemoides	Leucopogon propinquus	Stylidium brunonianum	Stylidium adpressum/cygnorum	
Xylomelum occidentale	Xanthosia huegelii	Lysimachia arvensis	Stylidium piliferum	Tetratheca hirsuta (glabrous)	
		Macrozamia riedlei	Ursinia anthemoides	Thysanotus thyrsoideus	

Species lists from six sites from FCT 21a
3 species in all six sites
[Drosera erythrorhiza, Lagenophora huegelii, Hibbertia hypericoides; two herbs and a very widespread small shrub]
10 species in five sites
11 species in four sites
The rest in 3 sites or less.
Thysanotus patersonii/manglesii is mixed (at 4 sites)
Bossiaea eriocarpa a complex of species

So, floristically quite diverse.
Coupled with the soil/geomorphology variation and geographic range this tells us we have a unit of high order synthesis.
Close to formation level of synthesis.

The result?

In the case of Gibson *et al.* 1994 FCT 21a, we have a unit that is well above the level that the EPA says it makes assessments at.

Yet, FCT21a is one of three subgroups of FCT21. So the original 30 groups are higher level still. That makes them well above the vegetation alliance level of synthesis and in the order of the vegetation formation level of synthesis (but of a floristic scale, not a combined structure, dominance, floristics (lower levels) scale).

AND, the Gibson *et al* FCTs are the basis of most TECs on the Swan Coastal Plain.

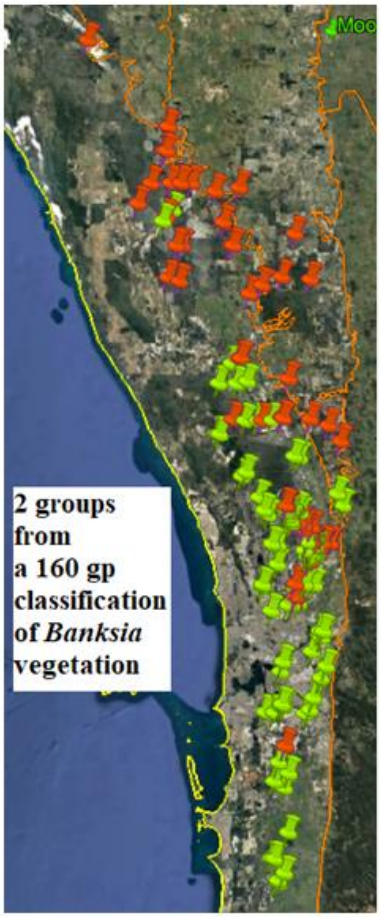
So, we have a multi-dimensioned tragedy:

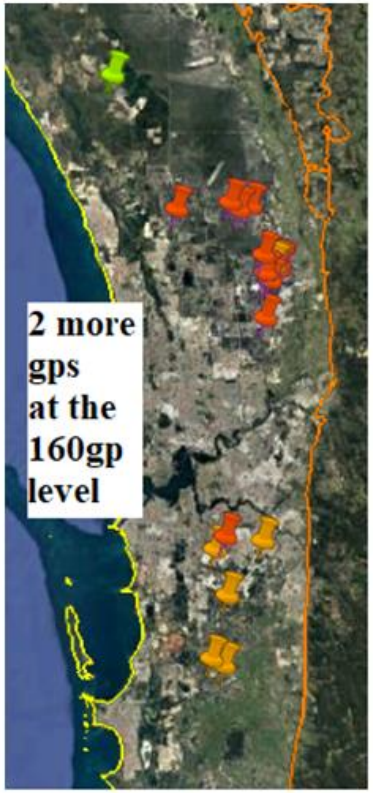
1. The basis of definition of rare vegetation is out of kilter with EPA assessments; so much of what is actually rare at the level(s) the EPA says it makes assessments does not get flagged as such in EPA processes.

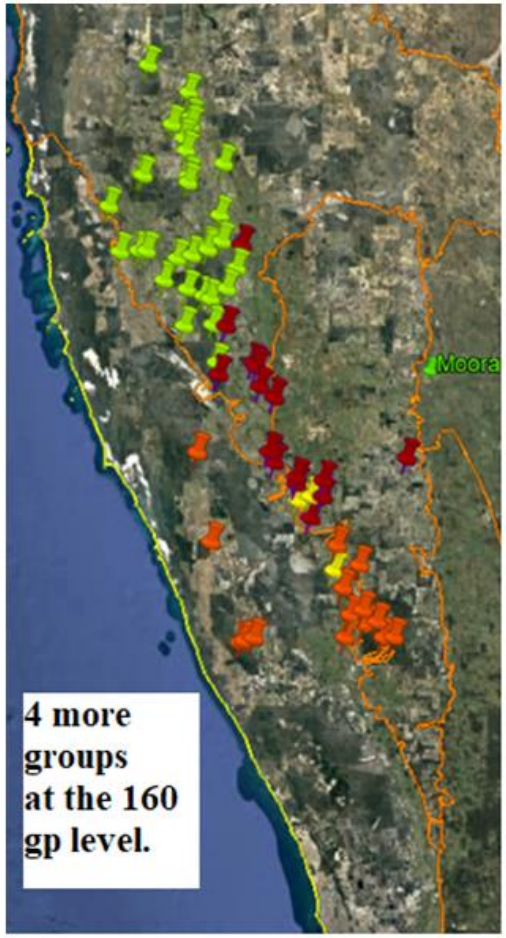
2. All EPA assessments using the classification are undermined by the level of units set.

3. The classification was the result of a large amount of work by many people (the authors and volunteer quadrat recorders who care about the flora, but the classification level failed that effort.

The available data is not perfect, but can it support units on the Swan Coastal Plain and adjoining areas at a level more suitable for EIA?







Viable?

At that level there are quite a few groups with one site only, but also there are some with a lot of sites so it is probably reasonable.

The data set needs more correction and some sites should probably be deleted.

Given that work a classification near this level would be a significant step forward.

So, how viable is it to move to larger data sets and floristics analysis of them?

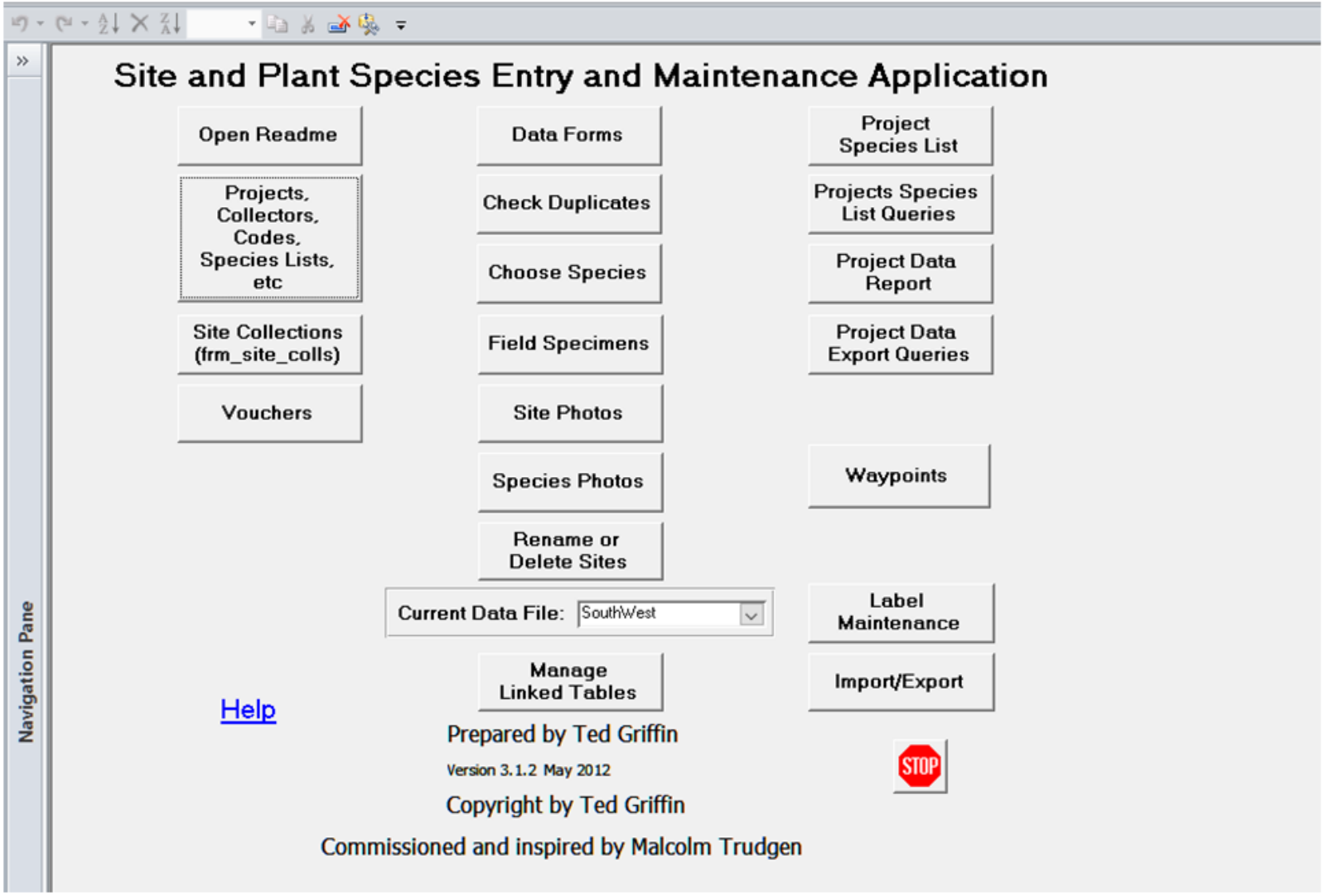
What is required?

- **Data acquisition – recording of quadrats or good quality unpegged sites**
- **Identification to a reasonable standard**
- **Entry into a data base**
- **Data correction**
- **Analysis**

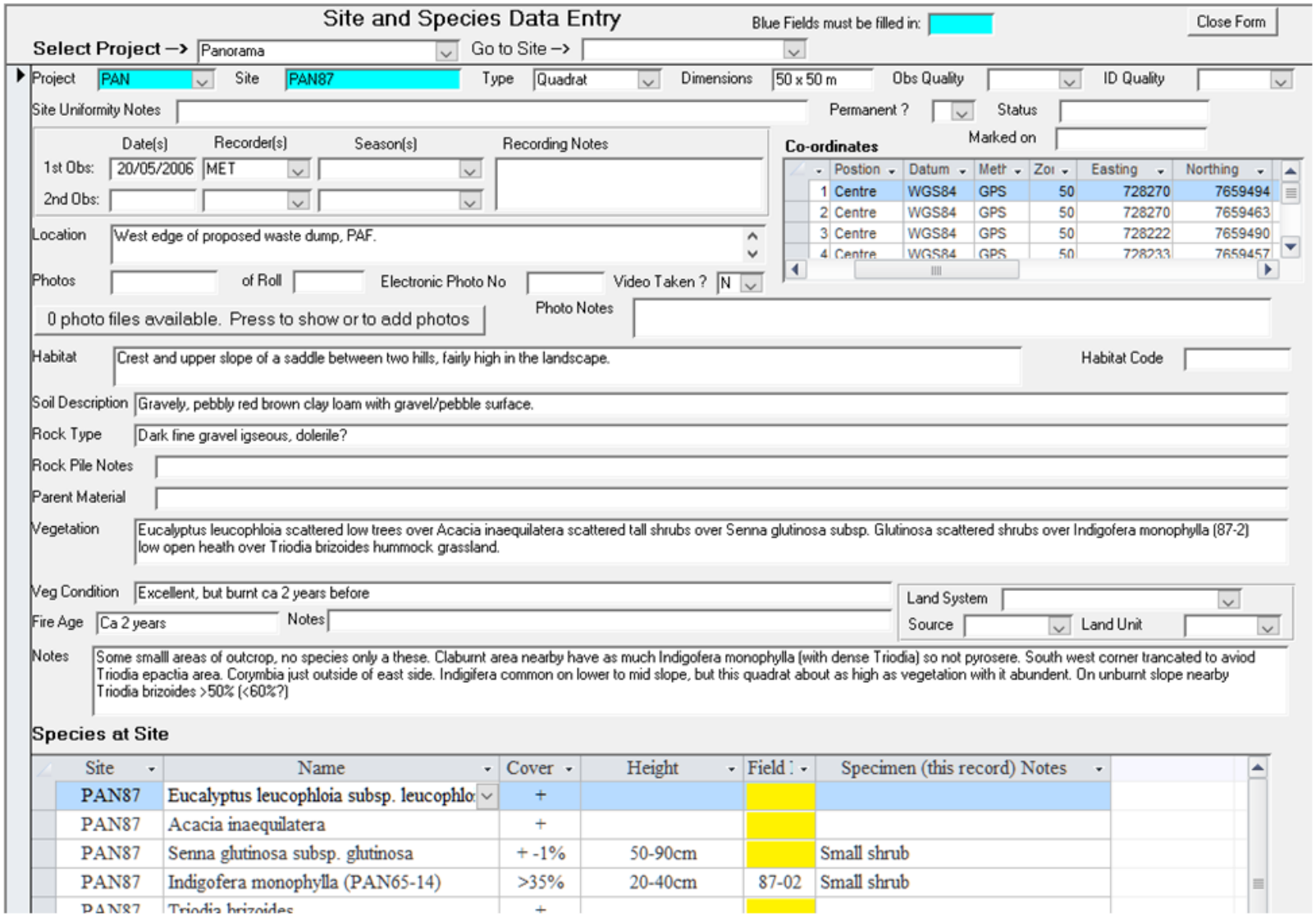
Data acquisition: A quadrat in *Allocasuarina campestris* closed scrub. Note the GPS sitting on the peg.

Identifications

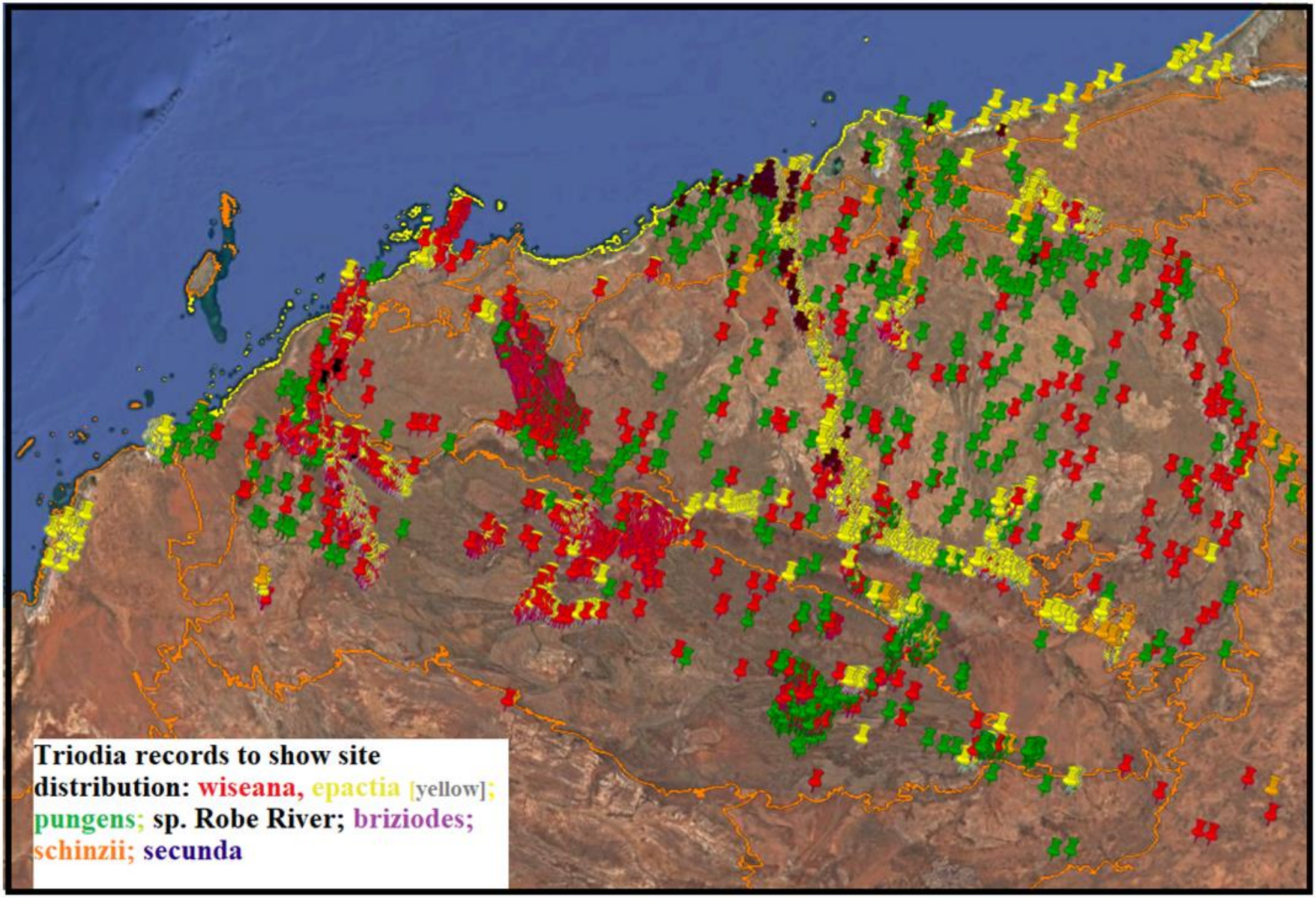
For the Pilbara data set identify or check as many of specimens as possible against a Pilbara reference set.



A Microsoft Access data base structured for vegetation site data (there are lots of alternatives).



An example of the data entered for a site (list truncated). It's not all as complete as this, unfortunately


Triodia records to show site distribution: wiseana, epactia [yellow]; pungens; sp. Robe River; briziodes; schinzii; secunda

090	Proteaceae		Y	19137	Hakea lorea subsp. lorea							
090	Proteaceae			16905	Hakea lorea subsp. suberea	x					Hakea lorea subsp. lorea	All the records are PRP. It is an excluded name.
			Y	2178	Hakea macrocarpa							Two GNIM collections. Is on Fbase for PIL.
090	Proteaceae			2196	Hakea preissii							This taxon is very widespread and needs taxonomic review.
090	Proteaceae		Y	2200	Hakea rhombales							SE PIL. Leaves not divided.
090	Proteaceae		Y	-1539	Hakea sp.	x						
090			Y	16897	Hakea stenophylla subsp. stenophylla							Just in W end of PIL on FBase.
090	Proteaceae			2210	Hakea suberea	x					Hakea lorea subsp. lorea	
310	Boraginaceae		Y	-60029	Halgania cyanea var. Allambi Stn (B.W. Strong 676)							
310	Boraginaceae			17487	Halgania cyanea var. latisepala	x					Halgania cyanea var. Allambi Stn (B.W. Strong 676)	
310	Boraginaceae		Y	6688	Halgania erecta							Florabase shows just in/on border of far SE of PIL. Record in data set is PRP. In?
310	Boraginaceae			6690	Halgania gustafsenii	x					Halgania gustafsenii var. compactus	
310	Boraginaceae		N	17484	Halgania gustafsenii var. compactus							Have used var compactus, but needs checking (is all one taxo
310	Boraginaceae			17493	Halgania gustafsenii var. gustafsenii	x					Halgania gustafsenii var. compactus	
310	Boraginaceae			-60001	Halgania solanacea	x					Halgania solanacea var. Mt Doreen (G.M. Chippendale 4206)	
310	Boraginaceae		N	17489	Halgania solanacea var. hirsuta	x					Halgania solanacea var. Mt Doreen (G.M. Chippendale 4206)	
310	Boraginaceae		Y	30258	Halgania solanacea var. Mt Doreen (G.M. Chippendale 4206)							
310	Boraginaceae		Y	-1538	Halgania sp.	x						
276	Haloragaceae			6174	Haloragis gossei	x					Haloragis gossei var. gossei TaxonID 23465	
196	Haloragaceae		Y	23465	Haloragis gossei var. gossei							

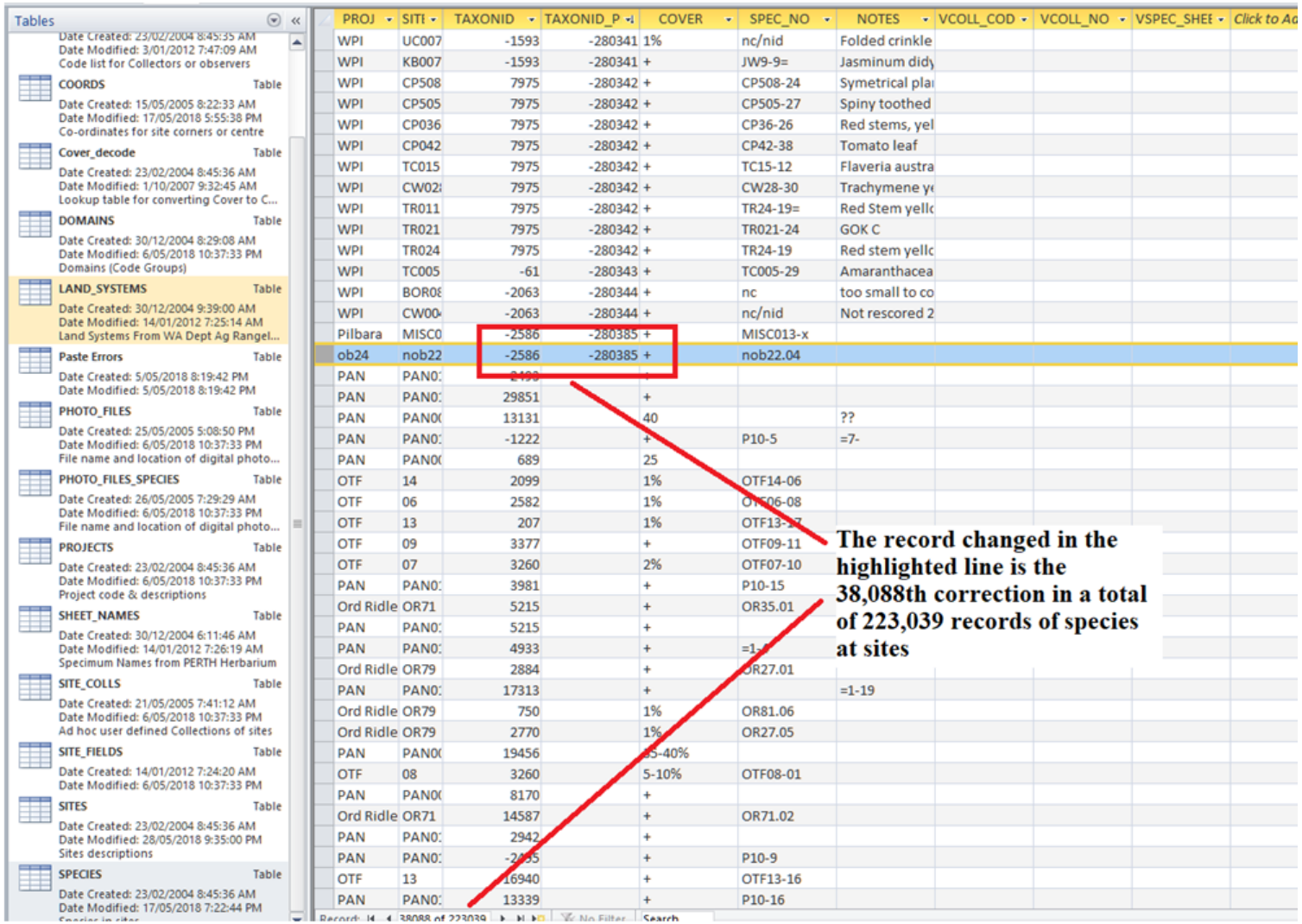
Metadata for name corrections to ensure consistency. 3,472 lines (names) in the excel file.

All changes made by MET, no software based corrections.

Some corrections are about reducing the % of error, rather than absolute correction.

Site	Prev Name	Name	Cover	Height	Field	Specimen
PAN86	Abutilon dioicum	Abutilon sp. Dioicum (A.A. Mitchell PRP	+	45cm	86-21	Corolla yello
PAN86	Abutilon dioicum	Abutilon sp. Dioicum (A.A. Mitchell PRP	+	90cm	86-24	Annual erec
PAN86		Acacia bivenosa	+	1.7m		Open shrub
PAN86		Acacia colei var. colei	+	3cm	86-25	Perennial sh
PAN86	Acacia tumida var. ? tumida	Acacia tumida var. pilbarensis	10-50%	2-3.5m		Spindly tall s
PAN86		Amaranthus sp.	+	90cm	86-02	Stem bright
PAN86		Atalaya hemiglauca	+	1.6		Small shrub
PAN86		Bulbostylis barbata	+	12cm		Annual sedg
PAN86		Cajanus cinereus	+	15-20cm		Juvenile
PAN86		Cenchrus ciliaris	+	75cm		A few tusso
PAN86		Cleome viscosa	+	75cm		Dead
PAN86		Corchorus parviflorus	+	50cm	86-08	Shrub, flowe
PAN86		Corymbia hamersleyana	+		86-11	Small tree
PAN86	Crotalaria medicaginea	Crotalaria medicaginea var. neglecta	+	60cm-1m	86-05	
PAN86	Mukia maderaspatana	Cucumis maderaspatanus	>1%	40cm	86-09	Scrambling v
PAN86		Cymbopogon ambiguus	+	50-90cm	86-15	Perennial tus
PAN86		Cyperus hesperius	+	30cm	86-03	Leaves v sh
PAN86		Eragrostis tenellula	+	15cm		Annual gras
PAN86		Eriachne pulchella subsp. dominii	+	25cm	86-27	Annual gras
PAN86		Euphorbia clementii	+	40cm		Dead annual

All original names are kept in the data in case of revised opinions on changes.



You can peek into the data and see how many corrections have been made!

Analysis: lots of alternatives, e.g. PATN, vegclust.

```
##### Empty working environment #####
Nothing to change.
Run this chunk.
```{r cars}
rm(list = ls(pattern = ""))
```


Import and Process Data
Import and process list of TAXONID's to exclude from the analysis.
Make sure the file name is the one you want ("folder name/this is the filename.csv")
```{r pressure, echo=FALSE, message=FALSE, warning=FALSE}
exclude_list <- read_csv("C:/Users/Serratus/Documents/R/vegclust/Input data/SW species to exclude.csv",
                                col_names = FALSE,
                                col_types = cols(X1 = col_integer())) %>%
  select(TAXONID = X1) %>%
  drop_na()
```


Import and process geocode data.
Note that you can have the FULL geocode list, and the code lower down will only use the ones
for the PROJ codes in the site-species data.
Make sure the file name is the one you want ("folder name/this is the filename.csv")
```{r pressure, echo=FALSE, message=FALSE, warning=FALSE}
data_y <- read_csv("C:/Users/Serratus/Documents/R/vegclust/Input data/SW geocodes.csv") %>%
  mutate(
         PROJ = case_when(PROJ == "Cund&Calla" ~ "CundCalla",
                          TRUE                 ~ PROJ)) %>%
  unite(PROJ,
        SITE,
        col = "Site",
        sep = "") %>%
  distinct()
```

Import and process site-species data.
Make sure the file name is the one you want ("folder name/this is the filename.csv")
Press play, then scroll to the next chunk.
This one can be a little slow (about 30 seconds)
```{r pressure, echo=FALSE, message=FALSE, warning=FALSE}
data_x <- read_csv("C:/Users/Serratus/Documents/R/vegclust/Input data/SWSitesSpecies_sheet1.csv",
```

If you are lucky, a wonderful young botanist will set up "vegclust" for you so you can enter your (corrected) data, joins of species and exclusions into the right files and places.

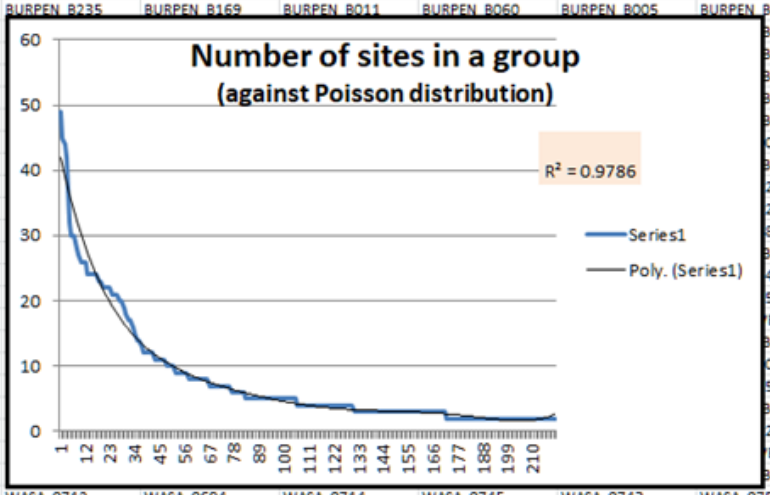
And then press a few buttons, wait a while and see what pops out.

Well it can be quite a long time, depending on the size of the data set, the number of groups and the number of iterations.

Some of the "vegclust" run stages.
```

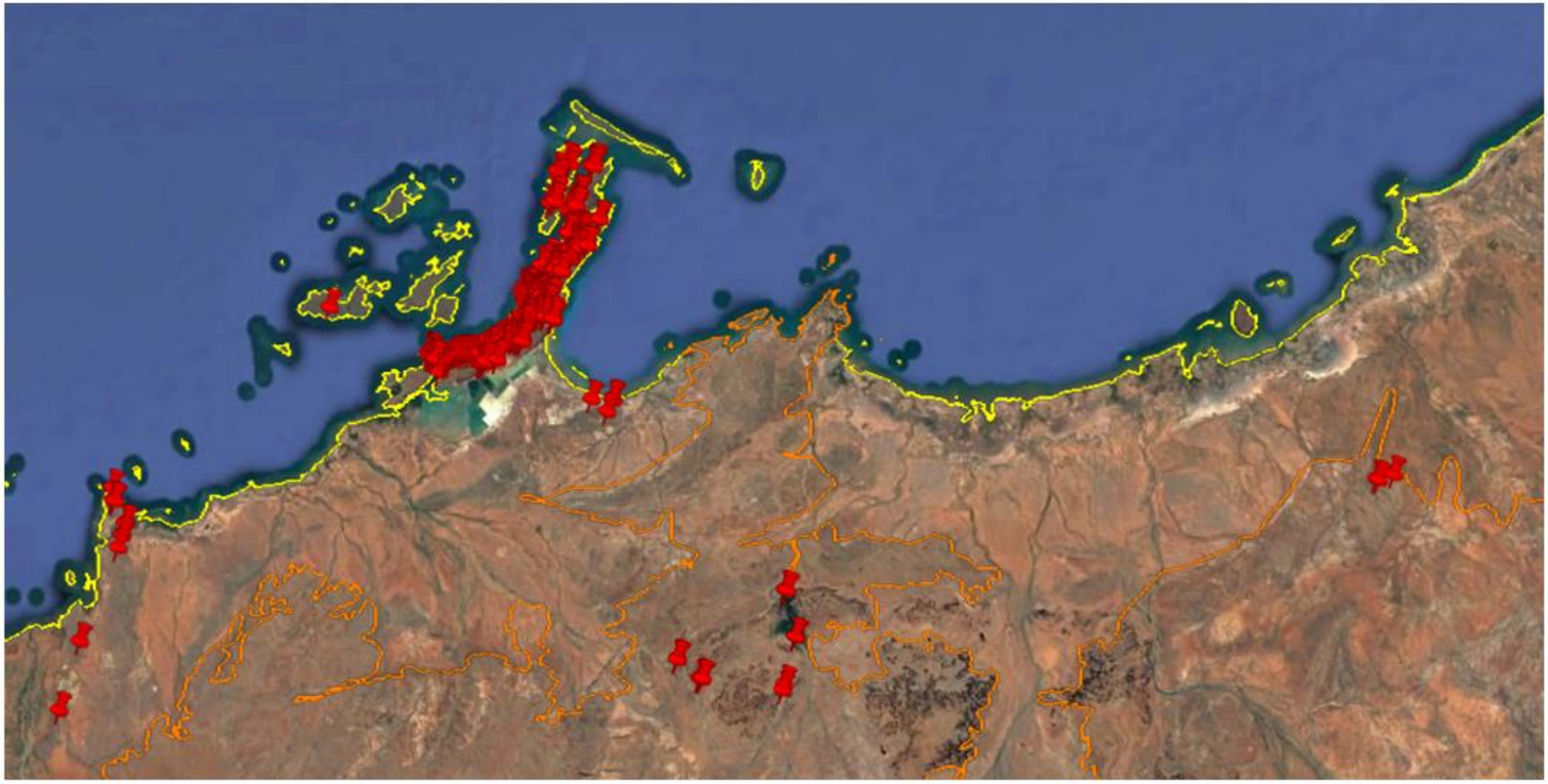
So, before some results, can we be sure the data is up to it?

Number of members	Average distance	Central site	Group Members								
49	1.75E-37	167-Site num 0||	BURPEN_B195	BURPEN_B046	BURPEN_B082	BURPEN_B238	BURPEN_B192	BURPEN_B031	BURPEN_B010	BURPEN_B066	BURPEN_B232
45	2.53E-30	57-Site num 0||	BURPEN_B010	BURPEN_B195	BURPEN_B238	BURPEN_B169	BURPEN_B061	BURPEN_B002	BURPEN_B066	BURPEN_B046	BURPEN_B082
44	1.50E-33	112-Site num 0||	BURPEN_B066	BURPEN_B082	BURPEN_B046	BURPEN_B031	BURPEN_B195	BURPEN_B039	BURPEN_B045	BURPEN_B235	BURPEN_B085
42	1.75E-37	92-Site num 0||	BURPEN_B046	BURPEN_B195	BURPEN_B082	BURPEN_B031	BURPEN_B066	BURPEN_B045	BURPEN_B010	BURPEN_B192	BURPEN_B044
32	4.26E-31	1743-Site num 0||	WASA_0668	WASA_1017	WASA_1231	WASA_0683	WASA_0655	WASA_0663	WASA_1255	WASA_1253	WASA_0666
30	4.06E-31	1958-Site num 0||	WASA_1017	WASA_0900	WASA_0668	WASA_1225	WASA_0999	WASA_1231	WASA_0962	WASA_0683	WASA_0884
30	4.33E-27	50-Site num 0||	BURPEN_B003	BURPEN_B066	BURPEN_B005	BURPEN_B169	BURPEN_B018	BURPEN_B004	BURPEN_B010	BURPEN_B082	BURPEN_B046
28	7.16E-27	129-Site num 0||	BURPEN_B084	BURPEN_B182	BURPEN_B079	BURPEN_B056	BURPEN_B085	BURPEN_B193	BURPEN_B066	BURPEN_B169	BURPEN_B039
27	1.16E-28	156-Site num 0||	BURPEN_B181	BURPEN_B002	BURPEN_B162	BURPEN_B019	BURPEN_B005	BURPEN_B195	BURPEN_B010	BURPEN_B169	BURPEN_B238
26	5.04E-31	101-Site num 0||	BURPEN_B055	BURPEN_B056	BURPEN_B235	BURPEN_B082	BURPEN_B090	BURPEN_B084	BURPEN_B080	BURPEN_B021	BURPEN_B046
26	1.70E-30	52-Site num 0||	BURPEN_B005	BURPEN_B193	BURPEN_B194	BURPEN_B195	BURPEN_B091	BURPEN_B003	BURPEN_B181	BURPEN_B235	BURPEN_B066
26	1.91E-27	66-Site num 0||	BURPEN_B019	BURPEN_B181	BURPEN_B235	BURPEN_B169	BURPEN_B011	BURPEN_B060	BURPEN_B005	BURPEN_B004	BURPEN_B090
24	7.81E-35	78-Site num 0||	BURPEN_B031	BURPEN_B046						B018	BURPEN_B183
24	5.04E-31	102-Site num 0||	BURPEN_B056	BURPEN_B055						B079	BURPEN_B010
24	1.70E-30	165-Site num 0||	BURPEN_B193	BURPEN_B005						B082	BURPEN_B007
24	5.38E-28	166-Site num 0||	BURPEN_B194	BURPEN_B195						B039	BURPEN_B232
24	6.27E-27	65-Site num 0||	BURPEN_B018	BURPEN_B045						B084	BURPEN_B039
23	3.35E-30	1941-Site num 0||	WASA_1000	WASA_0999						00	WASA_1251
23	8.01E-30	85-Site num 0||	BURPEN_B039	BURPEN_B066						B235	BURPEN_B194
22	1.31E-35	1788-Site num 0||	WASA_0712	WASA_0714						21	WASA_0680
22	7.06E-33	1703-Site num 0||	WASA_0628	WASA_0752						23	WASA_0819B
22	3.35E-30	1940-Site num 0||	WASA_0999	WASA_1000						84	WACOOWES_0909
22	1.16E-28	49-Site num 0||	BURPEN_B002	BURPEN_B181						B173	BURPEN_B169
21	4.34E-33	1967-Site num 0||	WASA_1231	WASA_1257						41	WASA_0657
21	4.06E-31	1925-Site num 0||	WASA_0900	WASA_1017						57	WASA_1227
21	7.34E-31	1965-Site num 0||	WASA_1227	WASA_1231						ES_0919	WASA_1257
20	1.54E-31	131-Site num 0||	BURPEN_B090	BURPEN_B091						B019	BURPEN_B169
20	5.94E-26	895-Site num 0||	WACOOWES_0919	WASA_1017						00	WASA_1227
19	4.34E-33	1982-Site num 0||	WASA_1257	WASA_1231						51	WASA_1255
18	9.58E-32	164-Site num 0||	BURPEN_B192	BURPEN_B195						B039	BURPEN_B169
17	1.73E-28	1688-Site num 0||	WASA_0614	WASA_0605						20	WASA_0750
17	1.16E-26	883-Site num 0||	WACOOWES_0907	WASA_0705						ES_0909	WACOOWES_0902
16	7.16E-27	157-Site num 0||	BURPEN_B182	BURPEN_B084						B056	BURPEN_B018
15	3.68E-29	1784-Site num 0||	WASA_0708	WASA_0634	WASA_0712	WASA_0694	WASA_0714	WASA_0745	WASA_0743	WASA_0753	WASA_0732
14	6.67E-35	1752-Site num 0||	WASA_0677	WASA_0675	WASA_0618	WASA_0610	WASA_0676	WASA_0619	WASA_0606	WASA_0695	WASA_0678
14	1.28E-24	68-Site num 0||	BURPEN_B021	BURPEN_B082	BURPEN_B010	BURPEN_B066	BURPEN_B195	BURPEN_B046	BURPEN_B018	BURPEN_B066	BURPEN_B193
13	2.09E-26	153-Site num 0||	BURPEN_B173	BURPEN_B195						BURPEN_B192	BURPEN_B082
12	1.54E-31	132-Site num 0||	BURPEN_B091	BURPEN_B090						BURPEN_B066	BURPEN_B084
12	1.17E-30	91-Site num 0||	BURPEN_B045	BURPEN_B046						BURPEN_B194	BURPEN_B003
12	3.68E-29	1709-Site num 0||	WASA_0634	WASA_0708						WASA_0754	WASA_0740
12	2.96E-27	1933-Site num 0||	WASA_0962	WASA_1017						WASA_0684	WACOOWES_0919
12	9.58E-27	124-Site num 0||	BURPEN_B079	BURPEN_B084						BURPEN_B055	BURPEN_B005
11	1.31E-35	1790-Site num 0||	WASA_0714	WASA_0712						WASA_0636	WASA_0713
11	3.90E-26	234-Site num 0||	CAPPRE_M047	CAPPRE_M049						CAPPRE_M078	CAPPRE_M079
11	1.02E-25	58-Site num 0||	BURPEN_B011	BURPEN_B019						BURPEN_B004	BURPEN_B054
11	1.71E-24	110-Site num 0||	BURPEN_B064	BURPEN_B195	BURPEN_B181	BURPEN_B010	BURPEN_B084	BURPEN_B085	BURPEN_B031	BURPEN_B169	BURPEN_B003
11	1.10E-23	134-Site num 0||	BURPEN_B093	BURPEN_B082	BURPEN_B066	BURPEN_B193	BURPEN_B084	BURPEN_B085	BURPEN_B031	BURPEN_B090	BURPEN_B055



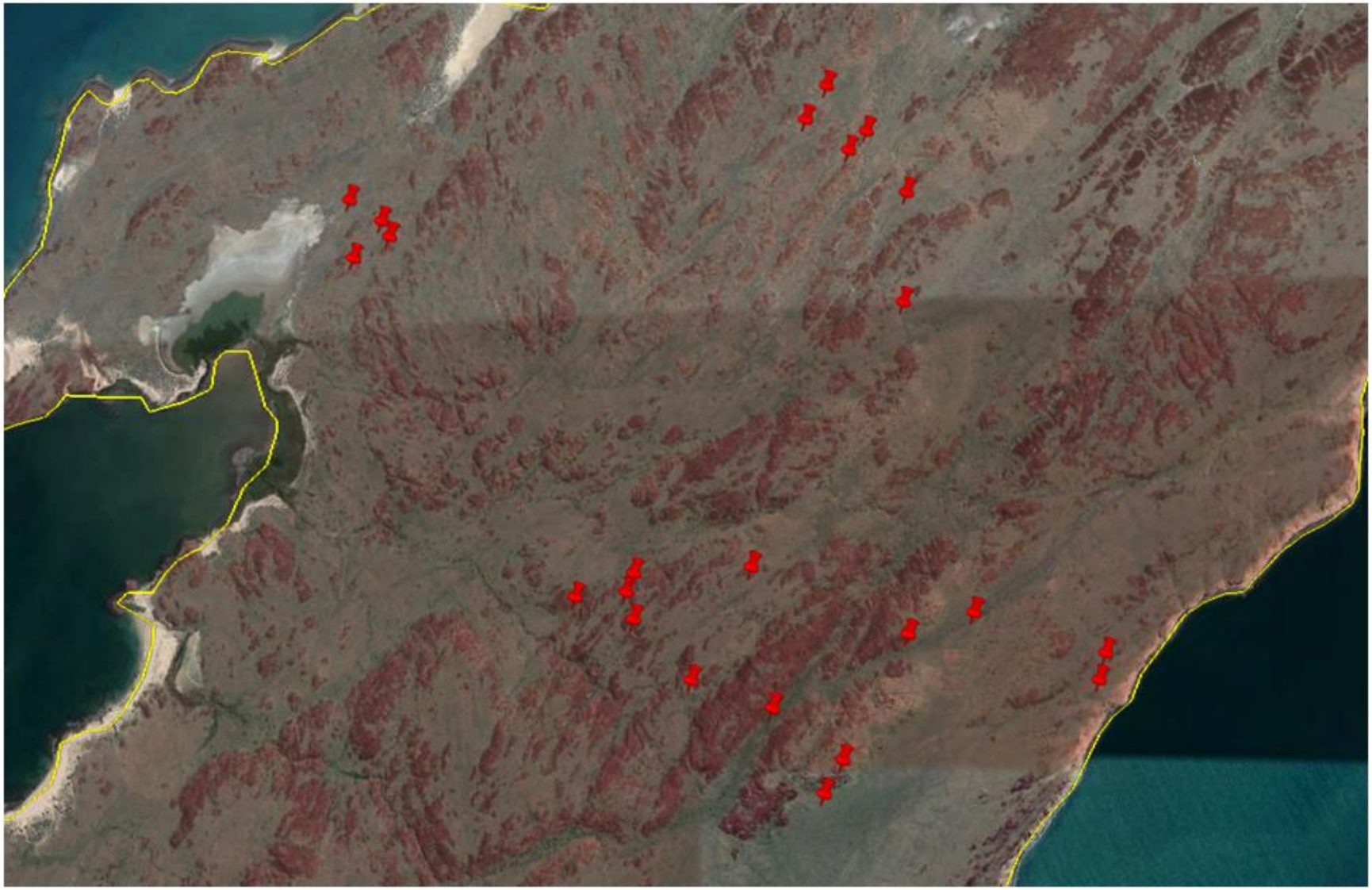
220 group classification of Pilbara data set
Sized to give no groups with only one site
Perennial species only
The fit of the number of sites/group to the Poisson distribution indicates the data is of good quality

It seems so; this was run before 38,000 corrections were made to the 8,000 site Pilbara data set.

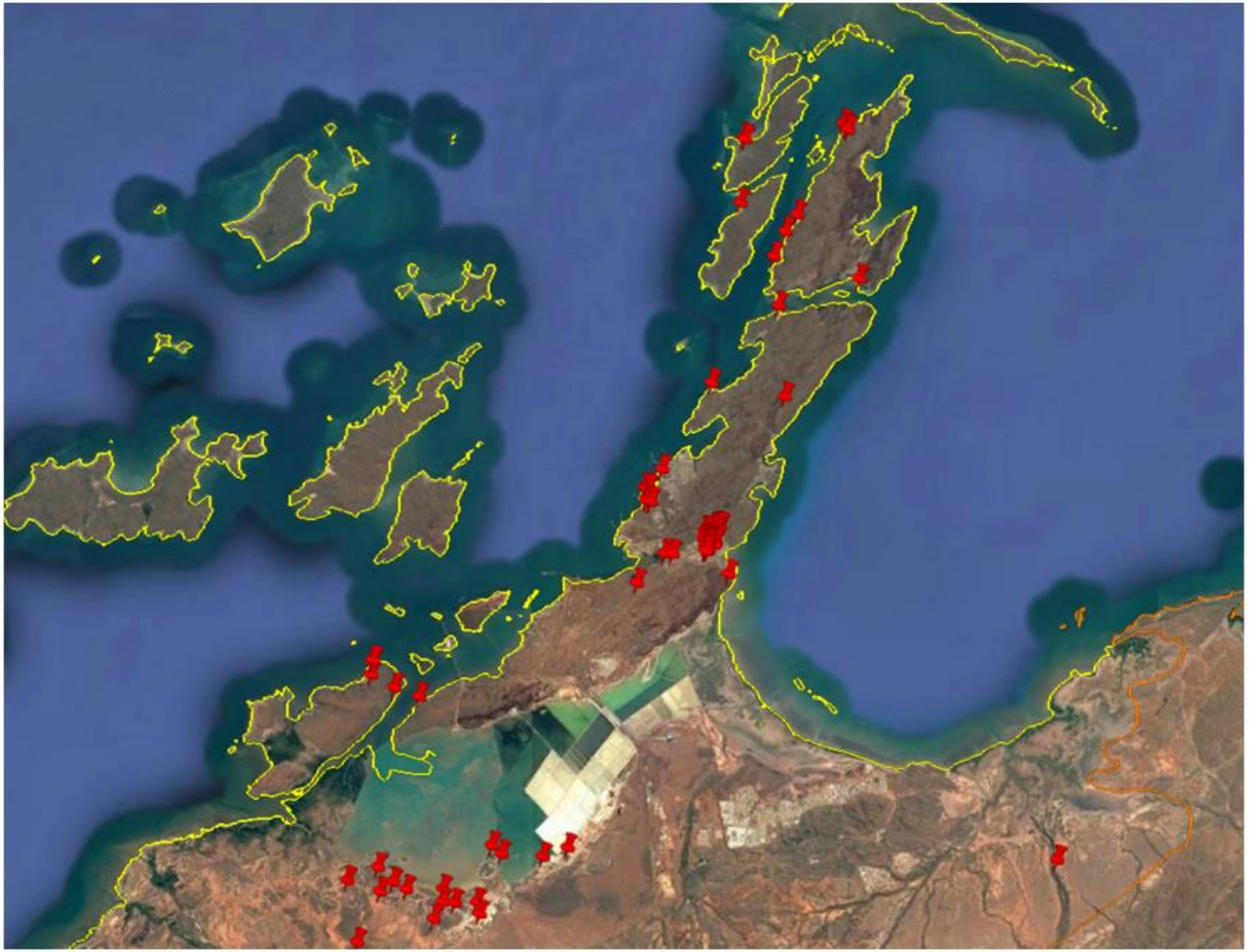


"Vegclust" ten group analysis of 8,054 Pilbara sites. One group is the slope and rock piles (boulder scree) on the Burrup Peninsula and adjoining islands and at a few rock piles at inland locations.

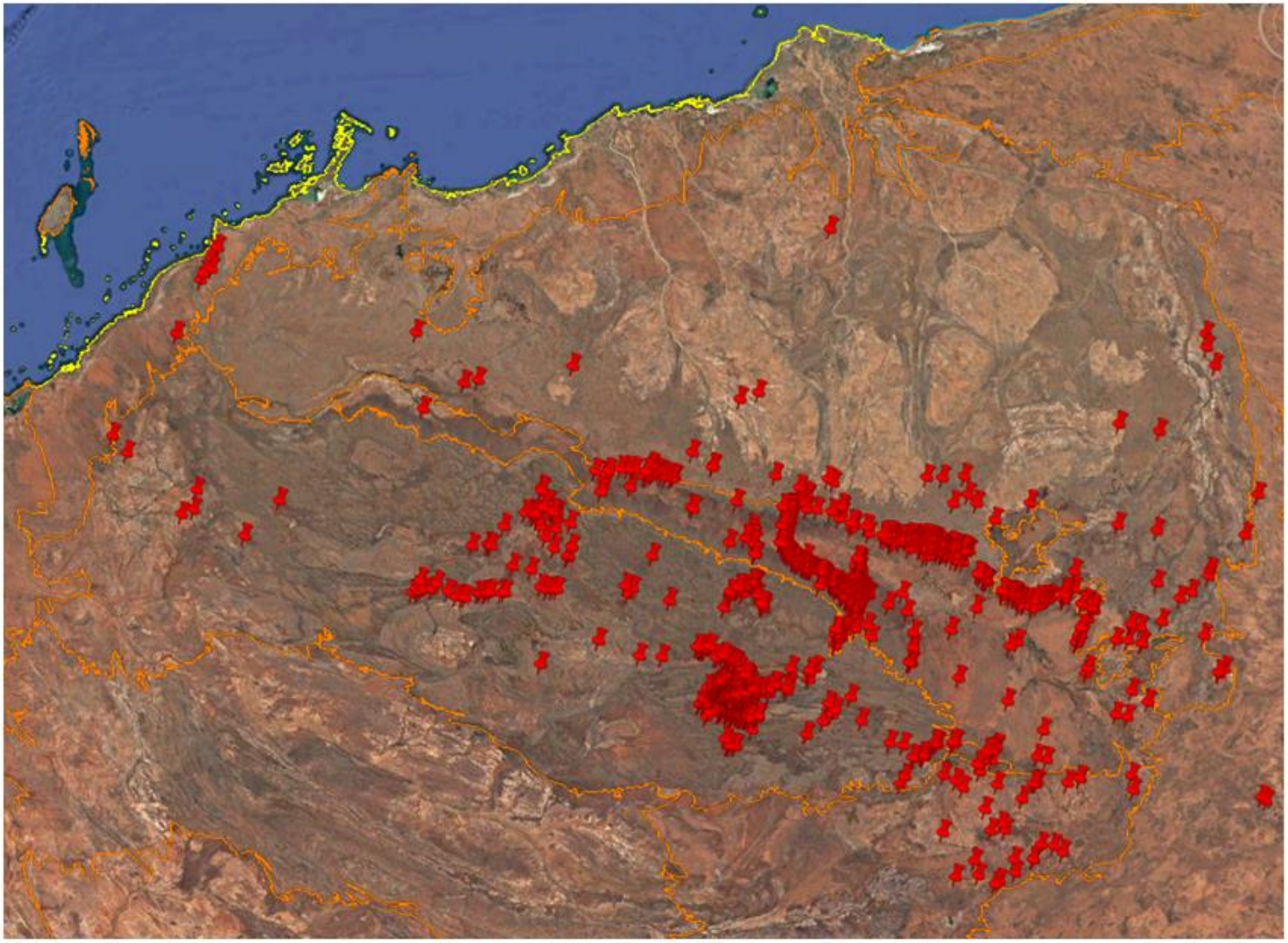
Obviously this Peninsula has very high conservation value for all vegetation types found there, they are very restricted, and highly diverse in detailed floristic analysis.



Closer view of Burrup Peninsula sites.

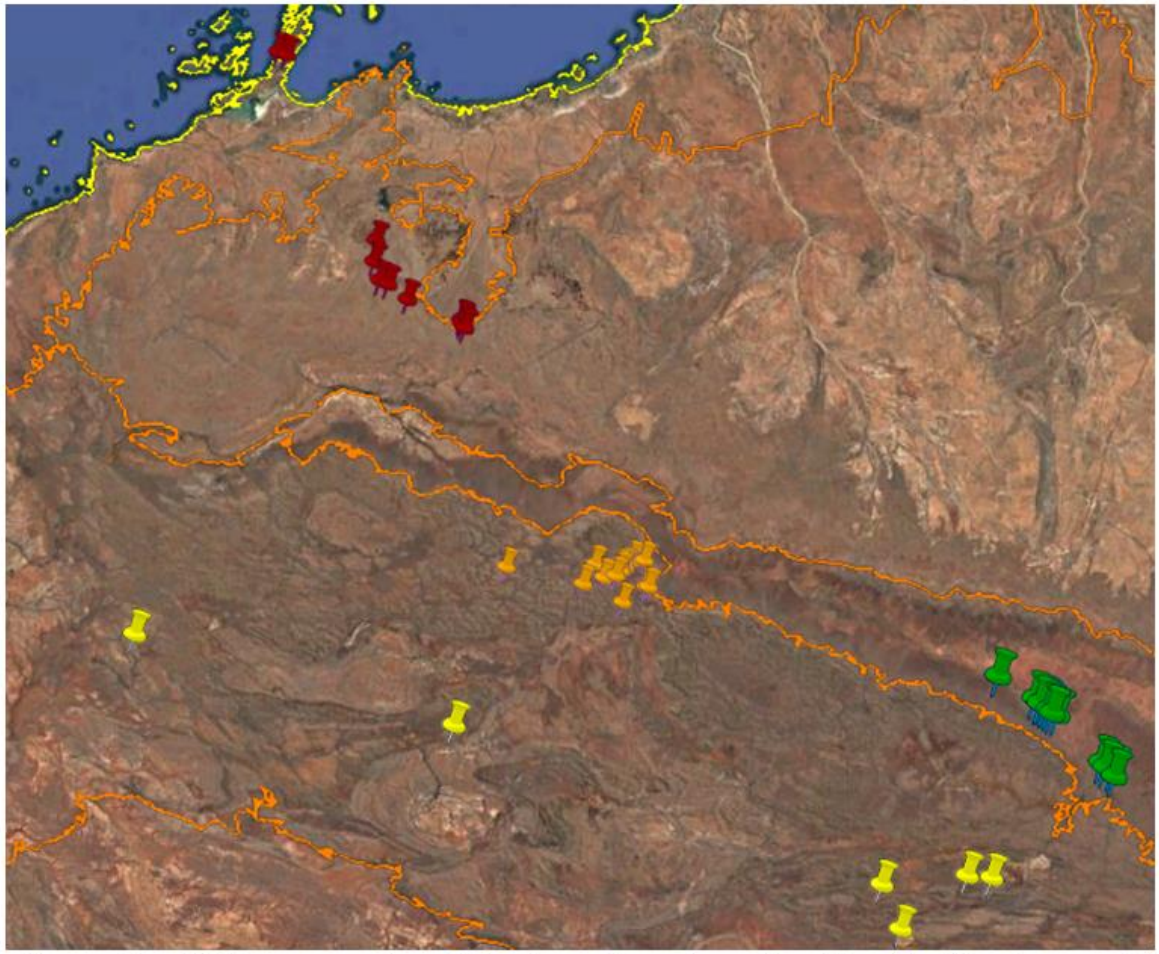


One other group at the ten group level has sites on the Burrup Peninsula. These are on the coastal sand. The unit extends along the coast and has some sites inland



"Vegclust" ten group analysis of 8,054 Pilbara sites. This group mainly the Hamersley Range and similar geology along the south edge of the Chichester Range (not the basalts!). Mostly Mulga (*Acacia aneura* group) sites.

Pilbara 800 group analysis. Red pins: sites from six surveys on basalt soils (cracking clays). Green pins: sites from three surveys, Mulga, mostly on slopes of Chichester Range.
[This is a different analysis using a KMeans implementation not vegclust]



Four groups from the 800 group classification. One localised in the Fortescue Valley. One localised in in the central Hamersley Range. One in the Chichester Range, but also with sites on the Burrup Peninsula. And one with sites scattered across the Hamersley Range. All with moderate numbers of sites. This is a from a fairly basic clustering methodology.

Where to from here?

Well, obviously more data entry and correction, followed by more robust analysis.

But then, who decides what should be acceptable for consultants to address as vegetation of conservation significance.

Are Government Departments too constrained?

Should professional bodies rise to the challenge of making data sets available and analyses practical for identifying vegetation of conservation significance?