



# Biodiversity-related Investigations Government Working Group (BIGWG)

## Summary

## Worsley Alumina



**bhpbilliton**  
resourcing the future

# Key factors

- Linkage of all the studies to provide robust data for analysis and landscape modelling
- Output of investigations
- Monitoring programs – short and long term
- Reporting process and structure
- Partnerships – Data gathering and sharing

# Linkage of all the studies

## Scope – Studies

- Vegetation mapping, including remnant vegetation, RFA vegetation complexes, detailed site vegetation types, poorly represented vegetation communities and other diverse ecotype zones
- Threatened species and ecological communities (registered and nominated)
- Key habitat required for the maintenance of the identified threatened species
- Topographical and drainage information
- Ground-water and surface-water dependent ecosystems, as well as areas potentially sensitive to 'upstream' hydrological changes
- Survey sites, transects, etc, used during the biodiversity investigations
- Key threatening processes (where geospatial information can be generated)
- Environmentally sensitive areas (ESA's)
- Formal and informal reserves, old growth forest and fauna habitat zones (FHZ's).
- Ecological Corridors
- Refine the definition of these corridors
- Undertake landscape modelling

# Threatening processes

- To be taken into account and considered with all the studies
  - Fire
  - Dieback
  - Weeds and Feral animals
  - Climate Change
  - Mining

## Climate change - proposed approach

- Literature review.
- Gather and analyse historical data.
- Undertake climate change modelling to assess likely impacts on flora and fauna.
- Establish long-term monitoring program.
- See example of Hydrological proposal (WEC)



# Output of investigations

- Maps
- Reports
  - The *Biodiversity-related Investigations Report* will be submitted to the Minister for the Environment for endorsement following completion of the investigations and prior to the lodgement of the draft Bauxite Mine Plan and the commencement of ground-disturbing activities relating to construction or mining. (*Ministerial Condition 719:M8-6*)
- Data
- Modelling results

# Monitoring programs

## Objectives

- The main objectives are to identify suitable indicators, parameters or criteria to be used in measuring maintenance of the key biodiversity values identified, and ongoing monitoring requirements. Long-term monitoring will also assess the effects of climate change
- The ongoing review and analysis of the results from the monitoring programs will be used to inform the ongoing review of biodiversity management, including rehabilitation prescriptions, thus providing the basis for adaptive management

# Modelling parameters

- Relevant parameters for the key biodiversity values
- Changes in the distribution of forest disease and weeds
- Changes in the occurrence of pest species
- Groundwater standing water levels and quality, and stream levels/flows and quality
- Vegetation health and condition, which may include the use of remote sensing techniques (e.g. LANDSAT, digital aerial photography, etc) and/or modern leaf reflectance techniques)
- Relevant bio-indicators, which will be developed specifically for both faunal and botanical values, covering species with a range of attributes, such as life histories and habitat specificity. In identifying the bio-indicators, their suitability for assessing the following factors will be considered:
  - direct and indirect impacts of mining
  - impacts of key threatening processes
  - effects of climate change
  - rehabilitation success.
- Worsley will consult with the EMLG during the process of identifying relevant monitoring parameters

# Annual Reporting to EMLG

- The results of the investigations will be reviewed and interpreted after each field season and the findings will be included in Worsley's Annual Environmental Report which is submitted to the EMLG in September of each year



# Partnerships

## Scope

- As part of these biodiversity-related investigations, opportunities may arise for Worsley to develop working partnerships to undertake collaborative studies with other organisations, companies, environmental groups, research institutions or government agencies
- Whilst outside the requirements of Ministerial Statement 719, establishing partnerships with key bodies or organisations may facilitate the collection and interpretation of regional environmental information that could be beneficial to the wider community or other stakeholders
- Through the implementation of these biodiversity-related investigations, Worsley will identify key partnership opportunities and establish collaborative study programs where appropriate to investigate further matters of regional significance
- Issue - There are a number of issues with obtaining data from various agencies and organisations which we are endeavouring to resolve however Worsley seeks the support and cooperation from members of BIGWG to assist with the provision of data relating to the project area

# Biodiversity Investigations Government Working Group



Thank you

# Agenda

- BIGWG and Group introductions
- Background presentation, role of the EMLG and outline of meeting
- Presentations from individual specialists
- Discussion topics arising from investigations to date:
  1. Investigations area - buffer width - DEC
  2. Fauna trapping methodologies -
  3. Definition of stream dependant ecosystems - scope
  4. Southern envelopes flora and fauna surveys – access issue
  5. Key ecological linkages definitions to be finalised - scope
- Action items for the next meeting
- Summary and Close

# Role of the BIGWG

## Biodiversity Investigations Government Working Group

- A sub-committee of the Worsley Environmental Management Liaison Group (EMLG)
- Review the proposed biodiversity-related investigations Process and advise the EMLG accordingly
- Reports directly to the EMLG:
  - On development of the *draft* Scope (completed)
  - During implementation of *revised* Scope
- Comprises expert representatives of the Worsley EMLG member agencies
- Provides specific advice and guidance on technical and policy aspects of the biodiversity-related investigations



# Role of the BIGWG

- Biodiversity-related Investigations Report to be submitted to Minister for Environment for endorsement (on advice of EPA, DEC & Conservation Commission WA)



# Role of the BIGWG

## Worsley approach

- Involve key Government agencies in technical review of progressive results (vs. final report)
- Present findings to EMLG (and other stakeholders) at annual BIGWG workshop
- Seek feedback on previous findings
- Mechanism for changes to biodiversity-related investigations based on findings
- Circulate draft Biodiversity-related Investigations Report for BIGWG review prior to submission to the Minister for Environment

## Biodiversity Working Group (BWG)

- Worsley
- Strategen
- Bennett Environmental Consulting/Mattiske Consulting - Flora
- Bamford Consulting Ecologists - Fauna
- Water & Environmental Consults - Hydrological
- Curtin University of Technology - Landscape Ecology

## Biodiversity Investigations Government Working Group (BIGWG)

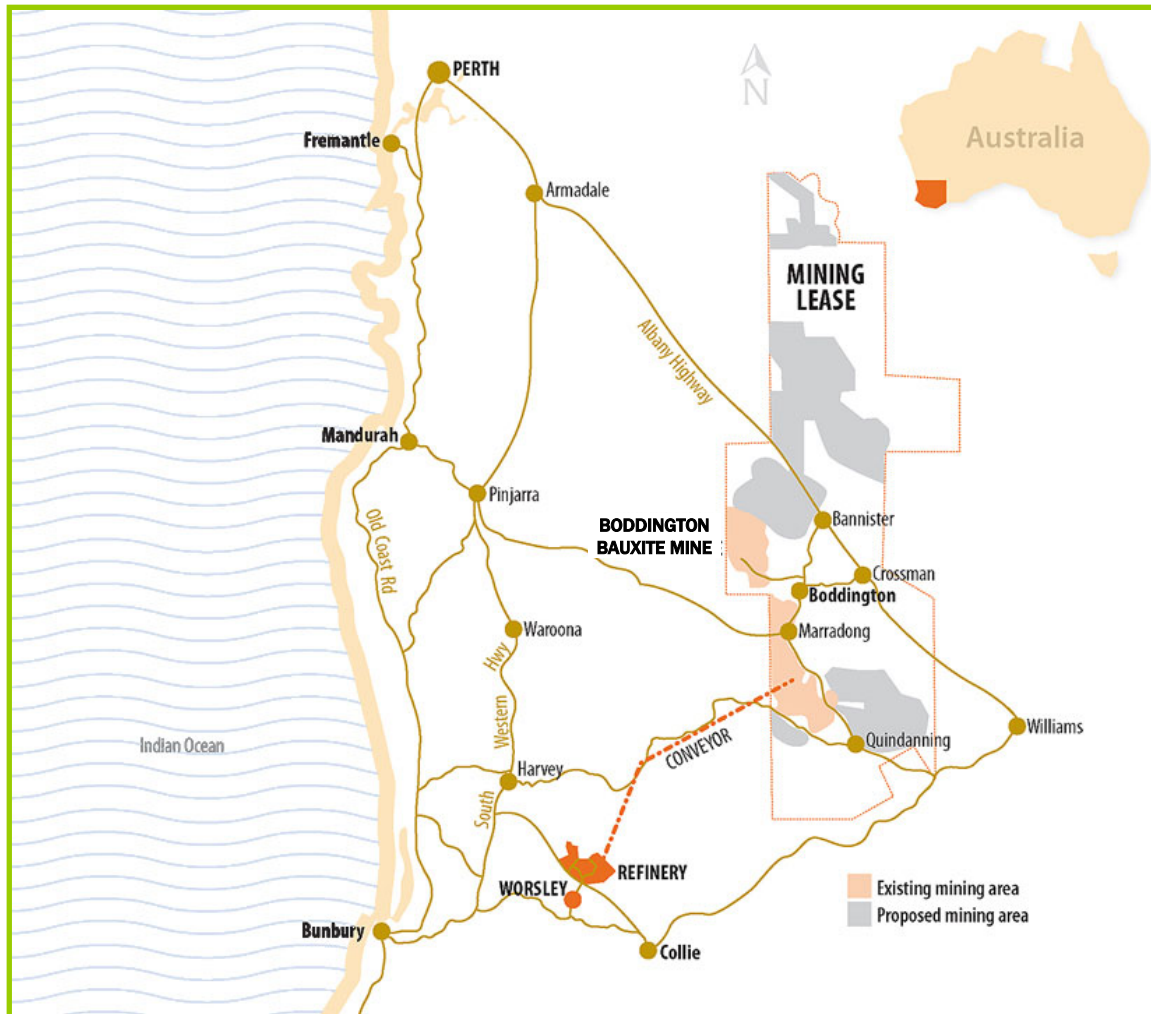
- Department of State Development – (Chair)
- Department of Environment and Conservation
- Department of Water
- Department of Agriculture and Food WA
- Museum of WA
- Department of Mines and Petroleum

# Background - approval status

- Under Worsley State Agreement (requiring approval to enter Helena River catchment)
  - Granted in January 2006 and subject to compliance with Environmental Approval Conditions
- Under EPA Act
  - Granted April with conditions
- Under EPBC Act
  - Approval with conditions received June 2007



# Worsley expansion



# Environmental approval conditions

- Standard conditions relating to implementation and compliance audit and review
- Standard (industry) conditions relating to greenhouse gas and decommissioning
- Specific key factor conditions relating to:
  - Management and protection of biodiversity
  - Development of transport corridor and mining plans
  - Rehabilitation management
  - Water supply protection (specific to public water supply catchments)
  - Air quality management

# Biodiversity related conditions

- Biodiversity related investigations – conditions 8-1 to 8-6
  - Requirement to have a scope of investigations endorsed by Minister for the Environment (completed April 2008)
  - Conduct investigations
  - Requirement to prepare a biodiversity related investigations report to be endorsed by the Minister

## Biodiversity protection conditions

- Outcome based conditions for key values known and understood now – e.g. avoidance of poorly represented vegetation complexes or heath land
- Establishes protection mechanisms for issues to be determined by investigations – e.g. significant habitat identified
- Biodiversity protection conditions to be incorporated in transport corridor route plans and mining plans required by conditions 10 and 11
- Rehabilitation plan to be prepared for new mining areas

# Environmental Management Liaison Group

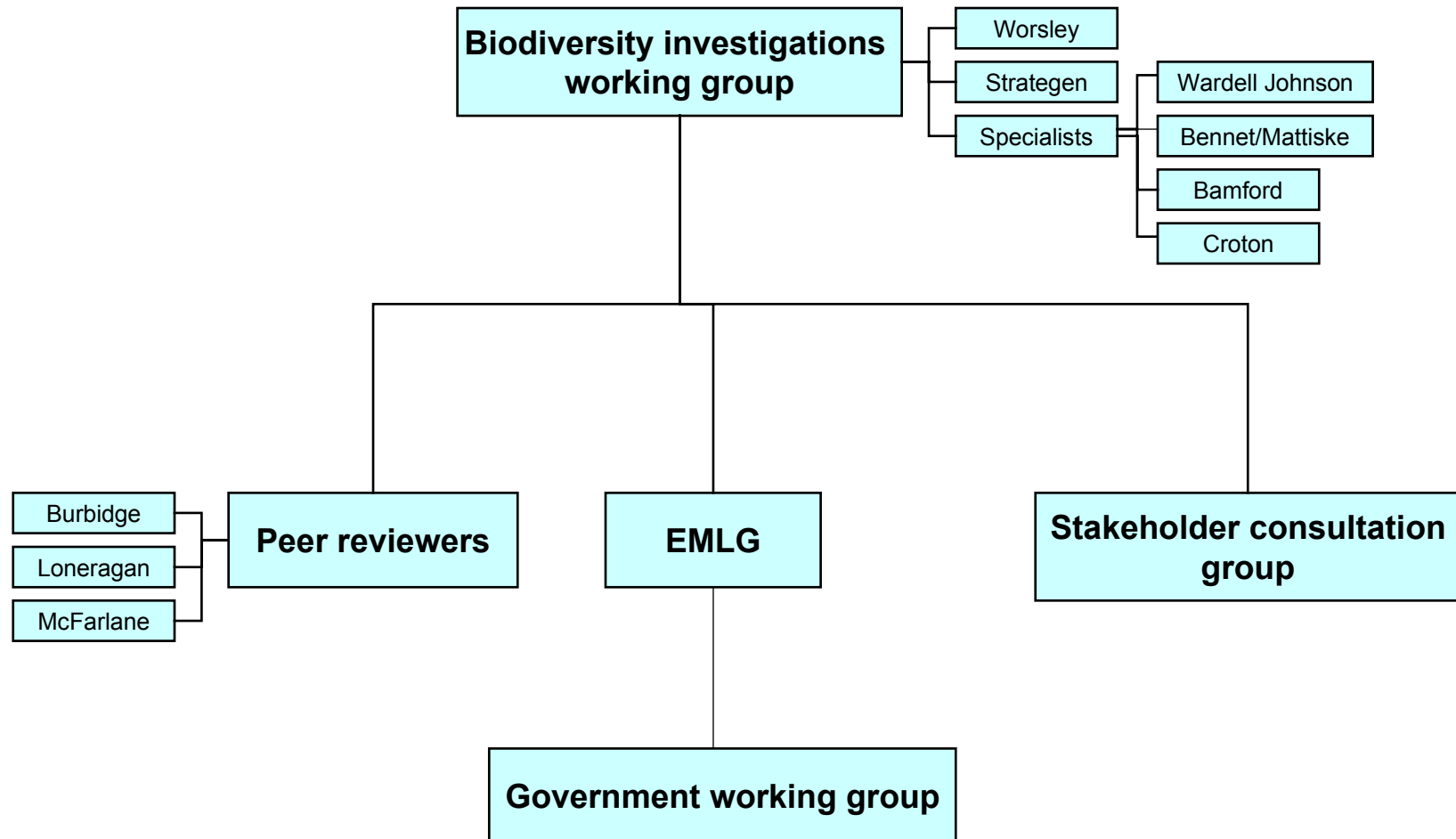
- EMLG established in 1996 following Statement 423. Greater role for the group now required by Statement 719
- Membership
  - Key agencies involved to date have been DoIR, DoE, CALM, DoA, WRC (DoIR, DEC, DAFWA, DoW)
  - Allows other agencies to be involved or to become members of the EMLG as required

## Prescribed function

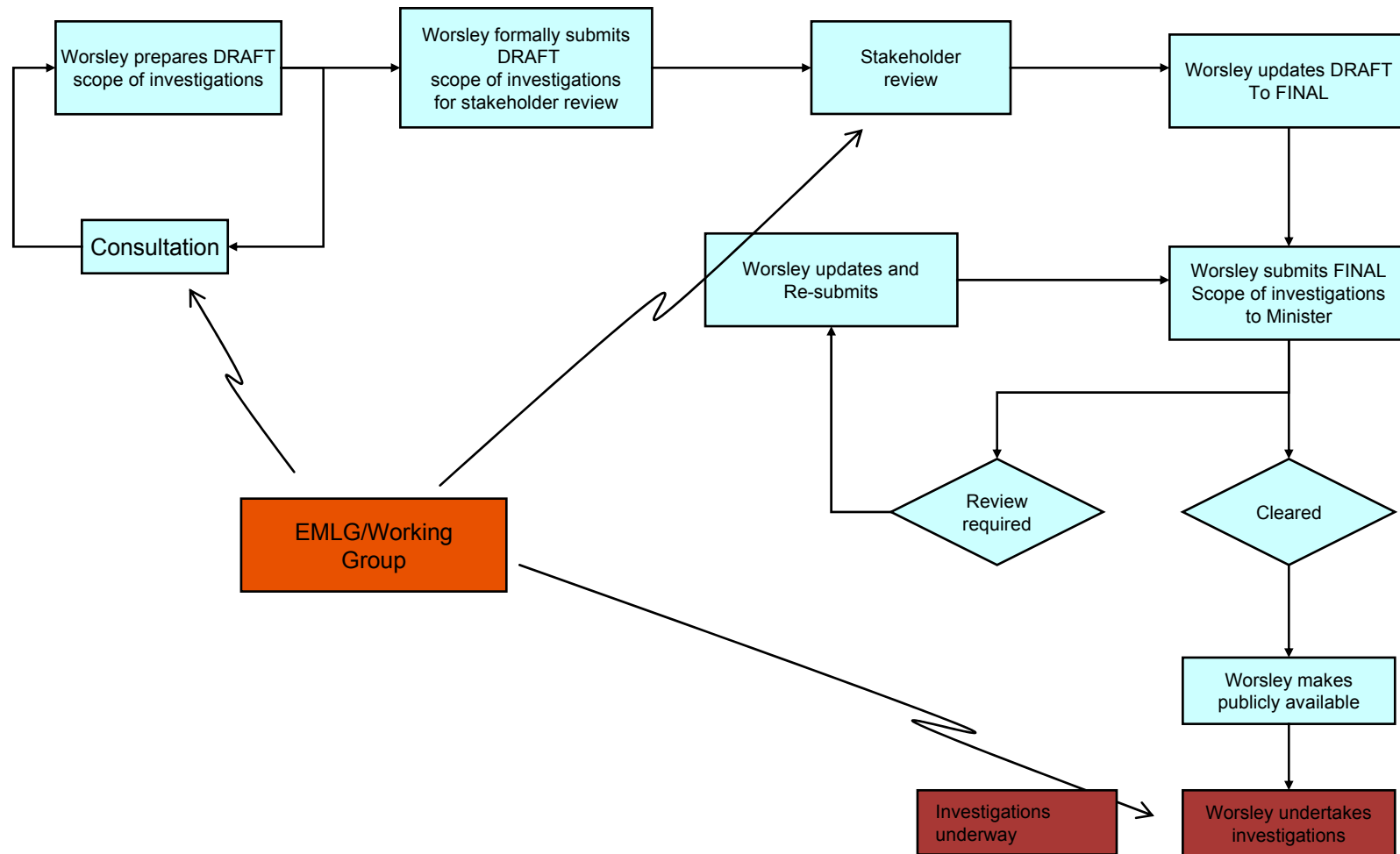
- Review of draft scope of investigations
- Review of draft rehabilitation plan
- Review of draft bauxite mining plans
- Review of rolling Ten Year Mine Plans (Agreement Act)
- Review of environmental performance



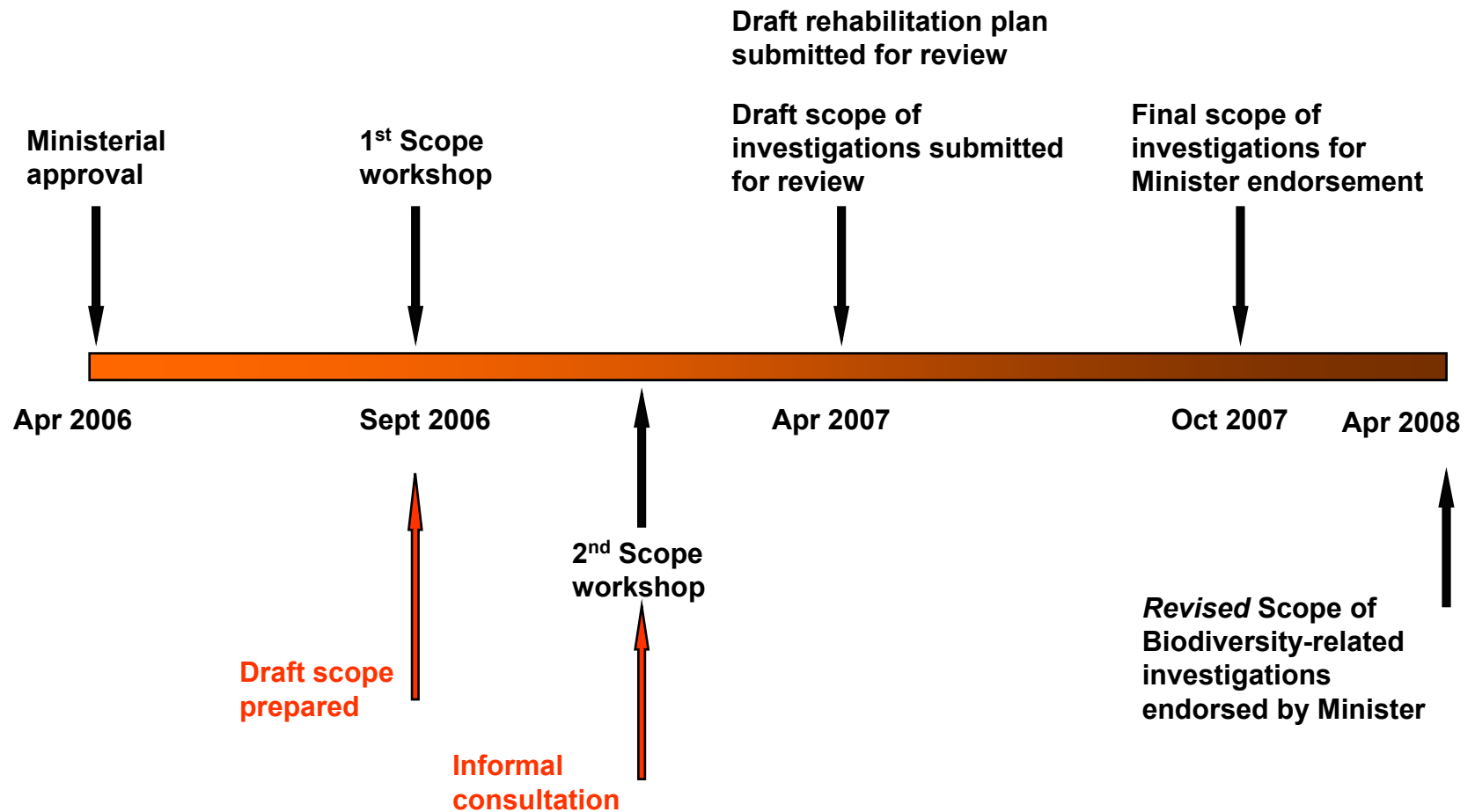
# Managed process



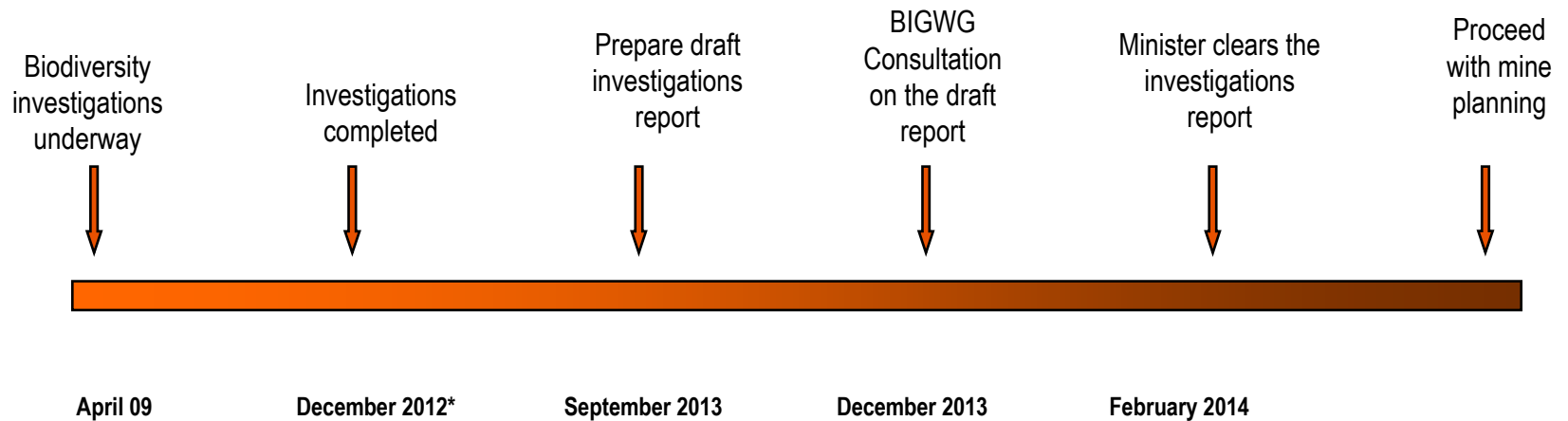
# Scope of biodiversity investigations



# Schedule and status 06/07



# Revised schedule and status 09



\* Subject to private property access

# Biodiversity Investigations Status (scope)

## Hydrology and Landform objectives

- To characterise the landform (*Condition 719:M8-1(7)*)
- To determine groundwater systems and the occurrence and distribution of groundwater-dependent ecosystems (*Condition 719:M8-1(11)*)
- To determine stream flow and quality, and stream-dependent ecosystems (*Condition 719:M8-1(12)*)

# Flora and Vegetation Objectives

- To determine the occurrence and spatial extent of floristic and vegetation communities at the local and regional scale (*Condition 719:M8-1(1)*)
- To establish the condition of floristic and vegetation communities identified in 1 above (*Condition 719:M8-1(2)*)
- To determine the occurrence and spatial extent of TECs including nominated TECs (*Condition 719:M8-1(3)*) within new mining envelopes and bauxite transport corridors and adjoining areas and as appropriate at the local and regional scale
- To determine the occurrence and extent of Declared Rare and Priority Flora pursuant to the *Wildlife Conservation Act 1950* and other Priority Flora as identified in the database maintained by the Department of Conservation and Land Management (*DEC*) (*Condition 719:M8-1(4)*) within new mining envelopes and bauxite transport corridors and adjoining areas
- To determine the occurrence, severity and spatial extent of forest disease and the potential for the spread of forest disease (*Condition 719:M8-1(6)*) within new mining envelopes and bauxite transport corridors and adjoining areas
- To investigate the weed and pest severity status in State Forest (*Condition 719:M8-1(13)*) within new mining envelopes and bauxite transport corridors and adjoining areas

# Fauna Objectives

- To identify and define the spatial extent of fauna habitat, including specifically, habitat for Threatened, Priority listed and other significant Fauna, and significant Short Range Endemic fauna, and other significant invertebrate taxa (*Condition 719:M8-1(8)*) within new mining envelopes and bauxite transport corridors and adjoining areas
- To determine the occurrence and abundance within the new mining envelopes and bauxite transport corridors and adjoining areas of:
  - Vertebrate fauna, including specifically, threatened fauna as defined in the *Wildlife Conservation Act 1950* or the Commonwealth EPBC Act
  - Priority fauna as defined and listed by the Department of Environment and Conservation
  - Obligate tree hollow nesting or roosting species
  - Species requiring specialised habitats or resources, including Honey Possums (*Condition 719:M8-1(9)*)
- To define the occurrence and abundance of significant Short Range Endemic and other significant invertebrate taxa (*Condition 719:M8-1(10)*) within new mining envelopes and bauxite transport corridors and adjoining areas

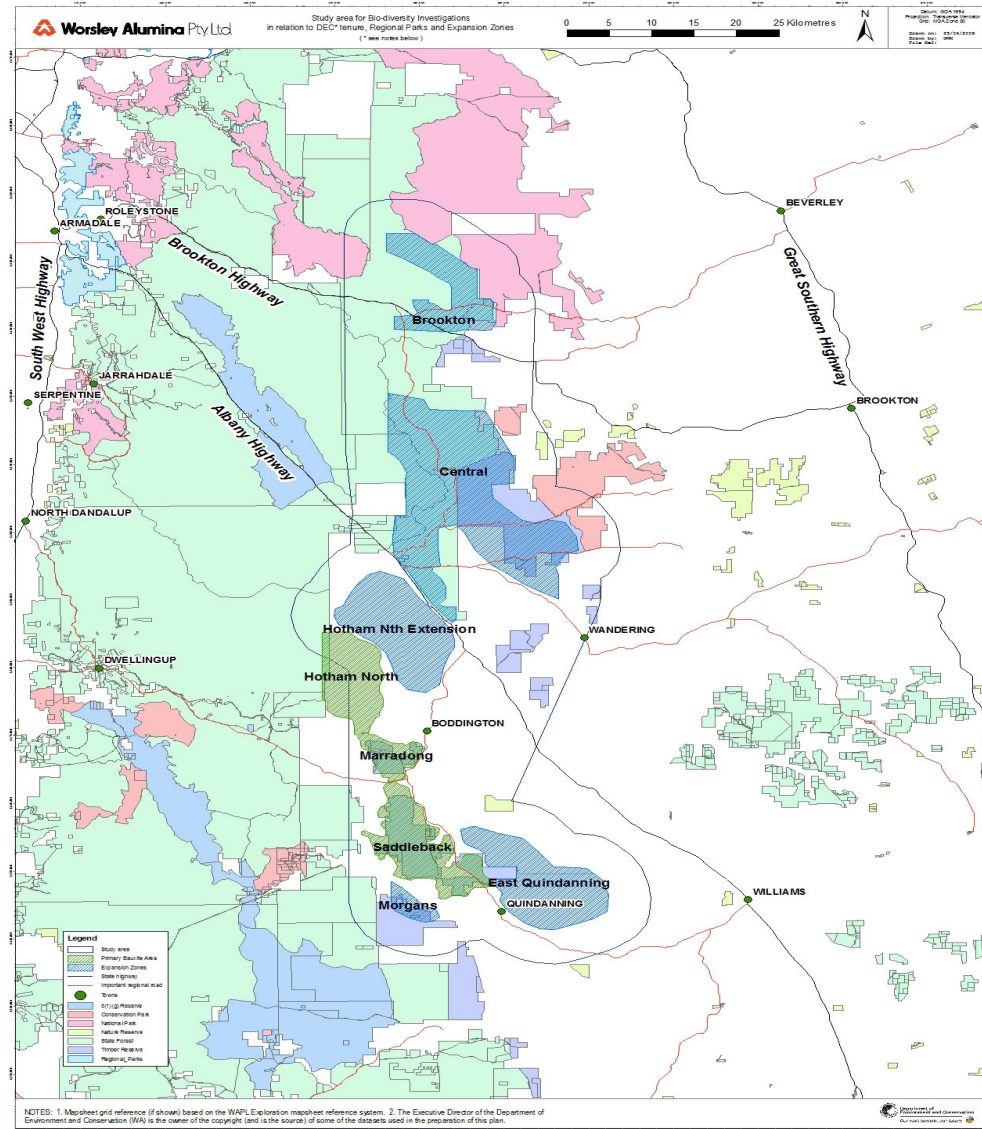
# Ecological Linkages and Landscape

## Study objectives:

- To identify the role and significance of ecological linkages (*Condition 719:M8-1(5)*)
- To identify the ecological linkages on surveyed plans (as required in the Biodiversity-related Investigations Report by *Condition 719:M8-6(5)*)
- To identify the key ecological linkages, in consultation with the EMLG



# Proposed Study area



# Threatening processes

- To assess the relative and cumulative impacts on biodiversity values of the following:
  - forest disease (after *Condition 719:M8-1(6)*)
  - weed and pest severity status (including feral animals) (after *Condition 719:M8-1(13)*)
  - habitat fragmentation
  - fire
  - mining activities and other human impacts (including bee-keeping, logging etc.).
- To assess the impacts on biodiversity values of:
  - climate change (after *Condition 719:M8-1(14)*)

# Specialist presentation format

- Outline baseline data
- Study objectives
- Key results of recent studies
- Critical issues
- Examples of mapping including possible ecological corridors
- Future study requirements
- Suggested survey methodologies for the future studies

# Specialist presentations

- **Flora studies**  
Eleanor Bennett of Bennett Environmental Consulting
- **Fauna studies**  
Mike Bamford of Bamford Consulting Ecologists
- **Hydrological Studies**  
James Croton of Water and Environmental Consultants
- **Landscape Ecology**  
Grant Wardell-Johnston of Curtin University of Technology

# Fauna Investigations in the Worsley Northern Expansion Area; 2004-2009

**MIKE BAMFORD**

**WES BANCROFT**

**MAT BROOK**



Bamford  
Consulting  
Ecologists

Strategen

# Objectives of fauna investigations

(ministerial condition 719: M8-1)

## Broadly:

Document fauna assemblage and investigate occurrence, abundance, patterns of distribution, habitat. Focus on significant species.

Identify significant habitats and recognise species dependent on these (eg. obligate hollow nesting species).

Include SRE invertebrates.

Processes (fire, hydrology, climate change, feral species, ecological linkages).

Provide information for landscape ecology modelling and to recognise bio-indicators for impact assessment/monitoring

# Approach to Investigations

Desktop review

Transect sampling (pitfalls and bird censusing); patterns of distribution across lease and across catenary sequence

Elliott and cage trapping for CWR mammals

Black-cockatoos (continuous recording and nest-searching)

Brush Wallaby (continuous recording)

Aural surveys for frogs (hydrology; climate change bio-indicators)

SREs from pitfalls and searching

Spotlighting (significant owls and mammals)

Phascogale nest boxes

Bats

## Fauna assemblage

Rich due to size of area, topographic variation and biogeographic range. Wheatbelt element well-represented

### Vertebrates

Frogs:	11	(16)
Reptiles:	33	(57)
Birds:	81	(114)
Mammals:	24	(32)

### Potential SRE invertebrates

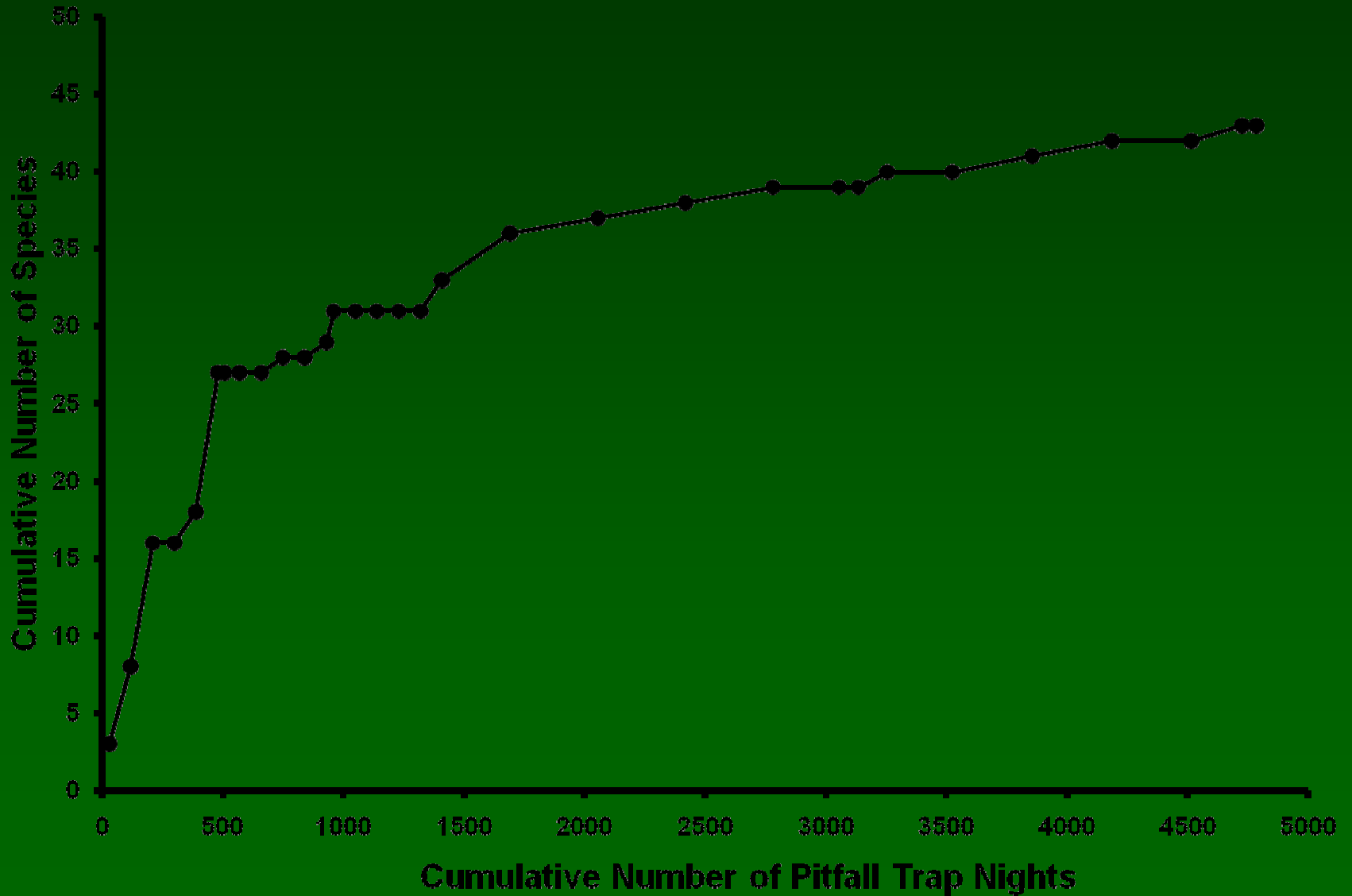
Mygalomorph spiders (6 species)

Scorpions (3 species)

Pseudoscorpions and millipedes target of 2009 studies



# Species accumulation curve for pitfall sampling (frogs, reptiles and small mammals)



## Significant species (recorded)

Reptiles: Carpet Python, Darling Range Ctenotus

Birds: black-cockatoos, Peregrine Falcon, species threatened in wheatbelt, Barking Owl

Mammals: Chuditch, Quenda, Red-tailed Phascogale, Tammar

Invertebrates: trapdoor spider *Gaius aff. villosus*

Also many species on edge of range

## Summary: Trapping effort and results

### Sampling effort

Pitfall traps	4800	823 captures
Cage and Elliott traps	2750	44 captures
Bird censussing	7800	4738 records
Frog aural records	4	205 records
Brush Wallaby	opp	65 sightings
Carnaby's Black-Cockatoo	opp	38 sightings
Red-tailed Black-Cockatoo	opp	20 sightings
Baudin's Black-Cockatoo	opp	3 sightings
Peregrine Falcon	opp	2 sightings
Spotlighting		1 Barking Owl

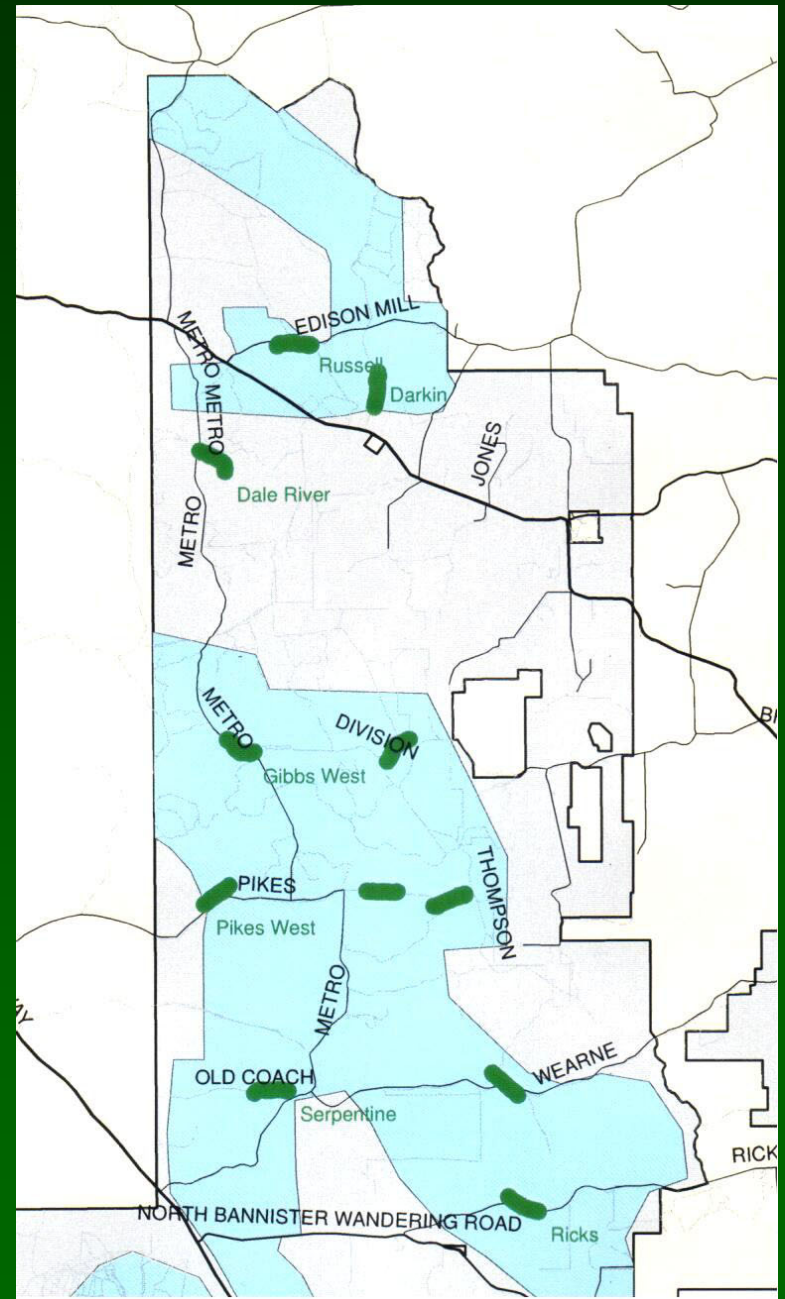
# Transect sampling

Each transect 30 pitfall/  
census points

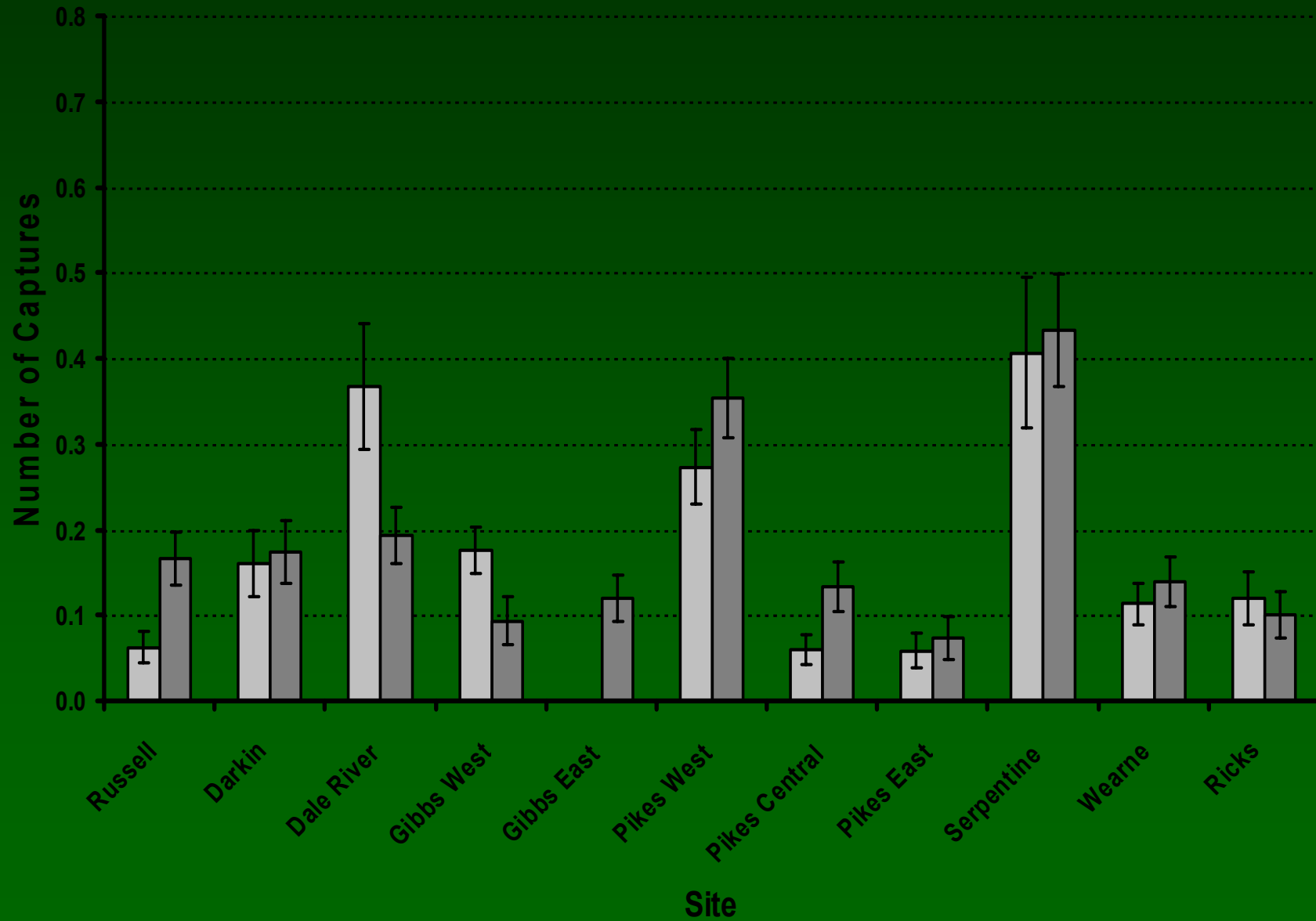
Transects spread across project  
area

Each transect from low to high in  
landscape

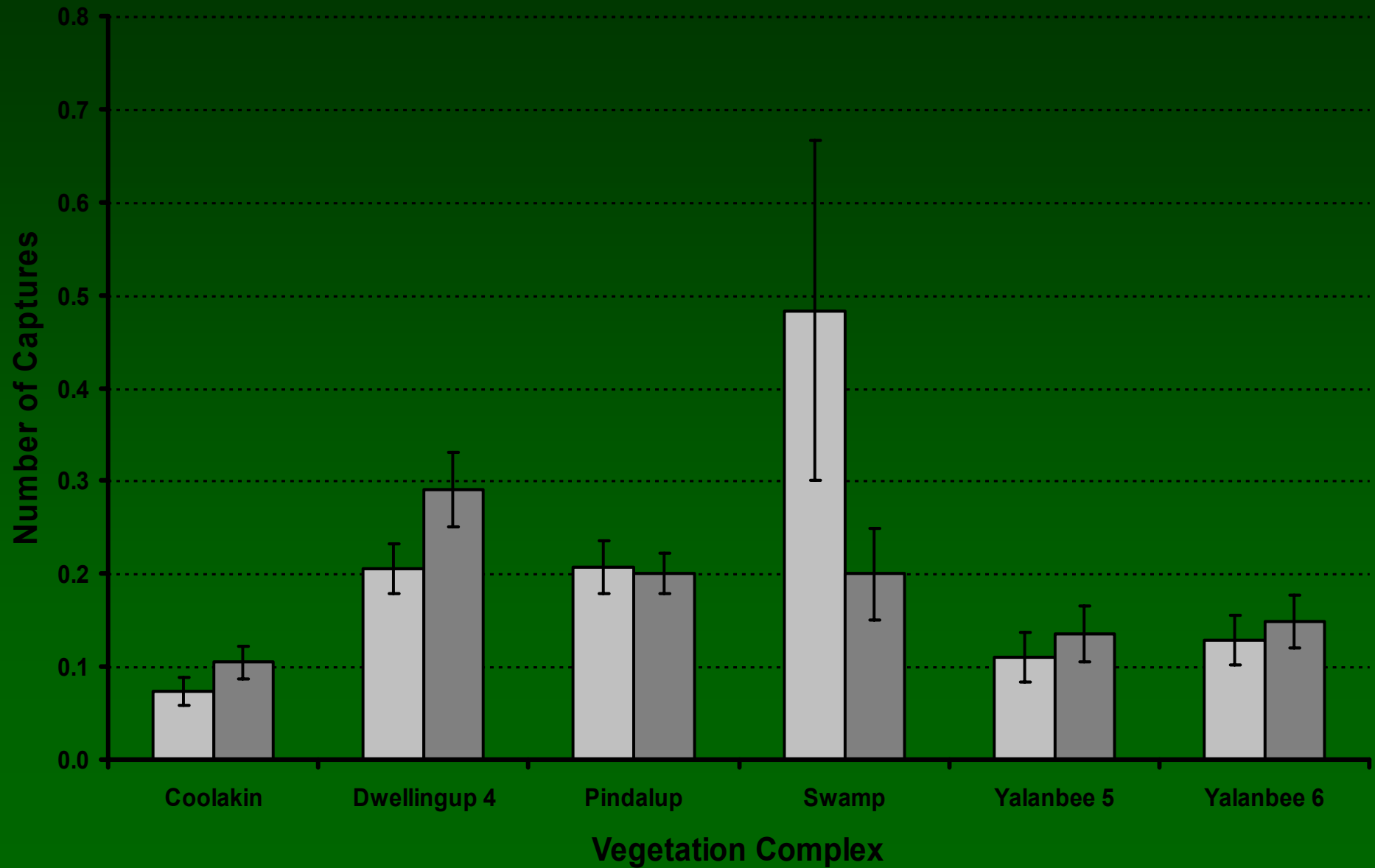
Data from transects can be  
analysed to examine patterns of  
distribution in many ways  
(species groups, wrt vegetation,  
individual species, across whole  
site, within a transect)....



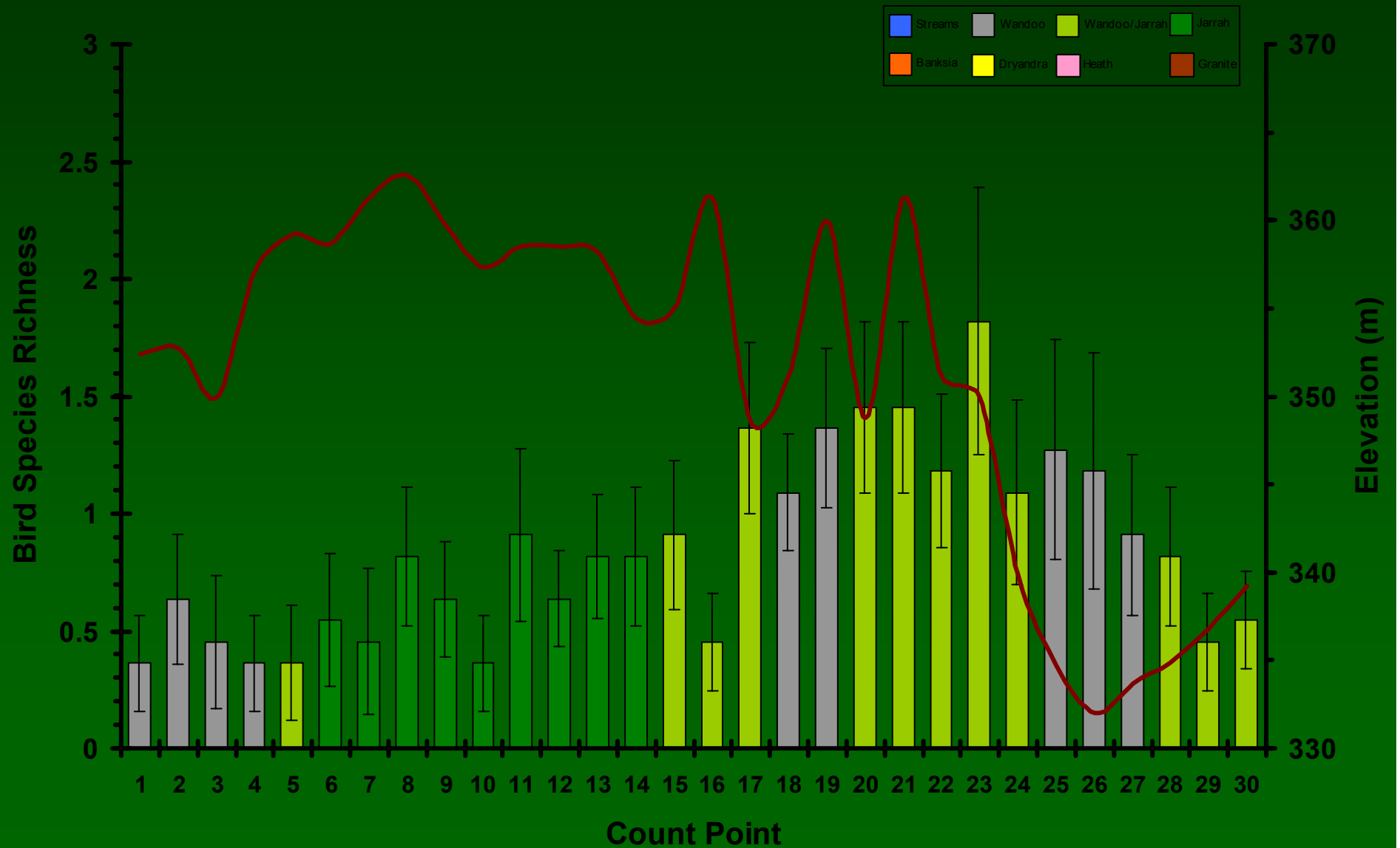
# Transects: mean captures per pitfall



# Transects: Mean captures/pitfall versus vegetation complex

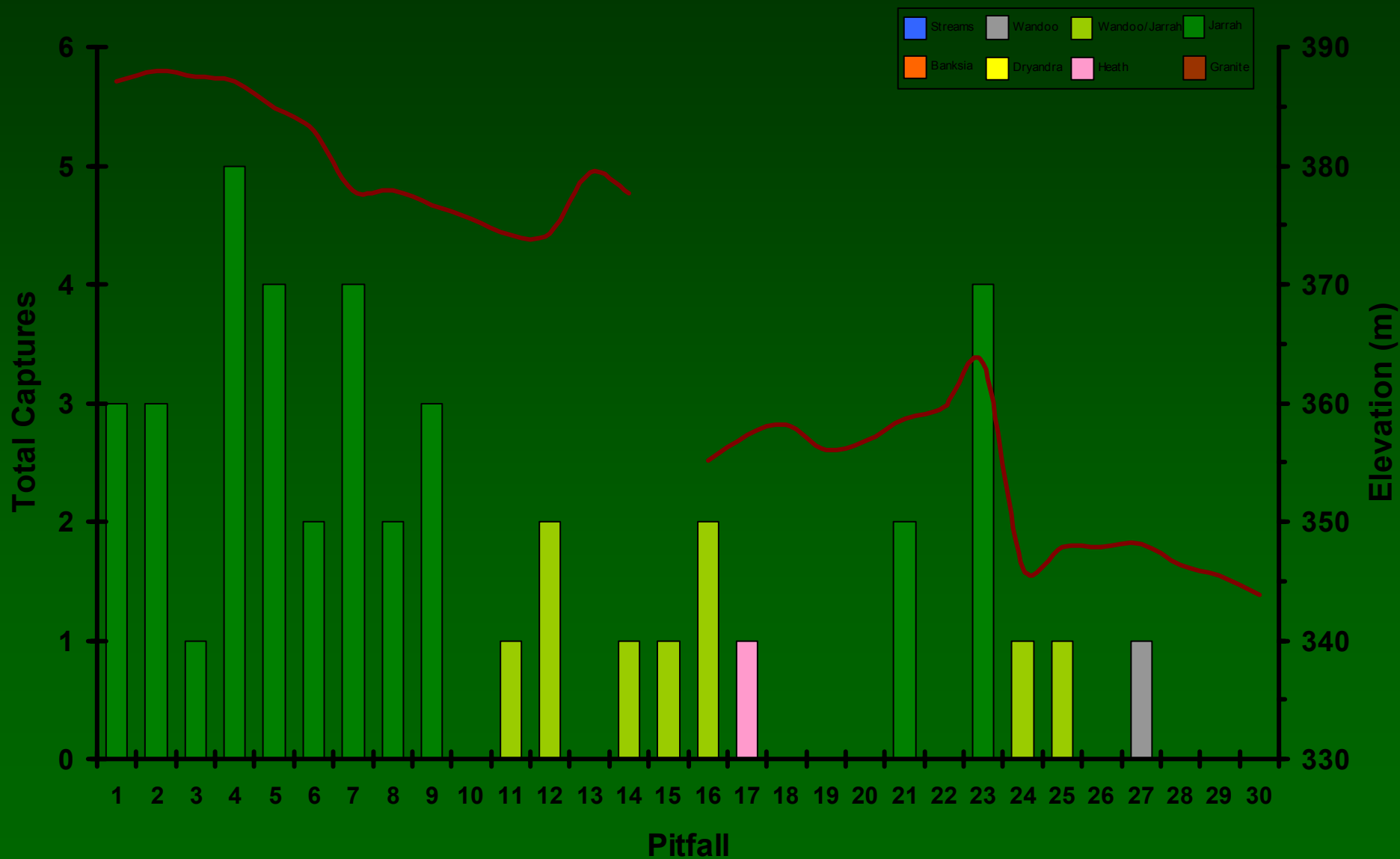


# Transects: daily bird species richness per sampling location on Rick's Transect

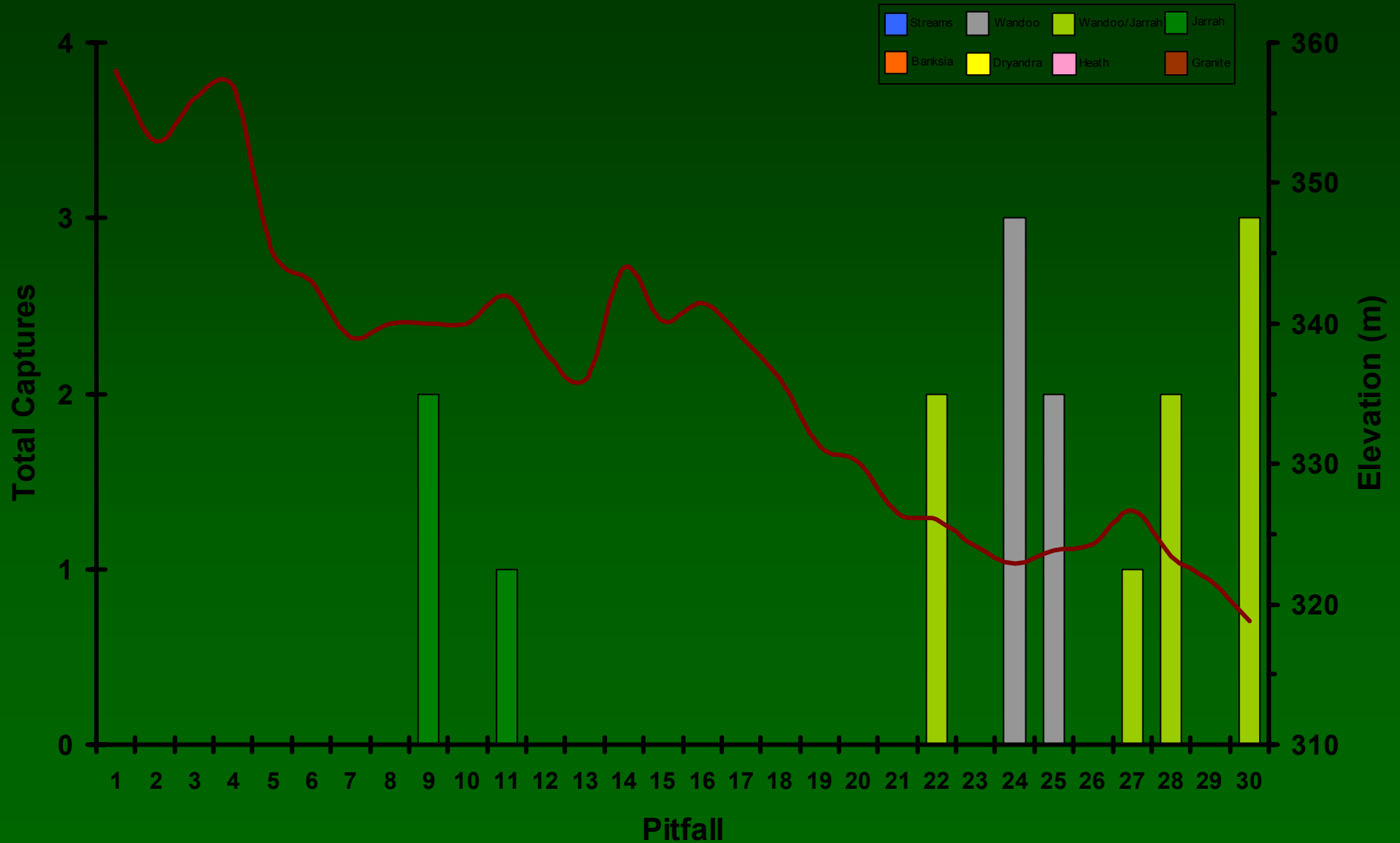




# Transects: *Morethia obscura* numbers caught along Serpentine Transect



# Transects: *Sminthopsis gilberti* numbers caught along Darkin Transect



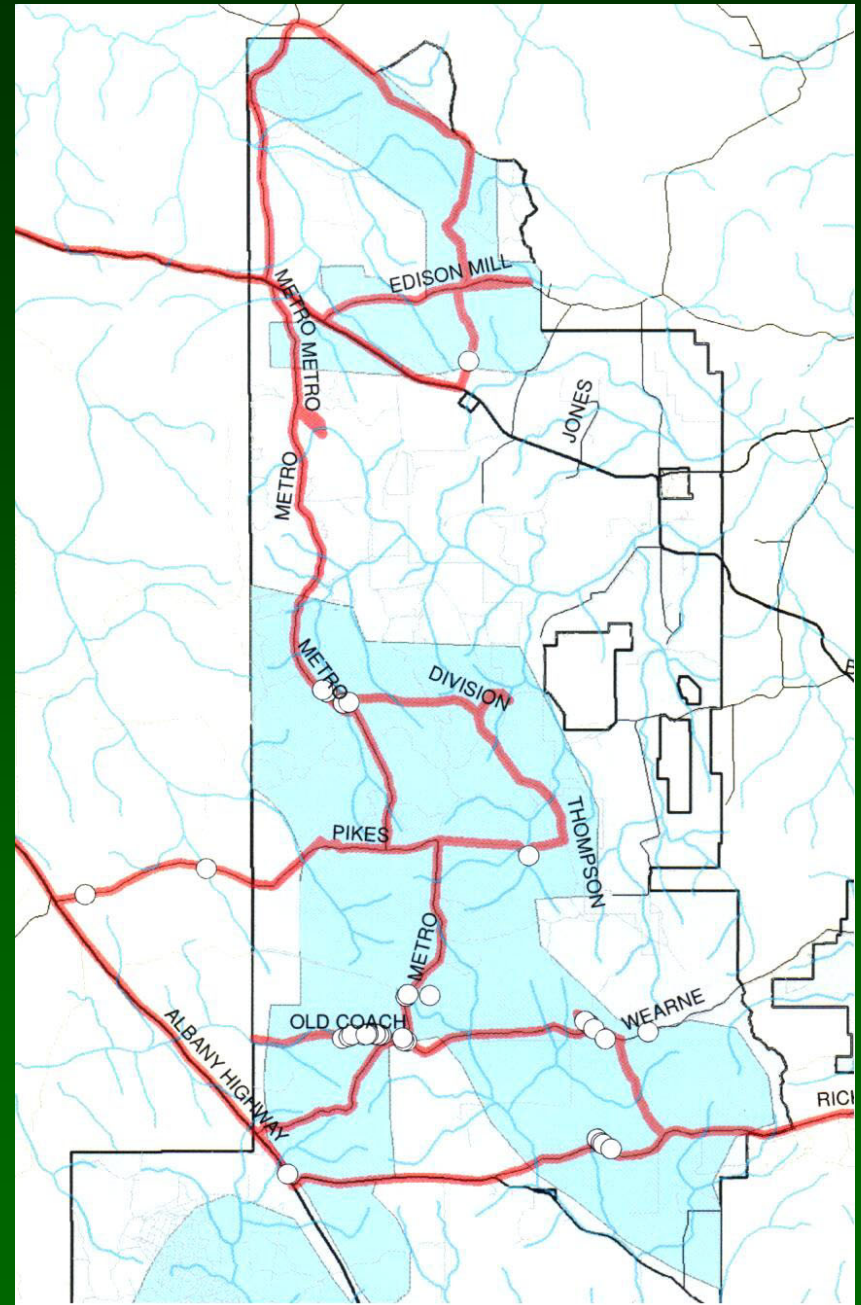
# Black-Cockatoos

Very high conservation significance

Easily detected

Observations on foraging, nesting and presence/absence.

Eg: Carnaby's Black-Cockatoo . Dryandra and Marri important for foraging. Cluster of sightings in south-west near at least one nest.

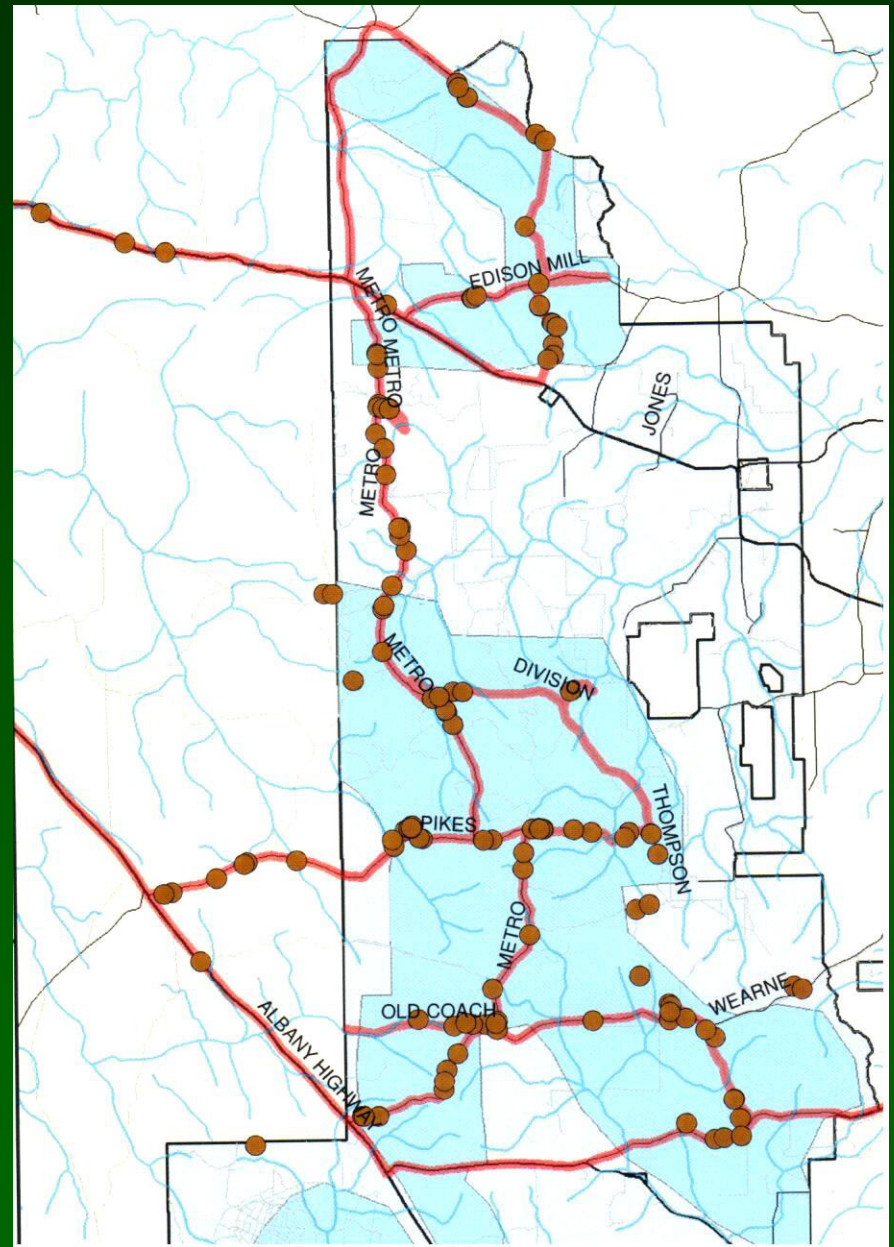


# Brush Wallaby

Regularly observed.

Throughout study area.

Close association with  
Dryandra thickets.





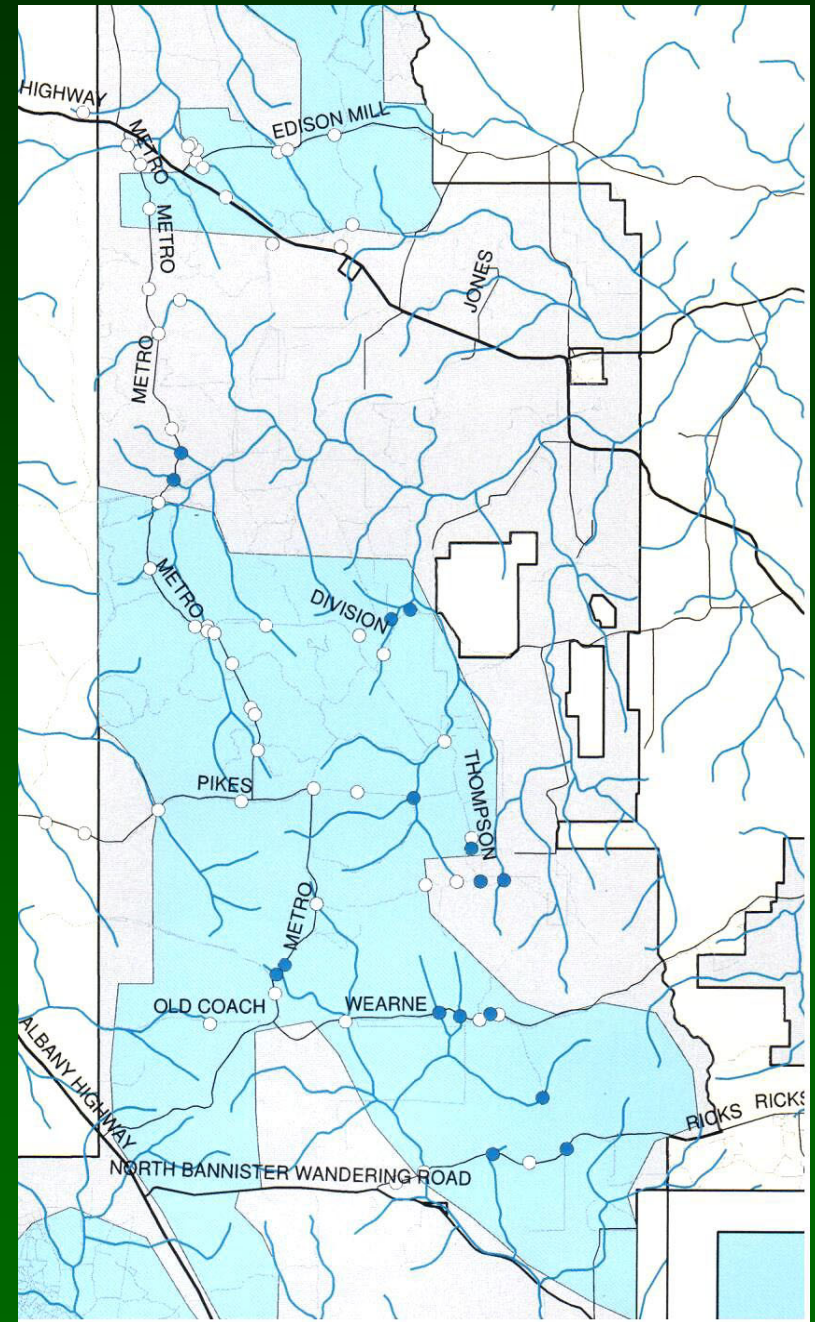
# Frogs

Very readily surveyed in evenings when calling: 205 records of 11 species in 4 evenings

Distribution of records can be linked to environmental parameters (*H. albopunctatus*)

Aural surveys followed by ground surveys looking for breeding sites

Frogs likely to be sensitive to hydrological change due to mining and declining rainfall



# Audit of sampling approaches

## Transect sampling.

Reasonable sample sizes (especially birds). Useful for analysis and modelling of distribution and habitat associations. Measures of abundance for monitoring of impacts. More transects needed to increase coverage of landform and vegetation types.

## Recording of Black-Cockatoos and Brush Wallabies.

Developing good picture of distribution, abundance and habitat associations. Seasonal trends not being sampled.

## Aural surveys of frogs.

Rapid collection of data useful for determining distribution, habitat associations and modelling. Survey area needs to be expanded to improve coverage.

## Audit of sampling approaches (2)

### Trapping of CWR mammals.

Large effort for small return; 22 Mardo and 16 Chuditch captures in 2750 trapnights. These records do little more than confirm the presence of species.

### SREs from pitfalls and searching.

Rich assemblage of mygalomorph spiders documented. Distribution along transects can be analysed as for vertebrates. Cryptic SRE invertebrates (eg. pseudoscorpions) under-sampled.

### Spotlighting.

Large effort for small return. Unlikely to collect sufficient data for robust analyses. Has confirmed presence of Barking Owl.

## Audit of sampling approaches (3)

### Phascogale nest boxes.

Of 100 nest-boxes, one used by a Mardo and one possibly used by a phascogale after one year. Little value to project.

### Bats.

Major component of the mammal fauna (7 of 20 native species recorded). Great potential for aural survey approach across the landscape using Anabat or similar system.



## **Future sampling** (approaches to be discontinued)

Some components of investigations are not likely to fulfil objectives:

Trapping of CWR mammals.

Large effort for small return.

Spotlighting.

Large effort for small return.

Phascogale nest boxes.

Very low rate of usage and difficult to see how use of nest boxes will contribute to biodiversity investigations. Continue to monitor existing boxes.

## **Future sampling** (approaches to be continued)

### Transect sampling.

Expand coverage with new transects. Retain some old transects to act as controls. More transects needed to increase coverage of landform and vegetation types. Transect approach suitable for long-term monitoring.

### Recording of Black-Cockatoos and Brush Wallabies.

Continue when in area doing any other work. Increase seasonal coverage (particularly for black-cockatoos). Targetted nest-searching in areas of high activity.

### Aural surveys of frogs.

Expand coverage and repeat surveys at some existing locations to act as controls. Repeat surveys annually at some sites for monitoring.

## **Future sampling** (approaches to be continued)

### SRE invertebrates.

Continue collection from transects. Undertake targeted searching in specific habitats for pseudoscorpions and millipedes.

### Bats.

Establish an aural monitoring programme using echolocation recording equipment to identify species present at a range of sites across landscape and vegetation.



**Flora and Vegetation  
Investigations for Scope of  
Biodiversity-related Investigations  
for the Worsley Alumina 4.4 Mta  
Expansion in ML258SA**

**Bennett Environmental Consulting  
Pty Ltd**





# OBJECTIVES

1. To determine the occurrence and spatial extent of floristic and vegetation communities at the local and regional scale (*Condition 719:M8-1(1)*);
2. To establish the condition of floristic and vegetation communities identified in 1 above (*Condition 719:M8-1(2)*);
3. To determine the occurrence and spatial extent of TECs including nominated TECs (*Condition 719:M8-1(3)*) within new mining envelopes and bauxite transport corridors and adjoining areas and as appropriate at the local and regional scale;
4. To determine the occurrence and extend of Declared Rare and Priority Flora pursuant to the Wildlife Conservation Act 1950 and other Priority Flora as identified in the database maintained by the Department of Conservation and Land Management (*Condition 719:M81-(4)*) within the mining envelopes, bauxite transport corridors and adjoining areas;
5. To determine the occurrence, severity and spatial extent of forest disease and the potential for the spread of forest disease (*Condition 719:M8-1(6)*) within new mining envelopes and bauxite transport corridors and adjoining areas; and
6. To investigate the weed and pest severity status in State Forest (*Condition 719:M8-1(13)*) within new mining envelopes and bauxite transport corridors and adjoining areas.

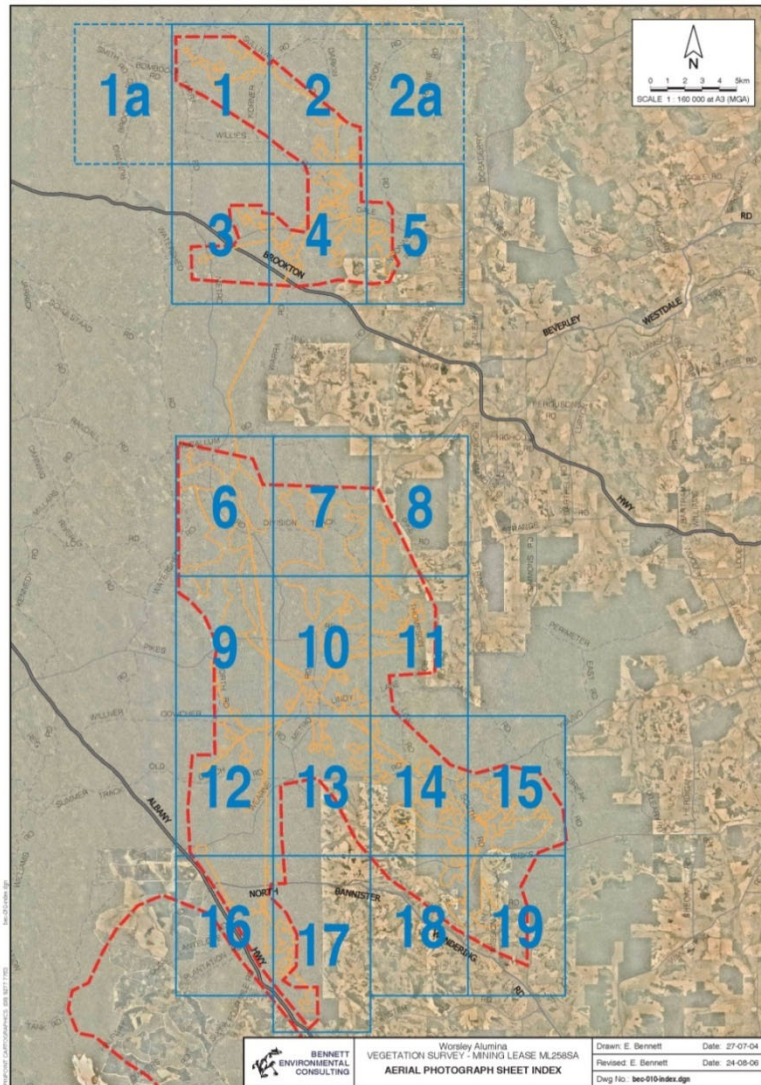


# BACKGROUND INFORMATION

## STUDY AREA

Brookton Mining Envelope

Central Mining Envelope





The field survey consists of 2 different methods:

1. Transects are walked by botanists 200m apart and vegetation information gathered every 200m for site type analysis. Whilst transects are being walked any Declared Rare or Priority Flora are recorded.
2. Permanent quadrats are established where all trees within the 20m x 20m quadrat are counted and all taxa within the nested 10m x 10m quadrat are recorded. A species accumulation curve check was undertaken.



Site type method chosen :

- as very large area to be covered
- method used by Matiske Consulting Pty Ltd

Quadrat method chosen:

- as used by Keighery *et al* when undertaking salinity study
- thought may have been possibility of some of those sites being used to compare the data obtained with survey

Field work undertaken in:

2004 only proposed mine pods were surveyed

2005 and 2006 Brookton Mining Envelope surveyed

2007 and 2008 Central Mining Envelope surveyed



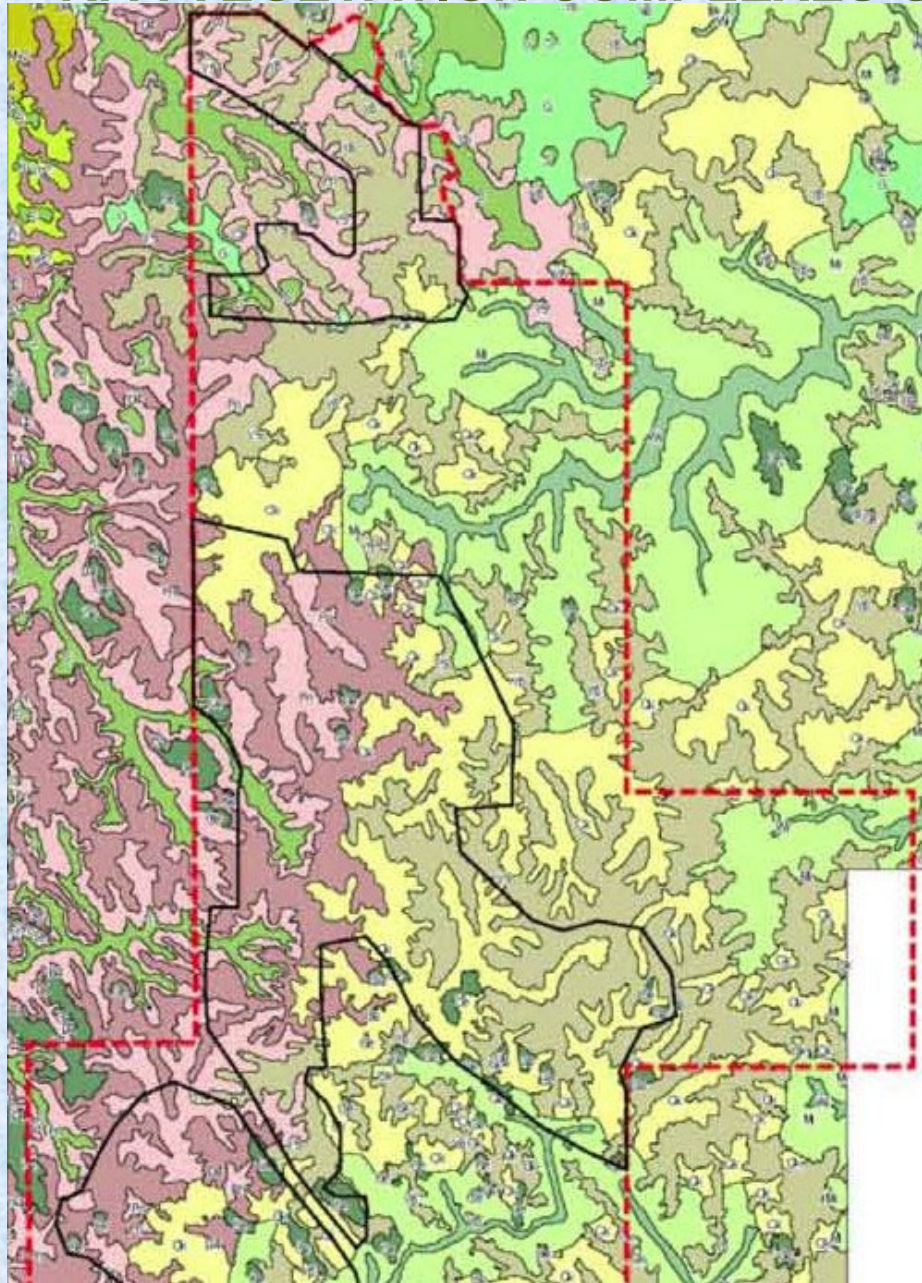
Previous surveys included:

- Loneragan included several sites in this area during his PhD research
- Havel (1975) described 26 site vegetation types for the Jarrah forest
- Matiske Consulting Pty Ltd (1999) and E.M. Matiske and Associates (1990, 1993)
- Ecologia Environmental Consultants (1994)
- Regional Forest Agreement (RFA) (Matiske and Havel, 1998)
- Keighery *et al.* (2004) assessing WA agricultural areas for salinity.

Williams and Mitchell (2002) Northern Jarrah Forest in *Biodiversity Audit of Western Australia's 53 Biogeographical Subregions*



# RFA VEGETATION COMPLEXES OF STUDY AREA



- Legend**
- ML259SA Mining Lease Boundary
  - Mining Areas
- Vegetation Complex**
- Cooke <math>\leftrightarrow</math>
  - Coolakia <math>\leftrightarrow</math>
  - Dalmore
  - Dalmore 2
  - Darkin 1
  - Darkin 2
  - Darkin 3
  - Darkin 4
  - Darkin 5
  - Dwellingup
  - Goosoping <math>\leftrightarrow</math>
  - Lukin 2
  - Michbin <math>\leftrightarrow</math>
  - Murray 2
  - Pindalup <math>\leftrightarrow</math>
  - Swamp <math>\leftrightarrow</math>
  - Williams
  - Yalanbee <math>\leftrightarrow</math>
  - Yarrngil 1 <math>\leftrightarrow</math>
  - Yarrngil 2



# Brookton Mining Envelope





## BROOKTON MINING ENVELOPE

Work undertaken in 2004, 2005 and 2006

Variations recorded in the vegetation

*Eucalyptus accedens* with on many ridges and upper slopes

*Eucalyptus marginata* subsp. *thalassica* and *Banksia attenuata* in the sandy soils

*Eucalyptus wandoo* on the lower slopes and flats



*Eucalyptus marginata* subsp. *thalassica* and *Corymbia calophylla* on the slopes

*Allocasuarina huegeliana* often associated with *Eucalyptus wandoo* around granite outcrops

*Eucalyptus rudis* and *Eucalyptus wandoo* along the drainage lines



Drainage lines



Occasional heaths



Occasional swamps



Occasional granite outcrops





## **BROOKTON MINING ENVELOPE**

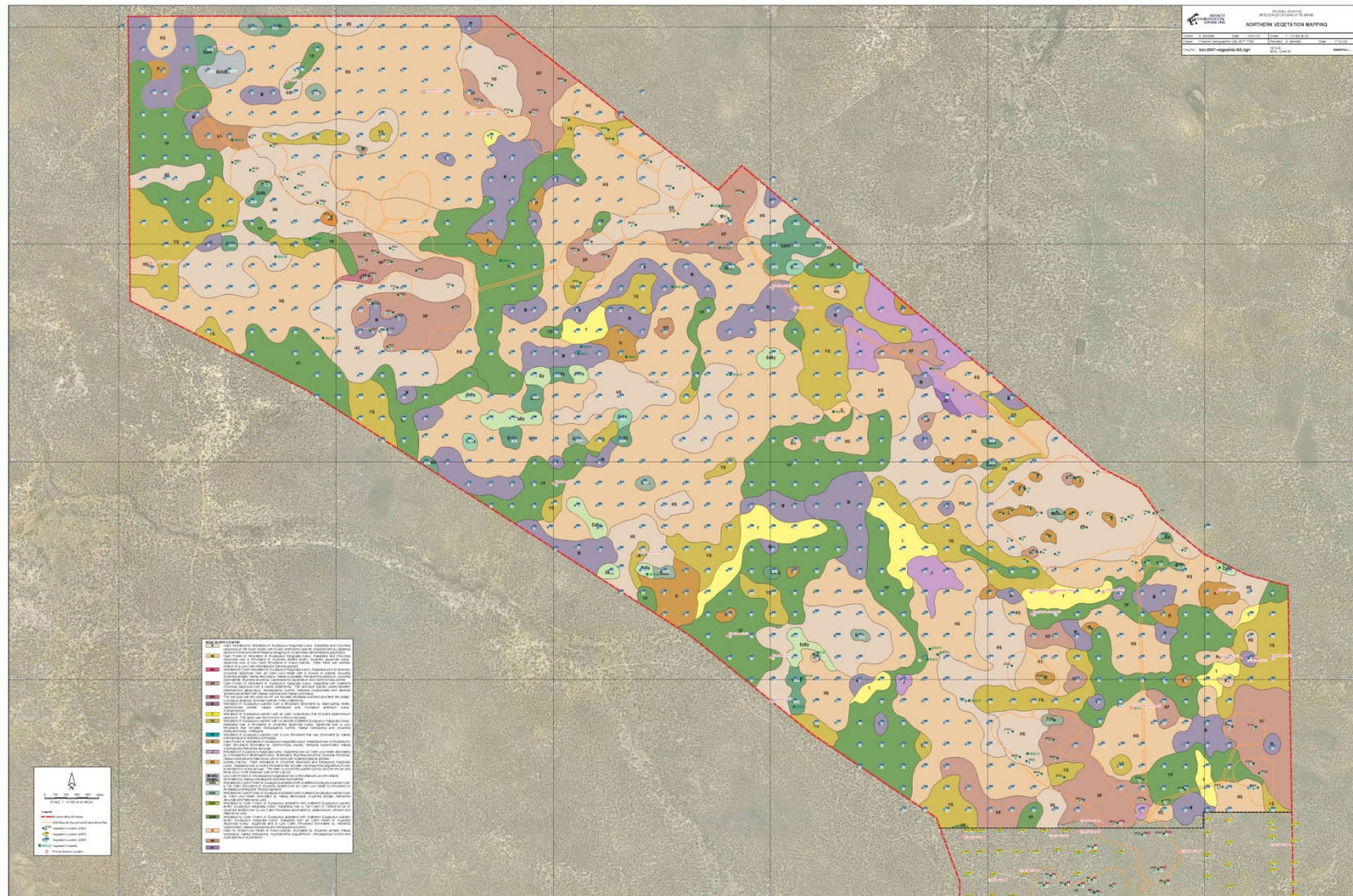
23 different site types recognised

None are Threatened Ecological Communities, although Michibin (granite rock surround) is listed as a poorly represented community

A total of 62 vascular plant families, 208 genera and 525 taxa were recorded.



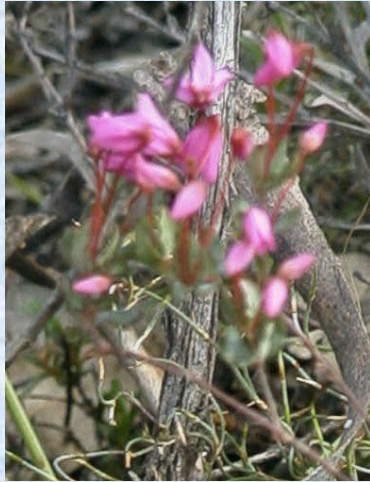
# BROOKTON MINING ENVELOPE – NORTHERN BROOKTON





## BROOKTON MINING ENVELOPE PRIORITY FLORA

*Tetradthea similis* – Priority 3



*Eucalyptus latens*– Priority 4



*Templetonia drummondii* – Priority 4



*Synaphea* sp. Darkin (P3)

### PLANTS WITH RESTRICTED DISTRIBUTION

*Stenanthemum nanum* was recently removed off the priority flora list

*Synaphea cuneata* was removed from the priority flora list in 2006

*Vittadinia australasica* var. *australasica* was recorded from one site. Previously recorded from Albany and Esperance



# BROOKTON MINING ENVELOPE

## IDENTIFYING AREAS TO BE PROTECTED (*Condition 9*)

All the different vegetation units recorded in the mine pods were also represented in the surrounding areas. However haul roads etc will also need to be constructed. Areas to be protected from disturbance include: granite rocks, heaths, drainage lines and swamps





## **BROOKTON MINING ENVELOPE MINING IMPLICATIONS**

Disturbance that have already occurred included:

1. Several 4-wheel drive tracks
2. Bike tracks throughout the bushland
3. Cutting and removal of fire wood
4. Dumping of rubbish
5. Dieback
6. Wandoo decline

## **BROOKTON MINING ENVELOPE OTHER LIMITATIONS**

- Northern section in Mundaring Weir catchment area
- Adjoins Wandoo National Park on eastern and north eastern sides
- Granite rocks
- Heaths
- Damplands

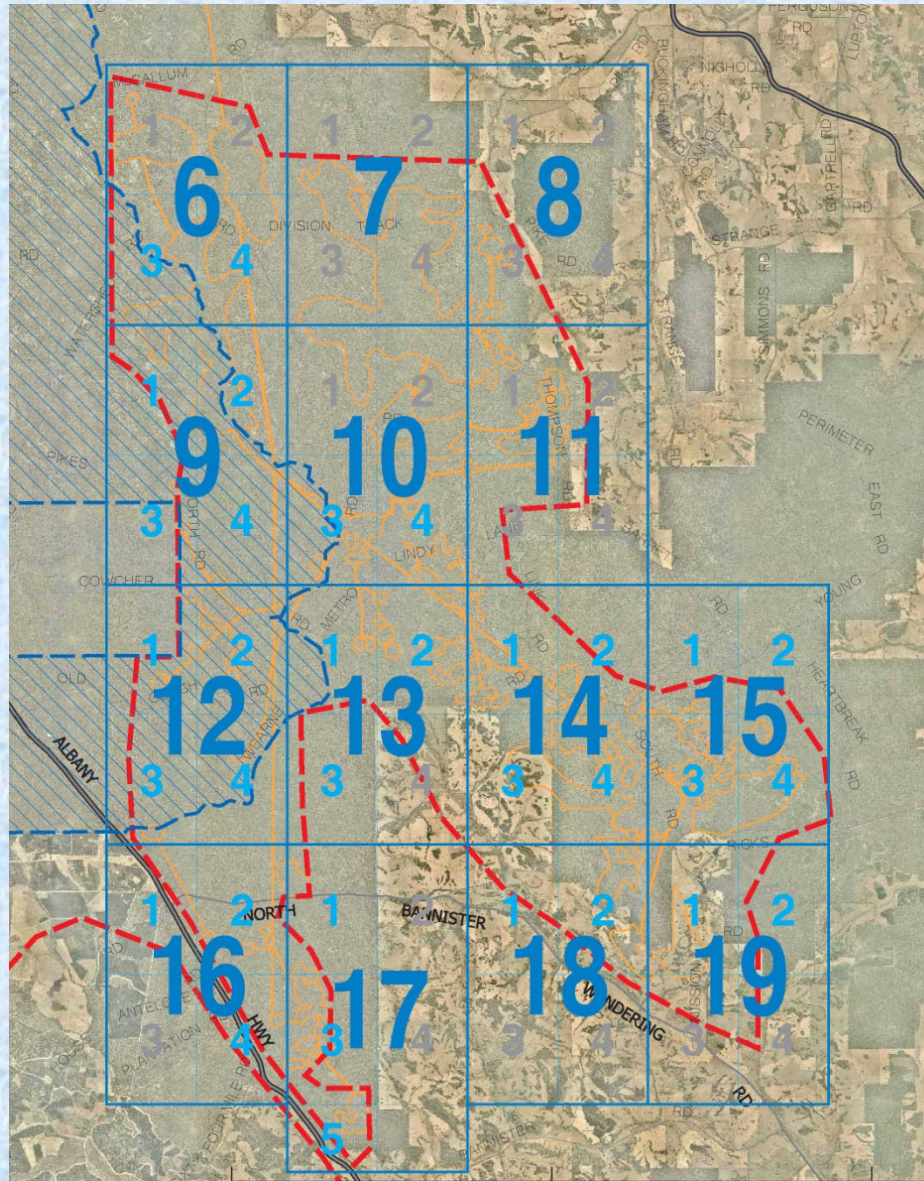


# Central Mining Envelope





# CENTRAL MINING ENVELOPE SURVEY AREA





## CENTRAL MINING ENVELOPE VEGETATION

Field work undertaken in:

2004 where only proposed mine pods were surveyed

2007 when surveys commenced in the northern section. Limitation to this was the wet weather both before and during the survey

2008 site type transects completed. This completes the site typing of the Central Mining Envelope

22 different site types recorded – 3 of which were mallee and 3 heaths

62 vascular plant families, 201 genera and 521 taxa



# CENTRAL MINING ENVELOPE VEGETATION

Variations recorded in the vegetation:

- *Eucalyptus marginata* subsp. *thalassica* dominant tree on slopes
- *Eucalyptus accedens* on the upper slopes and ridges including outcropping laterite
- *Eucalyptus wandoo* occurred typically on heavier soils of flats and lower slopes
- *Eucalyptus wandoo* and *Eucalyptus rudis* along the creeks and flat clay areas
- *Allocasuarina fraseriana* in a section along Wearne Road

*Allocasuarina huegeliana* around granite rocks

Granite rocks



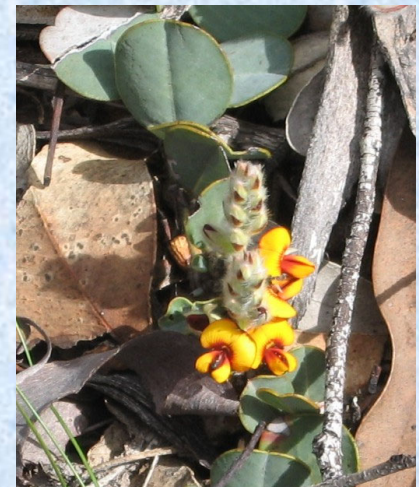
Heaths





## CENTRAL MINING ENVELOPE DECLARED RARE & PRIORITY FLORA

- *Verticordia fimbrialepis* subsp. *fimbrialepis* (DF)
- *Grevillea manglesii* subsp. *dissectifolia* (P1)
- *Lasiopetalum* sp. Toodyay (P1)
- *Acacia gemina* (P2)
- *Grevillea crowleyae* (P2)
- *Acacia oncinophylla* subsp. *oncinophylla* (P2)
- *Stylidium marradongense* (P3)
- *Synaphea aephynsa* (P3)
- *Synaphea pandurata* (P3)
- *Calothamnus rupestris* (P4)
- *Darwinia* sp. Dryandra (P4)
- *Eucalyptus exilis* (P4)
- *Eucalyptus latens* (P4)
- *Gastrolobium ovalifolium* (P4)
- *Lasiopetalum cardiophyllum* (P4)
- *Templetonia drummondii* (P4)
- *Tetratheca similis* (P3)





## CENTRAL MINING ENVELOPE 2008 SURVEY AREA

### PLANTS WITH RESTRICTED DISTRIBUTION

- *Leucopogon* sp. Darling Range
- *Stenanthemum nanum*
- *Synaphea cuneata*
- *Leucopogon* affin. *florulentus*
- *Eucalyptus aspersa*



- 2008 quadrats established along 8 of 10 pitfall trap sites



## CENTRAL MINING ENVELOPE DISTURBANCES

Bike tracks are common through the bushland



Recorded on higher ground and wetlands as well as across granite rocks



## CENTRAL MINING ENVLEOPE DISTURBANCES

Pig diggings



Dieback or the dry summers experienced has caused deaths



Several of the Wandoos were showing stress. Many had the upper branchlets dead, although none were assessed using the criteria of the Wandoo Study Group



## DECLARED RARE AND PRIORITY FLORA RECORDED 2004-2007

A search of the DEC Significant Flora database was undertaken for the lease and the surrounding area.

This resulted in

12 Declared Rare Flora, 7 Priority 1 Flora, 11 Priority 2 Flora, 20 Priority 3 Flora and 25 Priority 4 Flora.

The 2004-2007 surveys have recorded

1 Declared Rare Flora, 1 Priority 1 Flora, 1 Priority 2 Flora, 4 Priority 3 Flora and 7 Priority 4 Flora, 2 of which

*Acacia oncinophylla* subsp. *oncinophylla*, a Priority 3 Flora and *Calothamnus rupestris*, a Priority 4 were not listed by DEC

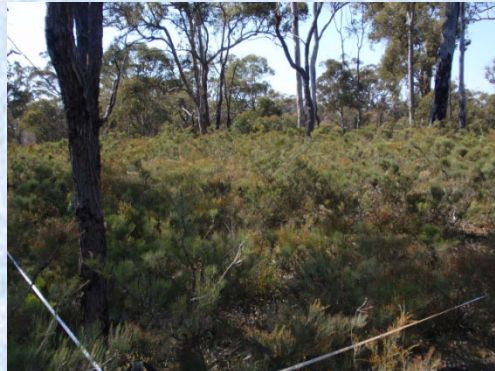


## VEGETATION CONDITION

- Keighery (1994) 6 point scale used
- Highest rating that can be assigned is very good (condition 3) due to logging, die back, fires
- Exception – granite rocks and some heaths condition 2
- 202 quadrats established 2004-2008
  - 5 quadrats: condition 2 – excellent
  - 7 quadrats: condition 2-3 – between excellent and very good
  - 140 quadrats: condition 3 – very good
  - 26 quadrats: condition 3-4 – between very good and good
  - 22 quadrats: condition 4 – good
  - 2 quadrats: condition 5 – degraded



Condition 2



Condition 3



Condition 4



## WEEDS

- Weeds recorded if dominant in site typing, all taxa in quadrats
- Occur mainly along farm boundaries, track and road edges
- 27 taxa recorded (Ecologia recorded 19)
- \**Romulea rosea* rated as high



## DIEBACK

Recorded during site typing survey

Low - <10%

Medium 10-50%

High – 50 - 75%

Very high – 75 - 90%

Very very high – 90%+

Age of Death

Recent death (leaves recently desiccated or discoloured)

Medium death (bark still on trees)

Old death (no leaves or bark left on trees)

Not dieback specialists - record using tree and understorey health

No detailed assessment of Wandoo stress



## THREATENED ECOLOGICAL COMMUNITIES

No TEC's are listed by DEC for the survey area

Only one of RFA vegetation complexes with <30% of pre-European area remaining  
Havel (2002) Michibin – 20% pre-European area remaining



## PROPOSED FURTHER SURVEYS

- 2009
  - Complete vegetation surveys of fauna transects
  - Additional quadrats
  - Identify areas and developing targeted detailed studies (Landscape analysis)
- 2010
  - Detailed studies on targeted areas identified from Landscape analysis
  - Southern areas



# HYDROLOGICAL AND LANDFORM INVESTIGATIONS FOR EXPANSION IN ML258SA

**James Croton &  
Geoff Mauger**  
Water &  
Environmental  
Consultants

1-May-09



# Investigation Objectives

The objectives of the hydrological and landform investigations (Section 4.1) are:

- 1.To characterise the landform (*Condition 719:M8-1(7)*).
- 2.To determine groundwater systems and the occurrence and distribution of groundwater-dependent ecosystems (*Condition 719:M8-1(11)*).
- 3.To determine stream flow and quality, and stream-dependent ecosystems (*Condition 719:M8-1(12)*).
- 4.To predict and monitor the impacts of climate change (*Condition 719:M8-1(14)*).

# Long-Term Monitoring Objectives

Key monitoring parameters for hydrology and landform (Section 8.1.2) are:

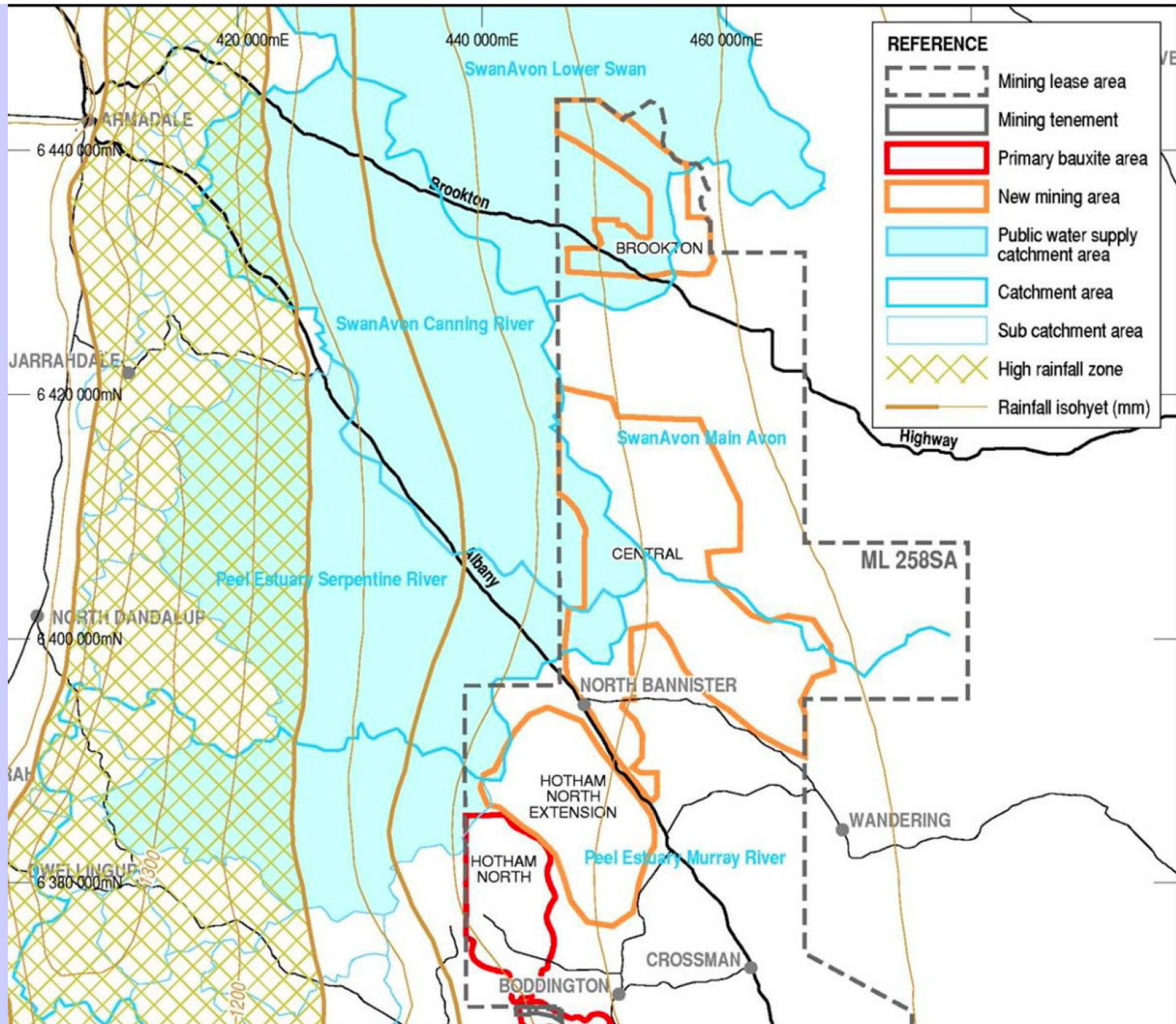
1. Groundwater\* standing water levels and quality, and stream levels/flows and quality.
2. Vegetation health and condition, which may include the use of remote sensing techniques (e.g. LANDSAT, digital aerial photography, etc. and/or modern leaf reflectance techniques).

\* - Groundwater monitoring program to be established if any groundwater dependent ecosystems are found during hydrological and landform investigations (Section 4.1.2).

# Water Supply Protection

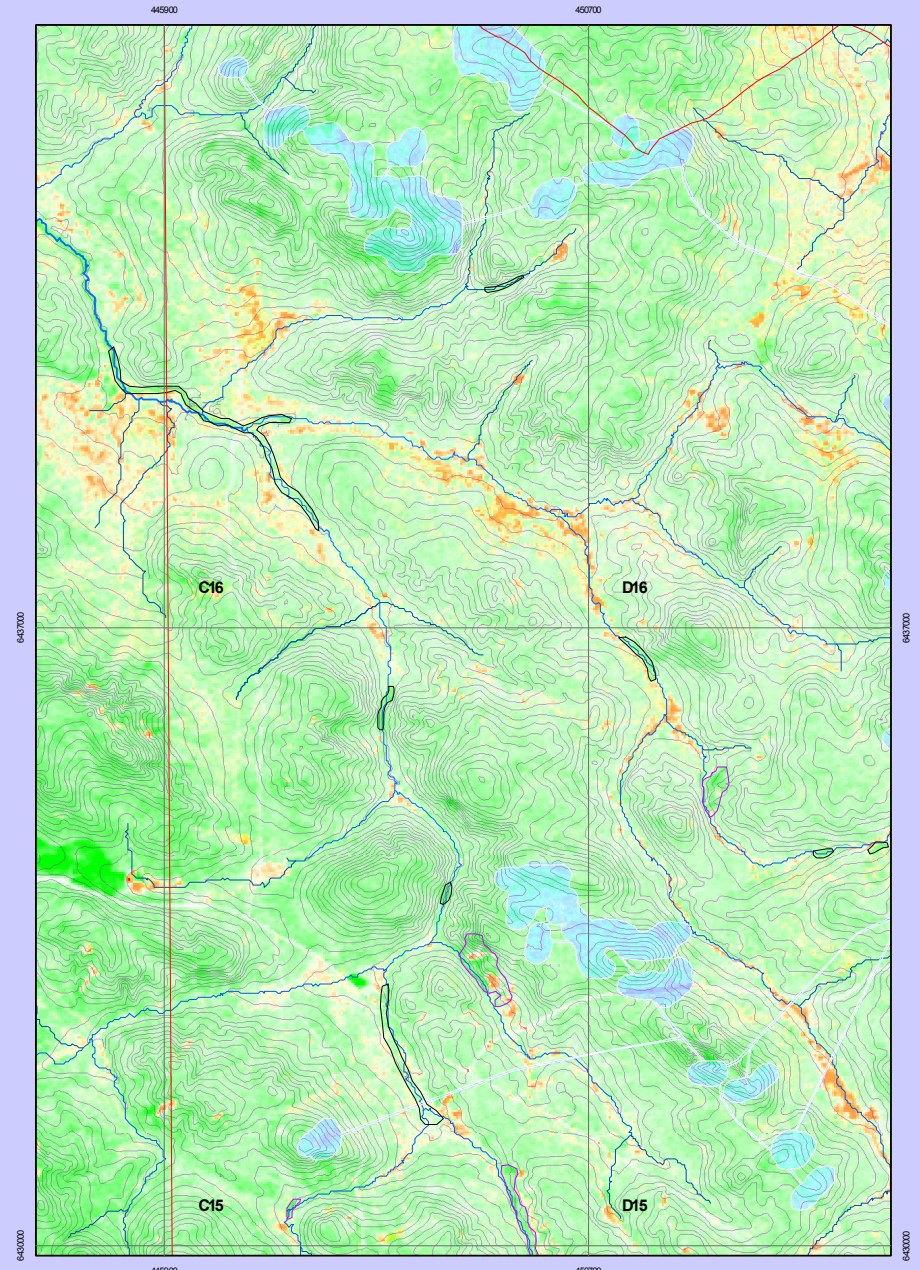
Prior to the commencement of any ground disturbing activities in areas proclaimed as water reserves or catchment areas under the *Country Areas Water Supply Act 1947*, the proponent shall prepare a **Water Resource Management Plan** to the requirements of the Minister of the Environment on advice of the Water and Rivers Commission and the Water Corporation. (*Conditions 719:M13-1 to 3*).







# APPROACH TO LANDFORM CHARACTERISATION STUDIES



# **Initial Desktop Studies**

## **Landform Classification**

Define the range of landform types and the existence of unusual areas, that is areas of possible ecologically significance.

## **Aerial Photo and LANDSAT Review**

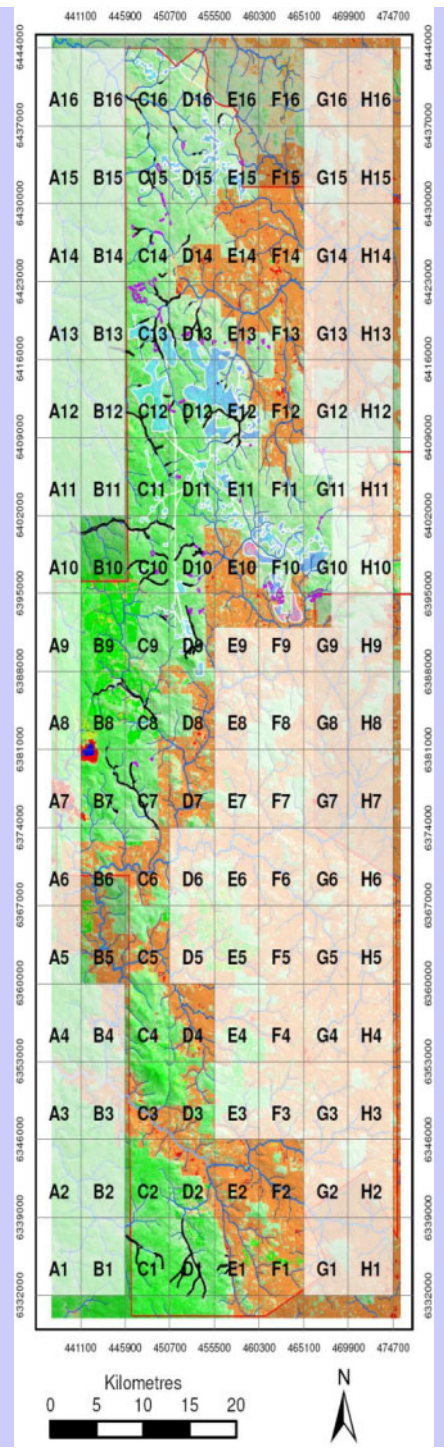
Highlight where vegetation form and density suggest groundwater dependence.

## **Flux Density Analysis**

Identify areas where groundwater may be playing a role in the ecosystems of the valleyfloor areas. Identify areas where rises in groundwater could be an issue.

# Study Area

Extent of study area and mapping classification system used. A system of cells was used to allow the maps to be broken up for presentation.





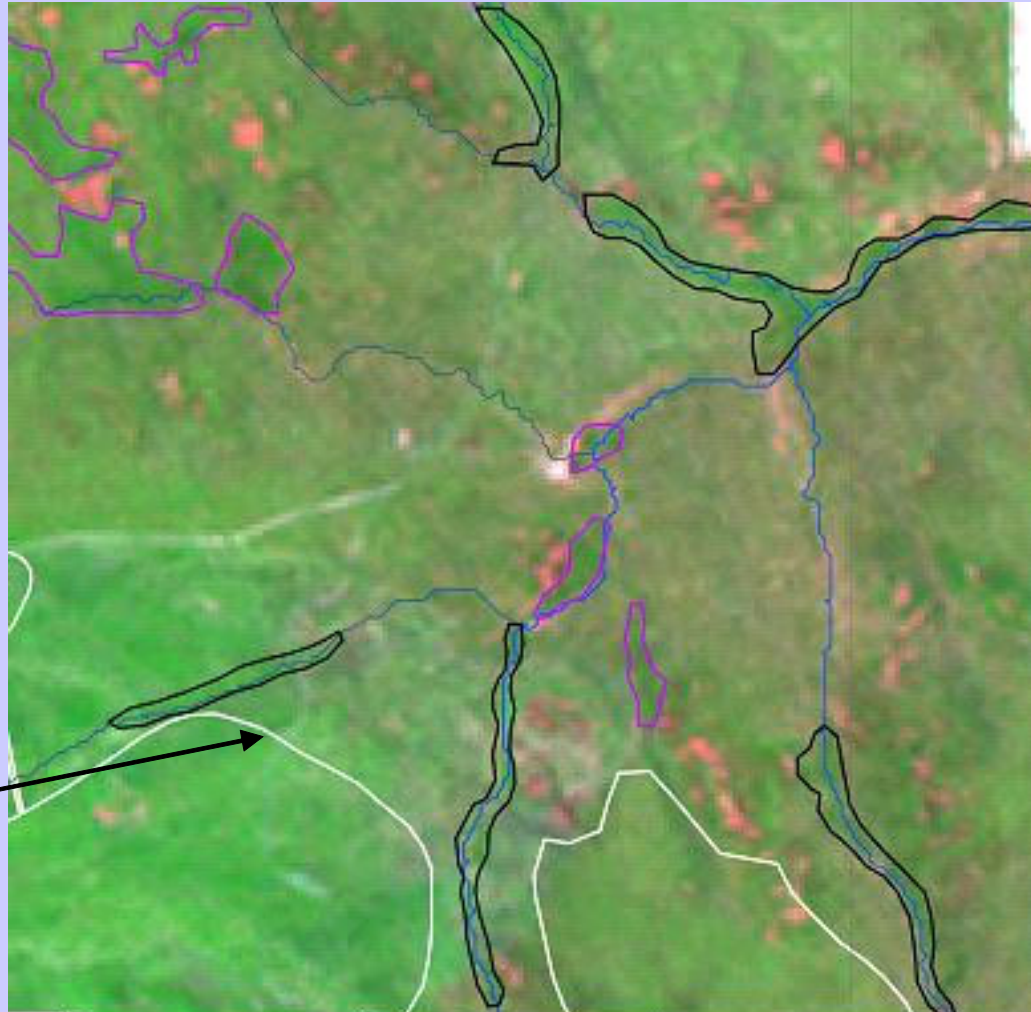
# Data Items Mapped to Date

- Vegetation LAI and false colour maps from LANDSAT.
- Aerial photographs.
- Vegetation complexes.
- Soils.
- Map features such as streams and rock outcropping.
- Topography

# Mapping Outputs to Date

- Mine area drainage directions.
- Areas of vegetation of elevated density which may imply some groundwater dependence.
- Definition of rock outcrops, their downslope areas and relationship to indicative mine areas.

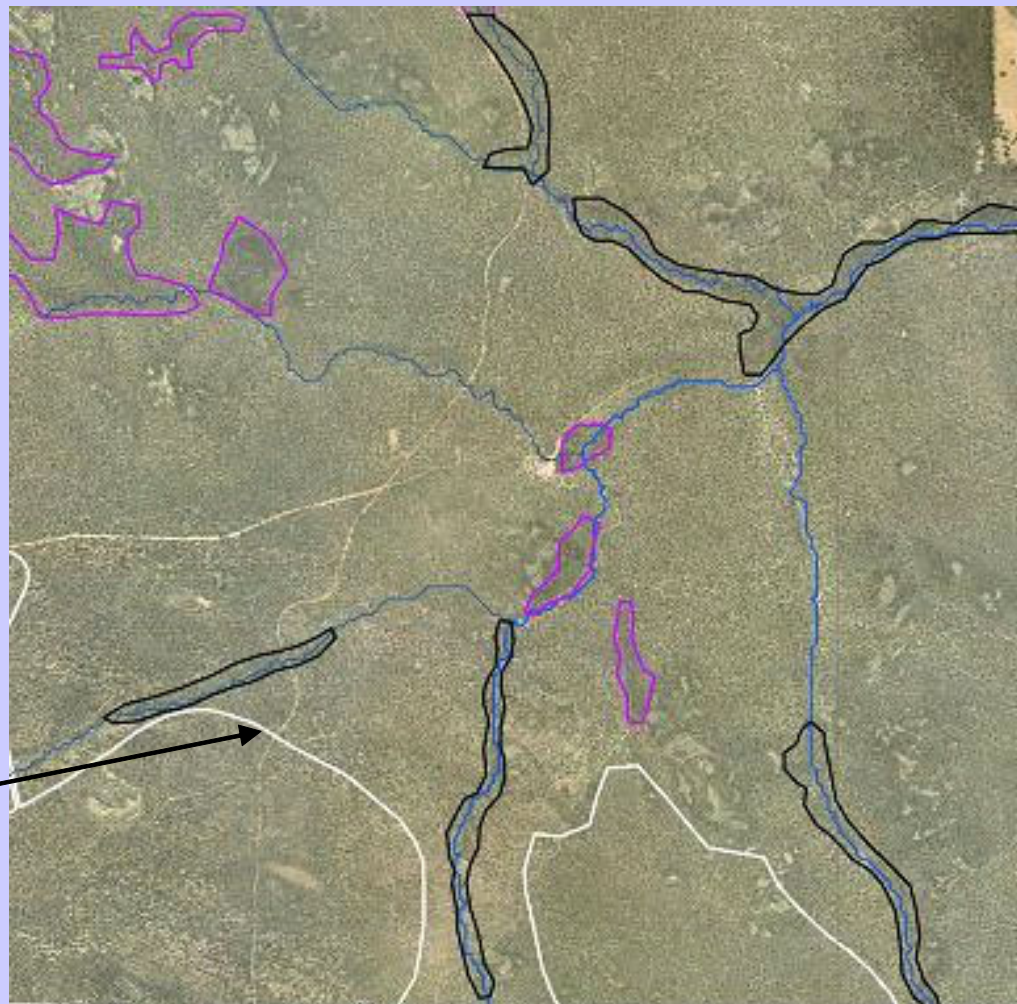
# False Image Landsat



Areas of Mine Plan  
2004 are shown as a  
white line boundary

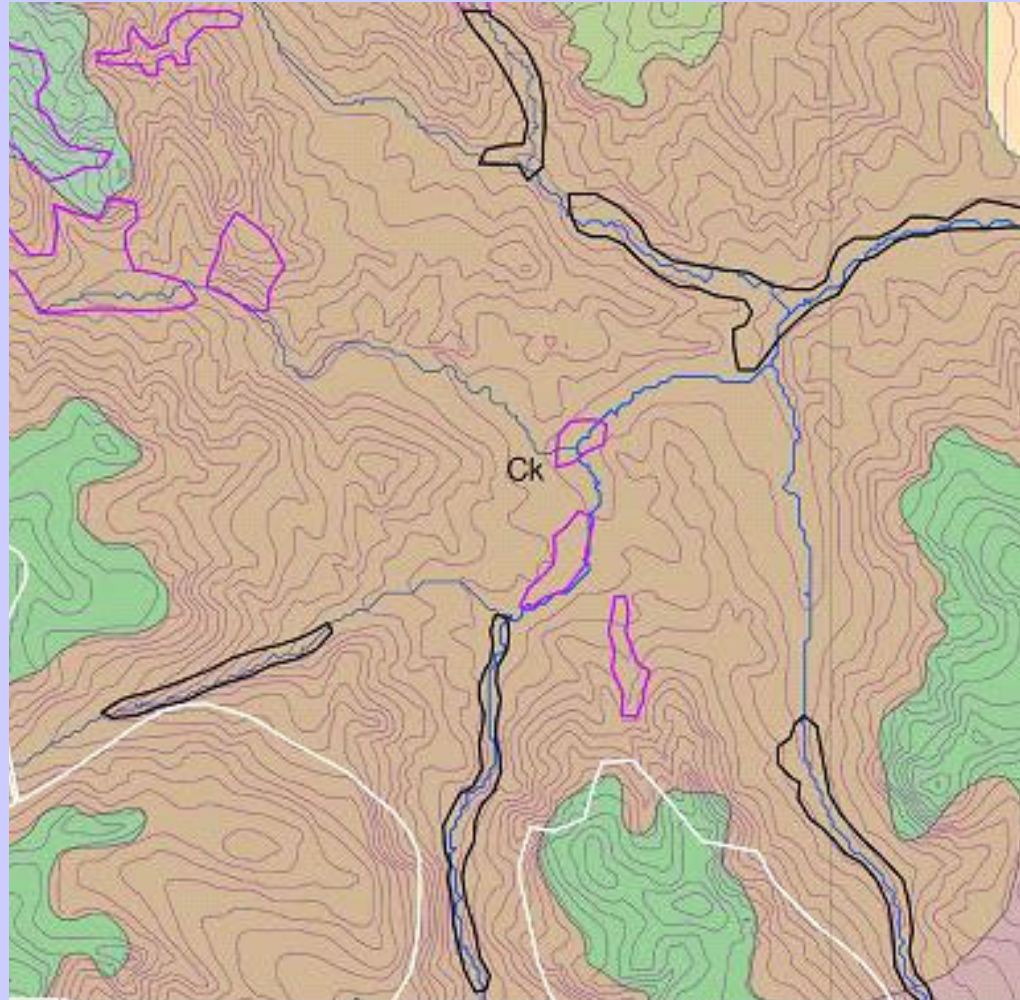


# Aerial Photograph



Areas of Mine Plan  
2004 are shown as a  
white line boundary

# Vegetation Complexes

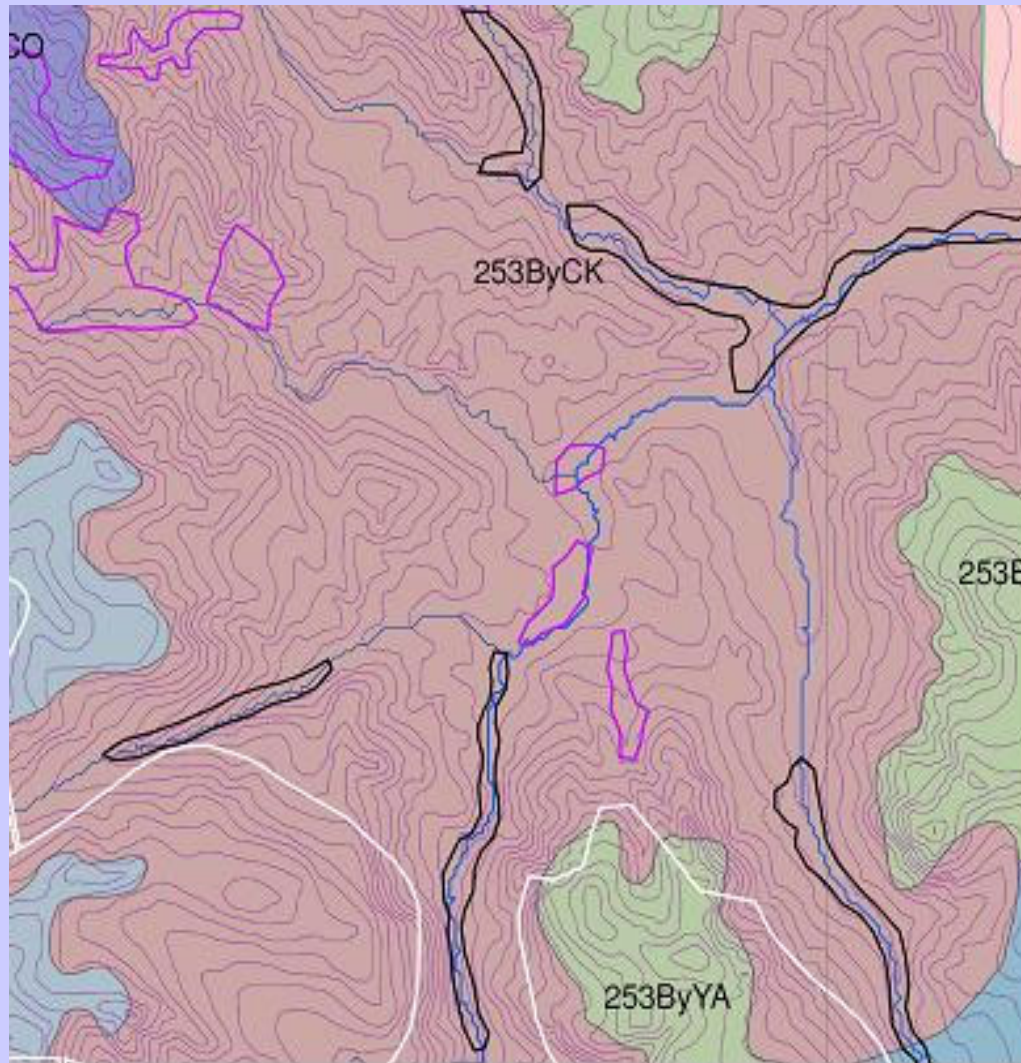


Remnant vegetation

Mapped remnant vegetation is transparently overlaid, making colours darker within forest areas



# Soil-Landform Mapping





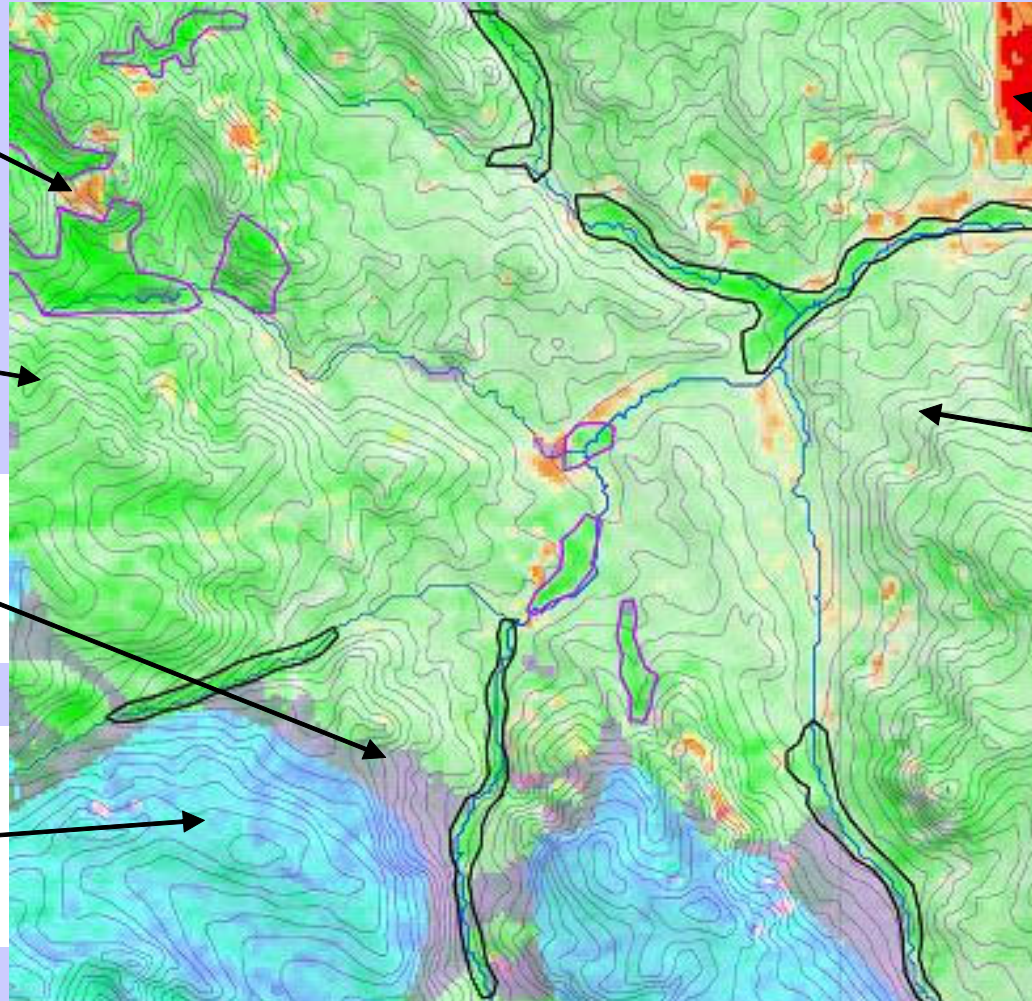
# Landsat Average LAI with Mineplan and Vegetation Areas of Interest

Rock outcrops

5 m contours

Purple areas are  
downslope of  
planned mining.

Areas of Mine Plan  
2004 are shown as a  
transparent blue  
overlay



Area classed as  
pasture is orange  
and bare ground is  
red.

Intensity of green is  
proportional to LAI

# Where To From Here

- Mapped areas of possible ground/surface-water dependence will be assessed in combination with stream data and vegetation and fauna data.
- Complete initial desktop hydrology studies. In particular, define areas of possible significant mining effects on the groundwater system and possible discharge.
- Define areas to be considered for further hydrological field investigation using stream in the process.
- Define areas for more detailed fauna and flora studies, particularly stream ecology studies using stream data in the process.



# STREAM MONITORING PROGRAMME





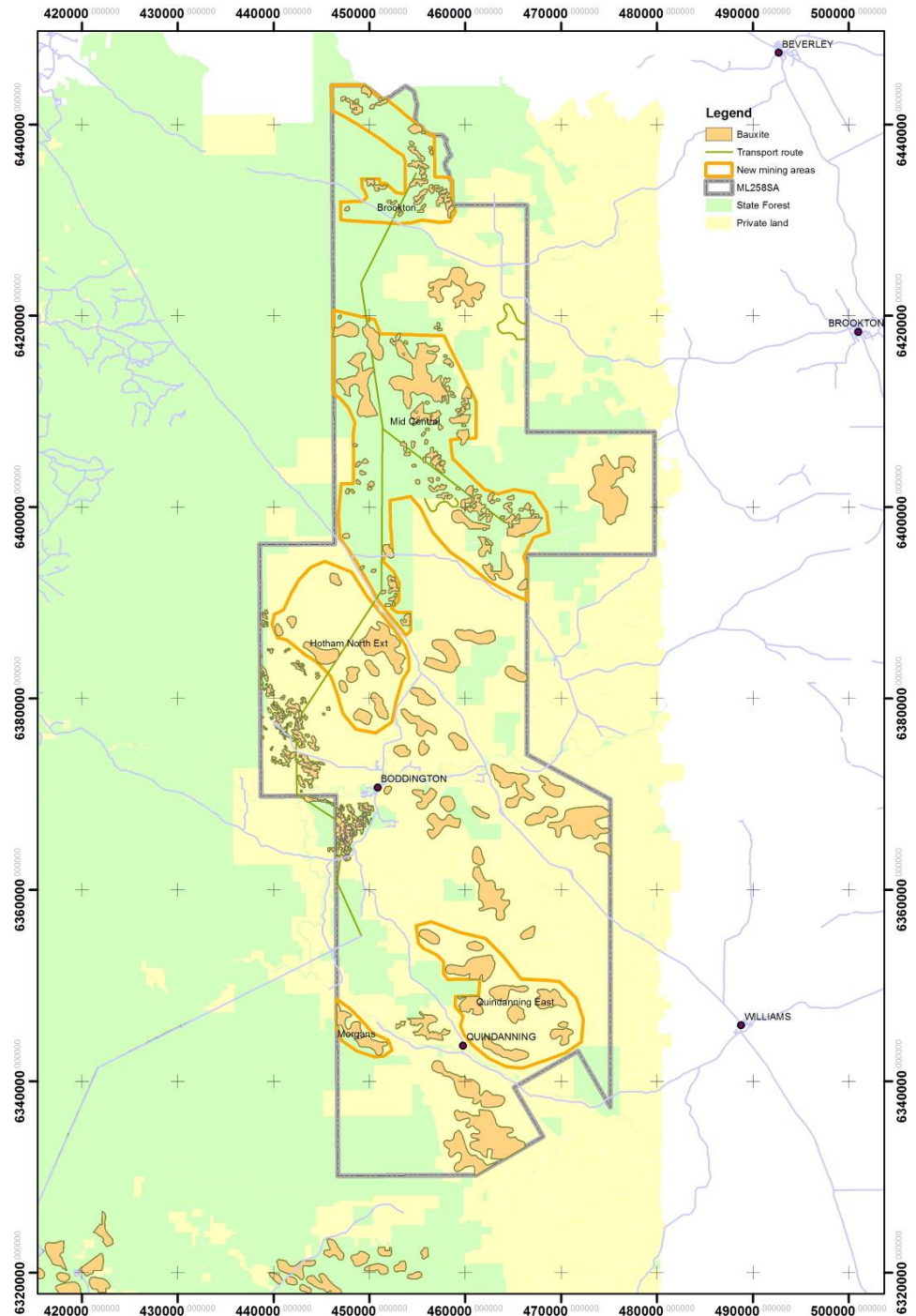
# Objectives

Worsley will develop and implement a stream water quality monitoring program for relevant chemical, physical and biological parameters (Section 4.1.2). Uses are:

- To define areas of groundwater discharge and thereby areas of possible groundwater dependent ecosystems.
- To define catchments with significant streamflow and thereby possible areas of surface-water dependent ecosystems
- To characterise the streams within the expansion area into hydrologic groupings for targeting of aquatic ecology studies.
- To allow landscape studies to be related to stream behaviour.
- To provide a baseline study of stream hydrology, stream salinity and stream chemistry of the expansion area.

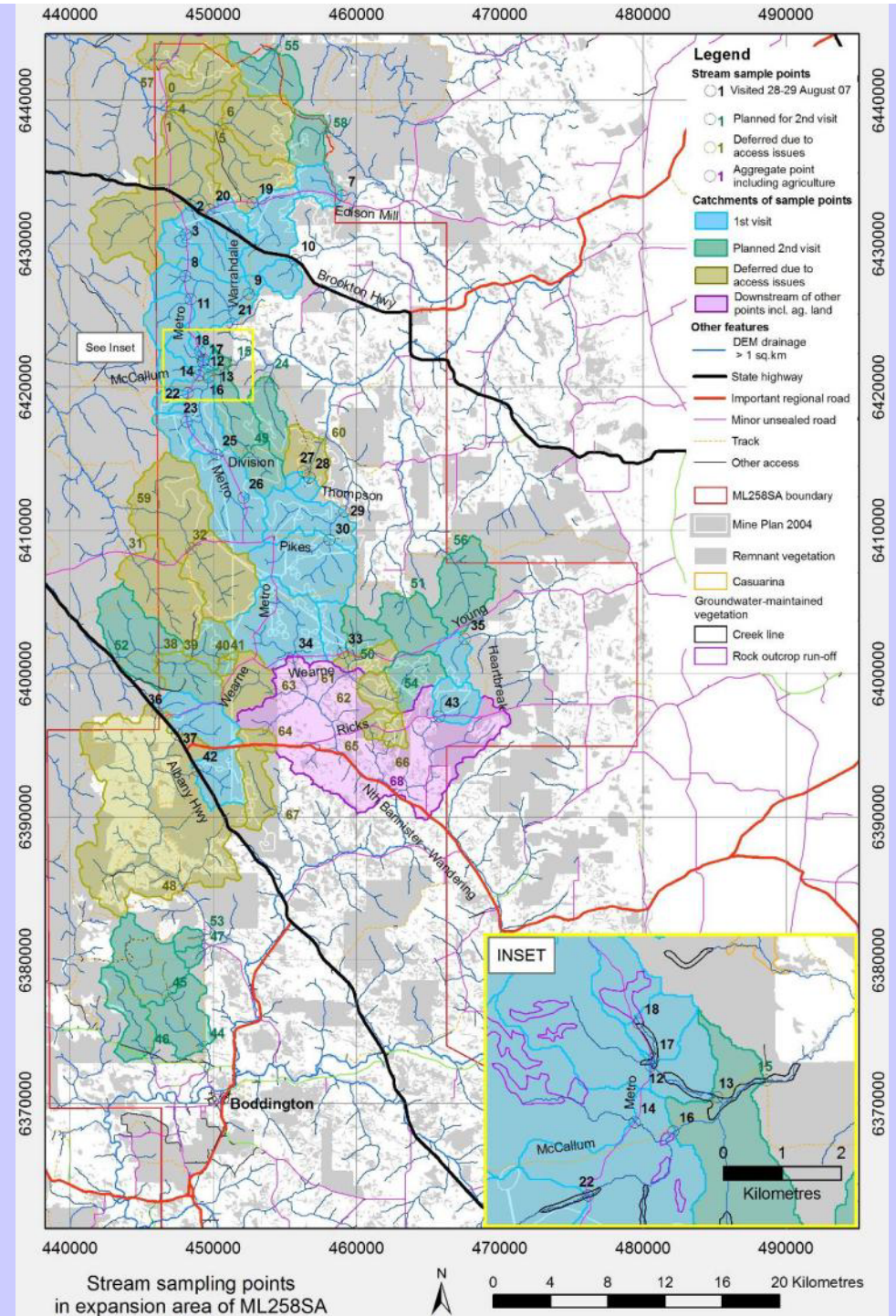
# Study Area

Extent of study area was defined as the new mining areas in the northern section, that is all those shown except Quindanning East and Morgans.



# Catchments

A series of catchments were defined that enclose the mine areas plus areas of special biodiversity interest, e.g. rock outcrops. There is a total of 69 catchments.





# Catchment Monitoring Points

- At each of the 69 catchment outflows a monitoring point was (or will be) established at which we estimate flow rates and measure pH and salinity (via EC).
- The monitoring is through winter and spring with emphasis on baseflow and its persistence as an indicator of groundwater discharge.
- Species sampling will be undertaken to refine differences in stream signature and to define baseline stream chemistry.



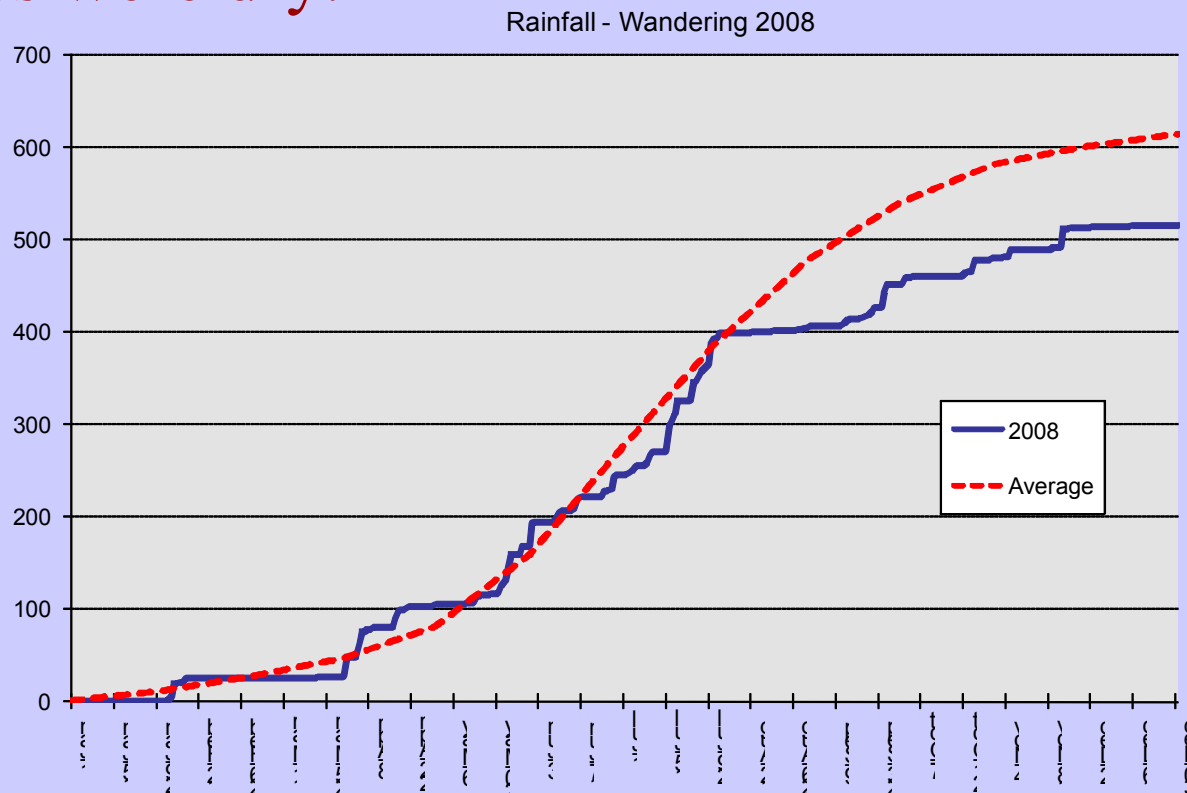
# Results to Date - 2007

- In August 2007 we visited 31 of the sites and established monitoring points. Of these 21 had defined flow and 22 were sampled.
- Two of the August 2007 sample points had salinities  $>700$  mg/L indicating groundwater discharge. The other 19 had salinities  $<200$  mg/L indicating surface origin.
- Stream chemistry analysis was done to commence the creation a baseline record.

# Results to Date - 2008

- In November 2008 we visited 62 sites and established monitoring points. The remaining seven sites have private property access issues that need resolving.
- Only one sample, from Bannister River, was obtained in 2008. All other sites were dry.

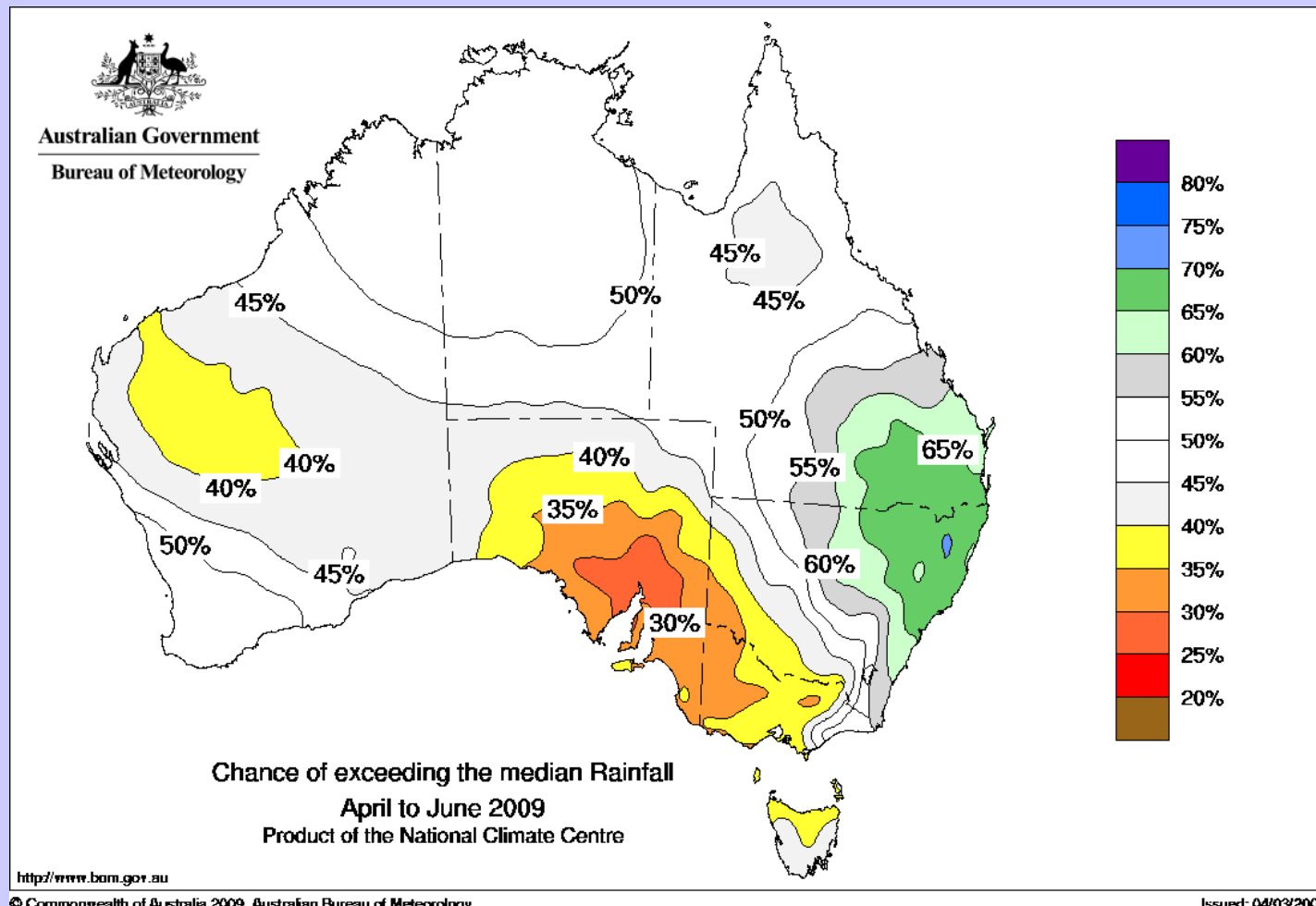
- The rainfall in 2008 had a protracted mid-winter dry-period and resulted in no significant flow for virtually all points.





# 2009 Plan

- Pray for consistent rainfall. However, while the east coast is in an above-average rainfall-period, western and southern Australia are predicted to be at or below average.



## 2009 Plan Cont'd

If reasonable rains and subsequent flows occur then:

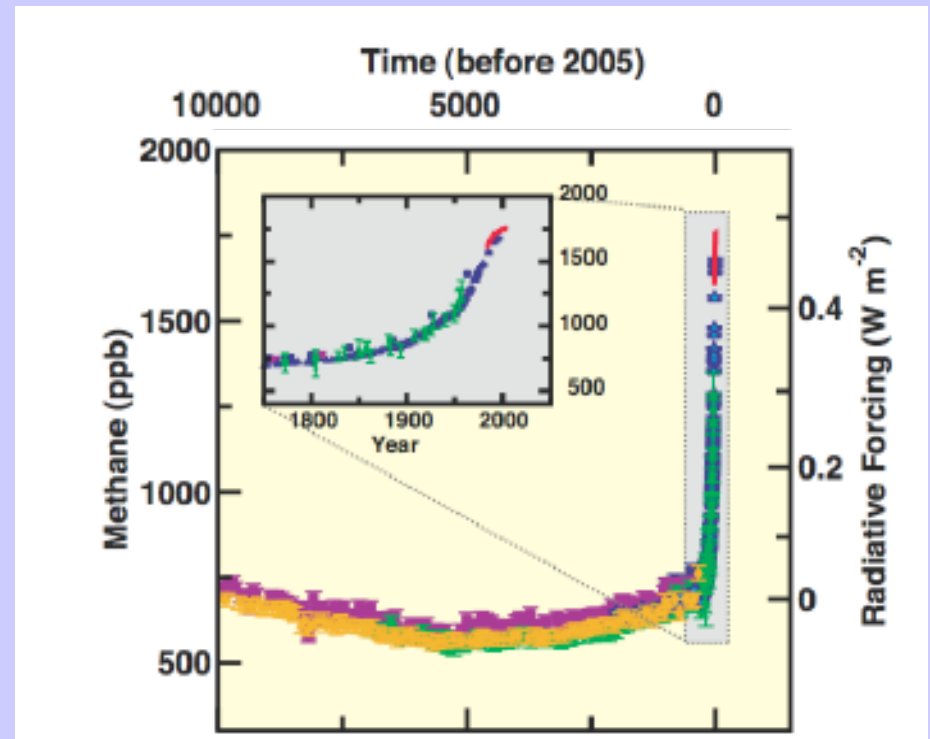
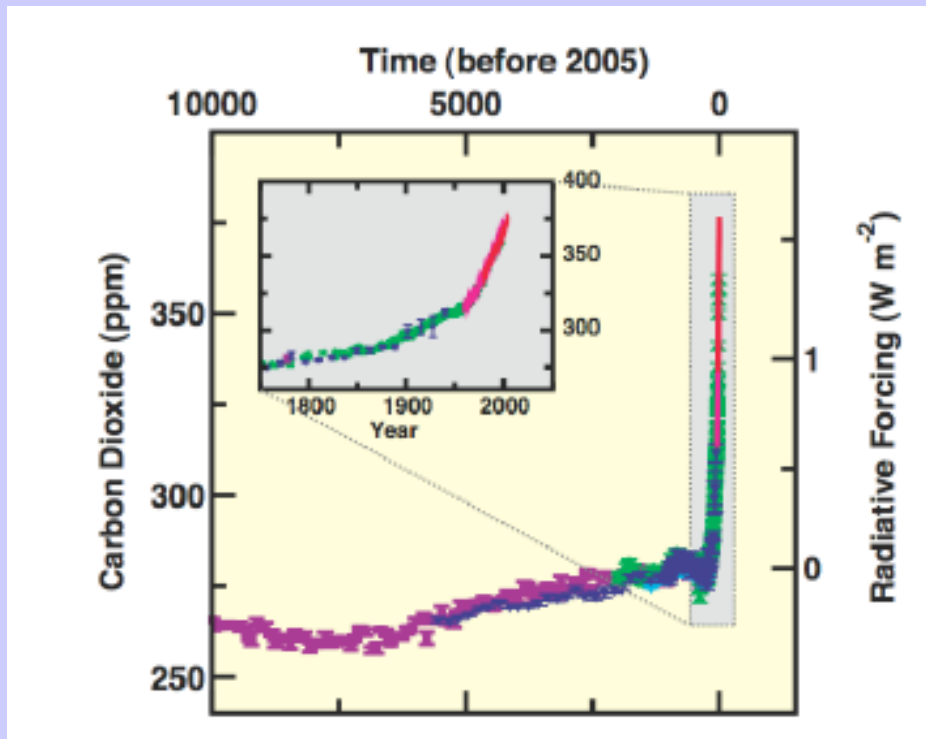
- Undertake standard monitoring of flow, salinity and pH for all sites on a “monthly” basis.
- Undertake chemical species sampling during the “best” sampling run.
- Decide on which streams should be part of stream ecology studies in 2010.

# Conclusions

- While the stream survey method adopted seems to be a sound one, it is at the mercy of the rainfall regime.
- The two years of data so far collected are highlighting the highly variable nature of streamflows in the study area with little or no significant flow over much of the area in the below-average rainfall year of 2008.
- The survey method is able to identify streams that have groundwater discharge and indicate catchments that may contain groundwater dependent ecosystems.
- The method is also able to define catchments with significant streamflow and possible areas with stream dependent ecosystems

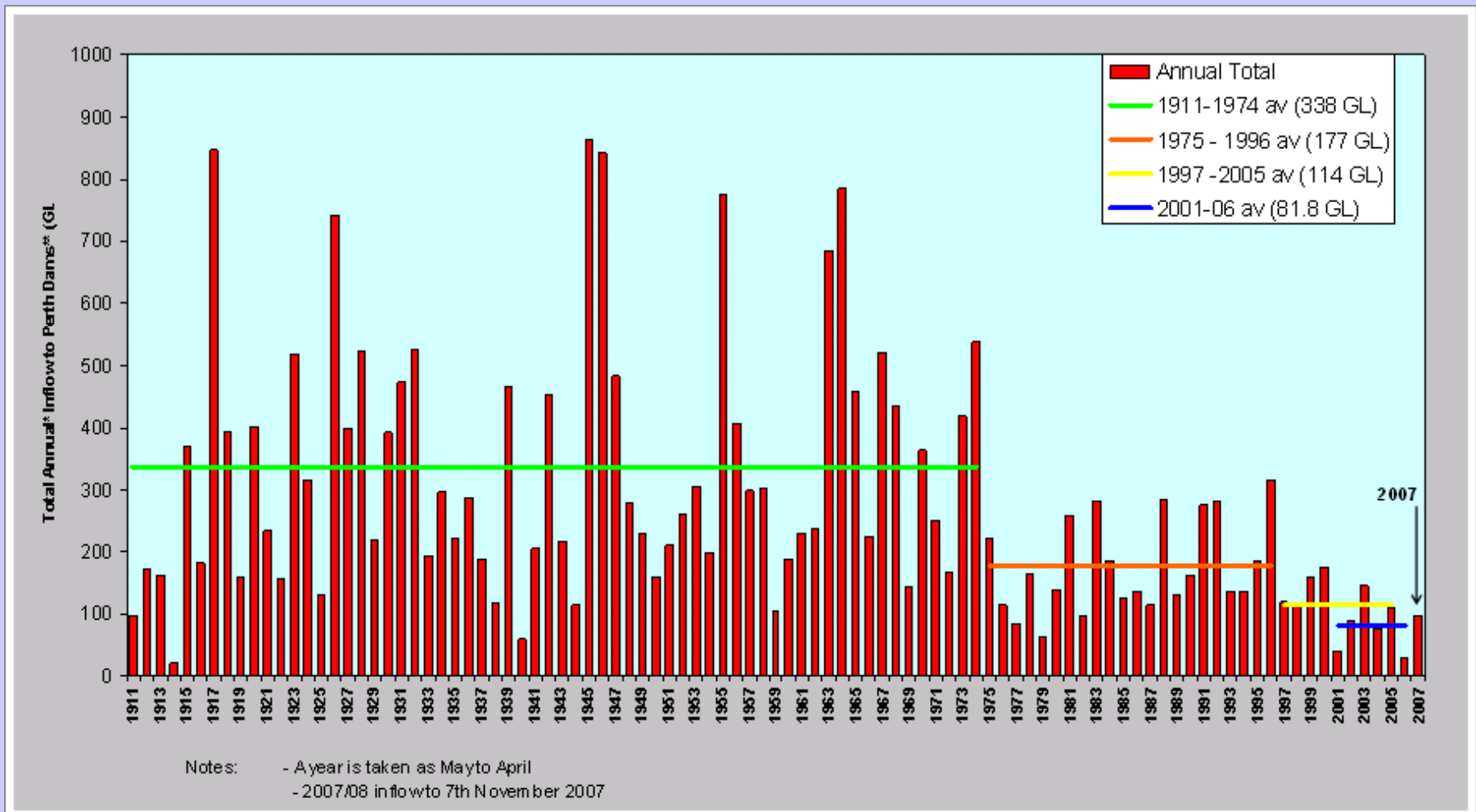


# CLIMATE CHANGE STUDIES



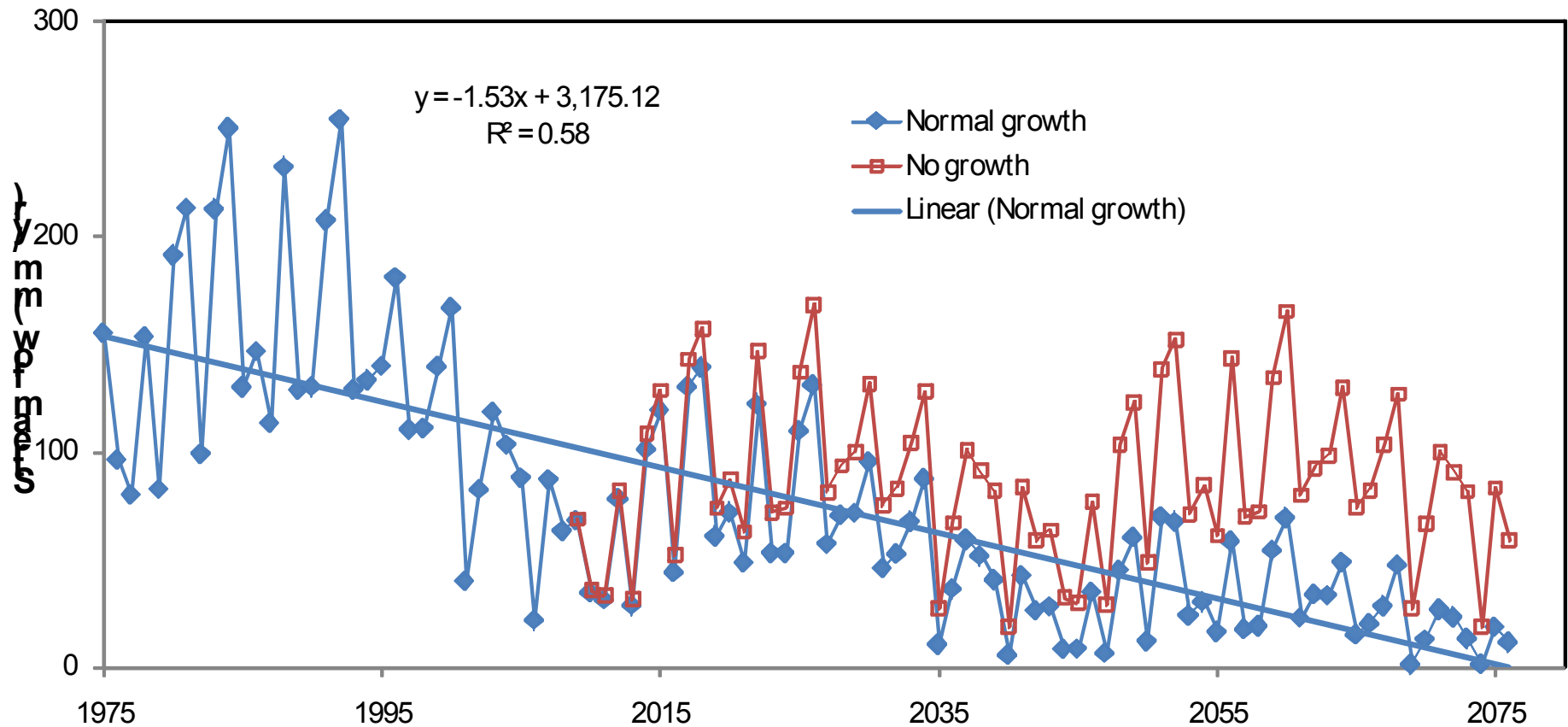
# Rainfall and Streamflow

There has been declines in rainfall since the late 1960s of 10% but much larger declines in streamflows due to non-linear behaviour.



# Rainfall and Forest Growth

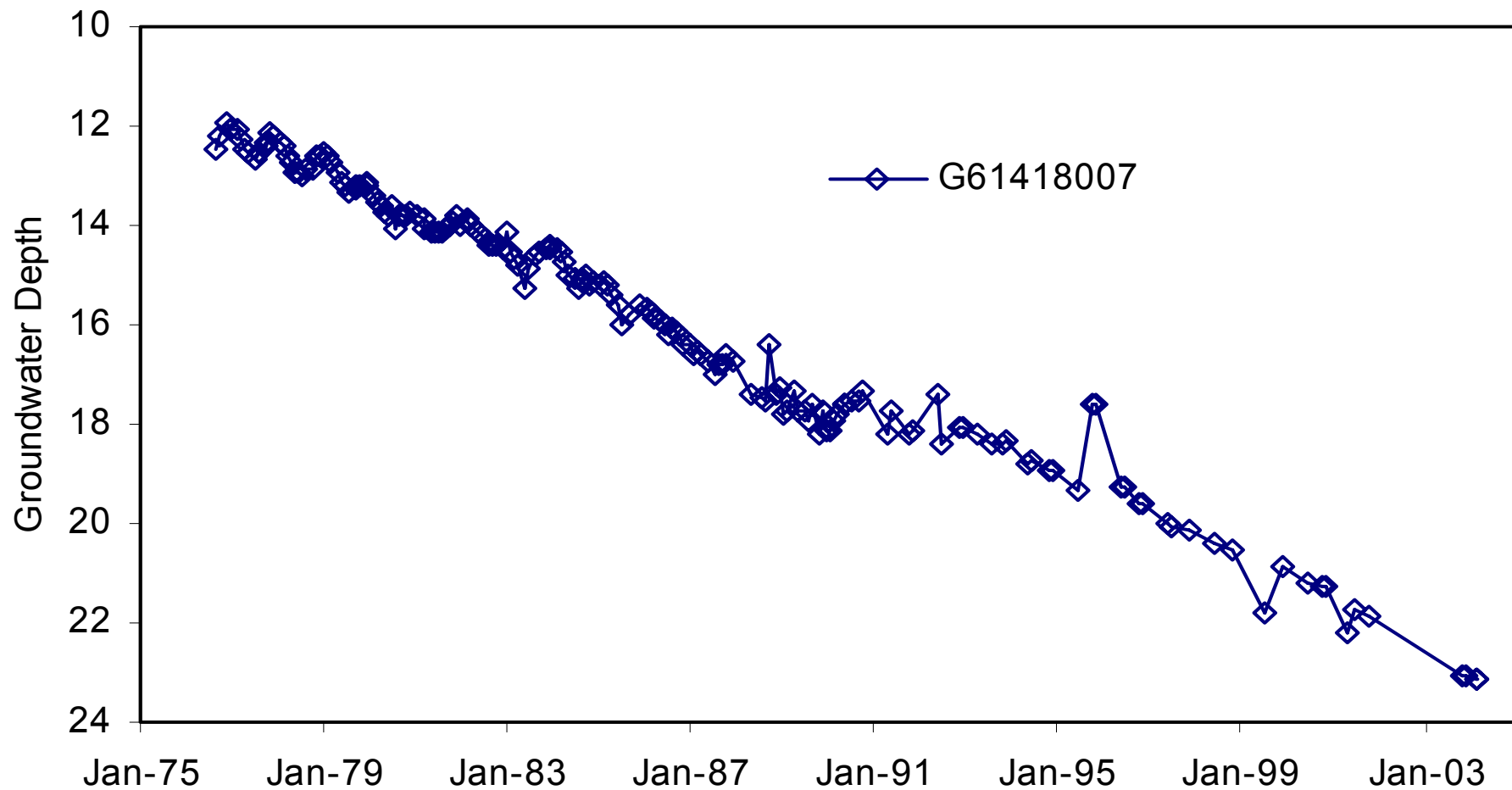
Example of predicted streamflow behaviour for 31 Mile Brook near Jarrahdale. There are predicted to be large effects with forest growth in combination with low rainfall.





# Rainfall and Groundwater

An example piezometer from the Hunt Catchments at Saddleback.



# Likely Ecological Effects - Forest

1. Jarrah, marri and wandoo are slow-growing, long-lived and are adapted to surviving drought and fire.
2. Reduction in forest productivity (e.g. stand height).
3. Plant communities vary across the forest in response to conditions that affect soil moisture, so plant species distributions will shift accordingly.
4. Fire-induced shifts.

# Likely Ecological Effects - Fire

1. Increased risk of intense wildfires.
2. Hotter, drier conditions.
3. Greater fuel loads due to reduced opportunities for prescription burns.



# Likely Ecological Effects - Fauna

Probably will be winners and losers.



# Likely Ecological Effects - Fauna

Loser - Mardos need dense ground cover and logs for protection.



Winner - *Morethia obscura* favours more open areas.



# Likely Ecological Effects - Frogs

Delayed autumn rains pose a risk for autumn breeders like these.

Moaning Frog  
(*Heleioporus eyrei*)

Sand Frog (*Heleioporus psammophilus*)





# Proposed Approach

- Prepare a review of potential effects of climate change on hydrology, flora and fauna. Include any available data of historical trends.
- Evaluate potential for predicative ecological modelling.
- Develop a long-term monitoring program.

# Landscape modelling for biodiversity assessment



Grant Wardell-Johnson  
Joselyn Fissioli

# The role of the Landscape Ecologist

- Enable planning for decision-making of future mining related activities
  - To contribute & advise the team concerning data collection, design & analysis
  - To analysis and interpret biodiversity associated data across the landscape
  - To model key biodiversity values across the landscape
  - To enable identification of key ecological linkages across the landscape



# Landscape modelling

- To identify
  - key biodiversity values to be protected
  - key ecological linkages (to be preserved and additional linkages that may be created)
  - proposed areas of zero disturbance and their respective buffer zones

# Field Survey

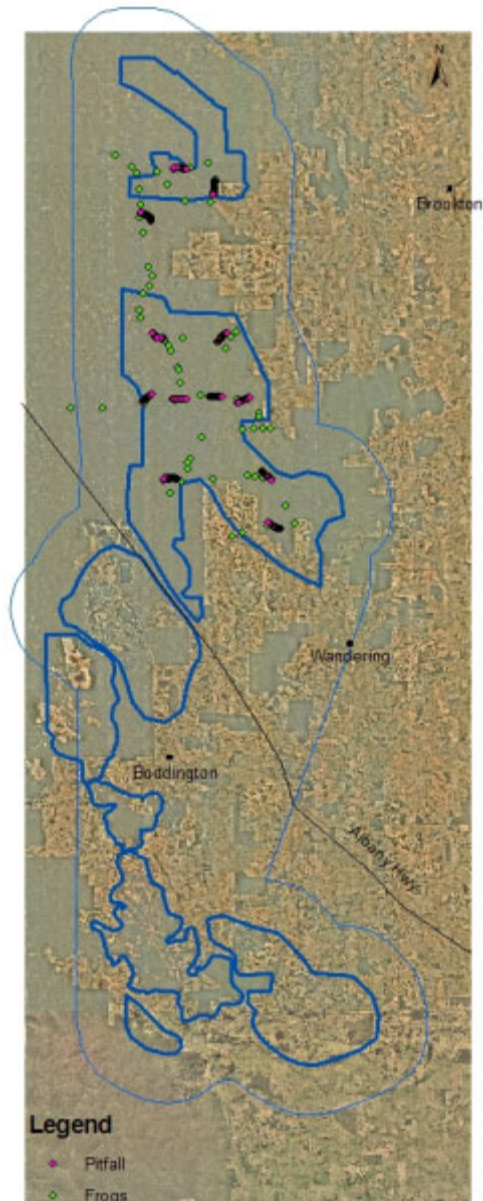
- Flora and fauna investigations will contribute towards identifying and mapping natural areas that support significant biodiversity values

# Data collected to date

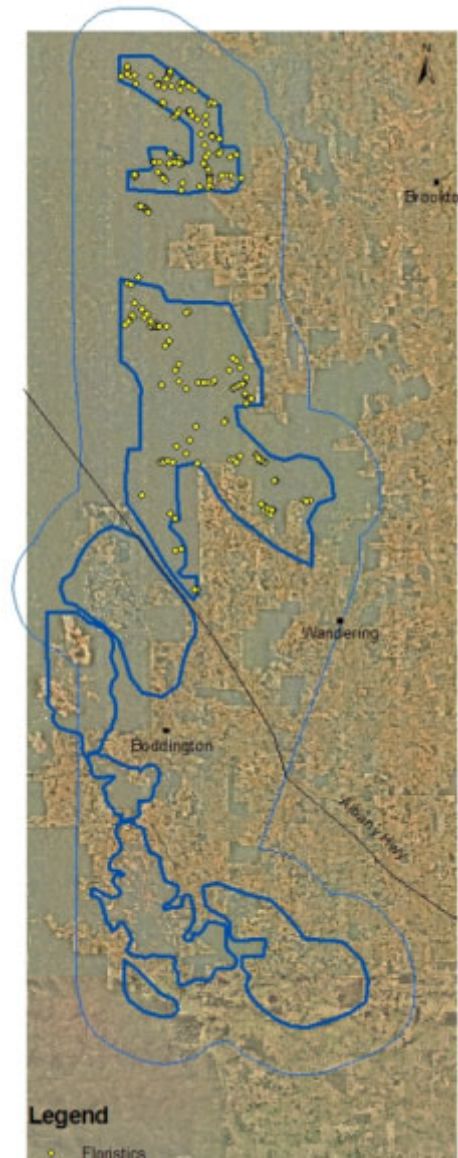
- **Floristics & vegetation** (Bennett consulting)
  - Floristic quadrats (201)
  - Site typing records (3759)
- **Fauna** (Bamford consulting)
  - Fauna plots (300 in 10 transects) - including trapping & bird survey
  - Frog aural records(70 sites), Cockatoo sightings, Bat recorder records
  - Narrow endemic invertebrates



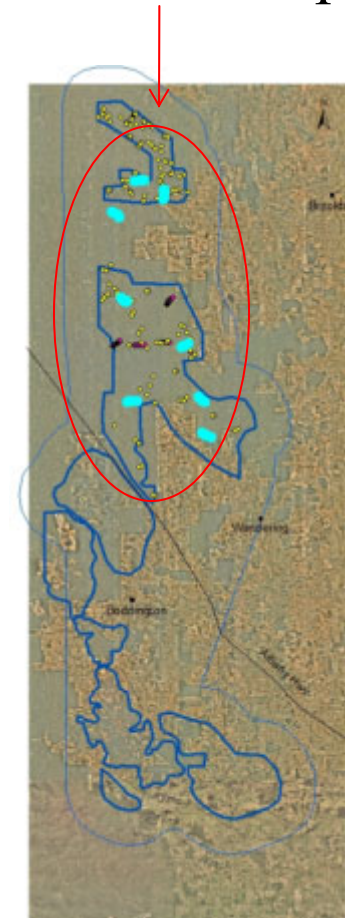
## Pitfall trap sites



## Floristic sites



Sites where pitfall traps and floristic quadrats overlap

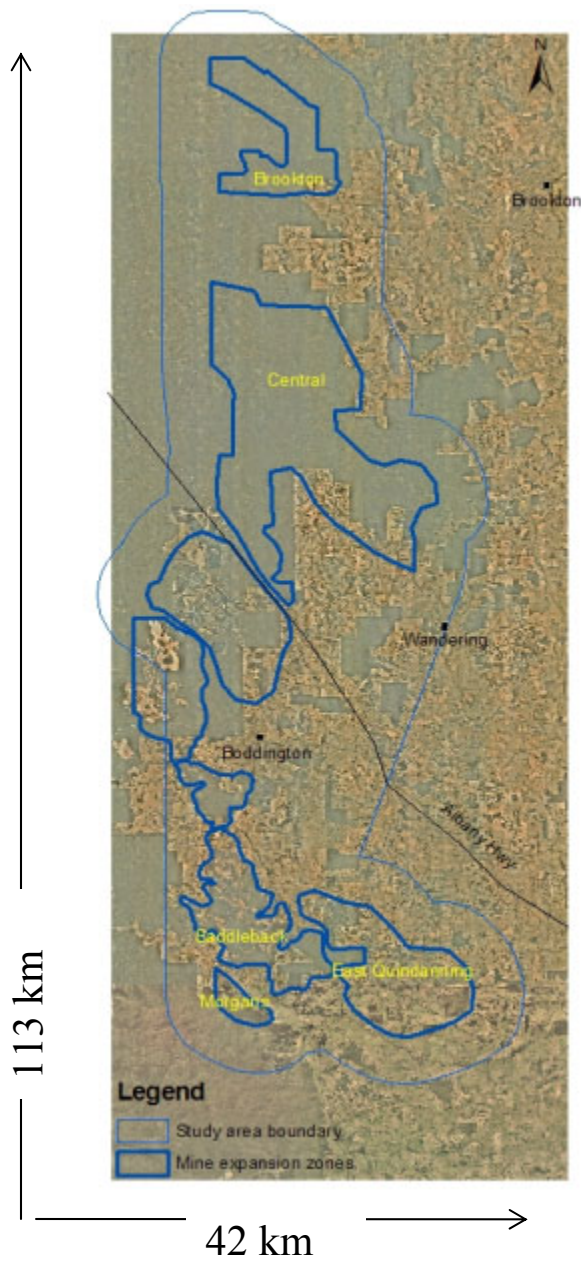


# How well does existing data cover the environmental range?

- Depends on the boundaries of the sampling/ study site
- Define a sampling plan (SR<sup>3</sup> Strategy, Cawsey, Austin et al. 2002)
  - First level - Rainfall and Landsat Imagery (which reflects topography, vegetation & soil - Geoff Maugher)
  - New plot location to cover geographical extent and range of different environments
  - Replication and randomisation

# Sampling/ study area

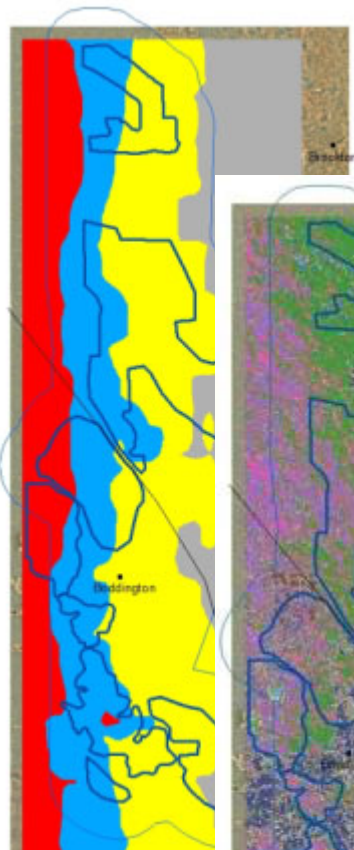
- Sampling / study area includes entire mining envelope, including a 5 km buffer
- All environments within this area sampled & modelled



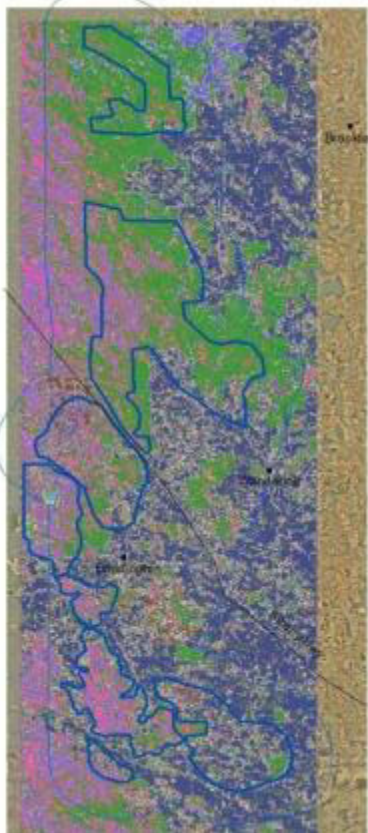
Study area = 2834.4 km<sup>2</sup>



## First level stratification of the study area

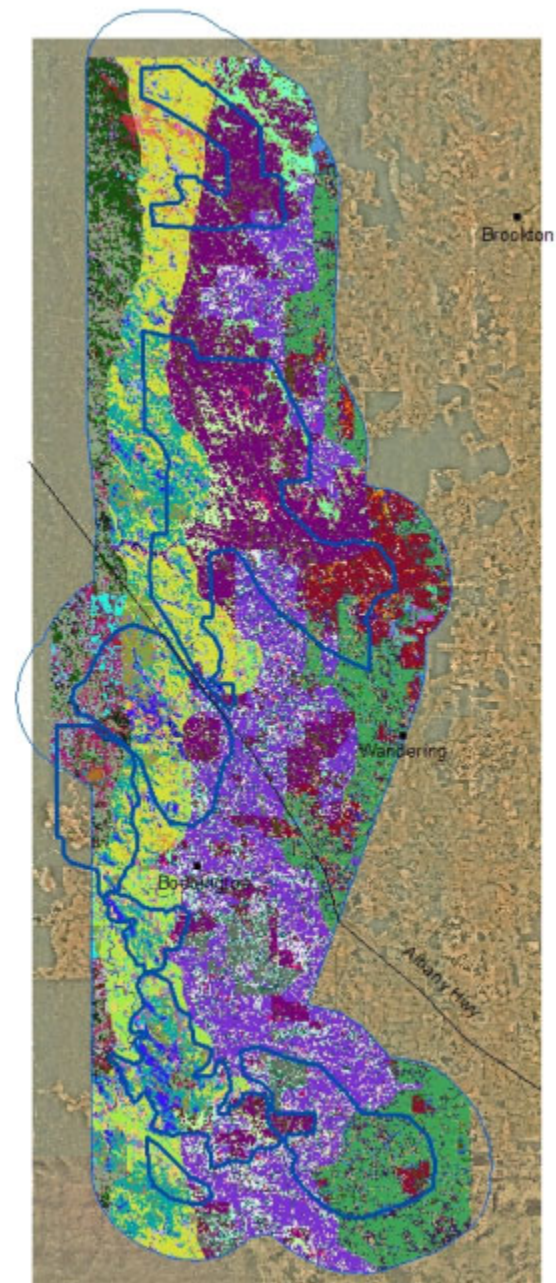


Average annual  
rainfall  
(4 classes)



Landsat Classification  
Units (16 groups)

= 64 different combinations



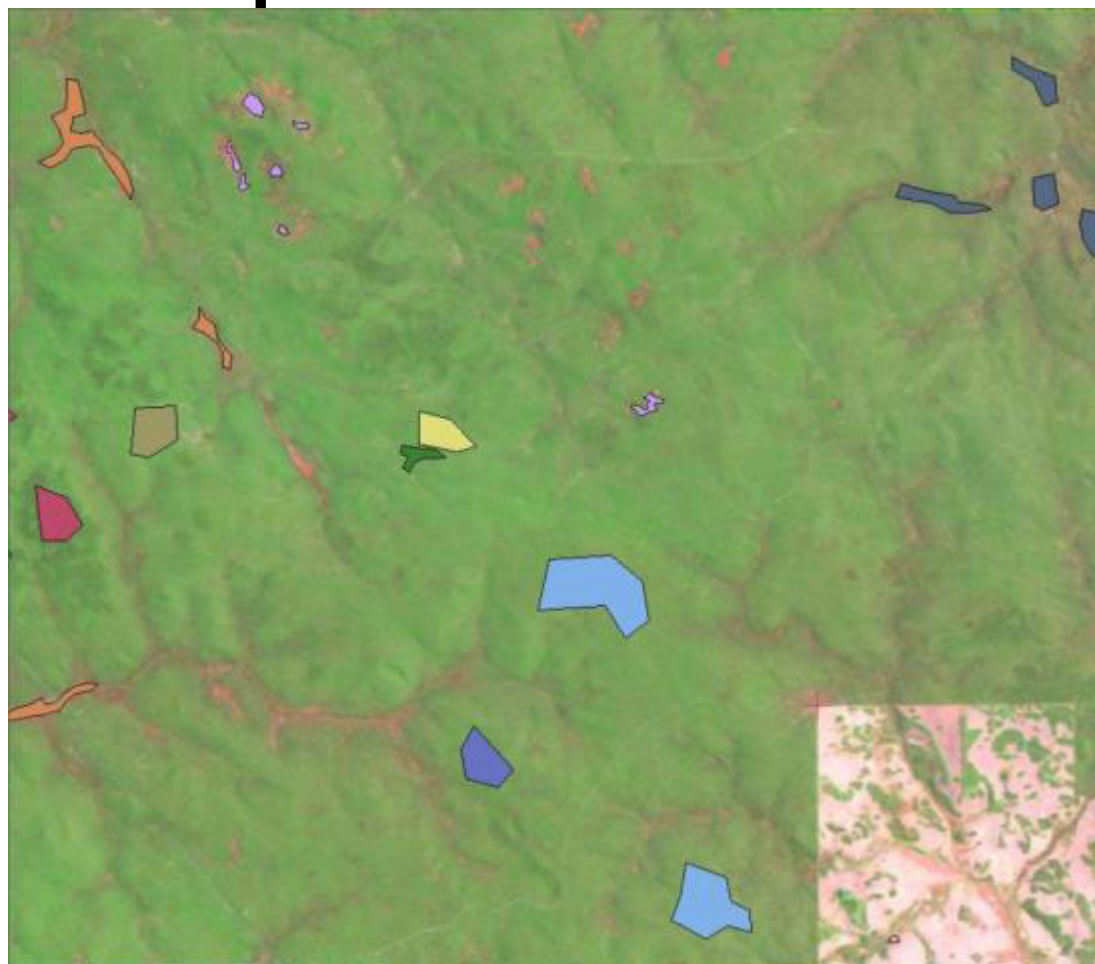
# Prepare Landsat scene

- Each pixel is average of 15 scenes excluding those where LAI had dropped suddenly due to burning, logging, etc, ie 'best average'.



# Map sample areas

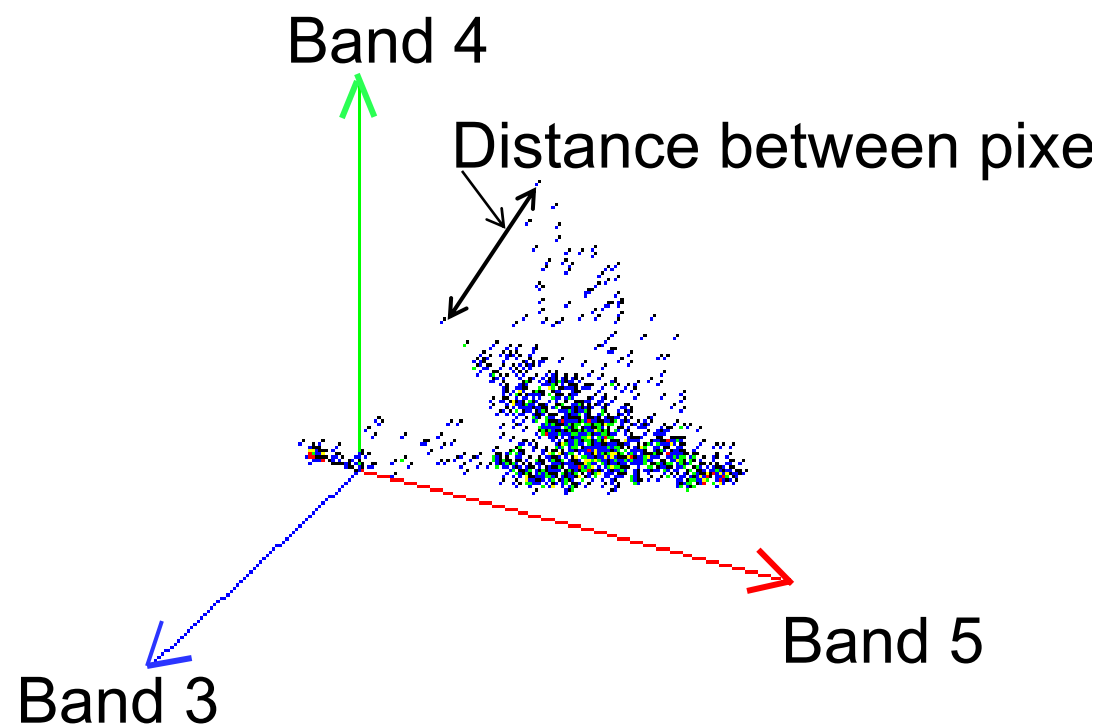
- Samples of areas of apparently different classes were mapped, and means and std devns of band values for the pixels computed.





# Assign pixels to classes

- Three Bands chosen
- Pixels assigned to sample class whose mean nearest (no. of std devns).



# Review areas generated

- If the mean of a pixel in contiguous area more than 4 std devns from all class means, then area statistics used to define new class. With the new set of classes, pixels were re-assigned.
- Number of classes reduced by amalgamation. Considered in order of increasing std devn, classes were merged.

# Visual grouping and simplification

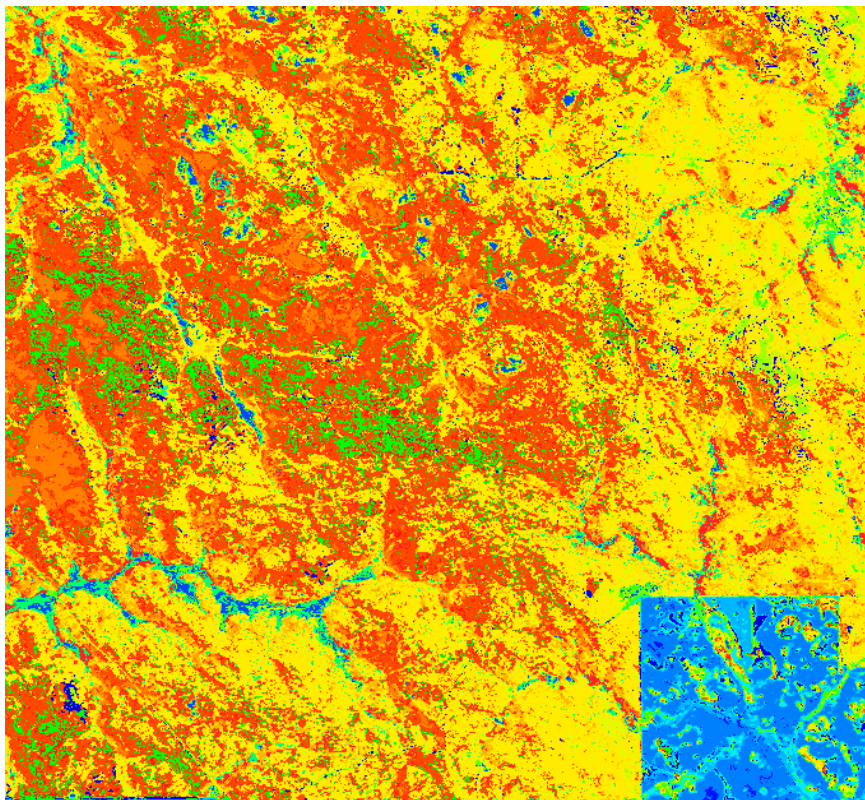
- Some classes closely associated when mapped & may have characteristics not relevant to forest density, e.g. hill shading varies temporally.
- Associated classes grouped, and an interpretation given to each class.
- To reduce complexity, areas less than 3 pixels re-assigned to most common adjacent class,.
- This step can be reversed when searching for unusual habitat



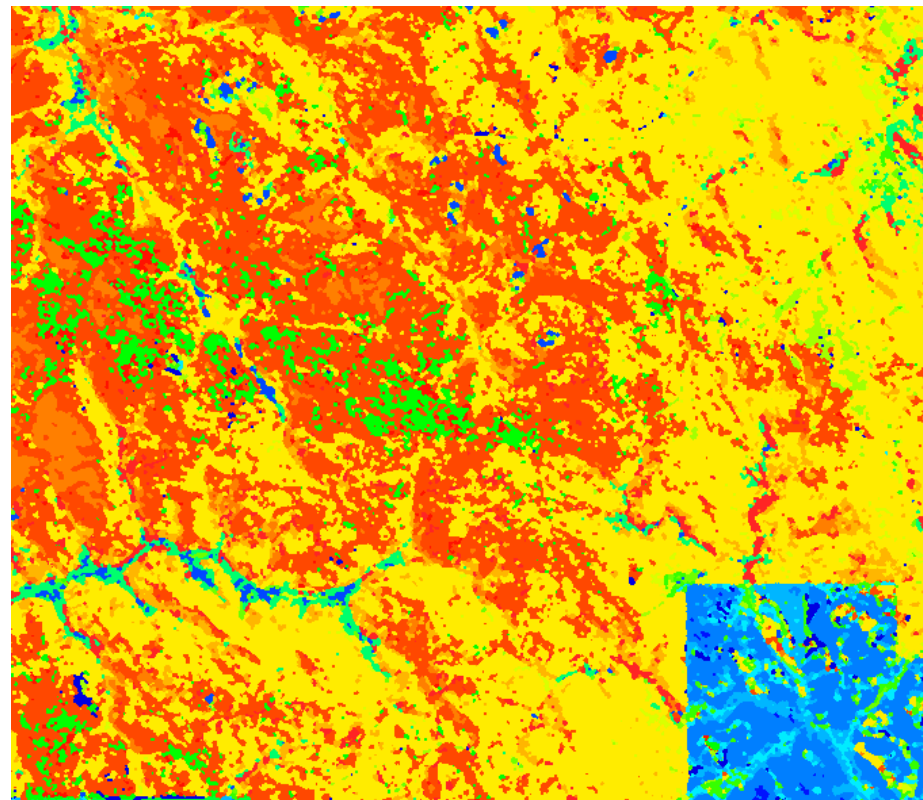
## Classes identified (24 – 8 not relevant) – draft names

- 1 unknown
- 2 water
- 3 shallow water
- 4 roads and bare
- 5 clay soils
- 6 rock outcrop
- 7 pasture
- 8 paddock trees
- 9 forest fringe
- 10 partial trees
- 11 young trees in pasture
- 12 swamp
- 13 plantation
- 14 plantation or quality forest
- 15 sand plain
- 16 sparse forest
- 17 low shaded forest
- 18 better sand plain
- 19 ne forest
- 20 quality ne forest
- 21 west forest shady side
- 22 west forest sunny side
- 23 west forest quality
- 24 rock veg

## Final classes



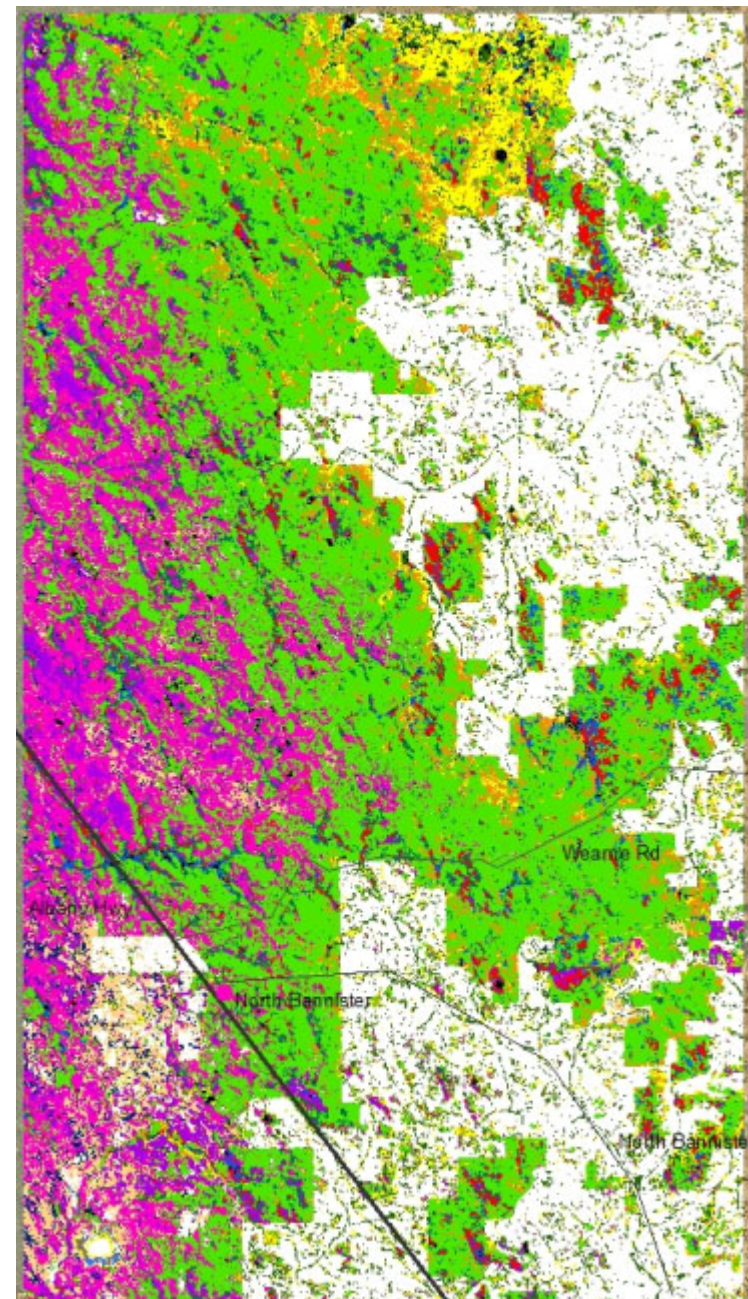
## Final classes de-fragmente



Some examples of the different groups include:

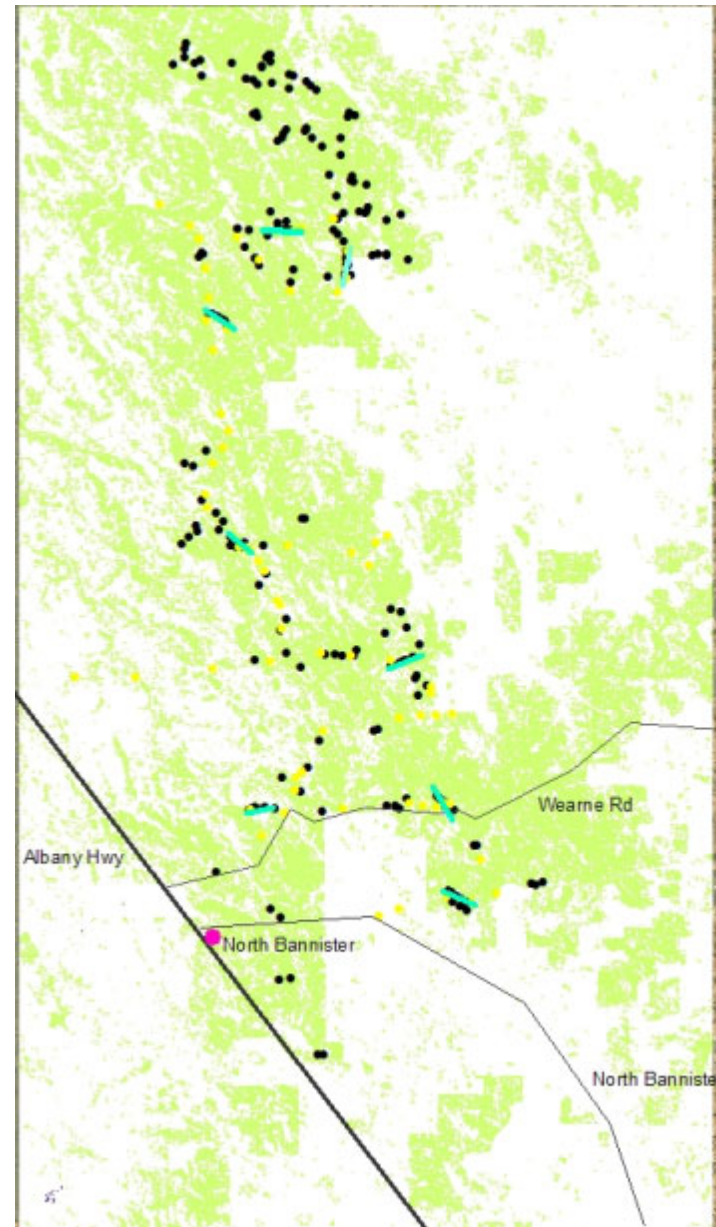
North East Forest  
West forest Sunny Side  
Sandplain  
Rock Vegetation

Class 110 in yellow  
represents dry forest

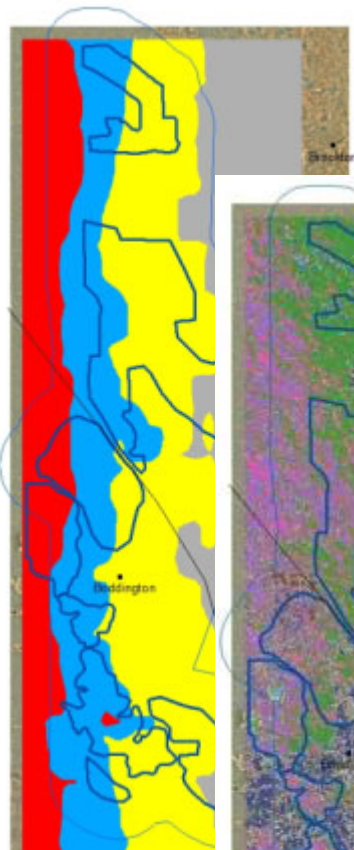




Most of the existing flora quadrats  
and fauna transects lie in the  
landsat group **North East Forest**



## First level stratification of the study area

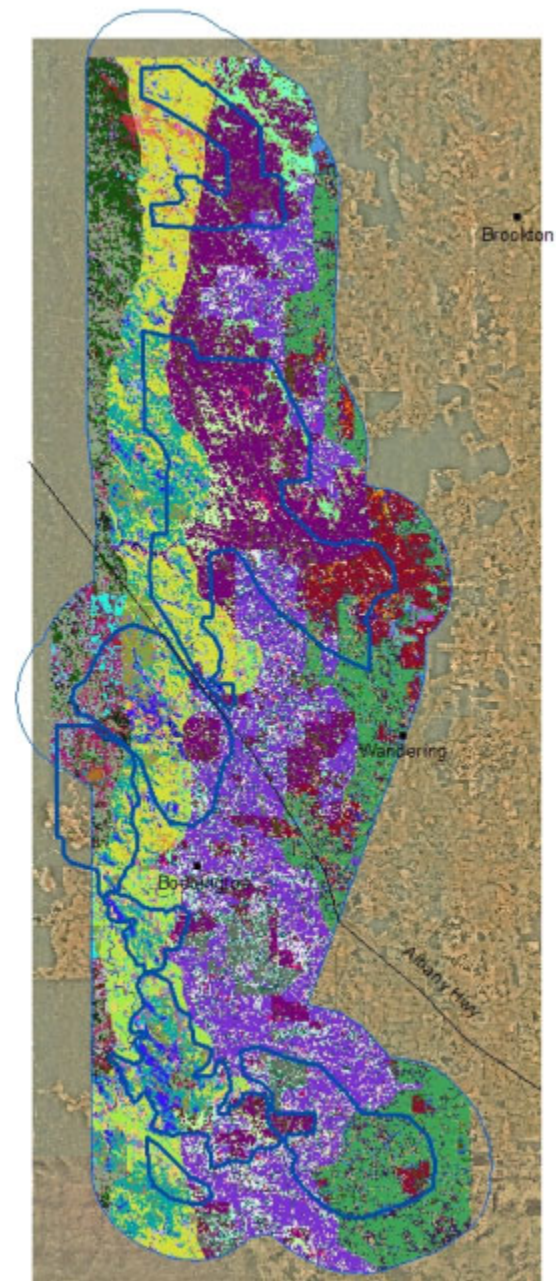


Average annual  
rainfall  
(4 classes)



Landsat Classification  
Units (16 groups)

= 64 different combinations



# Looking at data collected to date

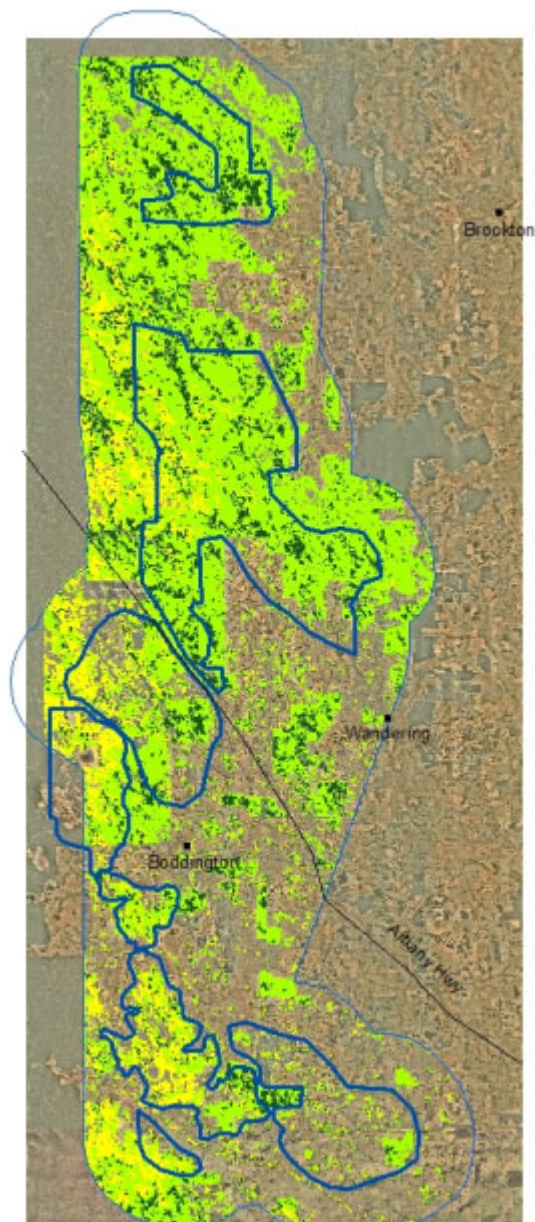
- How well does it cover the environmental range in the study area?

1. Plot in GIS

2. Overlay with relevant environmental variables



Landsat group	Average Annual Rainfall (mm)			
	500-600	600-700	700-800	> 800
Better NE forest	7	36	31	9
Better sand plain	16	50	16	4
Clay	3	3	1	1
Forest Fringe	37	69	17	3
Low Shade Forest	9	23	12	3
NE Forest	100	373	270	76
Plantation or quality forest	2	10	29	37
Roads and Bare	6	23	15	10
Rock Outcrop	1	2	3	1
Rock Vegetation	9	23	13	4
Sand plain	24	56	13	4
Sparse Forest	1	6	2	0
Swamp	6	9	5	3
West forest quality	0	2	8	12
West forest shady side	4	18	45	22
West forest sunny side	4	50	154	98



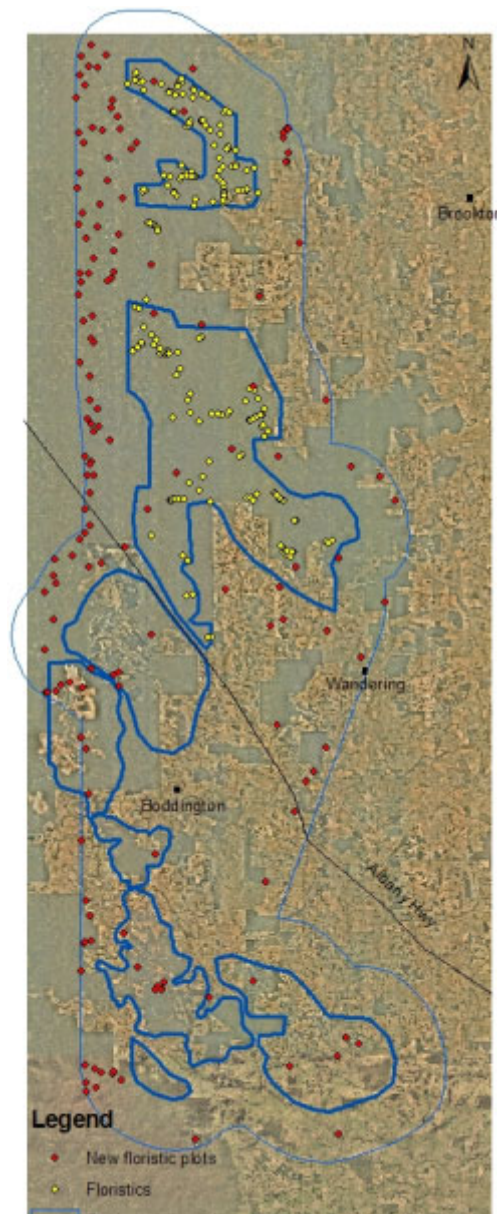
Landsat group	% Study Area	% Pitfall Sites	% Floristic Sites
North east forest	43	64	41
West forest sunny side	16	10	7
Better north east forest	4.3	6	2

# New quadrat location

- Using both the environmental classes and landsat imagery groups to
  - identify areas that are under sampled
  - locate rare environments
  - determine location of new floristic quadrats and fauna transects



# New sampling plan for floristic quadrats



The new floristic quadrats in combination with the existing floristic quadrats cover the environmental range across the study area

# Statistical modelling

- Using statistical methods (such as GAM, GRASP, BIOCLIM, and BIOMAPPER) to relate quadrat site environmental data with species presence / absence and or abundance
- The environmental variables that best explain the species presence / absence or abundance are then used to predicted the probability of the species distribution over the study area.

# Examples using existing data

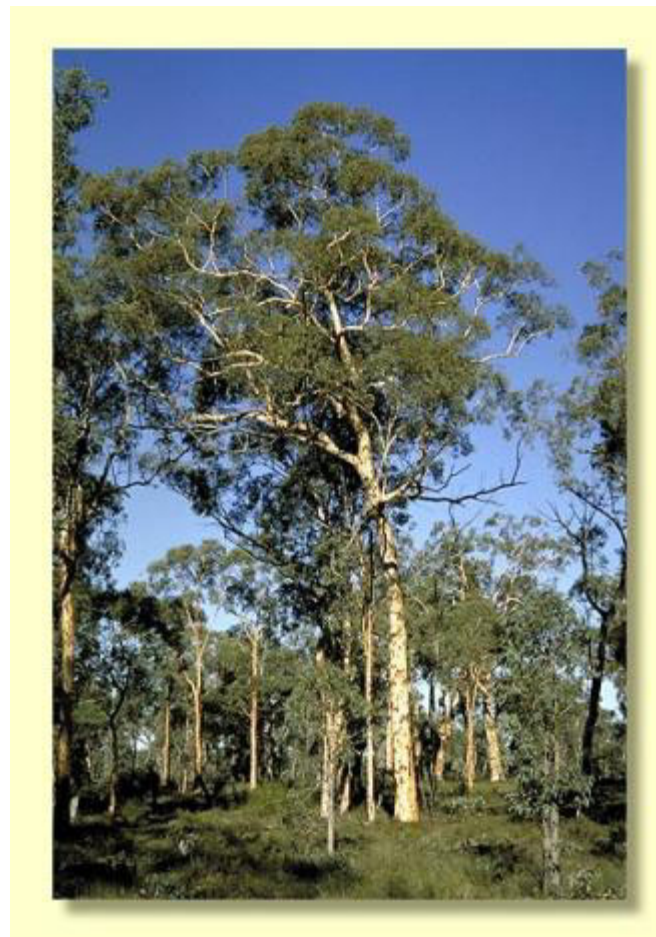
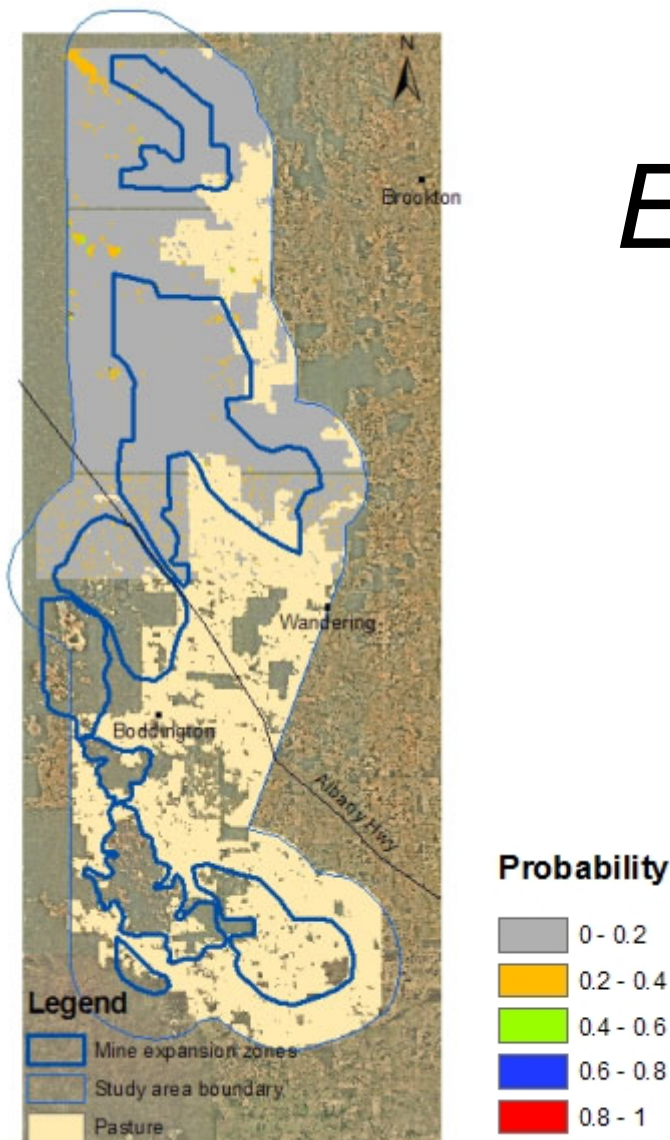
- Using the data collected to date the following species were modeled
  - *Eucalyptus accedens*
  - *Pseudophryne guentheri*
- Modeling was only done in the upper half of the study area
  - Lack of data in the lower half would influence predictions making them less reliable



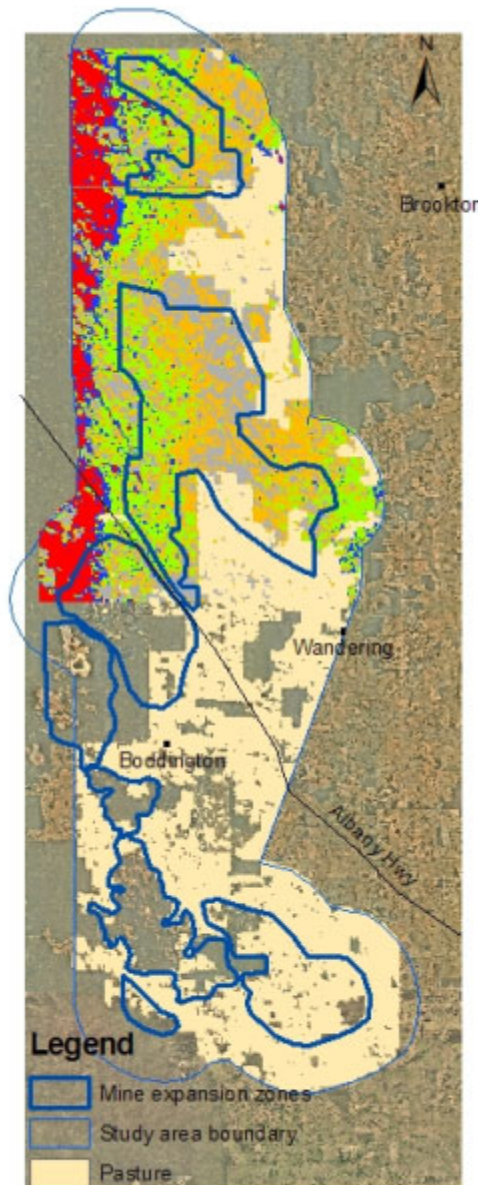
# Modelling individual species

- Relates species presence/ absence and or abundance to environmental data over the landscape
- Reliability of models depends on the quality of the species data collected as well as available GIS layers

# Predictive Map of *Eucalyptus accedens*



# Predictive map of *Pseudophryne guentheri*





# To model species and community distributions over the entire study area we need

- Quadrat based data of both flora and fauna that covers the environmental range across the whole study area
- GIS layers of relevant environmental variables

# Ecological Linkages Objectives

- Identify the role and significance of ecological linkages
- How – baseline surveys
  - Desktop reviews of hydrology, flora and fauna studies
  - These will determine the values of particular areas, identify patterns and changes in vegetation, flora, fauna and habitat across the landscape

# Ecological linkages

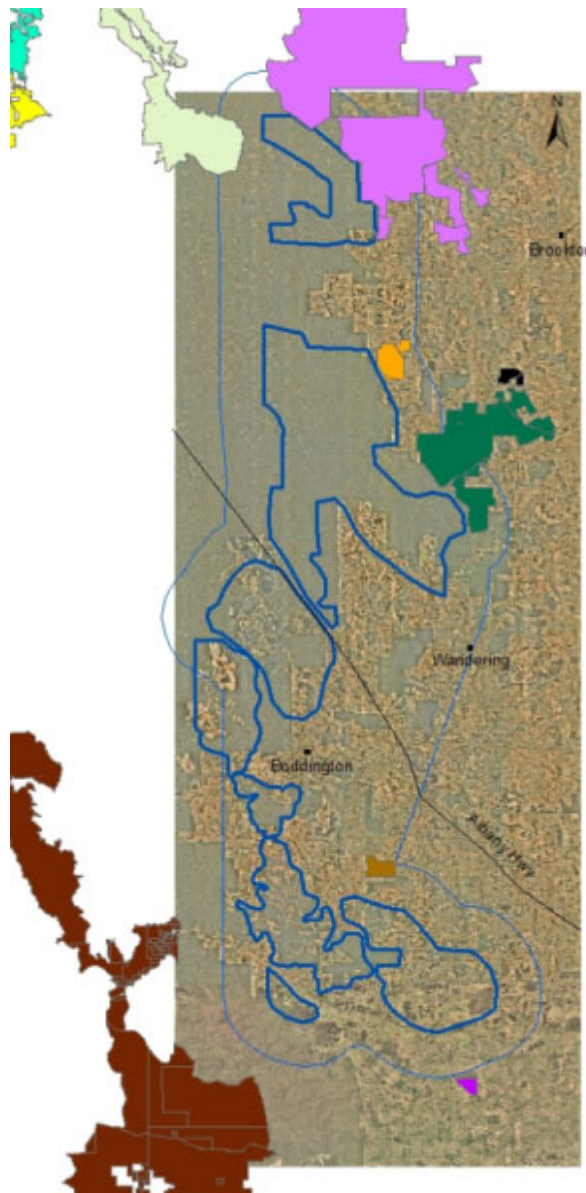
- Should be contiguous vegetation linking known areas of high conservation value
- Should incorporate major variation in plant communities and fauna habitat of the region
- Ecological linkages within study area should link to other ecological linkages outside area



# To identify key ecological linkages

- Need to map flora and fauna over the landscape
- To do this
  - Quadrat based data that covers the range of different environments in the study area
  - Use statistical modelling methods and GIS to predict species and assemblage occurrence over the landscape

# National Parks, Conservation Parks and Reserves in and around the study area



## Legend

- Lavender Nature Reserve
- Brookton Highway Nature Reserve
- Boyagarring Conservation Park
- Lupton Conservation Park
- Mooradung Nature Reserve
- Wellington National Park
- Korijekup Conservation Park
- Lane Poole Reserve
- Karnet Nature Reserve
- Gooralong Conservation Park
- Serpentine\_National\_Park
- Canning National Park
- Pickering Brook National Park
- Helena National Park
- Wandoo National Park
- Study area boundary
- Mine expansion zones

# Where to from here?

- After amalgamating existing data – prepare initial PATN analysis of all floristic quadrats. This will be redone once sampling completed – and landscape modelling will predict distributions of assemblages
- Modelling based on direct gradients (moisture availability, solar radiation, soil nutrients (or surrogate))