

# Granite Rock Pools as Rare Wetlands

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How could something so seemingly simple as  
a rock hole be so *complex*?

How could something so seemingly commonplace  
as a rock hole be so *rare*?

*Rock basins (or gnammas) are depressions in the bedrock surface and are  
one of the **most common and widely distributed of all granitic forms.***

(J.A. Bourne & C.R. Twidale. 2002. J Roy Soc W Aust 85: 83-102.)

Marbaleerup, WA



# Gnamma

- Rock pool, water hole, rock basin, weather pit, *tinaja*, *aguaje*, galt, vernal pool, etc.
- 'Minor' land form initiated (a) at weathering front, (b) at surface, (c) due to gravitational pressure (Campbell 1997, Withers 2000)

- Western Desert Aboriginal term now used globally in the description of waters, wetlands, or waters/wetlands mosaics in isolated rock formations (e.g., inselberg, monadnock, bornhardt)

Granite Mountains, CA



# Wetlands

*"areas of seasonally, intermittently, or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline, e.g., waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries"* (Australian Wetlands Advisory Committee 1977)

- Hydrology
- Chemistry
- Geomorphology



Carlawillup, WA

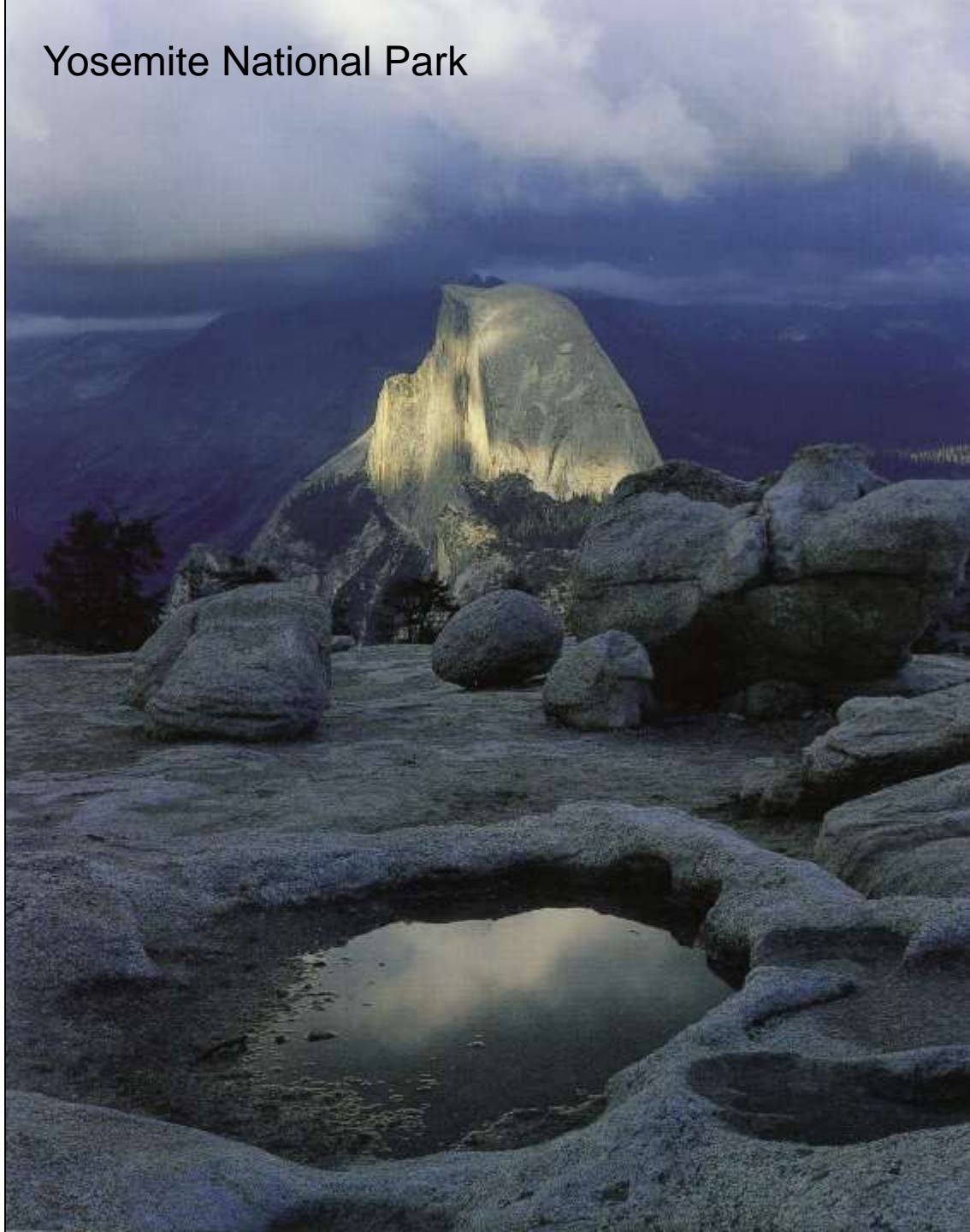
# Granite Rock Pool Examples



# Sweeny Granite Mountains Desert Research Center



# Yosemite National Park



# Corsica

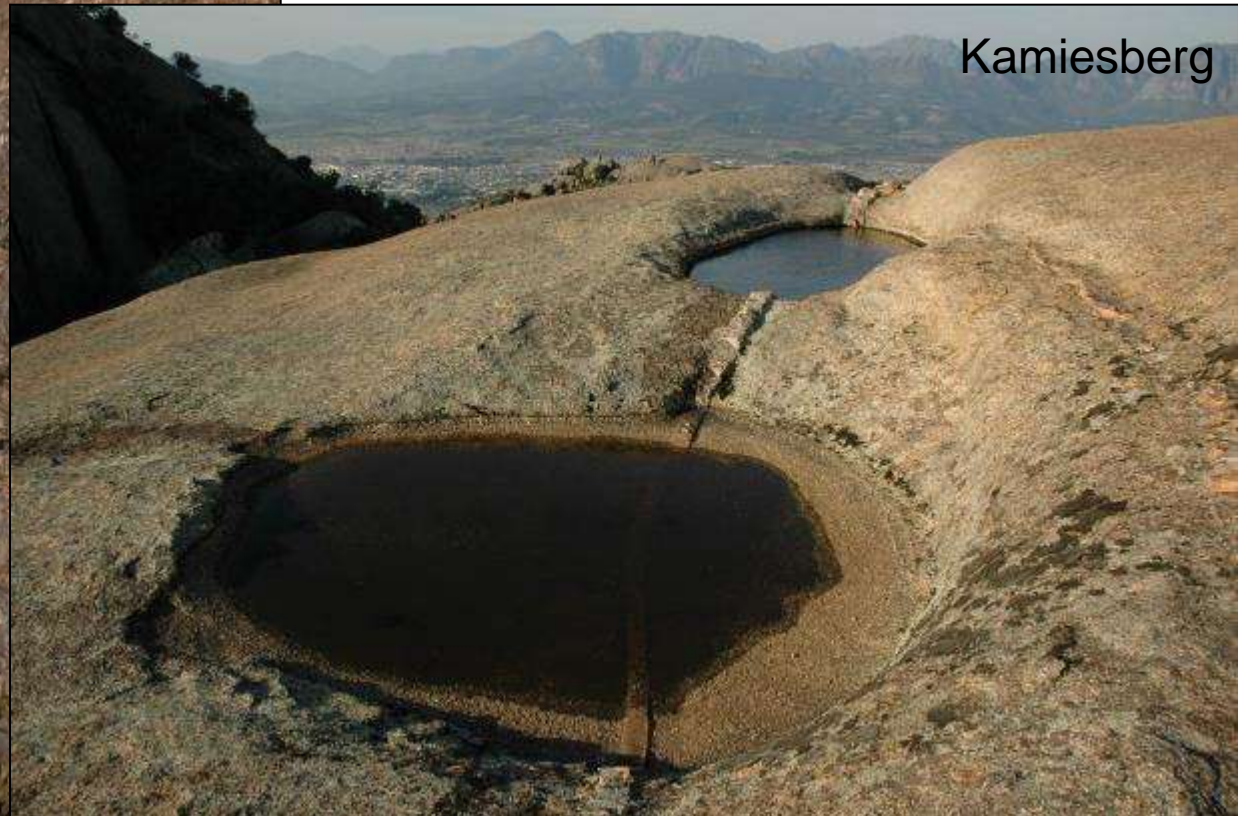




# *Sierra de Guadarrama, Spain*



# Cape Floristic Region South Africa



Kamiesberg

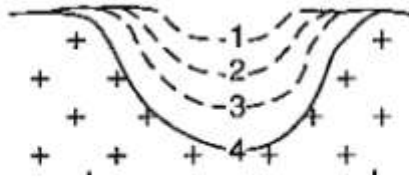


# Southwest Australia Floristic Region

Marbaleerup

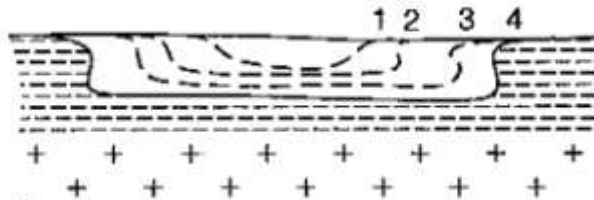
# Development of gnamma types

Timms, B. 2013. Geomorphology of pit gnammas in southwest Australia. *J. Roy. Soc. W. Aust.* 96:7-16.



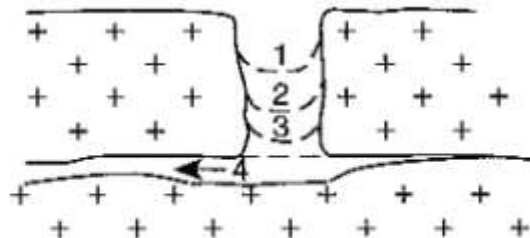
Homogenous  
Rock

Pit



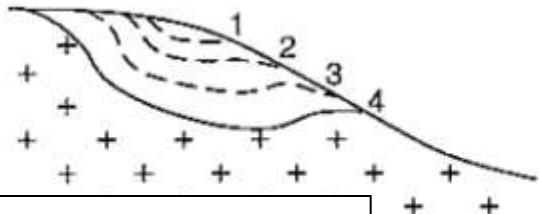
Indurated surface  
Laminated rock  
Homogenous  
rock

Pan



Homogenous rock  
Sheet joint

Cyindrical basin



Homogenous  
Rock

Armchair basin

## Step 1: Initiation of depression

- insolation → flaking
- crystalline irregularities
- lichen
- subaerial weathering (acids)

## Step 2: Break-up of rock

- further insolation
- wind
- moving water
- glacial ice
- wetting/drying cycles

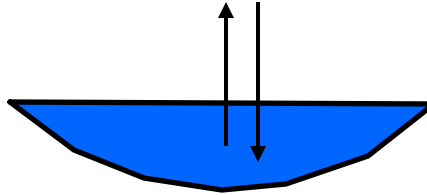
## Step 3: Removal of weathered material

- wind
- in solution
- humans

# Generalized Types of Depressional Wetlands

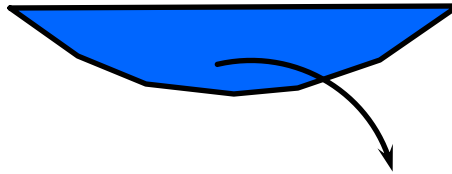
*(hydrologically speaking...)*

Perched



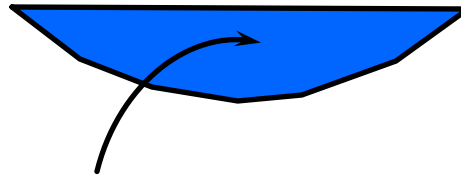
(many gnammas)

Recharge



(some gnammas)

Discharge



(a very few gnammas)

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Flow-Through



*Surface*

(many gnammas)



*Sub-surface*

(a very few gnammas)

# Pan Gnammas

Cape of Good Hope, SA



Yosemite, CA



Wave Rock, WA



Granite Mountains, CA



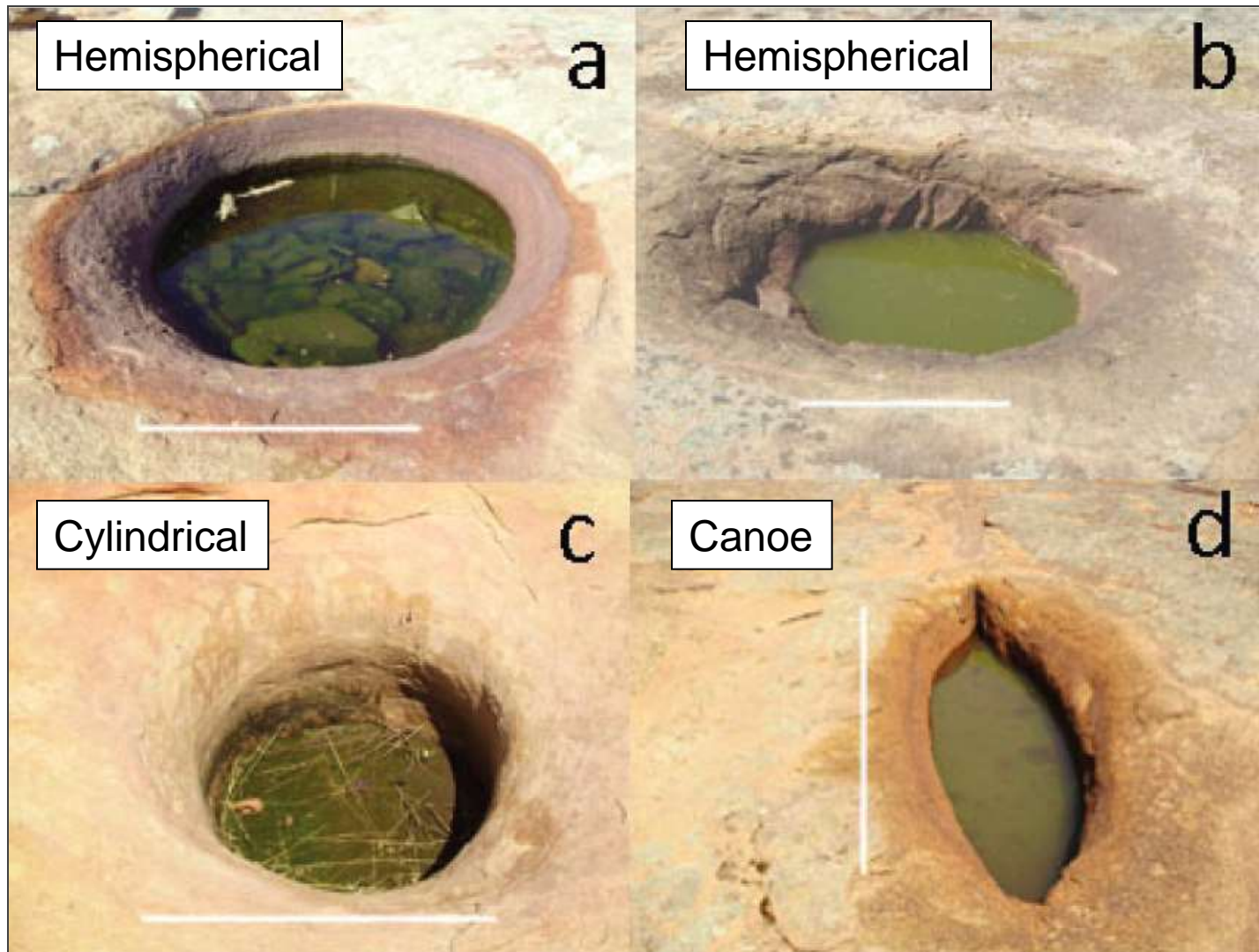
# Pit GnammaTypes

Table 1 from Timms, B. 2013. Geomorphology of pit gnammas in southwest Australia.  
*J. Roy. Soc. W. Aust.* 96:7-16.

Type	Name	Description	Frequency (%)
1a	Hemispherical	Hemispheric, no microlayering or joint control	21.25
1b	Hemispherical	Hemispheric, w/ layering and/or minor joint influence	30.00
2	Cylindrical	Cylindric – dominant vertical solution	11.25
3	Canoe	Elongate – major joint control	17.50
4	Trough	Positioned along major joint btw 2 rock blocks	5.00
5a	Underground shelf	Expanded depthwise at lower horizontal joint	2.50
5b	Flask	Expanded depthwise in homogenous rock	1.25
6	Lotic pothole	Evorsion trench along waterway	5.00
7a	Plunge pool	Active plunge pool on water course	5.00
7b	Plunge pool	Quiescent plunge pool along water course	1.25

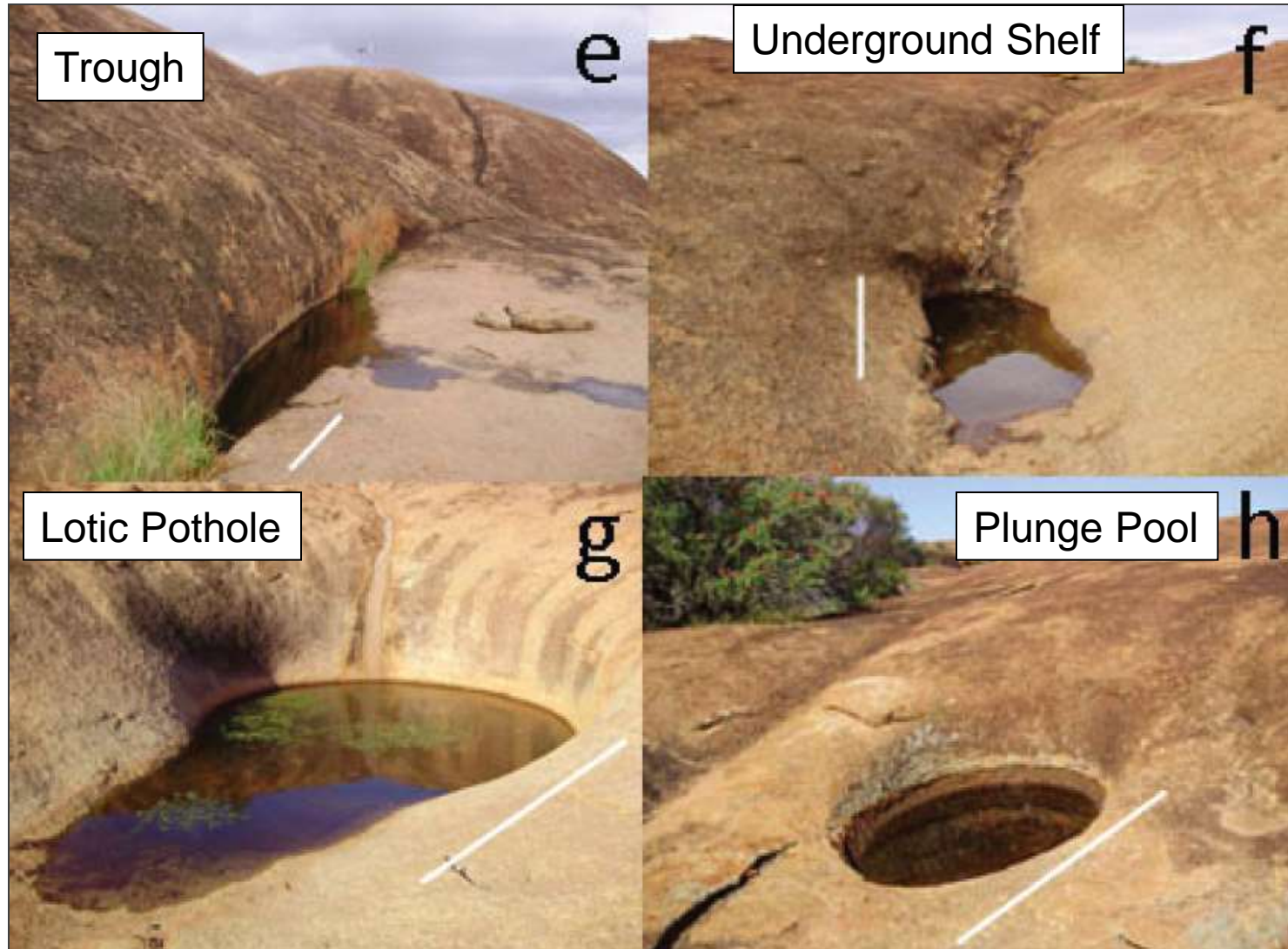
# Pit GnammaTypes (1)

(Depth:diameter >0.2)





# Pit Gnamma Types (2)



# Armchair Gnammas



Quanais (Gnamma Hill) Namaqualand



Unnamed rock near Cape Le Grand, WA



Boyatup, WA

Yosemite, CA



Marbaleerup, WA



## Riverine wetlands



Granite Mountains, CA

Roccapina  
Corsica



Wave Rock, WA



Riverine  
wetlands with  
rock pools  
(*tinaja*)

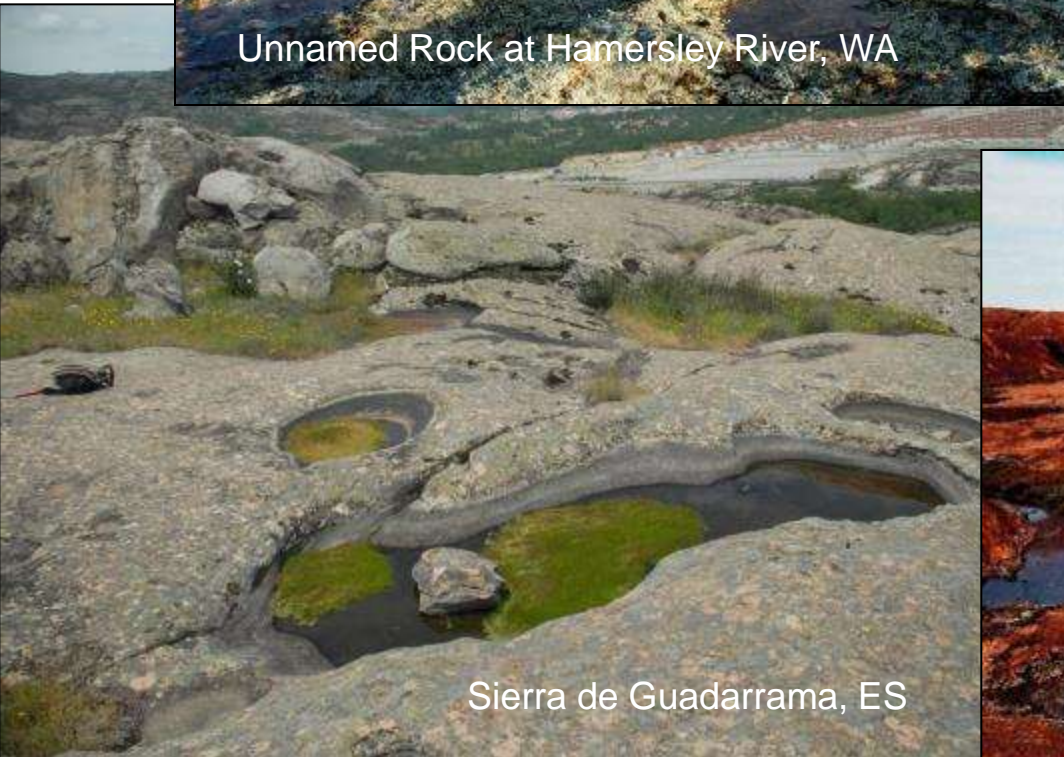
Carlawillup, WA



# Gnamma complex (‘Consanguineous wetland suites’)



Unnamed Rock at Hamersley River, WA



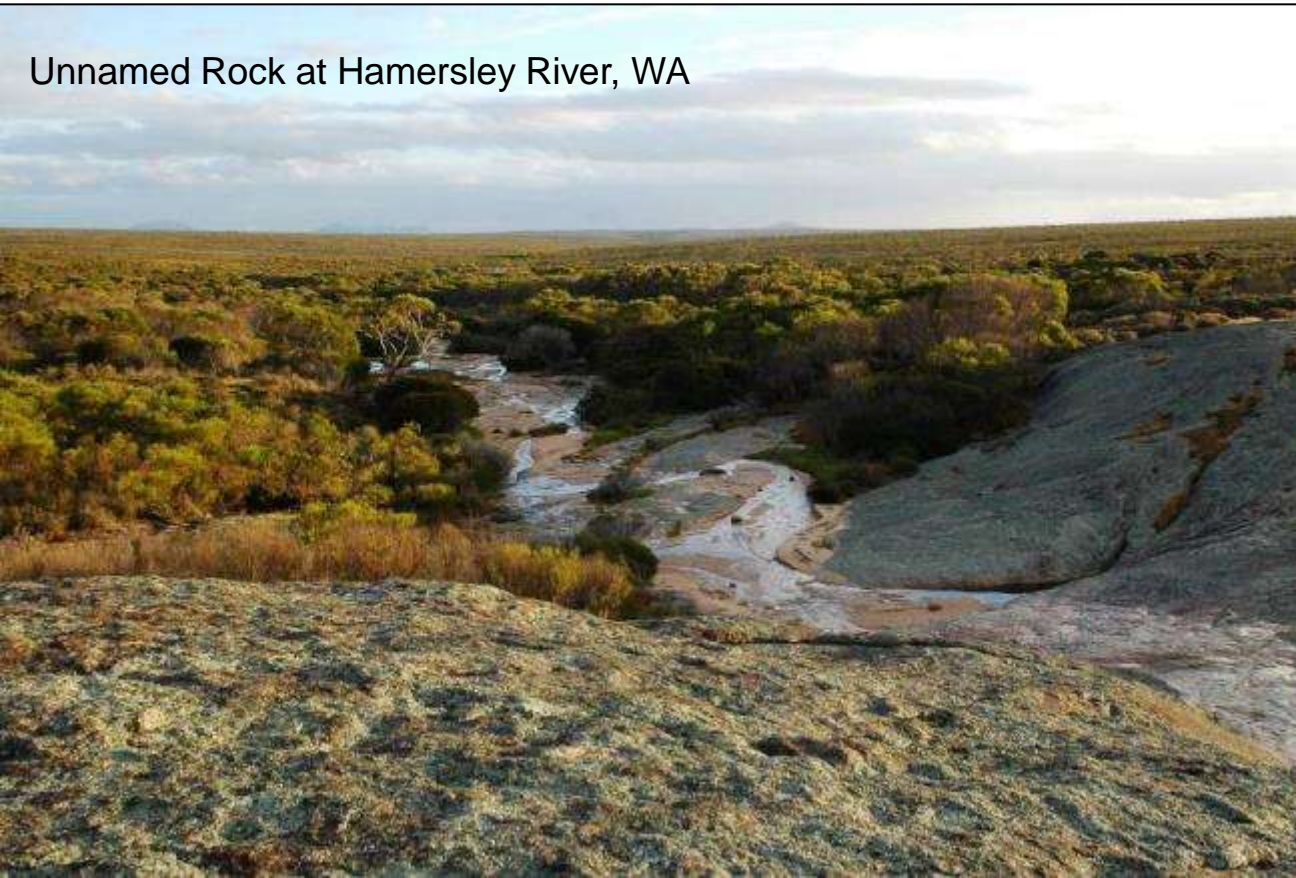
Sierra de Guadarrama, ES



Elachbutting Hill, WA

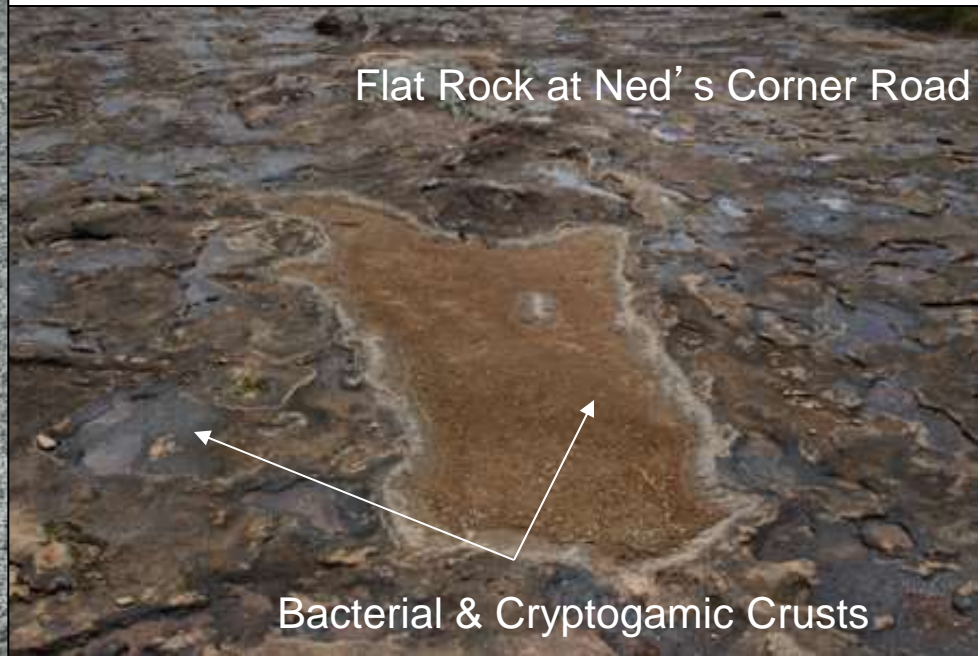
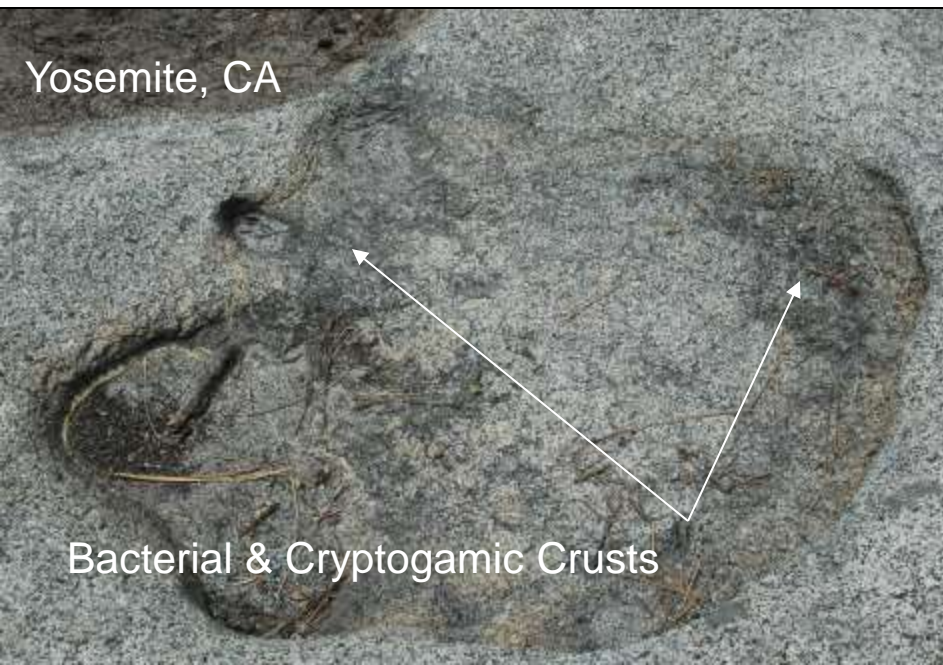
# Hydrologic Functions:

- (1) Surface & Shallow Subsurface Water Storage & Exchange
- (2) Landscape Hydrologic Connections



# Biogeochemistry

- (1) Cycling of Elements and Compounds
- (2) Detention of Imported Elements & Compounds
- (3) Particulate Retention
- (4) Export of Organic Carbon



# Native Plant Community

- (1) Native Plant Community Support
- (2) Native Detrital Community Support
- (3) Historical & Contemporary Refugia



8 species in the richest gnamma known



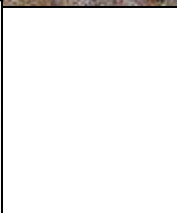
# Faunal Support/ Habitat

(Permanent, Partial, and Transitory Faunal Support (B Y Main 1997))

(1) Spatial Structure of Habitats

(2) Interspersion & Connectivity of Habitats

(3) Historical & Contemporary Refugia



*Litoria* sp.



Moaning Frog  
(*Heleioporus eyre*)



Quacking Frog  
(*Crinia georgiana*)



*Glyptophysa* sp.



Carlawillup, WA

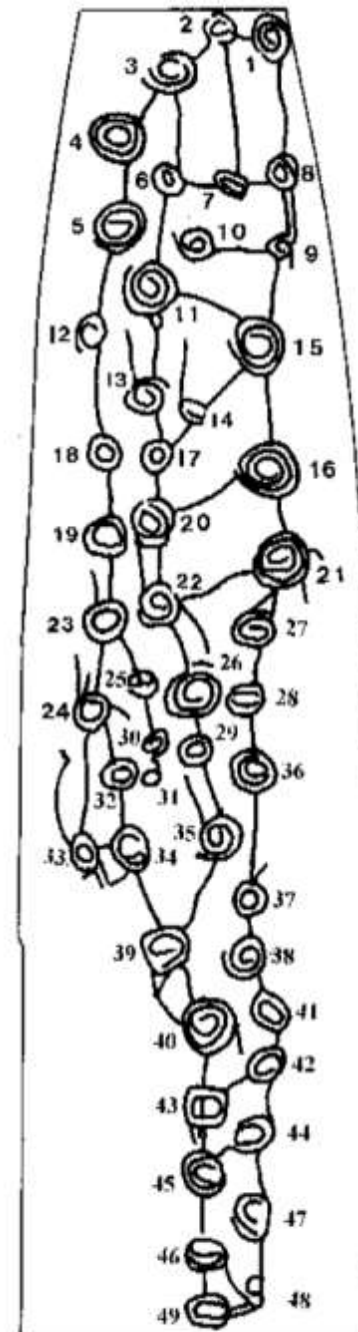
# Faunal Support

Humans and human use



Linda Syddick Napaltjarri *Walukurritje Rock Hole*

1. Labbi-labbi
3. Liuwiringa
5. Maiyada-maiyada
7. Kirindji
9. Markodarindja
11. Wirrkaldjarra
13. Luwano
15. Tjul'tjun'waridji
17. Tildi
19. Kuna
21. Yinindi
23. Tanda
25. Palta
27. Binbiyan
29. Yirabanda
31. Yappadarra
33. Yuldumallo
35. Mukuhanda
37. Kurruwildji
39. Kiribarro
41. Wangadjarro
43. Tjimarrri
45. Wirrarigulong
47. Miltji-miltji
49. Iola



2. Tananga
4. Kuntamumera
6. Wirra-wirra
8. Kanandibaroo
10. Kampanbarro
12. Pinna
14. Kira
16. Dandju
18. Wakilbi
20. Pintinba
22. Yalbirrimanno
24. Kurandal
26. Kura
28. Tjipallalla
30. Dangalli
32. Timbabiddi
34. Kunagarri
36. Mari-mari
38. Wallabarrarba
40. Yanna
42. Wornba
44. Kuntarunno
46. Danneriyono
48. Papulba

5.0 cm

# How could something so commonplace as a rock hole be so **complex**?

## Several **modes of formation**

- above and below ground
- role of water, solar radiation, etc.

## Several **sizes & shapes**; combinations thereof

- small, medium, large
- deep, shallow

## Several **hydrologic regimes**

- seasonal, intermittent, permanent
- lotic vs. lentic
- isolated, connected, or seasonally both

## *Not explored here*

- climate, age, pH, salinity, aspect, landscape setting, etc.

Traying gnammas - Nyingarn

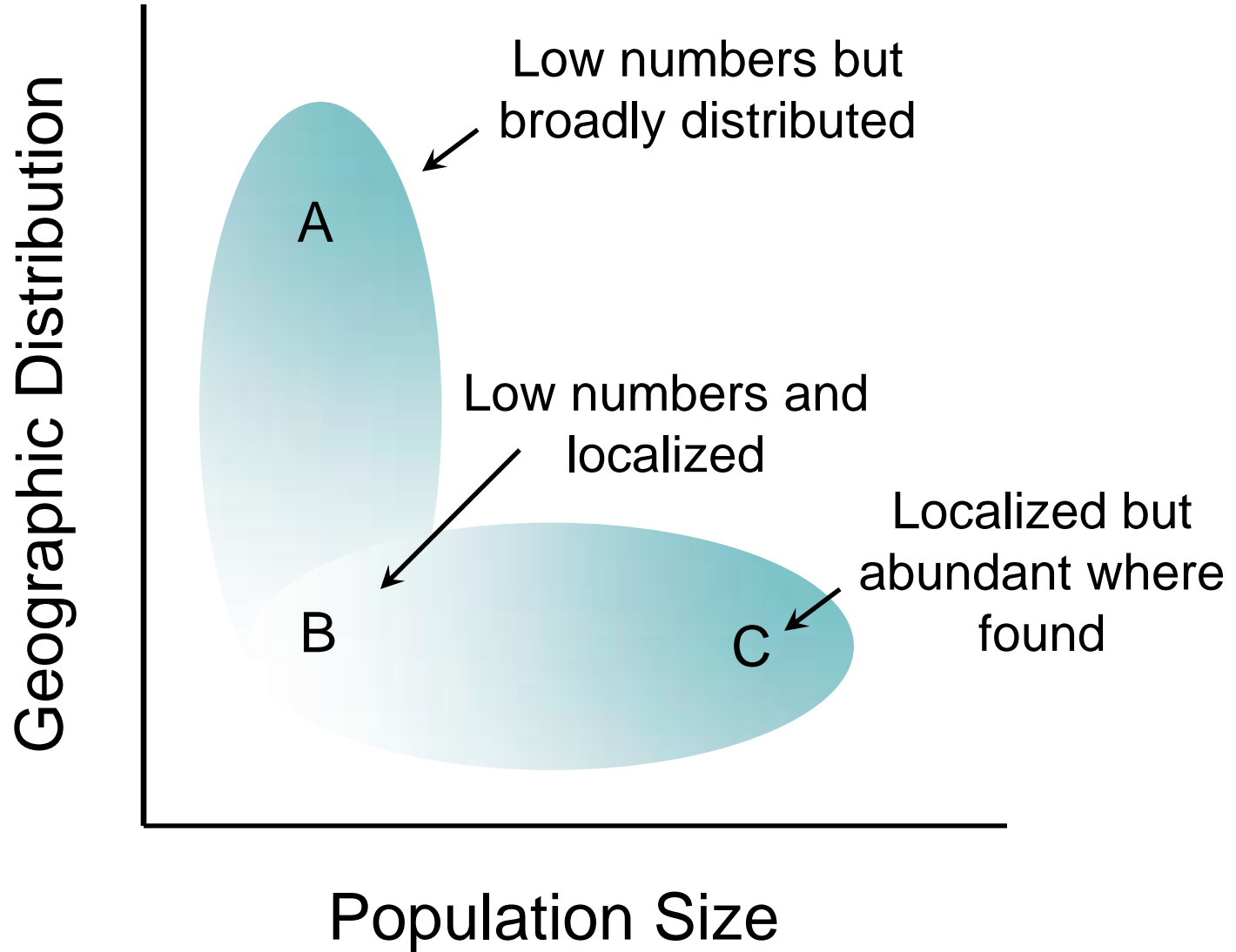




# Four Axes of Rarity

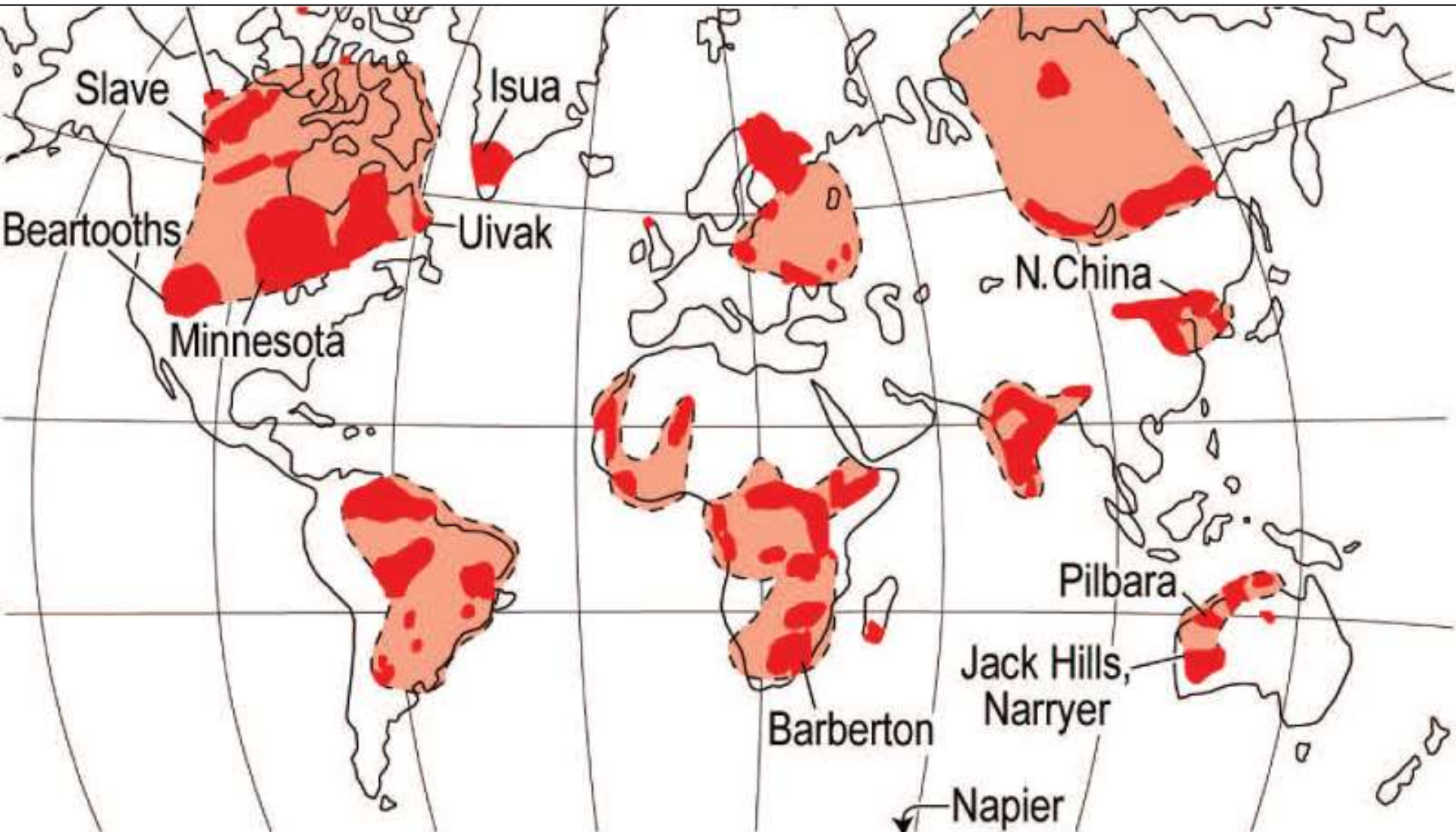
- Space
- Population Size
- Habitat Specificity
- Time

# Two Axes of Rarity

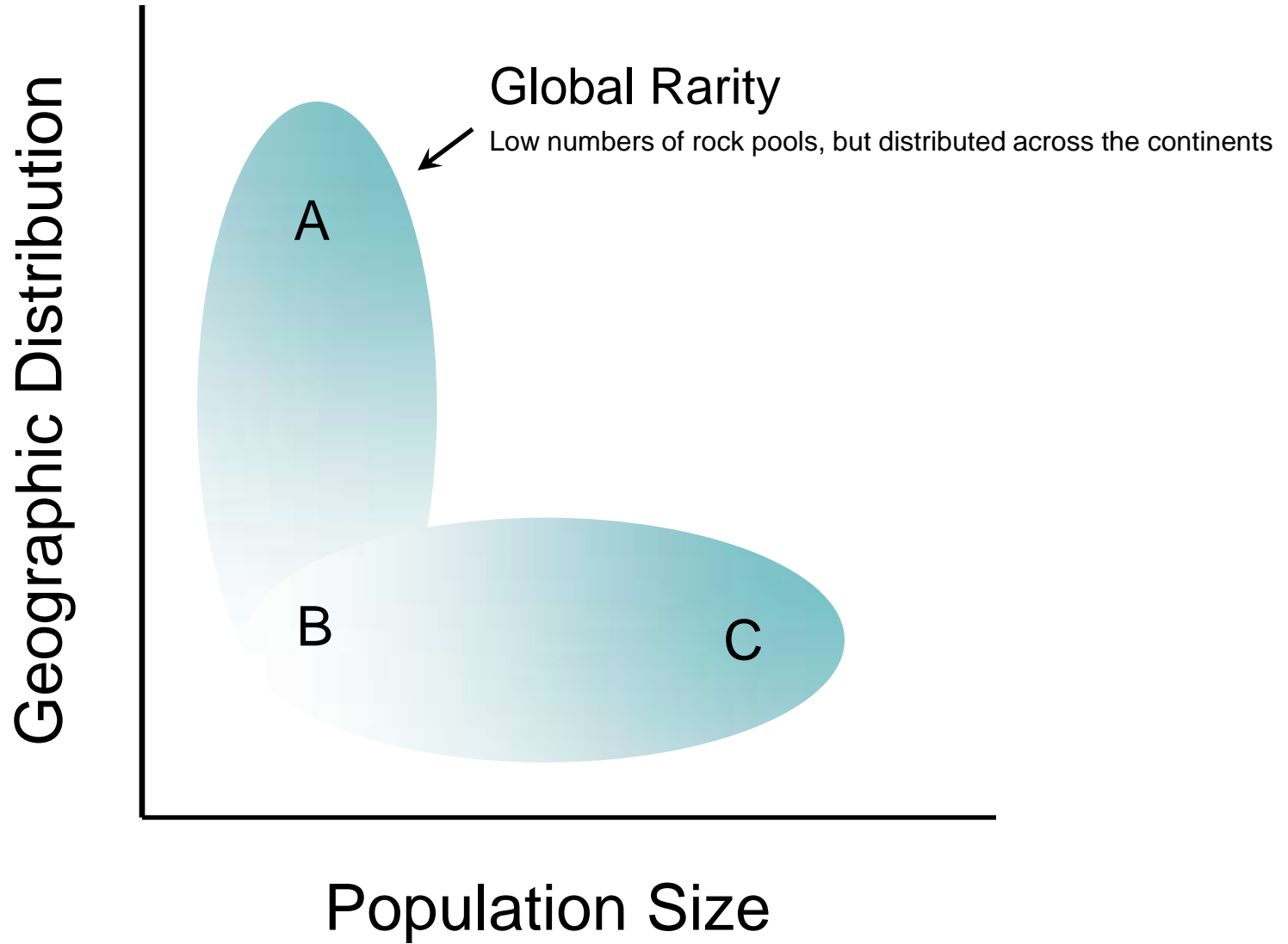


# “Granite” Rocks Global Distribution

Archean (3,800 mya) rocks



# Granite Rock Hole Rarity



# Landscape Scale: Wigha Point, W.A. Province, WA



Little Mount Lindesay  
Mount Lindesay

Mount Barker

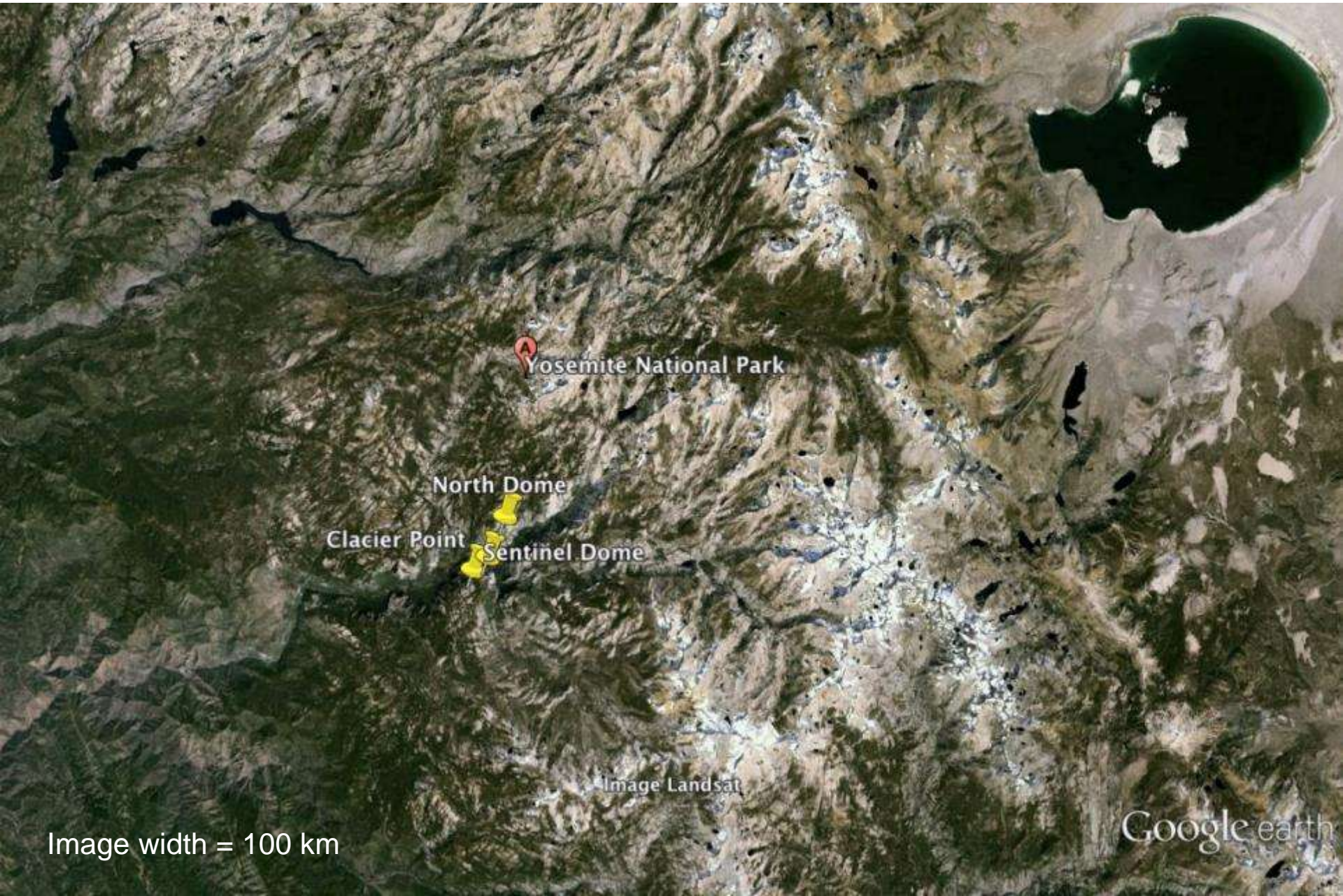
Image Landsat  
Image © 2016 CNES / Astrium

Image width = 100 km

Google earth



# Landcape Scale: Yosemite National Park



Yosemite National Park

North Dome

Clacier Point

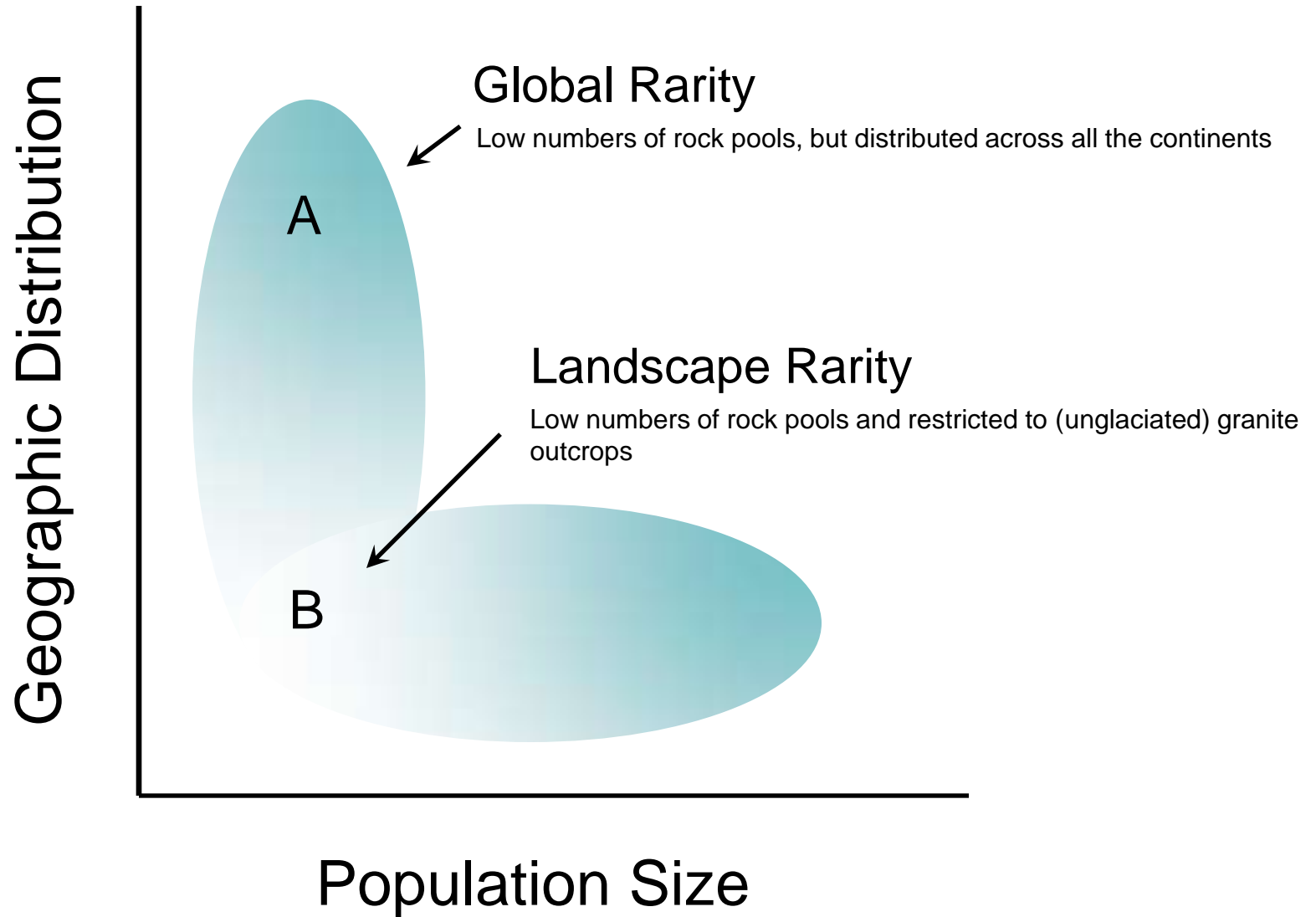
Sentinel Dome

Image Landsat

Google earth

Image width = 100 km

# Granite Rock Hole Rarity



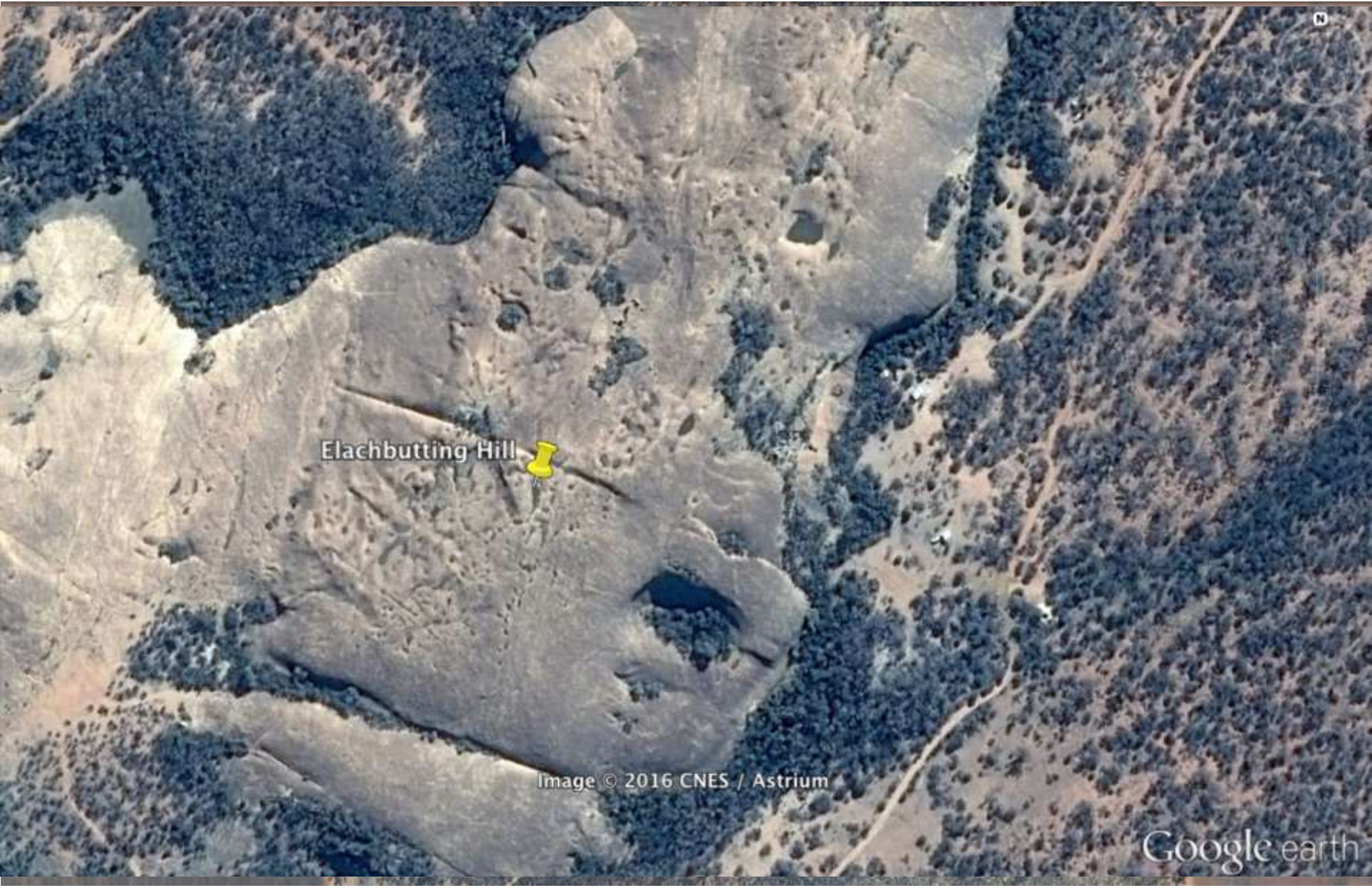
# Individual Rock Scale: Afghan Rock



Image © 2016 CNES / Astrium

Google earth

# Individual Rock Scale: Elachbutting Hill



Elachbutting Hill

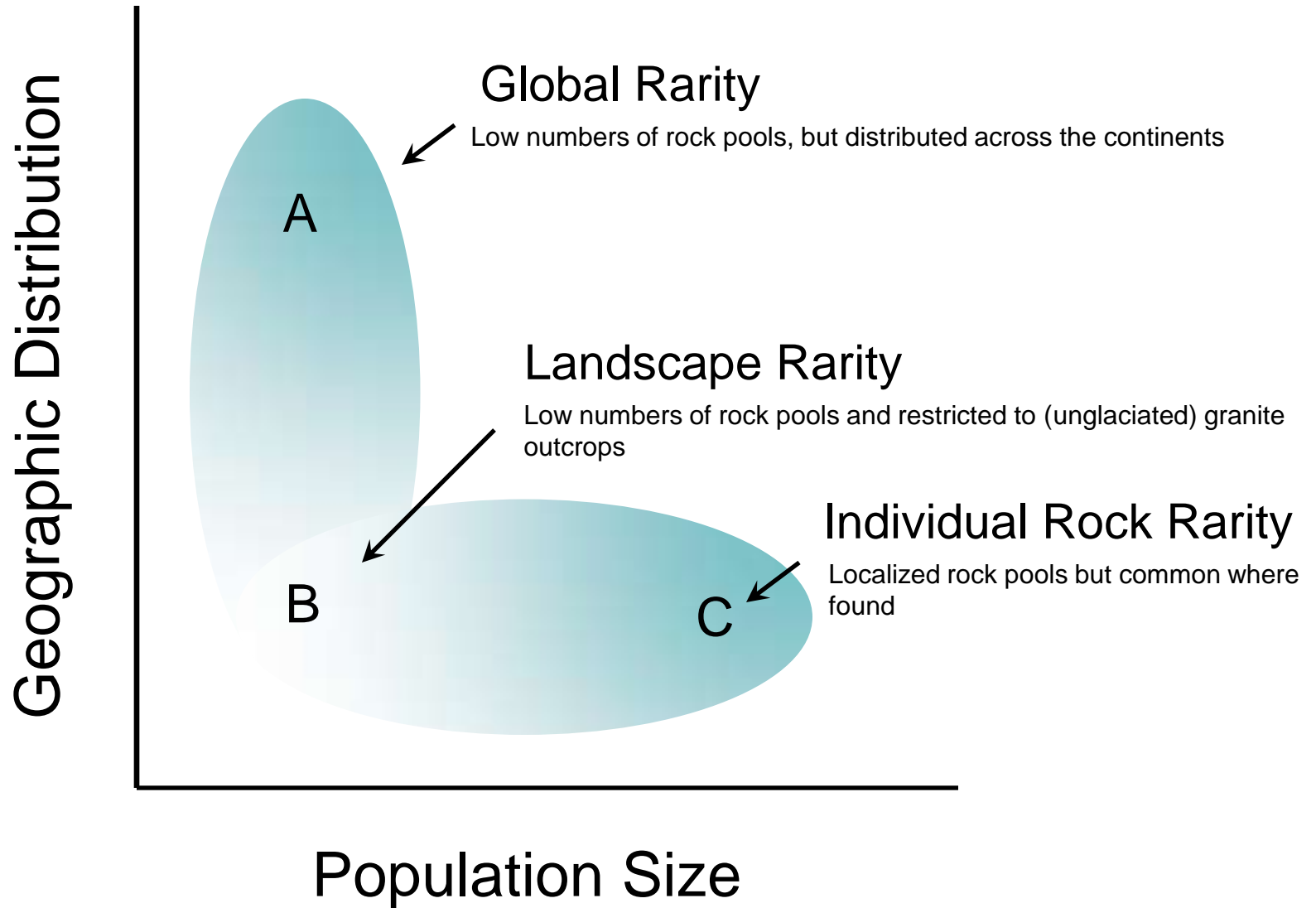
Image © 2016 CNES / Astrium

Google earth

# Individual Rock Scale: Yosemite National Park: Glacier Point



# Granite Rock Hole Rarity



# How could something so seemingly commonplace as a rock hole be so *rare*?

*Commonness and rarity for granite pools is a function of scale*

- At an **individual rock** scale, restricted to particular surfaces where they commonly occur
- At a **landscape** scale, both restricted faces and thus rare at this larger scale
- At a **global** scale, occur on all continents and thus rare at this largest scale



*Glossostigma drummondii*

# Protection for gnammas on continental & political scales

## A Directory of Important

# Wetlands in Australia

Third Edition

Home > Topics > Water > Water in our environment > Wetlands > Australian Wetlands Database > Directory of Important Wetlands in Australia

Water > Directory of Important Wetlands in Australia

Water in our environment > The Directory of Important Wetlands in Australia (the Directory) was first published in 1993. The Directory was compiled with the cooperation of conservation agencies and other resource managers in all jurisdictions.

Wetlands > The Directory not only identifies nationally important wetlands, it provides a substantial knowledge base of what defines wetlands, their variety, and the many Flora and Fauna species that depend on them. In addition, it contains information about their social and cultural values and some of the ecosystem services and benefits they provide. It is a valuable tool for managers and others interested in Australia's important wetlands.

About Wetlands > Although the Directory was previously published in hard copy, it is now no longer available in hard copy. However, the online inventory of the Directory is available at the [Australian Wetlands Database](#) and in the [Directory of Important Wetlands in Australia Fact Sheet](#). The Australian Wetlands Database holds descriptions of more than 900 Directory wetlands.

The Ramsar Convention on Wetlands >

Managing Wetlands >

Australian Wetlands Database >

Contact us

GO

About us

- 120/900 in Western Australia (0.13%)
- 4/120 are rock pool wetlands (4.4%)
- 1/120 are granite rock wetlands (0.8%)
- 1/4 located in SWAFR (Yorkkrakine Rock Pools)
- 0.0001% of WA state landmass





Rock Pools of Breaden Hills



Walter James Range



Gibson Desert Gnamma Holes



Yorkrakin

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

© 2016 Google  
Image Landsat

US Dept of State Geographer

Great Australian Bight

Spencer Gulf  
Gulf St Vincent  
Investigator Strait  
Encounter Bay

Google earth

Canberra

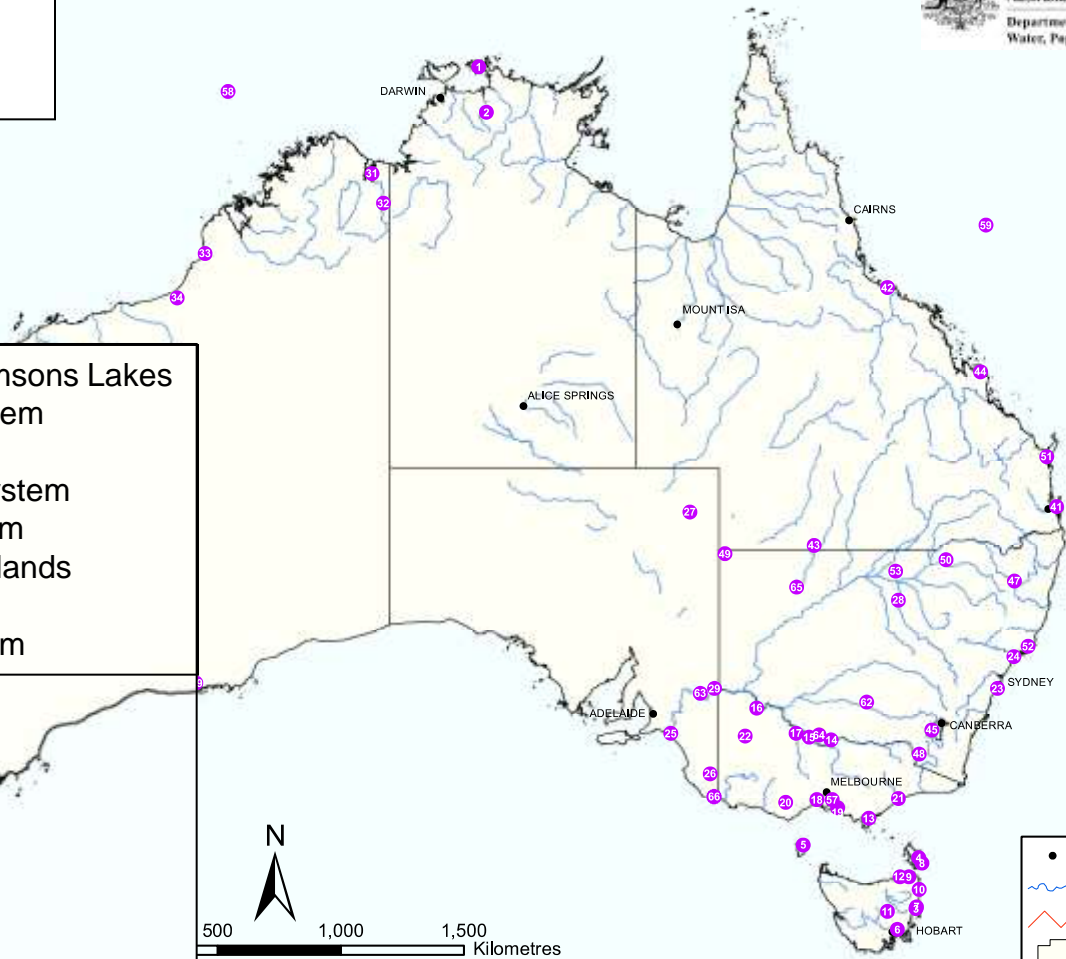
# Protection for gnammas on global scale



**Ramsar Wetlands** –  
Intergovernmental treaty  
that provides a  
framework for national  
action and international  
cooperation for the  
conservation and wise  
use of wetlands and their  
resources

- 65 Ramsar Wetlands in Australia (>8.3 million ha)
- 12/65 in (continental) Western Australia (14%)
- 499,475 ha (6.0%)
- 0/65 are rock pools or rock pool mosaics (0.0%)
- 0.0% of WA state landmass

# Ramsar Wetlands Of Australia



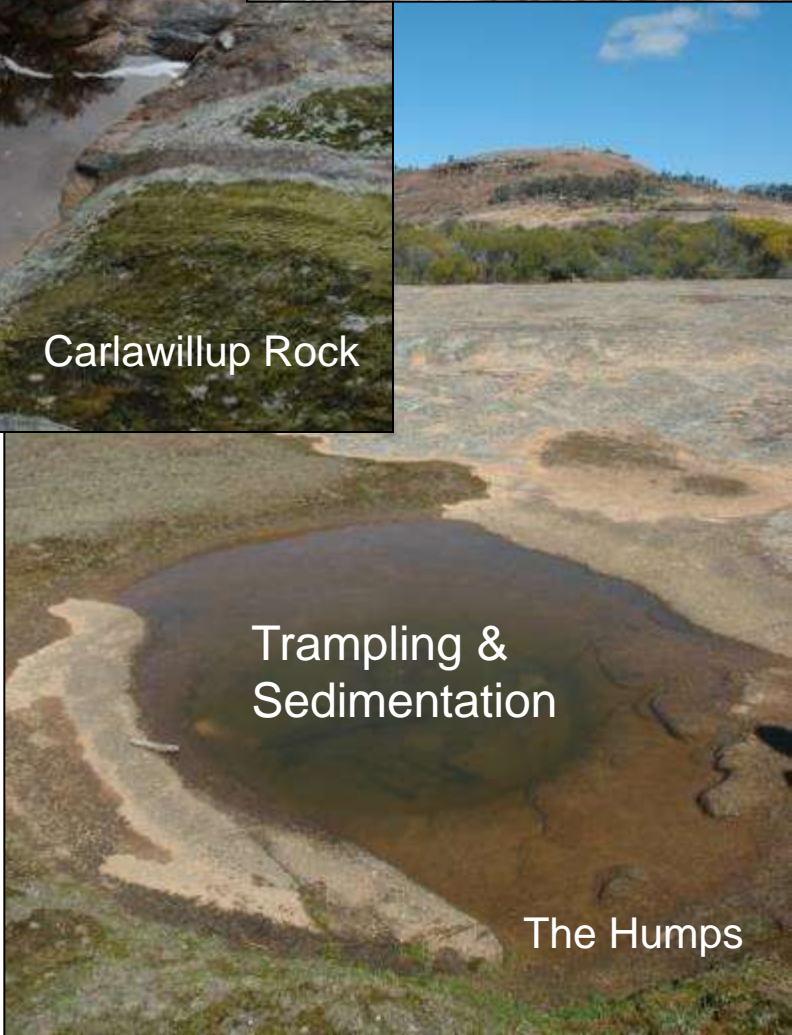
35- Forrestdale & Thomsons Lakes  
36- Peel-Yalgorup System  
37-Toolibin Lake  
38- Vasse-Wonerup System  
39-Lake Warden System  
54- Beecher Point Wetlands  
55- Lake Gore  
56- Muir-Byenup System

SWAFR

- Towns
- ~ Major Rivers
- Major Roads
- State and Territory Borders

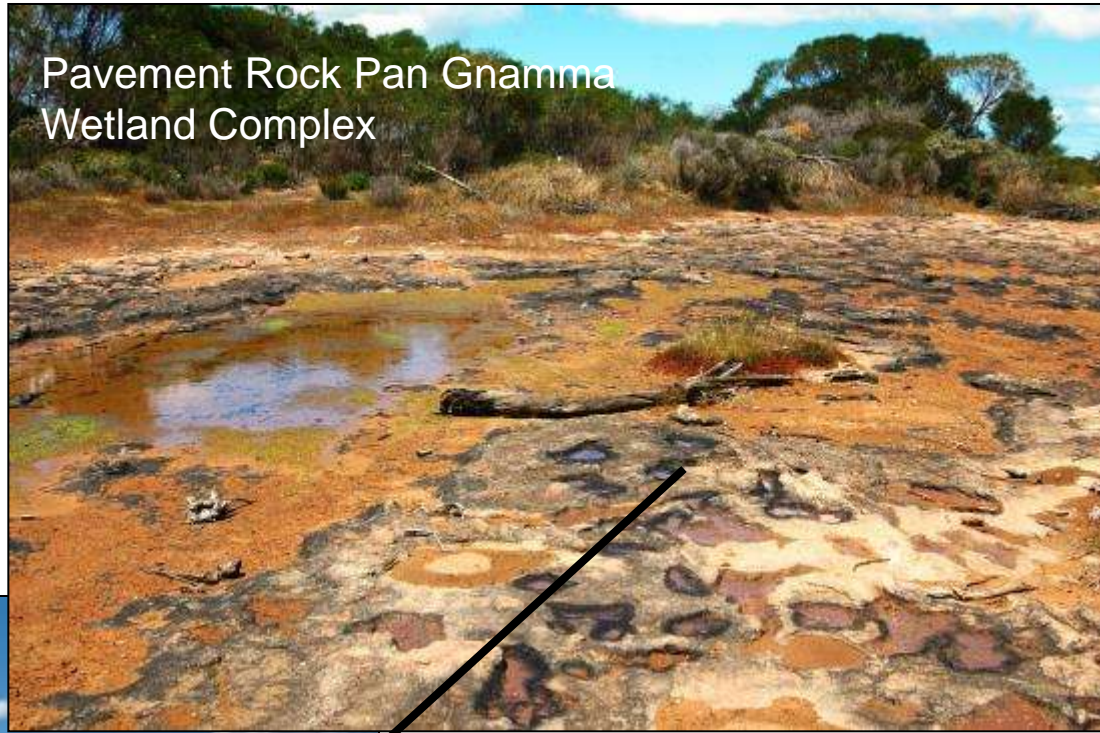
- |  |   |  |  |   |   |   |
|--|---|--|--|---|---|---|
| <b>Ramsar Wetlands</b>                   | 10 Jocks Lagoon   | 20 Western District Lakes                                | 30 <i>This site was part of Kakadu National Park. In 2010 it was merged with site 2.</i> | 40 Hosnies Spring(s) - Christmas Island | 50 Gywydir Wetlands                     | 60 Elizabeth and Middleton Reefs Marine National Nature Reserve |
| 1 Cobourg Peninsula                      | 11 Interlaken (Lake Crescent)                                   | 21 Gippsland Lakes                                       | 31 Ord River Floodplain  | 41 Moreton Bay                          | 51 Great Sandy Strait                   | 61 "The Dales", Christmas Island                                |
| 2 Kakadu National Park                   | 12 Little Waterhouse Lake                                       | 22 Lake Albacutya  | 32 Lakes Argyle and Kununurra  | 42 Bowling Green Bay                    | 52 Myall Lakes                          | 62 Fivebough and Tuckerbil Swamps                               |
| 3 Moulling Lagoon                        | 13 Corner Inlet   | 23 Towra Point Nature Reserve                            | 33 Roebuck Bay   | 43 Currawinya Lakes                     | 53 Narran Lake Nature Reserve           | 63 Banrock Station Wetland Complex                              |
| 4 Logan Lagoon                           | 14 Barmah Forest  | 24 Hunter Estuary Wetlands                               | 34 Eighty-mile Beach   | 44 Shoalwater and Corio Bays Area       | 54 Beecher Point Wetlands               | 64 NSW Central Murray State Forests                             |
| 5 Lavinia                                | 15 Gunbower Forest  | 25 The Coorong, and Lakes Alexandrina and Albert Wetland | 35 Forrestdale and Thomsons Lakes  | 45 Ginini Flats Wetland Complex         | 55 Lake Gore                            | 65 Paroo River Wetlands   |
| 6 Pitt Water-Orielton Lagoon             | 16 Hattah-Kulkyne Lakes   | 26 Bool and Hacks Lagoons                                | 36 Peel-Yalgorup System  | 46 Pulu Keeling National Park           | 56 Muir-Byenup System                   | 66 Piccaninnie Ponds Karst Wetlands                             |
| 7 Apsley Marshes                         | 17 Kerang Wetlands  | 27 Coongie Lakes   | 37 Toolibin Lake   | 47 Little Llangothlin Nature Reserve    | 57 Edithvale-Seaford Wetlands           |   |
| 8 East Coast Cape Barren Islands Lagoons | 18 Port Phillip Bay (Western Shoreline) and Bellarine Peninsula | 28 The Macquarie Marshes                                 | 38 Vasse-Wonerup System  | 48 Blue Lake                            | 58 Ashmore Reef National Nature Reserve |   |
| 9 Flood Plain Lower Ringarooma River     | 19 Western Port   | 29 Riverland   | 39 Lake Warden System  | 49 Lake Pinaroo (Fort Grey Basin)       | 59 Coral Sea Reserves                   |   |

# Degradation Processes



# Fragmentation

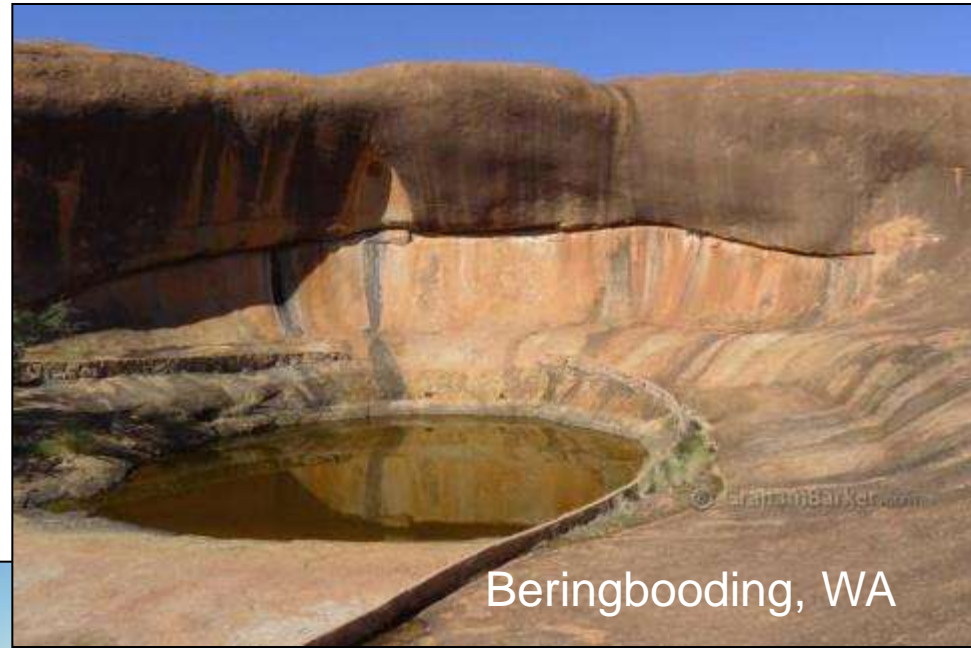
Pavement Rock Pan Gnamma  
Wetland Complex



Highway Throughfill (Ned's Corner Road)

Ned's Corner, WA

# Replacement/ Destruction / Diversion



Beringbooding, WA



King Rocks, WA

# Concluding thoughts

*Cylindropuntia acanthocarpa*

*Stipa speciosa*

*Lotus rigidus*

*Eriogonum wrightii wrightii*

- Many ways to be a rock hole; great variation within/among
- Rarest of the rare
- Perform critical ecosystem functions not replicated across the SWAFR and elsewhere
- Stewardship is essential