

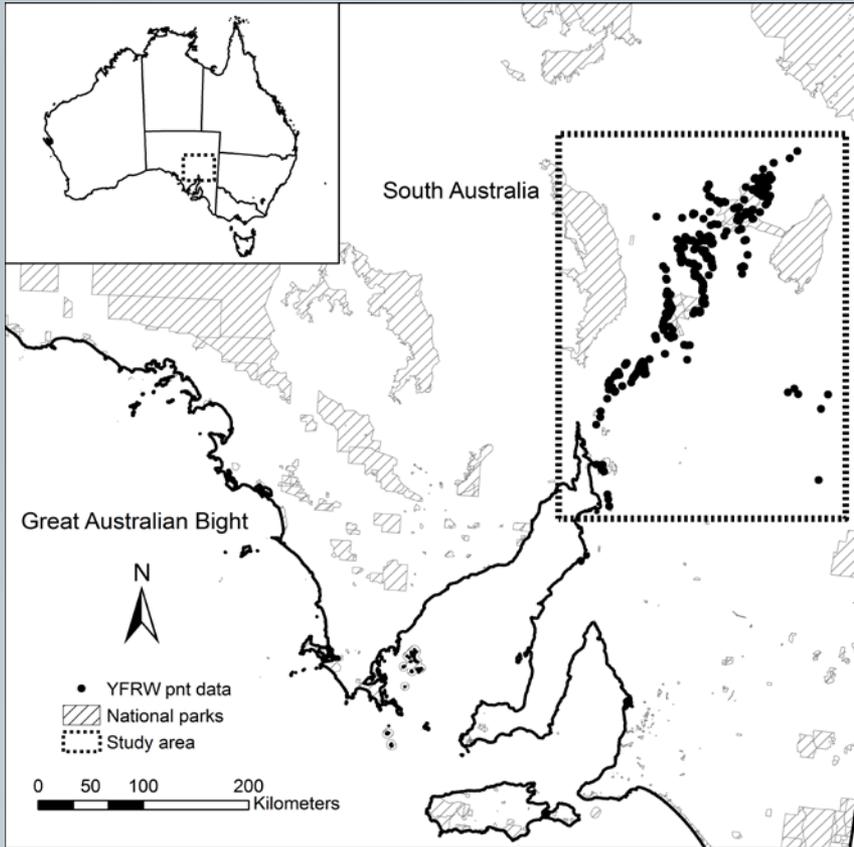
Population modelling issues in predicting the effects of climate-change

- a quick comparison of approaches

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Flinders University*

An aerial photograph of a mountainous region. The foreground shows a valley with a winding road and some vegetation. The middle ground and background consist of rolling hills and mountains, all shrouded in a thick, light-colored haze or fog, which obscures the details of the terrain. The overall color palette is muted, with various shades of brown, green, and grey.

1. Population Viability Analysis



P. x. xanthopus

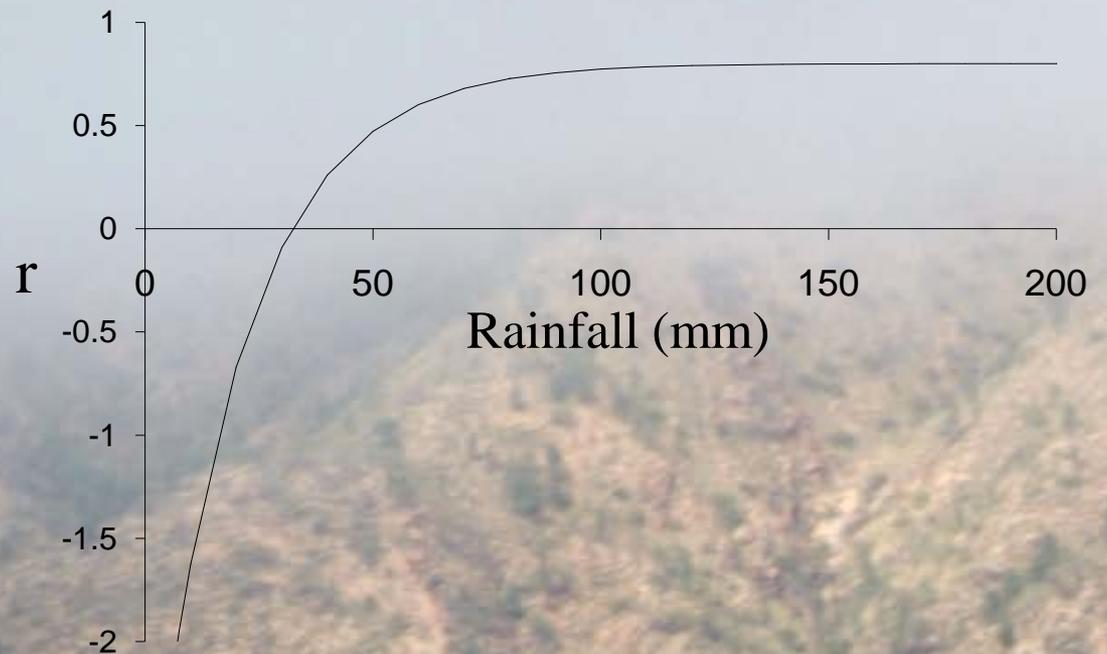


Rainfall and population response

N_t is the abundance at time t and N_{t-1} is the abundance at time $t + 1$.

$$r = \ln\left(\frac{N_{t+1}}{N_t}\right)$$

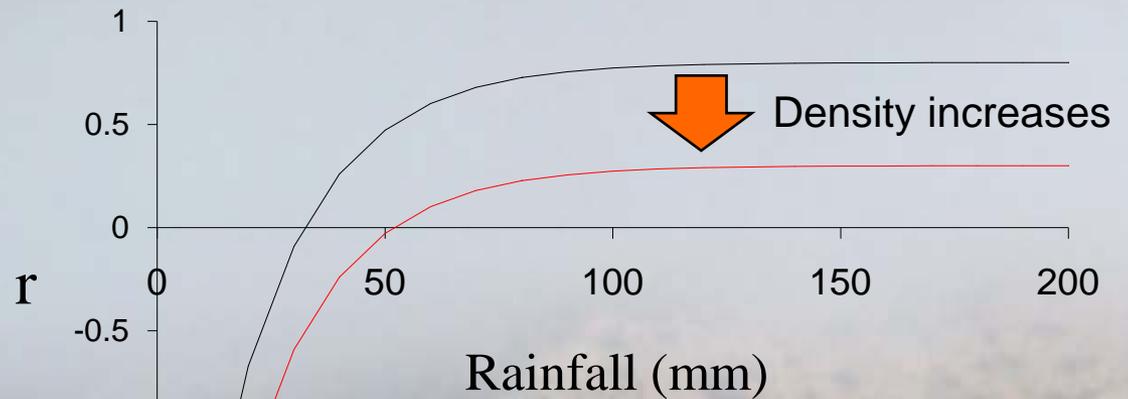
$$r = -a + c(1 - e^{-dv})$$



Response to rainfall and population density

Negative effects of density – intrinsic population regulation

$$r = -a + c(1 - e^{-dv}) - gD$$



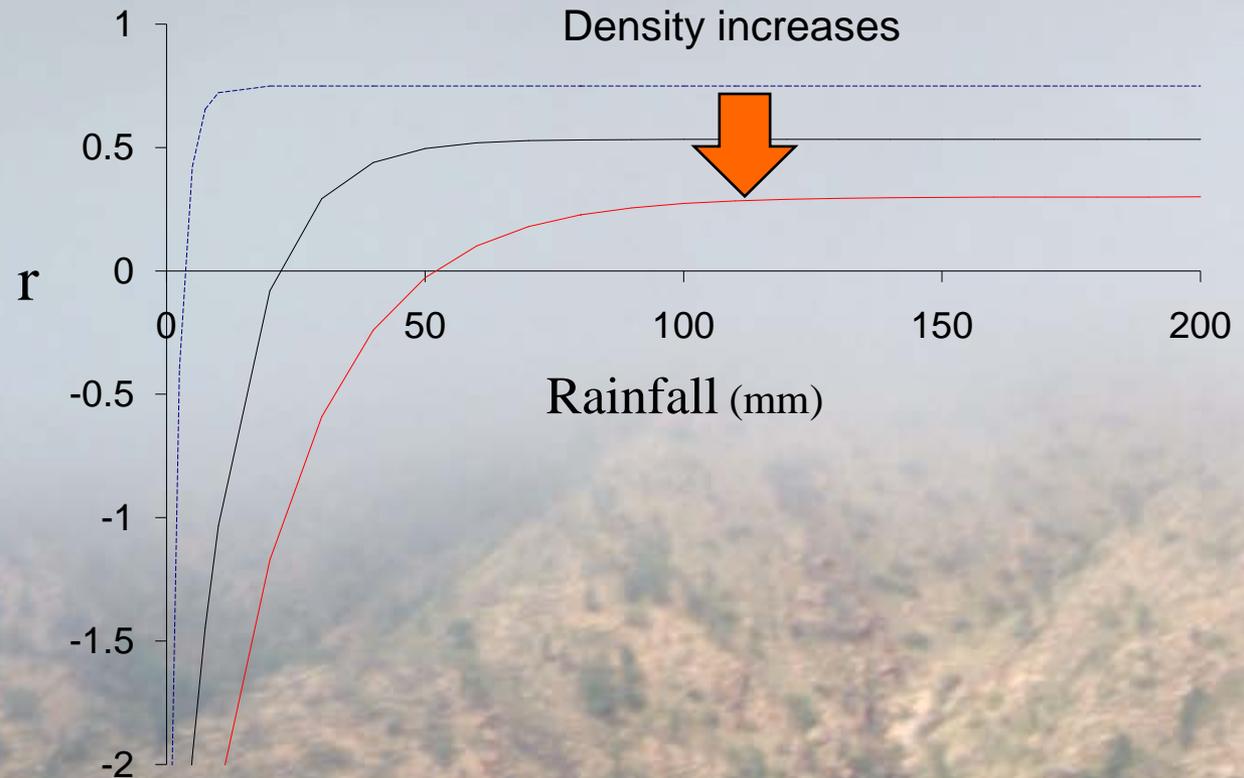
Response to rainfall and population density

However, the shape of response of rainfall may change with density-dependence

$$r = -a + c(1 - De^{-dv}) - gD$$

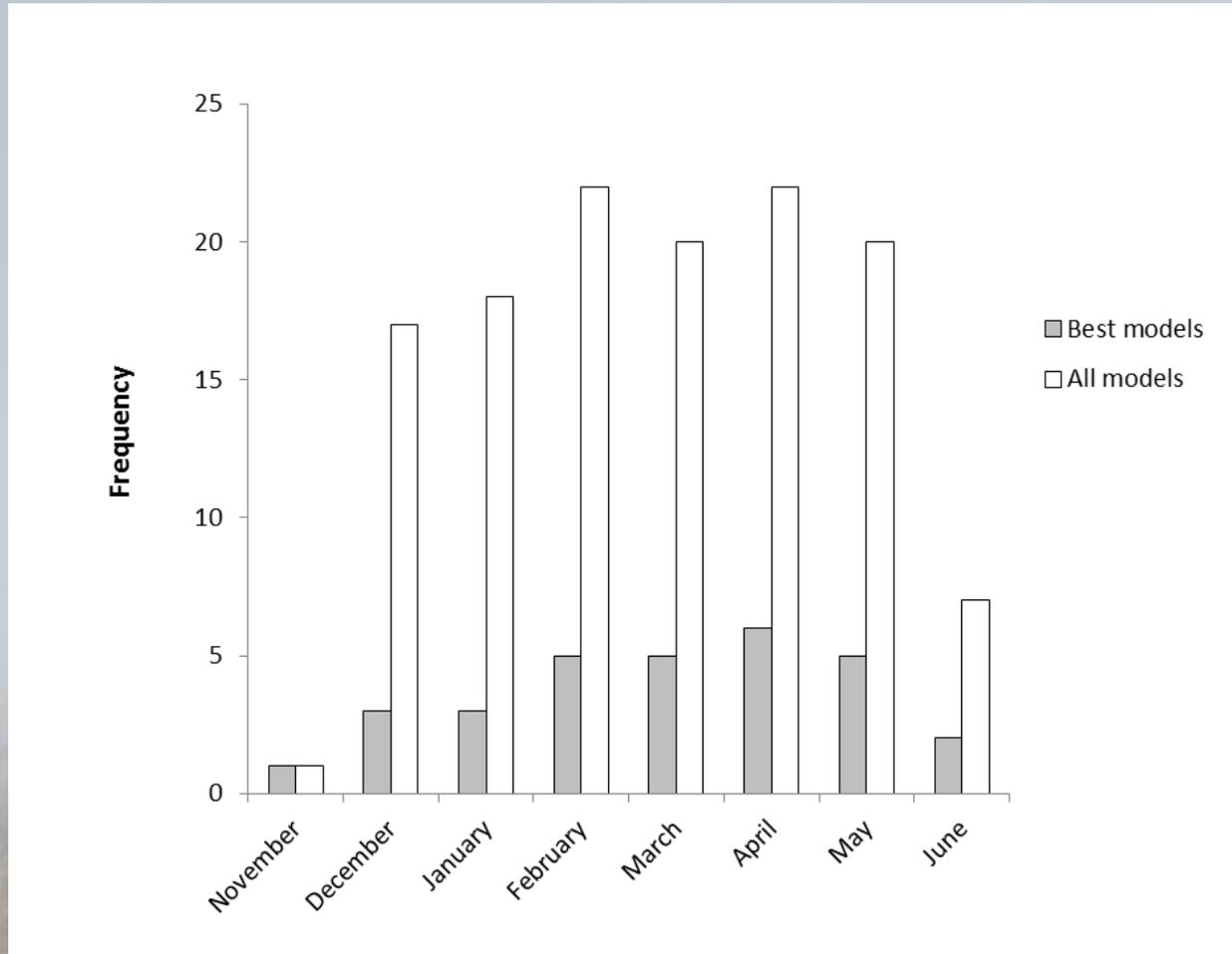
or

$$r = -a + c(1 - e^{-dv/D}) - gD$$



Rainfall period most affecting population growth rate of *P. x. xanthopus*

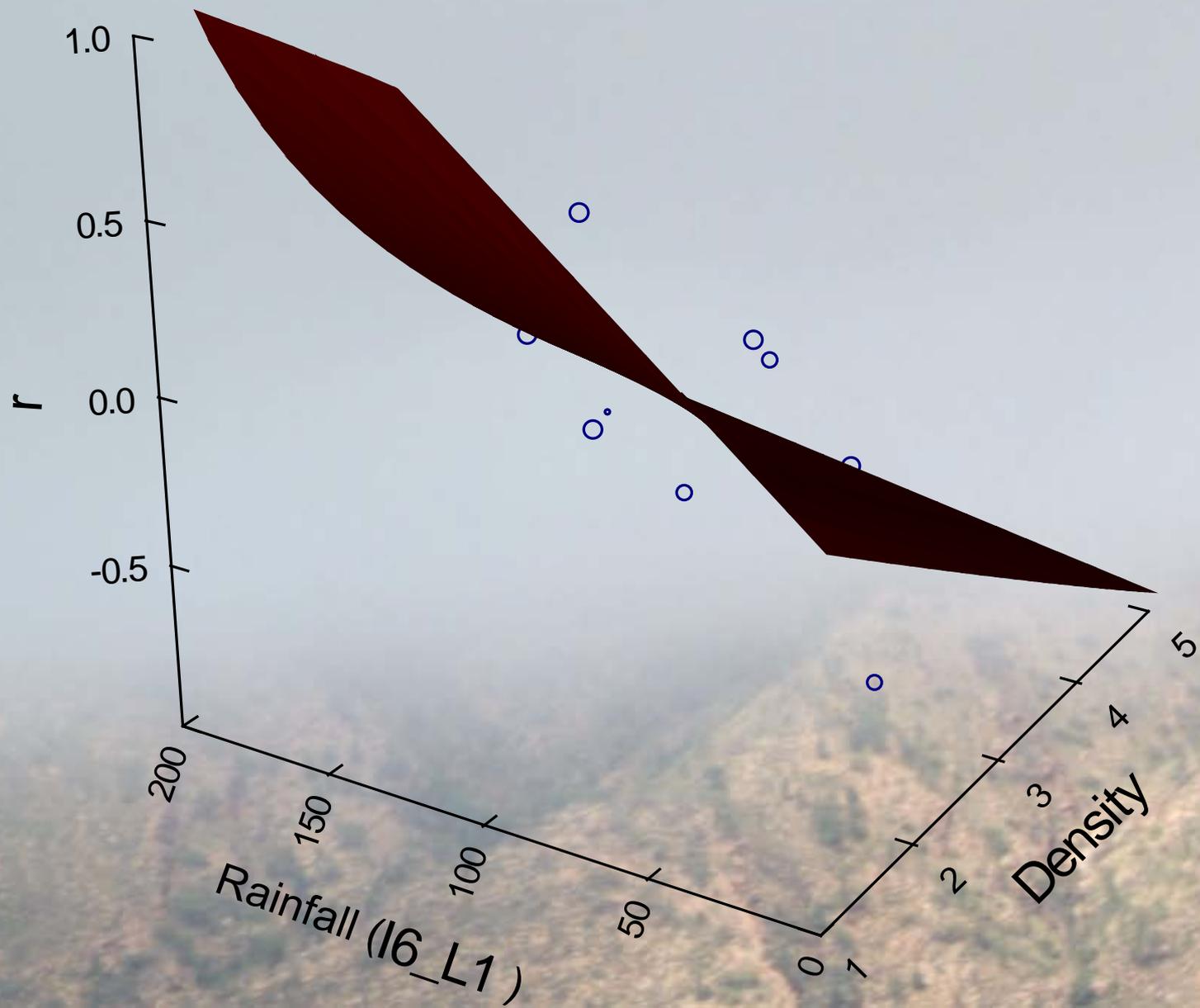
Summer and Autumn – driest months



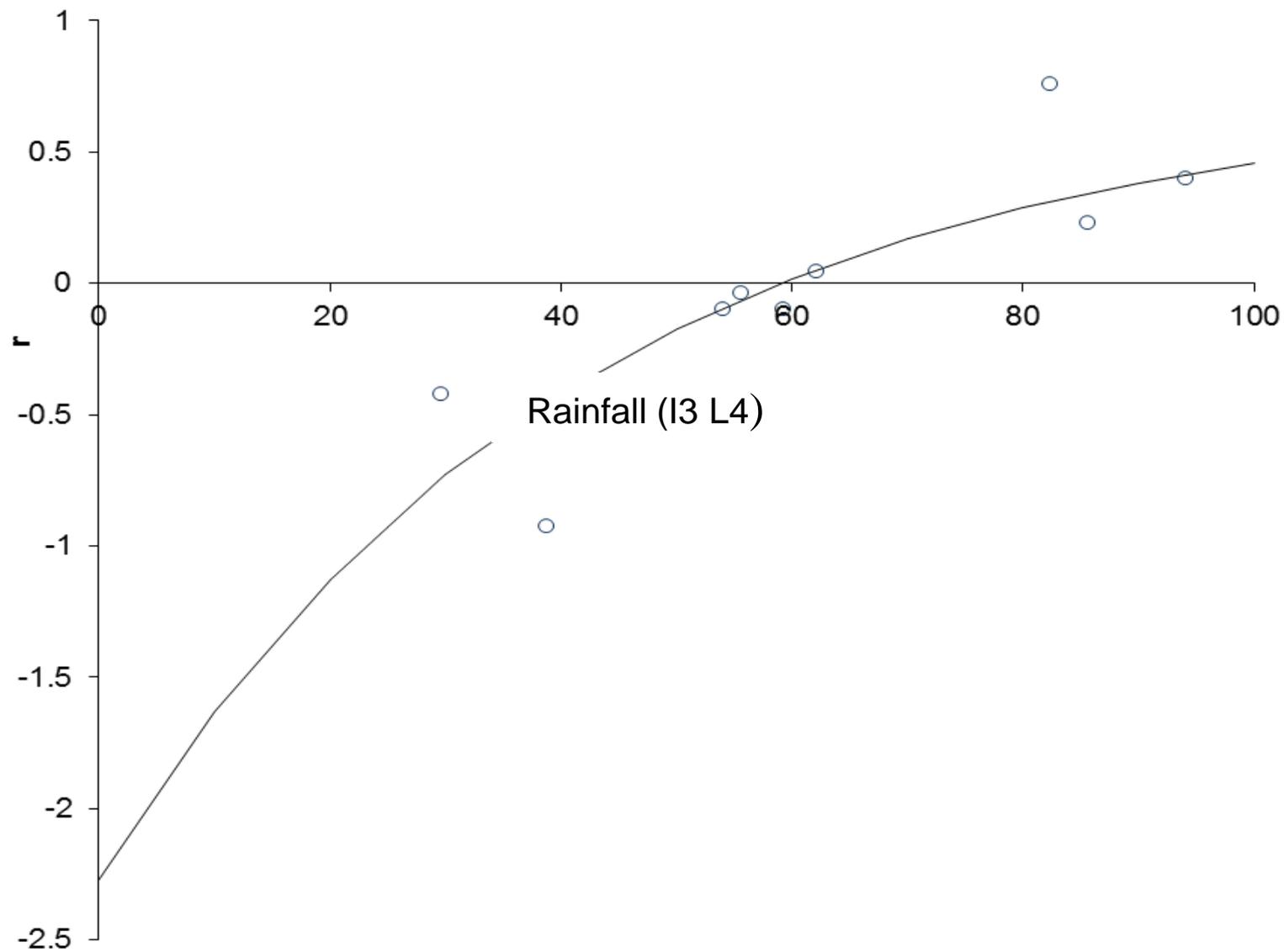
Best models for each zone after a QAIC and AIC, QAICc etc tests

Zone	Model	Rainfall Interval/Lag	R ²
Hawker	$-a + c(1 - e^{-dv})$	I3 L4	0.73
Bimbowrie Stn	$-a + c(1 - e^{-dv/D}) - gD$	I3 L0	0.77
Gammon Ranges	$-a + c(1 - e^{-dv})$	I3 L4	0.48
Depot Flat	$-a + c(1 - e^{-dv})$	I4 L1	0.40
Bunker Nth	$-a + c(1 - e^{-dv})$	I3 L1	0.48
Plumbago Stn	$-a + c(1 - e^{-dv/D}) - gD$	I4 L0	0.68
ABC Range	$-a + c(1 - e^{-dv}) - gD$	I6 L1	0.61

Density/Rainfall interaction with population growth rate r



Rainfall versus population growth rate only



Climate model selection

- Used a combination of climate models coupled with low, moderate and high climate sensitivity.
- GCMs provided by CSIRO were generated for 2030, under the medium emissions scenario (A1B) and for 2070, they were generated under both low (B1) and high emissions scenarios (A1F1).
- Three climate futures were of interest:
 - most likely, represented by the greatest number of models,
 - driest, those with the greatest projected reduction in annual rainfall and,
 - wettest, those with the greatest projected increase in annual rainfall.
- A total of 22 global models were considered and models identified as performing badly across Australia by Smith and Chandler (2010) were excluded.

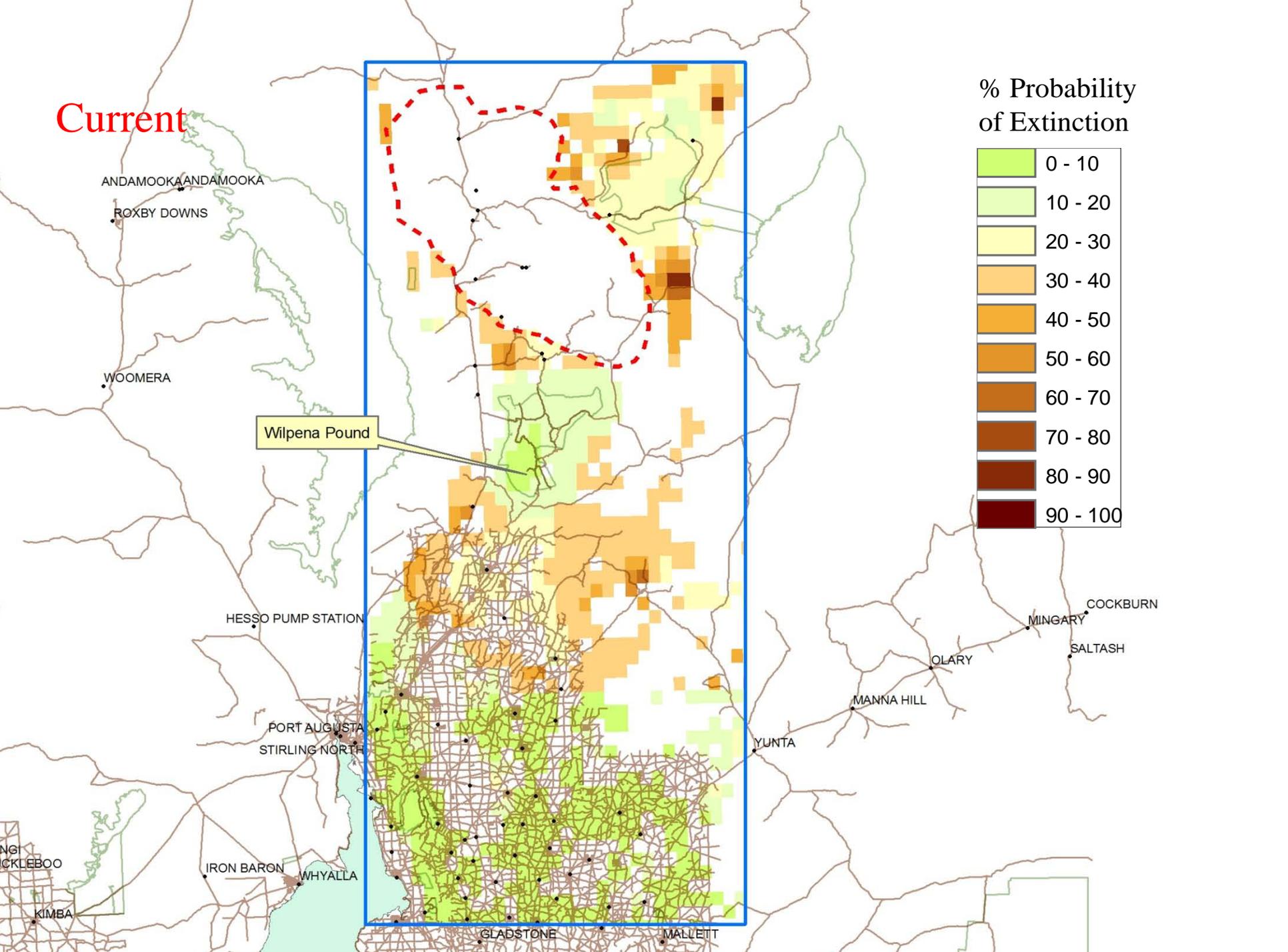
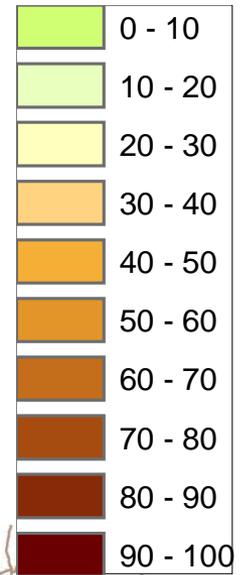
Climate model selection

- The performance of each model is assessed according to how well they produce observed seasonal patterns over the Australian continent.
- Like Smith and Chandler (2010) and Wheeton et al (2007), we were only interested in rainfall projections.
- Thus rainfall was the only measure used to assess model performance. This assessment was carried out in the Flinders Ranges of South Australia.
- A sub-set of models is then selected, based on the assumption that models which perform similarly in a particular area, and for a given emission scenario, also tend to yield similar changes in rainfall.

	Slightly Warmer <0.5	Warmer 0.5 to 1.5	Hotter 1.5 to 3.0	Much hotter > 3.0
Much drier < -15.0				2070: A1F1 (7) <u>Most Likely</u> CCSM3 2070: A1F1 (7) CSIRO-Mk3.5
Drier -5.0 to -15.0		2030: A1B (5) CSIRO-Mk3.5 2070: B1 (6) CSIRO-Mk3.5		
Little Change -5.0 to 5.0		2030: A1B (19) <u>Most Likely</u> CCSM3 2030: A1B (19) MIROC3.2(medres) 2070: B1 (18) <u>Most Likely</u> CCSM3 2070: B1 (18) MIROC3.2(medres)		
Wetter 5.0 to 15.0				
Much Wetter > 15.0				2070: B1 (1) MIROC3.2(medres)

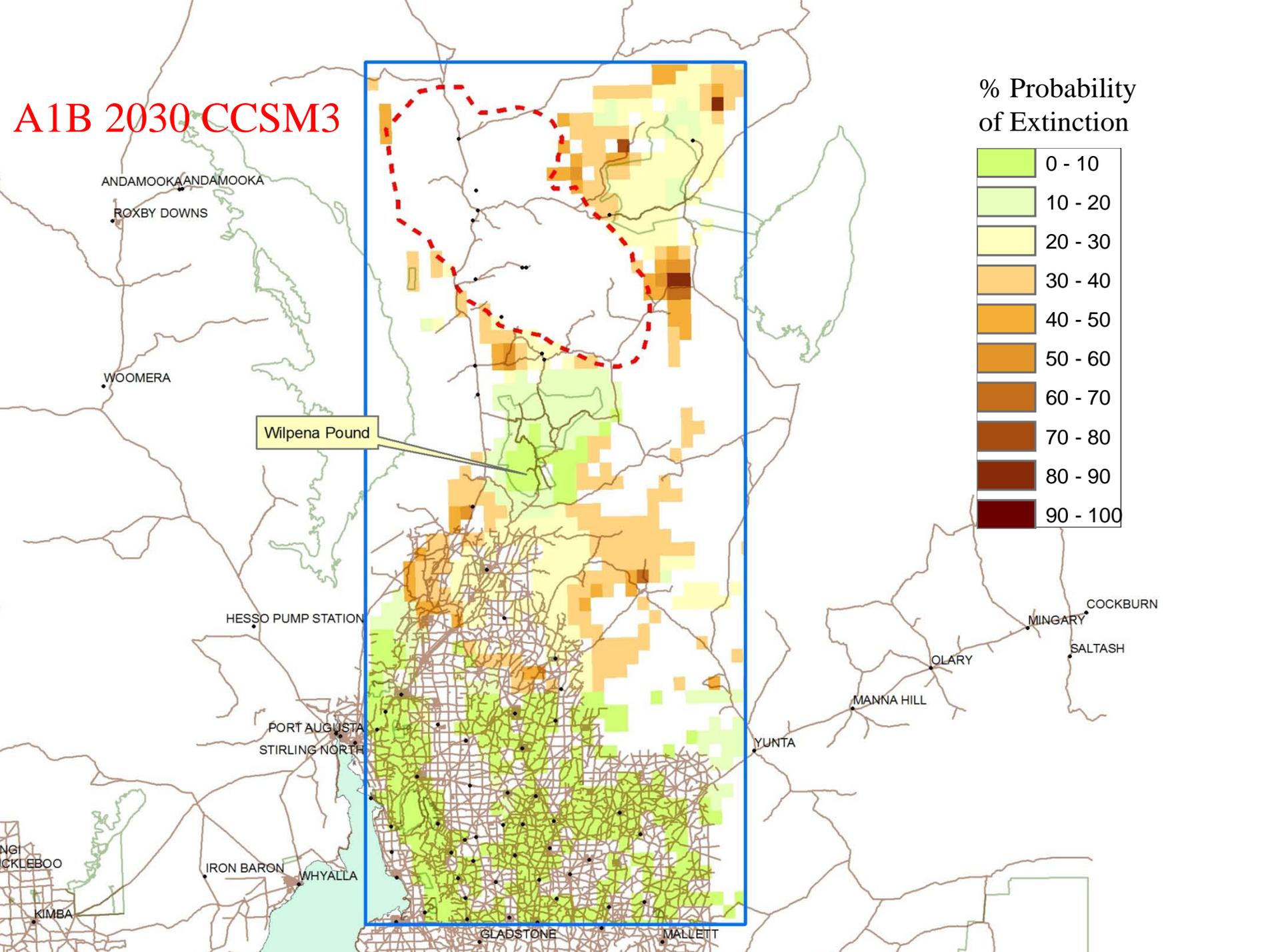
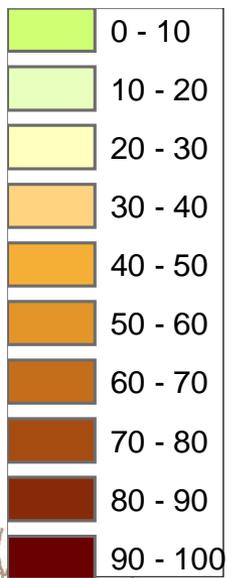
Current

% Probability of Extinction



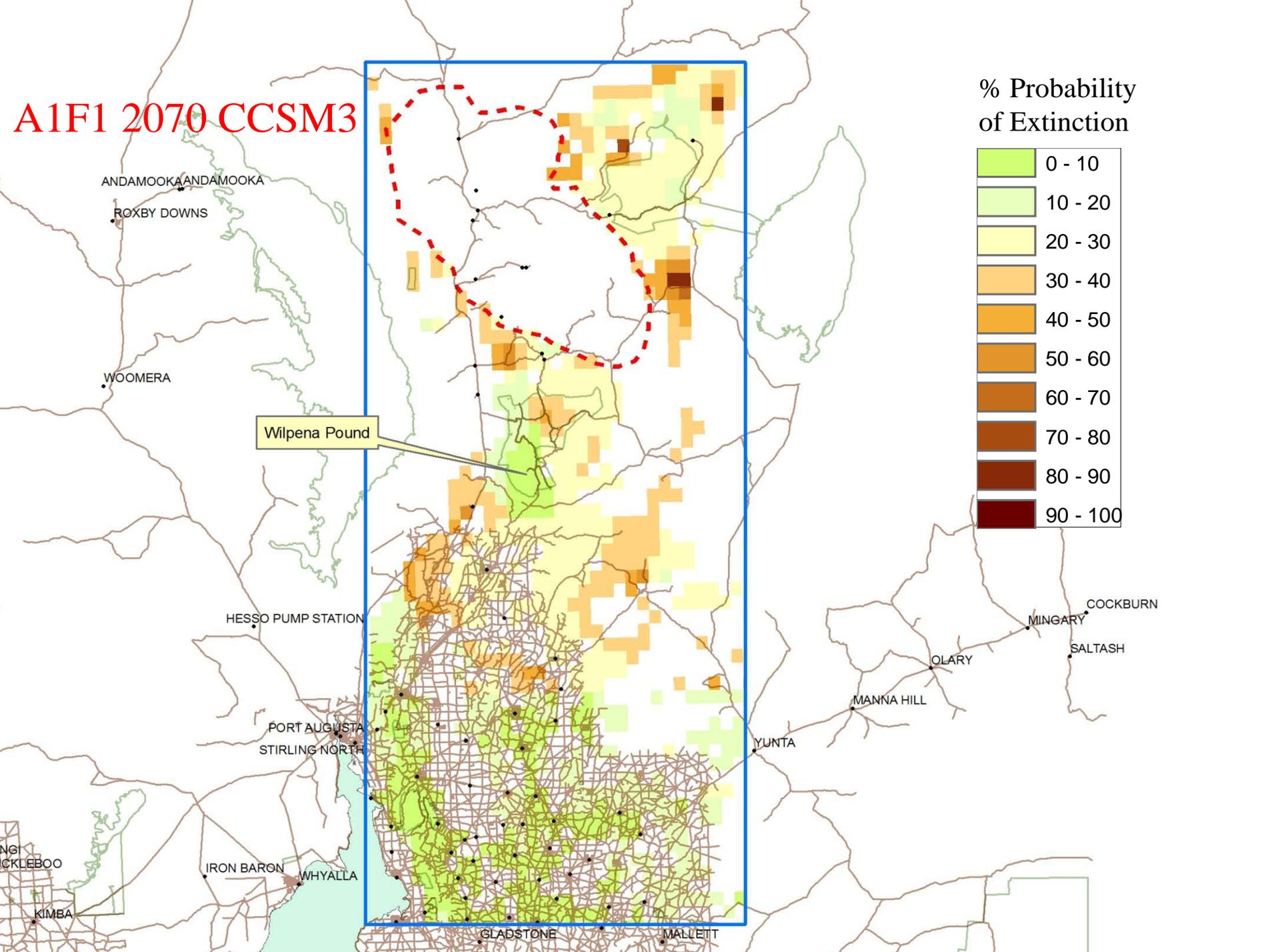
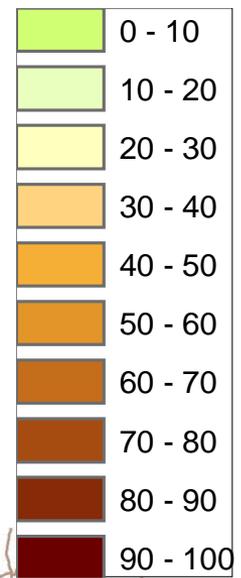
A1B 2030 CCSM3

% Probability of Extinction



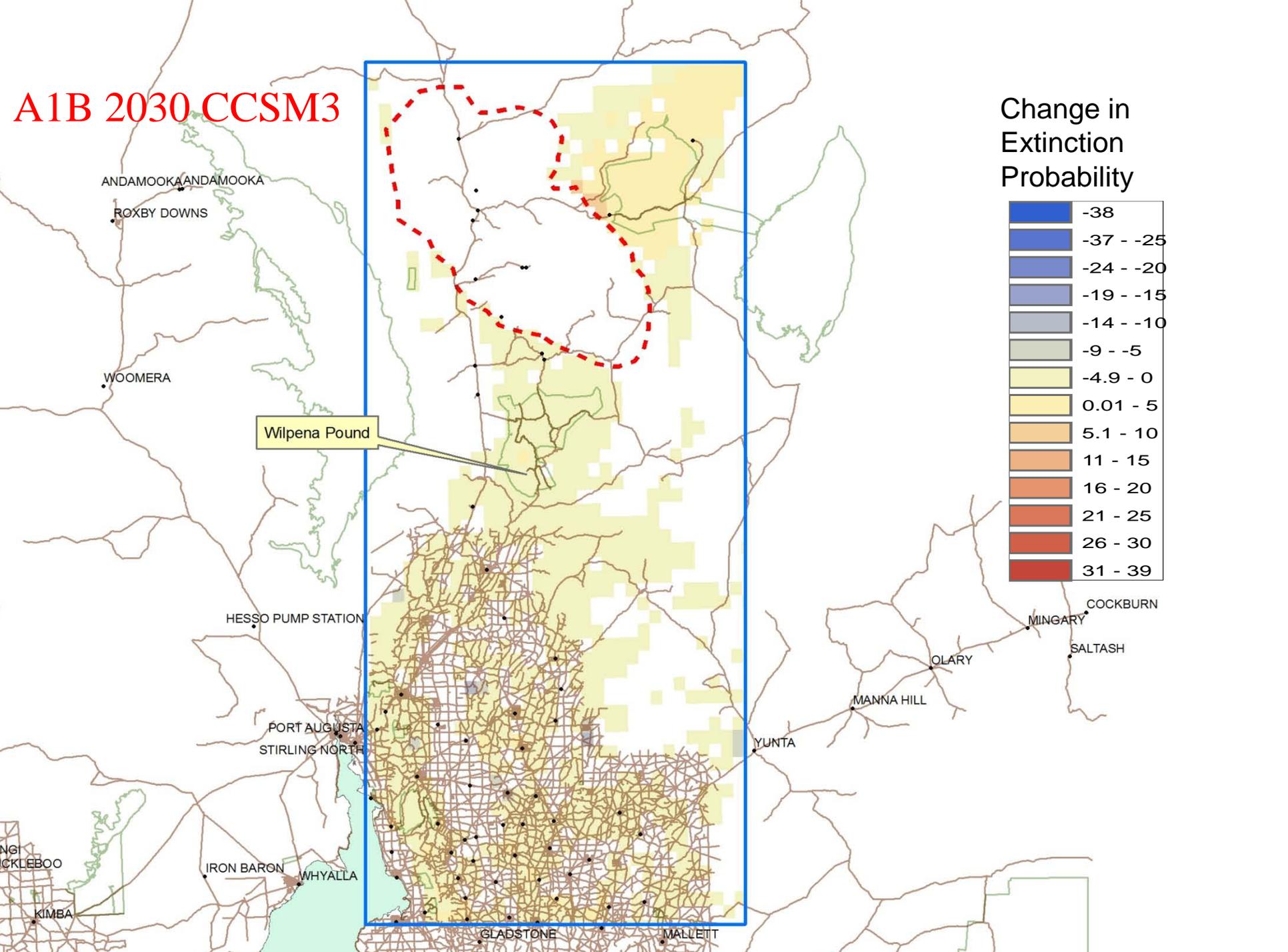
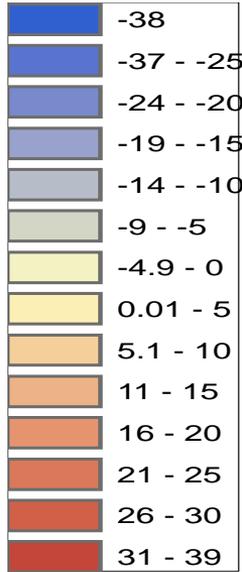
A1F1 2070 CCSM3

% Probability of Extinction



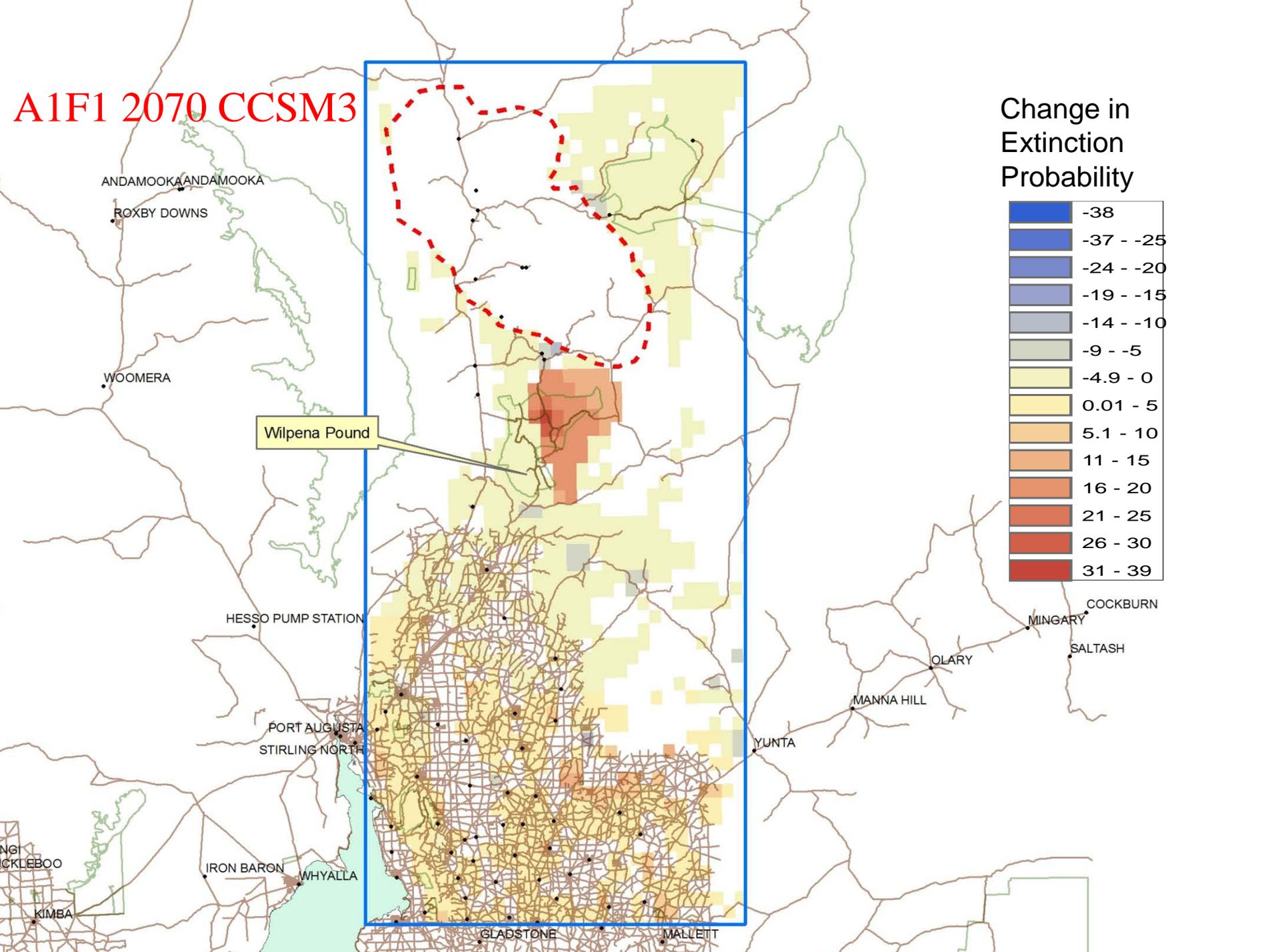
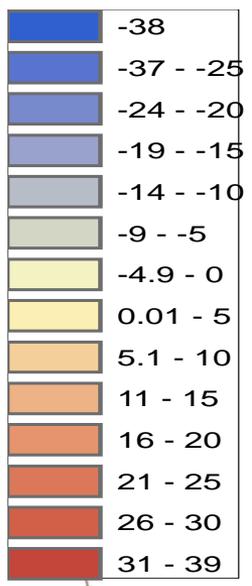
A1B 2030 CCSM3

Change in Extinction Probability



A1F1 2070 CCSM3

Change in Extinction Probability



An aerial photograph of a mountainous region. The terrain is covered in dense, dry-looking vegetation, appearing in shades of brown and tan. A prominent valley runs through the center of the image, where the vegetation is slightly darker and more green. The sky is a pale, hazy blue, suggesting a clear but slightly overcast day. The overall scene is a wide, panoramic view of a natural landscape.

An alternative approach

Environmental Envelopes

Species are thought to live in climate envelopes.

Envelopes are the minimum and maximum of:

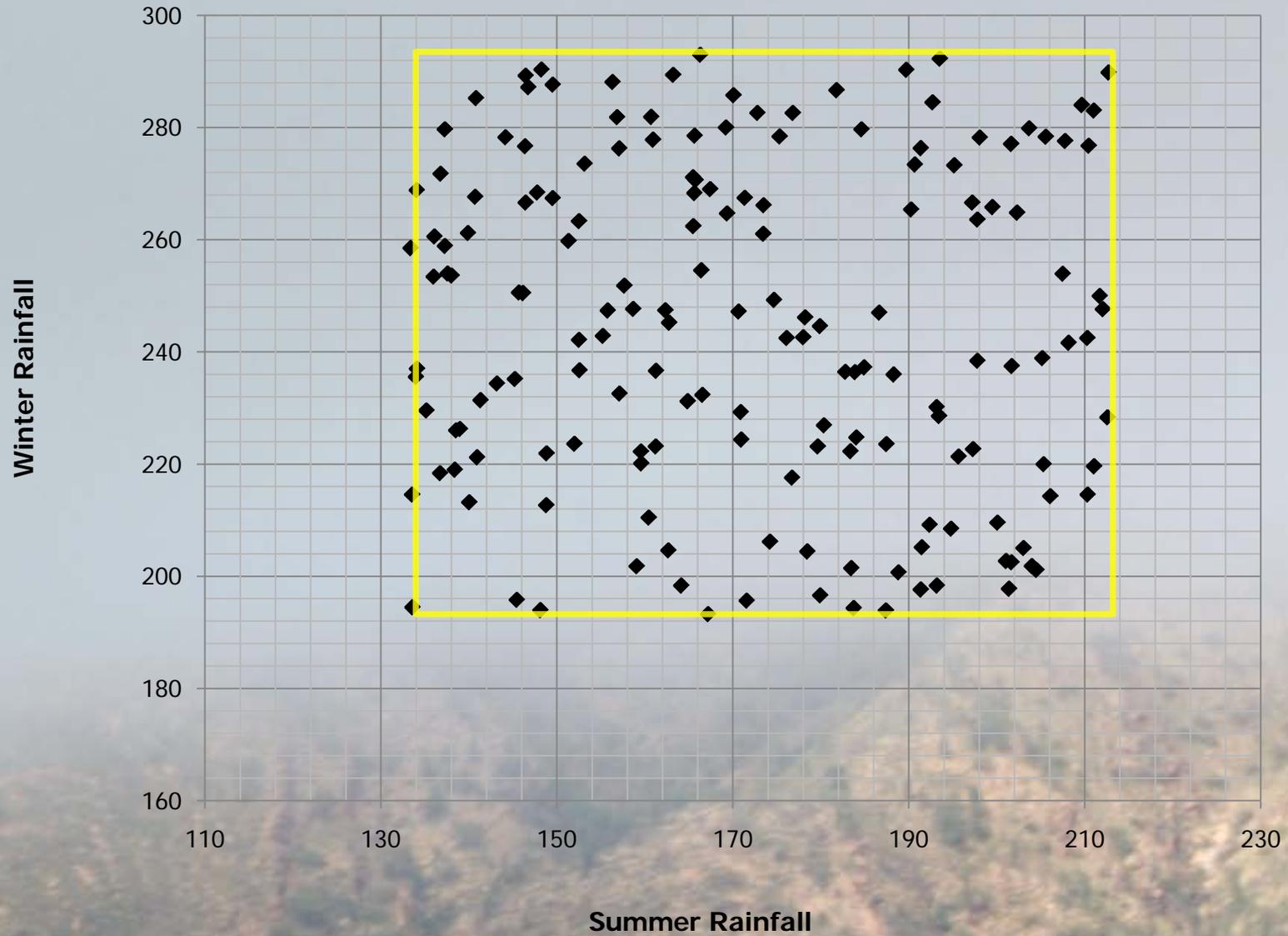
temperature, rainfall (annual, summer, winter etc), solar radiation and humidity.

They may also tolerate only a limited variability in these climate parameters.

Species may also live in certain environmental niches of soil, geology and topography.



Example



The data

Opportunistic sightings, aerial and ground survey data from DENR, collected by Copley (1984) and Lethbridge (2001, 2003, 2009, 2010) for *P. x. xanthopus*.

Environmental Envelopes

1. Used a range of BIOCLIM predictors:
 - Wettest season rainfall
 - Driest season rainfall
 - Annual rainfall
2. Added local topographic and geological data:
 - Geology
 - Slope
 - Elevation
 - Terrain microclimate measures
3. Spatially overlaid presence data on BIOCLIM, geology and topographic data

Environmental Envelopes

4. Established environmental envelopes (max/min ranges) based on current climate conditions, topography and categories of Geology.
5. Adjusted the climate layers according to the OZCLIM climate-change scenarios (5 km grid cells).
6. Predict the spatial range based on the envelopes (before and after OZCLIM adjustments)

ENVELOPE

Output Float File: C:\Research\S_Copley\ccsm2070.ft

CSV Points File (modified): C:\Research\S_Copley\Petrogale_xanthopus_training_joined_brief.csv
For model domain calculation. (This must be PA,E,N,Predictor1, Predictor2, ... PredictorN)
(NB: The second line must have under each heading (after PA,E,N) the letter c -- categorical or d - continuous)

Float List File: C:\Research\S_Copley\float_list_C_drive.txt
A text file (.txt) with all .flt files including full paths (e.g. C:\Folder\yy.flt).
(NB: .hdr file must have same path and prefix as .flt, can have more floats than required)

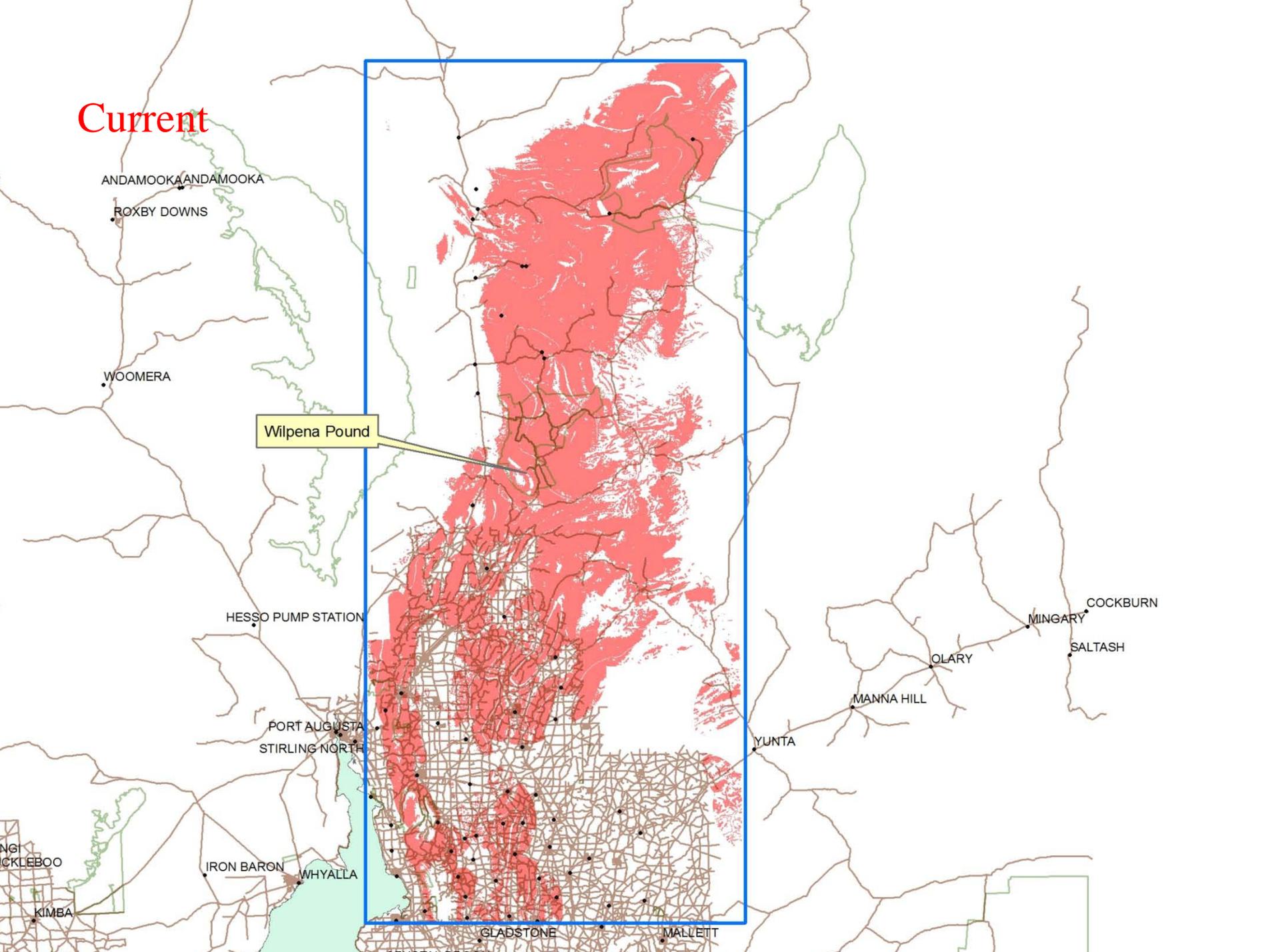
Envelope presences
 Envelope absences
 Adjust with climate-change data

All predictor grids same size (if known, speed up processing)
Zone (for predictor grids) 54
(when using OZCLIM. OZCLIM in lat/lon)

Folder with climate data:
C:\bc5\envelope\c2040\Mk3_A2_medium_percent

Cancel About OK

Current



ANDAMOOKA ANDAMOOKA

ROXBY DOWNS

WOOMERA

Wilpena Pound

HESSO PUMP STATION

PORT AUGUSTA

STIRLING NORTH

IRON BARON

WHYALLA

GLADSTONE

MALLETT

YUNTA

MANNA HILL

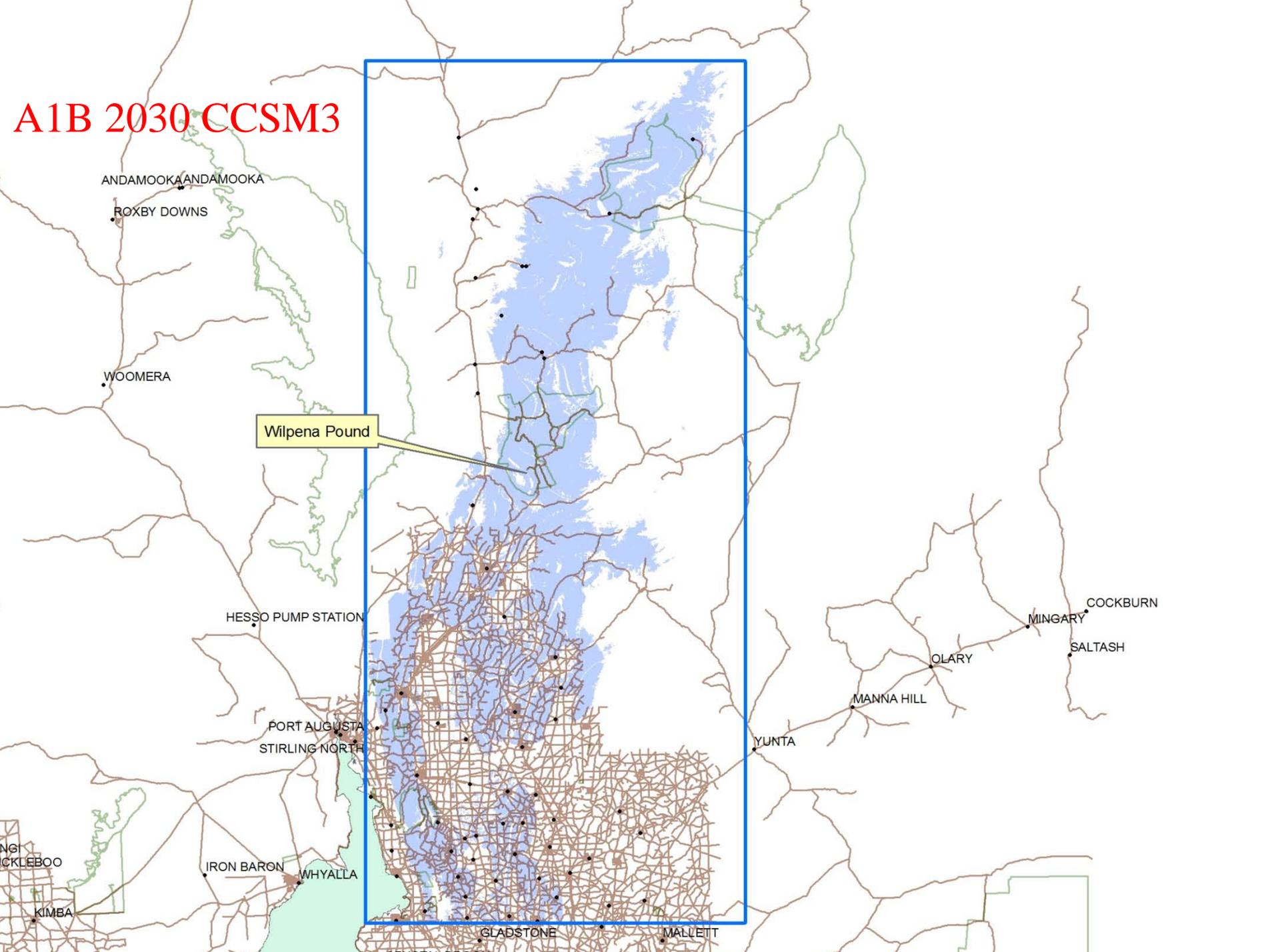
OLARY

MINGARY

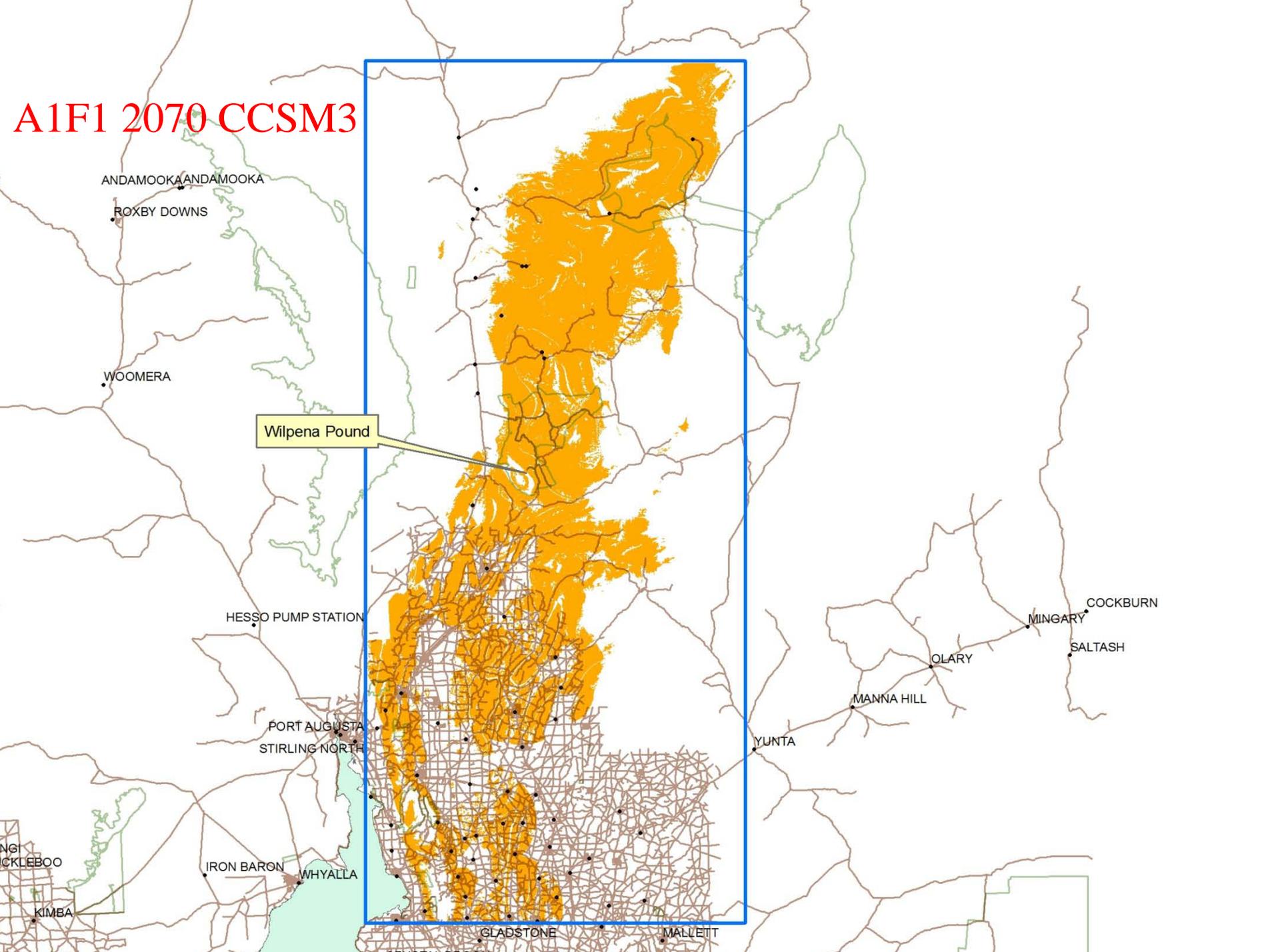
SALTASH

COCKBURN

A1B 2030 CCSM3



A1F1 2070 CCSM3



DODGY

Why?

- Envelope models are too abstract and better suited to biogeographical (continental) scales.
- Do not consider density dependence issues.
- Lack transparency and do not use any underpinning biological or ecological drivers.

An aerial photograph of a mountainous region, likely in a developing country, showing a central valley and surrounding hills. The terrain is covered in dense, low-lying vegetation, possibly agricultural fields or scrubland. The sky is overcast and hazy, creating a soft, diffused light across the scene. The overall color palette is muted, with various shades of brown, green, and grey.

Why trust either?

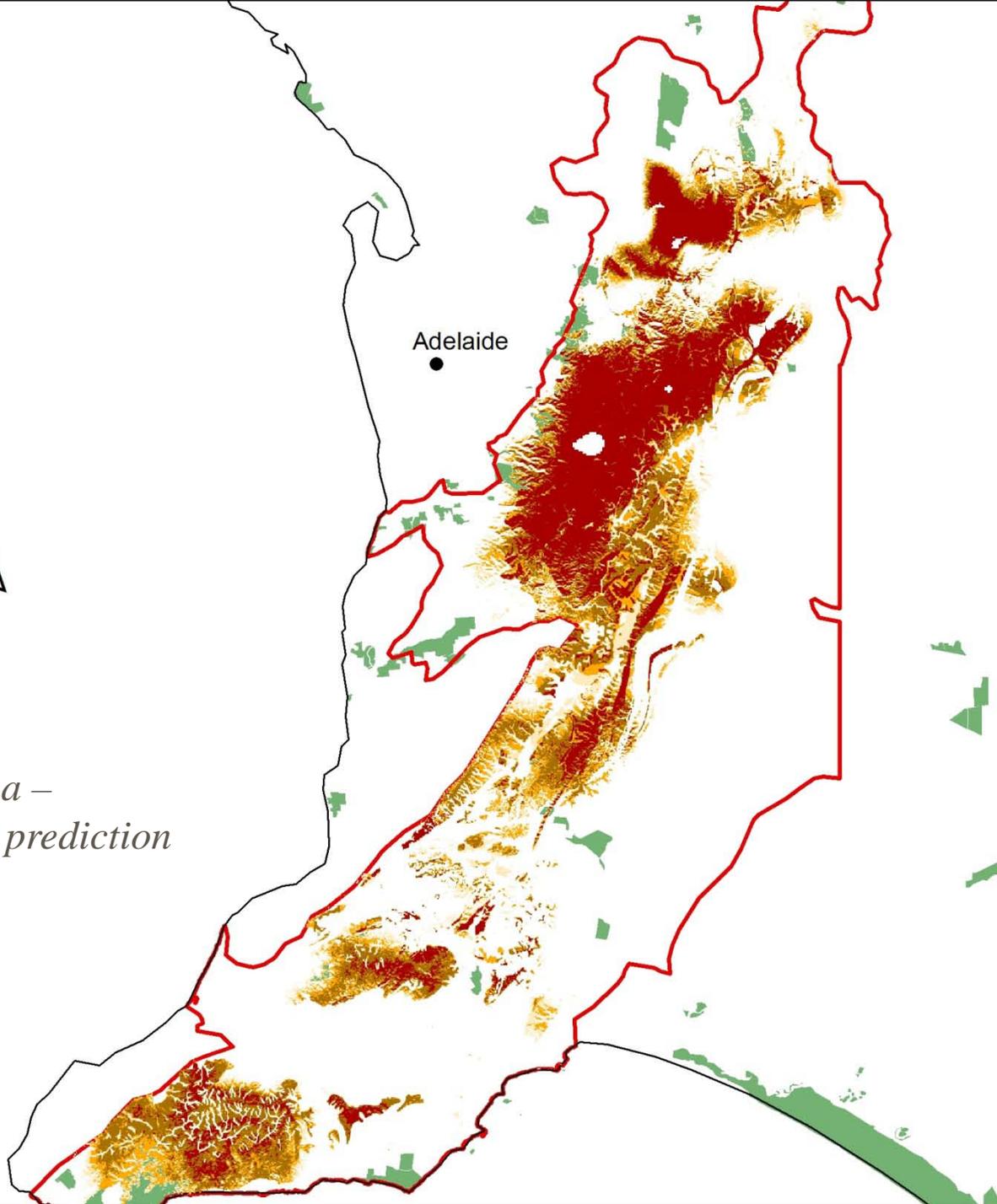
Neither approach adequately considers:

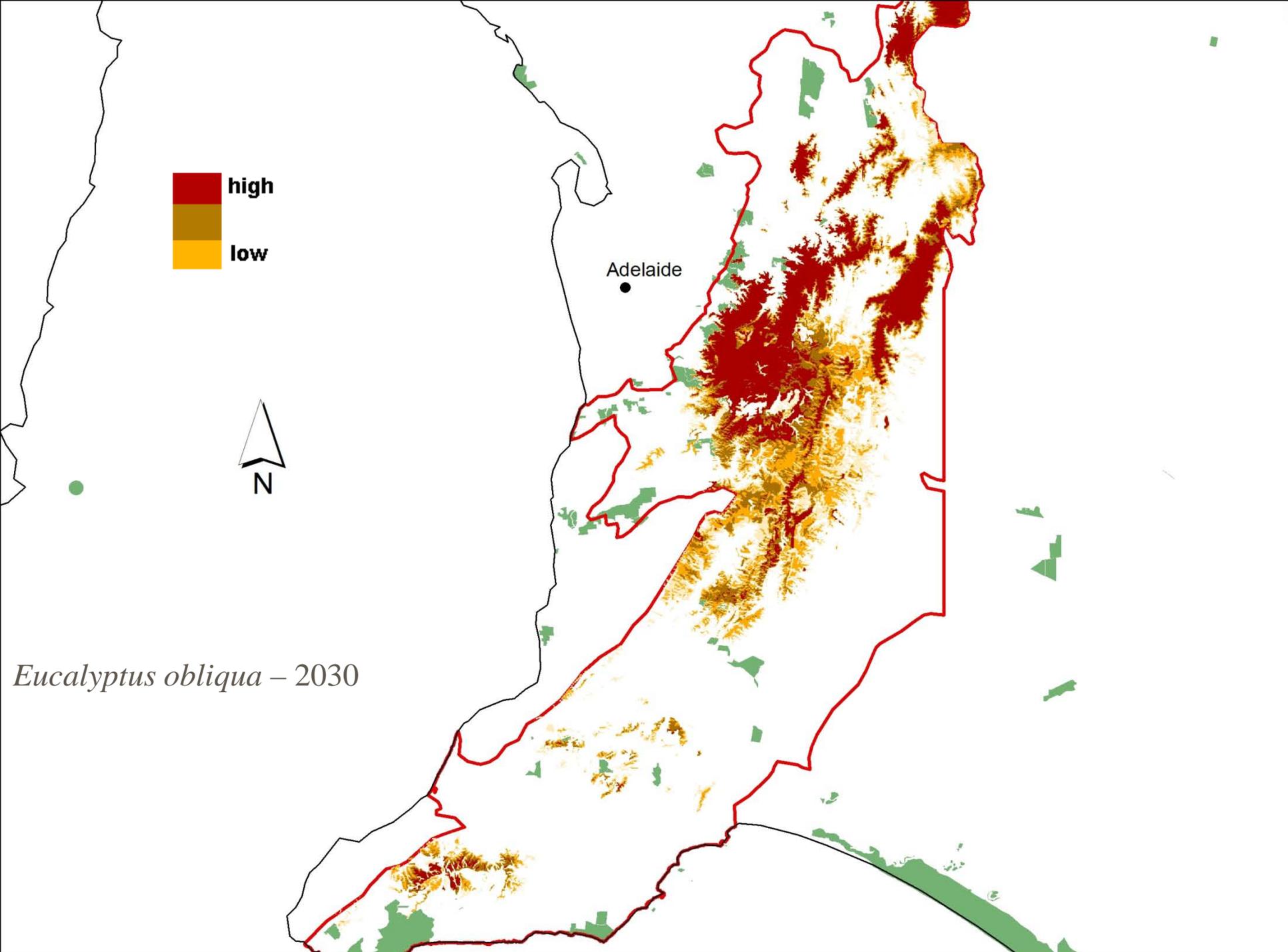
- How extreme events can disrupt/alter breeding cycles.
- Habitat fragmentation and its relationship to movement and gene flow.
- Interactive effects with other species.
 - Competition – e.g. increased pressure around permanent water.
 - Predation – e.g. increased susceptibility to predation .
 - Parasitism – e.g. plant insect attack from leaf eaters, borers
 - Changes in species composition/assemblages
- Pest species capitalising on disturbance (weeds, vertebrate pests).
- Behavioral responses like territoriality.
- Genetic diversity and adaptation.
- The extent to which wildlife health and disease is facilitated and exacerbates impact – e.g. increasing in virus vectors and host susceptibility
- Adaptation
- Connectivity and dispersal capacity
- Compounding effects of all of the above



Adelaide

Eucalyptus obliqua –
Realised niche prediction





Where research is needed

Population trend data

Few demographics and life history data available (more collection, similar species?)

Wildlife health and disease

Predispositions:

health - collecting /modelling chronic stress measures @ landscape

Vectors

tracking/modelling disease vectors - spatial

Genetic/adaptation understanding at landscape scale (climate scale)

Inbreeding depression, diversity, proportion of shared alleles

Understanding how spatial genetic patterns respond to landscape and climate change

PVA

Individual-based,

Spatially-explicit,

Models breeding structures, gene flow and movement

Use life history and movement data

Spatial PVA Revision 2.0

New random seed for this run? Quasi-extinction =

Simulations: Years: c: Run number:

Latin Hypercubes (uses +/- ranges systematically below - sensitivity analysis)

Use correlated rainfalls Unrestricted breeding Diapause

Allee search radius (kms): Max age: years

Fraction born female: Sexual maturity: years

Rainfall percentage: +/-

Dispersal Search effort:

Maximum Male disperse dist (kms):

Maximum Female disperse dist (kms):

Male alpha (-1/avg kms):

Female alpha (-1/avg kms):

Tick if the following measures are based on 6-monthly intervals (otherwise 12 months assumed)

1. Fecundity logit params: L1: I1: L2: I2:

B1 + B2 * rainfall1 + B3 * rainfall2

OR tick if only a mean fecundity = +/-

Target month for 1. and 2.:
(if 6 month intervals, this is one of two that are 6 months apart)

2. Adult survival logit params: L1: I1: L2: I2:

B1 + B2 * rainfall1 + B3 * rainfall2 + B4 * sex

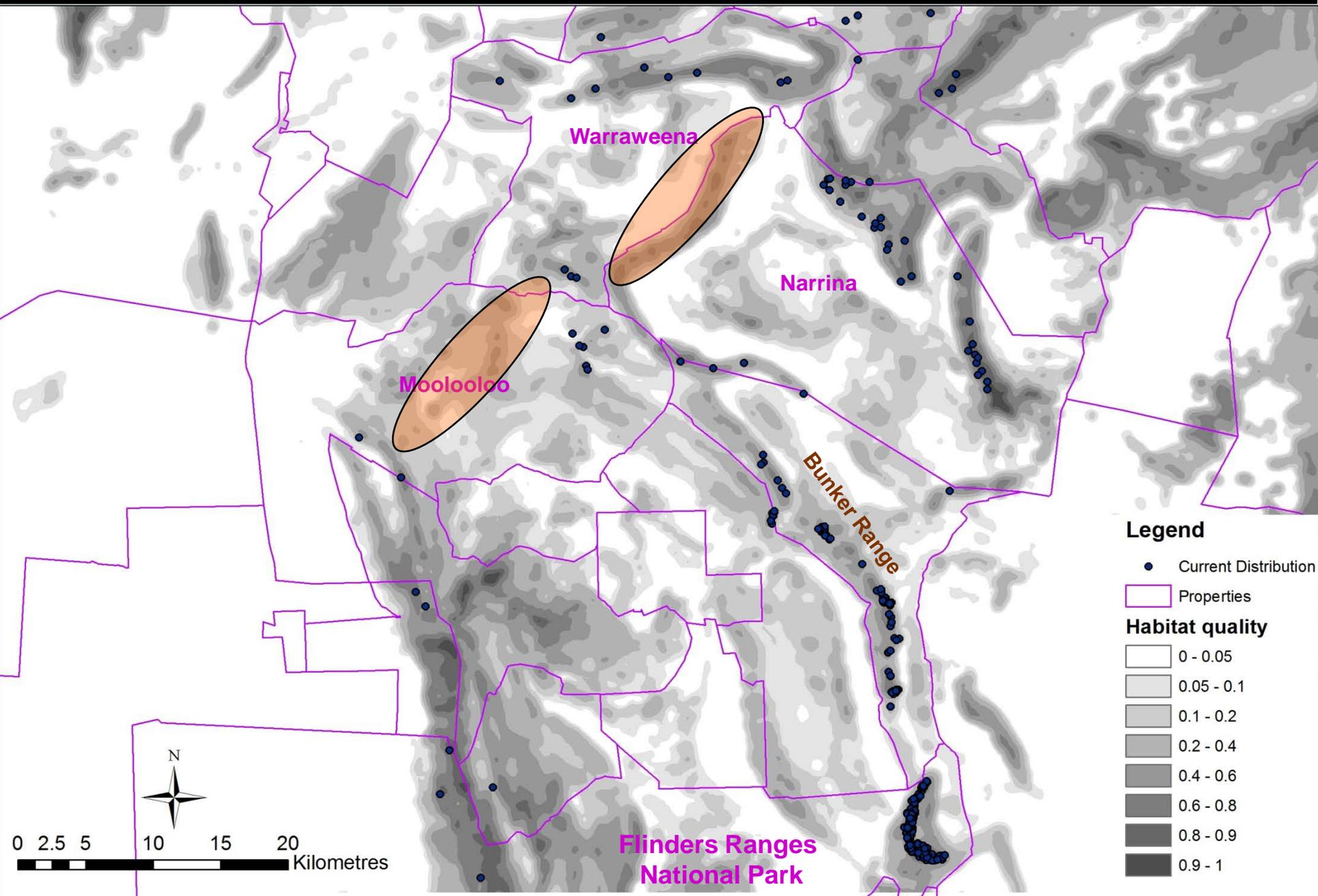
OR tick if only a mean adult survival = +/-

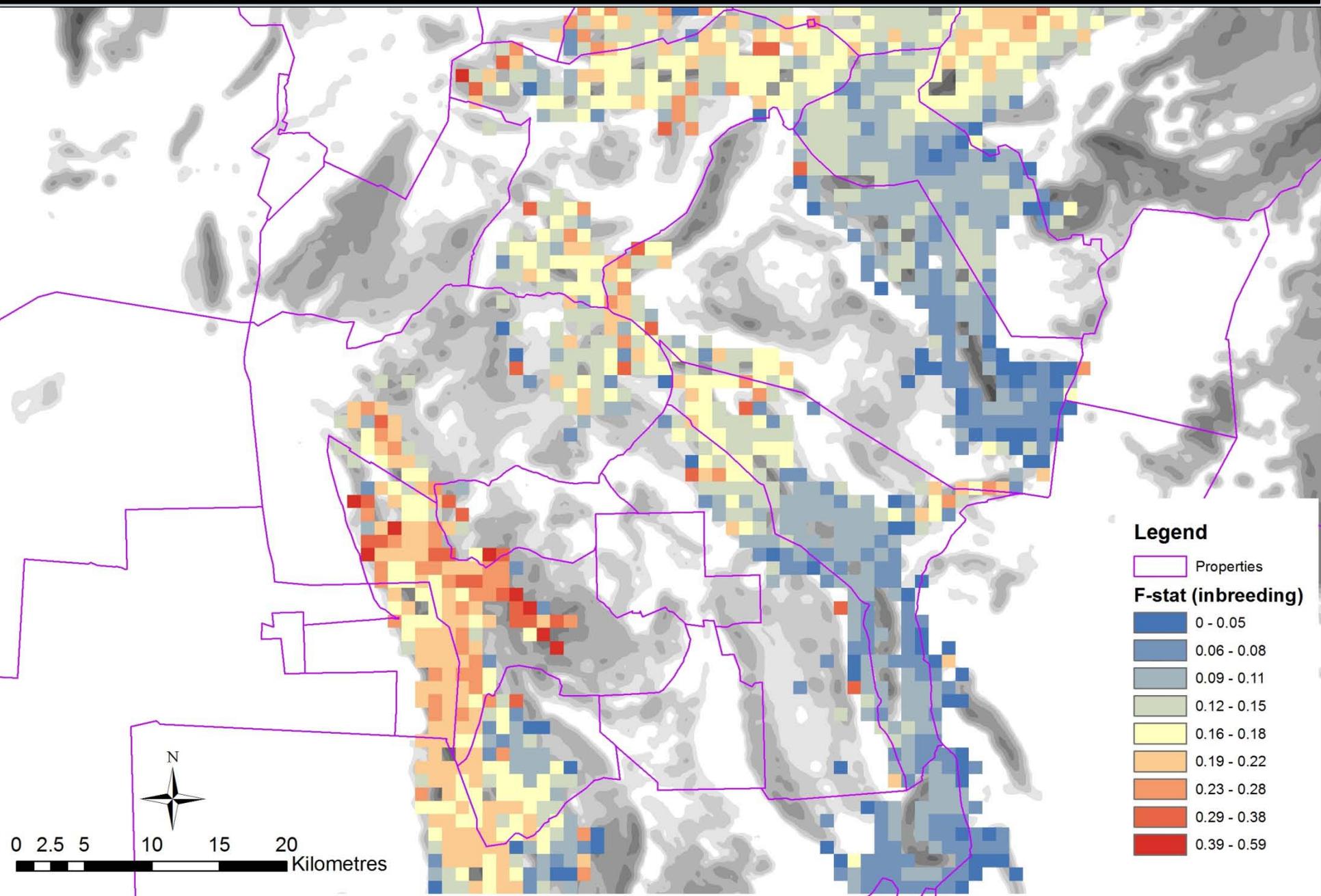
3. Juvenile survival: +/- Litter size: +/- Litters per annum:

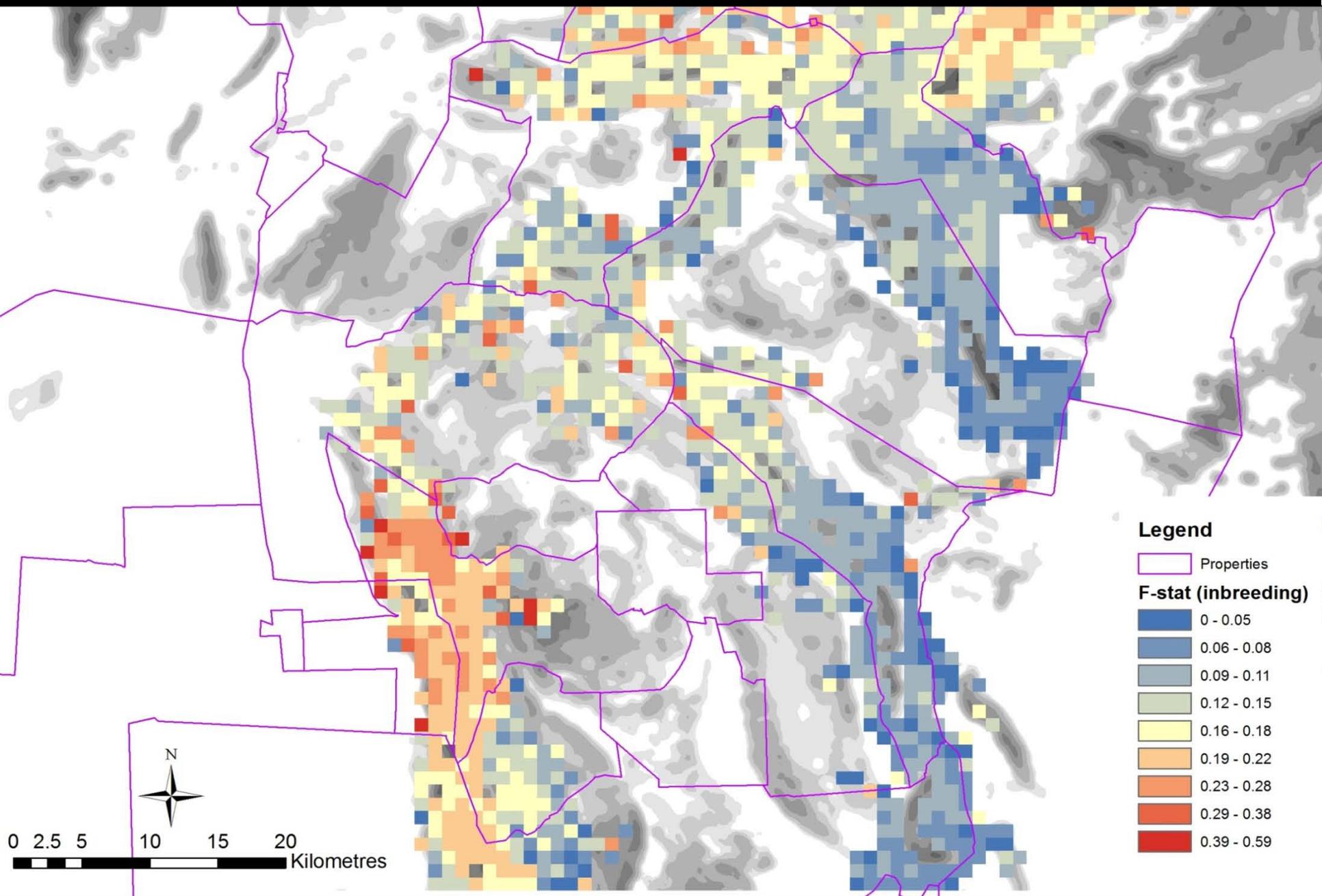
Cap population to carrying capacity? Dispersal triggered approaching carrying capacity (>0.8)?

Carrying Capacity (for a habitat quality cell value of 1.0) =: +/-

Pedigree file? Output sensitivity analysis to a BBN







Three tips for assessing and engaging “modellers”

Ask the “modeller” 10 natural history questions.

Keep the GIS wizz-kids away from the project and give them crayons to play with.

If a “modeller” uses the phrase “I can predict”, sack them.