



# Dealing with Drought: Refugia and Resilience

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# Scope

- Understanding the resilience of native fish to drought impacts (MD 1086)
- Protection and management of drought refugia (MD1087)



# Understanding Resilience (MD 1086)

- How does drought impact aquatic habitats in the MDB?
- How do native fish respond to drought impacts?



# Resistance and Resilience of MDB Fish to Drought Disturbance

McNeil, Gehrig & Sharpe (2009)

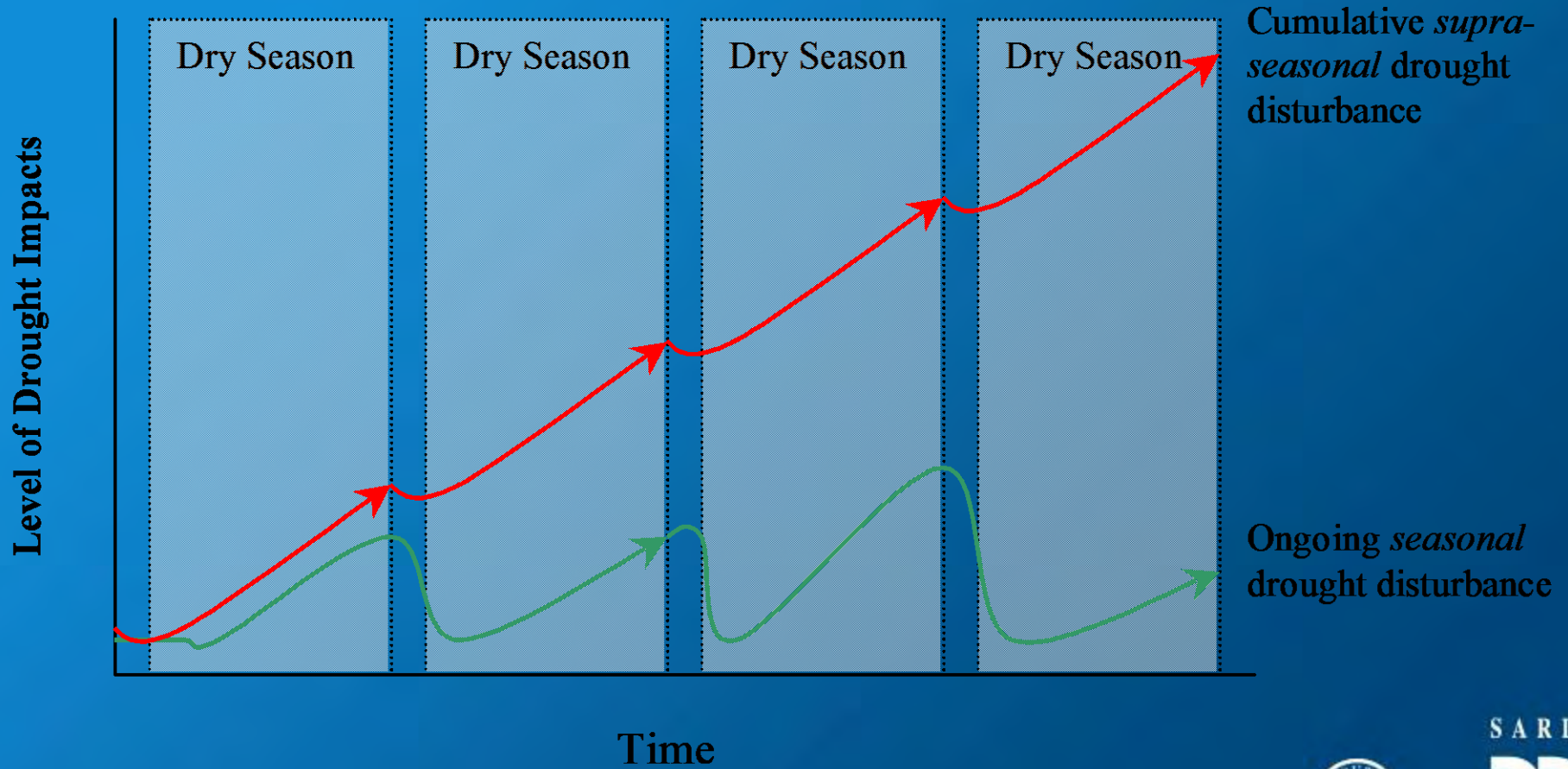
- Review the impacts of drought on freshwater habitats and fish
- Identify key resistance and resilience traits
- Develop conceptual models for fish responses
- Provide a framework for empirical models

# Resistance & Resilience Factors

- Resistance factors
  - Direct impacts of drought
    - Binary or chronic
    - Tolerance thresholds
    - Small temporal & spatial scale
- Resilience factors
  - Rebuilding viable populations
    - Recolonisation, fecundity, accessing spawning sites etc.
    - Large temporal & spatial scale



# Drought Disturbance



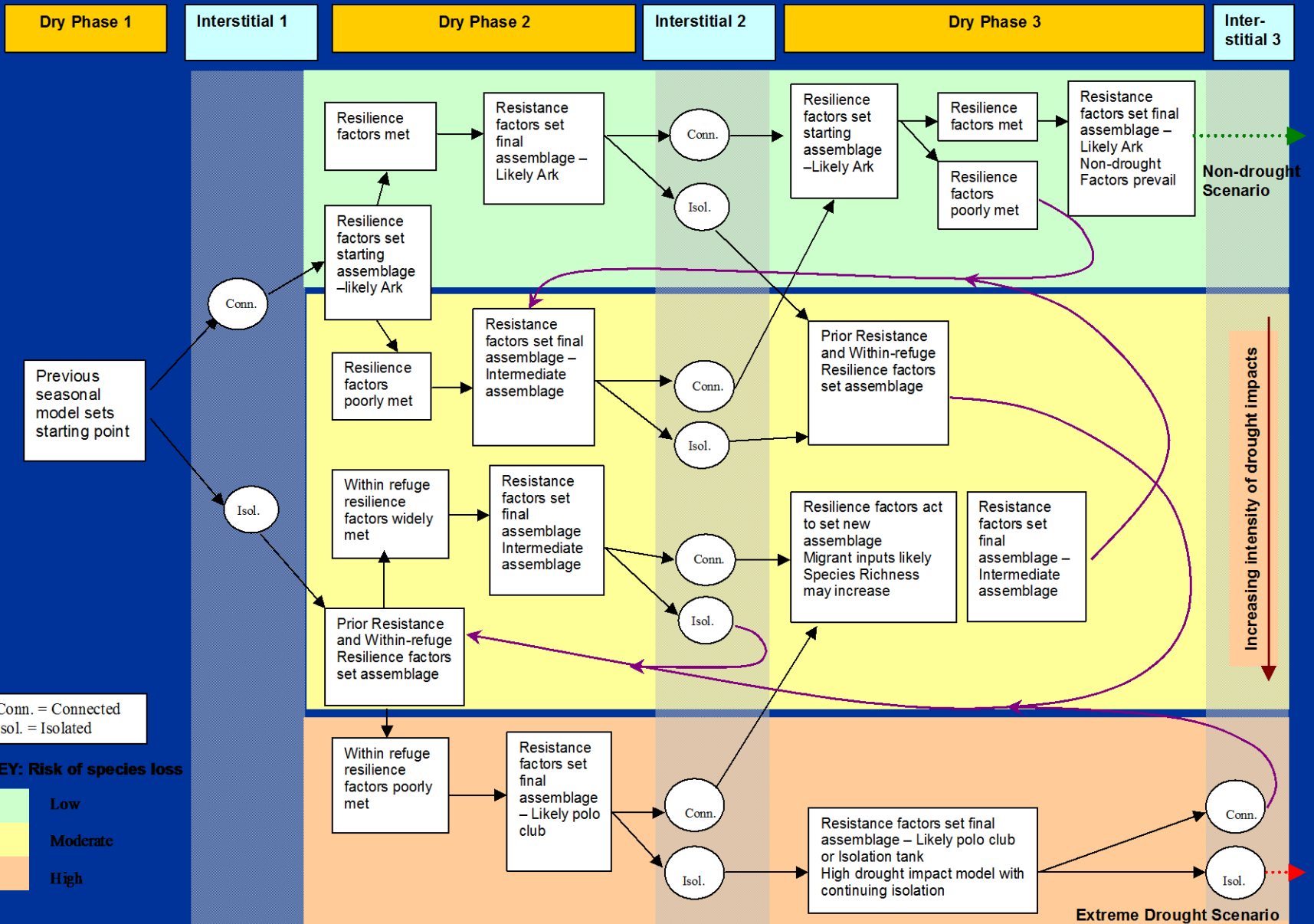
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# Supra-seasonal Conceptual framework



# Develop Empirical Models

- Conceptual model and species traits underpin empirical models
- Models predict likelihood of persistence under drought scenarios
- Based on species but applied to assemblages



$$\text{logit}(p_i(t+1)) = \text{logit}(p_i(t)) + \beta_{\text{resistance}} X(t) + \beta_{\text{resilience}} X(t) + \sum \text{Int}_{ij}$$

# Review fish traits

Murray cod ( <i>Maccullochella peelii peelii</i> ) Family: Percichthyidae		
Life history	<b>Abundance &amp; Distribution</b>	Limited abundance and patchy distribution in low-mid altitudes of Basin
	<b>Adult Habitat</b>	Associated with deep holes in rivers, wetlands, large woody debris
	<b>Adult micro-habitat associations</b>	Instream cover such as rocks, stumps, fallen trees and undercut banks
	<b>Home Range</b>	Acute (home snag)
	<b>Longevity (years)</b>	48+ years
	<b>Reproductive age (0-12 months) (1-3 years) (3+ years)</b>	4-5 years
	<b>Duration of spawning</b>	Short
	<b>Spawning style &amp; timing</b>	Single spawning, same time each year, Oct-Dec
	<b>Spawning cues &amp; habitat requirements</b>	Daylength. Circannual and min temp > 14°
	<b>Spawning migration</b>	Upstream migrations observed but not facultative
	<b>Spawning site</b>	Woody debris in faster flowing water
	<b>Courtship display</b>	Yes
	<b>No. of eggs (&gt;10,000) (2,000-10,000) (&lt;2,000)</b>	10,000 - 200,000
	<b>Size &amp; type of egg</b>	3 – 3.5 mm demersal adhesive
	<b>Egg Laying site</b>	Usually deposited onto a hard surface such as logs, rocks or clay banks
	<b>Time to hatching</b>	4.5 – 13 days
	<b>Parental Care</b>	Yes
	<b>Dispersal ability</b>	High, generally < than 10km
	<b>Larvae Size</b>	5 - 8 mm long (have large yolk sac)
	<b>Larvae/Juvenile functional feeding group</b>	Copepods and cladocerans, flood born items, chironomid and other insect larvae
<b>Adult Functional Feeding group</b>	'sit and wait' predator, its diet contains fish, crayfish and frogs, birds, eggs, lures	
<b>Adult size (&lt;150 mm) (150 - 450 mm) (&gt; 450mm)</b>	To 113kg and 1.8mTL (>450mm)	
<b>Schooling behaviour</b>	Not known	
Tolerance	<b>Tolerance to cease-to-flow periods</b>	High
	<b>Temperature</b>	Moderate (25-30°C), lower T <sub>critical</sub> = 10°C; upper T <sub>critical</sub> = 37°C
	<b>Conductivity (µS.cm<sup>-1</sup>)</b>	Moderate (observed 3000 µS.cm <sup>-1</sup> )
	<b>DO mg L<sup>-1</sup></b>	Moderate (down to 4)
Threats	<b>Turbidity</b>	High
	<b>Predators</b>	Birds, other Murray cod, Humans
	<b>Competitors</b>	
	<b>Other</b>	Overfishing (especially in breeding season); sedimentation causing habitat loss; altered flows; snag removal; cold-water pollution



How do individual species respond to drought?



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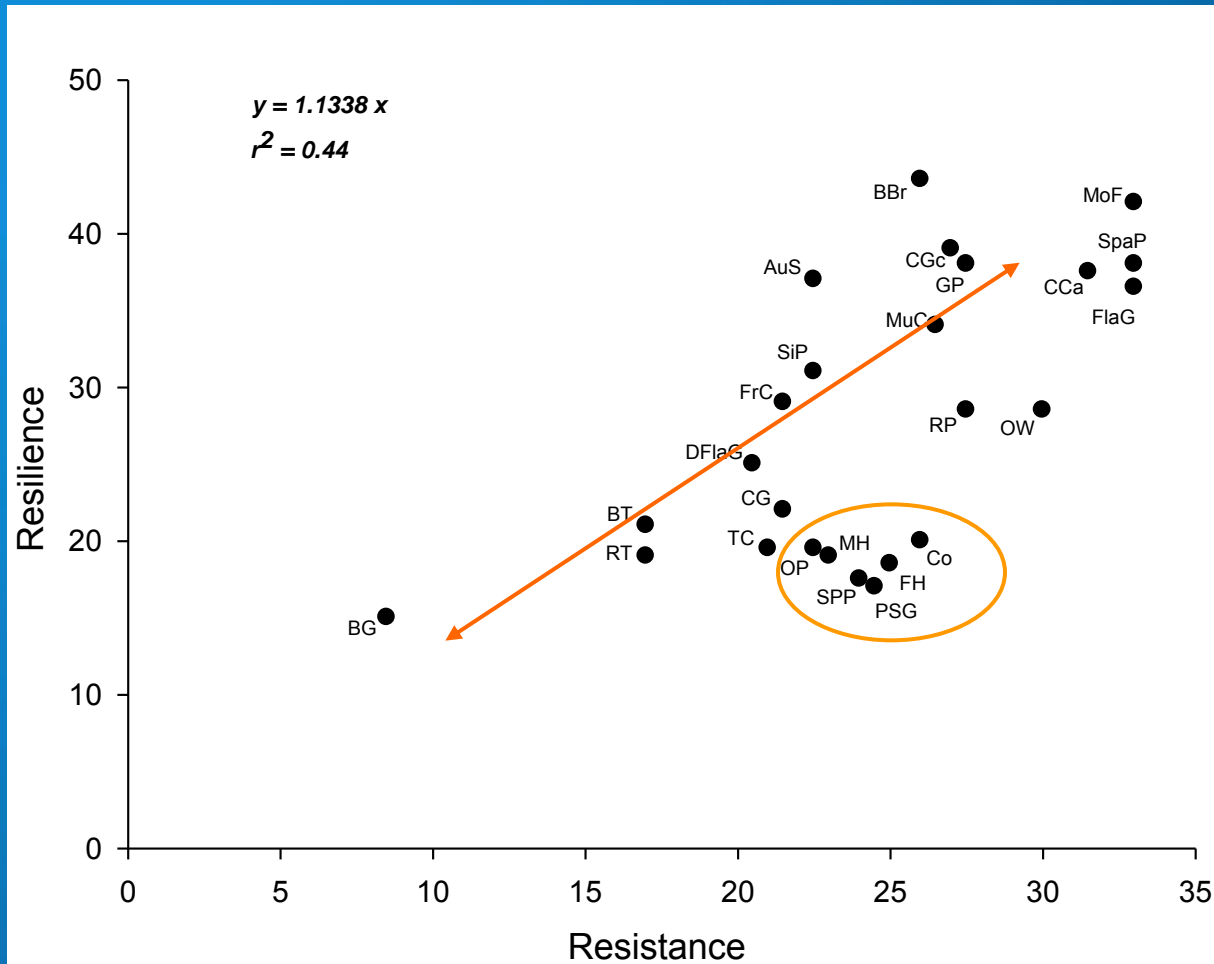


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# Resistance and Resilience Scores

Species	RESISTANCE TRAITS							RESILIENCE TRAITS										
	Low Flow	Temperature	Dissolved Oxygen	Salinity	Predator Susceptibilit	Feeding specificity	Resistance score (max =	Abundance	Distribution	patchiness	Longevity	Age to maturity	no flow spawners	Dispersal ability	Fecundity	Spawning constraints	Resilience Score (max	Total Score (max=84)
barred galaxias(BG)	0.5	0.5	0.5	1	1	5	8.5	5	1	0.5	2	1	1	2	1.5	1	15	23.5
rainbow trout (RT)	1	1	1	3	6	5	17	4	1	1	3	3	1	3	2	1	19	36
river blackfish (RB)	2	2	2	2	4	5	17	4.5	3	3	3	2	1.5	1	2	1	21	38
trout cod (TC)	4	2	2	2	5	6	21	1	1	0.5	5	5	1	1	3	2	19.5	40.5
purple-spotted gudgeon (PSG)	5.5	4	4	3	3	5	24.5	2	0.5	0.5	3	0.5	5	1.5	2	2	17	41.5
southern pygmy perch (SPP)	5	5	5	3	1	5	24	3	2	2	3	1	2	2	1	1.5	17.5	41.5
olive perchlet (OP)	5	4.5	4	3	1	5	22.5	4.5	1	0.5	1	1	5.5	1	2	3	19.5	42
murray hardyhead (MH)	5	5	5	6	1	1	23	5	0.5	0.5	1	1	6	1	1	3	19	42
common galaxias (CG)	3	3	3.5	6	1	5	21.5	6	1	1	2	1	2.5	3	3	2.5	22	43.5
flathead galaxias (FG)	6	4	4	3	3	5	25	2	1	1	2.5	1	6	1	2	2	18.5	43.5
dwarf flathead gudgeon (DFlaG)	2.5	3.5	3.5	4	2	5	20.5	4	3	3	2	2.5	2	2.5	3	3	25	45.5
congolli (Co)	4	2.5	2.5	6	6	5	26	5	1	1	4	2.5	2	1	2.5	1	20	46
freshwater catfish (FrC)	5	4	4	3	2.5	3	21.5	2	4	1	4	5	6	2	3	2	29	50.5
silver Perch (SiP)	4.5	5	4	3	1	5	22.5	3	3	4	4	4	1	5	5	2	31	53.5
redfin Perch (RP)	5	4	4	2.5	6	6	27.5	2	6	6	4	1.5	1	2.5	4	1.5	28.5	56
oriental Weatherloach (OW)	6	6	6	3	3	6	30	4	4	3	2.5	1	3	5	3	3	28.5	58.5
Australian Smelt (AuS)	5.5	4	4	6	1	2	22.5	5	6	6	1.5	0.5	6	6	1	5	37	59.5
murray Cod (MC)	4.5	5	2	3	6	6	26.5	4	4	4	6	6	2	2	4	2	34	60.5
golden perch (GP)	4.5	5	4	3	5	6	27.5	4	4	5	6	5	1	6	5	2	38	65.5
carp gudgeon complex (CGCo)	6	5	5.5	4.5	1	5	27	6	5	6	2	1	6	5	2	6	39	66
common carp (CCa)	6	6	5.5	5	3	6	31.5	6	6	6	5	1	1	5.5	6	1	37.5	69
bony bream (BB)	6	5	2	6	1	6	26	6	6	6	3	0.5	5	6	5	6	43.5	69.5
flathead gudgeon (FlaG)	6	5	6	6	4.5	5.5	33	6	6	6	2	1	5	2.5	3	5	36.5	69.5
spangled perch (SpaP)	4	6	6	6	5	6	33	4	4	5	3	1	4.5	7	4.5	5	38	71
mosquito fish (MoF)	6	6	6	6	3	6	33	6	6	6	2	1	6	4	5	6	42	75

# Resistance and Resilience Scores



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# Summary

- Literature review informs on drought impacts
- Identification of fish resistance/resilience traits
- Conceptual model development
- Empirical model design
- Field testing and validation

# Protecting Refugia (MD 1087)

- Develop information and tools for assisting managers



# Protecting Refugia

- Management & Expert workshop
- Questionnaires
- Regional Visits
  - Identify, characterise and prioritise local refugia
  - Identify management actions
  - Basin wide refugia network
- Pilot Valleys
  - Develop comprehensive management plans
  - Collect data and field test models

# Impending Outputs

- Legislative policy framework
- Drought Resistance and Resilience
- Critical Refugia for management
  
- Model development and validation
- Regional sessions
- Pilot Projects





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