Modelling how river flows influence feeding and breeding habitat of riverbed birds

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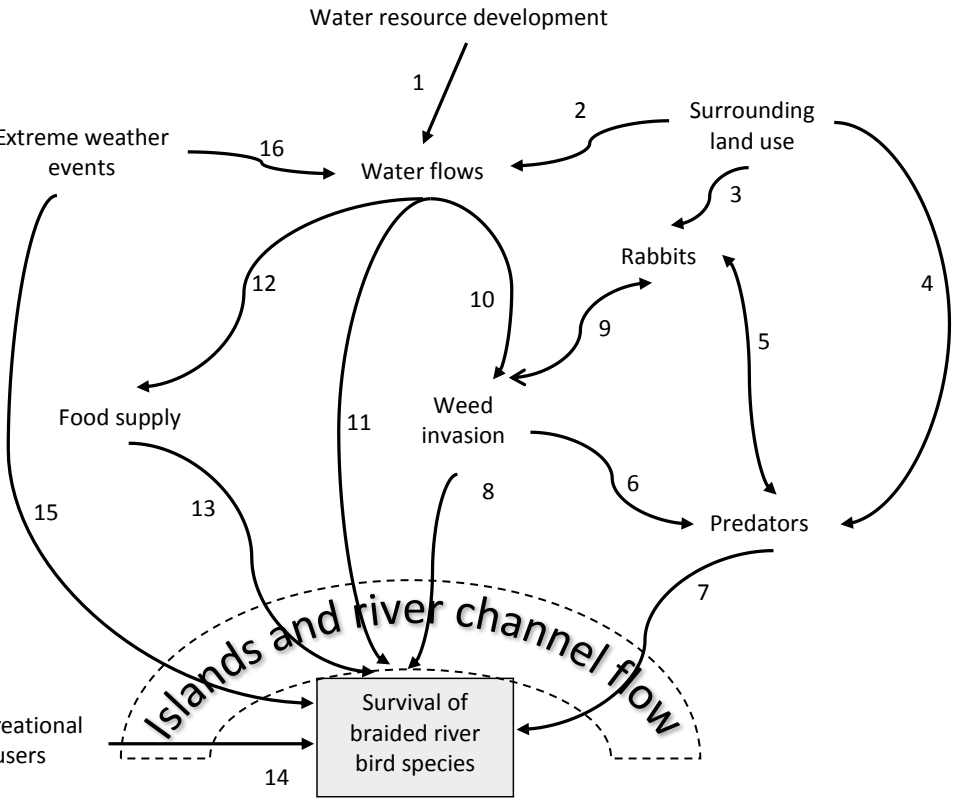
Content

- What is the model we are interested in = a systems picture
- Defining the baseline and what we want for the future = desired outcome
- Key system interactions that modelling can help us with
- Telling the story – application to flow management of the Hurunui River
- Conclusions

The model

- A ‘model’ in any context is just a simplification of reality
- We need models to make sense of complexity
- And braided rivers are one heck of a complex
- So, when we start thinking about river flows, feeding and breeding of riverbed birds, and water management, it helps to think of a system model
- And I quite like Rachel Keedwell’s – it’s simple, diagrammatic and roughly makes sense (with a small addition!) …

Relationships of some of the key factors impacting on survival of braided river birds (Adapted from Keedwell 2004)



1 – river flow is modified by abstraction, damming or a combination of the two, char river flows and flood frequencies and magnitudes;
2 – surrounding land use directly impacts on water quality and river management including flood protection schemes which reduce the area of active riverbed;
3 – rabbit control on farmland lowers rabbit abundance;
4 – differing land use practices changes habitat availability for predators;
5 – predator abundance is altered by changes to rabbit abundance but also helps control rabbit abundance;
6 – vegetation on riverbeds provide cover for predators;
7 – predators prey on eggs, chicks and adults;
8 – weeds, clog up breeding habitat (e.g., lupins) and alter feeding habitat (e.g., the invasive aquatic weed didymo);
9 – vegetation provides cover and food for rabbits, but some weed species are controlled by rabbit grazing;
10 – lowered water flows and floods allow vegetation to establish on riverbed or in t river (e.g., didymo);
11 – floods destroy nests, but with freshes also act as controls on terrestrial and aq weeds (e.g., didymo);
12 – lowered water flows can alter abundance of aquatic insects and feeding areas
13 – food abundance can influence survival of young or condition of breeding adults
14 – fishers, campers and four-wheel drivers can destroy nests or disturb breeding birds;
15 – extreme cold spells can kill eggs and chicks;
16 – high rainfalls can cause floods.

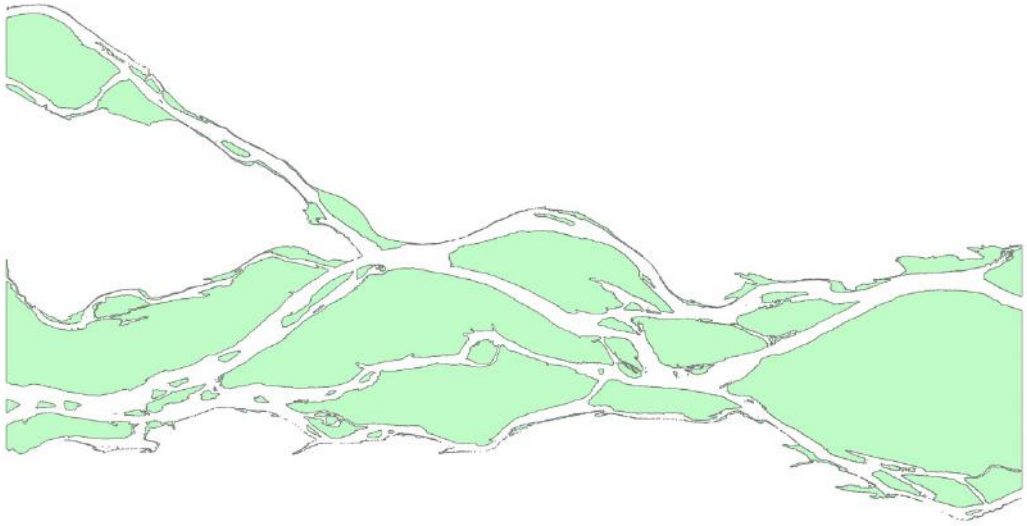
Defining habitat needs (for birds)

- Identify key life history stages, e.g., nesting on bare shingle near water during spring and early summer; feeding in or over water
- Measure flow related habitat needs in relation to key life history stages
- In conjunction with 2-dimensional habitat modelling (mostly via the work of NIWA scientists) recommend flows for nesting and feeding …

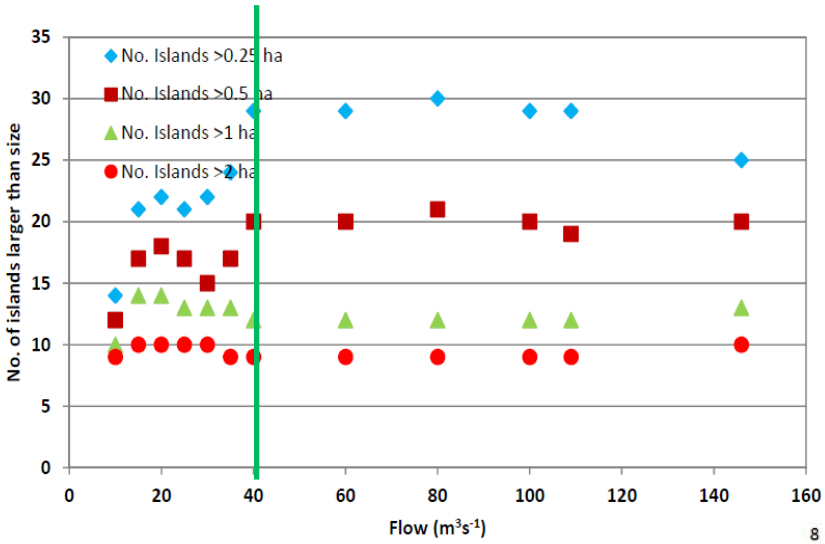
Waiau 2-dimensional modelling …

$20m^3s^{-1}$

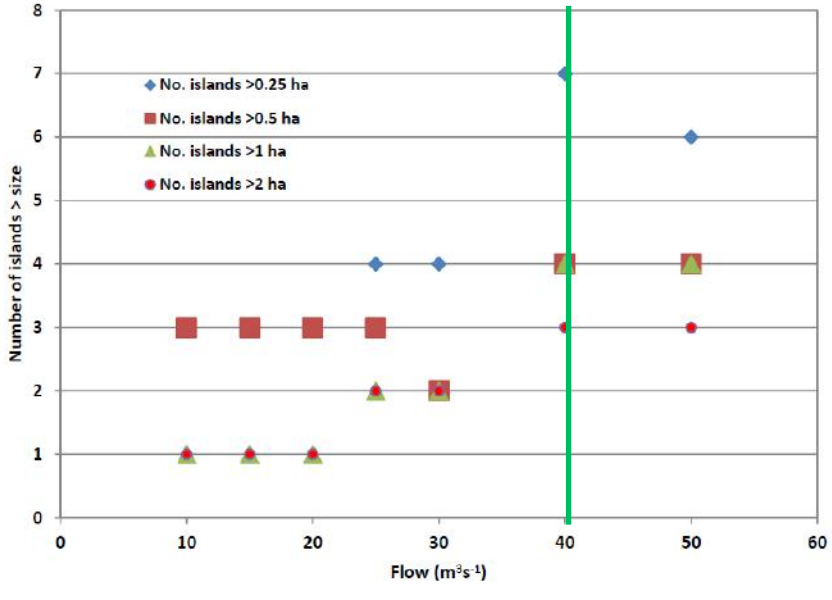
$40m^3s^{-1}$



Relationship between flow and number of islands greater than threshold sizes for Waiau and Hurunui rivers



Waiau River



Hurunui River

Weighted Usable Area (roughly area of preferred habitat) vs modelled flow for bird feeding/prey – Waiau and Hurunui rivers

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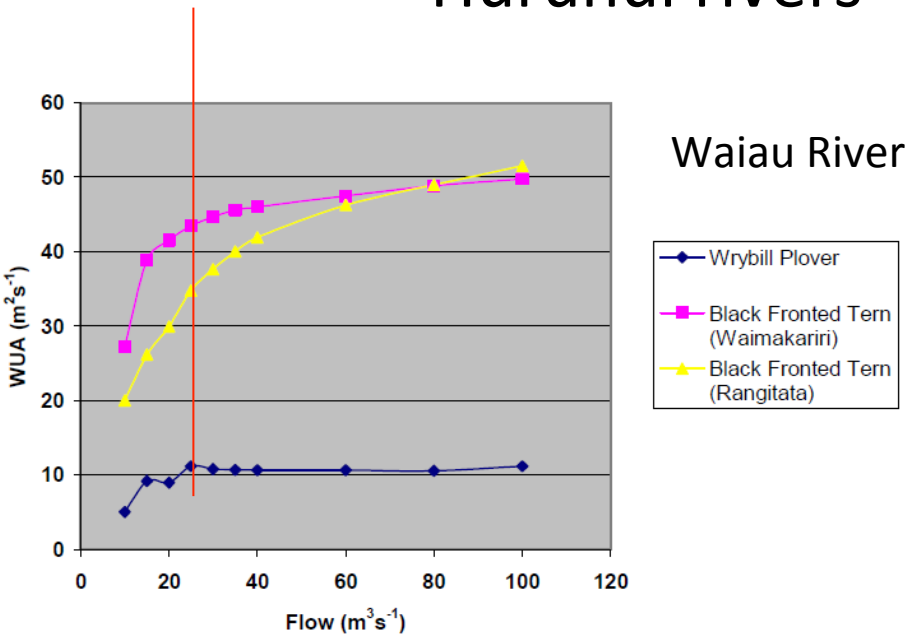
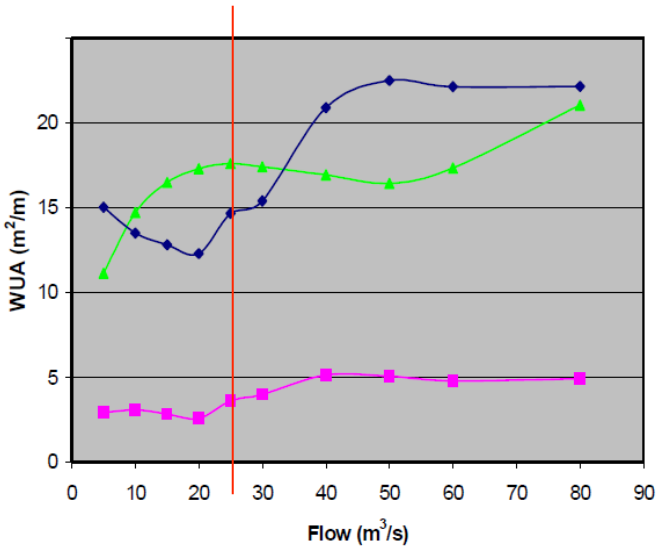
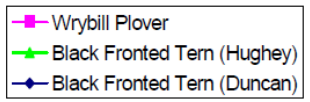


Waiau River

Hurunui River





Flow recommendations to meet bird habitat needs on Hurunui (and Waiau and) rivers

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Breeding:

- Nesting – **40** m^3/s to provide island security
- Periodic **floods** to keep the riverbed relatively clear of exotic vegetation

Foods and feeding:

- Foods – **25** m^3/s to maximise invertebrate food supply
- **Freshes** to flush periphyton etc

Dealing with probability and uncertainty

Considerable uncertainty predicting the effects of different abstraction scenarios on bird populations and their associated habitats

To illustrate how uncertainty varies between water management scenarios, predictions first expressed using a four-class system whereby scenarios are judged

- 'almost certainly',
- 'probably',
- 'possibly' or
- 'unlikely'

to achieve the desired bird outcome.

Assessed by:

- assessing each season's flow hydrograph against nesting and feeding and food related habitat criteria to assess flow adequacy for birds in that season; and
- summing each season's evaluation into an overall data set and determining the proportion of seasons with flows in each of the 4 classes listed above.

Uncertainty about predictions

- This overall evaluation is then considered in terms of the level of uncertainty about that prediction using a three-class system of:
  - 'high',
  - 'medium' and
  - 'low' levels of uncertainty (See next table).
- The combination of evaluating probability and uncertainty for each scenario is then shown in a **'best' (green)** to **'worst' (red)** matrix for each river.

bability of achieving desired bird outcomes and associated vels of uncertainty about the reliability of the assessment

Outcome achievement probability		Level of uncertainty about the measure of risk	
le	Interpretation	Scale	Interpretation
m o s t rtainly	More than a 95% chance that on average 15 years out of 20 when the outcome will be achieved	High	Little empirical ground-truthed supporting evidence
bably	More than an 80% chance that on average 15 years out of 20 when the outcome will be achieved	Medium	Some but limited empirical ground-truthed supporting evidence
ssibly	A greater than 50% chance that on average 15 years out of 20 when the outcome will be achieved	Low	Much existing field work and published research
likely	More than a 50% chance of outcome not being achieved, i.e., most years key needs will not be met		

Desired (bird) outcome

Desired outcome proposed for river nesting birds in the middle to lower reaches of the Hurunui River:

- Providing sufficient nesting and feeding habitat and associated resources to secure the existing populations of threatened and at risk bird species for the long term.
- This then means that flow related habitat needs are required to be met on at least 15 out of 20 years on average, recognising that in some years nature (floods and extreme low flows) already marginalises these needs.
- These habitat needs, because species can repeat nest, need to be met >80% of the time (or around 3 out of 4 months) during a breeding season.

Use all of the above and annual flow hydrographs for an informed assessment over a range of scenarios.

ydrograph evaluation matrix explanation

ecision criteria applied to each of 51 annual hydrographs for Hurunui Rivers
this is a lot of data over a long time period:

- If flows above 40 m^3/s line almost all of the time, i.e., >80%, then they 'Almost certainly' meet bird habitat needs;
- If flows above 40 m^3/s for >66% then they 'Probably' meet bird habitat needs;
- If flows above 40 m^3/s for around 50-65% of time then they 'Possibly' meet bird habitat needs;
- Otherwise flows 'Unlikely' to meet bird habitat needs.

xpert judgement was also used:

- If flows 'tailing' off at the end of the season and drop below 40 m^3/s line this is acceptable as breeding is nearly over;
- If flows above 40 m^3/s line for the first couple of months of breeding then this too is good.
- Where judgements 'are on the border' then in both circumstances the more positive evaluation is given.
- If large floods push the hydrograph above cut-off criteria then a downward classification is given.

Hurunui flow management scenarios

Natural – No abstraction.

Status quo – Abstraction of 6.2 m^3/s.

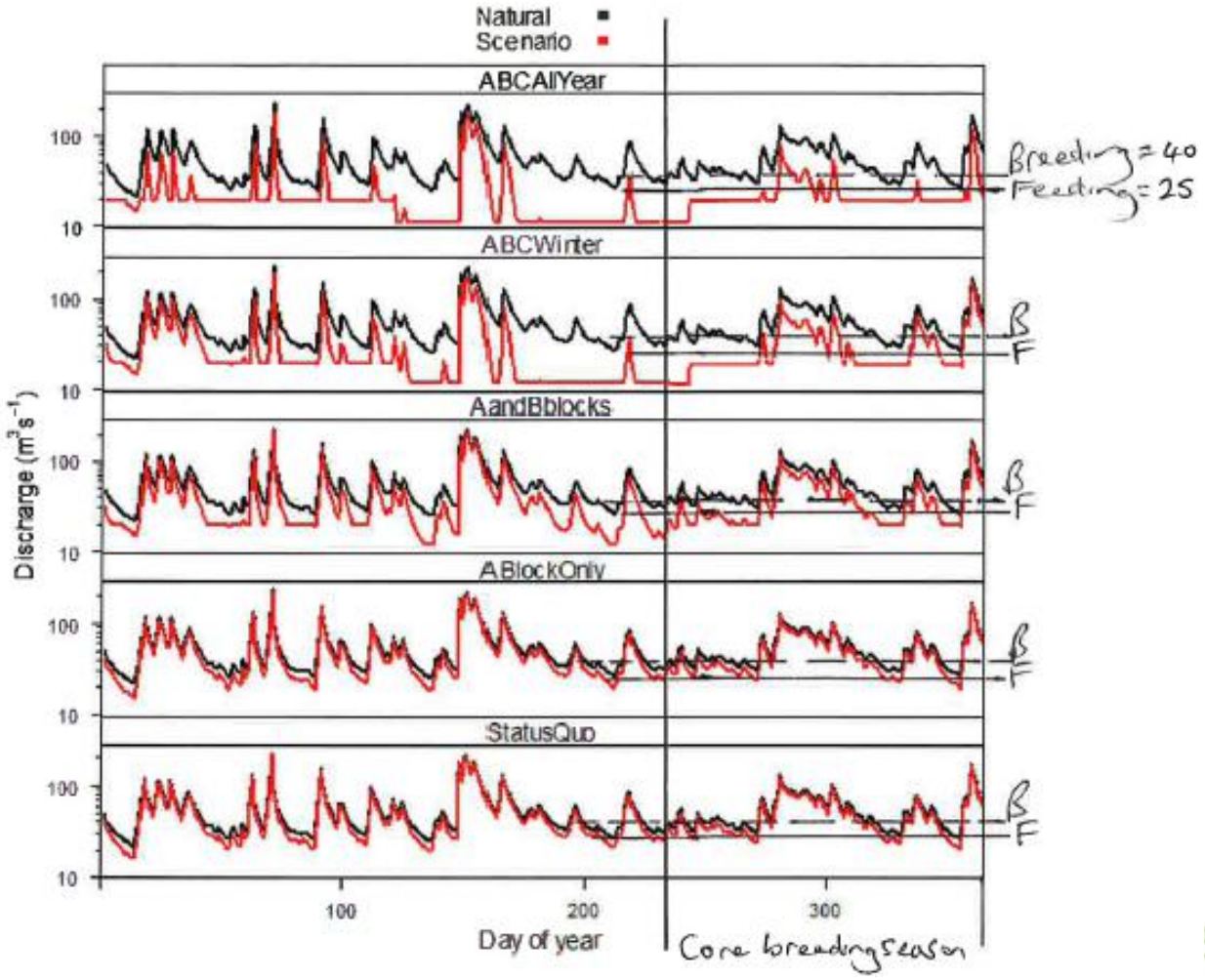
Scenario 1 – An A Block allocation of 7 m^3/s.

Scenario 2 – An A Block allocation of 7 m^3/s plus a B Block allocation of 10 m^3/s and B Block gap of 5 m^3/s.

Scenario 3 – ABC seasonal scenario that includes a C Block allocation of 0 m^3/s for December to February (summer), 16.5 m^3/s for March to May and September to November (autumn and spring) and 33 m^3/s for June to August (winter).

Scenario 4 – ABC all year that includes a C Block allocation of 33 m^3/s all year.

drographs for Hurunui at Mandamus for 1987, a typical year. Plots show the natural flow hydrograph (black) and the simulated rographs **(red)** for each of six management scenarios. Note that the vertical axis (discharge) is a log scale



Number and % of years when Hurunui flows suitable for breeding birds (N=51)

Scenario		Almost certainly (AC)	Probably (PR)	Possibly (PO)	Unlikely (UN)
Natural	No. yrs	20	15	9	7
	% yrs	39	29	18	14
	%yrs AC+PR	69			
	%yrs AC+PR+PO	87			
Status quo	No. yrs	17	17	10	7
	% yrs	33	33.3	19.6	14
	%yrs AC+PR	67			
	%yrs AC+PR+PO	86.6			
Scenario 1	No. yrs	17	14	12	8
	% yrs	33	27	24	16
	%yrs AC+PR	61			
	%yrs AC+PR+PO	85			
Scenario 2	No. yrs	7	10	19	15
	% yrs	14	20	37	29
	%yrs AC+PR	33			
	%yrs AC+PR+PO	70			
Scenario 3	No. yrs	0	8	8	35
	% yrs	0	16	16	69
	%yrs AC+PR	16			
	%yrs AC+PR+PO	32			
Scenario 4	No. yrs	0	0	4	47
	% yrs	0	0	7.8	92
	%yrs AC+PR	0			
	%yrs AC+PR+PO	7.8			

Scenario evaluation matrix for flow-related bird habitat requirements on the Hurunui. Note: any scenario that is 'green' is better than any that is 'lighter green' or 'yellow', and 'red' is worst.

		Uncertainty		
		Low	Medium	High
Probability (chance of achieving outcome)	Almost certainly			
	Probably	Natural, Status quo Scenario 1		
	Possibly			Scenario 2
	Unlikely	Scenario 3 Scenario 4		

Summary Hurunui flows for birds evaluation

- We can be **reasonably confident** that birdlife on the Hurunui will be sustained in decreasing order of likelihood and certainty by the following scenarios:
  - Natural, Status quo, Scenario 1
- It is **possible** but **very uncertain** that birdlife will be sustained by the following scenario:
  - Scenario 2
- We can be **confident** that birdlife is unlikely to be sustained with the following scenarios:
  - Scenario 3, Scenario 4

Conclusions

1. It is harder to meet flow requirements for birds on the Hurunui than it is on the Waiau, because the breeding season flows on the Waiau are higher. As a consequence a wider range of flow allocation scenarios exploiting larger potential takes can be envisaged as likely still meeting habitat needs on the Waiau than on the Hurunui.
2. Application of the approach indicates that no matter what you do with water allocation there is some impact on bird life. Thus, the higher the level of planned flow exploitation then the more mitigation that will be required.
3. While this sort of approach has been criticised I have seen nothing else that gives an equivalent or better approach to defining flow needs.