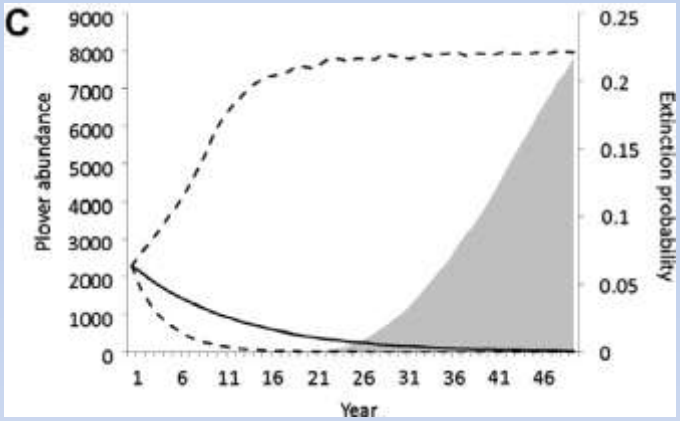
Past, Present and Future of Modeling Piping Plover Populations in the Great Plains



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Role of modeling

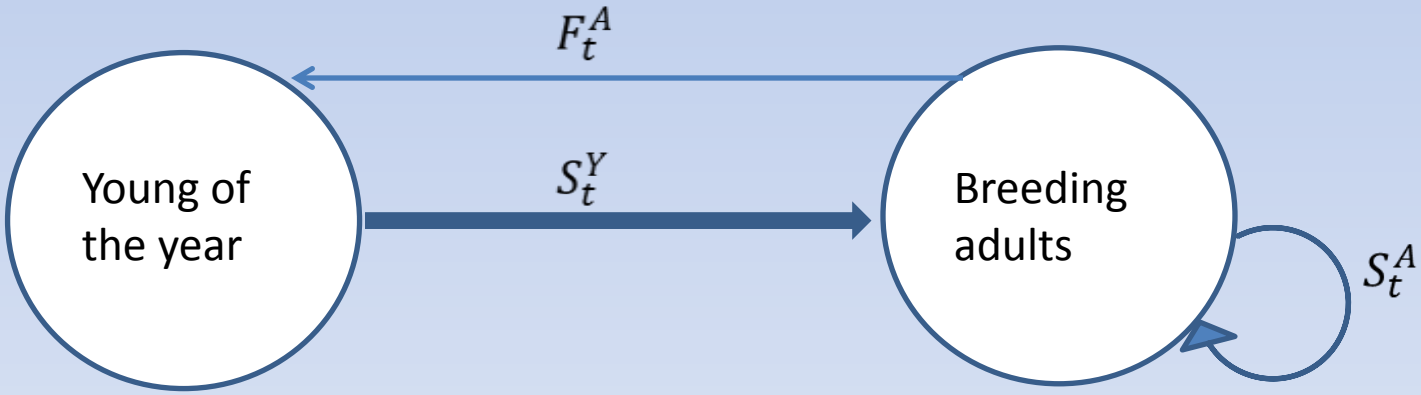
- Predictive tools
  - Predict population growth and extinction risk
  - Evaluate and compare management actions and outcomes
  - Evaluate uncertainty and expected variability
    - Evaluate research needs through sensitivity analyses
- Coalesce current, best data and literature

This presentation

- History of modeling plovers in the GP
  - Ryan et al. (1993)
  - Plissner and Haig (2000)
  - Larson et al. (2002)
  - McGowan and Ryan (2009)
- Modeling for recovery planning
  - Conceptual model to the recovery plan
  - Incorporating uncertainty
  - Uses and model out put

Ryan et al. 1993

$$N_{t+1} = N_t S_t^A + N_t F_t^A S_t^Y$$



Ryan et al. 1993

- Declining population
  - Highly sensitive to adult and juvenile survival
  - Extinction between 44 and 120 years

Table 1. Means of Great Plains Piping Plover reproductive rate, adult survival rate, and four levels of immature survival rate used in population simulations, with projected extirpation times.

Reproductive rate ($\bar{x} \pm SE$)[a]	*Adult survival* ($\bar{x} \pm SE$)[b]	*Immature survival* ($\bar{x} \pm SE$)[c]	*Years to extirpation (min–max)*[d]
0.86 ± 0.09	0.66 ± 0.06	0.46 ± 0.06	44 (25–54)
		0.53 ± 0.06	56 (28–77)
		0.60 ± 0.06	81 (29–105)
		0.66 ± 0.06	120 (36–148)

Plissner and Haig (2000) Metapopulation model

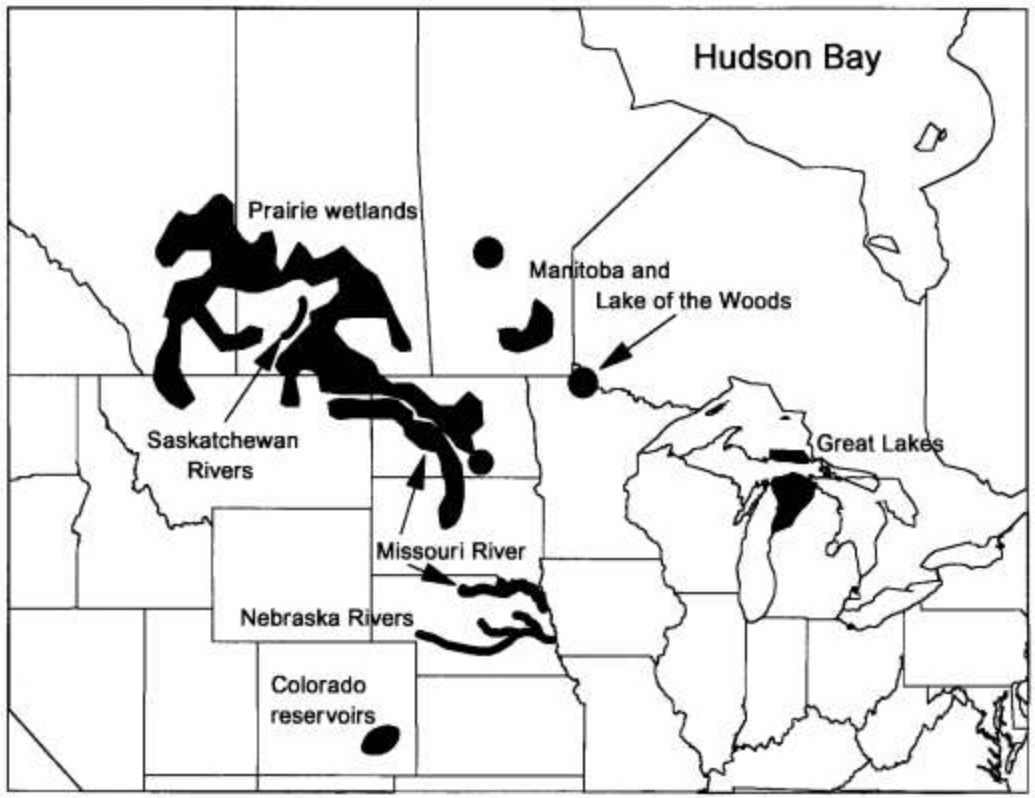


Fig. 1. 1996 piping plover breeding distributions and baseline metapopulation structure.

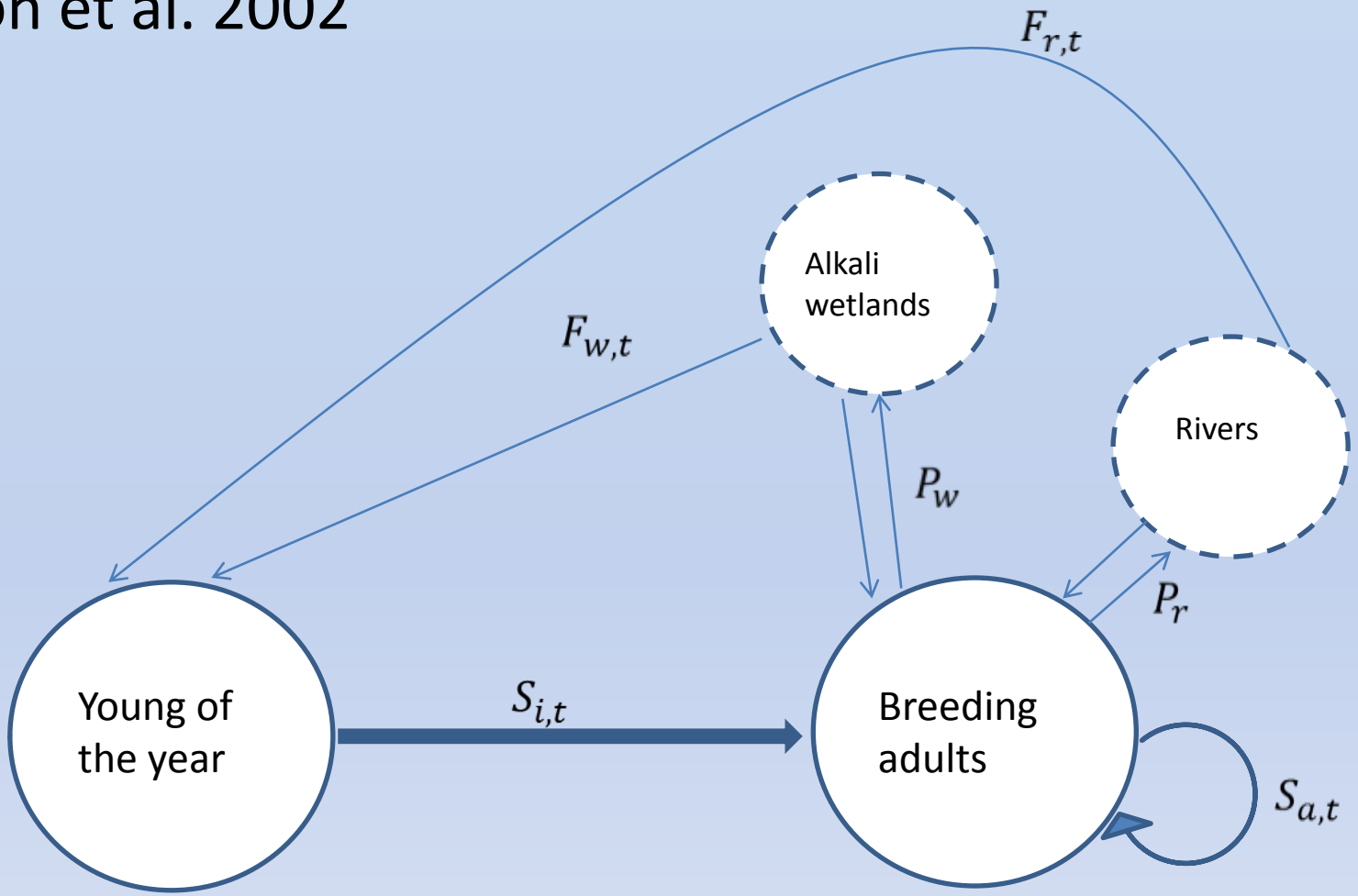
A dismal future predicted

Table 3
Results of Great Lakes/Great Plains/Prairie baseline model

	Population					
	Metapopulation	Great Lakes	Manitoba and Lake of the Woods	N. Missouri River and Coteau	Nebraska rivers	Colorado
Baseline model						
Probability of survival for 100 years (SE)	0.002 (0.002)	0	0	0.002 (0.002)	0	0
Mean final population size [a] (SE)	18 (0)	0	0	18(0)	0	0
Mean years to first extinction [b] (SE)	55.39 (0.56)	30.64 (0.75)	32.27 (0.44)	51.15 (0.56)	46.71 (0.52)	22.05 (0.39
Population growth rate (r)	−0.136	−0.103	−0.115	−0.142	−0.113	−0.091

[a] For populations persisting 100 years.
[b] For populations going extinct.

Larson et al. 2002



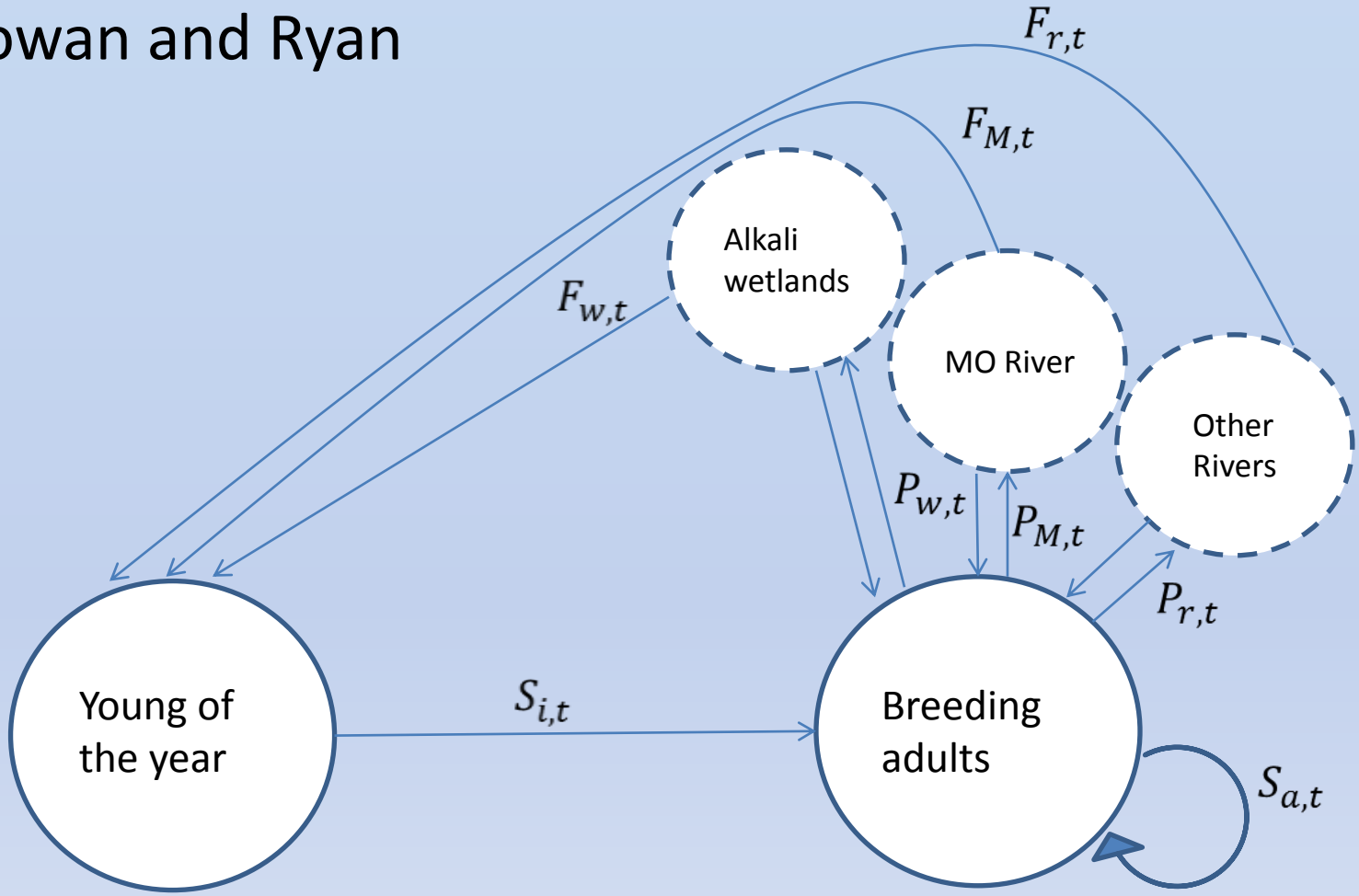
$$N_{t+1} = \left(P_{w,t}F_{w,t} + P_{r,t}F_{r,t}\right)N_t S_{i,t} + N_t S_{a,t}$$

Larson et al. results

Table 7. Growth rates and persistence times for the Great Plains population of piping plovers based on demographic simulation models and international censuses.

Source	Fledging rate[b]	Annual population decline (%)[c]	Persistence time (yr)[a] 25th–75th percentiles	Persistence time (yr)[a] $\bar{x}$
Current analysis				
Baseline model	0.85	6.2	39–62	107
Current management[d]	0.92	4.3	45–75	203
Proposed management[e]	0.99	2.8	52–94	242
Ryan et al. (1993)	0.86	7.6		81
Plissner and Haig (2000*b*)	1.25	12.7		55
Censuses, minimum decline[f]		1.0		
Censuses, maximum decline[g]		2.9		

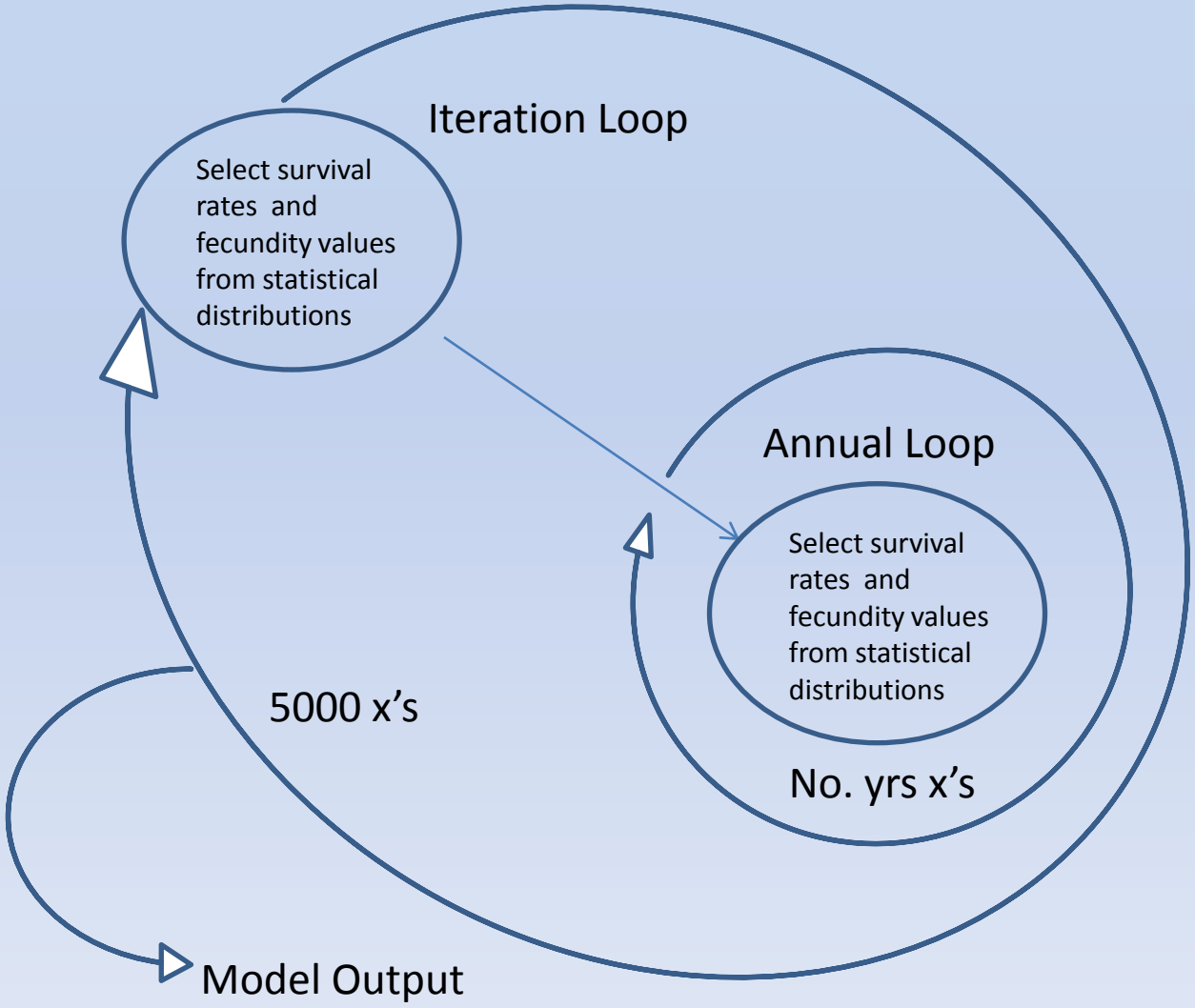
McGowan and Ryan 2009



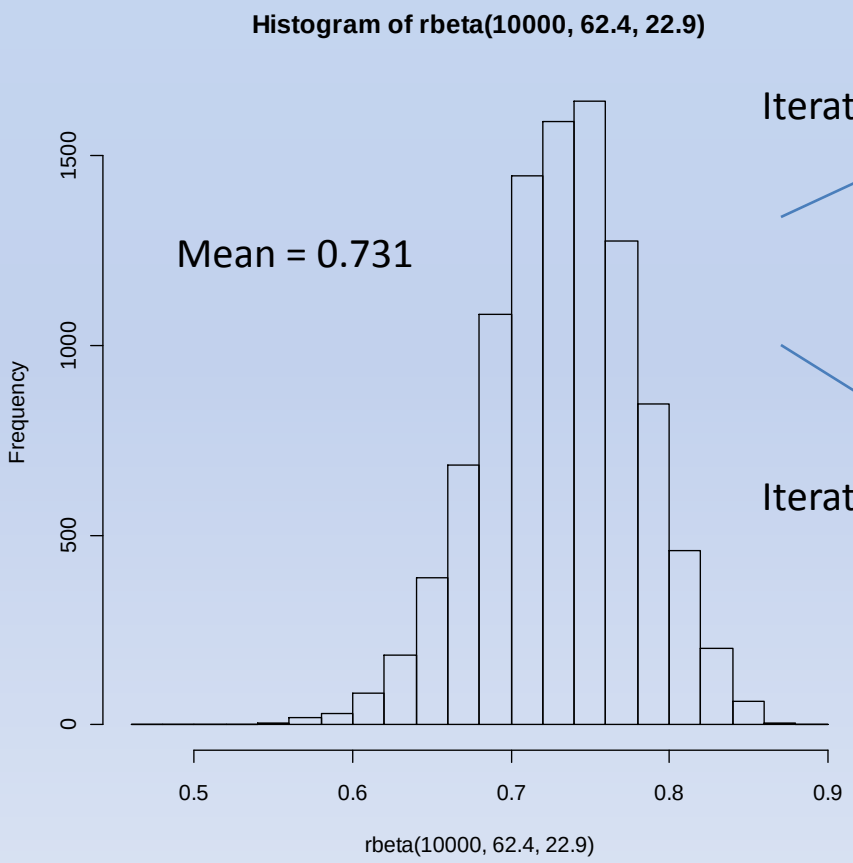
$$N_{t+1} = \left(P_{w,t}F_{w,t} + P_{M,t}F_{M,t} + P_{r,t}F_{r,t}\right)N_t S_{i,t} + N_t S_{a,t}$$

$$F_{M,t} = \frac{\left(\left((N_t\, P_{M,t}\, R_t\, C_t) - T_{e,t}\right) S_{n,t} - T_{c,t}\right) S_{c,t}}{(N_t\, P_{M,t})}$$

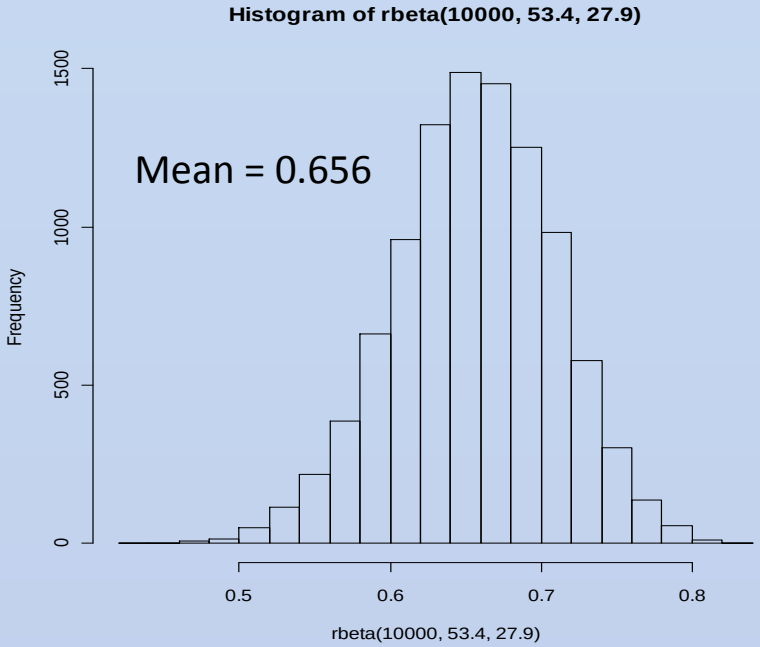
Hierarchical loop structure: parametric and environmental uncertainty



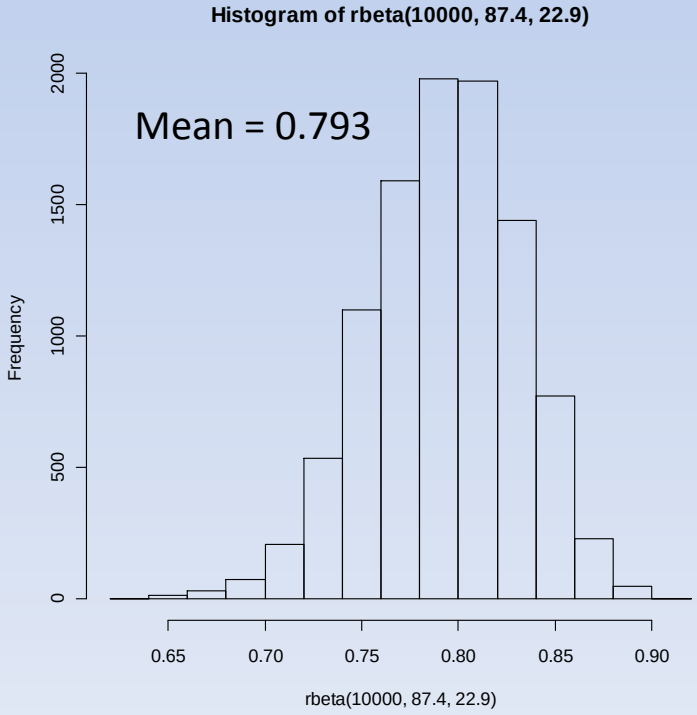
Modeling uncertainty in adult survival



Iteration 1

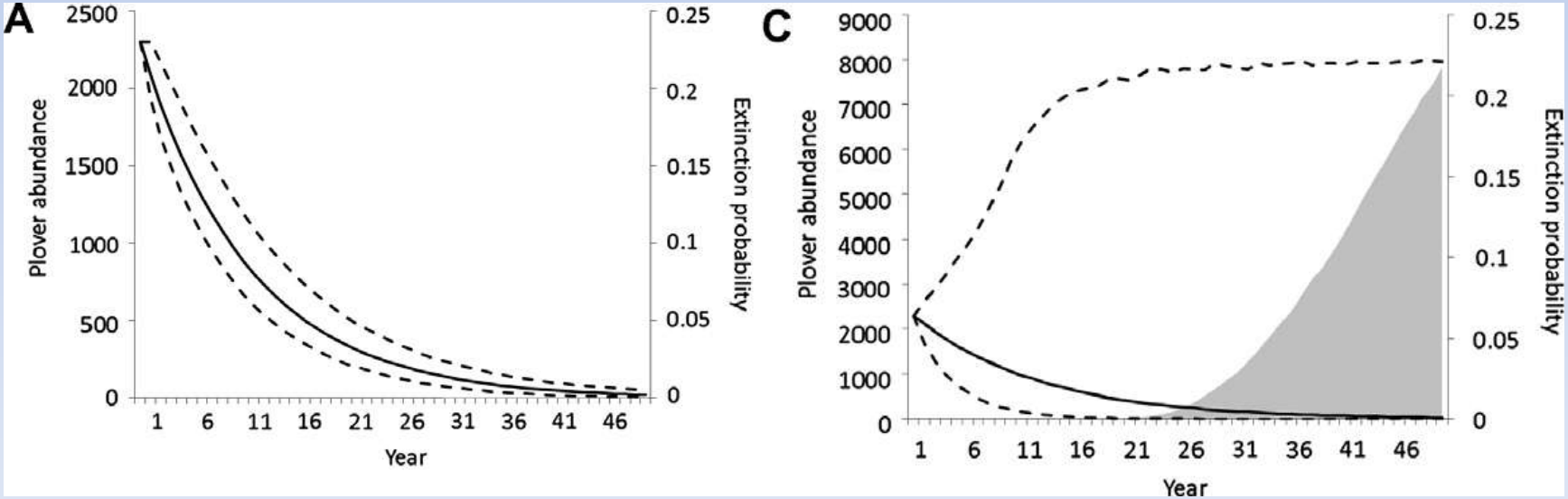


Iteration 2



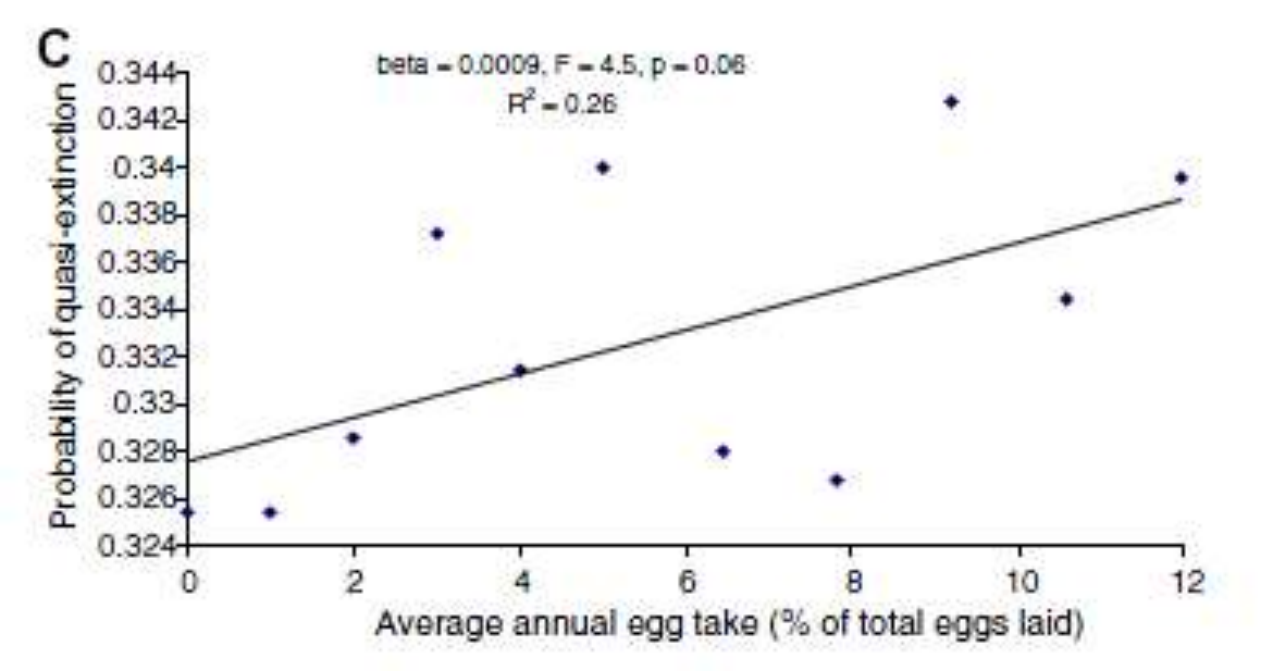
The effect of parametric uncertatinty

- Uncertatinty in mean parameter estimates leads to greater uncertainty in model output
  - Could explain the disparity between model predictions and count data



McGowan and Ryan 2009 results

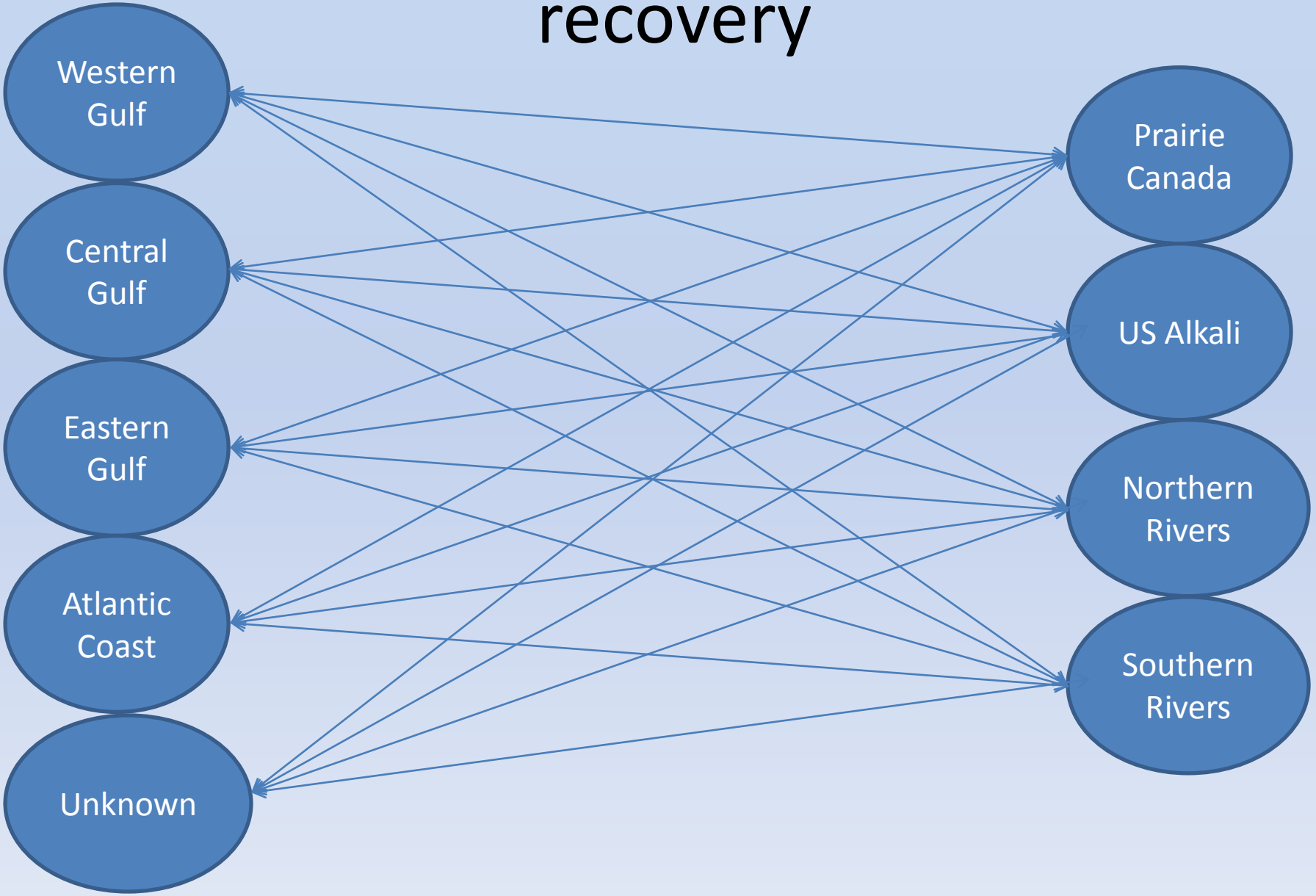
- Declining population predicted
  - >32% quasi extinction in just 30 yrs
  - Growth rate ~ 0.93 (-7% annually)



Modeling for recovery

- Develop a model that:
  - Is realistic but not bogged down in minutia
  - Represents the spatial range of the population
  - Captures both breeding and wintering seasons
  - Relevant to management and recovery criteria
  - Predicts extinction/recovery probability on a regional basis

Conceptual model for assessing recovery



Model attributes and objectives

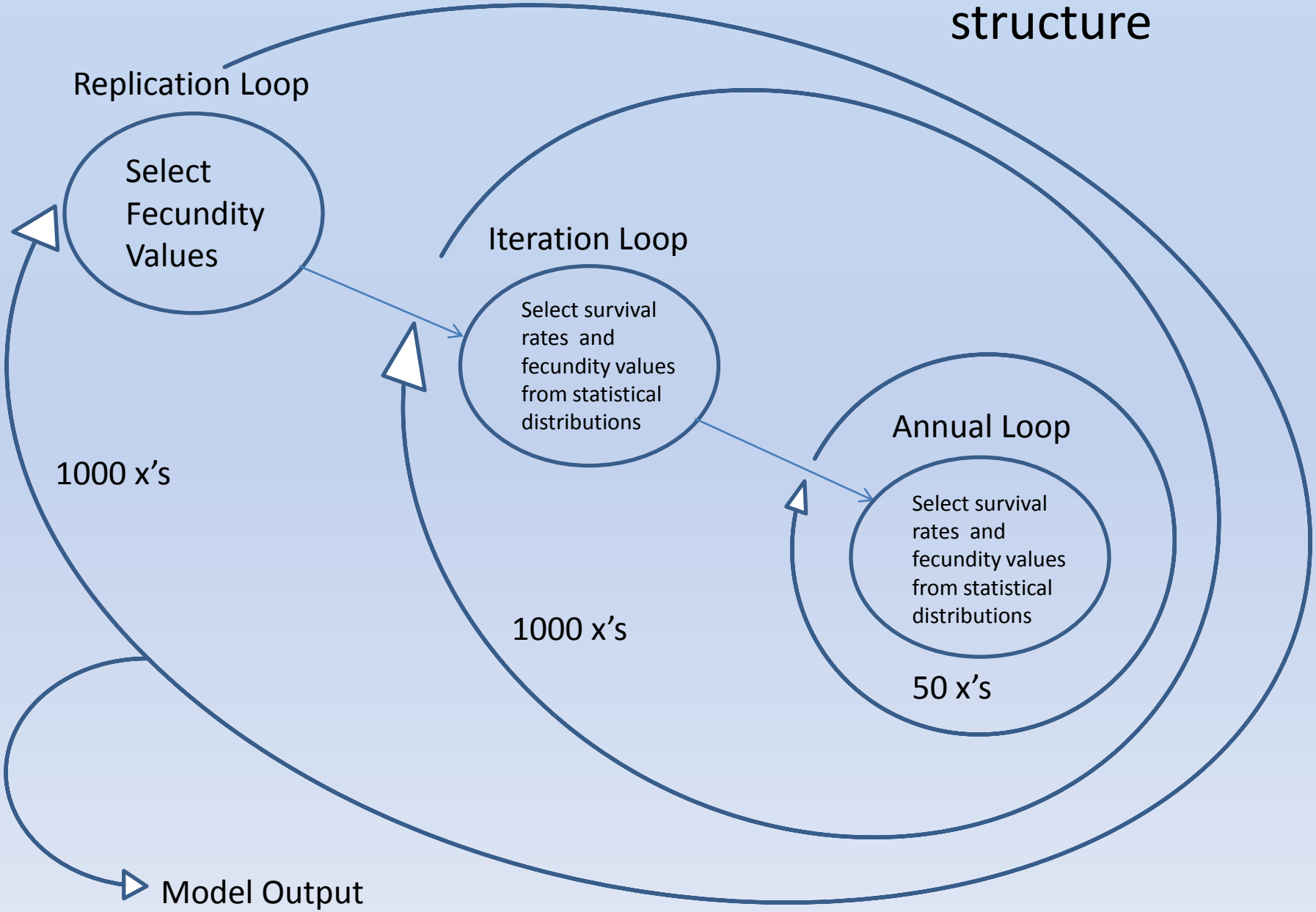
Attributes

- Spatially implicit metapopulation model
- Incorporate parametric uncertainty
- Incorporate observation uncertainty

Objectives

- Estimate abundance needed to sustain population in each region
- Estimate fledge ratios needed to achieve those abundance

Hierarchical loop structure



Sample model output

Replicate	N (median abundance at 50 yrs)	lb (2.5 percentile of abundance)	ub (97.5 percentile of abundance)	Pr (probability of exceeding recovery threshold)	FR1 (observed fledge ratio in region 1)	FR2 (observed fledge ratio in region 2)	FR3 (observed fledge ratio in region 3)
1	2	0	121.1	0	0.056	0.052	0.063
2	1.5	0	119.125	0	0.19	0.279	0.124
3	2			0	0.645	1.205	0.502
4	1.5			0	0.243	0.318	0.365
5	1	0	124.125	0			0.53
.			.	.			.
.	.	.	.	.			.
.	.	.	.	.	.	.	.
998	10907.5	1424.1	16325.425	0.895	3.678	1.585	1.363
999	10601.5	519.85	16318.125	0.867	2.061	1.17	1.53
1000	10979	522.65	16814.15	0.884	1.5		

Median abundance from 1000 iterations

1000 iterations each

Proportion of the 1000 iterations that exceeded a "recovery threshold"

Mean observed fledge ratio for the 1000 iterations

Lower and upper bound for the 1000 iterations