

How much would egg and duckling predation need to be reduced to reverse declines of ground-nesting waterfowl in Finland? A demographic scenario analysis

Supporting information

Maria Tirronen^{*1}, Purabi Deshpande², Markus Piha¹, and Andreas Lindén¹

¹*Natural Resources Institute Finland (Luke), Latokartanonkaari 9, FI-00790 Helsinki, Finland*

²*Department of Biology, University of Turku, FI-20014 Turku, Finland*

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^{*}Corresponding author, email: maria.tirronen@gmail.com

S1 Priors tested for σ^{env}

Table S1: Informative priors tested for the variance parameter σ^{env} of environmental noise. The prior mean was set approximately to the posterior mean that was obtained when using the uninformative prior $\sigma^{env} \sim \text{Unif}[0, \infty)$. Similarly, the prior standard deviation was set to the posterior standard deviation (for wigeon and southern tufted duck) or smaller (for tufted duck in Central Finland) obtained when using the uninformative prior. Informative priors were tested only for wigeon in Central Finland and tufted duck because sampling issues did not occur for wigeon in Southern Finland and teal with the uninformative prior.

Species	Environmental noise distribution	Prior for σ^{env} (Southern/Central pop.)
Eurasian wigeon	Relative normal, truncated	–/Normal(0.07,0.02)
Eurasian wigeon	Lognormal	–/Normal(0.07,0.02)
Tufted duck	Relative normal, truncated	Normal(0.15,0.04)/Normal(0.09,0.02)
Tufted duck	Lognormal	Normal(0.15,0.04)/Normal(0.09,0.02)

S2 Posteriors of σ^{env}

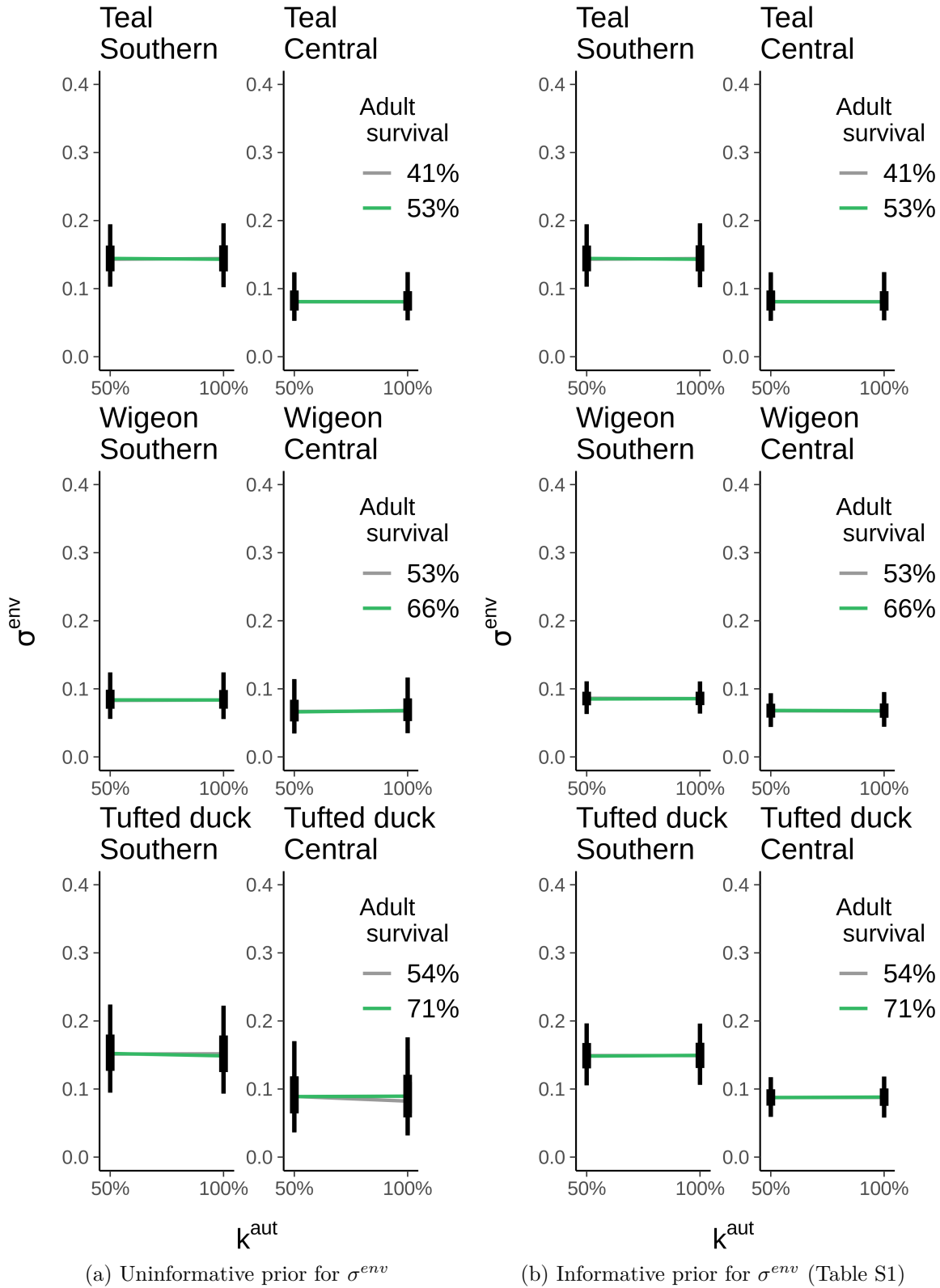


Figure S1: Posterior distributions of the variance parameter σ^{env} of environmental noise using different priors (uninformative/informative). The model assumed normal environmental noise proportional to mean abundances. Thick and thin vertical lines represent the 50 % and 90 % central credible intervals of the posterior distributions, respectively.

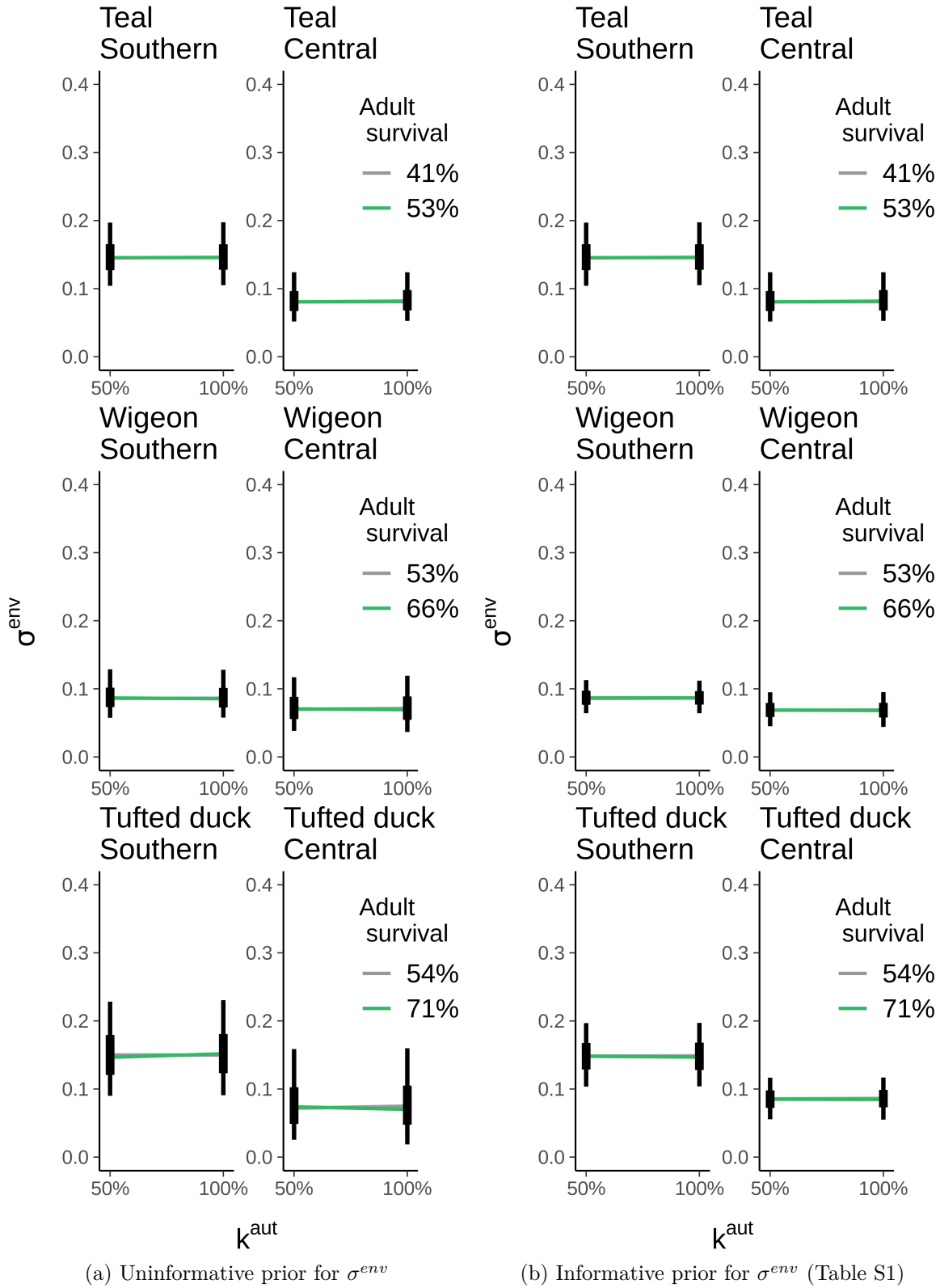


Figure S2: Posterior distributions of the variance parameter σ^{env} of environmental noise using different priors (uninformative/informative). The model assumed lognormal environmental noise. Thick and thin vertical lines represent the 50 % and 90 % central credible intervals of the posterior distributions, respectively.

S3 Posteriors of $S_{e \rightarrow f}$

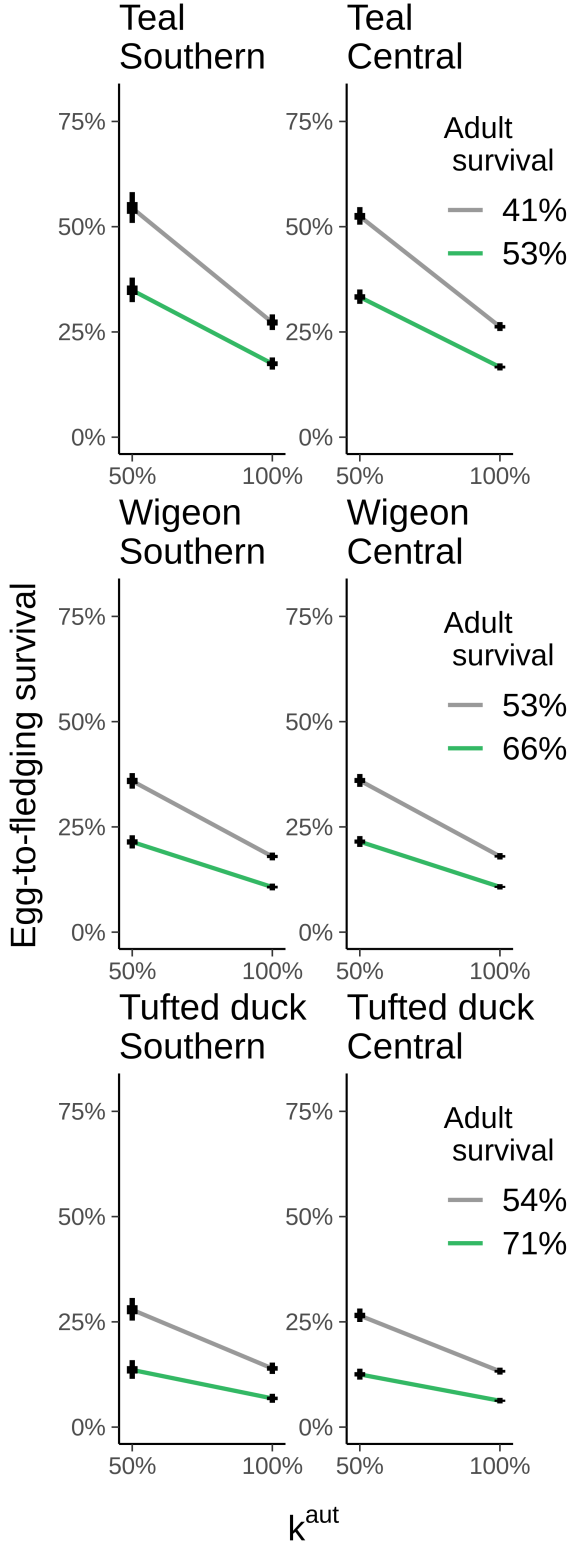
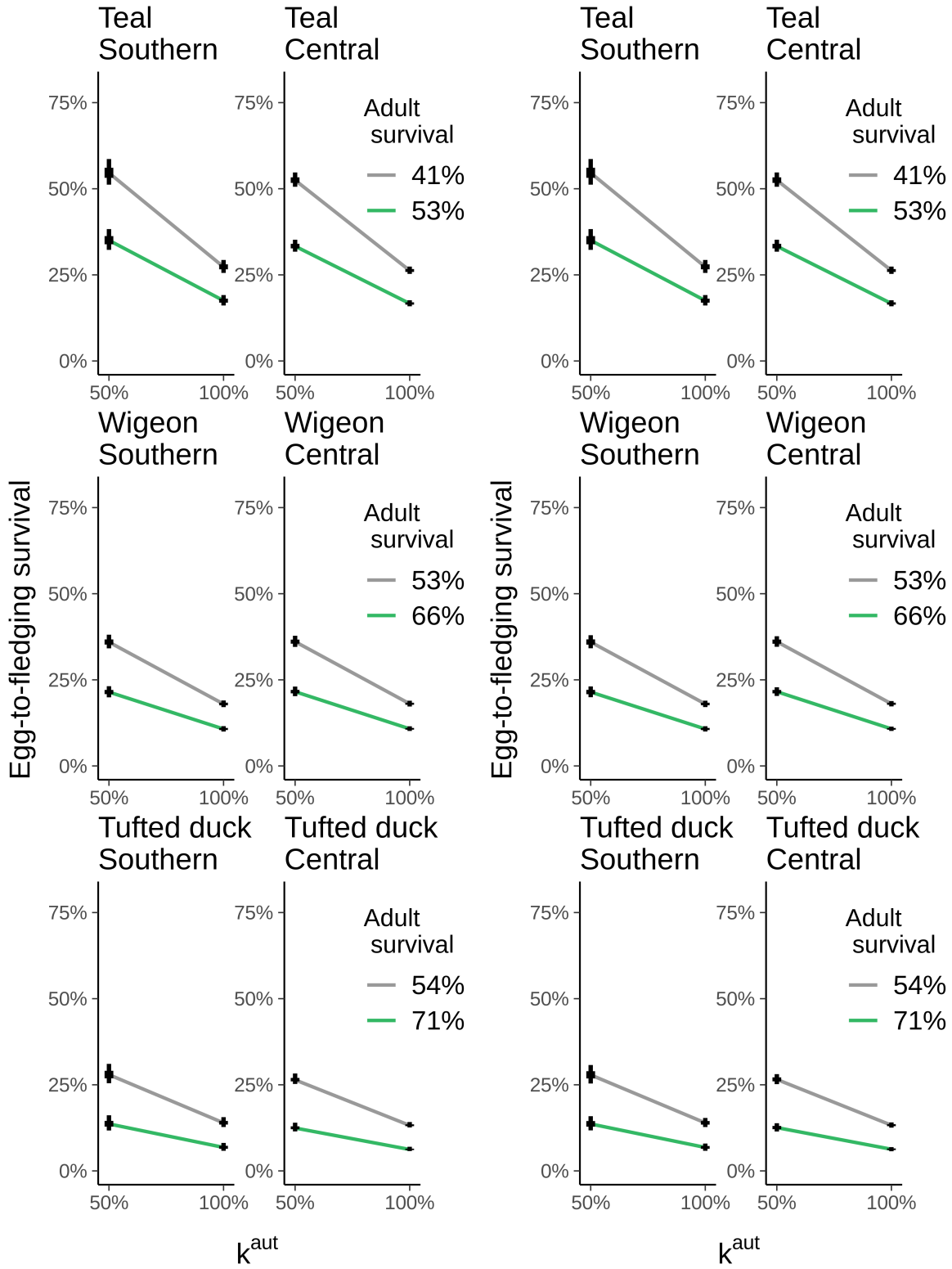


Figure S3: Posterior distributions of egg-to-fledging survival $S_{e \rightarrow f}$ using informative priors for σ^{env} (Table S1). The model assumed normal environmental noise proportional to mean abundances. Thick and thin vertical lines represent the 50 % and 90 % central credible intervals of the posterior distributions, respectively.



(a) Uninformative prior for σ^{env}

(b) Informative prior for σ^{env} (Table S1)

Figure S4: Posterior distributions of egg-to-fledging survival $S_{e \rightarrow f}$ using different priors (uninformative/informative) for σ^{env} . The model assumed lognormal environmental noise. Thick and thin vertical lines represent the 50 % and 90 % central credible intervals of the posterior distributions, respectively.

S4 Posteriors of S_e and S_d

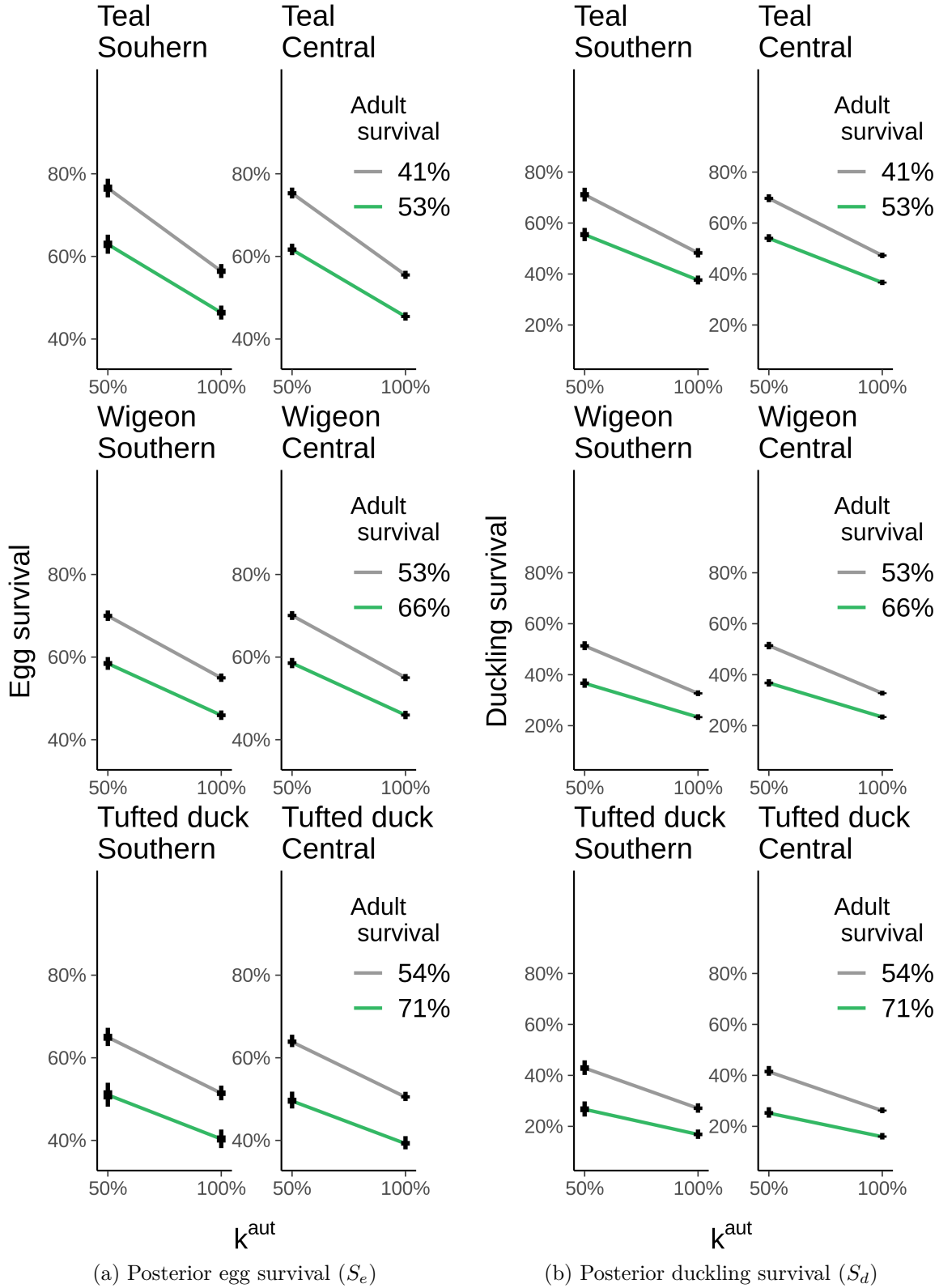


Figure S5: Posterior distributions of egg and duckling survival, simulated from the posterior of egg-to-fledging survival (eqn. (11) and (12) in the main document). The model assumed normal environmental noise proportional to mean abundances, uninformative prior for the variance parameter σ^{env} of environmental noise. Thick and thin vertical lines represent the 50% and 90% central credible intervals of the posterior distributions, respectively.

S5 Growth rate statistics – relative normal environmental noise and informative prior for σ^{env}

Table S2: Probabilities of population decline, and the posterior means and standard deviations of growth rates. The growth rates were estimated from index values between 1986 and 2024 using a model with relative normal environmental noise and informative priors (Table S1). The range is reported over tested adult and juvenile survival rates.

Population	$P[\lambda < 1]$	Mean $\pm$ Std of λ
Eurasian wigeon, Central F.	0.90	0.99 $\pm$ 0.01
Tufted duck, Southern F.	0.87-0.88	0.97 $\pm$ 0.03
Tufted duck, Central F.	0.99-1.00	0.95 $\pm$ 0.02

S6 Growth rate statistics – lognormal environmental noise

Table S3: Probabilities of population decline, and the posterior means and standard deviations of growth rates. The growth rates were estimated from index values between 1986 and 2024 using a model with lognormal environmental noise and uninformative prior for the variance parameter of environmental noise ($\sigma^{env} \sim \text{Unif}[0, \infty)$). The range is reported over tested adult and juvenile survival rates.

Population	$P[\lambda < 1]$	Mean $\pm$ Std of λ
Eurasian teal, Southern F.	0.32	1.01 $\pm$ (0.02-0.03)
Eurasian teal, Central F.	0.80-0.82	0.99 $\pm$ 0.01
Eurasian wigeon, Southern F.	0.85-0.86	0.98 $\pm$ (0.01-0.02)
Eurasian wigeon, Central F.	0.87-0.88	0.99 $\pm$ 0.01
Tufted duck, Southern F.	0.85-0.86	0.97 $\pm$ 0.03
Tufted duck, Central F.	0.99-1.00	0.95 $\pm$ (0.01-0.02)

Table S4: Probabilities of population decline, and the posterior means and standard deviations of growth rate. The growth rates were estimated from index values between 1986 and 2024 using a model with lognormal environmental noise and informative priors (Table S1). The range is reported over tested adult and juvenile survival rates.

Population	$P[\lambda < 1]$	Mean $\pm$ Std of λ
Eurasian wigeon, Central F.	0.88-0.90	0.99 $\pm$ 0.01
Tufted duck, Southern F.	0.87-0.88	0.97 $\pm$ (0.02-0.03)
Tufted duck, Central F.	1.00	0.95 $\pm$ 0.01

S7 Posteriors of relative abundance – lognormal environmental noise

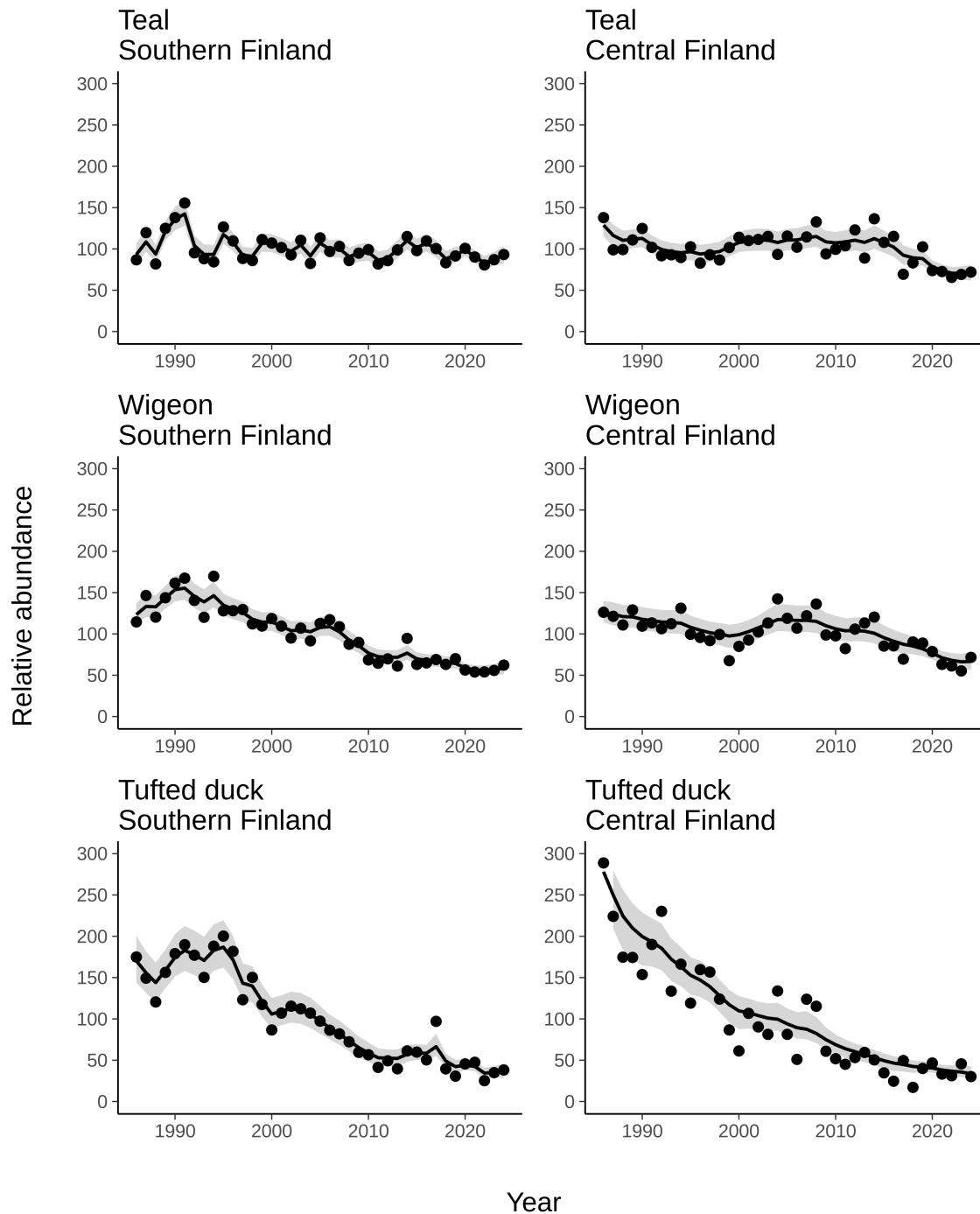


Figure S6: Posterior distributions of relative waterfowl abundance. The model assumed lognormal environmental noise with uninformative priors. Adult survival was set to the higher of the tested values for each species (Table 1 in the main document), and autumn juvenile survival was set at 50% of adult survival. The solid line represents the posterior medians, and the shaded area the 90% central credible intervals.

S8 Scenarios of predation reduction

S8.1 $M_e^{nat} = 0.02$

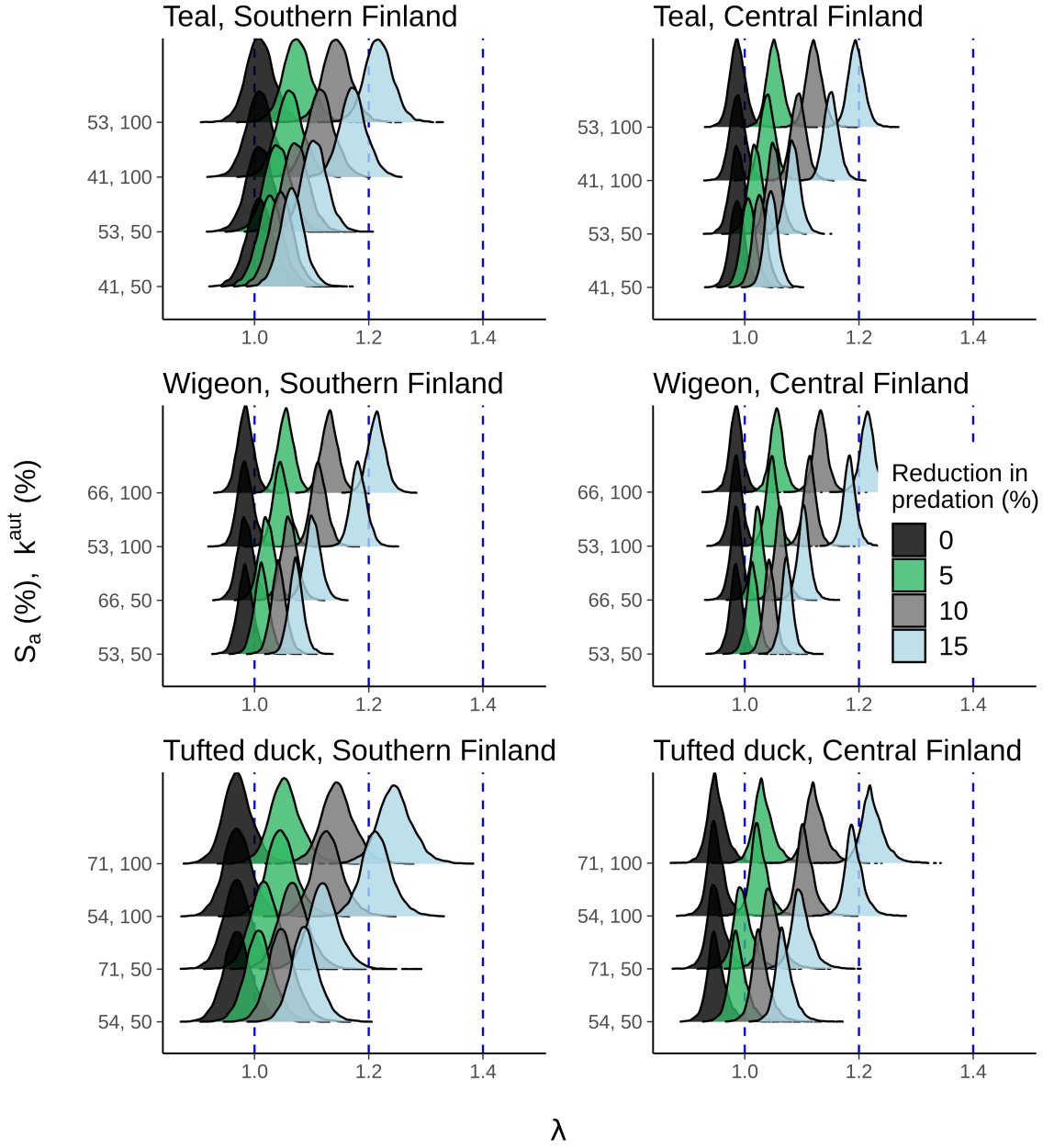


Figure S7: Impact of egg-to-fledging predation reduction on population growth rate. The model assumed natural egg mortality $M_e^{nat} = 0.02$, natural duckling mortality $M_d^{nat} = 0.05$, and relative normal environmental noise with uninformative priors.

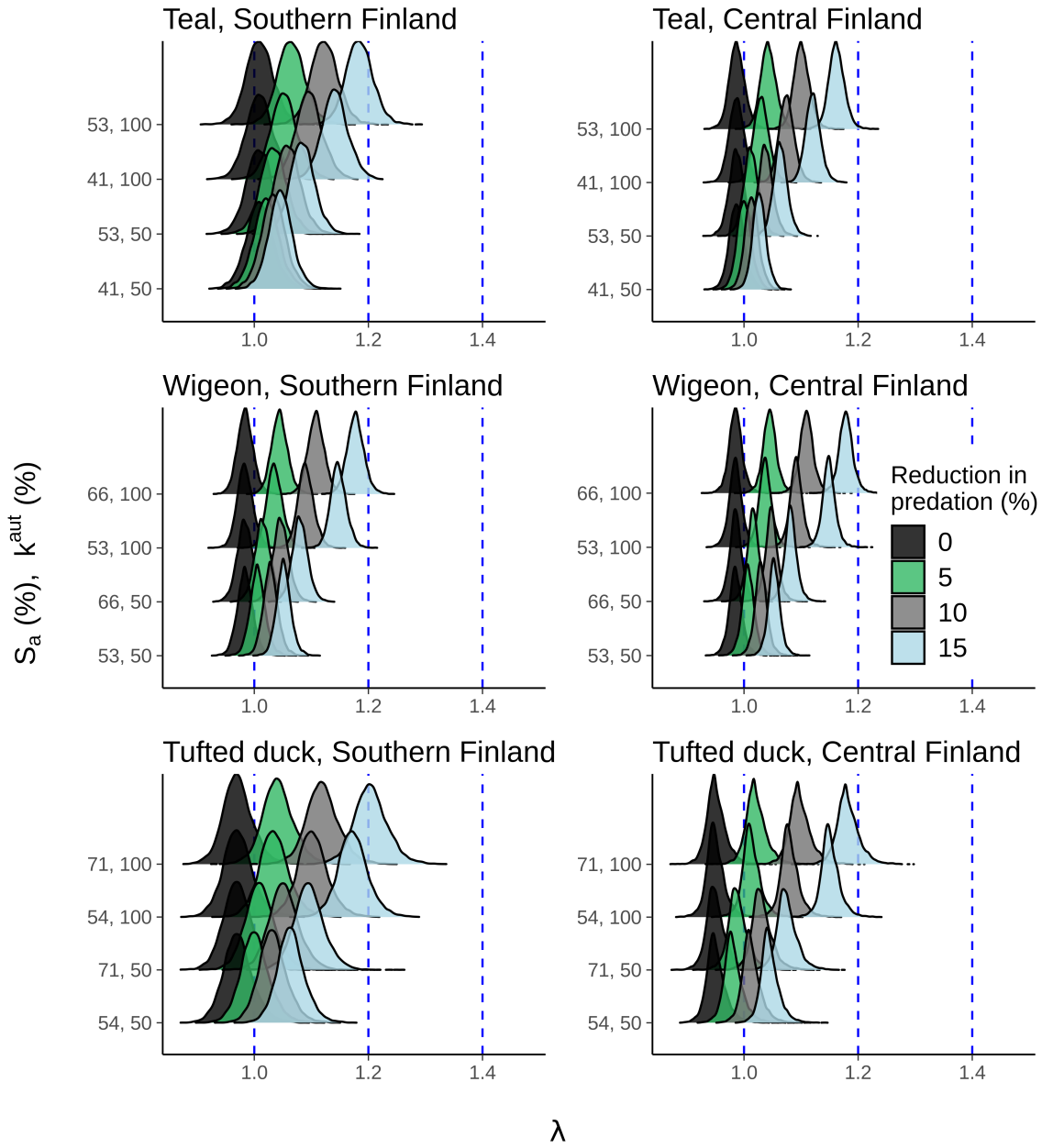


Figure S8: Impact of egg-to-fledging predation reduction on population growth rate. The model assumed natural egg mortality $M_e^{nat} = 0.02$, natural duckling mortality $M_d^{nat} = 0.20$, and relative normal environmental noise with uninformative priors.

S8.2 $M_e^{nat} = 0.05$

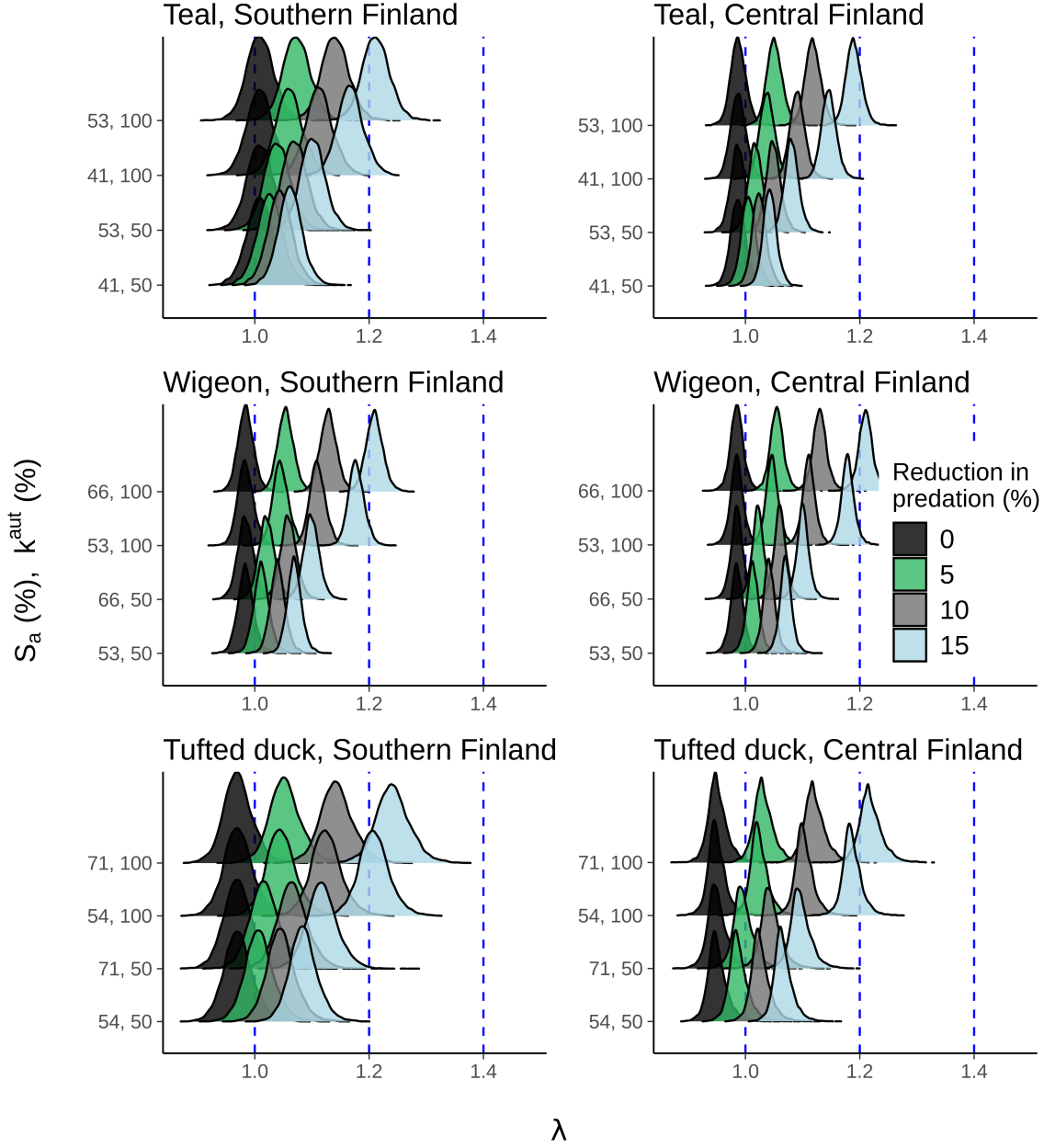


Figure S9: Impact of egg-to-fledging predation reduction on population growth rate. The model assumed natural egg mortality $M_e^{nat} = 0.05$, natural duckling mortality $M_d^{nat} = 0.05$, and relative normal environmental noise with uninformative priors.

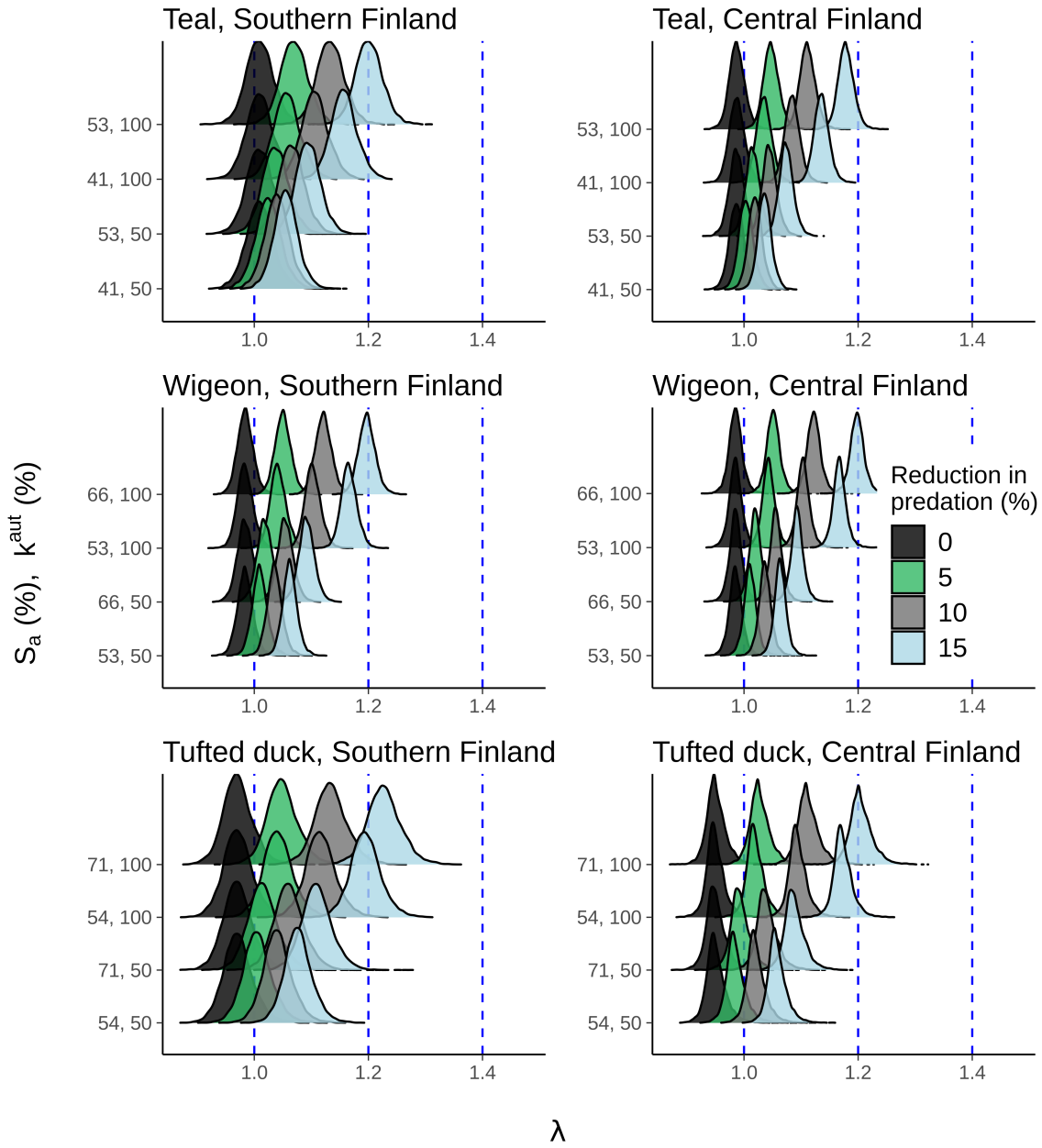


Figure S10: Impact of egg-to-fledging predation reduction on population growth rate. The model assumed natural egg mortality $M_e^{nat} = 0.05$, natural duckling mortality $M_d^{nat} = 0.10$, and relative normal environmental noise with uninformative priors.

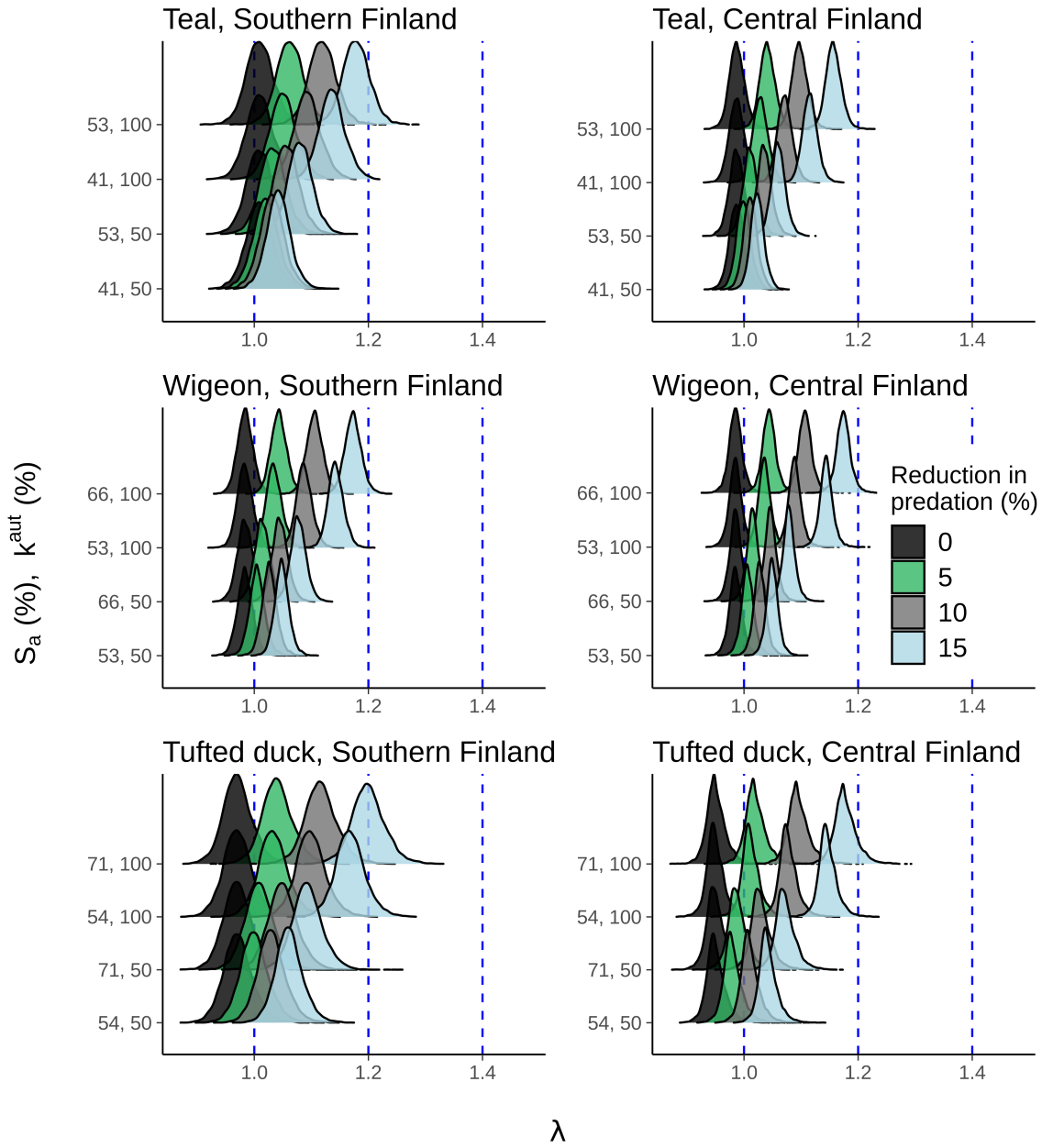


Figure S11: Impact of egg-to-fledging predation reduction on population growth rate. The model assumed natural egg mortality $M_e^{nat} = 0.05$, natural duckling mortality $M_d^{nat} = 0.20$, and relative normal environmental noise with uninformative priors.

S9 Required reduction in predation

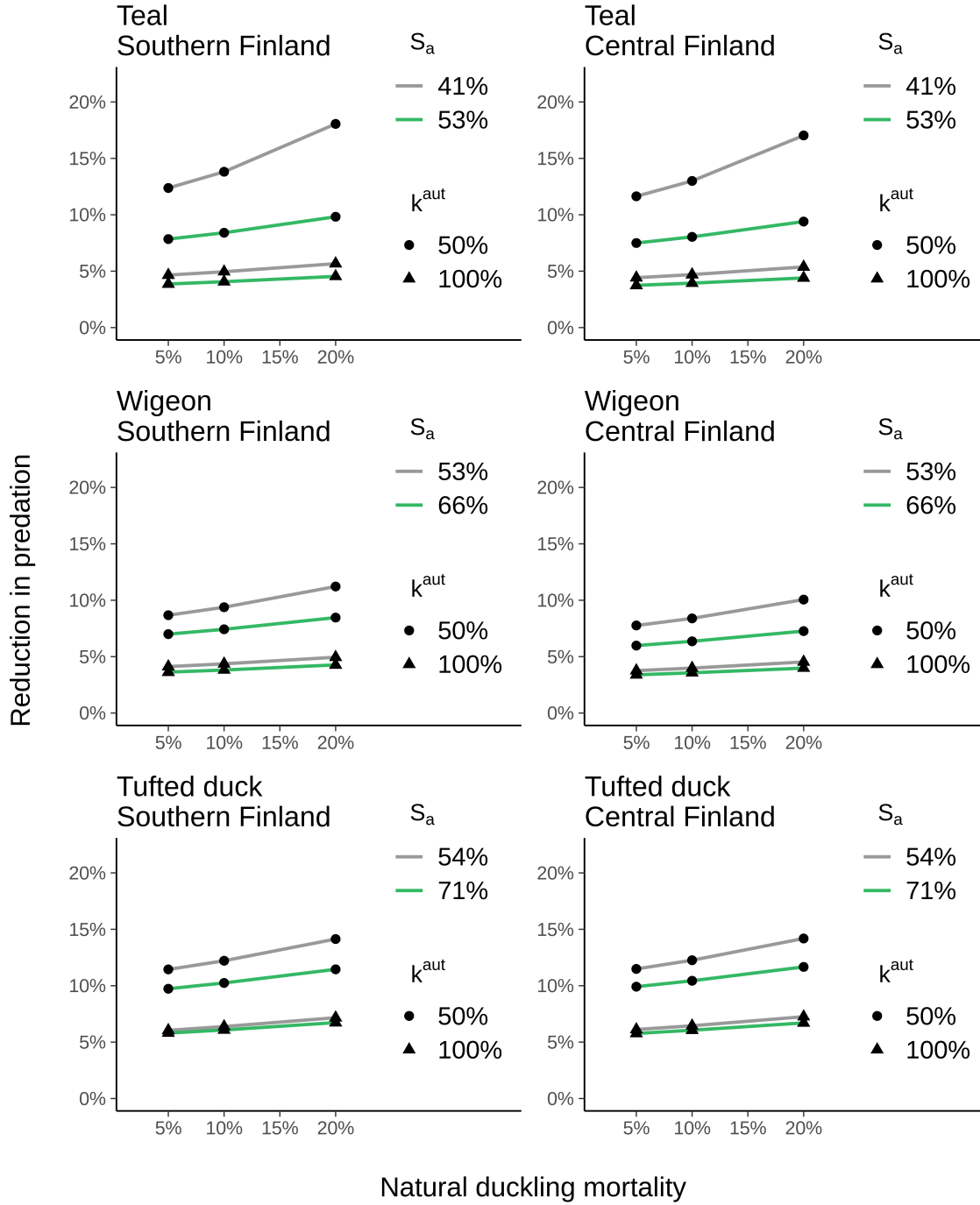


Figure S12: Reduction in egg-to-fledging predation (mortality) required to achieve a growing population with the probability of 0.99 ($P(\lambda > 1) = 0.99$). The model assumed natural egg mortality $M_e^{nat} = 0.05$ and relative normal environmental noise with uninformative prior for the variance parameter σ^{env} .