Table 1. Multi-level statistical model to estimate population trajectories in pre-defined geographic strata by integrating daily counts of migrants at a series of monitoring stations with estimates of breeding origins for a sample of migrants at a subset of stations. Equations are indexed by geographic strata (j), year (y), monitoring station (s), and day of year (d).

Description	Equations	
	Stratum-level population process model:	
Log-linear population change within stratum *j*, starting from baseline year y_0.	$\log(X_{j,y}) = \log(X_{j,y0}) + (y-1) \times slope_j$	(1)
	Migration process model:	
Number of migrants arriving at each station from each stratum controlled by migration parameter $\rho_{j,s}$.	$M_{j,s,y} = \rho_{j,s} X_{j,y}$	(2)
Expected abundance migrants arriving at a station from all regions. Additional temporal variance ($\varepsilon_{s,y}$) is controlled by parameter σ_ρ^2.	$T_{s,y} = \sum_1^J M_{j,s,y} \times \varepsilon_{s,y}$, where: $\varepsilon_{s,y} \sim Lognormal(0, \sigma_\rho^2)$	(3)
Seasonal temporal distribution of migrants arriving at the station follows a normal curve with a mean date μ_s and a standard deviation σ_s, where day of the year is indexed by d.	$\theta_{d,s,y} = T_{s,y} \times f(d, \mu_s, \sigma_s)$, where: $f(d, \mu_s, \sigma_s) = \frac{1}{\sigma_s\sqrt{2\pi}} e^{-\frac{1}{2}(\frac{d-\mu_s}{\sigma_s})}$	(4)
	Observation models:	
Observed number of migrants at each station on each day of year is Poisson distributed with log-normal overdispersion (controlled by ω_s^2), and an offset for survey effort (e.g., number of hours nets were operational on a day).	$n_{d,s,y} \sim Poisson(\lambda_{d,s,y})$, where: $\log(\lambda_{d,s,y}) \sim Normal(\log(\theta_{d,s,y}) + offset_{d,s,y}, \omega_s^2)$	(5)
Multinomial distribution describes the observed breeding origins for a sample of n birds collected at a station in a given year.	$\boldsymbol{Y_{s,y}} \sim Multinomial\left(n_{s,y}, \left(\frac{M_{1,s,y}}{\sum_1^J M_{j,s,y}}, \frac{M_{2,s,y}}{\sum_1^J M_{j,s,y}}, \ldots, \frac{M_{J,s,y}}{\sum_1^J M_{j,s,y}}\right)\right)$	(6)

Table 2. Specification of Bayesian priors for analysis of seasonal migration counts.

Parameter	*Prior*	*Notes*
		Stratum-level parameters:
$X_{j,y0}$	*Fixed to 1*	Ensures $\rho_{j,s}$ terms are identifiable. $X_{j,y}$ terms are rescaled to $N_{j,y}$ outside of fitting procedure based on independent estimate of abundance (e.g., based on a species distribution model describing breeding season abundance across a geographic stratum).
$slope_j$	*Normal(0,1)*	Log-linear temporal trend within stratum.
		Station-level parameters:
$\rho_{j,s}$	*Lognormal(0,4)*	Migration parameters (from stratum *j* to station *s*)
σ_s	*Uniform(0,2)*	Magnitude of year-to-year variation in station-level indices
μ_s	*Uniform(1,360)*	Day of year at which peak of migration occurs.
σ_s	*Uniform(0,20)*	Describes temporal dispersion of migration period within a season. Migration is assumed to follow a normal curve, such that approximately 95% of birds arrive at station within $\mu_s \pm 1.96\sigma_s$.
ω_s	*Uniform(0,2)*	Magnitude of extra-Poisson error in daily counts.

Table 3. Estimates of population trend and percent change relative to 1998 and 2008 within each stratum. Values are expressed as posterior median value followed by 95% credible interval in parentheses.

Stratum	Source of trend estimate	20-year trend	Prob trend is positive	% change since 1998	% change since 2008
West	Mig (pre)	+1.7 (-0.7 to +4.1)	0.92	+38.7 (-12.3 to +123.1)	+17.8 (-6.4 to +49.4)
West	Mig (post)	+1.3 (-1.6 to +3.5)	0.79	+29.7 (-27.2 to +98.1)	+13.9 (-14.7 to +40.7)
West	BBS	-2.7 (-5.3 to +0.3)	0.03	-42.7 (-66.1 to +5.9)	-33.2 (-59.2 to -2.7)
East	Mig (pre)	-4.6 (-7.3 to -2.1)	< 0.01	-61.3 (-78.2 to -33.9)	-37.8 (-53.3 to -18.7)
East	Mig (post)	-5.5 (-18.2 to +4.7)	0.31	-67.6 (-98.2 to +150.7)	-43.1 (-86.6 to +58.3)
East	BBS	-3.8 (-6.1 to -1.4)	< 0.01	-54.2 (-71.4 to -24)	-44.1 (-63.6 to -20.0)
Continental	Mig (pre)	-3.0 (-5.4 to -0.9)	< 0.01	-45.7 (-66.7 to -17.1)	-29.1 (-46.5 to -10.4)
Continental	Mig (post)	-3.7 (-16.1 to 2.1)	0.30	-53 (-97 to +51.3)	-34.7 (-85.7 to +21.0)
Continental	BBS	-3 (-5.1 to -0.7)	0.01	-46.1 (-64.9 to -12.6)	-36.9 (-56.7 to -14.7)