Supporting Information Appendix S1

A.T. Tredennick, M.B. Hooten, & P.B. Adler, "Do we need demographic data..."

Methods in Ecology and Evolution

Contents

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Hierarchical Bayesian models for vital rates

Here we describe the statistical models in complete detail, including full description of the Bayesian models and Stan code for each model. We write each model as three parts: (1) a data model (likelihood), (2) a process model, and (3) a parameter model. We then combine these three models to write the posterior and joint distributions as a single model statement. Following the full model expression we provide the Stan code that directly corresponds the statement of posterior and joint distributions. Note that Stan uses standard deviations (σ) to specify distributions rather than variances (σ^2) In our expressions of the posterior and joint distributions we use general probability notation where [.] represents some unspecified distribution. We do this for clarity of model presentation. All prior distributions are defined in the parameter model sections. For clarity, we avoid subscripting species.

Parameter to model notation keys

Table S1: Definition of parameters and model notation for IPM survival and growth models.

Parameter	Definition	Notation in statistical results tables
$\beta_{0,t}$	intercept for year t	`a[t]` where `t` is the numeric year
$\tilde{\beta}_0$	global intercept	`a_mu`
$\beta_{Q,q}$	random effect of quadrat group q	`gint[q]` where `q` is the quadrat group
$\beta_{s,t}$	size effect for year t	`b1[t]` where `t` is the numeric year
$\tilde{\beta}_s$	global size effect	`b1_mu`
$\beta_{d,1}$	effect of crowding	`w[1]`
$\beta_{d,2}$	crowding $\times$ size effect	`w[2]`
$\beta_{c,k}$	effect of climate covariate k	`b2[k]` where `k` is the climate effect
a	first parameter for growth variance	`tau`
b	second parameter for growth variance	`tauSize`

Table S2: Definition of parameters and model notation for IPM recruitment model.

Parameter	Definition	Notation in statistical results tables
$\beta_{0,t}$	intercept for year t	`a[t]` where `t` is the numeric year
$\tilde{\beta}_0$	global intercept	`a_mu`
$\beta_{Q,q}$	random effect of quadrat group q	`gint[q]` where `q` is the quadrat group
$\beta_{d,1}$	effect of plot cover	`dd`
$\beta_{c,k}$	effect of climate covariate k	`b2[k]` where `k` is the climate effect
p	mixing fraction for effective plot cover	`u`
ζ	size parameter for negative binimial likelihood	`theta`

Table S3: Definition of parameters and model notation for quadrat based model.

Parameter	Definition	Notation in statistical results tables
$\beta_{0,t}$	intercept for year t	`a[t]` where `t` is the numeric year
$\tilde{\beta}_0$	global intercept	`a_mu`
$\beta_{Q,q}$	random effect of quadrat group q	`gint[q]` where `q` is the quadrat group
$\beta_{s,t}$	cover effect for year t	`b1[t]` where `t` is the numeric year
$\tilde{\beta}_s$	global cover effect	`b1_mu`
$\beta_{c,k}$	effect of climate covariate k	`b2[k]` where `k` is the climate effect
τ	model variance in log normal likelihood	`tau`

Table S4: Climate effect key.

Integer ID (k)	Climate covariate
1	pptLag
2	ppt1
3	ppt2
4	TmeanSpr1
5	TmeanSpr2
6	ppt1 × TmeanSpr1
7	ppt2 × TmeanSpr2

Survival (IPM)

We used logistic regression to model the probability that genet i in quadrat q survives from time t to t+1 ($s_{i,q,t}$):

$$y^S_{i,q,t} \sim \text{Bernoulli}(s_{i,q,t}) \tag{1}$$

$$\text{logit}(s_{i,q,t}) = \beta_{0,t} + \beta_{s,t}x_{i,q,t} + \beta_{Q,q} + \mathbf{z}'_t\boldsymbol{\beta}_c + \beta_{d,1}w_{i,t} + \beta_{d,2}(x_{i,q,t}w_{i,q,t}) \tag{2}$$

where $x_{i,q,t}$ is the log of genet i basal area at time t, $\beta_{0,t}$ is a year specific intercept, $\beta_{Q,q}$ is the random effect for the qth quadrat to account for spatial variation, $\beta_{s,t}$ is the year-specific slope parameter for size, $\mathbf{z}$ is a vector of p climate covariates specific to year t, $\boldsymbol{\beta}_c$ is a vector of fixed climate effects of length p, $\beta_{d,1}$ is the effect of intraspecific crowding experienced by the focal genet at time t ($w_{i,q,t}$), and $\beta_{d,2}$ is a size by crowding ($x_{i,q,t}w_{i,q,t}$) interaction effect.

Data, process, and parameter models

$$\texttt{data} \qquad y^S_{i,q,t} \sim \text{Bernoulli}(s_{i,q,t}) \tag{3}$$

$$\texttt{process} \qquad \text{logit}(s_{i,q,t}) = \beta_{0,t} + \beta_{s,t} x_{i,q,t} + \beta_{Q,q} + \mathbf{z}'_t \boldsymbol{\beta}_c + \beta_{d,1} w_{i,t} + \beta_{d,2}(x_{i,q,t} w_{i,q,t}) \tag{4}$$

$$\texttt{parameters} \qquad \beta_{0,t} \sim \text{Normal}(\tilde{\beta}_0, \sigma^2_{\beta_0}) \tag{5}$$

$$\beta_{s,t} \sim \text{Normal}(\tilde{\beta}_s, \sigma^2_{\beta_s}) \tag{6}$$

$$\beta_{Q,q} \sim \text{Normal}(0, \sigma^2_Q) \tag{7}$$

$$\boldsymbol{\beta}_c \sim \text{Normal}(\mathbf{0}, \sigma^2_c \mathbf{I}) \tag{8}$$

$$\beta_{d,1} \sim \text{Normal}(0, 100) \tag{9}$$

$$\beta_{d,2} \sim \text{Normal}(0, 100) \tag{10}$$

$$\tilde{\beta}_0 \sim \text{Normal}(0, 100) \tag{11}$$

$$\tilde{\beta}_s \sim \text{Normal}(0, 100) \tag{12}$$

$$\sigma_Q \sim \text{Cauchy}(0, 5) \tag{13}$$

$$\sigma_{\beta_0} \sim \text{Cauchy}(0, 5) \tag{14}$$

$$\sigma_{\beta_s} \sim \text{Cauchy}(0, 5) \tag{15}$$

Full expression of posterior and joint distributions

$$[\boldsymbol{\beta_0}, \tilde{\beta}_0, \boldsymbol{\beta_s}, \tilde{\beta}_s, \boldsymbol{\beta_Q}, \boldsymbol{q}, \boldsymbol{\beta_c}, \beta_{d,1}, \beta_{d,2}, \sigma^2_Q, \sigma^2_{\beta_0}, \sigma^2_{\beta_s} | y^S_{i,q,t}] \propto \tag{16}$$

$$\prod_{t=1}^{T} \prod_{i=1}^{n} [y^S_{i,q,t} | \beta_{0,t}, \beta_{s,t}, \beta_Q, \boldsymbol{\beta_c}, \beta_{d,1}, \beta_{d,2}] \times \tag{17}$$

$$[\beta_{0,t} | \tilde{\beta}_0, \sigma^2_{\beta_0}] \times \tag{18}$$

$$[\beta_{s,t} | \tilde{\beta}_s, \sigma^2_{\beta_s}][\boldsymbol{\beta_c} | \sigma^2_{\beta_c}] \times \tag{19}$$

$$\prod_{q=1}^{Q_{tot}} [\beta_{Q,q} | \sigma^2_Q] \times \tag{20}$$

$$[\beta_{d,1}][\beta_{d,1}][\tilde{\beta}_0][\tilde{\beta}_s][\sigma_Q][\sigma_{\beta_0}][\sigma_{\beta_s}] \tag{21}$$

Stan code for model

```
data{
  // All Data
  int<lower=0> N; // observations
  int<lower=0> Yrs; // years
  int<lower=0> yid[N]; // year id
  int<lower=0> Covs; // climate covariates
  int<lower=0> G; // groups
  int<lower=0> gid[N]; // group id
  int<lower=0,upper=1> Y[N]; // observation vector
  matrix[N,Covs] C; // climate matrix
  vector[N] X; // size vector
  matrix[N,2] W; // crowding matrix
  real beta_tau; // prior sdev for climate effects
}
parameters{
  real a_mu;
  vector[Yrs] a;
  real b1_mu;
  vector[Yrs] b1;
  vector[Covs] b2;
  vector[2] w;
  vector[G] gint;
  real<lower=0> sig_a;
  real<lower=0> sig_b1;
  real<lower=0> sig_G;
}
transformed parameters{
  real mu[N];
  vector[N] climEff;
  vector[N] crowdEff;
  climEff <- C*b2;
  crowdEff <- W*w;
  for(n in 1:N){
    mu[n] <- inv_logit(a[yid[n]] + gint[gid[n]] +
                          b1[yid[n]]*X[n] + crowdEff[n] + climEff[n]);
  }
}
model{
  // Priors
  a_mu ~ normal(0,10);
  w ~ normal(0,10);
  b1_mu ~ normal(0,10);
  sig_a ~ cauchy(0,5);
  sig_b1 ~ cauchy(0,5);
```

```
  sig_G ~ cauchy(0,5);
  gint ~ normal(0, sig_G);
  b2 ~ normal(0, beta_tau);
  a ~ normal(a_mu, sig_a);
  b1 ~ normal(b1_mu, sig_b1);

  // Likelihood
  Y ~ binomial(1,mu);
}
}
```

Growth (IPM)

We modeled growth as a Gaussian process describing log genet size ($y^G_{i,q,t+1}$) at time $t+1$ in quadrat q as a function of log size at time t and climate covariates:

$$y^G_{i,q,t+1} \sim \text{Normal}(\mu_{i,q,t+1}, \sigma^2_{x_{i,q,t+1}}) \tag{22}$$

$$\mu_{i,q,t+1} = \beta_{0,t} + \beta_{s,t} x_{i,q,t} + \beta_{Q,q} + \mathbf{z}'_t \boldsymbol{\beta}_c + \beta_{d,1} w_{i,q,t} + \beta_{d,2}(x_{i,q,t} w_{i,q,t}) \tag{23}$$

where $\mu_{i,q,t+1}$ is log of genet is predicted size at time $t+1$, and all other parameters are as described for the survival regression. We capture non-constant error variance in growth by modeling the variance in the growth regression ($\sigma^2_{xi,q,t+1}$) as a nonlinear function of predicted genet size:

$$\sigma^2_{x_{i,q,t+1}} = a \exp[b \times \mu_{i,q,t+1}] \tag{24}$$

where $\mu_{i,q,t+1}$ is log of predicted genet size predicted from the growth regression (Eq. 4), and a and b are constants.

Data, process, and parameter models.

$$
\begin{aligned}
&\texttt{data} & y^G_{i,q,t+1} &\sim \text{Normal}(\mu_{i,q,t+1}, \sigma^2_{x_{i,q,t+1}}) & (25)\\
&\texttt{process} & \mu_{i,q,t+1} &= \beta_{0,t} + \beta_{s,t}x_{i,q,t} + \beta_{Q,q} + \mathbf{z}'_t\boldsymbol{\beta}_c + \beta_{d,1}w_{i,q,t} + \beta_{d,2}(x_{i,q,t}w_{i,q,t}) & (26)\\
& & \sigma^2_{iQ,t} &= ae^{b\mu_{iQ,t+1}} & (27)\\
&\texttt{parameters} & \beta_{0,t} &\sim \text{Normal}(\tilde{\beta}_0, \sigma^2_{\beta_0}) & (28)\\
& & \beta_{s,t} &\sim \text{Normal}(\tilde{\beta}_s, \sigma^2_{\beta_s}) & (29)\\
& & \beta_{Q,q} &\sim \text{Normal}(0, \sigma^2_Q) & (30)\\
& & \boldsymbol{\beta}_c &\sim \text{Normal}(\mathbf{0}, \sigma^2_c\mathbf{I}) & (31)\\
& & \beta_{d,1} &\sim \text{Normal}(0, 100) & (32)\\
& & \beta_{d,2} &\sim \text{Normal}(0, 100) & (33)\\
& & \tilde{\beta}_0 &\sim \text{Normal}(0, 100) & (34)\\
& & \tilde{\beta}_s &\sim \text{Normal}(0, 100) & (35)\\
& & \sigma_Q &\sim \text{Cauchy}(0, 5) & (36)\\
& & \sigma_{\beta_0} &\sim \text{Cauchy}(0, 5) & (37)\\
& & \sigma_{\beta_s} &\sim \text{Cauchy}(0, 5) & (38)\\
& & a &\sim \text{Normal}(0, 100) & (39)\\
& & b &\sim \text{Normal}(0, 100) & (40)
\end{aligned}
$$

86 **Full expression of posterior and joint distributions**

$$
\begin{aligned}
&[\boldsymbol{\beta_0}, \tilde{\beta}_0, \boldsymbol{\beta_s}, \tilde{\beta}_s, \beta_{Q,q}, \boldsymbol{\beta_c}, \beta_{d,1}, \beta_{d,2}, \sigma^2_Q, \sigma^2_{\beta_0}, \sigma^2_{\beta_s}, a, b | y^G_{i,q,t+1}] \propto & (41)\\
&\qquad \prod_{t=1}^{T}\prod_{i=1}^{n}[y^G_{i,q,t+1}|\beta_{0,t}, \beta_{s,t}, \beta_Q, \boldsymbol{\beta_c}, \beta_{d,1}, \beta_{d,2}, a, b]\times & (42)\\
&\qquad [\beta_{0,t}|\tilde{\beta}_0, \sigma^2_{\beta_0}]\times & (43)\\
&\qquad [\beta_{s,t}|\tilde{\beta}_s, \sigma^2_{\beta_s}][\boldsymbol{\beta_c}|\sigma^2_{\beta_c}]\times & (44)\\
&\qquad \prod_{q=1}^{Q_{tot}}[\beta_{Q,q}|\sigma^2_Q]\times & (45)\\
&\qquad [\beta_{d,1}][\beta_{d,1}][\tilde{\beta}_0][\tilde{\beta}_s][\sigma_Q][\sigma_{\beta_0}][\sigma_{\beta_s}][a][b] & (46)
\end{aligned}
$$

87 **Stan code for model**

88 **Recruitment (IPM)**

Our data allows us to track new recruits, but we cannot assign a specific parent to new genets. Therefore, we model recruitment at the quadrat level. We assume the number of individuals, $y^R_{q,t+1}$, recruiting at time $t+1$ in quadrat q follows a negative binomial distribution:

$$y_{q,t+1}^R \sim \text{NegBin}(\lambda_{q,t+1}, \phi) \tag{47}$$

where λ is the mean intensity and ϕ is the size parameter. We define λ as a function of quadrat composition and climate in the previous year:

$$\lambda_{q,t+1} = \tilde{c}_{q,t} \exp\left(\beta_{0,t} + \beta_{Q,q} + \mathbf{z}_t' \boldsymbol{\beta}_c + \beta_d \sqrt{\tilde{c}_{q,t}}\right) \tag{48}$$

where $\tilde{c}_{q,t}$ is effective cover (cm^2) of the focal species in quadrat q at time t, and all other terms are as in the survival and growth regressions. Effective cover is a mixture of observed cover (c) in the focal quadrat (q) and the mean cover across the entire group ($\bar{c}$) of Q quadrats in which q is located:

$$\tilde{c}_{q,t} = p c_{q,t} + (1 - p)\bar{c}_{Q,t} \tag{49}$$

where p is a mixing fraction between 0 and 1 that is estimated when fitting model.

Data, process, and parameter models

$$\begin{aligned}
&\texttt{data} & y_{q,t+1}^R &\sim \text{NegBin}(\lambda_{q,t+1}, \phi) && (50)\\
&\texttt{process} & \lambda_{q,t+1} &= \tilde{c}_{q,t} \exp\left(\beta_{0,t} + \beta_{Q,q} + \mathbf{z}_t' \boldsymbol{\beta}_c + \beta_d \sqrt{\tilde{c}_{q,t}}\right) && (51)\\
&\texttt{parameters} & \beta_{0,t} &\sim \text{Normal}(\tilde{\beta}_0, \sigma_{\beta_0}^2) && (52)\\
&& \beta_{Q,q} &\sim \text{Normal}(0, \sigma_Q^2) && (53)\\
&& \boldsymbol{\beta}_c &\sim \text{Normal}(\mathbf{0}, \sigma_c^2 \mathbf{I}) && (54)\\
&& \beta_d &\sim \text{Uniform}(-10, 10) && (55)\\
&& \tilde{\beta}_0 &\sim \text{Normal}(0, 100) && (56)\\
&& \sigma_Q &\sim \text{Cauchy}(0, 5) && (57)\\
&& \sigma_{\beta_0} &\sim \text{Cauchy}(0, 5) && (58)\\
&& \phi &\sim \text{Uniform}(0, 10) && (59)\\
&& u &\sim \text{Uniform}(0, 1) && (60)
\end{aligned}$$

Full expression of posterior and joint distributions

$$\begin{aligned}
&[\boldsymbol{\beta_0}, \tilde{\beta}, \boldsymbol{\beta_Q}, \boldsymbol{\beta_c}, \beta_d, \sigma_Q^2, \sigma_{\beta_0}^2, \phi, u | y_{q,t+1}^R] \propto && (61)\\
&\qquad \prod_{t=1}^{T} \prod_{i=1}^{n} [y_{q,t+1}^R | \beta_{0,t}, \beta_{Q,q}, \beta_d, \boldsymbol{\beta_c}, \phi, u] \times && (62)\\
&\qquad [\beta_{0,t} | \tilde{\beta}, \sigma_{\beta_0}^2][\boldsymbol{\beta_c} | \sigma_{\beta_c}^2] \times && (63)\\
&\qquad \prod_{q=1}^{Q_{tot}} [\beta_{Q,q} | \sigma_Q^2][\boldsymbol{\beta_c}][\beta_d][\tilde{\beta}_0][\sigma_Q][\sigma_{\beta_0}][\phi][u] && (64)
\end{aligned}$$

Stan code for model

```
data{
  int<lower=0> N; // observations
  int<lower=0> Yrs; // years
  int<lower=0> yid[N]; // year id
  int<lower=0> Covs; // climate covariates
  int<lower=0> G; // groups
  int<lower=0> gid[N]; // group id
  int<lower=0> Y[N]; // observation vector
  matrix[N,Covs] C; // climate matrix
  vector[N] parents1; // crowding vector
  vector[N] parents2; // crowding vector
  real<lower=0> tau; // prior variance
}
parameters{
  real a_mu;
  vector[Yrs] a;
  vector[Covs] b2;
  real dd;
  real gint[G];
  real<lower=0> sig_a;
  real<lower=0> theta;
  real<lower=0> sig_G;
  real<lower=0, upper=1> u;
}
transformed parameters{
real mu[N];
vector[N] climEff;
vector[N] trueP1;
vector[N] trueP2;
vector[N] lambda;
vector[N] q;
climEff <- C*b2;
  for(n in 1:N){
    trueP1[n] <- parents1[n]*u + parents2[n]*(1-u);
    trueP2[n] <- sqrt(trueP1[n]);
    mu[n] <- exp(a[yid[n]] + gint[gid[n]] + dd*trueP2[n] + climEff[n]);
    lambda[n] <- trueP1[n]*mu[n];
    q[n] <- lambda[n]*theta;
  }
}
model{
// Priors
  u ~ uniform(0,1);
```

```
  theta ~ uniform(0,10);
  a_mu ~ normal(0,10);
  dd ~ uniform(-10,10);
  sig_a ~ cauchy(0,5);
  sig_G ~ cauchy(0,5);
  for(g in 1:G)
   gint[g] ~ normal(0, sig_G);
  for(y in 1:Yrs){
    a[y] ~ normal(a_mu, sig_a);
  }
  for(j in 1:Covs)
    b2[j] ~ normal(0, tau);

// Likelihood
  Y ~ neg_binomial_2(q, theta);
}
```

Quadrat based model (QBM)

The model for quadrat cover change from time t to $t+1$ is

$$y^{P}_{q,t+1} \sim \mathrm{LogNormal}(\mu_{q,t+1}, \sigma^2)^1_0 \tag{65}$$

$$\mu_{q,t+1} = \beta_{0,t} + \beta_{s,t} x_{q,t} + \beta_{Q,q} + \mathbf{z}'_t \boldsymbol{\beta}_c \tag{66}$$

where $\mu_{q,t+1}$ is the log of proportional cover in quadrat q at time $t+1$, and all other parameters are as in the individual-level growth model (Eq. 4) except that x now represents log of proportional cover. The log normal likelihood includes a truncation (subscript 0, superscript 1) to ensure that predicted values do not exceed 100% cover.

Data, process, and parameter models.

$$
\begin{aligned}
&\texttt{data} & y^P_{q,t+1} &\sim \text{LogNormal}(\mu_{q,t+1}, \sigma^2)^1_0 && (67)\\
&\texttt{process} & \mu_{q,t+1} &= \beta_{0,t} + \beta_{s,t}x_{q,t} + \beta_{Q,q} + \mathbf{z}'_t\boldsymbol{\beta}_c && (68)\\
&\texttt{parameters} & \beta_{0,t} &\sim \text{Normal}(\tilde{\beta}_0, \sigma^2_{\beta_0}) && (69)\\
& & \beta_{s,t} &\sim \text{Normal}(\tilde{\beta}_s, \sigma^2_{\beta_s}) && (70)\\
& & \beta_{Q,q} &\sim \text{Normal}(0, \sigma^2_Q) && (71)\\
& & \boldsymbol{\beta}_c &\sim \text{Normal}(\mathbf{0}, \sigma^2_c\mathbf{I}) && (72)\\
& & \tilde{\beta}_0 &\sim \text{Normal}(0, 100) && (73)\\
& & \tilde{\beta}_s &\sim \text{Normal}(0, 100) && (74)\\
& & \sigma_Q &\sim \text{Cauchy}(0, 5) && (75)\\
& & \sigma_{\beta_0} &\sim \text{Cauchy}(0, 5) && (76)\\
& & \sigma_{\beta_s} &\sim \text{Cauchy}(0, 5) && (77)\\
& & \sigma^2 &\sim \text{Inverse Gamma}(0.001, 0.001) && (78)
\end{aligned}
$$

Full expression of posterior and joint distributions

$$
\begin{aligned}
&[\boldsymbol{\beta_0}, \tilde{\beta}_0, \boldsymbol{\beta_s}, \tilde{\beta}_s, \boldsymbol{\beta_Q}, \boldsymbol{\beta_c}, \sigma^2_Q, \sigma^2_{\beta_0}, \sigma^2_{\beta_s}, \sigma^2 | y^P_{q,t+1}] \propto && (79)\\
&\qquad \prod_{t=1}^{T}\prod_{i=1}^{n}[y_{q,t+1}|\beta_{0,t}, \beta_{s,t}, \beta_{Q,q}, \boldsymbol{\beta_c}]\times && (80)\\
&\qquad [\beta_{0,t}|\tilde{\beta}_0, \sigma^2_{\beta_0}]\times && (81)\\
&\qquad [\beta_{s,t}|\tilde{\beta}_s, \sigma^2_{\beta_s}][\boldsymbol{\beta_c}|\sigma^2_{\beta_c}]\times && (82)\\
&\qquad \prod_{q=1}^{Q_{tot}}[\beta_{Q,q}|\sigma^2_Q]\times && (83)\\
&\qquad [\tilde{\beta}_0][\tilde{\beta}_s][\sigma_Q][\sigma_{\beta_0}][\sigma_{\beta_s}][\sigma] && (84)
\end{aligned}
$$

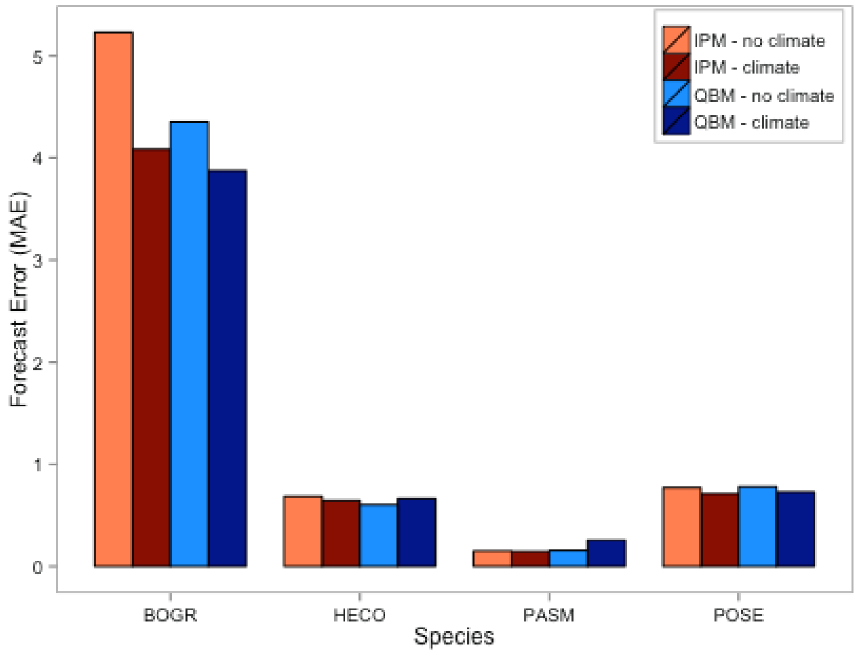
Stan code for model

```
data{
  int<lower=0> N; // observations
  int<lower=0> Yrs; // years
  int<lower=0> yid[N]; // year id
  int<lower=0> Covs; // climate covariates
  int<lower=0> G; // groups
  int<lower=0> gid[N]; // group id
  real<lower=0,upper=1> Y[N]; // observation vector
  real<lower=0> sd_clim; // prior sd on climate effects
  matrix[N,Covs] C; // climate matrix
```

```
  vector[N] X; // size vector
}
parameters{
  real a_mu;
  vector[Yrs] a;
  real b1_mu;
  vector[Yrs] b1;
  vector[Covs] b2;
  vector[G] gint;
  real<lower=0> sig_a;
  real<lower=0> sig_b1;
  real<lower=0> sig_G;
  real<lower=0> sigmaSq;
}
transformed parameters{
  real mu[N];
  vector[N] climEff;
  real<lower=0> tau;
  tau <- sqrt(sigmaSq);
  climEff <- C*b2;
  for(n in 1:N)
    mu[n] <- a[yid[n]] + gint[gid[n]] + b1[yid[n]]*X[n] + climEff[n];
}
model{
  // Priors
  a_mu ~ normal(0,10);
  b1_mu ~ normal(0,10);
  sig_a ~ cauchy(0,5);
  sig_b1 ~ cauchy(0,5);
  sig_G ~ cauchy(0,5);
  gint ~ normal(0, sig_G);
  b2 ~ normal(0,sd_clim);
  a ~ normal(a_mu, sig_a);
  b1 ~ normal(b1_mu, sig_b1);
  sigmaSq ~ inv_gamma(1, 1);

  //Likelihood
  Y ~ lognormal(mu, tau);
}
}
```

Supporting Figures



Significance Tests

	BOGR	HECO	PASM	POSE
IPM - no climate vs. QBM - no climate	$P = 1$	$P = 1$	$P = 0.23$	$P = 0.54$
IPM - climate vs. QBM - climate	$P = 0.89$	$P = 0.48$	$\boldsymbol{P < 0.001}$	$P = 0.41$
IPM - climate vs. IPM - no climate	$\boldsymbol{P < 0.001}$	$P = 0.07$	$P = 0.28$	$\boldsymbol{P = 0.029}$
QBM - climate vs. QBM - no climate	$\boldsymbol{P < 0.001}$	$P = 0.87$	$P = 1$	$\boldsymbol{P = 0.007}$

Figure S1: Comparison of one-step-ahead, out-of-sample forecast error (mean absolute error) between the IPM and QBM models with and without the inclusion of climate covariates.

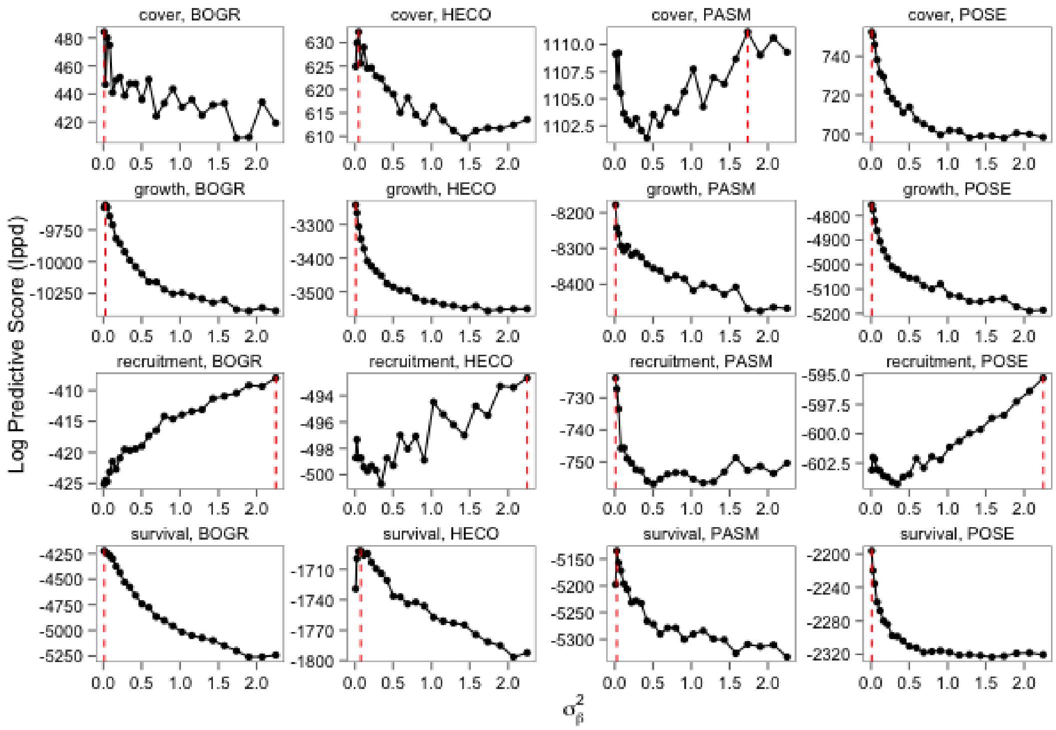


Figure S2: Results from ridge regression: summed log pointwise predictive densities (*lppd*) as a function of the prior variance of climate covariates. Dashed, red vertical lines show the highest prior variance with the highest *lppd* indicating the value of prior variance for optimal prediction.

Supporting Tables

In all tables, “mean_value” is the mean parameter estimate, “sd_value” is the standard deviation of the estimate from the MCMC, “lo_BCI” is the lower limit of the 95% Bayesian Credible Interval, and “up_BCI” is the upper limit of the 95% Bayesian Credible Interval. See Tables S1-S4 for definitions and notations for model parameters.

Table S5: Statistical results from IPM survival model for *B. gracilis.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	0.64	0.29	0.06	1.21
a.1.	0.46	0.35	-0.24	1.20
a.10.	0.55	0.36	-0.15	1.25
a.11.	0.23	0.40	-0.54	1.04
a.12.	0.40	0.47	-0.53	1.35
a.13.	0.99	0.53	-0.03	2.06
a.2.	0.29	0.38	-0.46	1.02
a.3.	0.34	0.40	-0.47	1.11
a.4.	0.48	0.27	-0.05	1.00
a.5.	-0.40	0.28	-0.96	0.13
a.6.	1.62	0.25	1.16	2.14
a.7.	1.41	0.25	0.92	1.94
a.8.	1.32	0.27	0.80	1.84
a.9.	0.60	0.29	0.05	1.17
b1_mu	0.73	0.17	0.39	1.07
b1.1.	0.86	0.13	0.62	1.11
b1.10.	0.52	0.09	0.35	0.70
b1.11.	0.30	0.08	0.15	0.46
b1.12.	0.08	0.08	-0.07	0.23
b1.13.	0.11	0.10	-0.08	0.30
b1.2.	0.90	0.12	0.67	1.14
b1.3.	0.96	0.12	0.74	1.20
b1.4.	1.41	0.07	1.27	1.55
b1.5.	0.70	0.07	0.57	0.83
b1.6.	1.51	0.15	1.23	1.80
b1.7.	1.04	0.11	0.83	1.27
b1.8.	0.12	0.07	-0.03	0.26
b1.9.	0.95	0.10	0.75	1.16
b2.1.	-0.04	0.10	-0.22	0.15
b2.2.	0.05	0.09	-0.12	0.22
b2.3.	0.03	0.09	-0.16	0.21
b2.4.	-0.02	0.10	-0.21	0.16
b2.5.	-0.03	0.09	-0.19	0.15
b2.6.	0.06	0.09	-0.13	0.24
b2.7.	0.03	0.09	-0.15	0.21
gint.1.	0.08	0.17	-0.28	0.43
gint.2.	0.07	0.17	-0.28	0.41
gint.3.	-0.33	0.17	-0.68	-0.01
gint.4.	0.40	0.18	0.05	0.76
gint.5.	-0.19	0.17	-0.54	0.14
gint.6.	-0.08	0.17	-0.44	0.26
sig_a	0.70	0.19	0.43	1.16
sig_b1	0.55	0.14	0.35	0.87
sig_G	0.36	0.18	0.16	0.77
w.1.	-0.09	0.00	-0.10	-0.08
w.2.	0.02	0.00	0.02	0.03

Table S6: Statistical results from IPM survival model for *H. comata.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	1.28	0.32	0.63	1.95
a.1.	0.41	0.50	-0.58	1.36
a.10.	2.01	0.39	1.27	2.81
a.11.	0.92	0.43	0.10	1.78
a.12.	0.87	0.60	-0.29	2.09
a.13.	1.25	0.69	-0.06	2.61
a.2.	1.42	0.57	0.28	2.50
a.3.	1.03	0.64	-0.27	2.26
a.4.	1.11	0.52	0.09	2.16
a.5.	-0.34	0.45	-1.30	0.51
a.6.	2.18	0.50	1.25	3.19
a.7.	2.32	0.41	1.59	3.16
a.8.	1.70	0.35	1.07	2.47
a.9.	1.70	0.32	1.08	2.34
b1_mu	0.79	0.12	0.58	1.04
b1.1.	0.89	0.16	0.59	1.23
b1.10.	0.86	0.17	0.55	1.22
b1.11.	0.79	0.13	0.56	1.06
b1.12.	1.05	0.16	0.77	1.38
b1.13.	0.65	0.13	0.41	0.91
b1.2.	0.64	0.15	0.35	0.95
b1.3.	0.58	0.15	0.30	0.89
b1.4.	0.51	0.09	0.33	0.70
b1.5.	0.24	0.10	0.05	0.43
b1.6.	0.86	0.29	0.34	1.50
b1.7.	0.93	0.26	0.47	1.49
b1.8.	1.31	0.23	0.93	1.82
b1.9.	0.87	0.16	0.57	1.21
b2.1.	0.01	0.21	-0.41	0.43
b2.2.	0.13	0.23	-0.34	0.59
b2.3.	0.13	0.24	-0.33	0.60
b2.4.	-0.15	0.21	-0.57	0.27
b2.5.	-0.02	0.22	-0.46	0.40
b2.6.	0.13	0.24	-0.35	0.61
b2.7.	0.15	0.24	-0.32	0.61
gint.1.	0.02	0.15	-0.28	0.33
gint.2.	0.03	0.15	-0.26	0.34
gint.3.	0.22	0.16	-0.04	0.55
gint.4.	-0.16	0.16	-0.51	0.12
gint.5.	0.01	0.14	-0.28	0.30
gint.6.	-0.13	0.16	-0.47	0.15
sig_a	0.98	0.27	0.57	1.67
sig_b1	0.35	0.11	0.19	0.64
sig_G	0.23	0.15	0.03	0.59
w.1.	-0.36	0.04	-0.44	-0.28
w.2.	0.14	0.03	0.09	0.19

Table S7: Statistical results from IPM survival model for *P. smithii*.

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	2.95	0.26	2.44	3.46
a.1.	2.40	0.38	1.64	3.13
a.10.	3.13	0.25	2.66	3.62
a.11.	3.01	0.34	2.37	3.71
a.12.	3.05	0.46	2.22	4.01
a.13.	2.86	0.44	2.01	3.78
a.2.	2.26	0.39	1.44	2.97
a.3.	2.10	0.49	1.10	2.96
a.4.	3.30	0.49	2.40	4.32
a.5.	2.00	0.36	1.25	2.65
a.6.	3.66	0.44	2.86	4.59
a.7.	3.53	0.35	2.90	4.24
a.8.	3.64	0.33	3.03	4.33
a.9.	3.38	0.28	2.85	3.95
b1_mu	1.35	0.15	1.06	1.66
b1.1.	0.80	0.18	0.45	1.16
b1.10.	1.35	0.16	1.05	1.68
b1.11.	1.68	0.17	1.37	2.03
b1.12.	1.97	0.20	1.59	2.37
b1.13.	1.70	0.15	1.41	2.00
b1.2.	0.74	0.10	0.54	0.95
b1.3.	0.82	0.10	0.63	1.02
b1.4.	1.74	0.21	1.34	2.16
b1.5.	0.83	0.12	0.61	1.07
b1.6.	1.34	0.29	0.79	1.92
b1.7.	1.43	0.24	1.00	1.90
b1.8.	1.55	0.23	1.10	2.02
b1.9.	1.66	0.17	1.34	2.02
b2.1.	-0.07	0.14	-0.32	0.21
b2.2.	0.10	0.14	-0.20	0.38
b2.3.	0.13	0.15	-0.16	0.42
b2.4.	-0.22	0.15	-0.49	0.09
b2.5.	0.01	0.14	-0.27	0.28
b2.6.	0.10	0.15	-0.19	0.38
b2.7.	0.14	0.15	-0.16	0.43
gint.1.	0.13	0.10	-0.05	0.36
gint.2.	-0.18	0.11	-0.40	0.02
gint.3.	-0.03	0.10	-0.22	0.18
gint.4.	-0.01	0.12	-0.24	0.23
gint.5.	-0.06	0.11	-0.27	0.17
gint.6.	0.16	0.11	-0.03	0.39
sig_a	0.76	0.27	0.36	1.43
sig_b1	0.51	0.14	0.31	0.85
sig_G	0.20	0.12	0.08	0.46
w.1.	-0.45	0.03	-0.52	-0.39
w.2.	0.14	0.03	0.09	0.19

Table S8: Statistical results from IPM survival model for *P. secunda*.

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	1.31	0.37	0.65	2.15
a.1.	1.14	0.48	0.23	2.17
a.10.	0.53	0.37	-0.12	1.35
a.11.	0.96	0.40	0.25	1.79
a.12.	1.56	0.42	0.83	2.47
a.13.	1.45	0.45	0.62	2.42
a.2.	1.48	0.48	0.66	2.50
a.3.	1.42	0.46	0.62	2.38
a.4.	1.16	0.45	0.34	2.13
a.5.	1.35	0.41	0.62	2.16
a.6.	1.70	0.40	1.02	2.53
a.7.	1.41	0.38	0.77	2.17
a.8.	1.63	0.38	0.97	2.46
a.9.	1.29	0.37	0.65	2.05
b1_mu	0.71	0.08	0.56	0.87
b1.1.	0.75	0.19	0.38	1.13
b1.10.	0.47	0.07	0.33	0.61
b1.11.	0.52	0.09	0.34	0.70
b1.12.	0.73	0.13	0.49	0.98
b1.13.	0.85	0.12	0.62	1.09
b1.2.	0.70	0.16	0.39	1.03
b1.3.	0.60	0.16	0.28	0.90
b1.4.	1.00	0.12	0.78	1.24
b1.5.	0.74	0.11	0.53	0.97
b1.6.	0.90	0.12	0.68	1.13
b1.7.	0.63	0.09	0.46	0.81
b1.8.	0.56	0.10	0.36	0.75
b1.9.	0.86	0.09	0.70	1.03
b2.1.	-0.05	0.09	-0.21	0.12
b2.2.	-0.02	0.09	-0.19	0.15
b2.3.	-0.01	0.09	-0.19	0.16
b2.4.	0.03	0.08	-0.12	0.19
b2.5.	0.02	0.08	-0.14	0.18
b2.6.	-0.02	0.08	-0.18	0.15
b2.7.	-0.00	0.09	-0.17	0.16
gint.1.	-0.14	0.35	-0.92	0.48
gint.2.	-0.61	0.37	-1.46	0.01
gint.3.	0.16	0.35	-0.60	0.79
gint.4.	-0.15	0.37	-1.02	0.48
gint.5.	0.55	0.36	-0.21	1.22
gint.6.	0.01	0.35	-0.74	0.65
sig_a	0.44	0.13	0.25	0.76
sig_b1	0.22	0.07	0.12	0.38
sig_G	0.58	0.39	0.24	1.58
w.1.	-0.98	0.07	-1.13	-0.84
w.2.	0.21	0.05	0.11	0.31

Table S9: Statistical results from IPM growth model for *B. gracilis.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	0.74	0.22	0.33	1.20
a.1.	0.94	0.30	0.37	1.54
a.10.	1.24	0.26	0.72	1.74
a.11.	0.31	0.34	-0.34	1.01
a.12.	0.76	0.45	-0.11	1.67
a.13.	0.50	0.49	-0.43	1.48
a.2.	1.08	0.33	0.42	1.73
a.3.	0.55	0.38	-0.21	1.26
a.4.	0.68	0.30	0.11	1.28
a.5.	-0.56	0.26	-1.10	-0.07
a.6.	0.64	0.20	0.24	1.04
a.7.	1.26	0.16	0.96	1.57
a.8.	1.44	0.17	1.13	1.78
a.9.	0.78	0.20	0.41	1.18
b1_mu	0.77	0.03	0.70	0.84
b1.1.	0.88	0.05	0.79	0.98
b1.10.	0.76	0.03	0.70	0.83
b1.11.	0.88	0.04	0.80	0.95
b1.12.	0.70	0.04	0.61	0.79
b1.13.	0.78	0.04	0.70	0.86
b1.2.	0.78	0.04	0.71	0.85
b1.3.	0.74	0.04	0.67	0.81
b1.4.	0.88	0.03	0.83	0.93
b1.5.	0.57	0.05	0.47	0.66
b1.6.	0.87	0.04	0.79	0.95
b1.7.	0.67	0.03	0.61	0.73
b1.8.	0.71	0.03	0.65	0.77
b1.9.	0.79	0.03	0.73	0.86
b2.1.	-0.02	0.13	-0.27	0.23
b2.2.	0.09	0.14	-0.18	0.36
b2.3.	0.05	0.14	-0.22	0.31
b2.4.	-0.05	0.14	-0.33	0.22
b2.5.	0.06	0.13	-0.19	0.31
b2.6.	0.11	0.14	-0.16	0.38
b2.7.	0.06	0.13	-0.21	0.32
gint.1.	-0.07	0.07	-0.22	0.07
gint.2.	0.04	0.07	-0.11	0.18
gint.3.	0.09	0.07	-0.06	0.23
gint.4.	0.02	0.07	-0.12	0.17
gint.5.	0.07	0.07	-0.07	0.21
gint.6.	-0.17	0.07	-0.32	-0.04
sig_a	0.66	0.18	0.40	1.09
sig_b1	0.11	0.03	0.07	0.19
sig_G	0.14	0.08	0.06	0.35
tau	1.50	0.06	1.39	1.61
tauSize	-0.22	0.01	-0.24	-0.19
w.1.	-0.03	0.00	-0.04	-0.03
w.2.	0.01	0.00	0.00	0.01

Table S10: Statistical results from IPM growth model for *H. comata.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	0.65	0.22	0.23	1.08
a.1.	0.98	0.28	0.43	1.52
a.10.	1.08	0.15	0.79	1.39
a.11.	0.22	0.19	-0.16	0.59
a.12.	0.48	0.27	-0.03	1.01
a.13.	0.68	0.30	0.06	1.27
a.2.	0.58	0.33	-0.07	1.20
a.3.	0.01	0.37	-0.72	0.73
a.4.	0.43	0.30	-0.17	1.01
a.5.	-0.54	0.29	-1.10	0.03
a.6.	1.18	0.24	0.70	1.65
a.7.	1.88	0.12	1.65	2.11
a.8.	0.63	0.12	0.38	0.87
a.9.	0.79	0.14	0.52	1.05
b1_mu	0.62	0.06	0.49	0.74
b1.1.	0.57	0.09	0.38	0.76
b1.10.	0.72	0.03	0.66	0.79
b1.11.	0.71	0.04	0.63	0.78
b1.12.	0.77	0.04	0.70	0.84
b1.13.	0.63	0.03	0.56	0.69
b1.2.	0.73	0.09	0.55	0.92
b1.3.	0.37	0.10	0.17	0.56
b1.4.	0.60	0.05	0.50	0.70
b1.5.	0.31	0.10	0.12	0.50
b1.6.	0.65	0.12	0.41	0.89
b1.7.	0.41	0.05	0.31	0.52
b1.8.	0.87	0.04	0.79	0.96
b1.9.	0.74	0.04	0.66	0.82
b2.1.	-0.03	0.09	-0.21	0.15
b2.2.	0.04	0.09	-0.12	0.22
b2.3.	0.03	0.09	-0.16	0.21
b2.4.	-0.03	0.09	-0.21	0.15
b2.5.	0.01	0.09	-0.17	0.19
b2.6.	0.05	0.10	-0.13	0.24
b2.7.	0.03	0.10	-0.16	0.22
gint.1.	0.01	0.06	-0.10	0.12
gint.2.	0.03	0.06	-0.07	0.15
gint.3.	-0.08	0.06	-0.21	0.01
gint.4.	-0.02	0.06	-0.14	0.09
gint.5.	0.05	0.06	-0.05	0.17
gint.6.	0.02	0.06	-0.09	0.14
sig_a	0.72	0.19	0.45	1.18
sig_b1	0.20	0.06	0.12	0.34
sig_G	0.08	0.05	0.01	0.21
tau	1.31	0.06	1.19	1.43
tauSize	-0.26	0.03	-0.31	-0.21
w.1.	-0.14	0.04	-0.21	-0.07
w.2.	0.03	0.01	-0.00	0.05

Table S11: Statistical results from IPM growth model for *P. smithii.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	-0.06	0.07	-0.18	0.07
a.1.	0.01	0.12	-0.22	0.26
a.10.	0.03	0.06	-0.10	0.16
a.11.	-0.05	0.09	-0.23	0.12
a.12.	-0.14	0.11	-0.37	0.08
a.13.	-0.10	0.14	-0.38	0.17
a.2.	0.01	0.14	-0.28	0.28
a.3.	-0.09	0.14	-0.38	0.17
a.4.	-0.15	0.15	-0.45	0.14
a.5.	-0.30	0.10	-0.51	-0.10
a.6.	0.15	0.10	-0.03	0.36
a.7.	-0.12	0.06	-0.23	-0.00
a.8.	0.02	0.06	-0.08	0.13
a.9.	-0.04	0.06	-0.16	0.09
b1_mu	0.59	0.04	0.52	0.66
b1.1.	0.59	0.04	0.52	0.67
b1.10.	0.66	0.03	0.60	0.71
b1.11.	0.62	0.03	0.57	0.67
b1.12.	0.65	0.02	0.60	0.69
b1.13.	0.68	0.02	0.63	0.73
b1.2.	0.49	0.03	0.43	0.54
b1.3.	0.35	0.03	0.30	0.41
b1.4.	0.52	0.03	0.46	0.58
b1.5.	0.46	0.04	0.39	0.53
b1.6.	0.66	0.05	0.57	0.75
b1.7.	0.65	0.03	0.58	0.72
b1.8.	0.64	0.03	0.58	0.70
b1.9.	0.69	0.03	0.64	0.74
b2.1.	-0.07	0.05	-0.16	0.03
b2.2.	0.05	0.08	-0.11	0.21
b2.3.	0.02	0.08	-0.13	0.18
b2.4.	0.02	0.05	-0.08	0.11
b2.5.	0.04	0.06	-0.07	0.14
b2.6.	0.07	0.08	-0.07	0.22
b2.7.	0.03	0.07	-0.11	0.17
gint.1.	0.03	0.04	-0.05	0.11
gint.2.	-0.06	0.04	-0.15	0.02
gint.3.	-0.09	0.04	-0.18	-0.01
gint.4.	-0.00	0.05	-0.10	0.09
gint.5.	0.07	0.04	-0.02	0.15
gint.6.	0.06	0.04	-0.03	0.14
sig_a	0.17	0.05	0.09	0.29
sig_b1	0.12	0.03	0.08	0.19
sig_G	0.09	0.04	0.04	0.21
tau	0.44	0.01	0.43	0.46
tauSize	0.28	0.03	0.21	0.34
w.1.	-0.06	0.01	-0.08	-0.04
w.2.	-0.01	0.01	-0.03	0.01

Table S12: Statistical results from IPM growth model for *P. secunda.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	0.51	0.19	0.15	0.89
a.1.	0.77	0.30	0.22	1.36
a.10.	-0.01	0.15	-0.30	0.30
a.11.	0.06	0.23	-0.42	0.49
a.12.	0.32	0.29	-0.29	0.88
a.13.	0.65	0.34	-0.05	1.31
a.2.	0.76	0.31	0.15	1.36
a.3.	1.08	0.35	0.45	1.79
a.4.	0.03	0.30	-0.56	0.64
a.5.	0.48	0.24	0.04	0.99
a.6.	1.53	0.19	1.18	1.92
a.7.	0.22	0.15	-0.06	0.53
a.8.	0.27	0.12	0.05	0.50
a.9.	0.50	0.11	0.28	0.73
b1_mu	0.54	0.05	0.44	0.63
b1.1.	0.45	0.12	0.21	0.68
b1.10.	0.32	0.04	0.24	0.40
b1.11.	0.50	0.05	0.40	0.59
b1.12.	0.44	0.06	0.33	0.55
b1.13.	0.57	0.05	0.46	0.67
b1.2.	0.43	0.09	0.25	0.61
b1.3.	0.51	0.08	0.35	0.66
b1.4.	0.82	0.06	0.71	0.93
b1.5.	0.55	0.05	0.47	0.64
b1.6.	0.64	0.04	0.57	0.72
b1.7.	0.56	0.04	0.48	0.64
b1.8.	0.60	0.04	0.53	0.67
b1.9.	0.60	0.03	0.54	0.66
b2.1.	-0.07	0.09	-0.23	0.10
b2.2.	-0.05	0.09	-0.23	0.13
b2.3.	-0.05	0.09	-0.21	0.13
b2.4.	0.11	0.09	-0.08	0.28
b2.5.	-0.03	0.09	-0.20	0.16
b2.6.	-0.04	0.09	-0.22	0.14
b2.7.	-0.05	0.09	-0.22	0.12
gint.1.	-0.03	0.09	-0.21	0.15
gint.2.	-0.13	0.11	-0.35	0.06
gint.3.	-0.01	0.08	-0.19	0.16
gint.4.	-0.01	0.10	-0.22	0.19
gint.5.	0.23	0.09	0.05	0.42
gint.6.	-0.05	0.09	-0.23	0.12
sig_a	0.56	0.17	0.32	0.98
sig_b1	0.15	0.04	0.09	0.26
sig_G	0.18	0.09	0.07	0.41
tau	1.05	0.04	0.98	1.13
tauSize	-0.08	0.03	-0.13	-0.03
w.1.	-0.25	0.06	-0.37	-0.14
w.2.	0.07	0.03	0.01	0.12

Table S13: Statistical results from IPM recruitment model for *B. gracilis.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	2.81	0.56	1.67	3.97
a.1.	2.71	0.76	1.09	4.08
a.10.	2.76	0.61	1.54	3.98
a.11.	2.70	0.68	1.30	3.99
a.12.	2.84	0.71	1.39	4.22
a.13.	2.90	0.67	1.53	4.23
a.2.	2.97	0.65	1.70	4.28
a.3.	2.76	0.71	1.23	4.14
a.4.	2.73	0.71	1.21	4.06
a.5.	2.69	0.63	1.46	3.92
a.6.	3.13	0.56	2.10	4.32
a.7.	2.82	0.55	1.72	3.93
a.8.	2.86	0.55	1.76	4.02
a.9.	2.65	0.66	1.31	3.89
b2.1.	-0.10	0.26	-0.64	0.40
b2.2.	0.30	1.07	-1.81	2.45
b2.3.	0.13	1.04	-1.88	2.21
b2.4.	0.51	0.29	-0.06	1.09
b2.5.	0.12	0.30	-0.46	0.70
b2.6.	0.33	0.96	-1.56	2.28
b2.7.	-0.50	0.98	-2.44	1.38
dd	-1.33	0.19	-1.69	-0.95
gint.1.	-0.40	0.38	-1.24	0.18
gint.2.	0.01	0.34	-0.73	0.71
gint.3.	-0.01	0.31	-0.67	0.59
gint.4.	0.03	0.36	-0.69	0.76
gint.5.	-0.05	0.32	-0.74	0.59
gint.6.	0.42	0.34	-0.11	1.18
sig_a	0.36	0.27	0.02	1.01
sig_G	0.48	0.31	0.05	1.26
theta	0.35	0.05	0.26	0.47
u	0.18	0.21	0.01	0.98

Table S14: Statistical results from IPM recruitment model for *H. comata.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	3.05	0.34	2.40	3.70
a.1.	2.80	0.70	1.40	4.12
a.10.	2.98	0.44	2.13	3.85
a.11.	3.27	0.54	2.26	4.39
a.12.	2.56	0.63	1.31	3.77
a.13.	2.99	0.74	1.53	4.52
a.2.	2.80	0.73	1.33	4.17
a.3.	3.11	0.68	1.72	4.44
a.4.	2.93	0.75	1.37	4.39
a.5.	2.93	0.48	2.00	3.89
a.6.	2.94	0.52	1.90	3.96
a.7.	4.40	0.36	3.73	5.12
a.8.	2.96	0.39	2.21	3.74
a.9.	3.06	0.44	2.20	3.96
b2.1.	-0.24	0.28	-0.81	0.33
b2.2.	-0.41	1.12	-2.73	1.71
b2.3.	-0.32	1.04	-2.39	1.71
b2.4.	-0.23	0.35	-0.92	0.49
b2.5.	-0.86	0.36	-1.56	-0.12
b2.6.	-0.37	0.99	-2.24	1.67
b2.7.	0.35	0.98	-1.55	2.28
dd	-1.32	0.17	-1.65	-0.99
gint.1.	-0.06	0.13	-0.40	0.18
gint.2.	-0.04	0.13	-0.38	0.21
gint.3.	0.08	0.14	-0.12	0.45
gint.4.	0.02	0.13	-0.23	0.32
gint.5.	0.02	0.13	-0.22	0.33
gint.6.	-0.01	0.14	-0.36	0.27
sig_a	0.75	0.27	0.37	1.40
sig_G	0.15	0.14	0.01	0.49
theta	1.31	0.20	0.97	1.75
u	1.00	0.00	1.00	1.00

Table S15: Statistical results from IPM recruitment model for *P. smithii*.

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	5.64	0.33	5.06	6.32
a.1.	6.90	0.50	6.03	7.93
a.10.	5.92	0.31	5.32	6.44
a.11.	6.19	0.34	5.55	6.89
a.12.	5.45	0.37	4.67	6.19
a.13.	5.37	0.41	4.56	6.23
a.2.	5.64	0.54	4.67	6.61
a.3.	4.59	0.46	3.76	5.52
a.4.	5.48	0.40	4.76	6.30
a.5.	4.29	0.41	3.35	5.12
a.6.	6.03	0.30	5.48	6.69
a.7.	5.82	0.28	5.28	6.40
a.8.	6.30	0.28	5.85	6.86
a.9.	5.48	0.28	4.95	6.07
b2.1.	-0.02	0.08	-0.19	0.15
b2.2.	0.07	0.09	-0.12	0.23
b2.3.	-0.00	0.10	-0.17	0.20
b2.4.	-0.04	0.09	-0.21	0.13
b2.5.	0.04	0.09	-0.15	0.21
b2.6.	0.04	0.10	-0.12	0.24
b2.7.	0.03	0.09	-0.15	0.20
dd	-4.24	0.26	-4.77	-3.81
gint.1.	0.05	0.15	-0.21	0.40
gint.2.	0.00	0.16	-0.32	0.35
gint.3.	0.04	0.14	-0.23	0.36
gint.4.	-0.23	0.22	-0.72	0.04
gint.5.	0.05	0.15	-0.22	0.41
gint.6.	0.13	0.17	-0.11	0.54
sig_a	0.81	0.23	0.50	1.37
sig_G	0.21	0.19	0.01	0.65
theta	1.56	0.18	1.22	1.96
u	1.00	0.00	1.00	1.00

Table S16: Statistical results from IPM recruitment model for *P. secunda.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	3.72	0.32	3.07	4.34
a.1.	3.41	0.60	2.15	4.53
a.10.	3.48	0.41	2.67	4.33
a.11.	3.43	0.51	2.34	4.39
a.12.	3.82	0.54	2.68	4.89
a.13.	3.72	0.64	2.46	5.01
a.2.	3.91	0.59	2.66	5.14
a.3.	4.01	0.58	2.84	5.16
a.4.	3.67	0.63	2.31	4.90
a.5.	3.24	0.45	2.34	4.12
a.6.	3.79	0.44	2.91	4.67
a.7.	3.31	0.45	2.44	4.16
a.8.	4.47	0.36	3.78	5.17
a.9.	4.10	0.37	3.37	4.82
b2.1.	0.02	0.24	-0.44	0.51
b2.2.	0.12	1.11	-2.13	2.32
b2.3.	0.02	1.03	-2.10	1.98
b2.4.	0.33	0.32	-0.32	0.95
b2.5.	-0.16	0.31	-0.78	0.45
b2.6.	0.11	1.00	-1.86	2.14
b2.7.	0.15	0.95	-1.68	2.11
dd	-1.68	0.16	-1.98	-1.37
gint.1.	-0.06	0.20	-0.48	0.36
gint.2.	-0.04	0.23	-0.51	0.40
gint.3.	0.34	0.23	-0.02	0.85
gint.4.	-0.26	0.25	-0.82	0.14
gint.5.	0.00	0.22	-0.43	0.46
gint.6.	0.03	0.21	-0.37	0.49
sig_a	0.62	0.23	0.28	1.17
sig_G	0.33	0.21	0.03	0.86
theta	1.15	0.16	0.88	1.49
u	1.00	0.00	1.00	1.00

Table S17: Statistical results from QBM population model for *B. gracilis*.

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	-0.38	0.36	-1.07	0.29
a.1.	-0.10	0.40	-0.85	0.69
a.10.	-0.09	0.31	-0.70	0.52
a.11.	-0.20	0.33	-0.83	0.46
a.12.	-0.32	0.42	-1.15	0.54
a.13.	-0.46	0.46	-1.37	0.48
a.2.	-0.22	0.37	-0.94	0.51
a.3.	-0.94	0.38	-1.71	-0.23
a.4.	-0.18	0.41	-1.01	0.61
a.5.	-3.02	0.39	-3.82	-2.27
a.6.	0.70	0.52	-0.25	1.76
a.7.	-0.25	0.37	-0.97	0.48
a.8.	0.27	0.33	-0.38	0.91
a.9.	-0.04	0.30	-0.58	0.57
b1_mu	0.89	0.04	0.81	0.99
b1.1.	0.99	0.10	0.82	1.20
b1.10.	0.76	0.07	0.62	0.90
b1.11.	0.98	0.07	0.84	1.13
b1.12.	0.88	0.08	0.71	1.03
b1.13.	0.90	0.09	0.73	1.07
b1.2.	0.90	0.07	0.76	1.04
b1.3.	0.91	0.07	0.78	1.05
b1.4.	0.87	0.07	0.74	1.01
b1.5.	0.81	0.09	0.62	0.97
b1.6.	1.02	0.09	0.86	1.20
b1.7.	0.78	0.07	0.64	0.91
b1.8.	0.87	0.07	0.73	1.01
b1.9.	0.94	0.08	0.80	1.10
b2.1.	-0.01	0.09	-0.18	0.17
b2.2.	0.04	0.09	-0.14	0.22
b2.3.	0.03	0.10	-0.16	0.22
b2.4.	-0.04	0.10	-0.23	0.15
b2.5.	0.01	0.09	-0.18	0.19
b2.6.	0.04	0.10	-0.14	0.23
b2.7.	0.02	0.10	-0.17	0.21
gint.1.	-0.04	0.07	-0.21	0.07
gint.2.	0.02	0.07	-0.11	0.18
gint.3.	0.02	0.07	-0.11	0.17
gint.4.	0.02	0.07	-0.11	0.18
gint.5.	-0.01	0.07	-0.16	0.12
gint.6.	-0.02	0.07	-0.18	0.09
sig_a	1.07	0.32	0.62	1.81
sig_b1	0.12	0.05	0.03	0.22
sig_G	0.07	0.07	0.01	0.26
tau	0.69	0.03	0.63	0.76

Table S18: Statistical results from QBM population model for *H. comata*.

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	-0.68	0.37	-1.43	0.06
a.1.	-0.80	0.56	-1.86	0.32
a.10.	-0.20	0.41	-1.00	0.60
a.11.	-1.00	0.47	-1.91	-0.08
a.12.	-0.91	0.60	-2.06	0.30
a.13.	-0.82	0.67	-2.11	0.47
a.2.	-0.71	0.56	-1.81	0.36
a.3.	-0.87	0.59	-2.03	0.23
a.4.	-0.60	0.64	-1.77	0.68
a.5.	-2.55	0.55	-3.70	-1.46
a.6.	0.60	0.61	-0.61	1.79
a.7.	-0.14	0.48	-1.14	0.73
a.8.	-0.35	0.38	-1.08	0.40
a.9.	-0.52	0.39	-1.28	0.25
b1_mu	0.88	0.05	0.78	0.97
b1.1.	0.88	0.07	0.75	1.04
b1.10.	0.87	0.07	0.74	1.01
b1.11.	0.88	0.06	0.76	1.01
b1.12.	0.88	0.07	0.75	1.03
b1.13.	0.90	0.07	0.77	1.05
b1.2.	0.87	0.07	0.73	1.00
b1.3.	0.88	0.07	0.75	1.03
b1.4.	0.87	0.07	0.74	1.00
b1.5.	0.88	0.07	0.75	1.03
b1.6.	0.87	0.06	0.74	0.99
b1.7.	0.83	0.07	0.69	0.95
b1.8.	0.87	0.06	0.75	0.99
b1.9.	0.88	0.06	0.75	1.00
b2.1.	-0.12	0.18	-0.48	0.25
b2.2.	0.08	0.20	-0.28	0.46
b2.3.	0.08	0.19	-0.29	0.45
b2.4.	-0.13	0.18	-0.48	0.23
b2.5.	0.01	0.18	-0.34	0.37
b2.6.	0.09	0.19	-0.29	0.48
b2.7.	0.09	0.19	-0.29	0.48
gint.1.	0.01	0.07	-0.11	0.16
gint.2.	0.01	0.08	-0.13	0.18
gint.3.	0.00	0.07	-0.13	0.15
gint.4.	0.00	0.07	-0.13	0.16
gint.5.	-0.00	0.07	-0.14	0.15
gint.6.	-0.00	0.07	-0.16	0.14
sig_a	0.95	0.29	0.52	1.67
sig_b1	0.05	0.04	0.01	0.14
sig_G	0.06	0.07	0.00	0.25
tau	0.74	0.04	0.66	0.83

Table S19: Statistical results from QBM population model for *P. smithii.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	-0.83	0.23	-1.32	-0.39
a.1.	-0.87	0.33	-1.54	-0.23
a.10.	-0.70	0.30	-1.29	-0.09
a.11.	-0.78	0.30	-1.37	-0.18
a.12.	-0.97	0.31	-1.64	-0.41
a.13.	-0.87	0.36	-1.58	-0.13
a.2.	-0.79	0.36	-1.46	-0.06
a.3.	-0.86	0.33	-1.52	-0.22
a.4.	-0.89	0.34	-1.57	-0.24
a.5.	-0.99	0.31	-1.62	-0.42
a.6.	-0.64	0.33	-1.29	0.04
a.7.	-0.83	0.28	-1.39	-0.29
a.8.	-0.75	0.29	-1.31	-0.19
a.9.	-0.87	0.28	-1.43	-0.32
b1_mu	0.87	0.03	0.80	0.94
b1.1.	0.88	0.05	0.78	0.98
b1.10.	0.86	0.04	0.78	0.93
b1.11.	0.86	0.04	0.77	0.94
b1.12.	0.88	0.05	0.79	0.98
b1.13.	0.89	0.05	0.80	1.00
b1.2.	0.86	0.05	0.76	0.95
b1.3.	0.88	0.05	0.79	0.98
b1.4.	0.86	0.05	0.77	0.95
b1.5.	0.88	0.04	0.80	0.97
b1.6.	0.86	0.04	0.77	0.93
b1.7.	0.87	0.04	0.79	0.94
b1.8.	0.87	0.04	0.79	0.95
b1.9.	0.89	0.04	0.81	0.97
b2.1.	-0.16	0.13	-0.43	0.09
b2.2.	-0.38	0.97	-2.22	1.53
b2.3.	-0.04	0.85	-1.71	1.67
b2.4.	-0.15	0.20	-0.54	0.27
b2.5.	0.10	0.21	-0.31	0.51
b2.6.	0.68	0.87	-1.09	2.28
b2.7.	0.19	0.80	-1.41	1.74
gint.1.	0.06	0.09	-0.09	0.29
gint.2.	-0.05	0.10	-0.28	0.12
gint.3.	0.01	0.09	-0.15	0.20
gint.4.	-0.10	0.11	-0.37	0.06
gint.5.	0.03	0.10	-0.14	0.25
gint.6.	0.04	0.10	-0.13	0.27
sig_a	0.25	0.16	0.02	0.63
sig_b1	0.03	0.02	0.00	0.08
sig_G	0.12	0.11	0.01	0.40
tau	0.65	0.03	0.59	0.72

Table S20: Statistical results from QBM population model for *P. secunda.*

Parameter	mean_value	sd_value	lo_BCI	up_BCI
a_mu	-1.25	0.35	-1.96	-0.54
a.1.	-1.27	0.56	-2.43	-0.19
a.10.	-1.95	0.56	-3.27	-1.00
a.11.	-1.61	0.51	-2.68	-0.61
a.12.	-1.33	0.51	-2.32	-0.34
a.13.	-1.07	0.51	-2.01	0.02
a.2.	-1.24	0.53	-2.28	-0.24
a.3.	-0.70	0.55	-1.76	0.42
a.4.	-1.25	0.48	-2.10	-0.25
a.5.	-1.26	0.50	-2.15	-0.18
a.6.	-0.43	0.51	-1.50	0.54
a.7.	-1.63	0.36	-2.35	-0.94
a.8.	-1.36	0.39	-2.17	-0.57
a.9.	-1.13	0.41	-1.91	-0.32
b1_mu	0.77	0.06	0.64	0.89
b1.1.	0.77	0.08	0.60	0.93
b1.10.	0.69	0.11	0.45	0.87
b1.11.	0.79	0.09	0.63	0.98
b1.12.	0.77	0.08	0.62	0.93
b1.13.	0.76	0.08	0.61	0.91
b1.2.	0.76	0.08	0.61	0.92
b1.3.	0.74	0.08	0.57	0.90
b1.4.	0.83	0.09	0.68	1.04
b1.5.	0.83	0.09	0.67	1.03
b1.6.	0.68	0.10	0.47	0.86
b1.7.	0.78	0.09	0.60	0.98
b1.8.	0.78	0.08	0.62	0.94
b1.9.	0.77	0.08	0.63	0.93
b2.1.	-0.07	0.09	-0.27	0.11
b2.2.	-0.04	0.09	-0.22	0.13
b2.3.	-0.04	0.09	-0.22	0.14
b2.4.	0.04	0.09	-0.13	0.22
b2.5.	-0.02	0.09	-0.19	0.16
b2.6.	-0.05	0.09	-0.23	0.14
b2.7.	-0.04	0.09	-0.22	0.14
gint.1.	0.02	0.10	-0.17	0.25
gint.2.	-0.08	0.12	-0.39	0.10
gint.3.	0.04	0.10	-0.15	0.27
gint.4.	-0.08	0.12	-0.38	0.10
gint.5.	0.07	0.12	-0.12	0.37
gint.6.	0.03	0.10	-0.17	0.25
sig_a	0.59	0.26	0.14	1.18
sig_b1	0.08	0.05	0.01	0.19
sig_G	0.14	0.12	0.01	0.44
tau	0.70	0.04	0.63	0.77

Table S21: Statistical tests to assess whether models without climate covariates have higher accuracy and lower error than models with climate covariates. t-tests are one-sided.

comparison	performance_measure	test_type	test_statistic	df	p_value	species
simple IPM vs. climate IPM	rho	t	-1.703	279.000	0.955	BOGR
simple IPM vs. climate IPM	MAE	t	-3.715	280.000	1.000	BOGR
simple QBM vs. climate QBM	rho	t	-1.798	279.000	0.963	BOGR
simple QBM vs. climate QBM	MAE	t	-3.340	280.000	1.000	BOGR
simple IPM vs. climate IPM	rho	t	0.246	169.000	0.403	HECO
simple IPM vs. climate IPM	MAE	t	-1.472	170.000	0.929	HECO
simple QBM vs. climate QBM	rho	t	0.747	169.000	0.228	HECO
simple QBM vs. climate QBM	MAE	t	1.145	170.000	0.127	HECO
simple IPM vs. climate IPM	rho	t	0.201	215.000	0.421	PASM
simple IPM vs. climate IPM	MAE	t	-0.592	216.000	0.723	PASM
simple QBM vs. climate QBM	rho	t	0.631	215.000	0.264	PASM
simple QBM vs. climate QBM	MAE	t	4.276	216.000	0.000	PASM
simple IPM vs. climate IPM	rho	t	-1.072	195.000	0.858	POSE
simple IPM vs. climate IPM	MAE	t	-1.911	196.000	0.971	POSE
simple QBM vs. climate QBM	rho	t	-1.564	195.000	0.940	POSE
simple QBM vs. climate QBM	MAE	t	-2.468	196.000	0.993	POSE

Table S22: Statistical tests of model comparisons. Table shows results from one-sided t-tests for the particular comparison.

comparison	performance_measure	test_type	test_statistic	df	p_value	species
climate IPM vs. simple IPM	rho	t	0.798	279.000	0.213	BOGR
climate IPM vs. simple IPM	MAE	t	1.347	280.000	0.910	BOGR
climate QBM vs. simple QBM	rho	t	0.526	279.000	0.300	BOGR
climate QBM vs. simple QBM	MAE	t	-0.478	280.000	0.317	BOGR
simple IPM vs. simple QBM	rho	t	-0.961	279.000	0.831	BOGR
simple IPM vs. simple QBM	MAE	t	0.088	280.000	0.535	BOGR
climate IPM vs. climate QBM	rho	t	-0.024	279.000	0.509	BOGR
climate IPM vs. climate QBM	MAE	t	2.289	280.000	0.989	BOGR
climate IPM vs. simple IPM	rho	t	0.455	169.000	0.325	HECO
climate IPM vs. simple IPM	MAE	t	-2.292	170.000	0.012	HECO
climate QBM vs. simple QBM	rho	t	0.051	169.000	0.480	HECO
climate QBM vs. simple QBM	MAE	t	-0.746	170.000	0.228	HECO
simple IPM vs. simple QBM	rho	t	-0.461	169.000	0.677	HECO
simple IPM vs. simple QBM	MAE	t	1.626	170.000	0.947	HECO
climate IPM vs. climate QBM	rho	t	-0.299	169.000	0.617	HECO
climate IPM vs. climate QBM	MAE	t	0.289	170.000	0.613	HECO
climate IPM vs. simple IPM	rho	t	-0.883	215.000	0.811	PASM
climate IPM vs. simple IPM	MAE	t	0.410	216.000	0.659	PASM
climate QBM vs. simple QBM	rho	t	-0.008	215.000	0.503	PASM
climate QBM vs. simple QBM	MAE	t	3.218	216.000	0.999	PASM
simple IPM vs. simple QBM	rho	t	0.363	215.000	0.359	PASM
simple IPM vs. simple QBM	MAE	t	-0.276	216.000	0.391	PASM
climate IPM vs. climate QBM	rho	t	0.600	215.000	0.274	PASM
climate IPM vs. climate QBM	MAE	t	-3.487	216.000	0.000	PASM
climate IPM vs. simple IPM	rho	t	1.538	195.000	0.063	POSE
climate IPM vs. simple IPM	MAE	t	-1.844	196.000	0.033	POSE
climate QBM vs. simple QBM	rho	t	1.616	195.000	0.054	POSE
climate QBM vs. simple QBM	MAE	t	-0.963	196.000	0.168	POSE
simple IPM vs. simple QBM	rho	t	1.075	195.000	0.142	POSE
simple IPM vs. simple QBM	MAE	t	-0.788	196.000	0.216	POSE
climate IPM vs. climate QBM	rho	t	1.721	195.000	0.043	POSE
climate IPM vs. climate QBM	MAE	t	-1.830	196.000	0.034	POSE

Table S23: Statistical tests of model comparisons at different forecast horizons. Table shows results from one-sided t-tests for the particular comparison.

comparison	performance_measure	test_type	test_statistic	df	p_value	species	horizon
climate IPM vs. climate QBM	rho	t	-0.305	167.000	0.619	PASM	1.000
climate IPM vs. climate QBM	rho	t	0.262	149.000	0.397	POSE	1.000
climate IPM vs. climate QBM	rho	t	-0.538	129.000	0.704	HECO	1.000
climate IPM vs. climate QBM	rho	t	-1.231	129.000	0.890	BOGR	1.000
climate IPM vs. climate QBM	rho	t	-0.679	150.000	0.751	PASM	2.000
climate IPM vs. climate QBM	rho	t	-0.260	132.000	0.602	POSE	2.000
climate IPM vs. climate QBM	rho	t	-2.385	115.000	0.991	HECO	2.000
climate IPM vs. climate QBM	rho	t	-0.843	114.000	0.799	BOGR	2.000
climate IPM vs. climate QBM	rho	t	-0.109	129.000	0.543	PASM	3.000
climate IPM vs. climate QBM	rho	t	-2.423	112.000	0.992	POSE	3.000
climate IPM vs. climate QBM	rho	t	-2.043	98.000	0.978	HECO	3.000
climate IPM vs. climate QBM	rho	t	0.609	96.000	0.272	BOGR	3.000
climate IPM vs. climate QBM	rho	t	0.497	108.000	0.310	PASM	4.000
climate IPM vs. climate QBM	rho	t	-0.276	94.000	0.608	POSE	4.000
climate IPM vs. climate QBM	rho	t	-0.677	82.000	0.750	HECO	4.000
climate IPM vs. climate QBM	rho	t	0.059	78.000	0.477	BOGR	4.000
climate IPM vs. climate QBM	rho	t	-0.095	91.000	0.538	PASM	5.000
climate IPM vs. climate QBM	rho	t	-0.492	79.000	0.688	POSE	5.000
climate IPM vs. climate QBM	rho	t	-0.894	70.000	0.813	HECO	5.000
climate IPM vs. climate QBM	rho	t	-0.186	65.000	0.573	BOGR	5.000
climate IPM vs. climate QBM	rho	t	-0.365	75.000	0.642	PASM	6.000
climate IPM vs. climate QBM	rho	t	-0.613	66.000	0.729	POSE	6.000
climate IPM vs. climate QBM	rho	t	-2.420	59.000	0.991	HECO	6.000
climate IPM vs. climate QBM	rho	t	0.047	54.000	0.481	BOGR	6.000
climate IPM vs. climate QBM	rho	t	-0.309	62.000	0.621	PASM	7.000
climate IPM vs. climate QBM	rho	t	-0.390	53.000	0.651	POSE	7.000
climate IPM vs. climate QBM	rho	t	-0.752	50.000	0.772	HECO	7.000
climate IPM vs. climate QBM	rho	t	-1.131	44.000	0.868	BOGR	7.000
climate IPM vs. climate QBM	rho	t	-0.353	54.000	0.637	PASM	8.000
climate IPM vs. climate QBM	rho	t	-0.862	47.000	0.803	POSE	8.000
climate IPM vs. climate QBM	rho	t	-0.326	43.000	0.627	HECO	8.000
climate IPM vs. climate QBM	rho	t	-2.599	37.000	0.993	BOGR	8.000

Table S24: Statistical tests of model comparisons at different forecast horizons. Table shows results from one-sided t-tests for the particular comparison. Note the reverse order of comparisons relative to Table S23.

comparison	performance_measure	test_type	test_statistic	df	p_value	species	horizon
climate QBM vs. climate IPM	rho	t	0.305	167.000	0.381	PASM	1.000
climate QBM vs. climate IPM	rho	t	-0.262	149.000	0.603	POSE	1.000
climate QBM vs. climate IPM	rho	t	0.538	129.000	0.296	HECO	1.000
climate QBM vs. climate IPM	rho	t	1.231	129.000	0.110	BOGR	1.000
climate QBM vs. climate IPM	rho	t	0.679	150.000	0.249	PASM	2.000
climate QBM vs. climate IPM	rho	t	0.260	132.000	0.398	POSE	2.000
climate QBM vs. climate IPM	rho	t	2.385	115.000	0.009	HECO	2.000
climate QBM vs. climate IPM	rho	t	0.843	114.000	0.201	BOGR	2.000
climate QBM vs. climate IPM	rho	t	0.109	129.000	0.457	PASM	3.000
climate QBM vs. climate IPM	rho	t	2.423	112.000	0.008	POSE	3.000
climate QBM vs. climate IPM	rho	t	2.043	98.000	0.022	HECO	3.000
climate QBM vs. climate IPM	rho	t	-0.609	96.000	0.728	BOGR	3.000
climate QBM vs. climate IPM	rho	t	-0.497	108.000	0.690	PASM	4.000
climate QBM vs. climate IPM	rho	t	0.276	94.000	0.392	POSE	4.000
climate QBM vs. climate IPM	rho	t	0.677	82.000	0.250	HECO	4.000
climate QBM vs. climate IPM	rho	t	-0.059	78.000	0.523	BOGR	4.000
climate QBM vs. climate IPM	rho	t	0.095	91.000	0.462	PASM	5.000
climate QBM vs. climate IPM	rho	t	0.492	79.000	0.312	POSE	5.000
climate QBM vs. climate IPM	rho	t	0.894	70.000	0.187	HECO	5.000
climate QBM vs. climate IPM	rho	t	0.186	65.000	0.427	BOGR	5.000
climate QBM vs. climate IPM	rho	t	0.365	75.000	0.358	PASM	6.000
climate QBM vs. climate IPM	rho	t	0.613	66.000	0.271	POSE	6.000
climate QBM vs. climate IPM	rho	t	2.420	59.000	0.009	HECO	6.000
climate QBM vs. climate IPM	rho	t	-0.047	54.000	0.519	BOGR	6.000
climate QBM vs. climate IPM	rho	t	0.309	62.000	0.379	PASM	7.000
climate QBM vs. climate IPM	rho	t	0.390	53.000	0.349	POSE	7.000
climate QBM vs. climate IPM	rho	t	0.752	50.000	0.228	HECO	7.000
climate QBM vs. climate IPM	rho	t	1.131	44.000	0.132	BOGR	7.000
climate QBM vs. climate IPM	rho	t	0.353	54.000	0.363	PASM	8.000
climate QBM vs. climate IPM	rho	t	0.862	47.000	0.197	POSE	8.000
climate QBM vs. climate IPM	rho	t	0.326	43.000	0.373	HECO	8.000
climate QBM vs. climate IPM	rho	t	2.599	37.000	0.007	BOGR	8.000