Supplementary Information: Population-scale negative density dependence in per capita population growth rates: understanding the controls on abundance of a common tropical palm.

Marco D. Visser[*1,2], Helene C. Muller-Landau[†2], Joe Wright[‡2], Eelke Jongejans[§1], Hans de Kroon[¶1], Pieter A. Zuidema [‖3], Annieke Borst [**1], Gemma Rutten [††4], and Patrick A. Jansen [‡‡3]

[1]Department of Experimental Plant Ecology, Nijmegen University
[2]Smithsonian Tropical Research Institute, Republic of Panama
[3]Department of Environmental Sciences, Wageningen University
[4]Institute of Plant Sciences, University of Bern

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[*]m.visser@science.ru.nl
[†]mullerh@si.edu
[‡]WRIGHTJ@si.edu
[§]e.jongejans@science.ru.nl
[¶]h.dekroon@science.ru.nl
[‖]email@web.edu
[**]email@web.edu
[††]email@web.edu
[‡‡]email@web.edu

S1 Tables

Vital rate / stage	2008	2010	2012
Seeds	2197		
Recruits		389	214
Seedling growth		353	374
Seedling survival		517	502
Seedling to rosette		6	3
Rosette growth		292	295
Rosette survival		324	321
Rosette to stem		0	7
Stem growth			364
Stem survival			407
Reproduction	407		403

Table S1. table caption in main text

Model	Formulation	Priors	Description
1: Logistic model	$logit(Y(x)) = \beta_0 + \beta_1 x$	$\begin{cases} \beta_0 \sim Unif(-1000, 1000) \\ \beta_1 \sim Unif(-1000, 1000) \end{cases}$	Parameters β_0 indicates the point on x when Y(x) = 0.5, and β_1 is the rate of increase with size (x).
2: density dependant Logistic model	$logit(Y(x)) = \beta_0 + \beta_1 x + \beta_2 d$	$\begin{cases} \beta_0 \sim Unif(-1000, 1000) \\ \beta_1 \sim Unif(-1000, 1000) \\ \beta_2 \sim Unif(-1000, 1000) \end{cases}$	Parameters β_0 indicates the point on x when Y(x) = 0.5, and β_1 is the rate of increase with size (x) while β_2 is the rate of change over adult density d.

Table S2. Equations for all logistic models, including prior distributions, used for dichotomous variables. Details are given in the text.

Model	Formulation	Priors	Description
1: Exponential	$f(x) = \beta_0 e^{-\beta_0 x}$	$\left\{ \beta_0 \sim Unif(0, 100) \right.$	Parameters β_0 is the rate parameter, which indicates the frequency of x at zero and central tendency as mean= $1/\beta_0$ (x).
2: Weibull	$f(x) = \begin{cases} \frac{\beta_0}{\beta_1}(\frac{x}{\beta_1)}e^{-(x/\beta_1)^{\beta_0}}; x \geq 0 \\ 0; x < 0 \end{cases}$	$\begin{cases} \beta_0 \sim Unif(0, 1000) \\ \beta_1 \sim Unif(0, 1000) \end{cases}$	Here β_0 is the scale parameter, while β_1 is shape parameter of the distribution.
3: Log-normal	$f(x) = \frac{1}{x/\sqrt{2\pi\beta_1^2}} e^{-\frac{(lnx-\beta_0)^2}{2\beta_1^2}}$	$\begin{cases} \beta_0 \sim Unif(-1000, 1000) \\ \beta_1 \sim Unif(0, 1000) \end{cases}$	β_0 indicates the natural log of the mean and β_1 is standard deviation.

Table S3. Equations for all probability density functions, used to estimate univariate distributions. Details are given in the text.

Model	Formulation	Priors	Description
1: Null + constant variance	$Y(x) \sim N(\beta_0, \sigma = \beta_2)$	$\begin{cases} \beta_0 \sim Unif(-1000, 1000) \\ \sigma \sim Unif(0, 1000) \end{cases}$	Null model, growth is independent of size, and normally distributed where variation is described by σ^2.
2 A: Size dependent linear + constant variance	$Y(x) \sim N(\beta_0 + \beta_1 x, \sigma = \beta_2)$	$\begin{cases} \beta_{0,1} \sim Unif(-1000, 1000) \\ \sigma \sim Unif(0, 1000) \end{cases}$	Linear model with constant variance. Individual variation is described by σ^2.
3 A: Size dependent linear + Heteroscedasticity	$Y(x) \sim N(\beta_0 + \beta_1 x, \sigma = \beta_2 + \beta_3 x)$	$\begin{cases} \beta_{0,1,2} \sim Unif(-1000, 1000) \\ \beta_3 \sim Unif(0, 1000) \end{cases}$	Linear model, individual variation may increase with size as defined by $\beta_2 + \beta_3 x$, where β_3 is always positive.
4 A: Size dependent linear + Log-linear Heteroscedasticity	$Y(x) \sim N(\beta_0 + \beta_1 x, \sigma = \beta_2 + \beta_3 log(x))$	$\begin{cases} \beta_{0,1,2,4} \sim Unif(-1000, 1000) \\ \beta_3 \sim Unif(0, 1000) \end{cases}$	Linear model, individual variation may increase with size as defined by $\beta_2 + \beta_3 log(x)$, where β_3 is always positive.
2 B: Size & density dependent linear + constant variance	$Y(x) \sim N(\beta_0 + \beta_1 x + \beta_4 d, \sigma = \beta_2)$	$\begin{cases} \beta_{0,1,2} \sim Unif(-1000, 1000) \\ \sigma \sim Unif(0, 1000) \end{cases}$	Linear model where Y dependent on size (x) and density (d). Individual variation is described by σ^2.
3 B: Size & density dependent linear + Heteroscedasticity	$Y(x) \sim N(\beta_0 + \beta_1 x + \beta_4 d, \sigma = \beta_2 + \beta_3 x)$	$\begin{cases} \beta_{0,1,2,4} \sim Unif(-1000, 1000) \\ \beta_3 \sim Unif(0, 1000) \end{cases}$	Linear model where Y dependent on size (x) and density (d). Individual variation may increase with size as defined by $\beta_2 + \beta_3 x$, where β_3 is always positive.
4 B: Size & density dependent linear + Log-linear Heteroscedasticity	$Y(x) \sim N(\beta_0 + \beta_1 x + \beta_4 d, \sigma = \beta_2 + \beta_3 log(x))$	$\begin{cases} \beta_{0,1,2,4} \sim Unif(-1000, 1000) \\ \beta_3 \sim Unif(0, 1000) \end{cases}$	Linear model where Y dependent on size (x) and density (d). Individual variation may increase with size as defined by $\beta_2 + \beta_3 log(x)$, where β_3 is always positive.

Table S4. Equations for all linear models, including prior distributions, used for continuous dependent variables. Details are given in the text.

Vital.rate	Posterior.model.probabilty	Form
Density independent Seedling establishment	0.0613	$E(a) = logit^{-1}(\beta_0)$
Density dependent Seedling establishment	0.9387	$E(\bar{a}) = logit^{-1}(\beta_0 + \beta_4 a)$
Density independent Initial size	0.4954	$L(x_s) \sim \frac{1}{x_s/\sqrt{2\pi\beta_1^2}} e^{-\frac{(ln x_s - (\beta_0))^2}{2\beta_1^2}}$
Density dependent Initial size	0.5046	$L(x_s) \sim \frac{1}{x_s/\sqrt{2\pi\beta_1^2}} e^{-\frac{(ln x_s - (\beta_0 + \beta_4 a))^2}{2\beta_1^2}}$
Density independent Seedling growth	0.0847	$G_s(x_s, a) = \beta_0 + \beta_1 x_s$ & $V_s(x_s) = \beta_2 + \beta_3 x_s$
Density dependent Seedling growth	0.9153	$G_s(x_s, a) = \beta_0 + \beta_1 x_s + \beta_4 a$ & $V_s(x_s) = \beta_2 + \beta_3 x_s$
Density independent Seedling survival	0.9113	$S_s(x_s, a) = logit^{-1}(\beta_0 + \beta_1 x_s)$
Density dependent Seedling survival	0.0887	$S_s(x_s, a) = logit^{-1}(\beta_0 + \beta_1 x_s + \beta_4 a)$
Density independent Rosette growth	0.3416	$G_r(x_r, a) = \beta_0 + \beta_1 x_r$ & $V_r(x_r) = \beta_2 + \beta_3 ln(x_r)$
Density dependent Rosette growth	0.6584	$G_r(x_r, a) = \beta_0 + \beta_1 x_r + \beta_4 a$ & $V_r(x_r) = \beta_2 + \beta_3 ln(x_r)$
Density independent Rosette survival	0.8040	$S_r(x_r, a) = logit^{-1}(\beta_0 + \beta_1 x_r)$
Density dependent Rosette survival	0.1960	$S_r(x_r, a) = logit^{-1}(\beta_0 + \beta_1 x_r + \beta_4 a)$
Density independent Adult growth	0.5788	$G_h(x_h, a) = \beta_0 + \beta_1 x_h$ & $\sigma = \beta_2$
Density dependent Adult growth	0.4212	$G_h(x_h, a) = \beta_0 + \beta_1 x_h + \beta_4 a$ & $\sigma = \beta_2$
Density independent Adult survival	0.2351	$S_h(x_h, a) = logit^{-1}(\beta_0 + \beta_1 x_h)$
Density dependent Adult survival	0.7649	$S_h(x_h, a) = logit^{-1}(\beta_0 + \beta_1 x_h + \beta_4 a)$
Density independent Reproduction	0.2824	$S_h(x_h, a) = logit^{-1}(\beta_0 + \beta_1 x_h)$
Density dependent Reproduction	0.7176	$S_h(x_h, a) = logit^{-1}(\beta_0 + \beta_1 x_h + \beta_4 a)$

Table S5. table caption in main text

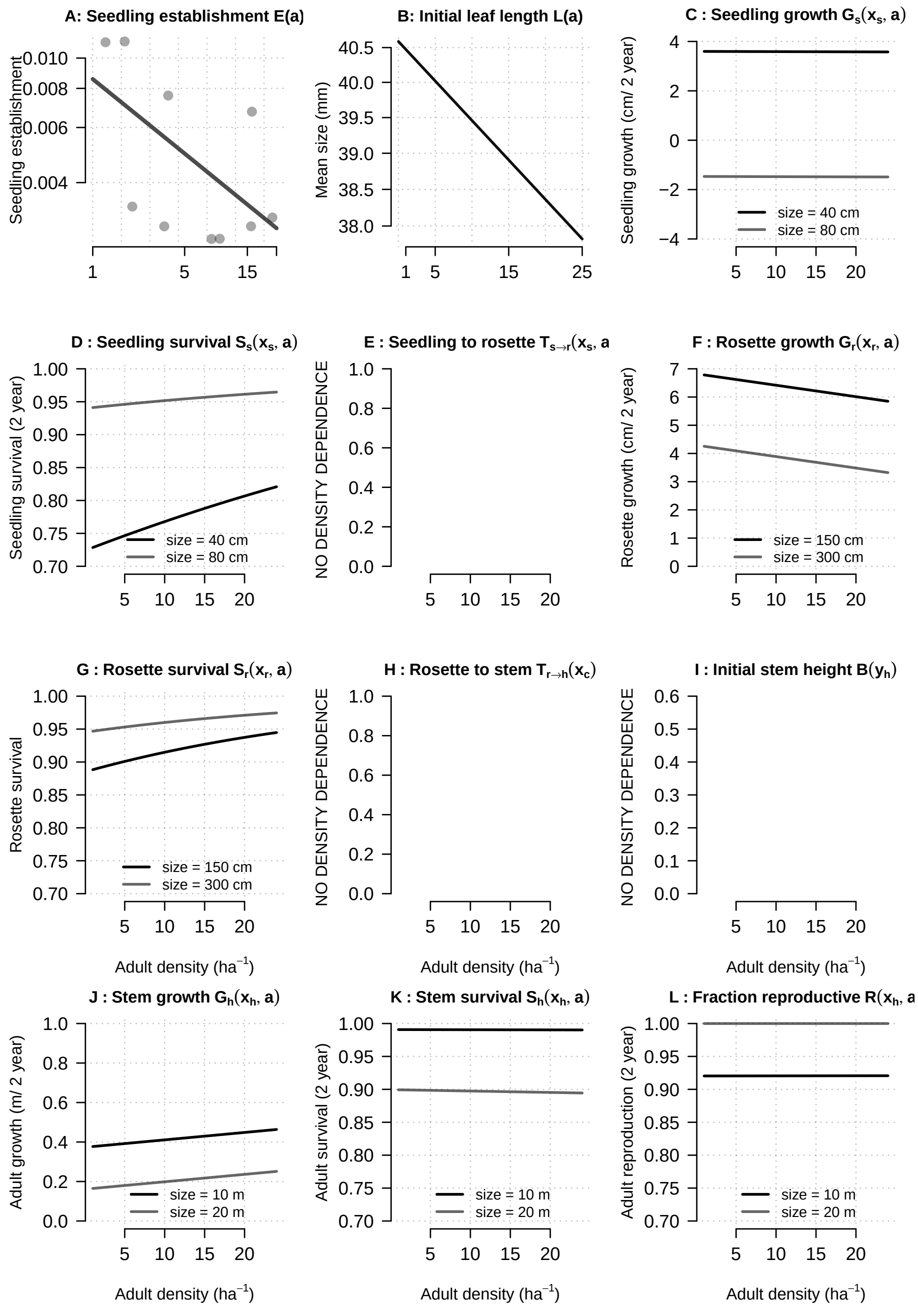
	Vital rate	β_0 (intercept/rate)	β_1 (size/sd)	Formula
1	Seedling to rosette	10.90	-0.09	$T_{s\rightarrow r}(x_s) = logit^{-1}(\beta_0 + \beta_4 x_s)$
2	Rosette to stemmed palm	9.21	-0.01	$T_{r\rightarrow h}(x_r) = logit^{-1}(\beta_0 + \beta_4 x_r)$
3	Initial size	7.43	0.00	$B(x_h) = \beta_0 e^{-\beta_0 x_h}$

Table S6. table caption in main text

	Inv. growth (2.5%)	Inv. growth (97.5%)	Stabilization θ (2.5%)	Stabilization θ (97.5%)	Eq. density (2.5%)	Eq. density (97.5%)
Seedling to rosette (midpoint)	1.0442	1.0580	-0.0289	-0.0103	0.3779	0.9424
Rosette to stem (midpoint)	1.0417	1.0598	-0.0289	-0.0116	0.3567	0.8573
Size-dependent seedling to rosette	1.0473	1.0492	-0.0200	-0.0198	0.4657	0.5424
Size-dependent rosette to stem	1.0481	1.0484	-0.0202	-0.0197	0.4719	0.5117

Table S7. table caption in main text

S2 Figures



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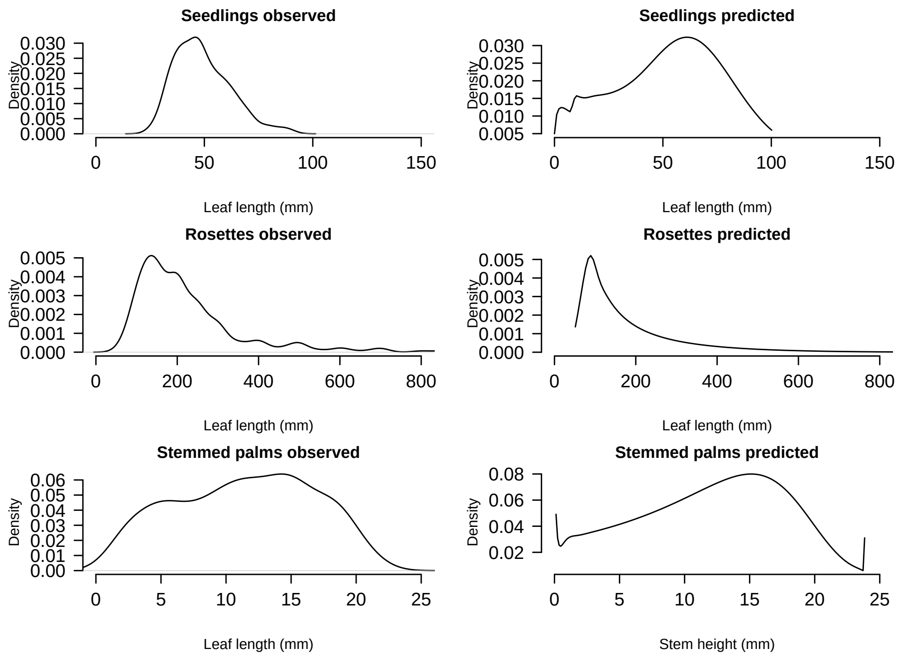

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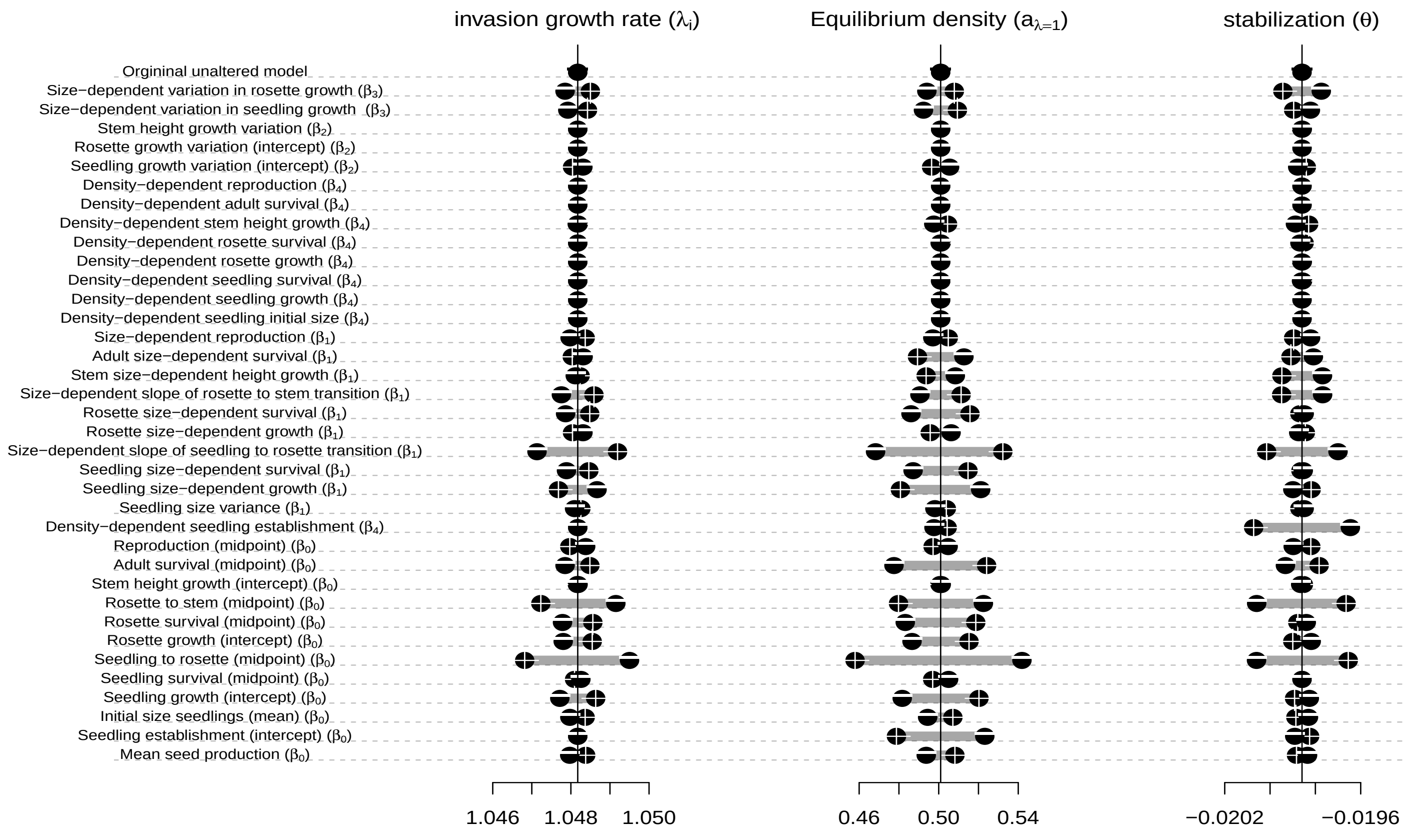

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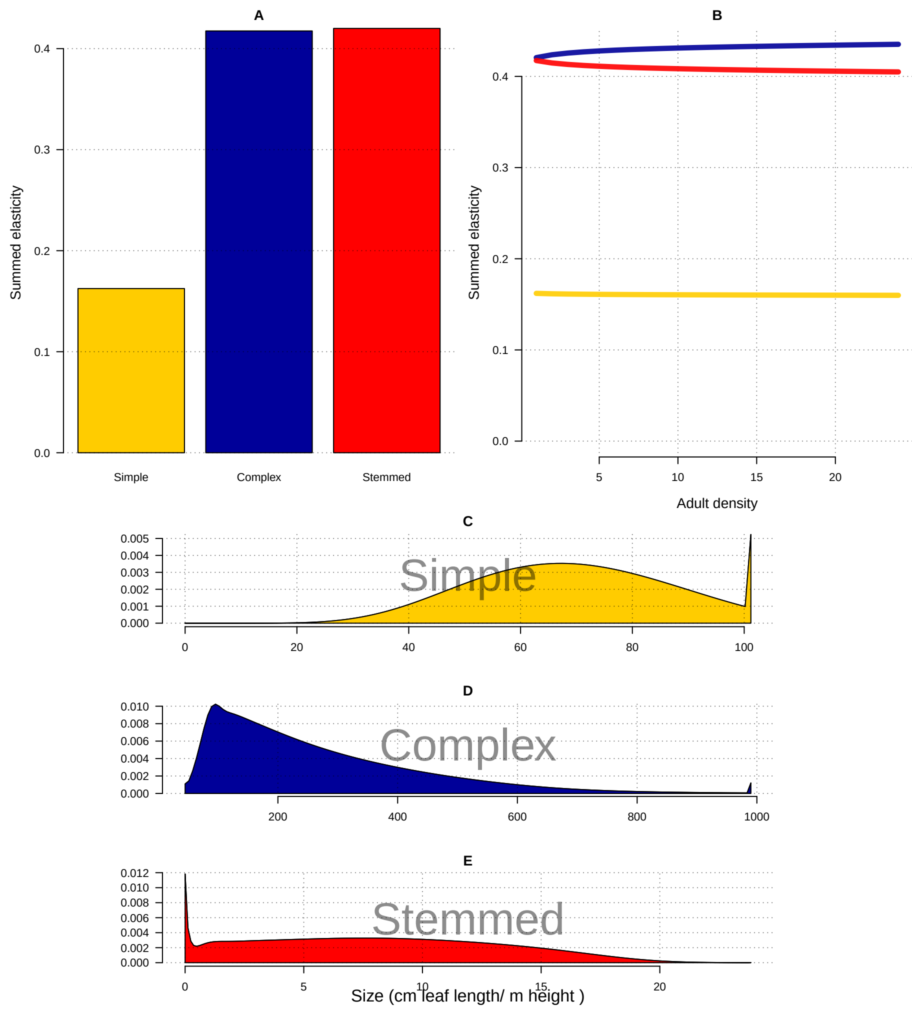

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