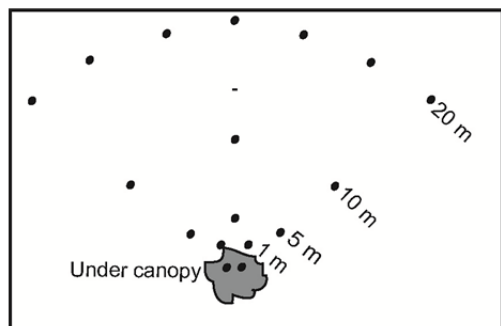


1

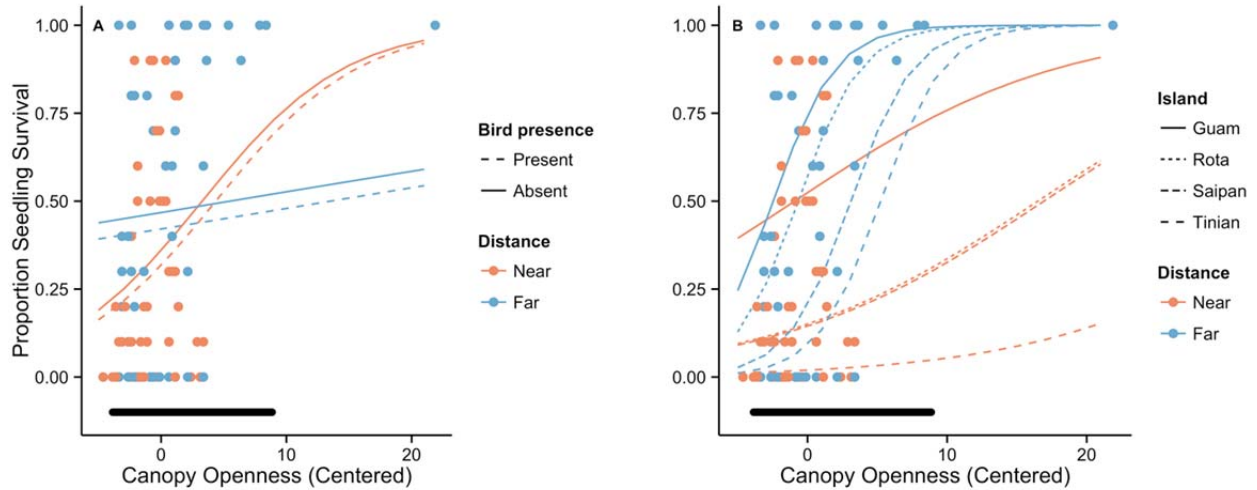


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3 **Supplementary Figure 1| Seed trap array configuration:** The focal tree is in grey; other trees
4 present at each site were mapped and included in the analysis, but are not shown here. Each black
5 dot represents a seed trap.

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9 **Supplementary Figure 2| Distance-dependent mortality:** Seedling survival of a) *Psychotria* and

10 b) *Premna* near (orange) and far (blue) from conspecific trees on islands with (dashed lines) and

11 without (solid line) dispersers, as a function of canopy openness (centered so a value of zero

12 corresponds to the mean openness of 9.12%). Model fits (lines) are plotted over observed data.

13 Bars at the bottom of each panel indicate the 95% quantiles of canopy openness across all species

14 and site.

Supplementary Table 1: Seed Dispersers in the Marianas. Distribution of avian seed dispersers in the Mariana Islands, and whether each species has been observed consuming *Psychotria* or *Premna* fruits in the wild during >100 hours of fruiting tree observations per species. Data on the Mariana Crow diet is supplemented by observations reported in Faegre¹. P=present and frugivory observations. P = currently present, HP = historically present but now extinct in the wild, A = absent.

Species	Guam	Rota	Tinian	Saipan	Psychotria	Premna
Micronesian Starling (<i>Aplonis opaca</i>)	P	P	P	P	Yes	Yes
Mariana Fruit Dove (<i>Ptilinopus roseicapilla</i>)	HP	P	P	P	Yes	Yes
White-throated Ground Dove (<i>Gallicolumba xanthonura</i>)	HP	P	P	P	No	Yes
Bridled White-eye (<i>Zosterops conspicillatus</i>)	HP	A	P	P	Yes	Yes
Rota Bridled White-eye (<i>Zosterops rotensis</i>)	A	P	A	A	No data	No data
Mariana Crow (<i>Corvus kubaryi</i>)	HP	P	A	A	Yes	Yes
Golden White-eye (<i>Cleptornis marchei</i>)	A	A	HP	P	Yes	Yes

26 **Supplementary Table 2: Proportion Seeds Ingested model coefficients.** Results from species-
 27 specific generalized linear mixed-effects models comparing the effect of island on the proportion
 28 seeds ingested for each plant species. Upon confirmation that the best-fitting model included island
 29 (based on AICc comparison with a null model; *Psychotria* $\Delta\text{AIC}_c = 11.48$; *Premna* $\Delta\text{AIC}_c =$
 30 11.40), we estimated 95% confidence intervals around the coefficients for each island using profile
 31 likelihood. Guam was set as the reference level for these treatment contrasts. Confidence intervals
 32 that do not include zero are in bold.

Factor Level	Coefficient (lower, upper CI)
<i>Psychotria</i>	
Intercept (Guam)	-4.13 (-5.59, -2.98)
Saipan	4.33 (2.71, 6.27)
Tinian	2.85 (1.23, 4.79)
Rota	3.32 (1.66, 5.38)
<i>Premna</i>	
Intercept (Guam)	-2.76 (-3.74, -1.80)
Saipan	3.84 (2.51, 5.33)
Tinian	2.24 (0.87, 3.63)
Rota	2.92 (1.55, 4.31)

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Supplementary Table 3: Germination Experiment model coefficients. Results from species-specific generalized linear models comparing the effect of seed condition (ingested by birds, mechanically de-pulped, whole fruit) on germination. Upon confirmation that the best-fitting model included treatment (based on AIC_c comparison with a null model; *Psychotria* $\Delta\text{AIC}_c = 31.05$, *Premna* $\Delta\text{AIC}_c = 33.5$), we estimated 95% confidence intervals around the coefficients for each treatment using profile likelihood, first using treatment contrasts with ‘whole fruit’ as the reference level, and then using treatment contrasts with ‘pulp manually removed’ as the reference level. Confidence intervals that do not include zero are in bold.

Reference Level	Factor Level	Coefficient (lower, upper CI)
<i>Psychotria</i>		
Whole fruit	Intercept	-1.85 (-2.34, -1.42)
	Pulp removed	0.65 (0.05, 1.26)
	Ingested	2.05 (1.52, 2.62)
Pulp Removed	Intercept	-1.20 (-1.61, -0.83)
	Ingested	1.40 (0.92, 1.90)
<i>Premna</i>		
Whole fruit	Intercept	-0.54 (-0.93, -0.17)
	Pulp removed	0.11 (-0.43, 0.66)
	Ingested	1.39 (0.88, 1.91)
Pulp Removed	Intercept	-0.43 (-0.83, -0.04)
	Ingested	1.28 (0.75, 1.81)

Supplementary Table 4: Seed Ingestion Relative to Distance model coefficients. Results from generalized linear mixed-effects models examining how the proportion of seeds ingested varies with the distance to the nearest conspecific tree. Only data from Saipan, Tinian, and Rota were included, as few seeds were found >5 m from a conspecific tree on Guam. Upon confirmation that the best-fitting model included an island by distance interaction (based on AICc comparison with all sub-models; *Psychotria* $\Delta AIC_c = 25.38$; *Premna* $\Delta AIC_c = 91.65$), we estimated 95% confidence intervals around the coefficients for each island using profile likelihood. Rota was set as the reference level for these treatment contrasts. Confidence intervals that do not include zero are in bold.

Factor Level	Coefficient (lower, upper CI)
<i>Psychotria</i>	
Intercept (Rota)	-2.30 (-3.12, -1.26)
Saipan	1.20 (-0.12, 2.26)
Tinian	0.45 (-0.87, 1.50)
Rota×Distance	0.46 (0.35, 0.58)
Saipan×Distance	0.12 (-0.02, 0.26)
Tinian×Distance	-0.15 (-0.29, -0.03)
<i>Premna</i>	
Intercept (Rota)	0.28 (-0.97, 1.52)
Saipan	0.04 (-1.68, 1.89)
Tinian	-1.51 (-3.28, 0.24)
Rota×Distance	-0.03 (-0.08, 0.02)
Saipan×Distance	0.27 (0.21, 0.32)
Tinian×Distance	0.28 (0.22, 0.34)

Supplementary Table 5: Dispersal Kernel model selection. Model selection for dispersal kernels fitted to seed trap data for two tree species on Guam and three nearby islands where native frugivorous birds are present. Kernels were either power-exponential (PE) or 2Dt, and the scale parameter was either identical for all islands (no island effects), distinct for Guam but identical on the other islands, or distinct for each island. All models include random site-level variation in tree fecundity per basal area. For each species, models are ranked in order of decreasing strength of evidence. MCMC output is summarized as posterior mean deviance ($\overline{D(\theta)}$), effective parameter dimension (p_V), differences in deviance information criterion (ΔDIC), model weight (w_{DIC}), and the posterior mean squared correlation (R^2) between fitted and observed $\log(\text{seeds} + 1)$.

Kernel	Island effects	$\overline{D(\theta)}$	p_V	ΔDIC	w_{DIC}	R^2
<i>Psychotria</i>						
2Dt	Guam vs. others	1368.49	23.99	0.00	0.845	0.59
2Dt	all distinct	1367.47	29.00	3.99	0.115	0.60
PE	Guam vs. others	1376.17	23.64	7.33	0.022	0.59
PE	all distinct	1374.04	26.16	7.72	0.018	0.59
2Dt	none	1392.96	22.62	23.10	0.000	0.57
PE	none	1396.07	24.91	28.51	0.000	0.55
<i>Premna</i>						
PE	Guam vs. others	1771.85	26.10	0.00	0.903	0.39
PE	all distinct	1771.17	31.46	4.68	0.087	0.39
2Dt	Guam vs. others	1782.42	24.79	9.26	0.009	0.37
2Dt	all distinct	1780.86	31.12	14.03	0.001	0.37
2Dt	none	1795.89	22.69	20.63	0.000	0.40
PE	none	1802.48	24.86	29.39	0.000	0.38

66 **Supplementary Table 6: Dispersal Kernel parameter estimates.** Parameter estimates (posterior means and 95% credible intervals)
67 for dispersal kernels fitted to seed trap data for two tree species on Guam and three nearby islands where native frugivorous birds are
68 present. Kernels were either power-exponential (PE) or 2Dt, and the scale parameter was either identical for all islands (no island
69 effects), distinct for Guam but identical on the other islands, or distinct for each island. All models include site-level variation in tree
70 fecundity per basal area as a lognormally distributed random effect with log-mean μ_β and SD σ_β . The island-specific kernel scale
71 parameters for Guam, Rota, Saipan, and Tinian are a_G , a_R , a_S , and a_T respectively; note that some of these may be identical depending
72 on the model structure. The negative binomial likelihood includes variance parameters k_1 and k_2 .

Kernel	Island effects	μ_β	σ_β	a_G	a_R	a_S	a_T	k_1	k_2
<i>Psychotria</i>									
2Dt	Guam vs. others	4.22 (3.38, 5.06)	1.17 (0.57, 2.14)	0.46 (0.19, 0.86)	3.42 (2.49, 4.61)	3.42 (2.49, 4.61)	3.42 (2.49, 4.61)	7.13 (2.02, 19.42)	2.02 (1.48, 2.62)
2Dt	all distinct	4.3 (3.5, 5.05)	0.98 (0.44, 1.83)	0.46 (0.21, 0.84)	7.81 (3.01, 21.4)	3.91 (2.5, 5.78)	2.49 (1.5, 3.82)	9.45 (2.38, 27.4)	1.93 (1.33, 2.55)
PE	Guam vs. others	4.06 (3.27, 4.76)	1.1 (0.55, 2)	0.05 (0.03, 0.09)	0.28 (0.19, 0.43)	0.28 (0.19, 0.43)	0.28 (0.19, 0.43)	10.03 (2.18, 30.96)	1.96 (1.36, 2.59)
PE	all distinct	4.17 (3.42, 4.82)	0.96 (0.46, 1.74)	0.05 (0.03, 0.08)	0.8 (0.24, 2.28)	0.31 (0.19, 0.53)	0.17 (0.1, 0.31)	11.47 (2.45, 32.9)	1.88 (1.26, 2.52)
2Dt	none	3.95 (2.93, 4.94)	1.57 (0.86, 2.67)	2.19 (1.5, 2.93)	2.19 (1.5, 2.93)	2.19 (1.5, 2.93)	2.19 (1.5, 2.93)	4.48 (1.22, 12.23)	2.43 (1.84, 3.13)
PE	none	3.94 (3.03, 4.76)	1.34 (0.71, 2.34)	0.21 (0.14, 0.38)	0.21 (0.14, 0.38)	0.21 (0.14, 0.38)	0.21 (0.14, 0.38)	14.31 (1.59, 75.07)	2.19 (1, 3.04)

Premna

PE	Guam vs. others	3.74 (2.55, 4.95)	1.93 (1.11, 3.23)	0.06 (0.04, 0.09)	0.41 (0.23, 0.74)	0.41 (0.23, 0.74)	0.41 (0.23, 0.74)	3.09 (1.04, 11.07)	3 (2.47, 3.64)
PE	all distinct	3.94 (2.75, 5.09)	1.84 (1.02, 3.13)	0.06 (0.04, 0.09)	1.13 (0.07, 9.2)	0.71 (0.25, 2.08)	0.39 (0.19, 0.88)	3.02 (1.03, 10.47)	3 (2.45, 3.67)
2Dt	Guam vs. others	3.82 (2.65, 5.07)	1.91 (1.09, 3.26)	0.86 (0.21, 1.78)	4.78 (3.08, 7.41)	4.78 (3.08, 7.41)	4.78 (3.08, 7.41)	3.94 (1.01, 14.88)	3.18 (2.6, 3.86)
2Dt	all distinct	3.98 (2.74, 5.43)	1.89 (1.04, 3.31)	0.82 (0.21, 1.71)	8.26 (0.63, 76.97)	7.55 (3.74, 15.04)	4.3 (2.18, 7.63)	3.96 (1.03, 14.43)	3.15 (2.57, 3.83)
2Dt	none	3.67 (2.34, 4.93)	2.14 (1.27, 3.54)	2.72 (1.79, 3.76)	2.72 (1.79, 3.76)	2.72 (1.79, 3.76)	2.72 (1.79, 3.76)	2.64 (0.94, 8.35)	3.4 (2.77, 4.16)
PE	none	3.72 (2.46, 5.01)	2.13 (1.26, 3.63)	0.19 (0.13, 0.28)	0.19 (0.13, 0.28)	0.19 (0.13, 0.28)	0.19 (0.13, 0.28)	2.82 (0.93, 9.4)	3.48 (2.84, 4.29)

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77 **Supplementary Table 7: Dispersal kernel summary statistics.** Summary statistics for the
 78 marginal distribution of seed dispersal distance (m) away from the parent tree. Estimates are
 79 based on dispersal kernels fitted to seed trap data for two species on Guam and three nearby
 80 islands where native frugivorous birds remain. The best-supported kernel model for each species
 81 was used to calculate the mean and mode of dispersal distance and the probability that a seed
 82 lands beneath the canopy of the parent (a distance of 2 m or 4 m for *Psychotria* or *Premna*
 83 respectively, based on the typical crown radius of trees measured at our study sites). Posterior
 84 means are shown, with 95% credible intervals in parentheses.

Kernel	Island	Mean	Mode	$P(r < r_c)$
<i>Psychotria</i>				
2Dt	Guam	0.73 (0.29, 1.35)	0.63 (0.38, 0.92)	0.94 (0.84, 0.99)
2Dt	islands with birds	5.37 (3.91, 7.24)	2.03 (1.69, 2.42)	0.26 (0.16, 0.39)
<i>Premna</i>				
PE	Guam	1.18 (0.78, 1.74)	0.24 (0.16, 0.35)	0.96 (0.91, 0.99)
PE	islands with birds	8.19 (4.63, 14.87)	1.64 (0.93, 2.97)	0.40 (0.20, 0.60)

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Supplementary Table 8: Model comparison for seedling distance-dependent mortality study. Model comparison for generalized linear mixed-effects models examining the effect of distance (near/far), bird presence (yes/no) or island, canopy openness, and the interaction between distance and canopy openness and distance and bird presence/island on seedling survival of *Psychotria* and *Premna*.

Model	ΔAIC_c	# parameters	AIC_c weights
<i>Psychotria</i>			
Distance×Canopy + Bird	0	6	0.73
Distance×Canopy + Distance×Bird	2.34	7	0.23
Distance×Canopy + Distance×Island	7.71	9	0.02
Distance + Canopy	8.05	4	0.01
Canopy	9.95	3	0.01
Distance + Canopy + Bird	10.19	5	0.00
Canopy + Bird	12.08	4	0.00
Distance	18.82	3	0.00
Distance + Bird	20.19	4	0.00
Bird	22.47	3	0.00
<i>Premna</i>			
Distance×Canopy + Distance×Island	0	11	0.61
Distance×Canopy + Island	1.17	8	0.34
Distance×Canopy + Distance×Bird	5.44	7	0.04
Distance + Canopy + Island	8.81	7	0.01
Distance + Canopy	19.67	4	0
Canopy + Island	40.04	6	0
Canopy	50.41	3	0
Distance + Island	134.24	6	0
Distance	148.95	3	0
Island	201.23	5	0

Supplementary Table 9: Seedling distance-dependent mortality model coefficients.

Estimated coefficients and confidence intervals for the best-fitting generalized linear mixed-effects model examining the effect of distance (near/far), bird presence (yes/no) or island, and canopy openness on seedling survival of *Psychotria* and *Premna*. We used profile likelihoods to estimate 95% confidence intervals around the coefficients, based on treatment contrasts with Guam (no birds) and distance=near as the reference levels. The two species (*Psychotria* and *Premna*) were analyzed separately. Confidence intervals that do not include zero are in bold.

Factor Level	Coefficient (lower, upper CI)
<i>Psychotria</i>	
Intercept (Distance = Near, Bird = Yes)	-0.76 (-1.28, -0.26)
Distance = Far	0.45 (0.09, 0.80)
Canopy openness	0.18 (0.10, 0.26)
Bird = No	0.19 (-0.63, 1.00)
Distance = Far $\times$ Canopy	-0.15 (-0.25, -0.06)
<i>Premna</i>	
Intercept (Distance = Near, Island = Guam)	0.09 (-0.70, 0.89)
Island = Rota	-1.81 (-3.17, -0.48)
Island = Saipan	-1.87 (-3.21, -0.55)
Island = Tinian	-4.00 (-6.32, -2.15)
Distance = Far	1.01 (0.52, 1.5)
Canopy	0.10 (-0.06, 0.25)
Distance = Far $\times$ Canopy	0.36 (0.17, 0.55)
Island = Rota $\times$ Distance = Far	0.86 (0.002, 1.73)
Island = Saipan $\times$ Distance = Far	-0.62 (0.149, 0.26)
Island = Tinian $\times$ Distance = Far	0.61 (-1.02, 2.63)

104 **Supplementary Table 10: Model comparison for study on distance-dependent mortality**
 105 **during germination and early seedling survival stages.** Model comparison for generalized
 106 linear models examining the effect of distance (near/far), canopy openness, and the study site on
 107 germination and early seedling survival of *Premna*.

Model	ΔAIC_c	# parameters	AIC_c weights
Germination			
Distance	0	2	0.48
Distance + Site	1.98	4	0.18
Distance + Site + Canopy	3.25	5	0.09
Canopy	3.31	2	0.09
Site + Canopy	4.52	4	0.05
Null	4.52	1	0.05
Distance×Canopy + Site	5.85	6	0.03
Site	5.97	3	0.02
Seedling Survival			
Distance + Site + Canopy	0	5	0.36
Distance + Site	0.53	3	0.28
Distance	1.10	2	0.21
Distance×Canopy + Site	2.03	6	0.13
Canopy + Site	5.85	4	0.02
Canopy	8.45	2	0.01
Site	8.51	3	0.01
Null	13.69	1	0.00

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Supplementary Table 11: Fitted parameters for distance-dependent mortality model

focused on germination and early seedling survival . Estimated coefficients and confidence intervals for the best-fitting generalized linear model examining the effect of distance (near/far), canopy openness, and site on germination and early seedling survival of *Premna*. We used profile likelihoods to estimate 95% confidence intervals around the coefficients, based on treatment contrasts with site=FORBI and distance=near as the reference levels. The two life stages (germination and early seedling survival) were analyzed separately. Confidence intervals that do not include zero are in bold.

Factor Level	Coefficient (lower, upper CI)
Germination	
Intercept (Distance = Near, Site = FORBI)	-2.75 (-3.04, -2.48)
Distance = Far	0.47 (0.12, 0.84)
Seedling Survival	
Intercept (Distance = Near, Site = FORBI)	-2.79 (-4.33, -1.64)
Distance = Far	1.72 (0.53, 3.22)
Canopy	0.21 (-0.02, 0.46)
Site = LADT	-0.69 (-2.29, 0.66)
Site = MTR1	0.67 (-0.32, 1.78)

121 **Supplementary Table 12: Integrative Metric of Bird Loss.** Predictions were generated by
 122 combining experimentally parameterized models of seed dispersal, seed ingestion by birds, seed
 123 germination, and seedling survival.

	Relative survival without birds	
Island	<i>Psychotria</i>	<i>Premna</i>
Guam	0.28 (0.17, 0.41)	0.13 (0.05, 0.28)
Rota	0.38 (0.24, 0.54)	0.10 (0.03, 0.21)
Saipan	0.28 (0.18, 0.41)	0.13 (0.04, 0.29)
Tinian	0.39 (0.25, 0.54)	0.08 (0.02, 0.23)

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126 **Supplementary References**

- 127 1.Faegre, S. K. Age-related differences in diet and foraging behavior of the critically endangered Mariana Crow
128 (Corvus kubaryi). (2014). Masters Thesis, University of Washington. Seattle. 35 p.