 DOI: 10.1086/679576

Appendix F from X. Xiao et al., "A Strong Test of the Maximum Entropy Theory of Ecology"

(Am. Nat., vol. 185, no. 3, p. E70)

Model Comparison for the Individual Size Distribution (ISD)

Muller-Landau et al. (2006) proposed four possible distributions (exponential, Pareto, Weibull, and quasi-Weibull) for diameter in old-growth forests under different assumptions of growth and mortality. Here, we compare the fit of three of the four distributions (exponential, Pareto, and Weibull) to the fit of the ISD predicted by the maximum entropy theory of ecology (METE; eq. [4]) using data from the 60 forest communities. The quasi-Weibull distribution, which has been shown to provide the best fit for the majority of communities (Muller-Landau et al. 2006), is not evaluated due to the difficulty in obtaining its maximum likelihood parameters when it is left truncated.

All distributions are left truncated to account for the fact that individuals below the minimal threshold in each community were excluded from the data sets. With the minimal size rescaled as 1 across communities (see "Methods"), the left-truncated exponential distribution takes the form

$$f(D) = \lambda e^{-\lambda(D-1)}, \tag{F1}$$

the left-truncated Pareto distribution takes the form

$$f(D) = \frac{\alpha}{D^{\alpha+1}}, \tag{F2}$$

and the left-truncated Weibull distribution takes the form

$$f(D) = \frac{k}{\lambda}\left(\frac{D}{\lambda}\right)^{k-1} e^{-(D/\lambda)^k}/e^{-(1/\lambda)^k}, \tag{F3}$$

where the diameter $D \geq 1$ for all three distributions.

Parameters in equations (F1), (F2), and (F3) were obtained with the maximum likelihood (MLE) method for each community. While analytical solutions exist for parameters in equation (F1) and equation (F2), MLE solutions for parameters in equation (F3) can only be obtained numerically. The three distributions of D were then transformed into distributions of D^2 (surrogate for metabolic rate; see "Methods") to be consistent with METE's prediction (eq. [4]) as

$$g(D^2) = \frac{1}{2D}f(D), \tag{F4}$$

where $f(D)$ is the left-truncated exponential, Pareto, or Weibull distribution in equation (F1), (F2), or (F3).

The fit of the ISD predicted by METE and the other three distributions was evaluated with Akaike's information criterion (AIC; Burnham and Anderson 2002). Corrected AIC (AIC_c), a second-order variant of AIC that corrects for finite sample size, was computed for each distribution as

$$\text{AIC}_c = 2k - 2\ln(L) + \frac{2k(k+1)}{n-k-1}, \tag{F5}$$

where k is the number of parameters in the corresponding distribution, n is the number of individuals in the community, and L is the likelihood of the distribution across all individuals (Burnham and Anderson 2002). Within a community, the distribution with a lower AIC_c value provides a better fit.

Our results show that overall the Weibull distribution provides the best fit for the ISD, which outperforms the other three distributions (i.e., has the smallest AIC_c value) in 50 of 60 communities. While METE is exceeded by the Weibull distribution in all except three communities, its performance is comparable to that of the other two distributions, with METE outperforming the exponential distribution in 24 communities and the Pareto distribution in 33 (table F1).

Table F1. Corrected Akaike's information criterion (AIC_c) values for the four distributions of the individual size distribution across communities

		AIC_c			
Data set	Site	Exponential	Pareto	Weibull	METE
UCSC FERP	FERP	85,971.15	82,823.11	**81,893.76**	88,390.74
ACA Amazon Forest Inventories	eno-2	3,047.892	3,123.951	**3,037.737**	3,048.544
Western Ghats	BSP104	8,447.378	8,232.82	**8,147.375**	8,597.933
Western Ghats	BSP11	9,670.786	9,737.739	**9,565.319**	9,756.008
Western Ghats	BSP12	8,072.348	7,580.985	**7,580.105**	8,005.097
Western Ghats	BSP16	6,505.854	6,465.984	**6,371.536**	6,473.227
Western Ghats	BSP27	4,158.854	4,352.934	**4,154.657**	4,168.587
Western Ghats	BSP29	5,200.085	5,601.832	**5,186.167**	5,246.872
Western Ghats	BSP30	**5,228.032**	5,550.478	5,229.22	5,272.148
Western Ghats	BSP36	5,363.257	4,997.568	**4,994.507**	5,613.485
Western Ghats	BSP37	6,648.723	**5,882.951**	5,940.894	6,702.201
Western Ghats	BSP42	4,862.353	4,579.541	**4,572.774**	4,912.597
Western Ghats	BSP5	6,316.684	**5,868.932**	5,879.056	6,344.512
Western Ghats	BSP6	8,362.132	8,224.467	**8,144.515**	8,368.706
Western Ghats	BSP65	10,730.14	10,597.32	10,418.12	**10,323.55**
Western Ghats	BSP66	6,127.039	6,078.716	**5,969.159**	6,118.758
Western Ghats	BSP67	5,733.979	6,116.641	**5,713.447**	5,970.901
Western Ghats	BSP69	9,639.039	9,839.743	**9,566.506**	9,677.272
Western Ghats	BSP70	7,568.366	7,643.62	7,475.877	**7,471.337**
Western Ghats	BSP73	**13,866.8**	14,638.34	13,867.97	14,056.6
Western Ghats	BSP74	10,384.88	10,164.99	**10,043.66**	10,178.07
Western Ghats	BSP75	**3,828.718**	4,032.776	3,830.225	3,844.366
Western Ghats	BSP79	10,012.15	10,192.38	**9,943.069**	10,014.63
Western Ghats	BSP80	10,351.04	10,721.97	**10,333.53**	10,392.1
Western Ghats	BSP82	7,775.241	8,109.038	**7,766.727**	7,779.842
Western Ghats	BSP83	**10,080.84**	10,603.67	10,082.84	10,184.62
Western Ghats	BSP84	9,941.77	10,676.22	**9,906.56**	10,087.81
Western Ghats	BSP85	4,090.759	4,051.023	**3,986.417**	4,092.965
Western Ghats	BSP88	9,539.878	10,007.25	9,532.9	**9,468.538**
Western Ghats	BSP89	7,758.469	8,040.773	**7,746.257**	7,749.632
Western Ghats	BSP90	7,802.77	8,287.765	**7,800.707**	7,891.673
Western Ghats	BSP91	8,443.673	9,081.623	**8,392.871**	8,709.277
Western Ghats	BSP92	5,010.321	5,156.128	**4,980.47**	5,037.136
Western Ghats	BSP94	4,995.435	5,113.566	**4,949.09**	4,997.738
Western Ghats	BSP98	6,338.305	6,535.699	**6,312.535**	6,336.033
Western Ghats	BSP99	8,329.191	8,461.831	**8,238.427**	8,268.363
BCI	bci	1,663,761	1,595,835	**1,580,094**	1,616,953
BVSF	BVPlot	2,801.075	2,851.043	**2,790.895**	2,792.688
BVSF	SFPlot	2,452.828	2,427.723	**2,409.388**	2,413.466
Cocoli	cocoli	7,3752.32	68,152.93	**67,835.59**	75,938.32
Lahei	heath1	9,947.228	9,966.227	**9,841.178**	9,888.052
Lahei	heath2	9,795.598	9,650.197	**9,595.179**	9,618.001
Lahei	peat	9,183.332	9,040.189	**8,961.699**	9,030.188
La Selva	1	5,518.14	5,434.672	**5,376.494**	5,555.8
La Selva	2	5,504.011	5,548.332	**5,444.005**	5,489.366
La Selva	3	6,337.174	6,328.63	**6,237.519**	6,294.73
La Selva	4	5,445.745	5,527.303	**5,402.815**	5,409.85
La Selva	5	4,410.166	4,318.777	**4,281.463**	4,440.427
Luquillo	lfdp	534,427.2	515,126.9	**509,926.5**	525,725.7
NC	12	45,716.48	44,860.83	**44,212.08**	45,592.31
NC	13	36,251.18	34,948.55	**34,539.55**	36,220.19
NC	14	56,695.06	52,506.98	**52,273.61**	55,964.15
NC	4	36,203.17	36,553.64	**35,587.05**	36,447.78
NC	93	34,667.37	33,277.48	**32,934.38**	34,730.18
Oosting	oosting	74,293.18	69,837.5	**69,718.9**	74,739.21
Serimbu	S-1	7,887.232	7,471.463	**7,463.06**	7,981.97
Serimbu	S-2	8,507.118	8,123.406	**8,102.843**	8,614.922
Shirakami	Akaishizawa	3,105.173	3,104.759	**3,057.59**	3,188.967
Shirakami	Kumagera	**3,473.692**	3,680.852	3,473.805	3,597.692
Sherman	sherman	191,735.8	188,206	**185,424**	190,339.9

Note: The distribution with the best fit (lowest AIC_c value) for each community is in boldface type. BCI = Barro Colorado Island, BVSF = DeWalt Bolivia forest plots, METE = maximum entropy theory of ecology, NC = North Carolina, UCSC FERP = University of California, Santa Cruz, Forest Ecology Research Plot.

Literature Cited Only in Appendix F

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer, New York.