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Supplement of

A question of scale: modeling biomass, gain and mortality distributions of a tropical forest

Nikolai Knapp et al.

Correspondence to: Nikolai Knapp (nikolai.knapp@thuenen.de)

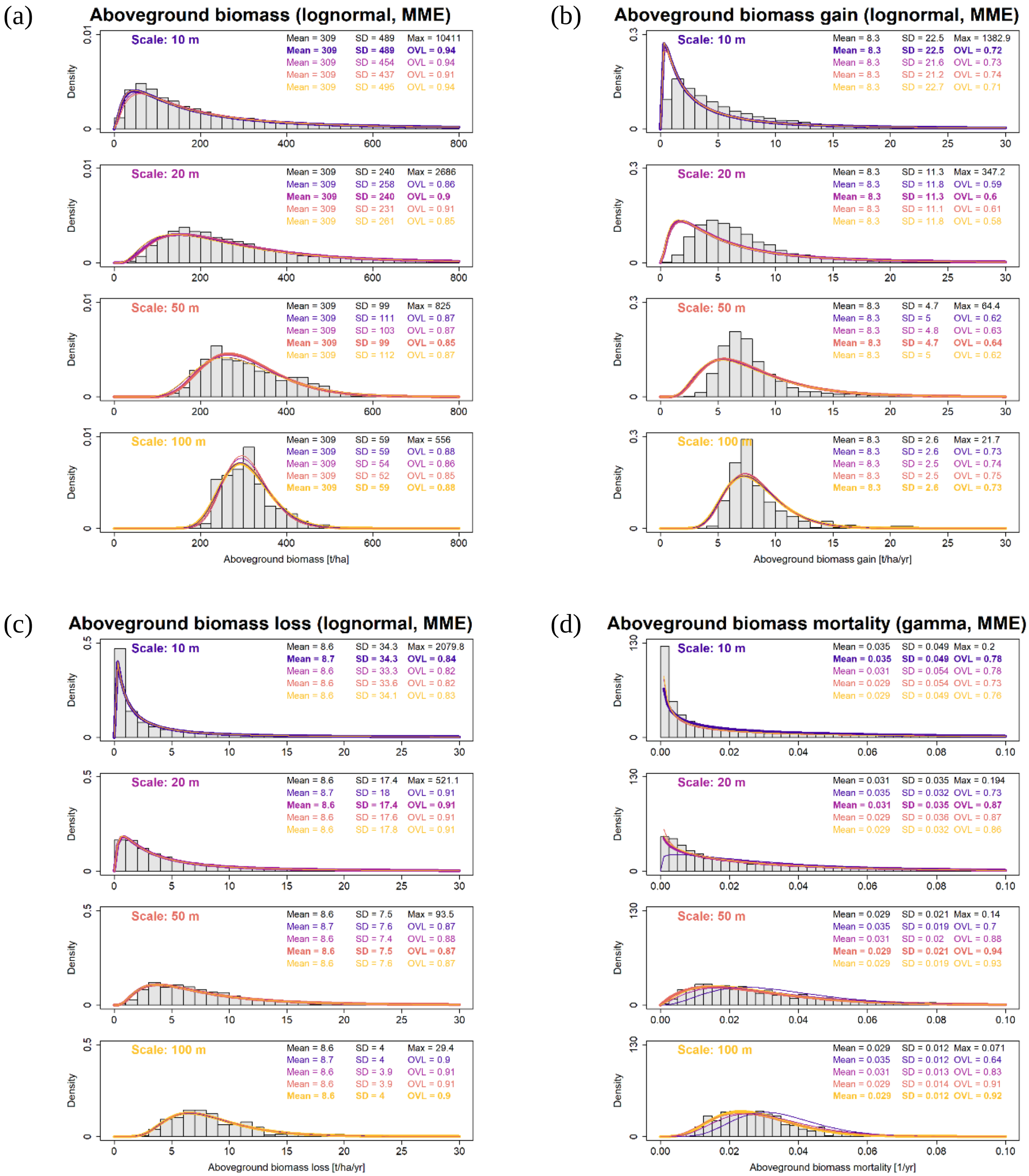

Figure S1: Frequency distributions for aboveground biomass (AGB), gain, loss and mortality analyzed at different scales. Shown are the best probability density functions (PDF) for each of the four variables at four different scales (represented by colors) and the respective empirical distributions from the field (grey histograms, statistics written in black). Bold lines represent fitted PDFs with their statistics written in bold font. Thin lines represent rescaled PDFs with their colors representing the reference scales and their statistics written in normal font. For each of the four variables, aboveground biomass (a), AGB gain (b), AGB loss (c) and AGB mortality (d), the best matching PDF and method (always MME) are plotted.

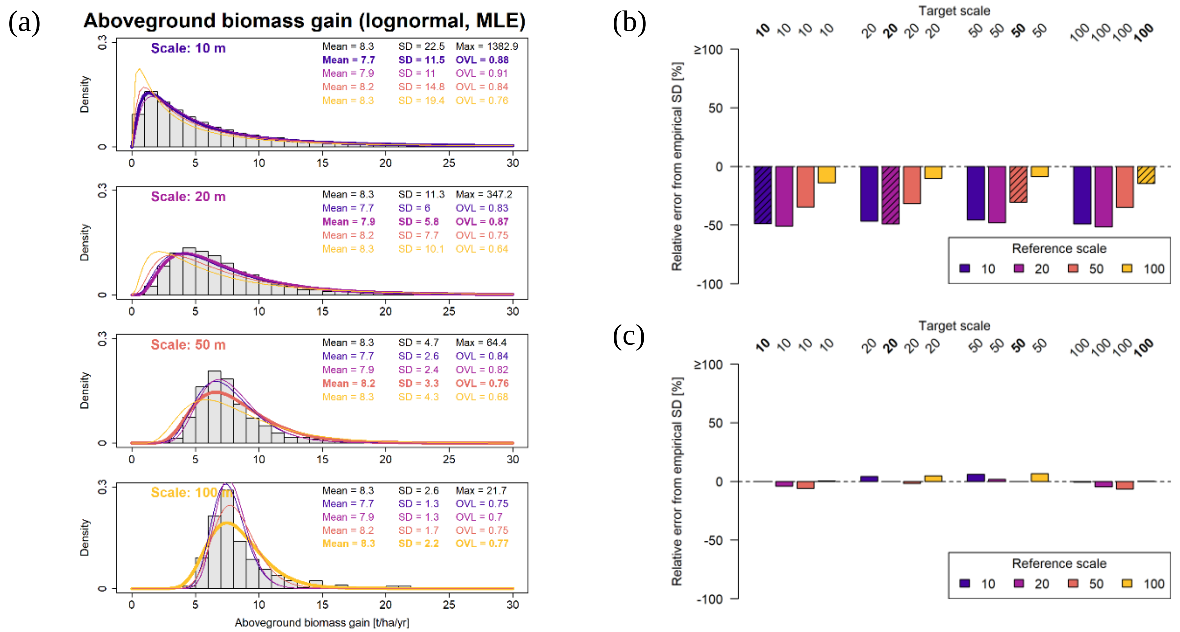

Figure S2: Second best probability density function (PDF) for AGB gain, derived with MLE fitting (a) and details about the relative errors of standard deviation (RESD) for the second best (b) and best (c) fit. (a) Compared to the best PDF (MME, Figure 2b) the overlaps (OVL) with the empirical distributions are higher, but the PDFs are less consistent across scales. The relative errors of standard deviation (RESD) are higher for the MLE fit (b, mean=35.6%) than for the MME fit (c, mean=3%) at all scales. This also applies to PDFs directly fitted at the respective scales (striped bars).

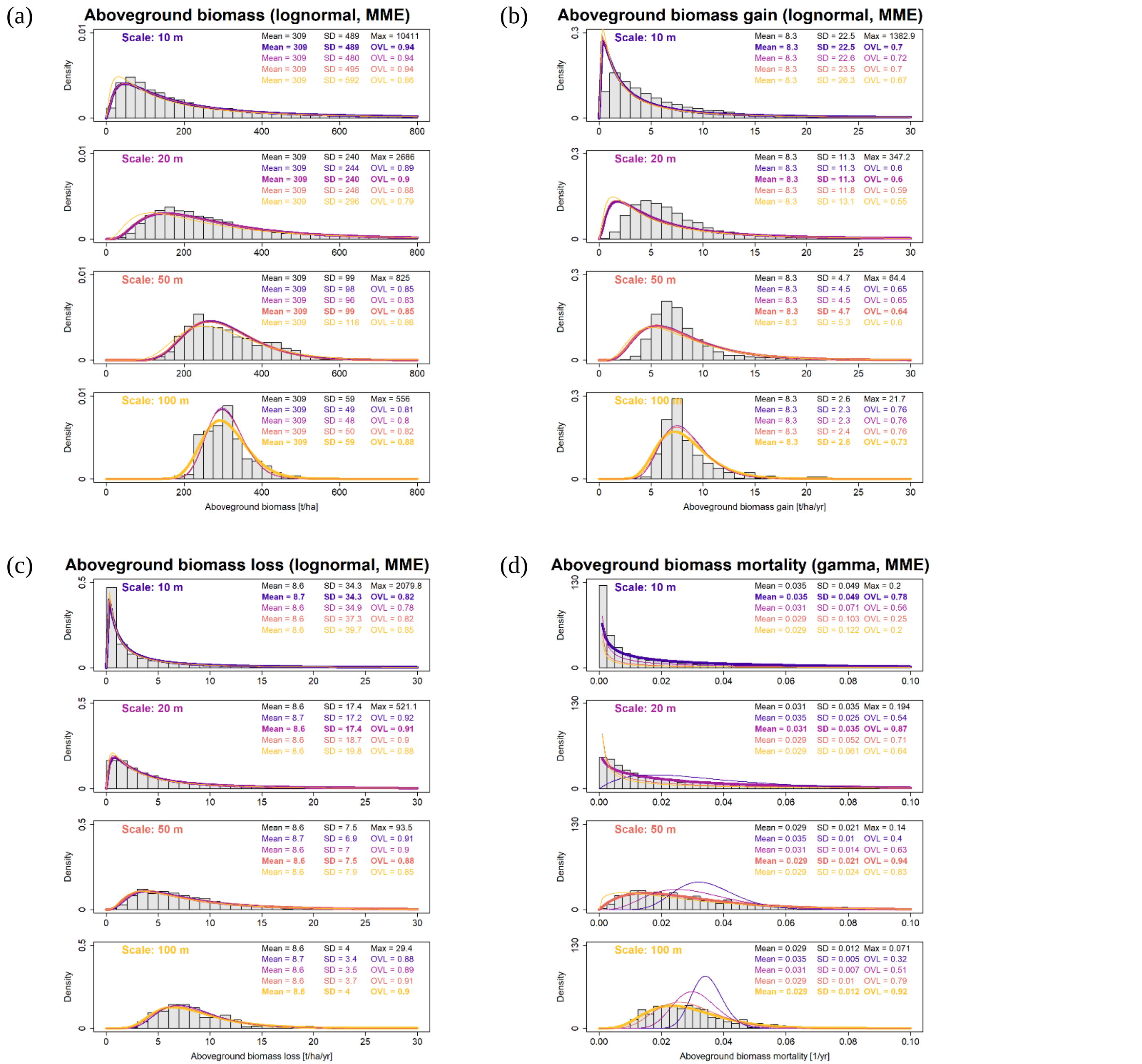

Figure S3: Frequency distributions for aboveground biomass (AGB), gain, loss and mortality analyzed at different scales. This graphic is equivalent to Figure S1, but rather than using the empirical scaling coefficients for each variable, a generic scaling coefficient of -0.5 was used for rescaling all variables. Obviously, this approach leads to inappropriate scaling results for mortality (d), visually and in terms of the OVL metric. But, also for the other variables (a-c), despite visual consistency among curves, the rescaled SD values drift away considerably from the one of the reference scale. This drift of SD values is avoided when using the empirical scaling coefficients (Figure S1).

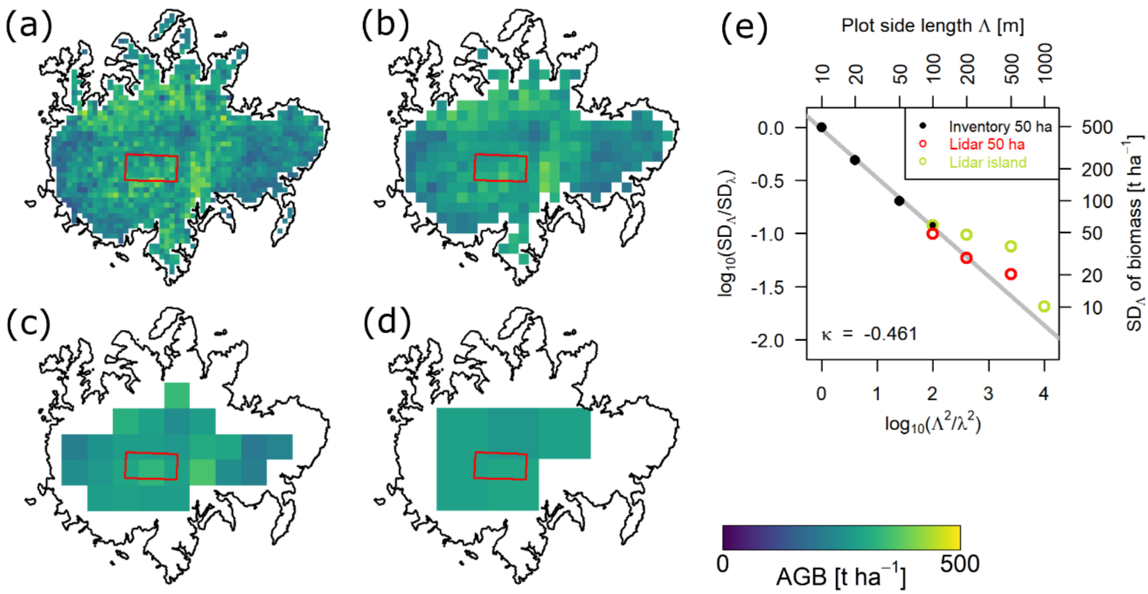

Figure S4. Scaling of aboveground biomass (AGB) across Barro Colorado Island. AGB was estimated from lidar-derived mean top-of-canopy height at 100-m scale (a) and aggregated to 200-m (b), 500-m (c) and 1000-m scale (d). Pixels intersecting the coast line were excluded. The 50-ha inventory plot is marked by the red rectangle. (e) shows the scaling of the standard deviation of the AGB distribution within (black: inventory; red: lidar) and beyond (green: lidar) the 50-ha plot. Regression line and scaling exponent κ are based on inventory only.

Table S1: Goodness-of-fit criteria values for simulated AGB distributions using 10- or 20-m as reference scale. The simulations differ in their input distributions for AGB gain (G) and mortality (M) and in the fitting methods (MLE = maximum likelihood estimation; MME = moments matching estimation). The goodness-of-fit criteria are mean distribution overlap (OVP) and mean relative error of standard deviation (RESD) when compared to the empirical AGB distributions at all scales. Settings leading to high goodness-of-fit (at their scale) are highlighted in bold font.

Reference scale	G distribution	G method	M distribution	M method	Mean OVL	Mean RESD
10	**lognormal**	**MLE**	**lognormal**	**MLE**	**0.645**	**0.225**
10	lognormal	MLE	lognormal	MME	0.531	0.319
10	lognormal	MLE	gamma	MLE	0.53	0.318
10	lognormal	MLE	gamma	MME	0.53	0.32
10	lognormal	MME	lognormal	MLE	0.59	1.008
10	lognormal	MME	lognormal	MME	0.457	0.26
10	lognormal	MME	gamma	MLE	0.455	0.26
10	lognormal	MME	gamma	MME	0.455	0.26
10	**gamma**	**MLE**	**lognormal**	**MLE**	**0.608**	**0.134**
10	gamma	MLE	lognormal	MME	0.517	0.465
10	gamma	MLE	gamma	MLE	0.516	0.464
10	gamma	MLE	gamma	MME	0.516	0.465
10	gamma	MME	lognormal	MLE	0.455	1.114
10	gamma	MME	lognormal	MME	0.414	0.319
10	gamma	MME	gamma	MLE	0.413	0.319
10	gamma	MME	gamma	MME	0.413	0.318
20	**lognormal**	**MLE**	**lognormal**	**MLE**	**0.749**	**0.14**
20	lognormal	MLE	lognormal	MME	0.672	0.271
20	lognormal	MLE	gamma	MLE	0.668	0.273
20	lognormal	MLE	gamma	MME	0.668	0.272
20	lognormal	MME	lognormal	MLE	0.615	0.509
20	lognormal	MME	lognormal	MME	0.559	0.35
20	lognormal	MME	gamma	MLE	0.555	0.346
20	lognormal	MME	gamma	MME	0.555	0.347
20	**gamma**	**MLE**	**lognormal**	**MLE**	**0.71**	**0.115**
20	gamma	MLE	lognormal	MME	0.642	0.247
20	gamma	MLE	gamma	MLE	0.639	0.249
20	gamma	MLE	gamma	MME	0.639	0.248
20	gamma	MME	lognormal	MLE	0.517	0.578
20	gamma	MME	lognormal	MME	0.497	0.408
20	gamma	MME	gamma	MLE	0.495	0.405
20	gamma	MME	gamma	MME	0.495	0.406

Table S2: Goodness-of-fit criteria values for simulated AGB distributions using 50- or 100-m as reference scale. The simulations differ in their input distributions for AGB gain (G) and mortality (M) and in the fitting methods (MLE = maximum likelihood estimation; MME = moments matching estimation). The goodness-of-fit criteria are mean distribution overlap (OVP) and mean relative error of standard deviation (RESD) when compared to the empirical AGB distributions at all scales. Settings leading to high goodness-of-fit (at their scale) are highlighted in bold font.

Reference scale	G distribution	G method	M distribution	M method	Mean OVL	Mean RESD
50	**lognormal**	**MLE**	**lognormal**	**MLE**	**0.769**	**0.097**
50	**lognormal**	**MLE**	**lognormal**	**MME**	**0.764**	**0.089**
50	**lognormal**	**MLE**	**gamma**	**MLE**	**0.758**	**0.086**
50	**lognormal**	**MLE**	**gamma**	**MME**	**0.757**	**0.087**
50	lognormal	MME	lognormal	MLE	0.64	0.445
50	lognormal	MME	lognormal	MME	0.637	0.429
50	lognormal	MME	gamma	MLE	0.632	0.422
50	lognormal	MME	gamma	MME	0.631	0.425
50	gamma	MLE	lognormal	MLE	0.688	0.137
50	gamma	MLE	lognormal	MME	0.686	0.127
50	gamma	MLE	gamma	MLE	0.682	0.123
50	gamma	MLE	gamma	MME	0.682	0.125
50	gamma	MME	lognormal	MLE	0.554	0.506
50	gamma	MME	lognormal	MME	0.554	0.488
50	gamma	MME	gamma	MLE	0.551	0.481
50	gamma	MME	gamma	MME	0.551	0.484
100	**lognormal**	**MLE**	**lognormal**	**MLE**	**0.7**	**0.349**
100	**lognormal**	**MLE**	**lognormal**	**MME**	**0.699**	**0.345**
100	**lognormal**	**MLE**	**gamma**	**MLE**	**0.696**	**0.342**
100	**lognormal**	**MLE**	**gamma**	**MME**	**0.695**	**0.343**
100	lognormal	MME	lognormal	MLE	0.633	0.545
100	lognormal	MME	lognormal	MME	0.632	0.541
100	lognormal	MME	gamma	MLE	0.63	0.537
100	lognormal	MME	gamma	MME	0.629	0.538
100	gamma	MLE	lognormal	MLE	0.596	0.43
100	gamma	MLE	lognormal	MME	0.596	0.426
100	gamma	MLE	gamma	MLE	0.594	0.423
100	gamma	MLE	gamma	MME	0.594	0.424
100	gamma	MME	lognormal	MLE	0.53	0.622
100	gamma	MME	lognormal	MME	0.53	0.618
100	gamma	MME	gamma	MLE	0.53	0.614
100	gamma	MME	gamma	MME	0.53	0.615

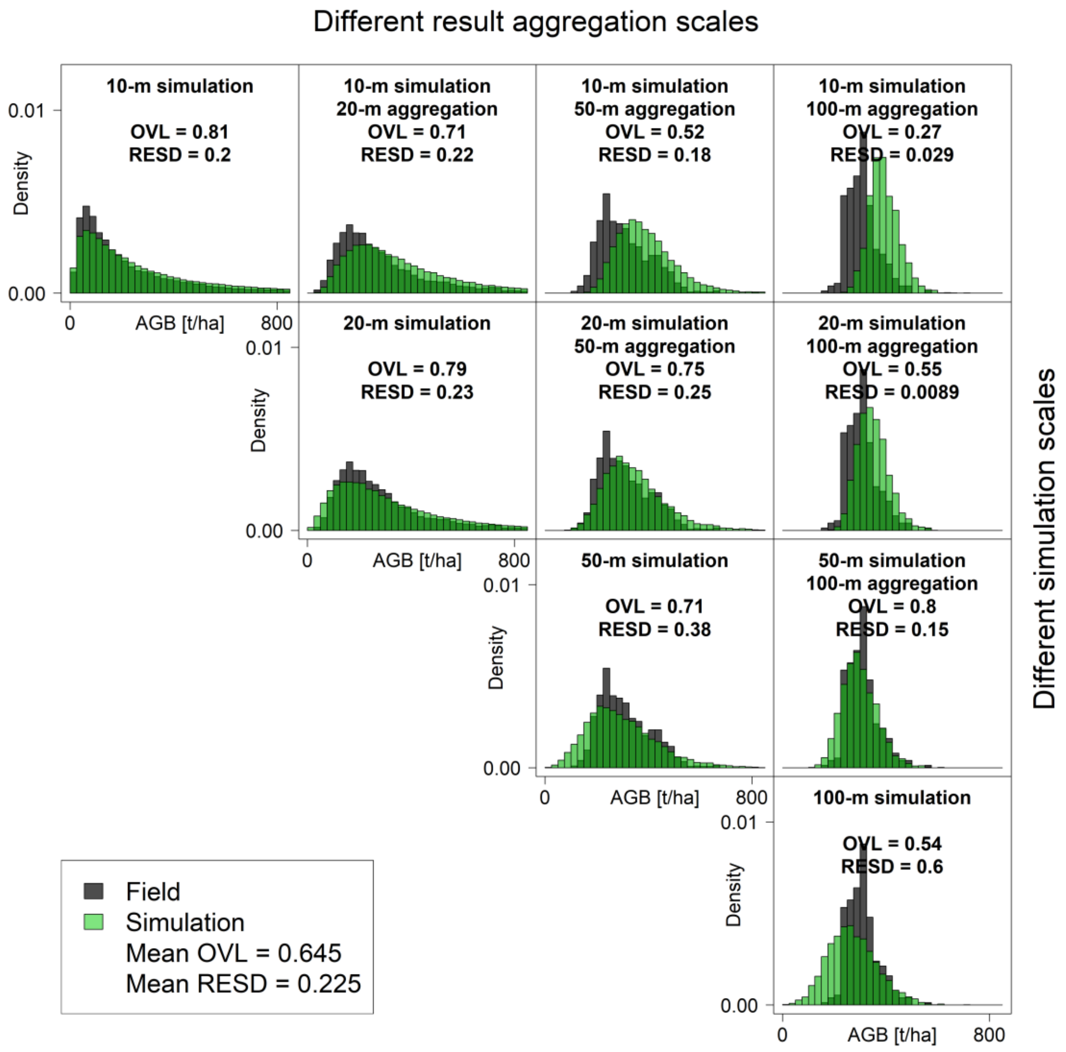

Figure S5: Simulated aboveground biomass (AGB) distributions (green) and field distributions (grey). Here, the reference scale was 10 m and the inputs G and M were modelled as lognormal distributions (MLE fits). Rows represent different spatial resolutions of the simulation. Columns represent different spatial resolutions of the result aggregation. For each pair of histograms, the overlap (OVL) and relative error of standard deviation (RESD) was calculated.

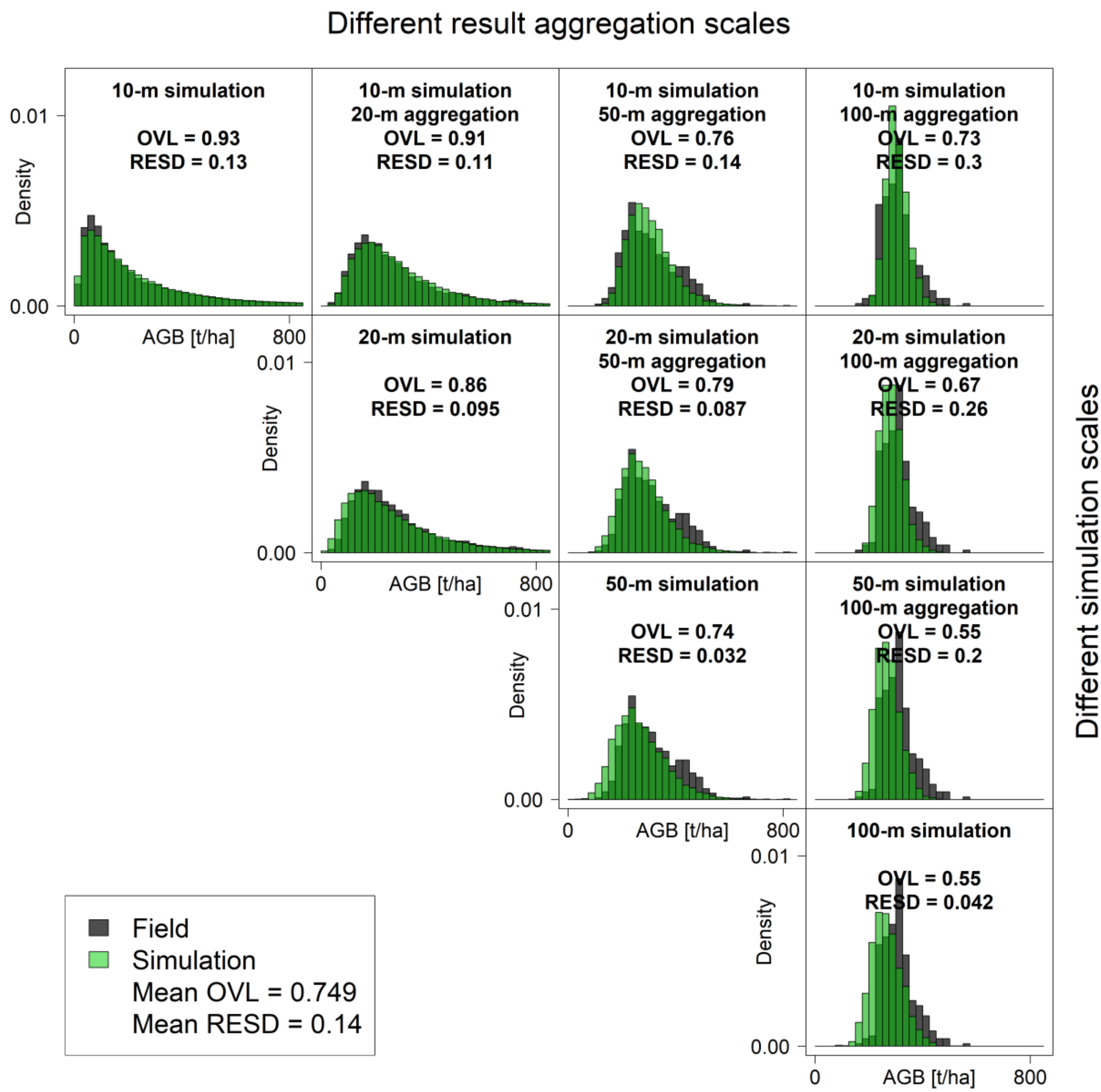

Figure S6: Simulated aboveground biomass (AGB) distributions (green) and field distributions (grey). Here, the reference scale was 20 m and the inputs G and M were modelled as lognormal distributions (MLE fits). Rows represent different spatial resolutions of the simulation. Columns represent different spatial resolutions of the result aggregation. For each pair of histograms, the overlap (OVL) and relative error of standard deviation (RESD) was calculated.

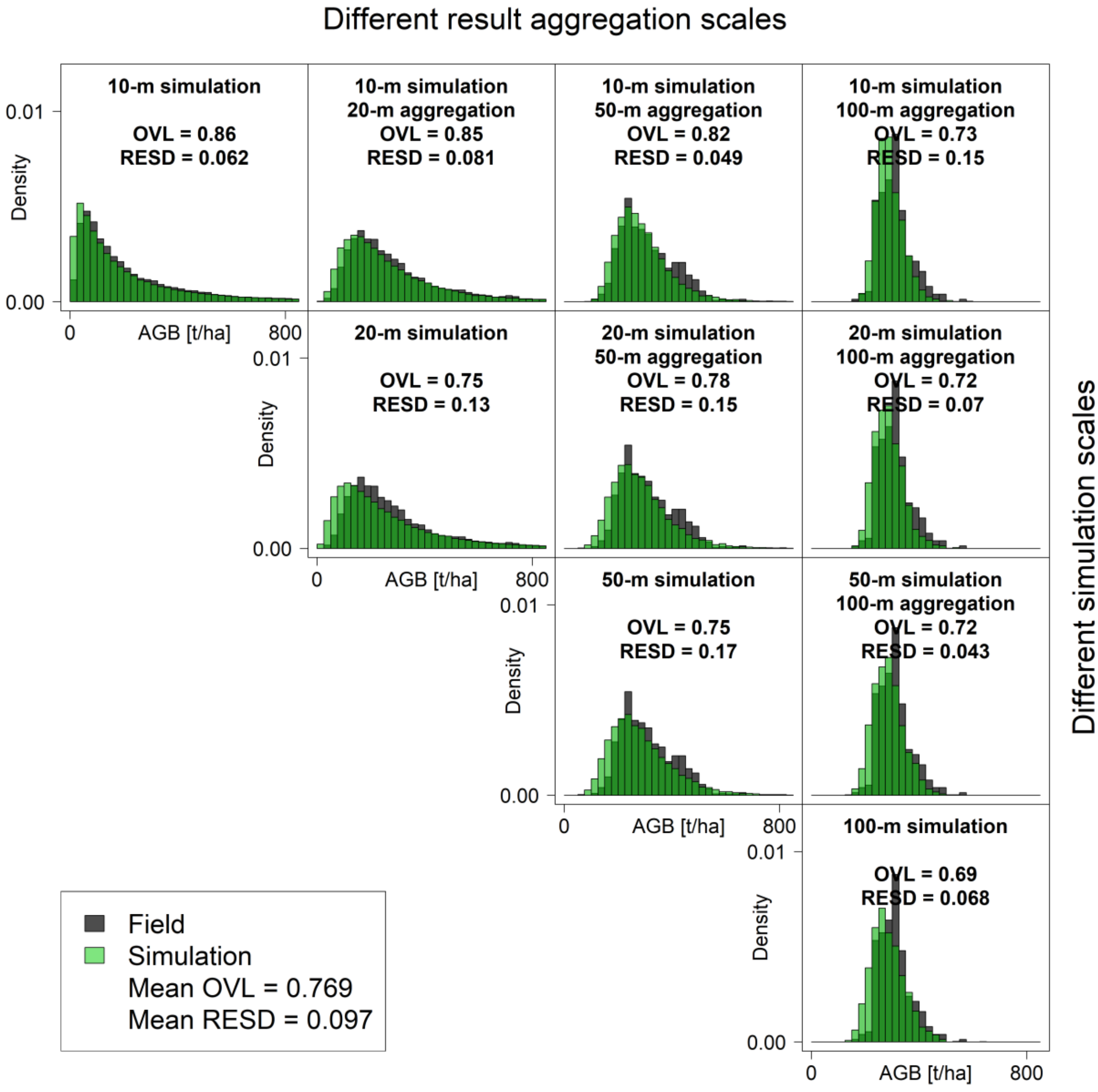

Figure S7: Simulated aboveground biomass (AGB) distributions (green) and field distributions (grey). Here, the reference scale was 50 m and the inputs G and M were modelled as lognormal distributions (MLE fits). Rows represent different spatial resolutions of the simulation. Columns represent different spatial resolutions of the result aggregation. For each pair of histograms, the overlap (OVL) and relative error of standard deviation (RESD) was calculated.

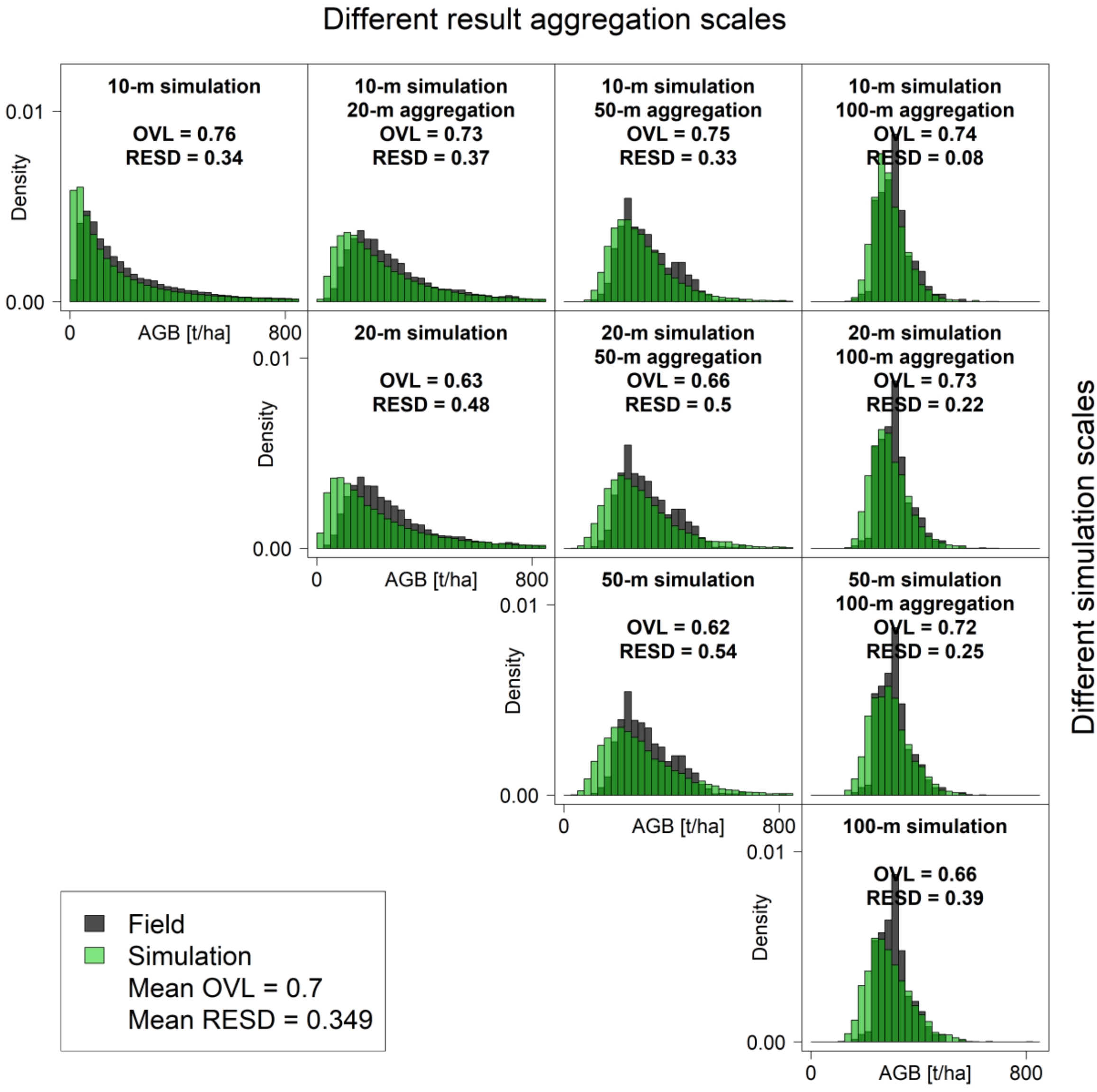

Figure S8: Simulated aboveground biomass (AGB) distributions (green) and field distributions (grey). Here, the reference scale was 100 m and the inputs G and M were modelled as lognormal distributions (MLE fits). Rows represent different spatial resolutions of the simulation. Columns represent different spatial resolutions of the result aggregation. For each pair of histograms, the overlap (OVL) and relative error of standard deviation (RESD) was calculated.

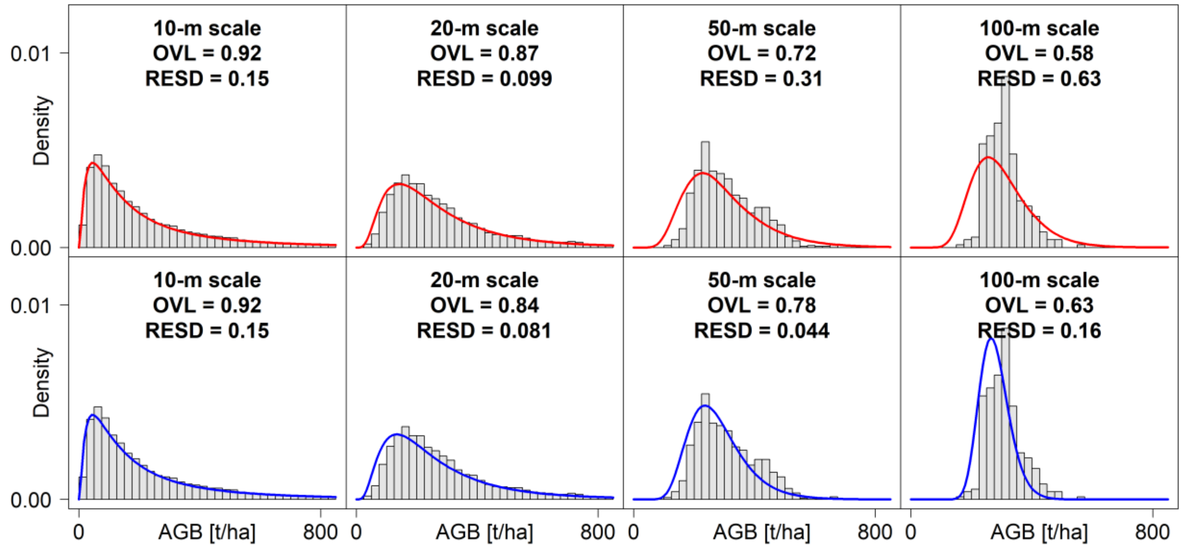

Figure S9: Aboveground biomass (AGB) distributions resulting from theory (colored lines) under the assumption of mortality as a white shot noise (WSN) compared to the ones from the field (grey histograms). Columns represent different spatial resolutions. The rows represent different approaches for how to deal with WSN at scales > 10 m: 1) by applying WSN at all scales (red, upper row); 2) by upscaling the SD with a scaling relationship and using a lognormal distribution as approximation at larger scales (blue, lower row). For each curve, the overlap (OVL) and relative error of standard deviation (RESD) with the field data was calculated.