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Supporting Information for
Climate change determines the sign of productivity trends in US forests

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6.7.1 Effect of changes in biomass losses on biomass stocks ($\Delta \mathrm{B}_{\mathrm{disturbance}}$)

To isolate the effect of changes in fractional biomass losses (L), we held $f_{yr}(\mathrm{year})$ and $f(\mathrm{age})$ in eq. 4 constant, and we varied $f_d(\mathrm{disturbance})$ over time according to the observed change in L at each plot. At the time of the first remeasurement ($\mathrm{T}_{\mathrm{first}}$), the model-predicted biomass stock for a given plot is $\widehat{\mathrm{B}}_{\mathrm{first}} = f_d(\mathrm{L}_{\mathrm{first}}) \times f_{yr}(\mathrm{year}_{\mathrm{first}}) \times f(\mathrm{age}_{\mathrm{first}})$, where $\mathrm{L}_{\mathrm{first}}$, $\mathrm{year}_{\mathrm{first}}$, and $\mathrm{age}_{\mathrm{first}}$ are plot-specific values. Similarly, at the time of the last measurement ($\mathrm{T}_{\mathrm{last}}$), and holding $f_{yr}(\mathrm{year})$ and $f(\mathrm{age})$ constant, the model-predicted biomass stock is $\widehat{\mathrm{B}}_{\mathrm{last}} \mid \mathrm{year}_{\mathrm{first}}, \mathrm{age}_{\mathrm{first}} = f_d(\mathrm{L}_{\mathrm{last}}) \times f_{yr}(\mathrm{year}_{\mathrm{first}}) \times f(\mathrm{age}_{\mathrm{first}})$. The annualized change in biomass stock (Mg·ha^{-1}·year^{-1}) at a given plot due to changing disturbance (fractional losses) is then $\Delta \mathrm{B}_{\mathrm{disturbance}} = \left(\widehat{\mathrm{B}}_{\mathrm{last}} \middle| \mathrm{year}_{\mathrm{first}}, \mathrm{age}_{\mathrm{first}} - \widehat{\mathrm{B}}_{\mathrm{first}}\right)/(\mathrm{T}_{\mathrm{last}} - \mathrm{T}_{\mathrm{first}})$. We averaged these values across plots within each ecoprovince to calculate the mean $\Delta \mathrm{B}_{\mathrm{disturbance}}$ values reported in Figs. 3 and S6-S7.

6.7.2 Effect of changes in the stand age distribution on biomass stocks ($\Delta \mathrm{B}_{\mathrm{age}}$)

To isolate the effect of changes in the stand age distribution, we held $f_d(\mathrm{disturbance})$ and $f_{yr}(\mathrm{year})$ in eq. 4 constant, and we varied $f(\mathrm{age})$ over time according to the observed change in stand age at each plot. The model-predicted biomass stock for a given plot at time $\mathrm{T}_{\mathrm{first}}$ is $\widehat{\mathrm{B}}_{\mathrm{first}}$ (as in section 6.7.1). The model-predicted biomass stock at time $\mathrm{T}_{\mathrm{last}}$, holding $f_d(\mathrm{disturbance})$ and $f_{yr}(\mathrm{year})$ constant, is $\widehat{\mathrm{B}}_{\mathrm{last}} \mid \mathrm{L}_{\mathrm{first}}, \mathrm{year}_{\mathrm{first}} = f_d(\mathrm{L}_{\mathrm{first}}) \times f_{yr}(\mathrm{year}_{\mathrm{first}}) \times f(\mathrm{age}_{\mathrm{last}})$. The annualized change in biomass stock (Mg·ha^{-1}·year^{-1}) at a given plot due to changing stand age is then $\Delta \mathrm{B}_{\mathrm{age}} = \left(\widehat{\mathrm{B}}_{\mathrm{last}} \middle| \mathrm{L}_{\mathrm{first}}, \mathrm{year}_{\mathrm{first}} - \widehat{\mathrm{B}}_{\mathrm{first}}\right)/(\mathrm{T}_{\mathrm{last}} - \mathrm{T}_{\mathrm{first}})$. We averaged these values across plots within each ecoprovince to calculate the mean $\Delta \mathrm{B}_{\mathrm{age}}$ values reported in Figs. 3 and S6-S7.

6.7.3 Effect of productivity trends on biomass stocks ($\Delta \mathrm{B}_{\mathrm{productivity\ trend}}$)

To isolate the effect of productivity trends (τ), we held $f_d(\mathrm{disturbance})$ and $f(\mathrm{age})$ constant, and we varied $f_{yr}(\mathrm{year})$ over time according to the remeasurement dates ($\mathrm{T}_{\mathrm{first}}$ and $\mathrm{T}_{\mathrm{last}}$) at each plot. The model-predicted biomass stock for a given plot at time $\mathrm{T}_{\mathrm{first}}$ is $\widehat{\mathrm{B}}_{\mathrm{first}}$ (as in section 6.7.1). The model-predicted biomass stock at time $\mathrm{T}_{\mathrm{last}}$, holding $f_d(\mathrm{disturbance})$ and $f(\mathrm{age})$ constant, is $\widehat{\mathrm{B}}_{\mathrm{last}} \mid \mathrm{L}_{\mathrm{first}}, \mathrm{age}_{\mathrm{first}} = f_d(\mathrm{L}_{\mathrm{first}}) \times f_{yr}(\mathrm{year}_{\mathrm{last}}) \times f(\mathrm{age}_{\mathrm{first}})$. The annualized change in biomass stock (Mg·ha^{-1}·year^{-1}) at a given plot due to τ is then $\Delta \mathrm{B}_{\mathrm{productivity\ trend}} = \left(\widehat{\mathrm{B}}_{\mathrm{last}} \middle| \mathrm{L}_{\mathrm{first}}, \mathrm{age}_{\mathrm{first}} - \widehat{\mathrm{B}}_{\mathrm{first}}\right)/(\mathrm{T}_{\mathrm{last}} - \mathrm{T}_{\mathrm{first}})$. We averaged these values across plots within each ecoprovince to calculate the mean $\Delta \mathrm{B}_{\mathrm{productivity\ trend}}$ values reported in Figs. 3 and S6-S7.

6.7.4 Uncertainty estimates for the biomass change components

We quantified the uncertainty in the biomass change components due to uncertainty in the parameter estimates for the temporally-balanced *nls* model fits (Table S5). For biomass change component c ($\Delta\mathrm{B_c}$), with parameters θ_c in the corresponding model term in eq. 4, we randomly generated 9999 parameter sets from the sampling distribution of θ_c. For each of these parameter sets, we calculated $\Delta\mathrm{B_c}$ for each inventory plot (as explained in sections 6.7.1-6.7.3) using the best-fit *nls* estimates for the parameters in the other two model terms in eq. 4. For each of the 9999 parameter sets, we calculated the mean of $\Delta\mathrm{B_c}$ across inventory plots in the ecoprovince ($\overline{\Delta\mathrm{B_c}}$). We then calculated the variance ($\mathrm{VAR_c}$) and standard deviation ($\mathrm{SD_c}$) across the 9999 realizations of $\overline{\Delta\mathrm{B_c}}$, and the 95% confidence interval as $\overline{\Delta\mathrm{B_c^*}} \pm 1.96 \times \mathrm{SD_c}$, where $\overline{\Delta\mathrm{B_c^*}}$ is the ecoprovince mean calculated with the best-fit *nls* estimates (the ecoprovince means reported in Figs. 3 and S6-S7). For $\Delta\mathrm{B_{age}}$, θ is multivariate (eqs. 2-3), and we generated parameter sets using the *mvrnorm* function in the MASS library in R, assuming the sampling distribution of θ is multivariate normal (1) with mean and variance-covariance matrix provided by the *nls* model fits (Table S5). For $\Delta\mathrm{B_{productivity\ trend}}$ and $\Delta\mathrm{B_{disturbance}}$, θ is univariate (consisting of τ and α, respectively), and we generated parameter values using the *rnorm* function in R with mean and standard deviation (*i.e.*, the standard error of the parameter estimate) provided by the *nls* model fits (Table S5).

Confidence intervals (CIs) for the sum of the $\Delta\mathrm{B}$ components ($\Delta\mathrm{B_{sum}}$; Figs. S6-S7) were estimated as follows: First, we estimated the variance of the sum of the $\Delta\mathrm{B}$ components ($\mathrm{VAR_{sum}}$) as the sum of the three variance components ($\mathrm{VAR_c}$). Then, we estimated the CI for $\Delta\mathrm{B_{sum}}$ as $\overline{\Delta\mathrm{B^*_{sum}}} \pm 1.96 \times \mathrm{SD_{sum}}$, where $\overline{\Delta\mathrm{B^*_{sum}}} = \overline{\Delta\mathrm{B^*_{age}}} + \overline{\Delta\mathrm{B^*_{productivity}}} + \overline{\Delta\mathrm{B^*_{disturbance}}}$, and $\mathrm{SD_{sum}} = \sqrt{\mathrm{VAR_{sum}}}$.

CIs for the indices used to evaluate the $\Delta\mathrm{B}$ components (*x*-axes of Figs. S6B-D) were estimated as follows: For the mean change in stand age ('Δ stand age'; Fig. S6B), the CI is ± 1.96 times the standard error of Δ stand age across inventory plots. For τ (Fig. S6C), the CI is ± 1.96 times the standard error of the τ parameter estimate. For $\alpha \overline{\frac{(\mathrm{L_{last}} - \mathrm{L_{first}})}{(\mathrm{T_{last}} - \mathrm{T_{first}})}}$ (Fig. S6D), the CI is ± 1.96 $\overline{\frac{(\mathrm{L_{last}} - \mathrm{L_{first}})}{(\mathrm{T_{last}} - \mathrm{T_{first}})}}$ times the standard error of the α parameter estimate (here, we treat $\overline{\frac{(\mathrm{L_{last}} - \mathrm{L_{first}})}{(\mathrm{T_{last}} - \mathrm{T_{first}})}}$ as a constant due to its small uncertainty at the ecoprovince level, and we use the identity that the standard deviation scales linearly with a constant multiplier).

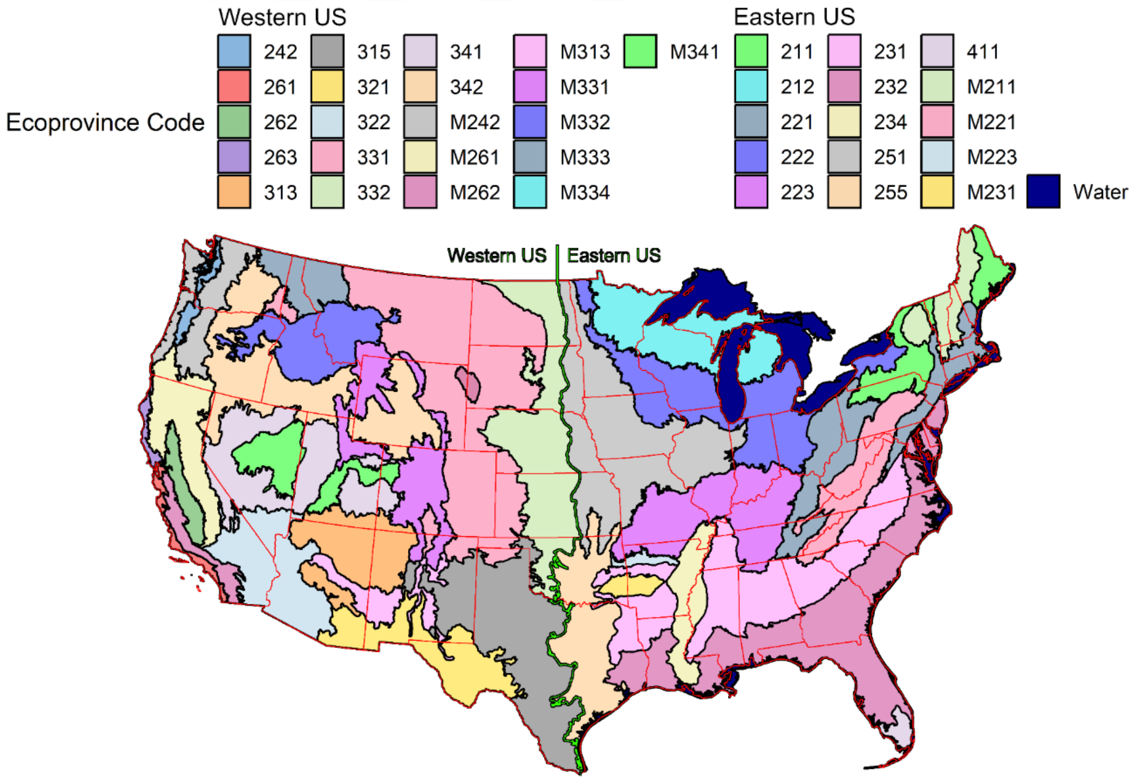


Fig. S1. Map of ecoprovinces in the coterminous US. Each ecoprovince is a geographic area with similar soil, climate conditions and potential natural vegetation (2). Ecoprovince boundaries (3) are shown in black. State political boundaries are shown in red. The green line near the center of the US divides east from west in our analysis. Ecoprovince names are given in Tables 1 and S2-S4.

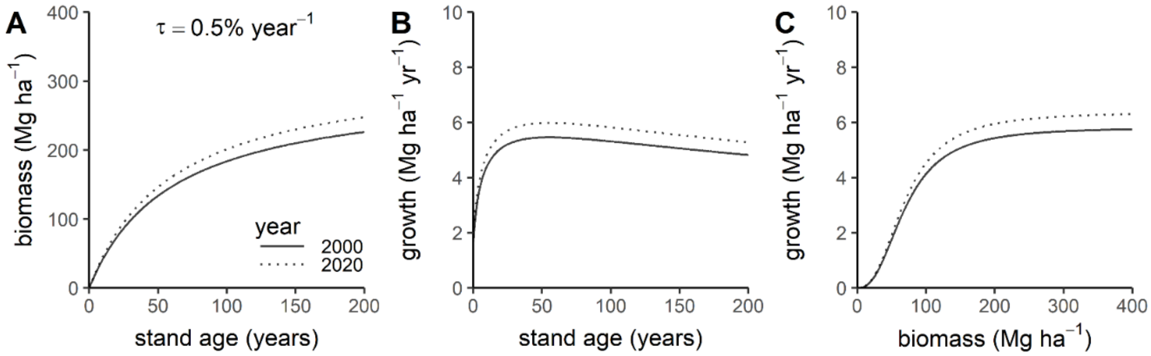


Fig. S2. Simplified graphical representations of non-linear models used to quantify productivity trends (τ). Archetypal shapes of curves are shown for (**A**) biomass stock as a function of stand age: biomass=f(stand age); (**B**) biomass production (growth) as a function of stand age: growth=f(stand age); and (**C**) growth as a function of biomass: growth=f(biomass). Each of the three model forms was fit separately for each US ecoprovince. Each model includes an estimated parameter (τ) that determines how the curve shifts up or down as a function of year. The examples in this figure show the difference between curves in the years 2000 (solid line) and 2020 (dotted line) if τ = 0.5% year^{-1}. The examples shown here do not illustrate the full flexibility of the functional forms we considered (*e.g.*, flexible shape in **B** and flexible *y*-intercept in **C**). See Methods for details.

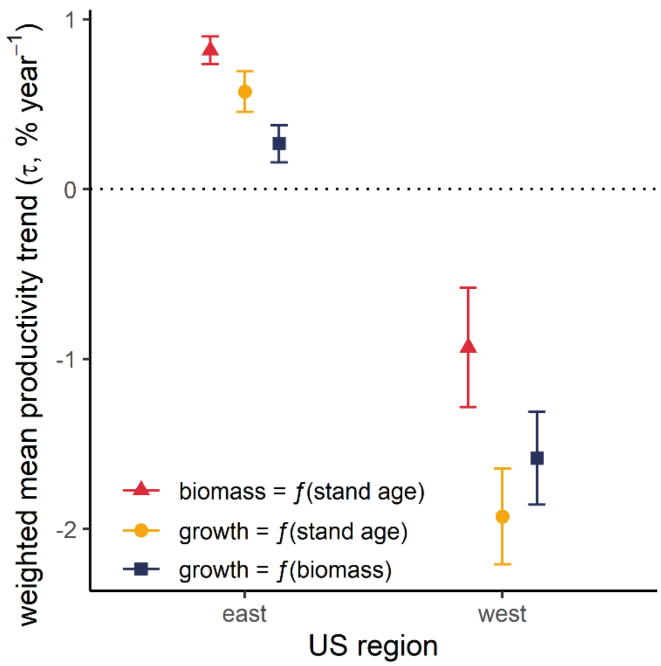
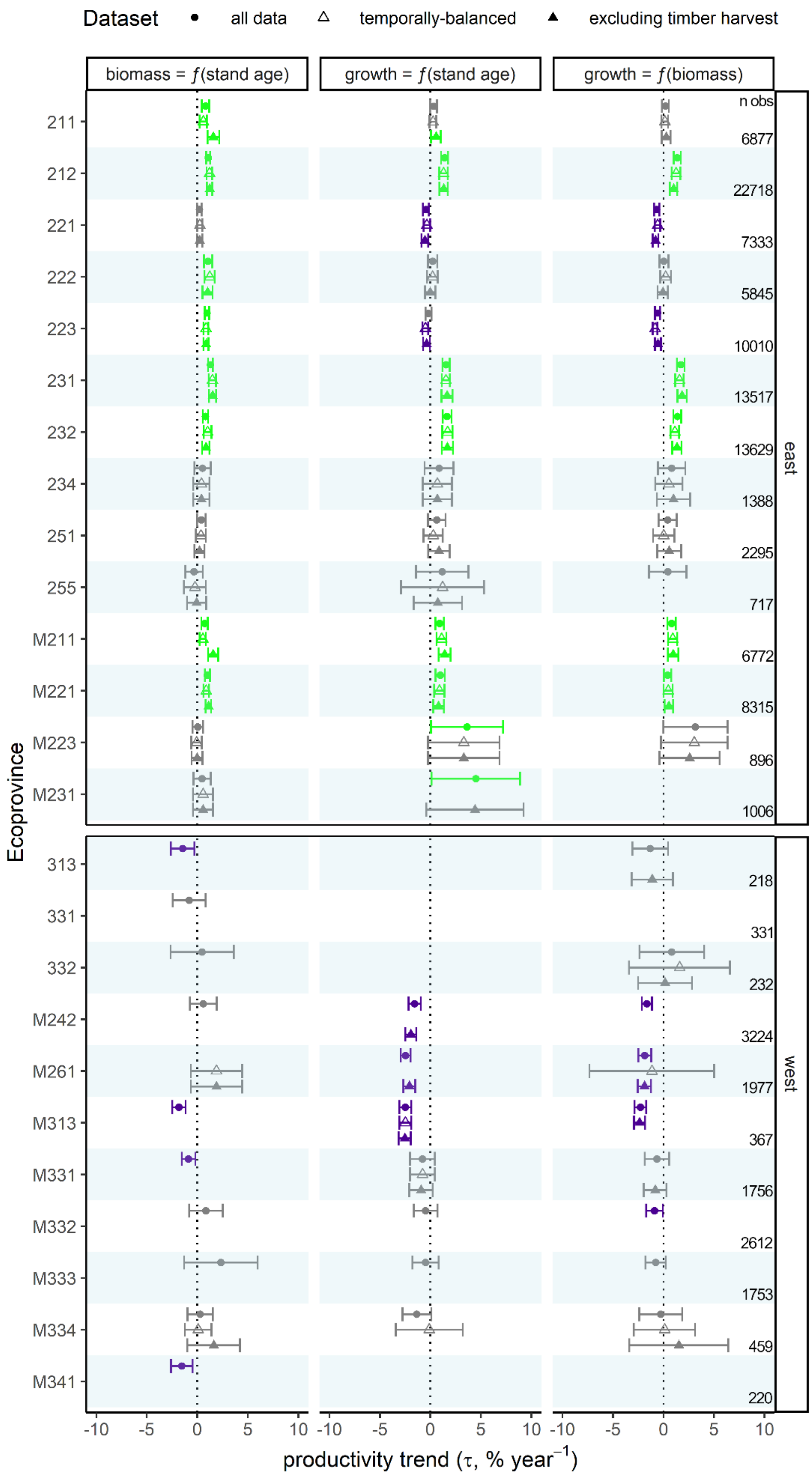


Fig. S3 (above). Comparison of weighted mean productivity trends (τ, % year^{-1}) for the eastern and western US by model functional form. Points are regional means and error bars are 95% confidence intervals. To calculate regional weighted means, each ecoprovince productivity trend (Tables S2-S4) was weighted by its inverse variance (4). For biomass = f(age), the weighted mean productivity trend is 0.82 (± 0.04) % year^{-1} for the eastern US (n = 14) and -0.92 (± 0.18, standard error) % year^{-1} for the western US (n = 11). For growth = f(age), the weighted mean productivity trend is 0.57 (± 0.06) % year^{-1} for the eastern US (n = 14) and -1.93 (± 0.14) % year^{-1} for the western US (n = 7). For growth = f(biomass), the weighted mean productivity trend is 0.27 (± 0.06) % year^{-1} for the eastern US (n = 13) and -1.58 (± 0.14) % year^{-1} in the western US (n = 10).

Fig. S4 (next page). Comparison of productivity trend (τ) parameter estimates from analyses using alternative datasets. We fit models to three alternative datasets: (1) 'all data' included all remeasurements of non-plantation forest plots that met the filtering criteria described in Methods; this dataset was used for all analyses in this paper unless stated otherwise; (2) the 'temporally-balanced' dataset only included the first and last plot remeasurement for plots with two or more remeasurements; the eastern US portion of this dataset was used to partition biomass change into components (Figs. 3 and S6-S7); and (3) the 'excluding timber harvest' dataset is the same as 'all data' except that it excludes plots where one or more harvested trees were reported during any remeasurement interval. Error bars show 95% confidence intervals. Estimates are not available in cases where the sample size was insufficient to constrain the model. For example, most western US plot locations have only been remeasured once, leading to small sample sizes for most western ecoprovinces in the 'temporally-balanced' dataset. See Methods section 6.4.5 for a more general discussion of convergence issues.



Dataset
all data
temporally-balanced
excluding timber harvest
biomass = ƒ(stand age)
growth = ƒ(stand age)
growth = ƒ(biomass)
n obs
211
6877
212
22718
221
7333
222
5845
223
10010
231
13517
232
13629
234
1388
251
2295
255
717
M211
6772
M221
8315
M223
896
M231
1006
east
313
218
331
331
332
232
M242
3224
M261
1977
M313
367
M331
1756
M332
2612
M333
1753
M334
459
M341
220
west
Ecoprovince
-10 -5 0 5 10
productivity trend (τ, % year⁻¹)

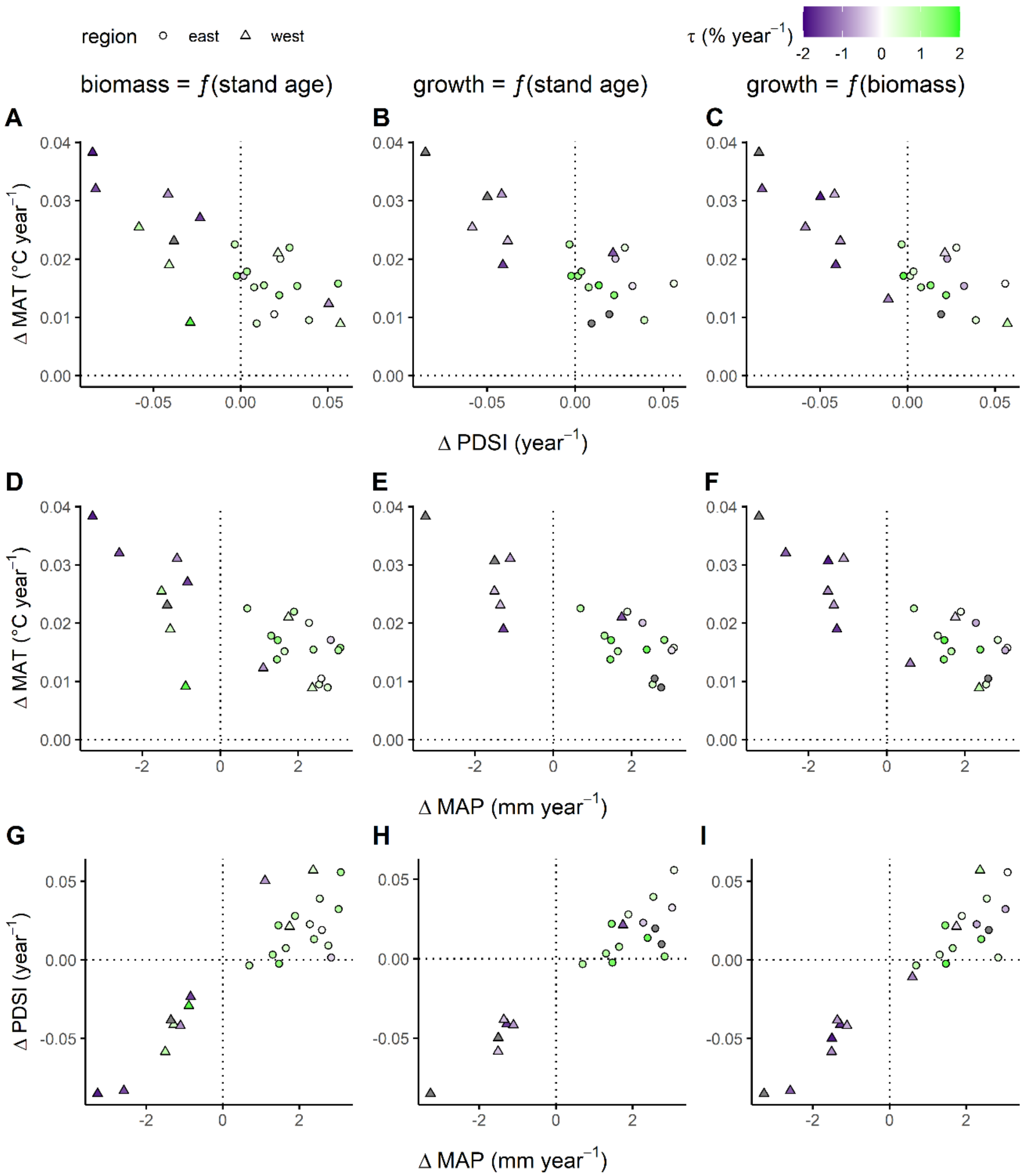


Fig. S5. Productivity trends (τ) for US ecoprovinces within bivariate climate-change spaces: (**A-C**) mean annual temperature change (ΔMAT) vs. change in the Palmer Drought Severity Index (ΔPDSI); (**D-F**) ΔMAT vs. mean annual precipitation change (ΔMAP); (**G-I**) ΔPDSI vs. ΔMAP. Each column shows results for one of the three model forms (Fig. S2). Each symbol represents an ecoprovince τ estimate (Tables S2-S4) on a truncated color scale (τ < -2 % year^{-1} colored dark purple, and τ > 2 % year^{-1} colored bright green). Across ecoprovinces, ΔMAT was negatively correlated with ΔPDSI and ΔMAP, and ΔPDSI and ΔMAP were positively correlated with each other. Thus, ecoprovinces that experienced the greatest warming tended to get drier (and tended to have τ < 0), and ecoprovinces that experienced the least warming tended to get wetter (and tended to have τ > 0). Climate change statistics for each ecoprovince are reported in Table 1.

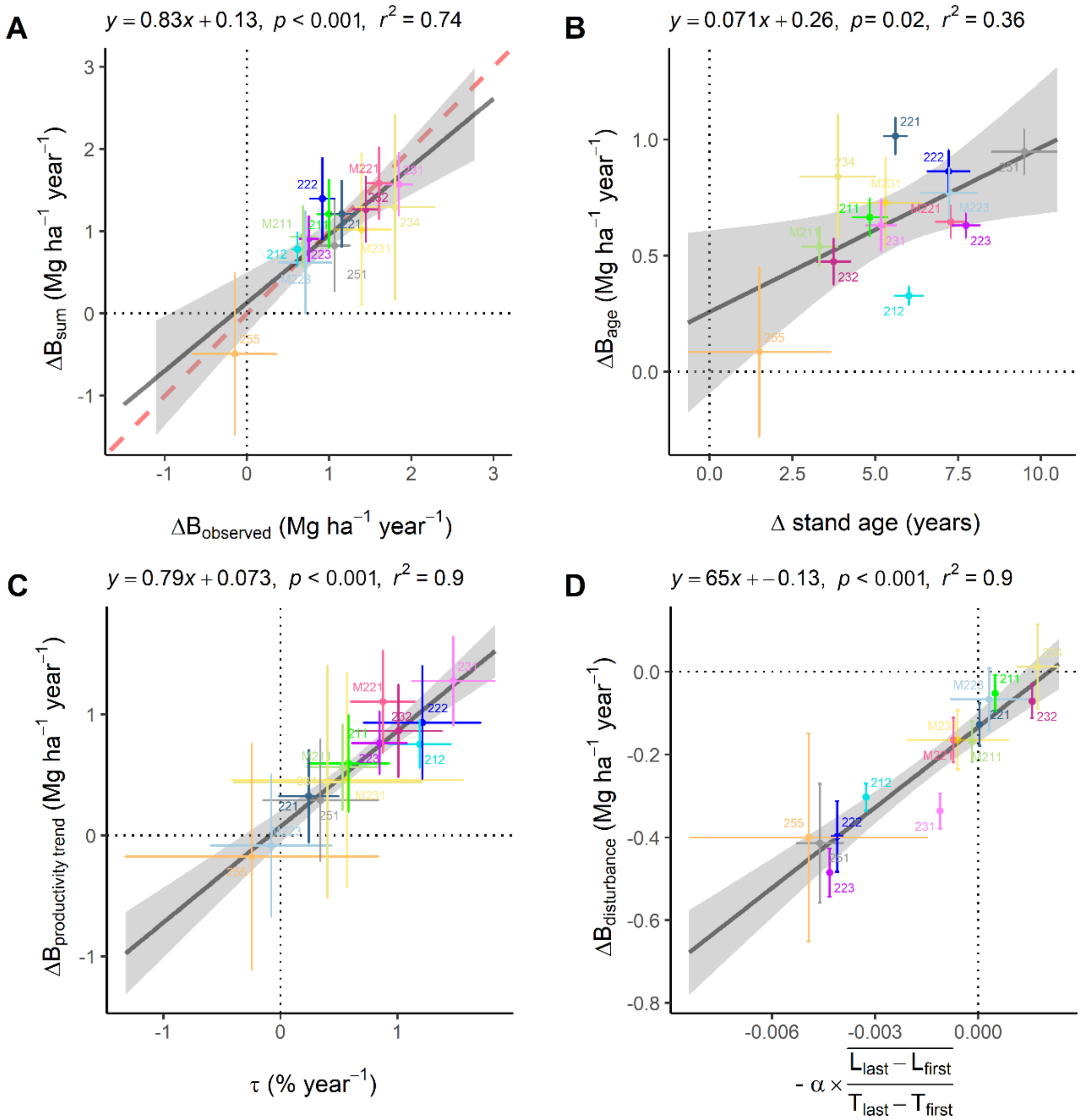


Fig. S6. Model evaluation for the biomass change partitioning analysis for 14 eastern US ecoprovinces, based on the temporally-balanced dataset (Table S5). Points are ecoprovince means and error bars are 95% confidence intervals. Eastern US ecoprovinces are color coded to match Fig. S1. (**A**) The sum of the modeled components of biomass change ($\Delta B_{sum} = \Delta B_{age} + \Delta B_{productivity\ trend} + \Delta B_{disturbance}$) in relation to the observed change in biomass ($\Delta B_{observed}$). The red dashed line is the 1:1 line. (**B**) Biomass change due to change in stand age (ΔB_{age}) in relation to the ecoprovince mean change in stand age (Δ stand age). Noise in the relationship is due to difference among ecoprovinces in age distributions and in biomass vs. age relationships. (**C**) Biomass change due to productivity trends ($\Delta B_{productivity\ trend}$) in relation to the τ parameter estimates. (**D**) Biomass change due to change in mortality and harvest losses ($\Delta B_{disturbance}$) in relation to an index that summarizes loss effects: the loss effect parameter (α) times the annualized mean change in fractional biomasses losses (L) between the first and last plot remeasurements (T_{first} and T_{last}, respectively). The minus sign that precedes $\boldsymbol{\alpha}$ makes the sign of the loss effect consistent with $\Delta B_{disturbance}$.

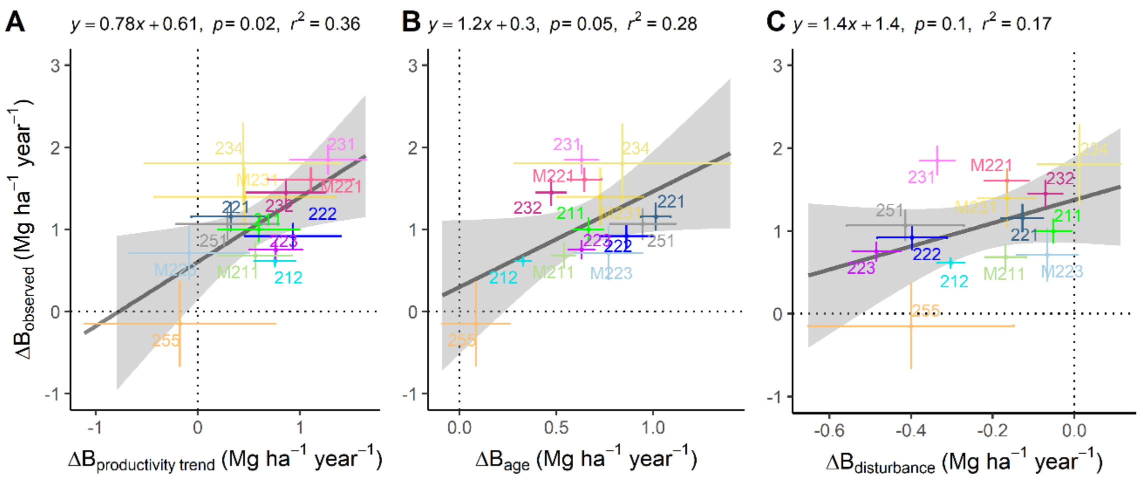


Fig. S7. Relationships between observed biomass change ($\Delta B_{observed}$) and modeled components of biomass change for 14 eastern US ecoprovinces. (**A**) biomass change due to productivity trends ($\Delta B_{productivity\ trend}$), (**B**) biomass change due to change in stand age (ΔB_{age}), and (**C**) biomass change due to change in mortality and harvest losses ($\Delta B_{disturbance}$). Points are ecoprovince means and error bars are 95% confidence intervals.

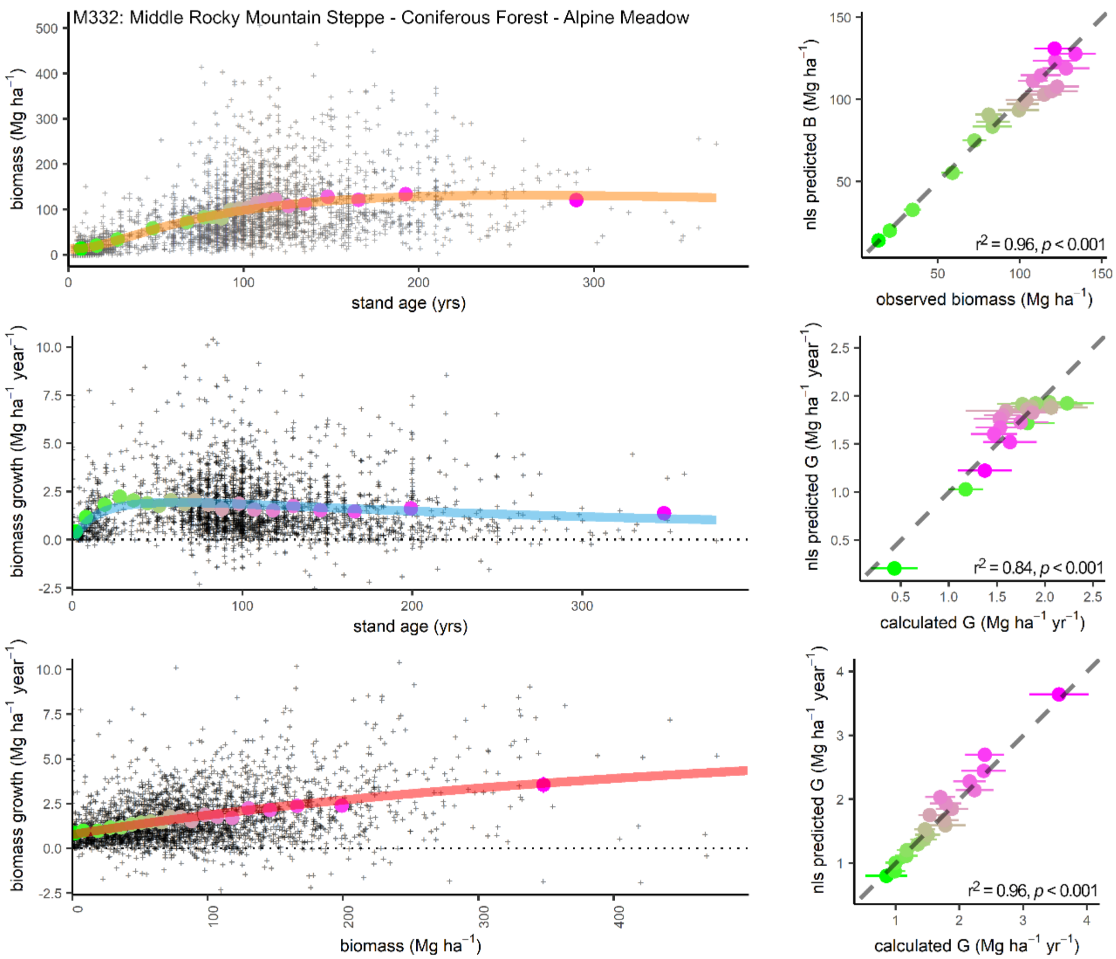


Fig. S8. Example of models fit to forest inventory data for ecoprovince M332 (Middle Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow) in the western US (see Fig. S1). **Left:** Data for individual FIA plots (small black symbols), data means in equal-sample-size bins (large colored dots) and fitted curves (parameter estimates in Tables S2-S4). All FIA plot data are shown, without regard for measurement date. Fitted curves are plotted based on the ecoprovince mean values for measurement date and fractional biomass losses (L). FIA plot data are noisy due to the small sample area, as well as heterogeneity in soil, climate, and disturbance history within ecoprovinces. Empirical estimates for biomass growth (G) are sometimes negative due to decreases in the expansion factors (trees per hectare, TPHa) of individual trees that grow from the microplot size-class to the subplot size-class (see details in Methods). **Right:** Data means by bin (with 95% confidence intervals, *x*-axes) in relation to the predicted value at the bin midpoint (point estimate, *y*-axes). Predictions are based on the bin means for measurement date and L, and therefore may differ slightly from the predicted curve in the left panel. Colors match the dots in the left panels. Dashed lines are the 1:1 line.

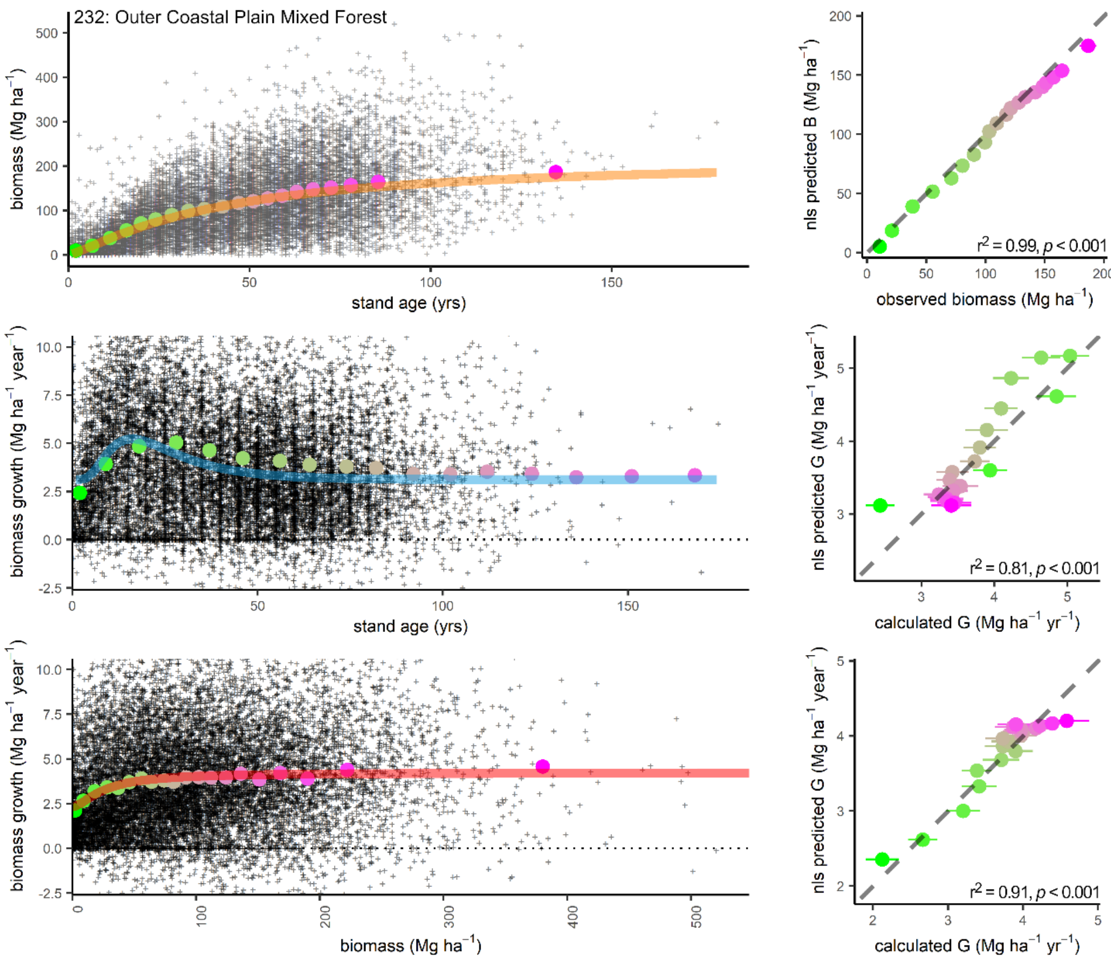


Fig. S9. Example of models fit to forest inventory data for ecoprovince 232 (Outer Coastal Plain Mixed Forest) in the eastern US. Details as in Fig. S8.

Table S1. Robustness of productivity trend (τ) estimates.

The table summarizes the number of pairwise comparisons within ecoprovinces that were consistent with respect to the sign and statistical significance of τ estimates. Consistency checks were performed within ecoprovinces across the three model forms (for a given data subset) and across the three data subsets (for each model form). The model forms and data subsets are described in Fig. S4. If three τ estimates were available for a given consistency check, then there were three pairwise comparisons. If two τ estimates were available, then there was one pairwise comparison. If only one τ estimate was available, then there were zero pairwise comparisons. For example, for ecoprovince 211, there were three pairwise comparisons for all consistency checks, whereas for ecoprovince 255, the number of pairwise comparisons ranged from zero to three. 'Consistent sign and significance' refers to pairwise comparisons where both τ estimates were significantly positive, both τ estimates were significantly negative, or both τ estimates were not significantly different from zero.

Comparison	consistent sign and significance	total number of pairwise comparisons
Across model forms – main dataset	42 (67%)	63
Across model forms – temporally balanced	33 (80%)	41
Across model forms – excluding timber harvest	34 (77%)	44
Across data subsets – pooled results from three model forms	134 (94%)	143

Table S2: Parameters for the biomass=f(age) model by US ecoprovince. The number of observations (N obs; *i.e.*, number of plot remeasurements), number of plot locations (N plots), and mean fraction of plot biomass lost to natural mortality or harvest during a remeasurement interval (Mean L; range: 0-1) are given. All models included the productivity trend parameter (τ, % year^{-1}) but only included the loss effect parameter (α, unitless) if it improved model fit (based on AIC). For the f(age) function (f(x) in eq. 1), both the Michaelis-Menten (eq. 2) and log-normal (eq. 3) functional forms were considered. For the Michaelis-Menten form, we considered the full version of eq. 2, as well as simpler forms lacking one or both of the intercept (*p*) and shape (*s*) parameters. Parameter estimates ('coef') and their standard errors for the best model (lowest AIC) are reported. For model selection details and figures showing predicted vs. observed values for each ecoprovince, see FIA_nlsModels_plotB_StdAge.html. Bin means R^2 is the coefficient of determination for the observed vs. predicted relationship for stand age bins (*e.g.*, top-right panels in Figs. S8-S9; values in italics are for 10 equal sample-sized bins, otherwise 20 equal sample-sized bins were used). *p*-value notation is as follows: *ns*: non-significant, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Region	Code	Ecoprovince	N obs	N plots	Mean L	Model-independent parameters					Michaelis-Menten function parameters								Log-normal function parameters								Bin means R^2
						τ (% year^{-1})			α		A		k		p		s		a		b		c		d		
						coef	s.e.	*p*	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	
East	211	Northeastern Mixed Forest	6877	2876	0.11	0.81	0.18	***	0.83	0.03	—	—	—	—	—	—	—	—	31.2	1.7	112.9	5.4	123.7	5.9	1.1	0.1	0.99
East	212	Laurentian Mixed Forest	22715	9499	0.12	1.17	0.11	***	0.77	0.03	—	—	—	—	—	—	—	—	23.0	0.8	67.5	1.6	103.1	2.2	1.1	<0.1	0.98
East	221	Eastern Broadleaf Forest	7333	3571	0.09	0.20	0.11	*ns*	0.88	0.03	—	—	—	—	—	—	—	—	46.5	10.5	143.4	12.8	119.2	8.1	1.1	0.1	0.99
East	222	Midwest Broadleaf Forest	5845	2589	0.12	1.06	0.21	***	0.87	0.04	—	—	—	—	—	—	—	—	19.4	3.7	96.7	5.4	101.3	4.5	1.0	0.1	0.99
East	223	Central Interior Broadleaf Forest	10010	3864	0.10	0.95	0.11	***	0.79	0.03	—	—	—	—	—	—	—	—	14.4	24.7	100.6	25.7	118.7	12.0	1.6	0.4	0.97
East	231	Southeastern Mixed Forest	13517	6193	0.14	1.29	0.12	***	0.71	0.02	220.2	6.6	42.7	2.3	-0.1	<0.1	—	—	—	—	—	—	—	—	—	—	0.99
East	232	Outer Coastal Plain Mixed Forest	13629	6626	0.16	0.79	0.19	***	0.87	0.01	206.2	9.6	41.3	2.9	—	—	1.2	<0.1	—	—	—	—	—	—	—	—	0.99
East	234	Lower Mississippi Riverine Forest	1388	778	0.14	0.53	0.41	*ns*	0.80	0.06	478.3	82.0	153.2	30.7	—	—	—	—	—	—	—	—	—	—	—	—	0.95
West	242	Pacific Lowland Mixed Forest	83	83	0.10	—	—	—	—	—	—		—		—	—	—	—	—	—	—	—	—	—	—	—	—
East	251	Prairie Parkland (Temperate)	2295	906	0.10	0.40	0.22	*ns*	0.72	0.07	148.6	10.2	5.2	5.4	-3.2	3.6	—	—	—	—	—	—	—	—	—	—	0.89
East	255	Prairie Parkland (Subtropical)	717	319	0.15	-0.33	0.44	*ns*	0.56	0.11	—	—	—	—	—	—	—	—	11.8	1.9	89.0	10.2	58.3	5.0	1.1	0.1	0.83
West	261	California Coastal Chaparral Forest and Shrub	25	25	0.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	262	California Dry Steppe	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	263	California Coastal Steppe - Mixed Forest and Redwood Forest	163	161	0.08	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	313	Colorado Plateau Semi-Desert	218	218	0.10	-1.45	0.59	*	—	—	—	—	—	—	—	—	—	—	40.2	12.3	148.9	39.3	142.8	8.7	0.6	0.1	0.79
West	315	Southwest Plateau and Plains Dry Steppe and Shrub	4	4	0.19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	321	Chihuahuan Semi-Desert	9	9	0.27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	322	American Semidesert and Desert	3	3	0.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	331	Great Plains/Palouse Dry Steppe	331	255	0.10	-1.58	0.49	**	0.86	0.12	314.6	431.8	373.9	734.1	0.1	0.2	—	—	—	—	—	—	—	—	—	—	0.58
West	332	Great Plains Steppe	232	128	0.11	0.48	1.58	*ns*	0.64	0.29	502.6	606.5	360.8	468.4	—	—	—	—	—	—	—	—	—	—	—	—	*0.91*
West	341	Intermountain Semi-Desert and Desert	66	64	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	342	Intermountain Semi-Desert	124	123	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
East	411	Everglades	96	63	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

East	M211	Adirondack-New England Mixed forest - Coniferous Forest - Alpine Meadow	6772	3006	0.12	0.72	0.16	***	0.82	0.02	—	—	—	—	—	—	—	—	11.9	2.9	157.0	10.9	207.7	26.6	1.7	0.1	0.98
East	M221	Central Appalachian Broadleaf Forest - Coniferous Forest - Meadow	8315	3810	0.07	0.99	0.12	***	0.90	0.04	—	—	—	—	—	—	—	—	49.4	12.7	102.1	12.6	100.6	3.2	1.1	0.1	0.98
East	M223	Ozark Broadleaf Forest Meadow	896	349	0.10	0.05	0.26	*ns*	0.90	0.07	225.9	25.3	51.4	12.3	-0.1	<0.1	—	—	—	—	—	—	—	—	—	—	0.85
East	M231	Ouachita Mixed Forest	1006	495	0.10	0.46	0.43	*ns*	0.77	0.08	306.5	52.1	133.5	26.0	—	—	—	—	—	—	—	—	—	—	—	—	0.93
West	M242	Cascade Mixed Forest	3224	3207	0.11	0.59	0.67	*ns*	1.08	0.07	—	—	—	—	—	—	—	—	0	5.4	467.6	77.2	581.4	102.2	2.1	0.1	0.97
West	M261	Sierran Steppe - Mixed Forest - Coniferous Forest - Alpine Meadow	1977	1807	0.11	7.9	4.3	*ns*	0.62	0.11	130.6	48.8	91.0	18.3	-0.1	<0.1	—	—	—	—	—	—	—	—	—	—	*0.97*
West	M262	California Coastal Range Coniferous Forest - Open Woodland - Shrub - Meadow	30	26	0.11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	M313	Arizona-New Mexico Mountains Semi-Desert - Open Woodland - Coniferous Forest - Alpine Meadow	367	367	0.13	-1.83	0.33	***	0.61	0.13	—	—	—	—	—	—	—	—	42.7	11.0	180.7	41.1	177.8	40.9	0.98	0.2	0.69
West	M331	Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow	1756	1756	0.22	-0.87	0.34	*	0.60	0.04	—	—	—	—	—	—	—	—	27.0	4.2	136.8	18.1	241.2	35.9	1.5	0.1	0.94
West	M332	Middle Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow	2612	2602	0.17	0.85	0.85	*ns*	0.46	0.05	—	—	—	—	—	—	—	—	11.7	2.5	104.6	20.3	258.3	37.5	1.7	0.1	0.96
West	M333	Northern Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow	1753	1742	0.16	2.33	1.86	*ns*	0.58	0.06	—	—	—	—	—	—	—	—	12.0	3.7	93.6	28.6	137.6	7.2	1.1	0.1	0.96
West	M334	Black Hills Coniferous Forest	459	181	0.16	0.28	0.64	*ns*	0.84	0.11	98.0	18.5	53.1	19.1	—	—	—	—	—	—	—	—	—	—	—	—	0.72
West	M341	Nevada-Utah Mountains Semi-Desert - Coniferous Forest - Alpine Meadow	220	220	0.22	-1.54	0.54	**	0.51	0.14	—	—	—	—	—	—	—	—	22.4	6.3	115.4	27.6	156.2	23.0	1.08	0.20	0.82

Table S3. Parameters for the growth=ƒ(age) model. For the ƒ(age) function (ƒ(x) in eq. 1), only the log-normal form (eq. 3) was considered. Other details follow Table S2. For model selection details and figures showing predicted vs. observed values for each ecoprovince, see FIA_nlsModels_BiomassG_StdAge.html.

Region	Code	Ecoprovince	N obs	N plots	Mean L	Model-independent parameters					Log-normal function parameters								Bin means R^2
						τ (% year^{-1})			α		a		b		c		d		
						coef	*s.e.*	*p*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	
East	211	Northeastern Mixed Forest	6877	2876	0.11	0.31	0.18	*ns*	0.64	0.03	0.0	1.6	3.4	1.6	34.5	1.8	2.5	0.7	0.72
East	212	Laurentian Mixed Forest	22715	9499	0.12	1.40	0.17	***	0.82	0.02	1.1	0.3	1.2	0.2	22.9	1.0	1.8	0.3	0.82
East	221	Eastern Broadleaf Forest	7333	3571	0.09	-0.45	0.15	***	0.76	0.04	0.0	30.6	4.4	30.6	39.0	8.0	2.8	10.7	0.69
East	222	Midwest Broadleaf Forest	5845	2589	0.12	0.22	0.23	*ns*	0.77	0.04	2.6	0.2	0.8	0.1	52.9	2.4	0.8	0.1	0.69
East	223	Central Interior Broadleaf Forest	10010	3864	0.10	-0.19	0.14	*ns*	0.62	0.04	1.7	1.4	2.0	1.4	28.6	4.3	1.7	0.9	0.95
East	231	Southeastern Mixed Forest	13517	6193	0.14	1.54	0.18	***	0.91	0.02	3.0	0.1	1.9	0.1	17.5	0.5	1.0	0.1	0.80
East	232	Outer Coastal Plain Mixed Forest	13629	6626	0.16	1.65	0.21	***	0.90	0.02	2.8	0.1	0.9	0.1	16.1	0.4	0.8	0.1	0.81
East	234	Lower Mississippi Riverine Forest	1388	778	0.14	0.86	0.72	*ns*	0.78	0.08	3.4	0.5	1.7	0.5	18.5	2.2	0.7	0.2	0.53
West	242	Pacific Lowland Mixed Forest	83	83	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
East	251	Prairie Parkland (Temperate)	2295	906	0.10	0.63	0.44	*ns*	0.42	0.10	1.9	1.1	0.8	1.1	42.9	4.5	1.1	1.1	0.14
East	255	Prairie Parkland (Subtropical)	717	319	0.15	1.17	1.32	*ns*	0.74	0.15	0.8	0.7	2.4	0.8	18.4	2.0	1.3	0.4	0.79
West	261	California Coastal Chaparral Forest and Shrub	25	25	0.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	262	California Dry Steppe	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	263	California Coastal Steppe - Mixed Forest and Redwood Forest	163	161	0.08	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	313	Colorado Plateau Semi-Desert	218	218	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	315	Southwest Plateau and Plains Dry Steppe and Shrub	4	4	0.19	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	321	Chihuahuan Semi-Desert	9	9	0.27	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	322	American Semidesert and Desert	3	3	0.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	331	Great Plains/Palouse Dry Steppe	331	255	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	332	Great Plains Steppe	232	128	0.11	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	341	Intermountain Semi-Desert and Desert	66	64	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	342	Intermountain Semi-Desert	124	123	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—
East	411	Everglades	96	63	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
East	M211	Adirondack-New England Mixed forest - Coniferous Forest - Alpine Meadow	6772	3006	0.12	0.91	0.21	***	0.63	0.03	1.9	0.5	1.2	0.5	32.6	2.0	1.6	0.5	0.58
East	M221	Central Appalachian Broadleaf Forest - Coniferous Forest - Meadow	8315	3810	0.07	0.97	0.23	***	0.83	0.06	2.6	0.2	1.3	0.2	31.4	4.3	0.9	0.2	0.79

East	M223	Ozark Broadleaf Forest Meadow	896	349	0.10	3.63	1.82	*	0.90	0.15	1.4	0.3	0.9	0.3	32.3	2.9	0.4	0.1	0.46
East	M231	Ouachita Mixed Forest	1006	495	0.10	4.49	2.23	*	0.93	0.09	1.4	0.3	0.9	0.3	24.4	1.8	0.3	0.1	0.26
West	M242	Cascade Mixed Forest	3224	3207	0.11	-1.56	0.30	***	0.97	0.08	6.0	0.6	4.3	0.8	35.2	1.7	0.3	0.1	0.51
West	M261	Sierran Steppe - Mixed Forest - Coniferous Forest - Alpine Meadow	1977	1807	0.11	-2.46	0.24	***	0.70	0.13	0.0	4.5	8.0	1.5	47.0	7.6	2.7	1.1	*0.55*
West	M262	California Coastal Range Coniferous Forest - Open Woodland - Shrub - Meadow	30	26	0.11	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	M313	Arizona-New Mexico Mountains Semi-Desert - Open Woodland - Coniferous Forest - Alpine Meadow	367	367	0.13	-2.49	0.30	***	0.58	0.15	0.0	5.1	3.4	5.1	61.9	17.7	2.1	2.3	0.54
West	M331	Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow	1756	1756	0.22	-0.79	0.63	*ns*	0.60	0.06	0.1	0.7	1.9	0.7	49.0	3.6	2.0	0.6	0.79
West	M332	Middle Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow	2612	2602	0.17	-0.47	0.59	*ns*	0.83	0.06	0.0	0.3	2.5	0.5	61.7	4.5	2.3	0.3	0.84
West	M333	Northern Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow	1753	1742	0.16	0.49	0.66	*ns*	0.88	0.06	1.0	0.2	3.3	0.6	47.9	1.8	1.4	0.1	0.91
West	M334	Black Hills Coniferous Forest	459	181	0.16	-1.34	0.73	*ns*	—	—	1.6	0.3	12.3	10.4	56.4	0.3	0.0	0.0	*0.20*
West	M341	Nevada-Utah Mountains Semi-Desert - Coniferous Forest - Alpine Meadow	220	220	0.22	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table S4. Parameters for the growth=ƒ(biomass) model. For the ƒ(biomass) function (ƒ(x) in eq. 1), only the Michaelis-Menten form (eq. 2) was considered. Other details follow Table S2. For model selection details and figures showing predicted vs. observed values for each ecoprovince, see FIA_nls3Models_BiomassG_plotB.html.

Region	Code	Ecoprovince	N obs	N plots	Mean L	Model-independent parameters					Michaelis-Menten function parameters								Bin means R^2
						τ (% year^{-1})			α		A		k		p		s		
						coef	*s.e.*	*p*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	
East	211	Northeastern Mixed Forest	6877	2876	0.11	0.19	0.17	*ns*	0.63	0.03	3.8	0.2	70.4	59.1	0.7	0.1	—	—	0.80
East	212	Laurentian Mixed Forest	22715	9499	0.12	1.36	0.18	***	0.80	0.02	3.1	0.2	19.5	4.1	—	—	0.6	0.1	0.99
East	221	Eastern Broadleaf Forest	7333	3571	0.09	-0.68	0.13	***	-0.74	0.04	5.4	0.2	23.6	2.8	—	—	—	—	0.78
East	222	Midwest Broadleaf Forest	5845	2589	0.12	0.04	0.22	*ns*	0.76	0.05	8.4	1.5	317.3	110.8	0.1	0.1	—	—	0.93
East	223	Central Interior Broadleaf Forest	10010	3864	0.10	-0.59	0.12	***	-0.68	0.04	5.1	0.2	42.0	3.4	—	—	—	—	0.62
East	231	Southeastern Mixed Forest	13517	6193	0.14	1.72	0.19	***	-0.87	0.02	3.8	0.1	2.6	0.4	—	—	—	—	0.63
East	232	Outer Coastal Plain Mixed Forest	13629	6626	0.16	1.37	0.20	***	0.87	0.02	2.9	0.1	26.1	4.9	1.6	0.4	0.5	0.1	0.91
East	234	Lower Mississippi Riverine Forest	1388	778	0.14	0.81	0.69	*ns*	-0.76	0.08	4.0	0.5	3.7	1.4	—	—	—	—	0.80
West	242	Pacific Lowland Mixed Forest	83	83	0.10		—	—	—	—	—	—	—	—	—	—	—	—	—
East	251	Prairie Parkland (Temperate)	2295	906	0.10	0.41	0.45	*ns*	-0.39	0.11	3.4	0.3	19.9	3.7	—	—	—	—	0.37
East	255	Prairie Parkland (Subtropical)	717	319	0.15	0.43	0.94	*ns*	-0.78	0.14	2.8	0.5	1.9	2.2	—	—	—	—	0.30
West	261	California Coastal Chaparral Forest and Shrub	25	25	0.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	262	California Dry Steppe	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	263	California Coastal Steppe - Mixed Forest and Redwood Forest	163	161	0.08	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	313	Colorado Plateau Semi-Desert	218	218	0.10	-1.31	0.90	*ns*	-0.88	0.25	5.1	1.7	145.0	49.7	—	—	—	—	0.53
West	315	Southwest Plateau and Plains Dry Steppe and Shrub	4	4	0.19	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	321	Chihuahuan Semi-Desert	9	9	0.27	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	322	American Semidesert and Desert	3	3	0.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	331	Great Plains/Palouse Dry Steppe	331	255	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	332	Great Plains Steppe	232	128	0.11	0.82	1.62	*ns*	0.66	0.24	5.1	2.2	147.5	104.2	0.1	0.0	—	—	0.86
West	341	Intermountain Semi-Desert and Desert	66	64	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	342	Intermountain Semi-Desert	124	123	0.12	1.94	5.44	*ns*	-0.99	0.25	3.3	2.7	82.5	33.3	—	—	—	—	0.87
East	411	Everglades	96	63	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
East	M211	Adirondack-New England Mixed forest - Coniferous Forest - Alpine Meadow	6772	3006	0.12	0.83	0.21	***	0.64	0.03	2.9	0.1	15.4	3.9	—	—	4.3	2.2	0.76

East	M221	Central Appalachian Broadleaf Forest - Coniferous Forest - Meadow	8315	3810	0.07	0.40	0.18	*	-0.82	0.06	4.3	0.2	26.4	3.7	—	—	—	—	0.49
East	M223	Ozark Broadleaf Forest Meadow	896	349	0.10	3.15	1.62	*ns*	-0.93	0.15	2.1	0.5	26.4	11.7	—	—	—	—	0.08
East	M231	Ouachita Mixed Forest	1006	495	0.10	5.54	2.85	*ns*	-0.84	0.11	1.6	0.5	13.2	4.9	—	—	—	—	0.14
West	M242	Cascade Mixed Forest	3224	3207	0.11	-1.65	0.25	***	-0.93	0.07	9.2	0.8	140.2	9.5	0.3	<0.1	2.6	0.4	0.95
West	M261	Sierran Steppe - Mixed Forest - Coniferous Forest - Alpine Meadow	1977	1807	0.11	-1.85	0.32	***	-0.71	0.11	14.0	1.6	193.1	23.7	—	—	—	—	*0.97*
West	M262	California Coastal Range Coniferous Forest - Open Woodland - Shrub - Meadow	30	26	0.11	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West	M313	Arizona-New Mexico Mountains Semi-Desert - Open Woodland - Coniferous Forest - Alpine Meadow	367	367	0.13	-2.29	0.29	***	-0.83	0.11	10.3	2.0	170.6	42.7	—	—	—	—	0.93
West	M331	Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow	1756	1756	0.22	-0.65	0.61	*ns*	0.71	0.06	7.1	4.8	638.5	642.9	0.1	<0.1	—	—	0.82
West	M332	Middle Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow	2612	2602	0.17	-0.89	0.42	*	0.89	0.05	13.1	4.8	661.4	325.8	0.1	<0.1	—	—	0.96
West	M333	Northern Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow	1753	1742	0.16	-0.78	0.51	*ns*	0.94	0.05	17.0	6.2	704.9	347.7	0.1	<0.1	—	—	0.96
West	M334	Black Hills Coniferous Forest	459	181	0.16	-0.27	1.08	*ns*	-0.81	0.13	2.7	0.71	33.9	10.7	—	—	—	—	0.90
West	M341	Nevada-Utah Mountains Semi-Desert - Coniferous Forest - Alpine Meadow	220	220	0.22	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table S5: Parameters for the biomass=f(age) model used to partition biomass change in the eastern US (Figs. 3 and S6-S7). Models were fit to the temporally-balanced dataset for 14 eastern US ecoprovinces (two remeasurements per plot location). The mean change in the fractional biomass losses, $\overline{\frac{(L_{last}-L_{first})}{(T_{last}-T_{first})}}$, is reported (see Fig. S6 for details). Other details follow Table S2. For model selection details and figures showing predicted vs. observed values for each ecoprovince, see FIA_nlsModels_plotB_StdAge_BiomassPartitioning.html.

Region	Code	Ecoprovince	N obs	N plots	$\overline{\frac{(L_{last}-L_{first})}{(T_{last}-T_{first})}}$	Model-independent parameters					Michaelis-Menten function parameters								Log-normal function parameters								Bin means R^2
						τ (% year^{-1})			α		A		k		p		s		a		b		c		d		
						coef	*s.e.*	*p*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	coef	*s.e.*	
East	211	Northeastern Mixed Forest	4838	2419	-0.00058	0.58	0.18	***	0.84	0.03	—	—	—	—	—	—	—	—	33.4	2.0	118.9	5.9	118.4	5.9	1.0	0.1	0.99
East	212	Laurentian Mixed Forest	12962	6481	0.00484	1.19	0.14	***	0.67	0.03	—	—	—	—	—	—	—	—	13.4	0.5	75.8	2.4	121.1	5.5	1.4	<0.1	0.97
East	221	Eastern Broadleaf Forest	5466	2723	-0.00005	0.24	0.13	*0.06*	0.81	0.03	—	—	—	—	—	—	—	—	21.1	2.7	179.5	10.5	156.8	15.7	1.5	0.1	0.99
East	222	Midwest Broadleaf Forest	3552	1776	0.00533	1.21	0.26	***	0.77	0.05	—	—	—	—	—	—	—	—	14.0	1.4	101.9	6.0	115.6	8.2	1.2	0.1	0.99
East	223	Central Interior Broadleaf Forest	6388	3194	0.00608	0.85	0.12	***	0.71	0.03	—	—	—	—	—	—	—	—	17.8	2.1	98.5	3.9	113.2	7.0	1.4	0.1	0.97
East	231	Southeastern Mixed Forest	7940	3970	0.00170	1.48	0.18	***	0.65	0.02	—	—	—	—	—	—	—	—	16.1	0.8	120.4	5.6	112.8	9.3	1.6	0.1	0.98
East	232	Outer Coastal Plain Mixed Forest	7790	3895	-0.00221	1.01	0.19	***	0.71	0.02	—	—	—	—	—	—	—	—	20.5	1.0	121.3	3.6	111.1	9.3	1.5	0.1	0.97
East	234	Lower Mississippi Riverine Forest	830	415	-0.00220	0.40	0.41	*ns*	0.79	0.07	—	—	—	—	—	—	—	—	0.0	5.9	340.8	204.4	375.4	940.5	2.6	0.7	0.94
East	251	Prairie Parkland (Temperate)	1392	696	0.00657	0.34	0.25	*ns*	0.70	0.09	—	—	—	—	—	—	—	—	24.4	4.1	93.3	7.4	102.7	8.9	1.1	0.1	0.97
East	255	Prairie Parkland (Subtropical)	444	222	0.00934	-0.24	0.55	*ns*	0.53	0.16	—	—	—	—	—	—	—	—	9.6	1.9	88.5	12.5	56	5.9	1.0	0.1	0.92
East	M211	Adirondack-New England Mixed forest - Coniferous Forest - Alpine Meadow	5108	2554	0.00022	0.53	0.16	***	0.81	0.03	—	—	—	—	—	—	—	—	14.6	3.0	155.7	10.1	179.8	19.8	1.6	0.1	0.98
East	M221	Central Appalachian Broadleaf Forest - Coniferous Forest - Meadow	5186	2593	0.00087	0.88	0.14	***	0.82	0.04	—	—	—	—	—	—	—	—	31.8	2.6	122.4	4.6	103.1	4.1	1.3	0.1	0.98
East	M223	Ozark Broadleaf Forest Meadow	602	301	-0.00036	-0.08	0.26	*ns*	0.90	0.10	298.7	41.7	95.8	18.9	—	—	—	—	—	—	—	—	—	—	—	—	0.88
East	M231	Ouachita Mixed Forest	680	340	0.00069	0.57	0.50	*ns*	0.86	0.11	315.8	62.8	147.8	33.1	—	—	—	—	—	—	—	—	—	—	—	—	0.93

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