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Scaling from individuals to ecosystems in an Earth System Model using a mathematically tractable model of height-structured competition for light

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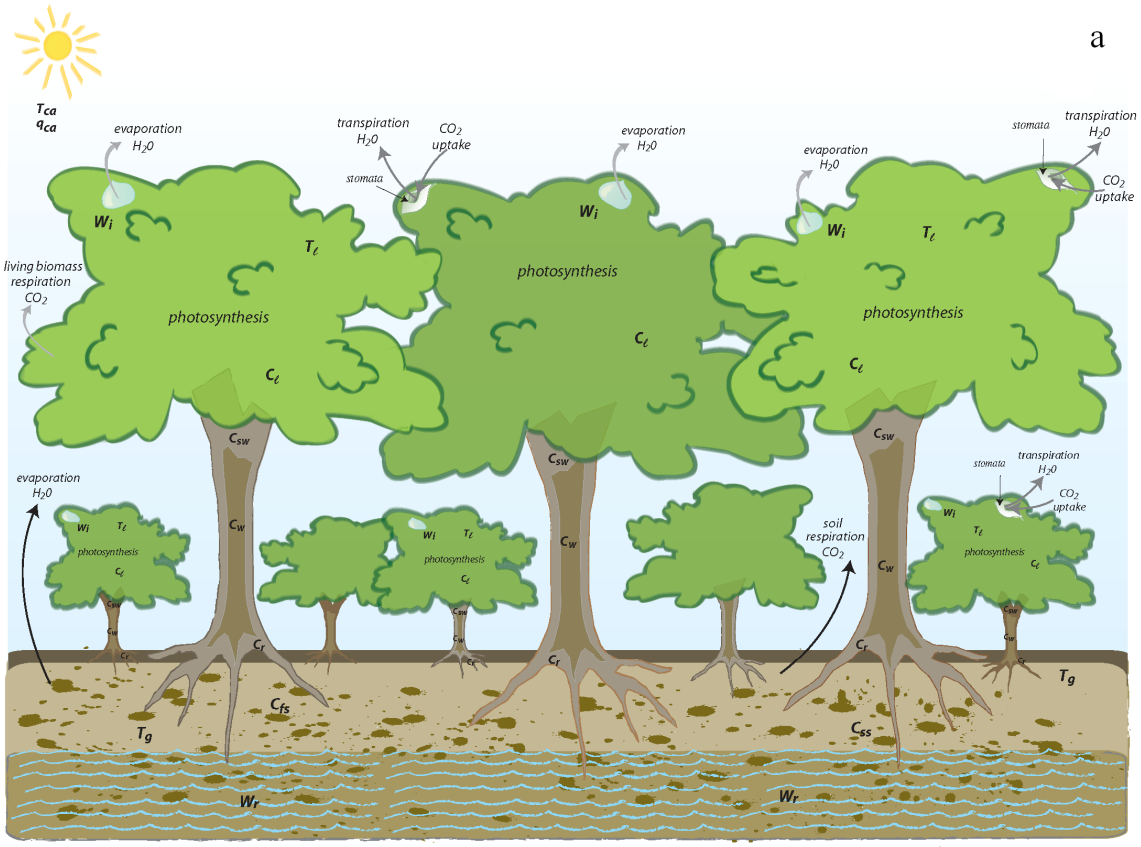
Figure D1 Model structure



a: Schematic diagram of vegetation structure and carbon pools in the LM3-PPA model. T_{ca}: air temperature, q_{ca}: air humidity, T_l leaf temperature; W_l: leaf water content, C_l: leaf

carbon, C_{SW}: sapwood carbon, C_W: heartwood carbon, C_r: fine root carbon, C_{fs}: fast soil carbon, C_{ss}: slow soil carbon, T_g: ground temperature, W_r: root zone soil water. b: Structure of the standard biogeochemical cycle (BGC) model. The C-pool structure in the standard BGC model is identical to that in LM3-PPA except that the standard BGC model ignores the seed C-pool (present in LM3-PPA, but omitted from Fig. D1a), which has negligible effect on simulated vegetation and soil C dynamics.

Figure D2 Diurnal patterns of radiation and, photosynthesis rates of canopy and understory trees simulated by the LM3-PPA model.

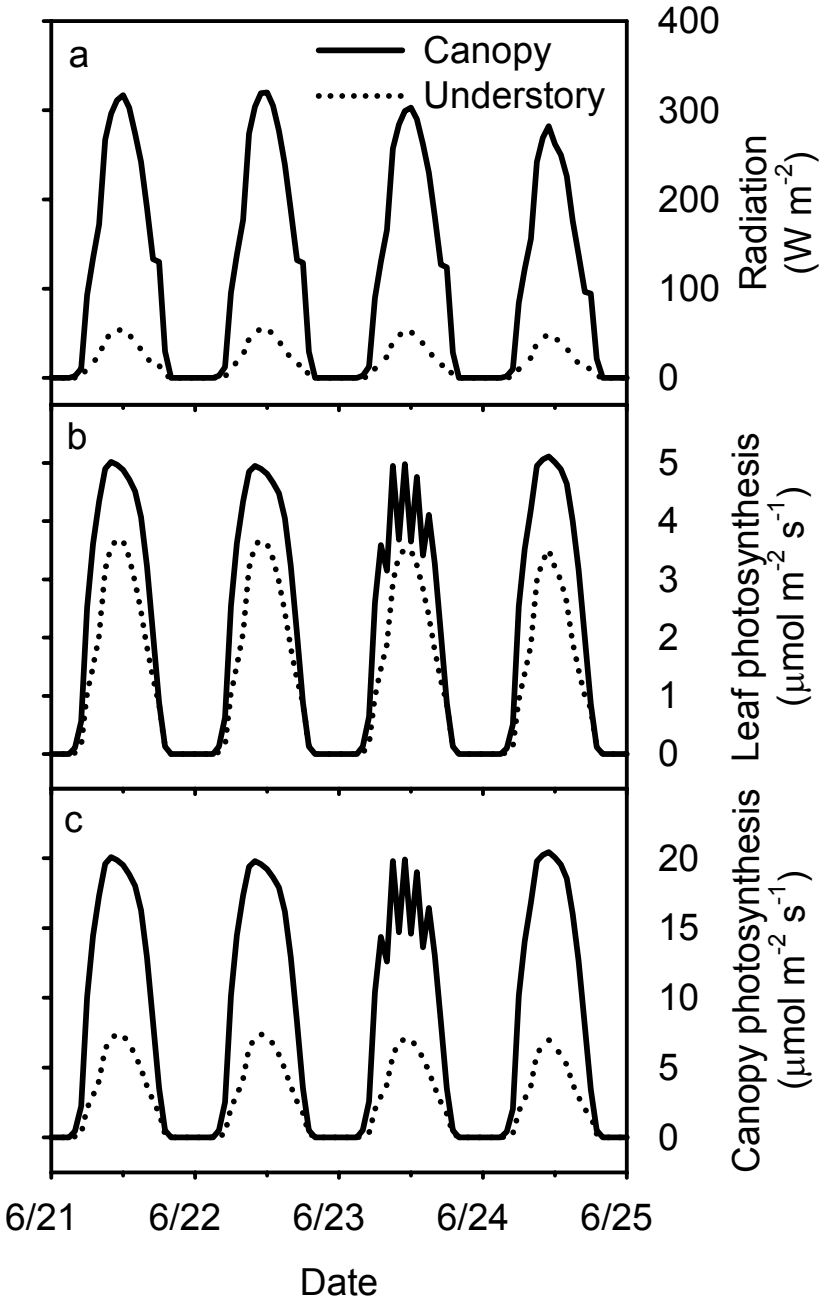


Figure D3 Dynamics of tree density and basal area in a single species model run (sugar maple, *Acer saccharum*).

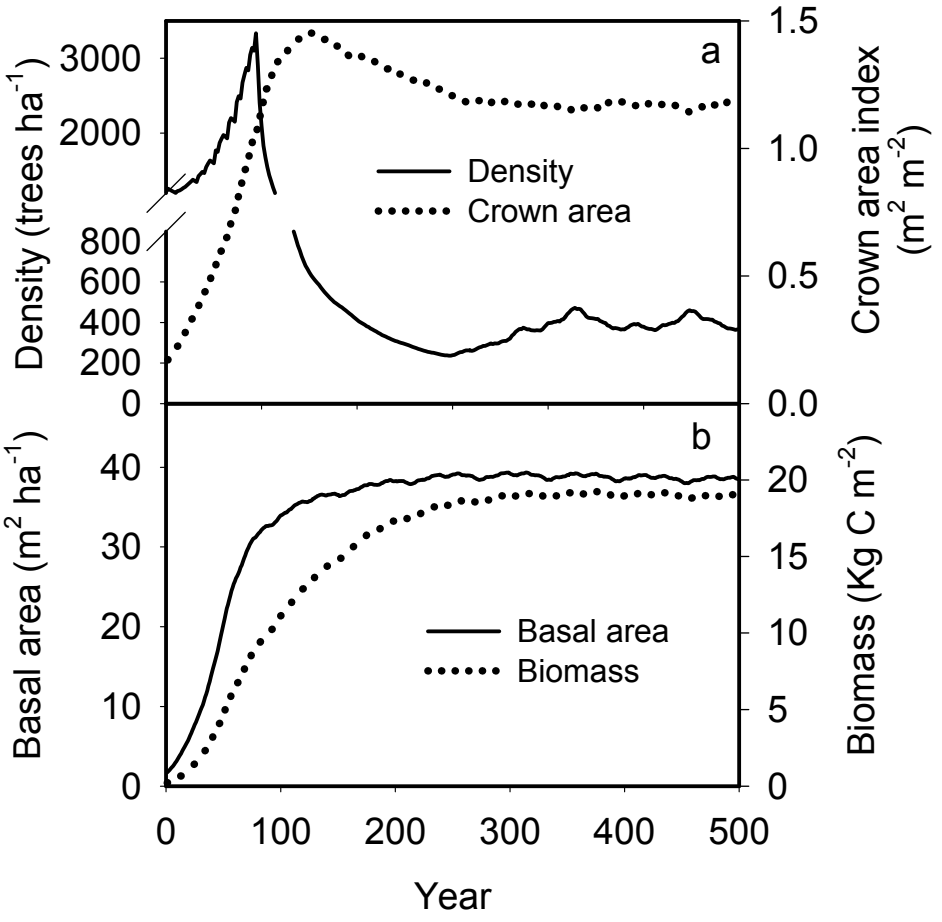
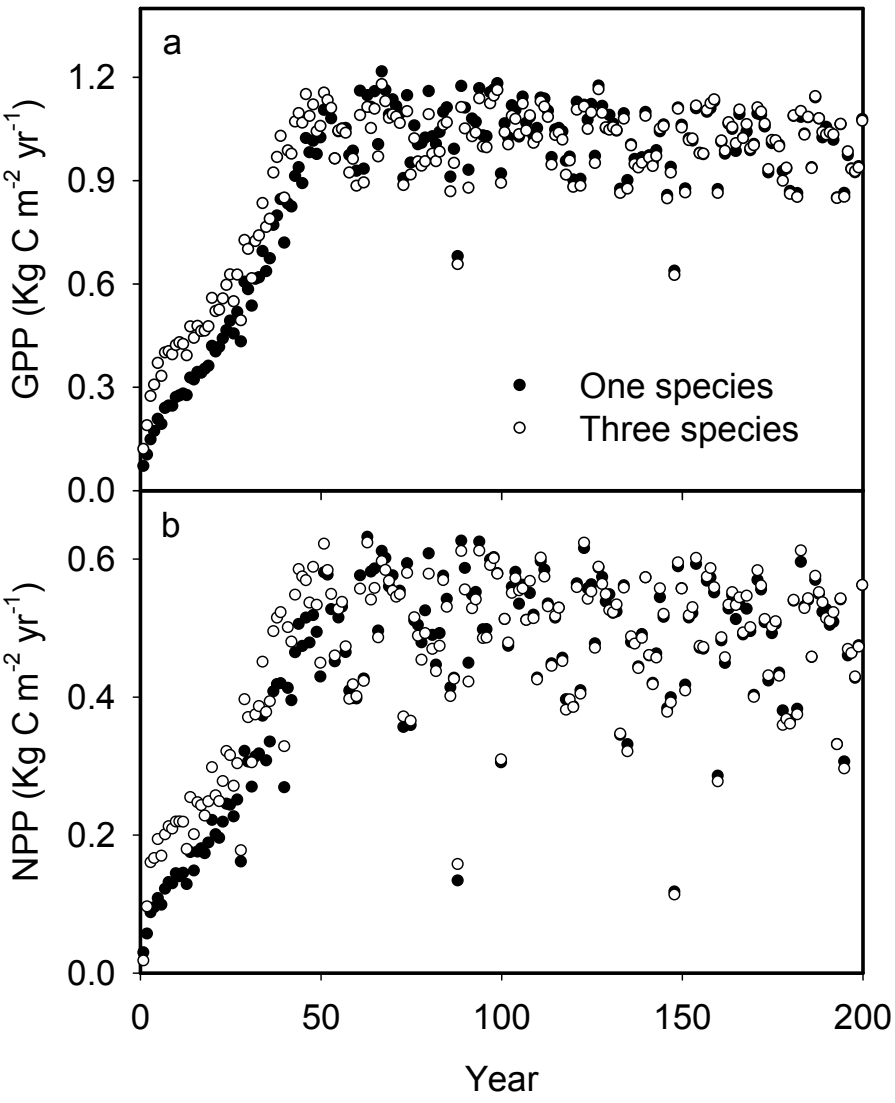


Figure D4 Temporal dynamics of GPP and NPP with forest succession



The one species model runs are of sugar maple (*Acer saccharum*). The three species model runs are of trembling aspen (*Populus tremuloides*), red maple (*Acer rubrum*), and sugar maple (*Acer saccharum*). The parameters can be found in Table 1 and Tables C3 and C4 in Appendix C.

Figure D5 Basal area dynamics from the succession model runs (a) and FIA chronosequences (b)

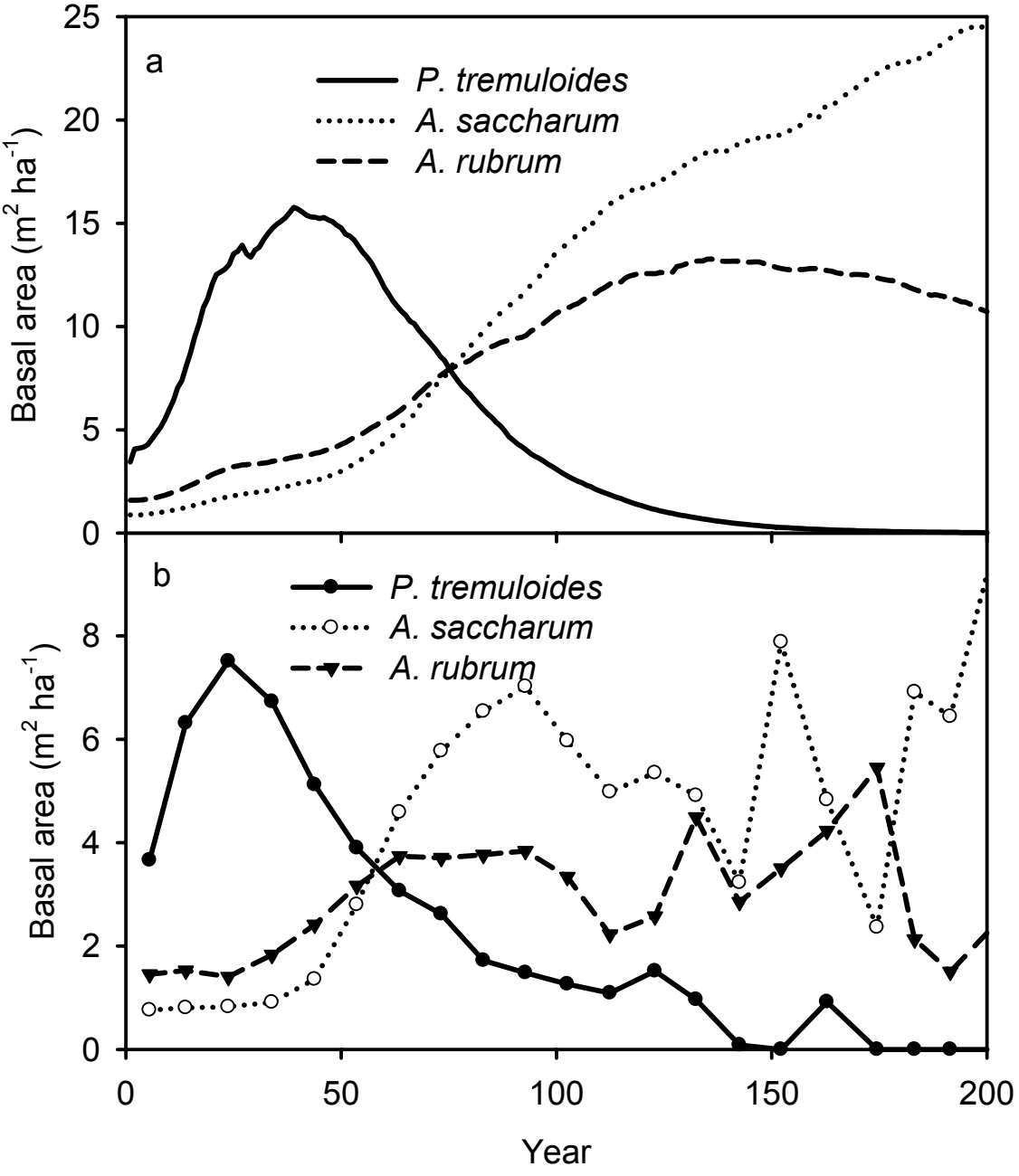
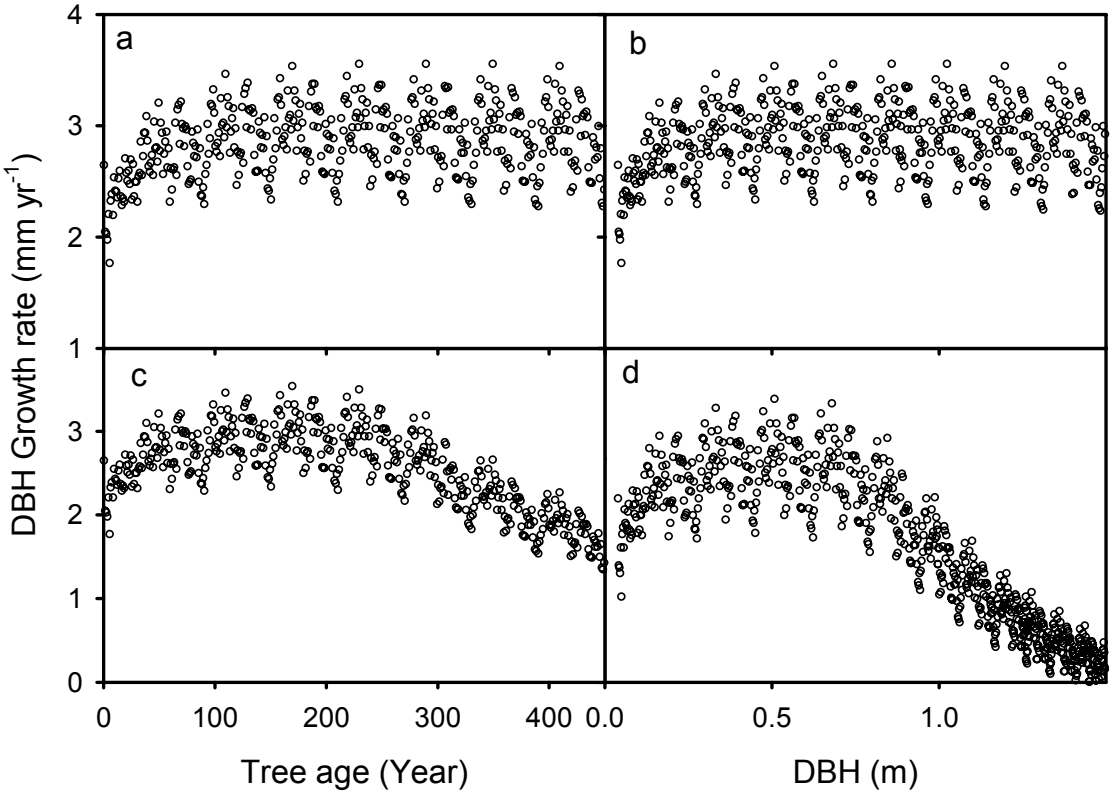
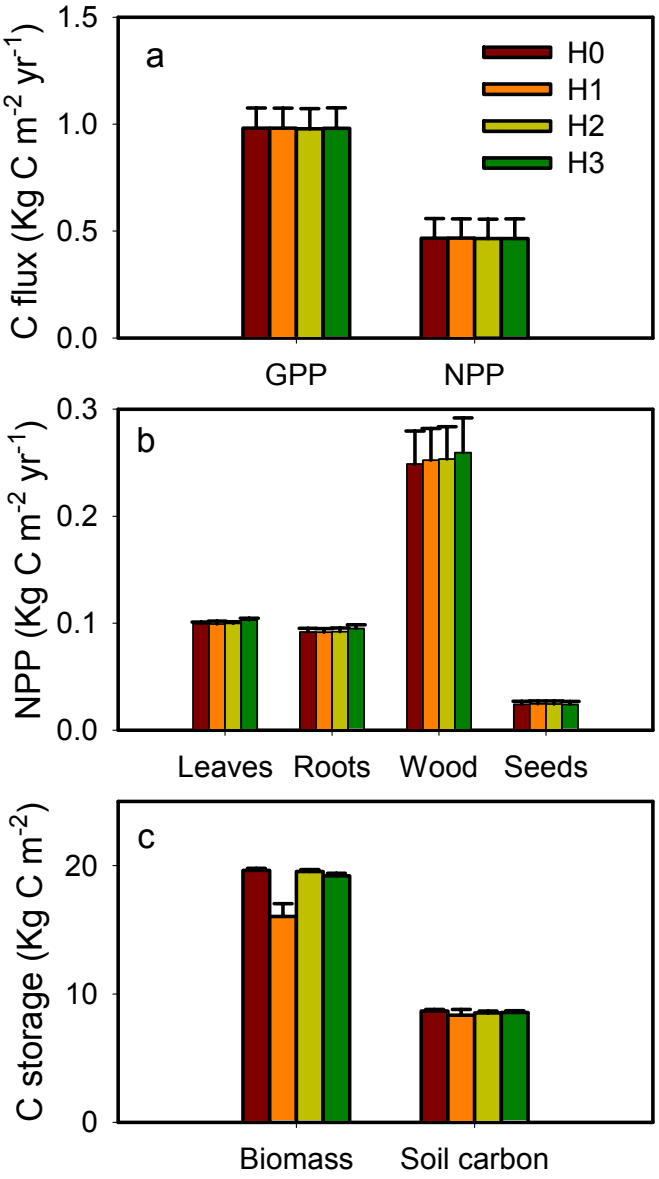


Figure D6 DBH growth rates of Sugar maple at the assumptions of constant crown area allometry with DBH (H0) and cessation of crown area expansion at high DBH (H2)



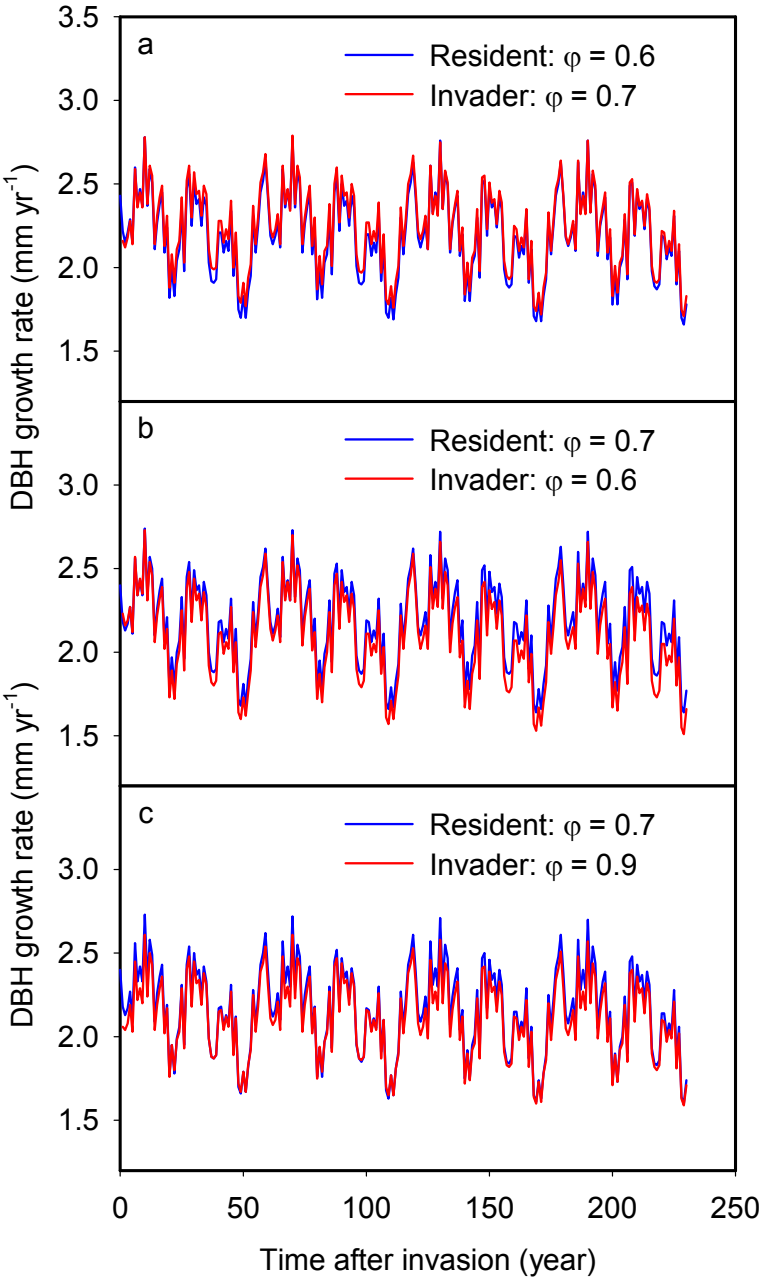
Panels a and b show the growth rate dynamics with tree age and diameter of breast height (DBH) at the baseline model (H0, constant allometry of canopy area with DBH). Panels c and d show the growth rates at the model H2 (cessation of crown area expansion when DBH > 0.8 m)

Figure D7 GPP, NPP, allocation to different plant tissues, and carbon storages in woody biomass and soil at quasi-equilibrium in one-species (*Acer saccharum*) LM3-PPA simulations under alternative models assumptions (H0-H3).



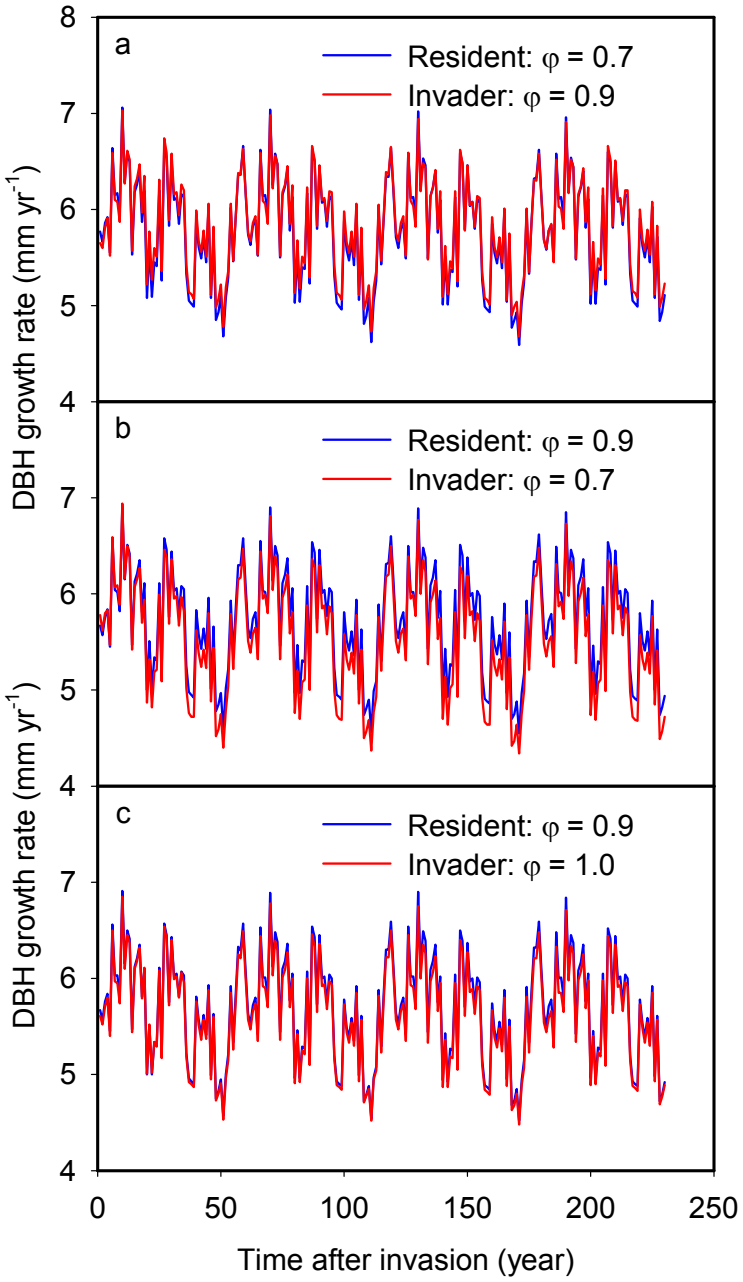
The data were averaged over the last 400 years of 1000-year simulations. The error bars represent one standard deviation. See Fig. 6 legend for brief description of H0-H3, and Table 2 and Fig. 1 for more details.

Figure D8 Temporal dynamics of DBH growth rates of the pairwise invasion simulations at the pre-industrial [CO_2] (280 ppm).



The growth rates are from the first cohort (the largest) of the residents and invaders in each simulation. The blue lines are for the resident and the redlines invader. a: Invasion of φ_{RL} 0.7 within the resident of φ_{RL} 0.6. b: Invasion of φ_{RL} 0.6 within the resident of φ_{RL} 0.7. c: Invasion of φ_{RL} 0.9 within the resident of φ_{RL} 0.7.

Figure D9 Temporal dynamics of DBH growth rates of the pairwise invasion simulations at the doubled [CO_2] (560 ppm).



The growth rates are from the first cohorts (the largest) of the residents and invaders in each simulation. The blue lines are for the resident and the redlines are invader. a: Invasion of φ_{RL} 0.9 within the resident of φ_{RL} 0.7. b: Invasion of φ_{RL} 0.7 within the resident of φ_{RL} 0.9. c: Invasion of φ_{RL} 1.0 within the resident of φ_{RL} 0.9.