

Supplementary Information II Supplementary figures

Competition alters predicted forest carbon cycle responses to nitrogen availability and elevated CO₂: simulations using an explicitly competitive, game-theoretic vegetation demographic model

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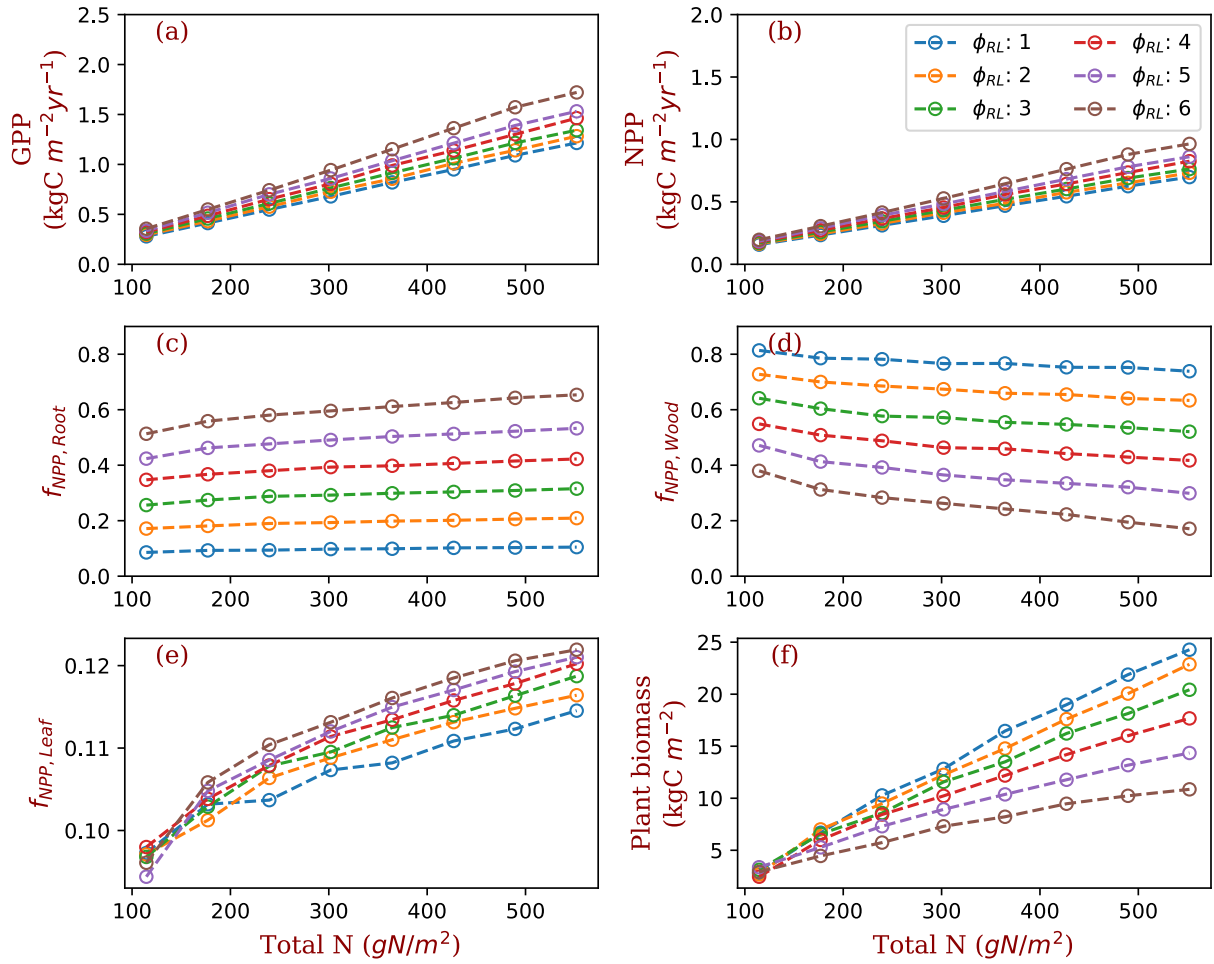
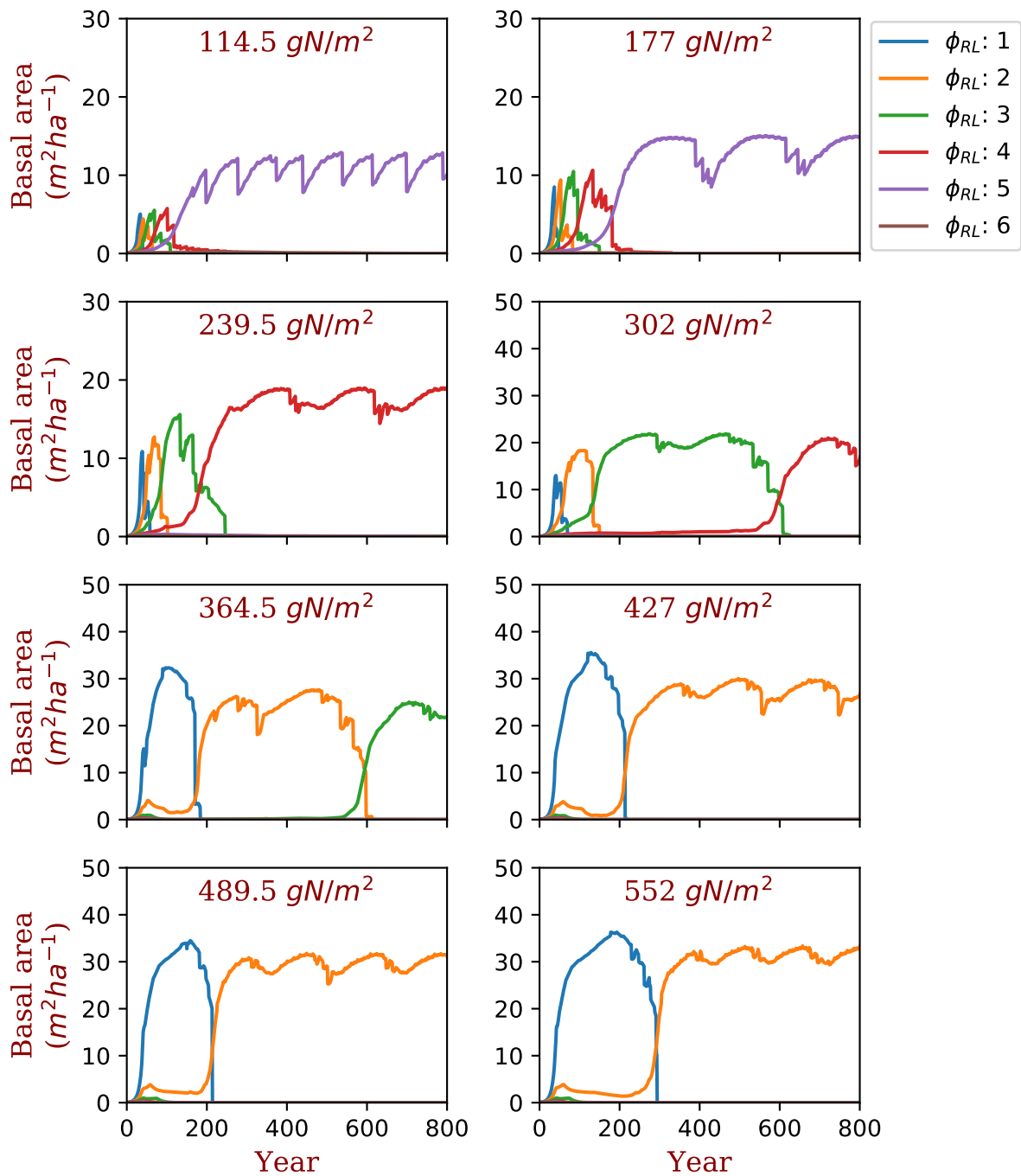


Figure S1 Monoculture runs at elevated [CO₂] (580 ppm). GPP: Gross primary production; NPP: Net primary production; $f_{NPP,x}$: the fraction of NPP allocated to x, where x can be Root (fine roots), Leaf (leaves in crown), and Wood (including tree trunk, stems, and coarse roots). The data are from the averages of the model run years from 1400 and 1800. Each model run is initiated with one PFT with fixed ratio of fine root area to leaf area (ϕ_{RL}).



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39 **Figure S2 Successional patterns of Polyculture runs I at ambient $[\text{CO}_2]$ (380 ppm).**

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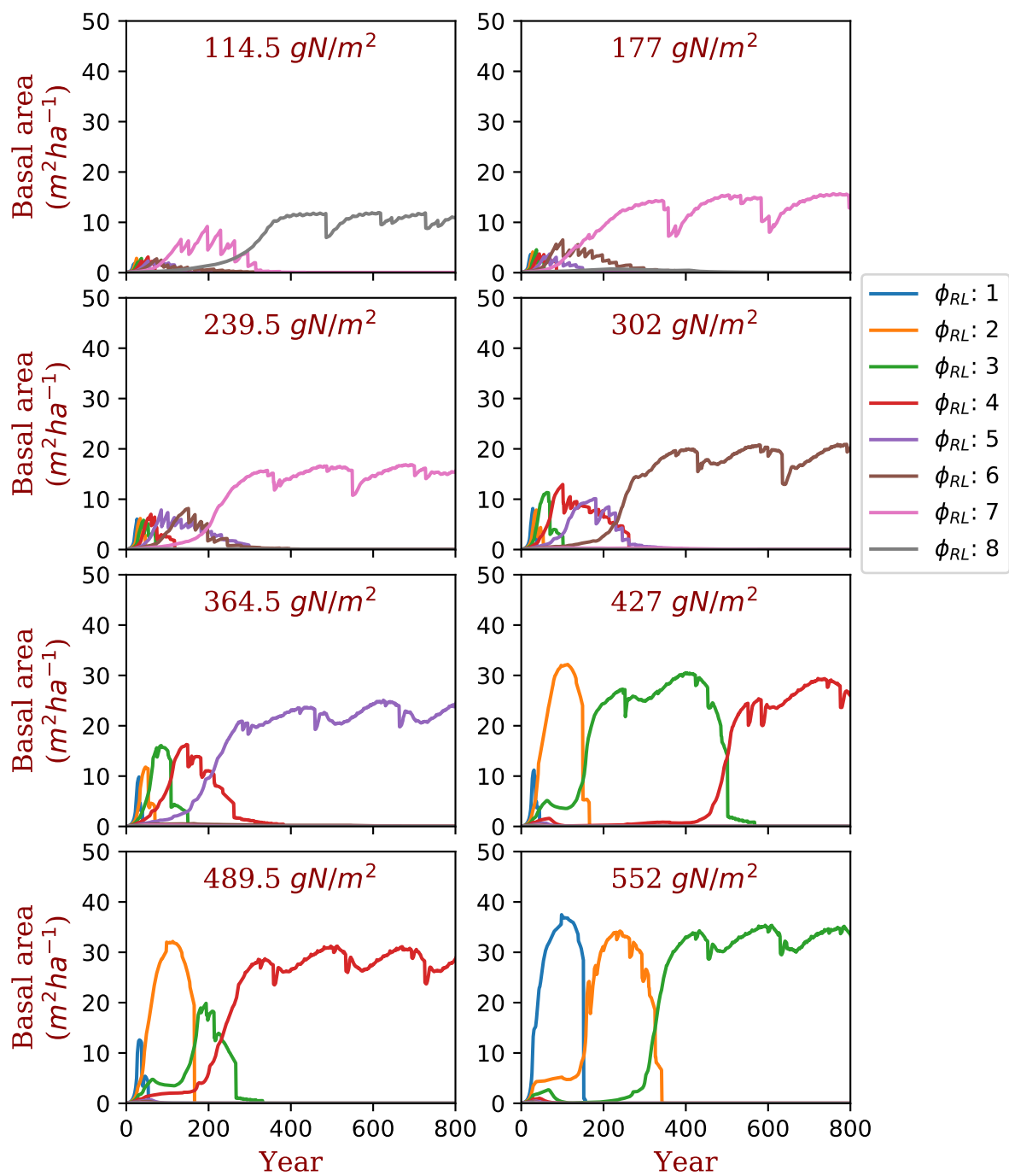


Figure S3 Successional patterns of Polyculture runs I at elevated $[\text{CO}_2]$ (580 ppm).

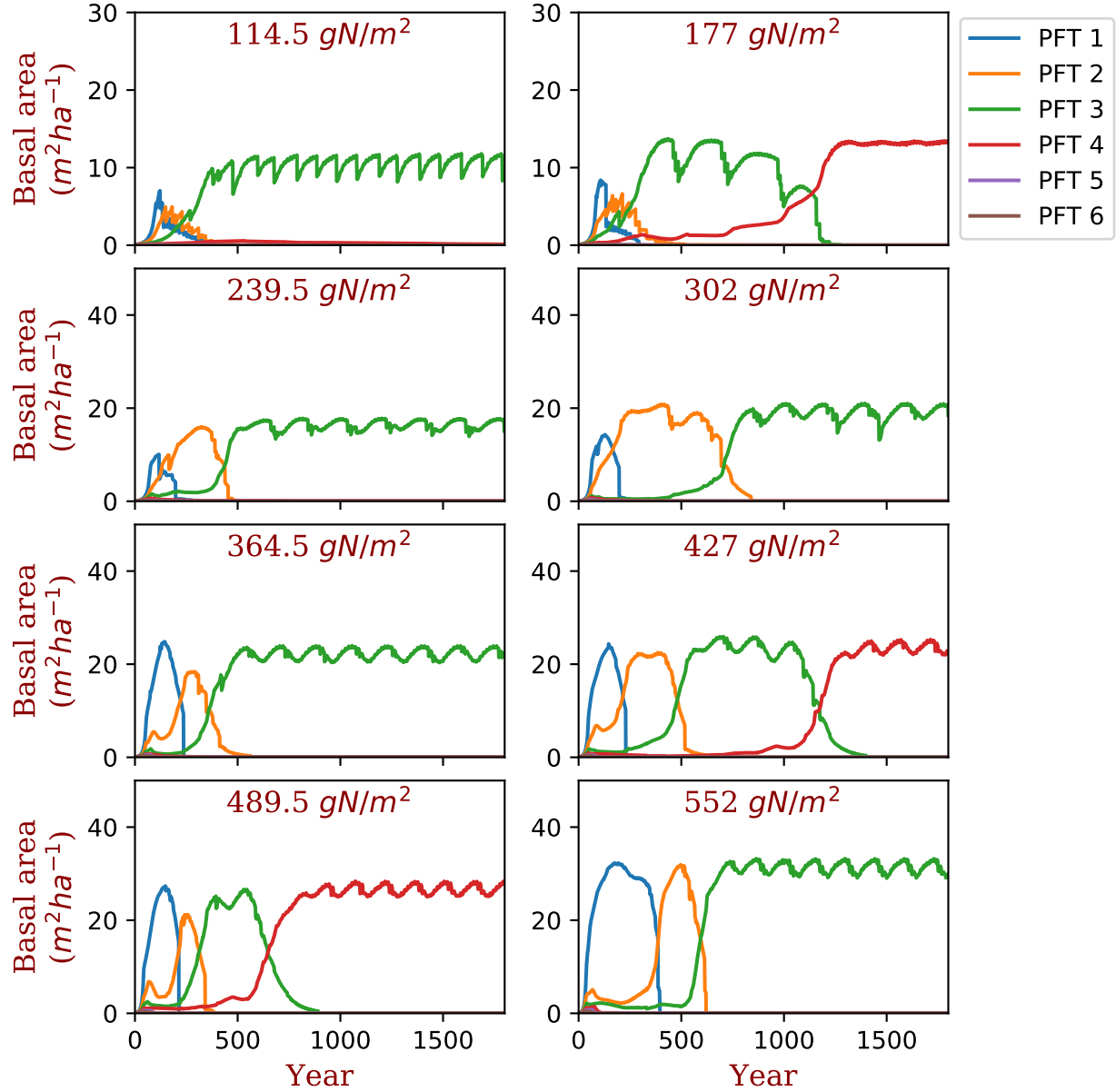


Figure S4 Successional patterns of polyculture runs II at ambient $[CO_2]$ (380 ppm). Let $i=1, 2, \dots, 8$ denote the eight N levels from 114.5 to 552 $gN\ m^{-2}$, the φ_{RL} of the six PFTs at each level are $(5.0-0.5i, 5.5-0.5i, \dots, 7.5-0.5i)$. For example:

At the nitrogen of 114.5 $gN\ m^{-2}$, PFTs 1~6 corresponding to the φ_{RL} of 4.5, 5.0, 5.5, ..., 7.0;

At the nitrogen of 177.0 $gN\ m^{-2}$, PFTs 1~6 corresponding to the φ_{RL} of 4.0, 4.5, 5.0, ..., 6.5;

...

At the nitrogen of 552.0 $gN\ m^{-2}$, PFTs 1~6 corresponding to the φ_{RL} of 1.0, 1.5, 2.0, ..., 3.5.

52 Winning PFTs at aCO₂ (**red**)

53 114.5 gN m⁻², φ_{RL} : 4.5, 5.0, **5.5**, 6.0, 6.5, 7.0, 7.5 8.0;

54 177.0 gN m⁻², φ_{RL} : 4.0, 4.5, 5.0, **5.5**, 6.0, 6.6, 7.0, 7.5;

55 239.5 gN m⁻², φ_{RL} : 3.5, 4.0, **4.5**, 5.0, 5.5, 6.0, 6.5, 7.0;

56 302.0 gN m⁻², φ_{RL} : 3.0, 3.5, **4.0**, 4.5, 5.0, 5.5, 6.0, 6.5;

57 364.5 gN m⁻², φ_{RL} : 2.5, 3.0, **3.5**, 4.0, 4.5, 5.0, 5.5, 6.0;

58 427.0 gN m⁻², φ_{RL} : 2.0, 2.5, 3.0, **3.5**, 4.0, 4.5, 5.0, 5.5;

59 489.5 gN m⁻², φ_{RL} : 1.5, 2.0, 2.5, **3.0**, 3.5, 4.0, 4.5, 5.0;

60 552.0 gN m⁻², φ_{RL} : 1.0, 1.5, **2.0**, 2.5, 3.0, 3.5, 4.0, 4.5 .

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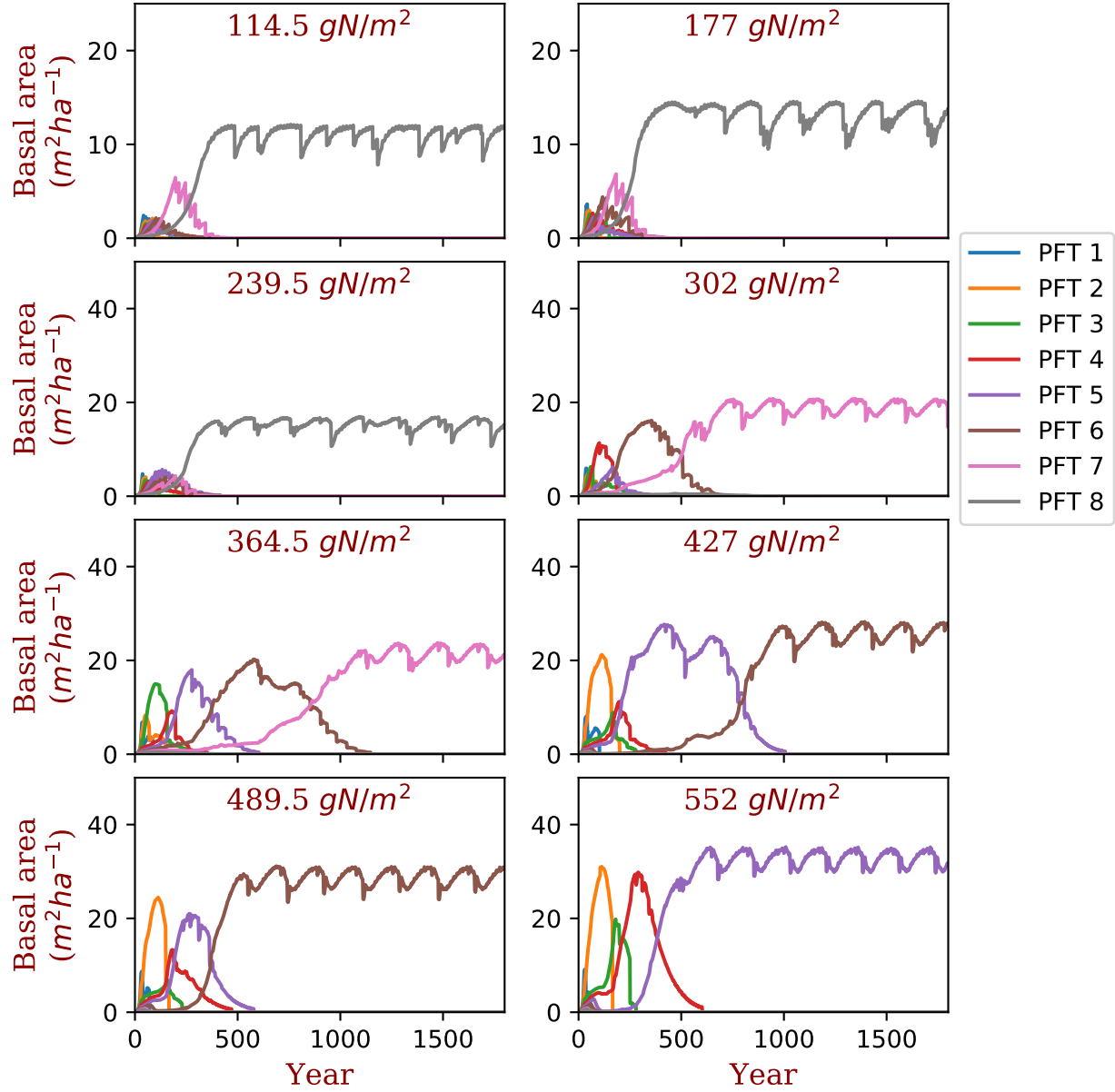


Figure S5 Successional patterns of polyculture runs II at elevated $[\text{CO}_2]$ (580 ppm). Let $i=1, 2, 3, \dots, 8$ denote the eight N levels from 114.5 to 552 gN m^{-2} , the φ_{RL} of the eight PFTs at each level are $(5.0-0.5i, 5.5-0.5i, \dots, 8.5-0.5i)$. For example:

At the nitrogen of 114.5 gN m^{-2} , PFTs 1~8 corresponding to the φ_{RL} of 4.5, 5.0, 5.5, ..., 8.0;

At the nitrogen of 177.0 gN m^{-2} , PFTs 1~8 corresponding to the φ_{RL} of 4.0, 4.5, 5.0, ..., 7.5;

...

At the nitrogen of 552.0 gN m^{-2} , PFTs 1~8 corresponding to the φ_{RL} of 1.0, 1.5, 2.0, ..., 4.5.

70 Winning PFTs at eCO₂ (**red**)

71 114.5 gN m⁻², φ_{RL} : 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5 **8.0**;

72 177.0 gN m⁻², φ_{RL} : 4.0, 4.5, 5.0, 5.5, 6.0, 6.6, 7.0, **7.5**;

73 239.5 gN m⁻², φ_{RL} : 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, **7.0**;

74 302.0 gN m⁻², φ_{RL} : 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, **6.0**, 6.5;

75 364.5 gN m⁻², φ_{RL} : 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, **5.5**, 6.0;

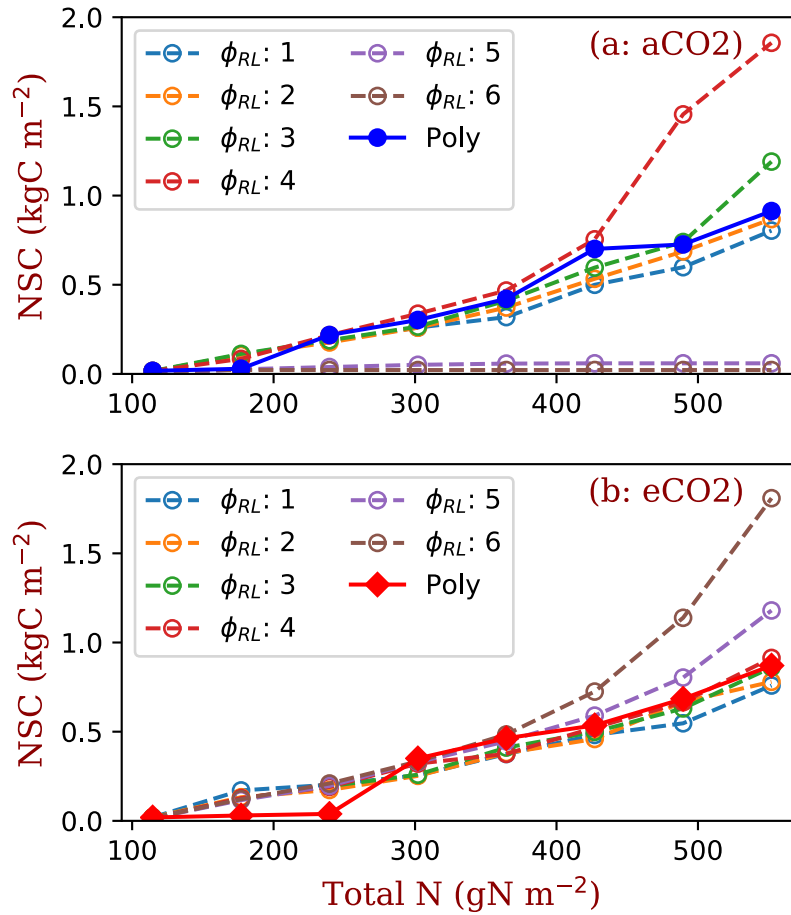
76 427.0 gN m⁻², φ_{RL} : 2.0, 2.5, 3.0, 3.5, 4.0, **4.5**, 5.0, 5.5;

77 489.5 gN m⁻², φ_{RL} : 1.5, 2.0, 2.5, 3.0, 3.5, **4.0**, 4.5, 5.0;

78 552.0 gN m⁻², φ_{RL} : 1.0, 1.5, 2.0, 2.5, **3.0**, 3.5, 4.0, 4.5 .

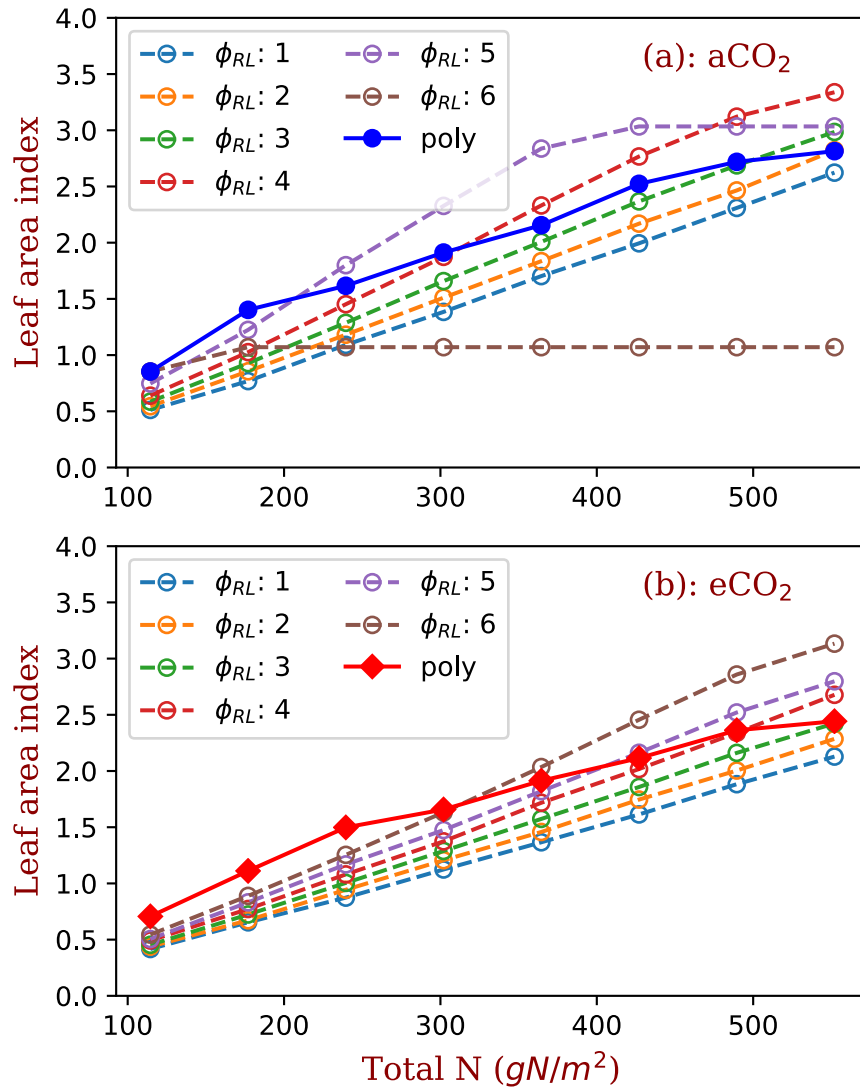
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82 **Figure S6 Non-structural carbon storage in monoculture and in polyculture runs at**
83 **equilibrium state.** Panel a is for ambient [CO₂] and panel b is elevated [CO₂]. The open symbols
84 with dashed lines represent monoculture runs The closed symbols with solid line represent
85 polyculture runs (blue-closed circles are for transpiration at aCO₂ and red-closed diamonds
86 eCO₂).



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88 **Figure S7 Leaf area index in monoculture and in polyculture runs at equilibrium state.**

89 Panel a is for ambient $[\text{CO}_2]$ and panel b is elevated v. The open symbols with dashed lines

90 represent monoculture runs The closed symbols with solid line represent polyculture runs (blue-

91 closed circles are for transpiration at aCO_2 and red-closed diamonds eCO_2).

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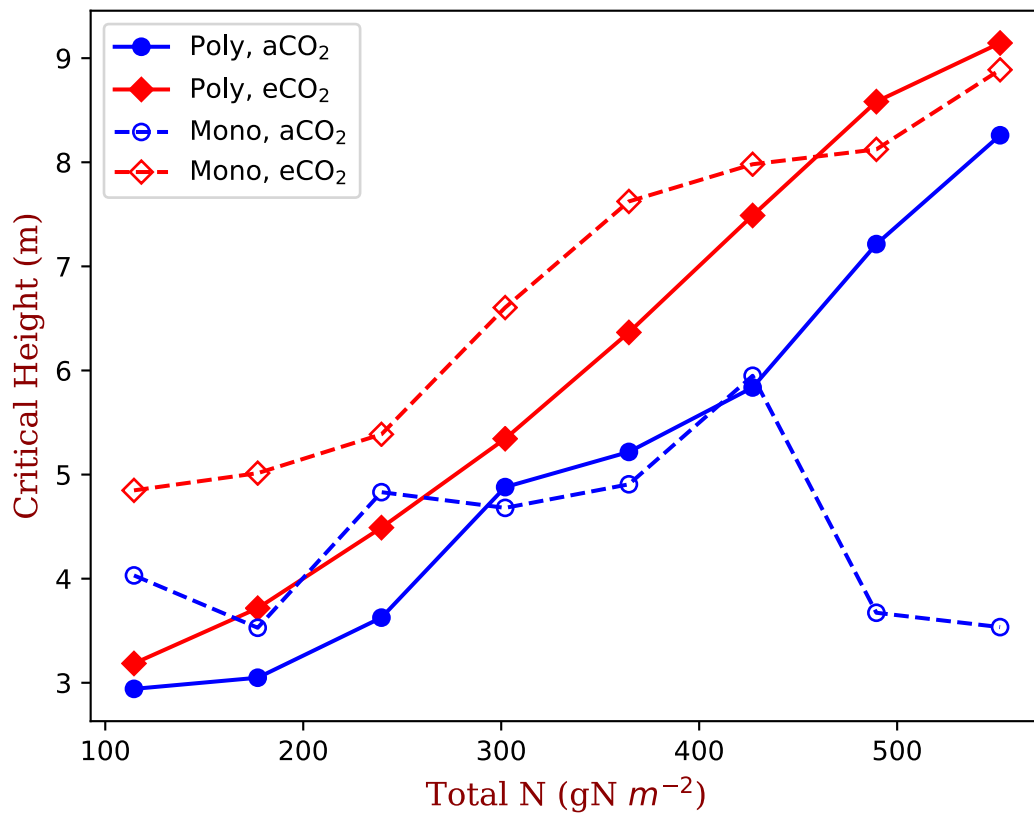
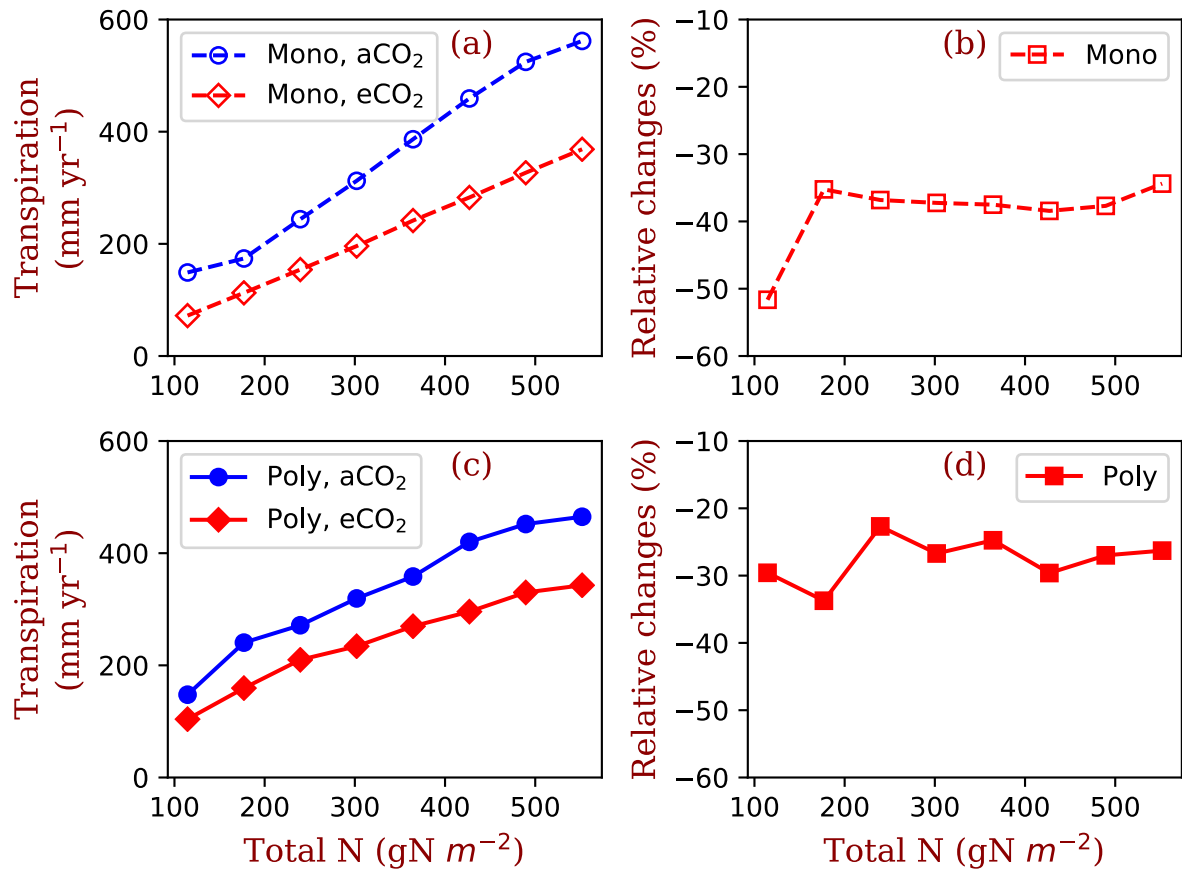


Figure S8 Critical height of mono- and poly-culture runs at the two [CO₂] levels (380 ppm and 580 ppm). The figure shows the data of the averages of the model run years from 1400 and 1800 of the model runs. The closed symbols with solid line represent poly-culture runs (comp.). The open symbols with dashed lines represent mono-culture runs (only the runs of $\phi_{RL}=4$).



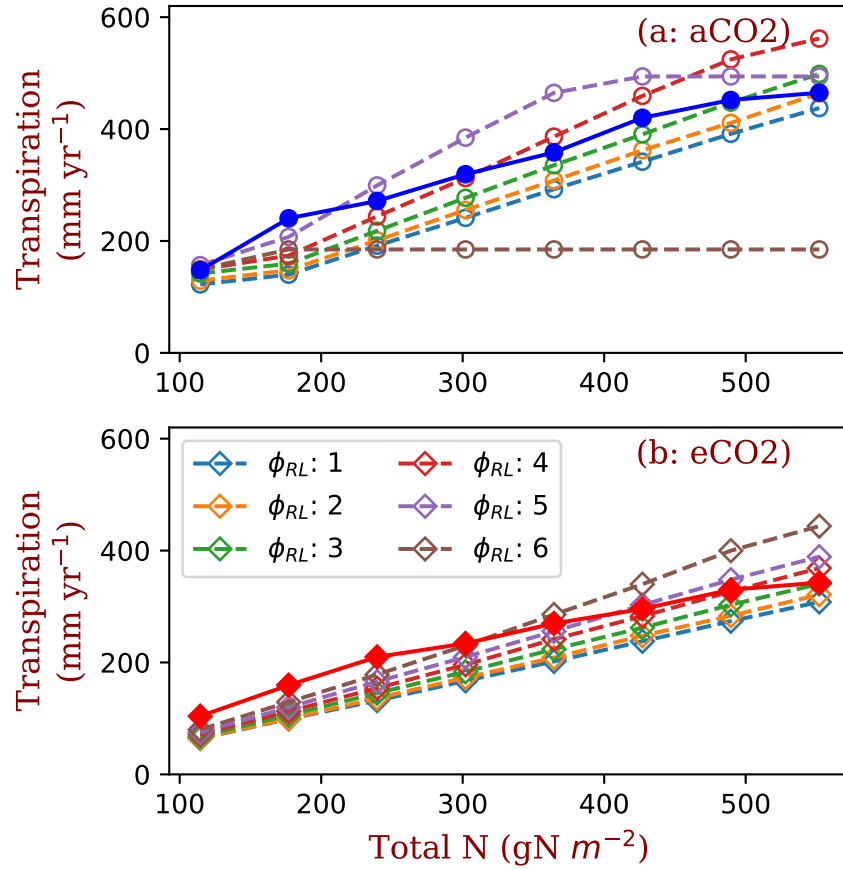
103 **Figure S9 Responses of transpiration to elevated $[\text{CO}_2]$ in monoculture and in polyculture**

104 **runs.** The open symbols with dashed lines represent monoculture runs (panels a and b, only

105 $\varphi_{\text{RL}}=4$ shown here.). The closed symbols with solid line represent polyculture runs (panels c and

106 d). The relative changes of transpiration at e CO_2 are calculated as: $100 \times (\text{Transp}_{\text{eCO}_2} - \text{Transp}_{\text{aCO}_2}) /$

107 $\text{Transp}_{\text{aCO}_2}$.



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110 **Figure S10 Mean annual transpiration in monoculture and in polyculture runs at**
 111 **equilibrium state.** Panel a is for ambient CO₂ and panel b is elevated CO₂. The open symbols
 112 with dashed lines represent monoculture runs The closed symbols with solid line represent
 113 polyculture runs (blue-closed circles are for transpiration at aCO₂ and red-closed diamonds
 114 eCO₂).

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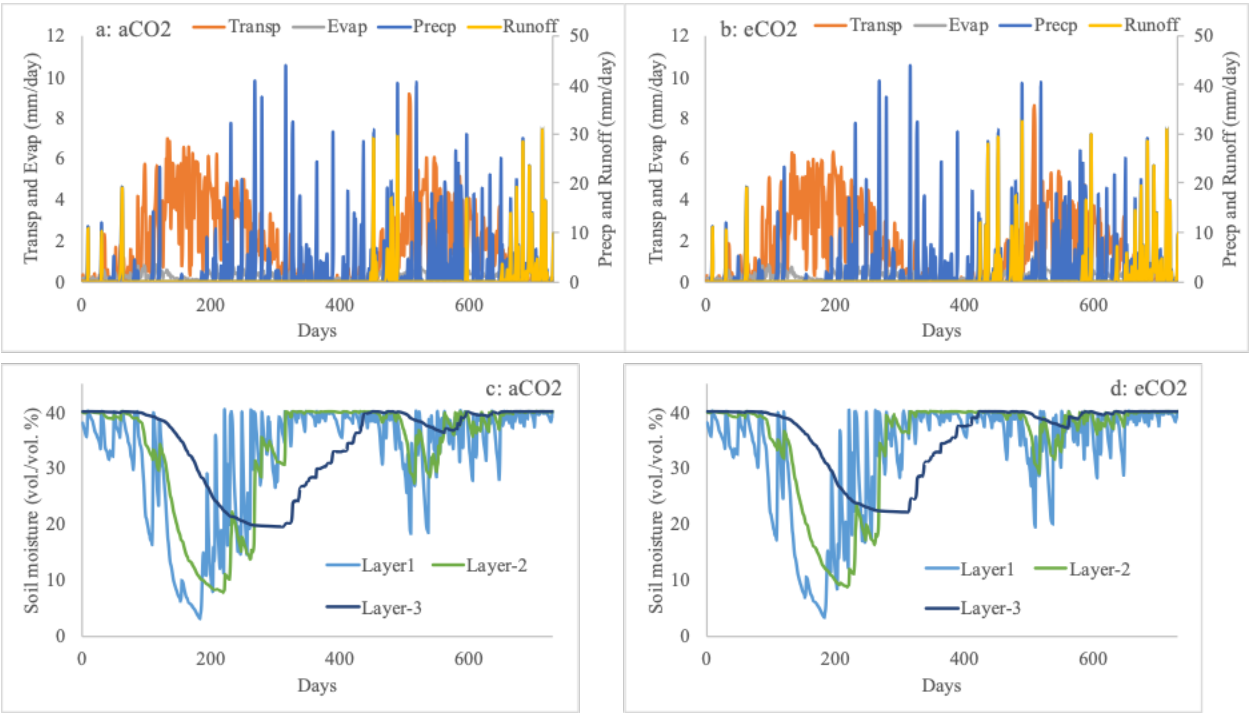


Figure S11 Water fluxes and soil moisture dynamics. Two years' daily water dynamics at ambient and elevated [CO₂], respectively, are shown in this figure, including daily precipitation (Precp), transpiration (Transp), soil surface evaporation (Evap), runoff, soil water content (vol./vol.) in layers 1 (0~0.05 m), 2 (0.05~0.5), and 3 (0.5~1.5 m).