Supporting Information

The Theoretical Limit to Plant Productivity

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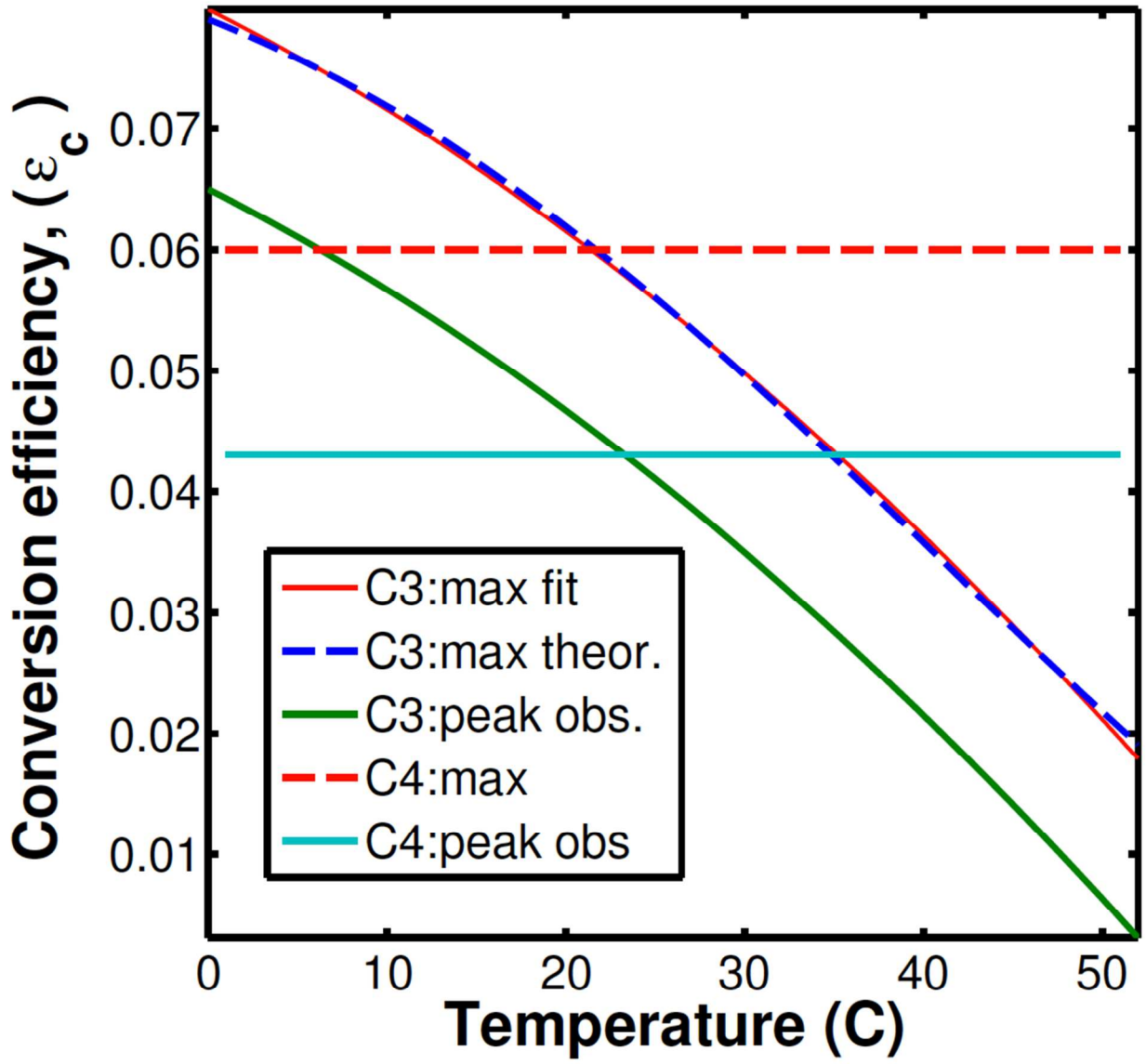
14 Pages; 3 Figures; 2 Tables



Supporting Figure 1. Temperature dependence of conversion efficiency used to model the theoretical upper limit to NPP. Functions were calculated assuming a CO_2 concentration of 379 μl l^{-1}. The theoretical maximum ε_c for C4 and C3 plants (1) are shown in dashed red line and the solid red line, respectively. The temperature dependence of ε_c for C3 plants derives primarily from relative changes in oxygenase and carboxylase functions of the

primary carboxylating enzyme, ribulose bisphosphate carboxylase-oxygenase, and the relative temperature dependencies of the diffusion coefficients for CO_2 and O_2 (2). The dashed blue line represents and independent calculation of ε_c for C3 crops (3). Here we assume that respiration is a constant fraction of photosynthesis. The solid teal line and the solid green line represent the maximum ε_c currently observed for a C4 and C3 plant, respectively.

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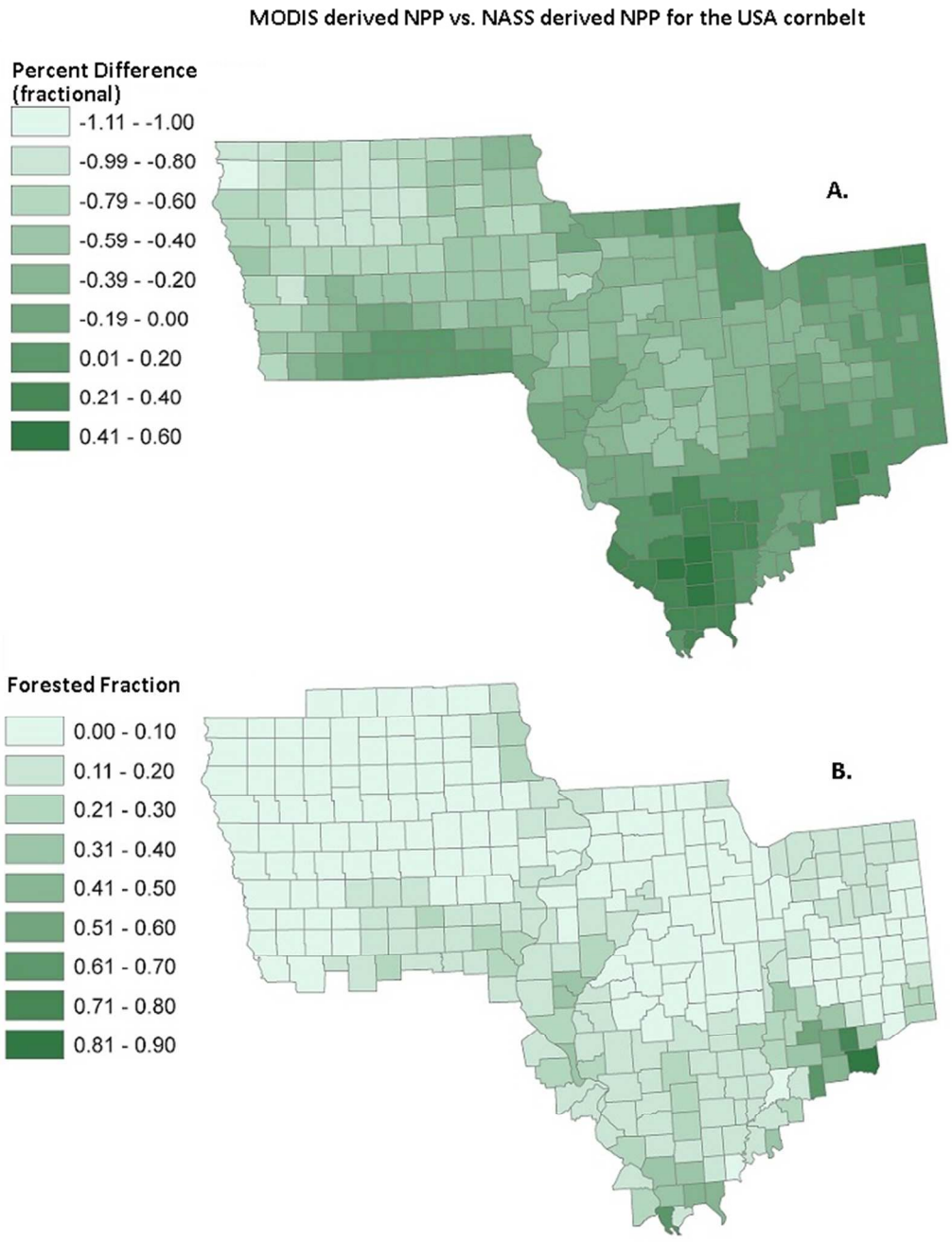
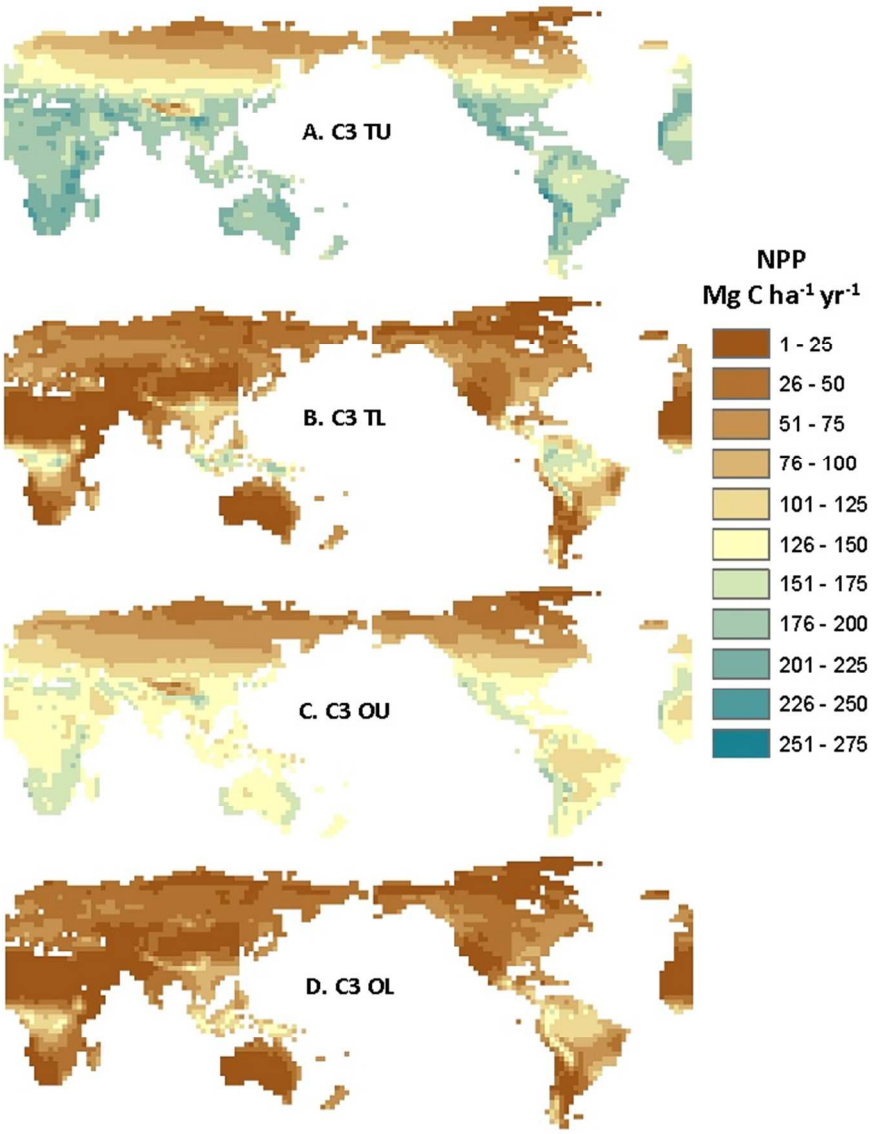
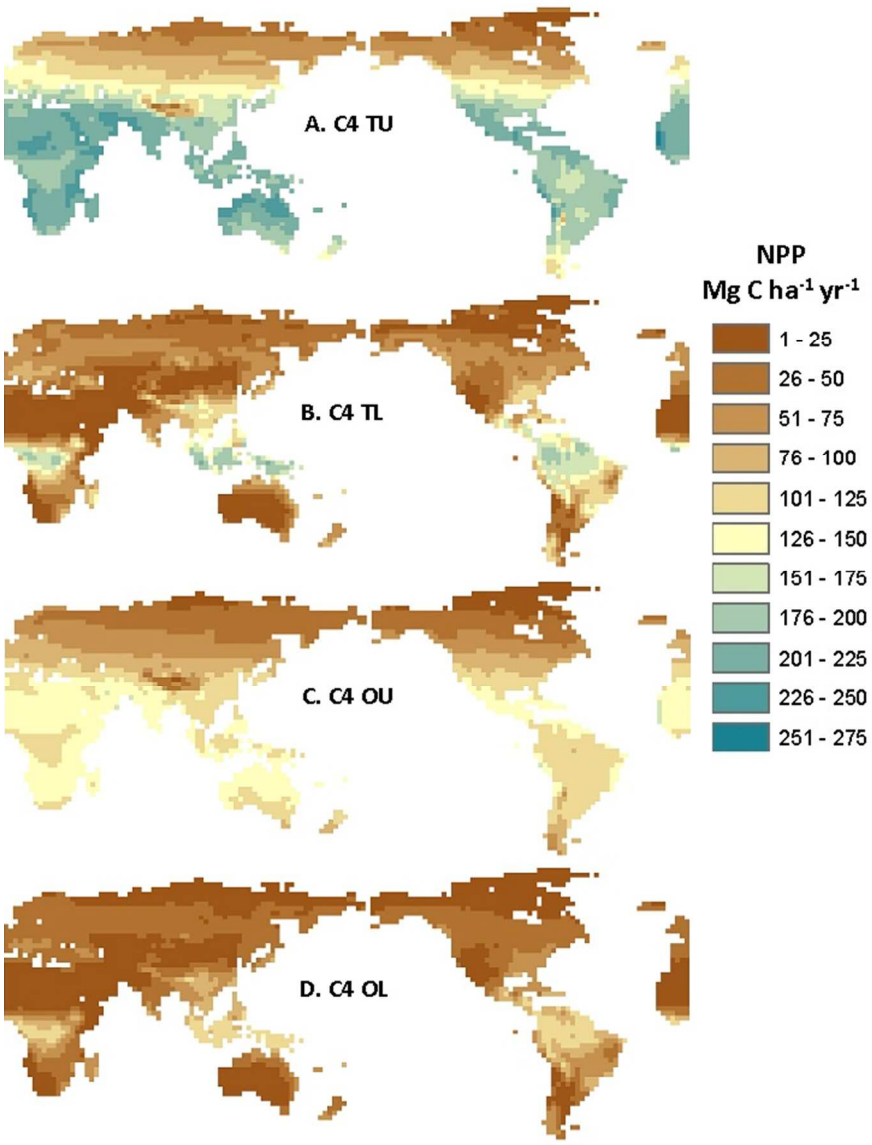


Supplemental Figure 2

Supporting Figure 2. Maps of the difference between MODIS derived NPP and National Agricultural Statistics (NASS) derived NPP for counties in Iowa, Illinois, and Indiana (US corn belt). A) Negative numbers indicate an underestimation of NPP by MODIS compared to NASS data while positive numbers indicated and overestimation compared to NASS data. B) The fractional forested land area of each county. As forested land area increases, the underestimation of NPP compared to MODIS is reduced. County average MODIS NPP was compared to county average crop NPP (area-weighted by crop type). NASS crop area in each county was calculated using the NASS cropland data layer (http://nassgeodata.gmu.edu/CropScape/).



Supporting Figure 3A



Supporting Figure 3B

Supporting Figure 3. Global distribution of predicted maximum net primary production (NPP; tC ha^{-1} y^{-1}) based on the theoretical maximum light conversion efficiency for a theoretical C3 crop (A) or a theoretical C4 crop (B). Values represent the predicted maximum total NPP (TU), maximum NPP supported by local water availability (TL), and NPP based using actual maximum observed conversion efficiency and local water availability (OL).

Crop (country)	Scientific name	WUE	Reference
Soybean (Australia)	*Glycine max*	0.044	2
Canola (Australia)	*Brassica napus*	0.057	7
Wheat (Argentina)	*Titicum aestivum*	0.045	4
Willow (Sweden)	*Salix viminalis*	0.048	4
C3 average		0.049	
Miscanthus (England)	*Miscanthus x giganteus*	0.095	1
Sugarcane (Australia)	*Saccharum officinarum*	0.083	3
Cord-grass (England)	*Spartina cynosuroides*	0.082	1
Bulrush Millett (India)	*Pennisetum typhoides*	0.095	5
Maize (US average)	*Zea mays*	0.101	6
C4 average		0.091	

Supporting Table 1. Water use efficiency for C3 and C4 crops (t DM / ha / mm *kPa), where values are normalized to daytime atmospheric VPD during the growing season. Average WUE is considerably greater for C4 than C3 crops. Because of the absence of photorespiration and the affinity of the primary carboxylating enzyme for CO_2, C4 plants operate a lower CO_2 concentration inside the leaf and lower stomata conductance, contributing to higher WUE than C3 crops.

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Location	Native Vegetation	ANPP	Introduced Vegetation	ANPP	ANPP Increase
Wisconsin, USA[1]	Restored prairie	0.8	No-till maize	5.1	540%
Iceland[2]	Boreal dwarf birch	1.0*	Nootka lupine	5.0*	400%
Illinois, USA[3]	Native prairie	3.2[4,5]	*Miscanthus giganteus*	8.2[6]	322%
Thailand[7]	Dry deciduous tropical forest	3.8[8]	Teak plantation	11.5	206%
Hawaii, USA[9]	Wet tropical forest	2.0	*Falcataria*-invaded forest	5.4	170%
Kansas, USA[10]	Tallgrass prairie	2.4[11]	*Juniperus* shrubland	4.9	102%
India[12]	Moist tarai sal forest	7.3	*Populus* plantation	12.5	71%
Texas, USA[13]	Coastal prairie	1.6	*Prosopis* shrubland	2.6	63%
India[14]	Dry deciduous tropical forest	9.6[15]*	Bamboo plantation	13.5	40%

Supporting Table 1 with references. Location, vegetation, and productivity (aboveground NPP; tC ha^{-1} yr^{-1}) of eight sites where annual productivity changes with conversion to non-native or cultivated vegetation. When native vegetation yield was not available in the cited article, it was drawn from a separate literature source from the same ecoregion. ANPP was converted to ANPP-carbon (ANPP-C) by a factor of 0.46 for grasslands[16], 0.47 for tropical species[2117], and 0.5 for temperate woody species[18,19]. *ANPP unavailable, NPP shown.

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