Supplement of

Optimizing shrub parameters to estimate gross primary production of the sagebrush ecosystem using the Ecosystem Demography (ED2) model

Table S1. Initial shrub (sagebrush) PFT parameters used to initialize ED2.

Parameter name	Description of parameter	Value for Shrub PFT
clumping_factor	A 0-1 factor indicating degree of clumpiness of leaves and shoots	0.84
orient_factor	0=leaves are randomly oriented; 1=all leaves are perfectly horizontal; 2=all leaves are perfectly vertical.	0
leaf_emiss_tir	Emissivity on thermal infra-red	9.70×10^{-1}
wood_emiss_tir	Emissivity on thermal infra-red	9.00×10^{-1}
leaf_reflect_vis	Leaf reflectance in visible spectrum (PAR)	3.00×10^{-1}
leaf_reflect_nir	Leaf reflectance in near infra-red spectrum (NIR)	5.77×10^{-1}
wood_reflect_vis	Wood reflectance in visible spectrum (PAR)	1.10×10^{-1}
wood_reflect_nir	Wood reflectance in near infra-red spectrum (NIR)	2.50×10^{-1}
leaf_trans_vis	Leaf transmittance in visible spectrum (PAR)	1.6×10^{-1}
leaf_trans_nir	Leaf transmittance in infra-red spectrum (NIR)	2.48×10^{-1}
wood_trans_vis	Wood transmittance in visible spectrum (PAR)	1.00×10^{-1}
wood_trans_nir	wood transmittance in infra-red spectrum (NIR)	1.00×10^{-1}
D0	The transpiration control in gsw	0.016
V_m_low_temp	Temperature [°C] below which leaf metabolic activity begins to rapidly decline	4.7137
V_m_high_temp	Temperature [°C] above which leaf metabolic activity begins to rapidly decline	45
V_{m0}	Maximum photosynthetic capacity at a reference temperature [µmol/m2/s]	16.5
dark_respiration_factor	Dark respiration factor (gamma). The rate of dark (i.e., leaf) respiration. Dimensionless because it is relative to V_{m0}.	0.0145
stomatal_slope	Slope of the Ball/Berry stomatal conductance-photosynthesis relationship, aka M factor.	8
cuticular_cond	Intercept of the Ball/Berry stomatal conductance relationship [µmol/m2/s]	1000
quantum_efficiency	Efficiency of using PAR to fix CO2 [mol_CO2/Einstein]	0.08
water_conductance	M2/yr/kgC_root	1.9×10^{-5}
leaf_width	Leaf width [m], which is used to compute the aerodynamic resistance	0.05

growth_resp_factor	This variable determines level of growth respiration. Starting with accumulated photosynthesis (P), leaf (Rl) and root respiration (Rr) are first subtracted, then, growth respiration = growth_resp_factor * (P - Rl - Rr)	0.333
leaf_turnover_rate	the inverse of leaf life span [1/year]	1
root_turnover_rate	the inverse of fine root life span [1/year]	0.33
storage_turnover_rate	Turnover rate of plant storage pools [1/year]	0.6243
f_labile	Fraction of litter that goes into labile (fast) carbon pool.	0.79
root_respiration_factor	the contribution of roots to respiration [umol_CO2/kg_fine_roots/second]	0.28
frost_mort	Mortality due to frost. Determines how rapidly trees die if it is too cold for them [1/years]	3
mort0	Looks like it is an adjustment to mortality due to low carbon balance for grasses and tropical plants	0
mort1	Controls the time scale at which plants out of carbon suffer mortality [1/years]. Used in calculation of mortality rates due to –ve C balance	1
mort2	Determines how poor the carbon balance needs to be before plants suffer large mortality rates. Used in calculation of mortality rates due to –ve C balance	20
mort3	Controls the density-independent mortality rate due to ageing [1/years]. PFT dependent mortality	0.001
seedling_mortality	Fraction of seedlings that suffer mortality without becoming a recruit	0.95
treefall_s_gtht	Survivorship fraction for trees with heights greater than treefall_hite_threshold. Used in management/disturbance strategies.	0
treefall_s_ltht	Survivorship fraction for trees with heights less than treefall_hite_threshold. Used in management/distrubance strategies.	0.1
fire_s_ltht	Fire survivorship fraction for trees with heights less than treefall_hite_threshold	0
fire_s_gtht	Fire survivorship fraction for trees with heights greater than treefall_hite_threshold	0
plant_min_temp	Below this temperature, mortality rapidly increases	-80
Rho	Wood density [g/cm^3].	0
SLA	Specific leaf area [m^2 leaf / kg C]	4.5
horiz_branch	Fraction of vertical branches	0.50
Q	Ratio between fine roots and leaves [kg_fine_roots/kg_leaves]	3.2

init_density	Initial plant density in a near-bare-ground run [plant/m²]	0.1
b1Ht	DBH-height allometry intercept (m)	4.7562
b2Ht	DBH-height allometry slope (1/cm)	-0.002594
hgt_ref	Reference height for diameter/height allometry	0
hgt_min	Minimum height of an individual [m]	0.25
hgt_max	Maximum height of an individual [m]	2.50
b1Bl_small	DBH-leaf allometry intercept [kg leaf biomass]	2.582×10^{-6}
b2Bl_small	DBH-leaf allometry slope	2.746
b1Bs_small	DBH-stem allometry intercept [kg stem biomass]	5.709×10^{-8}
b2Bs_small	DBH-stem allometry slope	4.149
b1Ca	DBH-canopy area allometry intercept	6.35×10^{-5}
b2Ca	DBH-canopy allometry slope	2.18
b1WAI	Wood area index intercept	0.0192×0.5
b2WAI	Wood area index slope	1.4648
b1Vol	DBH-volume intercept	2.035×10^{-5}
b2Vol	DBH-volume slope	2.314
b1Rd	Root depth from DBH intercept	-3.0
b2Rd	Root depth from DBH slope	0.15
init_density	Initial density of plants for near-bare-ground simulations [# of individuals/m2]	0.1
c2n_leaf	C:N ratio for leaf	98
phenology	0=evergreen; 1=drought deciduous; 2=cold deciduous; 3=light controlled; 4=drought deciduous based on 10 day average	0
wat_dry_ratio_grn	Water dry ratio for leaves	2.5
b1Cl	Used to compute the crown length, which will then be used to find the height of the bottom of the crown	1
b2Cl	Used to compute the crown length, which will then be used to find the height of the bottom of the crown	1
r_fract	Fraction of (positive) carbon balance devoted to reproduction	0.3
st_fract	Storage fraction	0
nonlocal_dispersal	Fraction of seed dispersal that is gridcell wide	0.325
repro_min_h	Minimum height plants need to attain before allocating reproduction	0.25

Table S2. Predicted GPP, Bias, and NSE (Nash-Sutcliffe efficiency) of ten best simulations (based on final year of simulation) for LS and WBS sites based on GPP observations from respective sites.

a. Ten best simulations for LS site

Rank	V_{mo}	SLA	stomatal slope	fine root turnover rate	Q-ratio	GPP (KgC/m2/yr)			Bias	NSE
						Shrub	C3 Grass	Total		
1	14	6	10	0.33	3.2	0.155	0.159	0.314	-0.203	0.251
2	19	9	7	0.11	3.2	0.422	0.000	0.422	-0.096	0.246
3	21.5	7.5	7	0.11	1.8	0.390	0.000	0.390	-0.127	0.217
4	19	9	7	0.22	3.2	0.397	0.000	0.397	-0.120	0.217
5	14	6	10	0.22	3.2	0.171	0.130	0.301	-0.216	0.210
6	19	9	7	0.22	1.8	0.393	0.000	0.393	-0.124	0.205
7	16.5	9	8	0.22	3.2	0.346	0.000	0.346	-0.171	0.204
8	14	9	8	0.11	1.8	0.336	0.000	0.336	-0.181	0.197
9	19	9	7	0.33	3.2	0.410	0.000	0.410	-0.107	0.193
10	21.5	7.5	7	0.11	3.2	0.383	0.000	0.383	-0.134	0.190
Mean	17.75	8.1	7.8	0.20	2.78	0.340	0.029	0.369	-0.148	0.213

b. Ten best simulations for WBS site

Rank	V_{mo}	SLA	stomatal slope	fine root turnover rate	Q-ratio	GPP (KgC/m2/yr)			Bias	NSE
						Shrub	C3 Grass	Total		
1	14	6	10	0.33	3.2	0.155	0.159	0.314	0.036	0.417
2	14	6	10	0.22	3.2	0.171	0.130	0.301	-0.002	0.379
3	21.5	4.5	10	0.33	3.2	0.289	0.000	0.289	-0.037	0.344
4	16.5	7.5	8	0.11	1.8	0.326	0.000	0.326	-0.041	0.340
5	19	7.5	8	0.22	3.2	0.336	0.000	0.336	-0.042	0.339
6	14	9	8	0.11	0.4	0.336	0.000	0.336	-0.044	0.337
7	16.5	7.5	8	0.22	1.8	0.325	0.000	0.325	-0.046	0.335
8	14	9	8	0.22	0.4	0.335	0.000	0.335	-0.046	0.335
9	14	9	8	0.33	1.8	0.334	0.000	0.334	-0.046	0.335
10	14	9	8	0.33	0.4	0.335	0.000	0.335	-0.048	0.333
Mean	15.75	7.5	8.6	0.20	1.9	0.294	0.029	0.323	-0.031	0.349

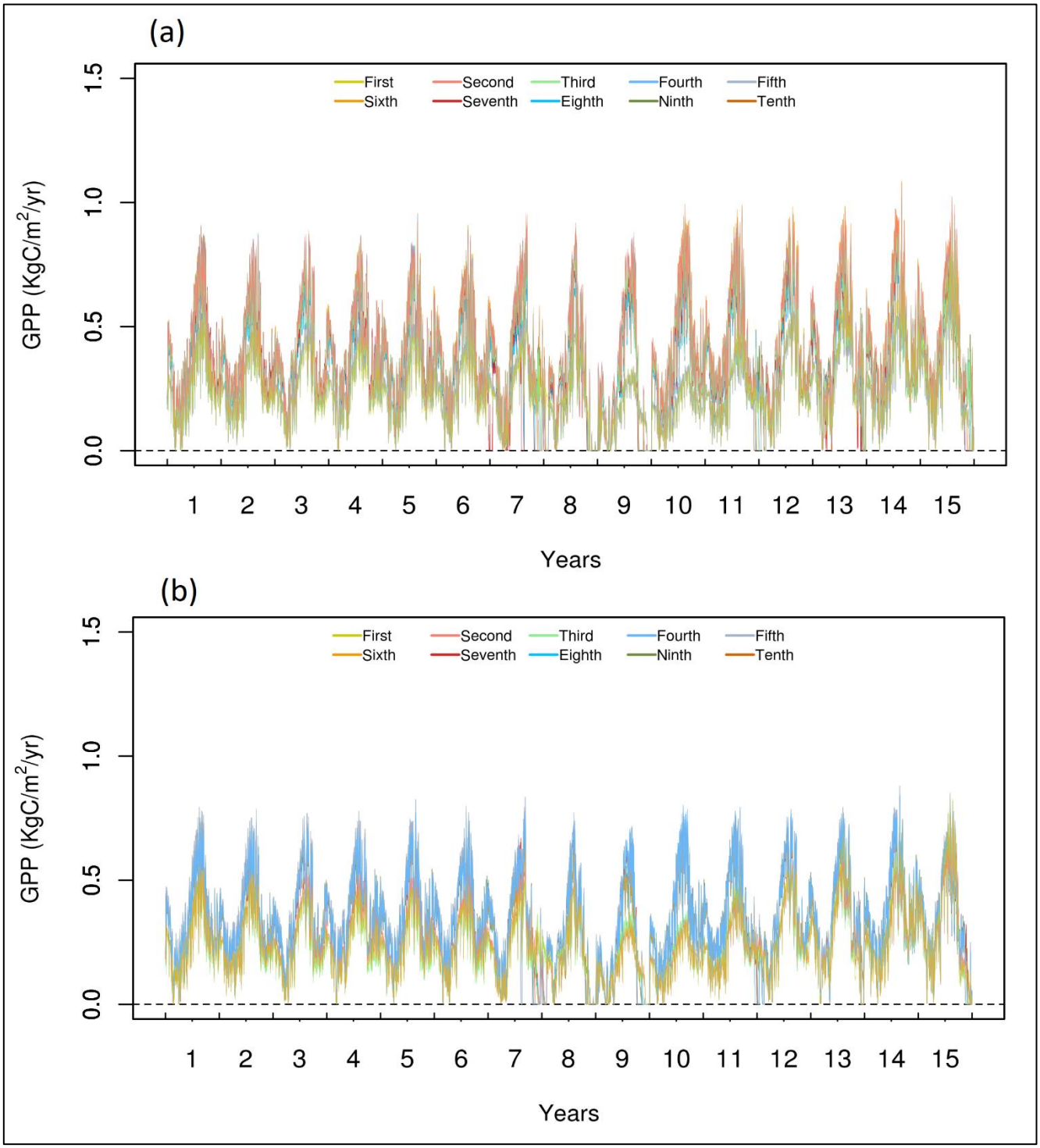

Figure S1. Annual GPP estimation from the ten best simulations (based on NSE) for each of EC stations; (a) LS and (b) WBS, for the entire 15 years.

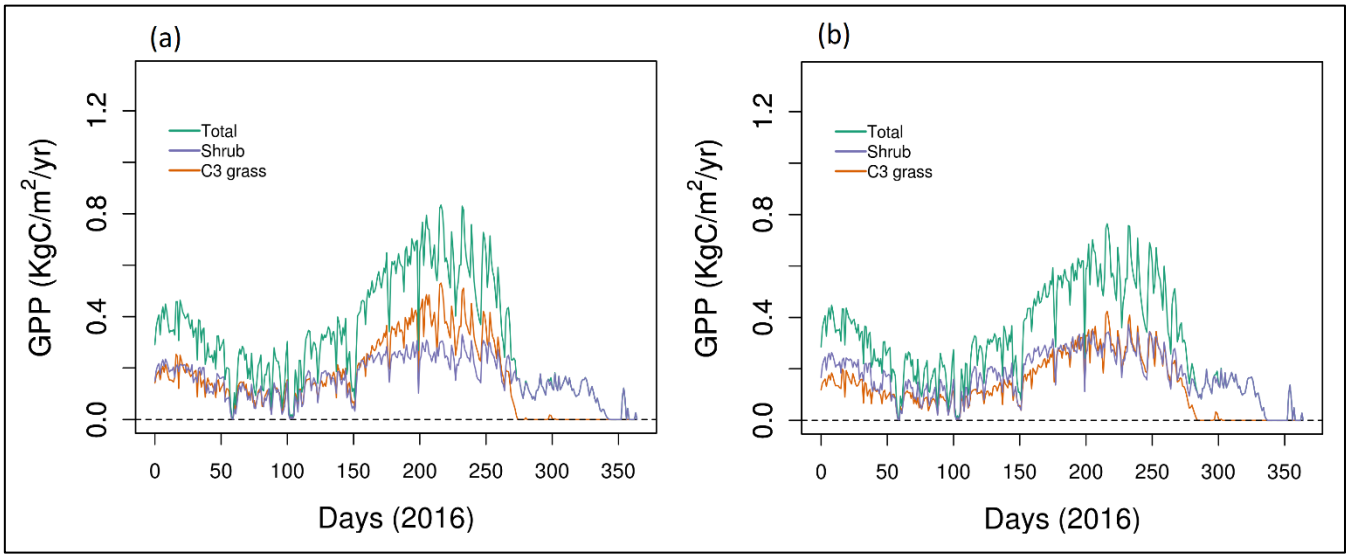

Fig S2. Total GPP dissected into shrub and C3 grass GPPs for two simulations (a) best simulation common to both EC sites (best case), (b) top fifth simulation for LS and top second simulation for WBS site.