Supplementary Material

1 Supplementary Tables

Table S1. Age assignation table.

Species	Height (cm)	Diameter (cm)	Cohort (years)
P. sylvestris	< 30	< 2.5	10
P. sylvestris	30-130	< 2.5	10
P. sylvestris	> 130	< 2.5	10
P. sylvestris	> 130	2.5 - 7.5	20
P. sylvestris	> 130	7.5 - 12.5	20
P. sylvestris	> 130	12.5 - 22.5	40
P. sylvestris	> 130	22.5 - 42.5	40
P. sylvestris	> 130	> 42.5	50
P. halepensis	< 30	< 2.5	10
P. halepensis	30-130	< 2.5	10
P. halepensis	> 130	< 2.5	10
P. halepensis	> 130	2.5 - 7.5	10
P. halepensis	> 130	7.5 - 12.5	30
P. halepensis	> 130	12.5 - 22.5	40
P. halepensis	> 130	22.5 - 42.5	40
P. halepensis	> 130	> 42.5	50
P. nigra	< 30	< 2.5	10
P. nigra	30-130	< 2.5	10
P. nigra	> 130	< 2.5	10
P. nigra	> 130	2.5 - 7.5	20
P. nigra	> 130	7.5 - 12.5	30
P. nigra	> 130	12.5 - 22.5	40
P. nigra	> 130	22.5 - 42.5	40
P. nigra	> 130	> 42.5	50
P. pinaster	< 30	< 2.5	10
P. pinaster	30-130	< 2.5	10
P. pinaster	> 130	< 2.5	10
P. pinaster	> 130	2.5 - 7.5	10
P. pinaster	> 130	7.5 - 12.5	30
P. pinaster	> 130	12.5 - 22.5	40
P. pinaster	> 130	22.5 - 42.5	40

Table S1. Age assignation table (cont.).

Species	Height (cm)	Diameter (cm)	Cohort (years)
P. pinaster	> 130	> 42.5	50
Q. pyrenaica	< 30	< 2.5	10
Q. pyrenaica	30-130	< 2.5	10
Q. pyrenaica	> 130	< 2.5	10
Q. pyrenaica	> 130	2.5 - 7.5	30
Q. pyrenaica	> 130	7.5 - 12.5	40
Q. pyrenaica	> 130	12.5 - 22.5	40
Q. pyrenaica	> 130	22.5 - 42.5	50
Q. pyrenaica	> 130	> 42.5	50
Q. faginea	< 30	< 2.5	10
Q. faginea	30-130	< 2.5	10
Q. faginea	> 130	< 2.5	10
Q. faginea	> 130	2.5 - 7.5	30
Q. faginea	> 130	7.5 - 12.5	40
Q. faginea	> 130	12.5 - 22.5	40
Q. faginea	> 130	22.5 - 42.5	40
Q. faginea	> 130	> 42.5	50
Q. ilex	< 30	< 2.5	10
Q. ilex	30-130	< 2.5	10
Q. ilex	> 130	< 2.5	10
Q. ilex	> 130	2.5 - 7.5	30
Q. ilex	> 130	7.5 - 12.5	40
Q. ilex	> 130	12.5 - 22.5	40
Q. ilex	> 130	22.5 - 42.5	40
Q. ilex	> 130	> 42.5	50
Pop. nigra	< 30	< 2.5	10
Pop. nigra	30-130	< 2.5	10
Pop. nigra	> 130	< 2.5	10
Pop. nigra	> 130	2.5 - 7.5	10
Pop. nigra	> 130	7.5 - 12.5	10
Pop. nigra	> 130	12.5 - 22.5	20
Pop. nigra	> 130	22.5 - 42.5	30
Pop. nigra	> 130	> 42.5	40
J. oxycedrus	< 30	< 2.5	10
J. oxycedrus	30-130	< 2.5	10
J. oxycedrus	> 130	< 2.5	10
J. oxycedrus	> 130	2.5 - 7.5	20

Table S1. Age assignation table (cont.).

Species	**Height (cm)**	**Diameter (cm)**	**Cohort (years)**
J. oxycedrus	> 130	7.5 - 12.5	30
J. oxycedrus	> 130	12.5 - 22.5	30
J. oxycedrus	> 130	22.5 - 42.5	40
J. oxycedrus	> 130	> 42.5	50
J. communis	< 30	< 2.5	10
J. communis	30-130	< 2.5	10
J. communis	> 130	< 2.5	20
J. communis	> 130	2.5 - 7.5	30
J. communis	> 130	7.5 - 12.5	30
J. communis	> 130	12.5 - 22.5	40
J. communis	> 130	22.5 - 42.5	50

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Table S2. Species parameters.

Species	Long.	Sex Mat	Effect. Seed Disp.	Max Dist.	Veg. Repr. Prob	Sprout Age Min
J. communis	600	17	2	30	0.2	0
J. oxycedrus	600	17	2	30	0.2	0
P. halepensis	150	20	100	1000	0	0
P. nigra	400	25	100	1000	0	0
P. pinaster	200	20	100	1000	0	0
P. sylvestris	300	25	100	1000	0	0
Pop. nigra	90	20	240	800	1	0
Q. faginea	300	15	300	700	1	0
Q. ilex	600	15	300	700	1	0
Q. pyrenaica	300	15	300	700	1	0
short shrubs	50	8	2	30	0.2	0
medium shrubs	50	8	2	30	0.2	0
tall shrubs	50	8	2	30	0.2	0

Table S2. Species parameters (cont.).

Species	Sprout Age Max	AmaxA/ AmaxB	FolN	HalfSat	H3	H4	PsnT Min
J. communis	600	5.3/21.5	0.85	264.5	115	155	3
J. oxycedrus	600	5.3/21.5	0.85	264.5	115	155	3
P. halepensis	0	5.3/21.5	1.19	282.5	118	160	3
P. nigra	0	5.3/21.5	1.02	245	115	155	2
P. pinaster	0	5.3/21.5	1.00	245	115	155	3
P. sylvestris	0	5.3/21.5	1.33	266.5	110	150	1
Pop. nigra	50	-46/71.9	2.5	227	105	145	2
Q. faginea	300	-46/71.9	1.92	224.5	115	155	3
Q. ilex	600	5.3/21.5	1.42	199	118	160	2
Q. pyrenaica	300	-46/71.9	1.85	224.5	110	150	1
short shrubs	50	5.3/21.5	0.70	170	118	160	2
medium shrubs	50	5.3/21.5	0.75	175	118	160	2
tall shrubs	50	5.3/21.5	0.80	180	118	160	2

Table S2. Species parameters (cont.).

Species	PsnT Opt	SLW max	SLW Del	TOfol	k	Frac Fol	Frac BelowG
J. communis	21	200	0	0.50	0.50	0.10	0.40
J. oxycedrus	21	200	0	0.66	0.50	0.10	0.40
P. halepensis	26	240	0	0.34	0.50	0.10	0.32
P. nigra	23	240	0	0.26	0.50	0.10	0.31
P. pinaster	25	240	0	0.24	0.50	0.10	0.32
P. sylvestris	20	240	0	0.36	0.50	0.10	0.30
Pop. nigra	31	85	0.2	1.00	0.58	0.02	0.31
Q. faginea	26	110	0.2	1.00	0.58	0.03	0.36
Q. ilex	28	150	0	0.52	0.50	0.08	0.37
Q. pyrenaica	22	80	0.2	1.00	0.58	0.03	0.34
short shrubs	27	100	0	0.75	0.50	0.10	0.35
medium shrubs	27	100	0	0.75	0.50	0.10	0.35
tall shrubs	27	100	0	0.75	0.50	0.10	0.30

LANDIS-II and PnET-Succession species-specific parameters and sources

Definitions based on Scheller et al. (2007) and Gustafson and Miranda (2019).

Long.: Longevity, species' maximum age. Unit: years. Source: data from Serrada et al. (2008) for all species except for Junipers and shrubs. *Pinus* spp. were given a low value within the reported range, since trees growing in pine plantations are expected to grow less than under optimal conditions. *Juniperus* spp. were given the same longevity as the maximum longevity species (*Q. ilex*) to avoid biomass overestimations, given that *Juniperus* spp. have often reported longevities above 1000 years. Shrubs were given a relatively short longevity for the same reason.

Sex Mat: Age at which the species matures sexually. Unit: years. Source: Serrada et al. (2008) TRY database (Kattge et al. (2020), Paula et al. (2009), Kleyer et al. (2008), Fitter and Peat (1994)). Data for *Juniperus* spp. corresponding to reported sexual maturity for *J. communis* according to TRY database. *Pinus* spp. based on sources and decreased since trees growing in pine plantations are expected to reach maturity later than under optimal conditions. *Pop. nigra* based on Serrada et al. (2008). *Quercus* spp. based on Serrada et al. (2008) for *Q. ilex*. Shrubs given a default low value.

Effect. Seed Disp.: Species' effective distance for dispersing seeds. Units: meters. Source: *Juniperus* spp. data for *Juniperus occidentalis* according to Cassell et al. (2019), *Pinus* spp. data corresponding to values for *P. sylvestris* according to Newton et al. (2013). *Quercus* spp. from Cantarello et al. (2017). Shrubs given same value as *Juniperus* spp.

Max Dist.: Species' maximum distance for dispersing seeds. Units: meters. Source: *Juniperus* spp. data for *Juniperus occidentalis* according to Cassell et al. (2019), Pinus spp. data corresponding to values for *P. sylvestris* according to Newton et al. (2013). *Quercus* spp. from Cantarello et al. (2017). Shrubs given same value as *Juniperus* spp.

Veg. Repr. Prob: Probability that the species resprouts. Units: none. Source: *Juniperus* spp. given a certain level of resprouting probability as *Juniperus* spp. have a weak capacity to resprout after fire (R. Navarro, pers. communication); *Pinus* spp. and *Quercus* spp. based on TRY database (Kattge et al. (2020), Fitter and Peat (1994), Sophie et al. (2005), Liebergesell et al., (2016), Hill et al. (n.d.)) and Valladares Conde (2005). Shrubs given a certain resprouting capacity as they represent a heterogeneous group.

Sprout Age Min: Minimum age required for the species to resprout. Units: years. Source: in the lack of data, the resprouting age was assumed to cover the whole lifespan of the species, given that it has the capacity to resprout (Vegetative reproduction probability > 0).

Sprout Age Max: Maximum age required for the species to resprout. Units: years. Source: in the lack of data, the resprouting age was assumed to cover the whole lifespan of the species, given that it has the capacity to resprout (Vegetative reproduction probability > 0).

AmaxA/AmaxB: Intercept and slope of relationship between foliar N and maximum net photosynthetic rate, such that Amax (nmol CO2 g^{-1} leaf s^{-1}) = AmaxA + AmaxB*FolN. Units: nmol CO2 g^{-1} leaf s^{-1}. Source: default starting value for evergreen/deciduous species Gustafson and Miranda (2019). Shrubs functional groups are assumed to behave as evergreen.

FolN: Foliar nitrogen content Units: %. Source: except for *J. communis* (same value as *J. oxycedrus*) and *Pop. nigra*, which is given the average value for *Populus* spp. according to Gustafson and Miranda (2019), all other species are based on based on TRY database (Kattge et al. (2020), Adler et al. (2014), Adriaenssens (2012), Atkin et al. (2015), Blonder et al. (2011), Campbell et al. (2007), Cornelissen (1996), Cornelissen et al. (2003), Cornelissen et al. (2004), Craine et al. (2009), Falster et al. (2015), Fitter and Peat (1994), Freschet et al. (2010), Garnier et al. (2007), Kattge et al. (2009), Kerkhoff et al. (2006), Lukeö et al. (2013), Maire et al. (2015), Medlyn et al. (1999), Milla and Reich (2011), Niinemets, (2001), Ogaya and Penuelas (2003), Ordonez et al. (2010), Pierce et al. (2013), Quested et al. (2003), Reich et al. (2009), Reich et al. (2008), Rolo et al. (2012), Vergutz et al. (2012), Walker (2014), Wright et al. (2004), Yahan et al. (2011).

HalfSat: Half saturation light level for photosynthesis. Units: μmol m^{-2} s^{-1}. Source: based on shade tolerance by Niinemets and Valladares (2006): *Juniperus* spp. value for *J. communis*; *Pinus* spp. values for *P. nigra*, *P. sylvestris* and *P. halepensis*; *Q. ilex* value for *Q. ilex; Q. faginea and Q. pyrenaica average value for Q. cerris*, *Q. petraea*, *Q. pubescens* and *Q. robur* (European deciduous Quercus spp.) and *Pop. nigra* value for *Pop. nigra*. Shrubs given a high tolerance to shade to allow their growth under the canopy. Shade tolerance was rescaled to recommended range 100-300 Gustafson and Miranda (2019).

H3: Water stress parameters according to Feddes et al. (1978). Units: m pressure head. Source: based on drought tolerance by Niinemets and Valladares (2006): *Juniperus* spp. value for *J. communis*; *Pinus* spp. values for *P. nigra*, *P. sylvestris* and *P. halepensis*; *Quercus* spp. value for *Q. ilex* and *Pop. nigra* value for *Pop. nigra*. *Q. faginea* and *Q. pyrenaica* adjusted within the rest of the species range. Shrubs given a high tolerance to drought as typical shrub species are sclerophyll drought-resistant ones. Drought tolerance was rescaled to recommended range 100-118 Gustafson and Miranda (2019).

H4: Water stress parameters according to Feddes et al. (1978). Units: m pressure head. Source: based on drought tolerance by Niinemets and Valladares (2006): *Juniperus* spp. value for *J. communis*; *Pinus* spp. values for *P. nigra*, *P. sylvestris* and *P. halepensis*; *Quercus* spp. value for

Q. ilex and *Pop. nigra* value for *Pop. nigra*. *Q. faginea* and *Q. pyrenaica* adjusted within the rest of the species range. Shrubs given a high tolerance to drought as typical shrub species are sclerophyll drought-resistant ones. Drought tolerance was rescaled to recommended range 140-160 Gustafson and Miranda (2019).

PsnTMin: Minimum average daytime temperature for photosynthesis. Units: °C. Source: *Pinus* spp., *Quercus* spp. and *Pop. nigra* values based on coldest month and average year temperatures for each species Serrada et al. (2008). *Juniperus* spp. given default values. Shrubs given intermediate warm values.

PsnTOpt: Optimal average daytime temperature for photosynthesis. Units: °C. Source: *Pinus* spp., *Quercus* spp. and *Pop. nigra* values based on warmest month and average year temperatures for each species Serrada et al. (2008). *Juniperus* spp. given default values. Shrubs given intermediate warm values.

SLWmax: Maximum specific leaf weight at the top of canopy. Units: g m^{-2}. Source: values given by comparison with species from the same Genus/shape form. *Quercus* spp. adjusted following observations by Rafa Navarro (pers. Communication).

SLWDel: Rate of change in specific leaf weight from the top of a canopy layer to the bottom. Units: g^{-1}fol. Source: default starting value for evergreen/deciduous species Gustafson and Miranda (2019).

TOfol: Turnover of foliage; fraction of foliage biomass lost per year. Units: proportion per year. Source: calculated based on leaf longevity reported by TRY database (Kattge et al. (2020), Fitter and Peat (1994), Wright et al. (2004), Kattge et al. (2009), Díaz et al. (2004), Adler et al. (2014)). Deciduous species are given value 1, as maximum turnover should not exceed this value. Shrubs functional groups given an intermediate value within the range of all other species.

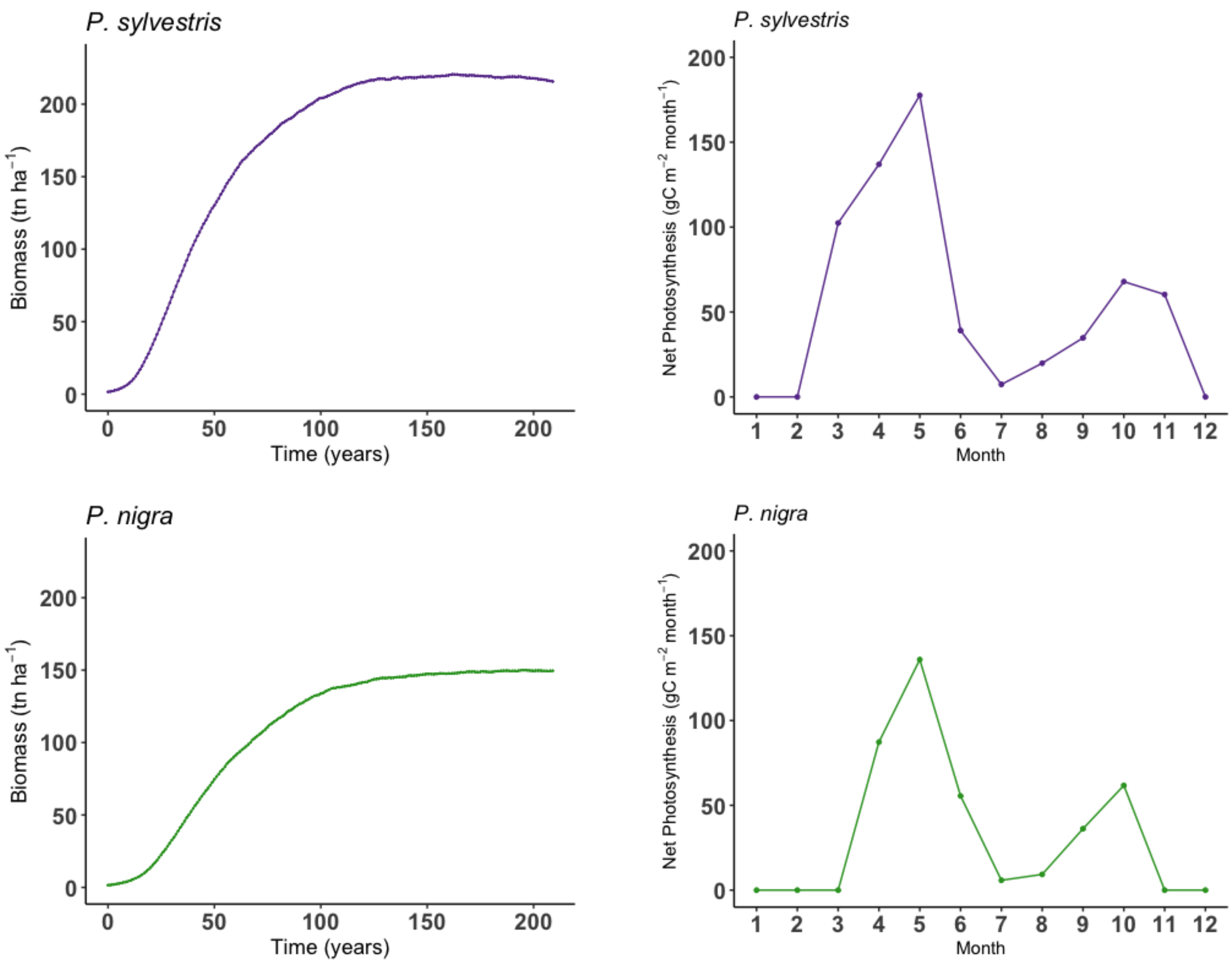
k: Canopy light attenuation constant; light extinction coefficient. Units: none. Source: default starting value for evergreen/deciduous species Gustafson and Miranda (2019). Shrubs functional groups are assumed to behave as evergreen.

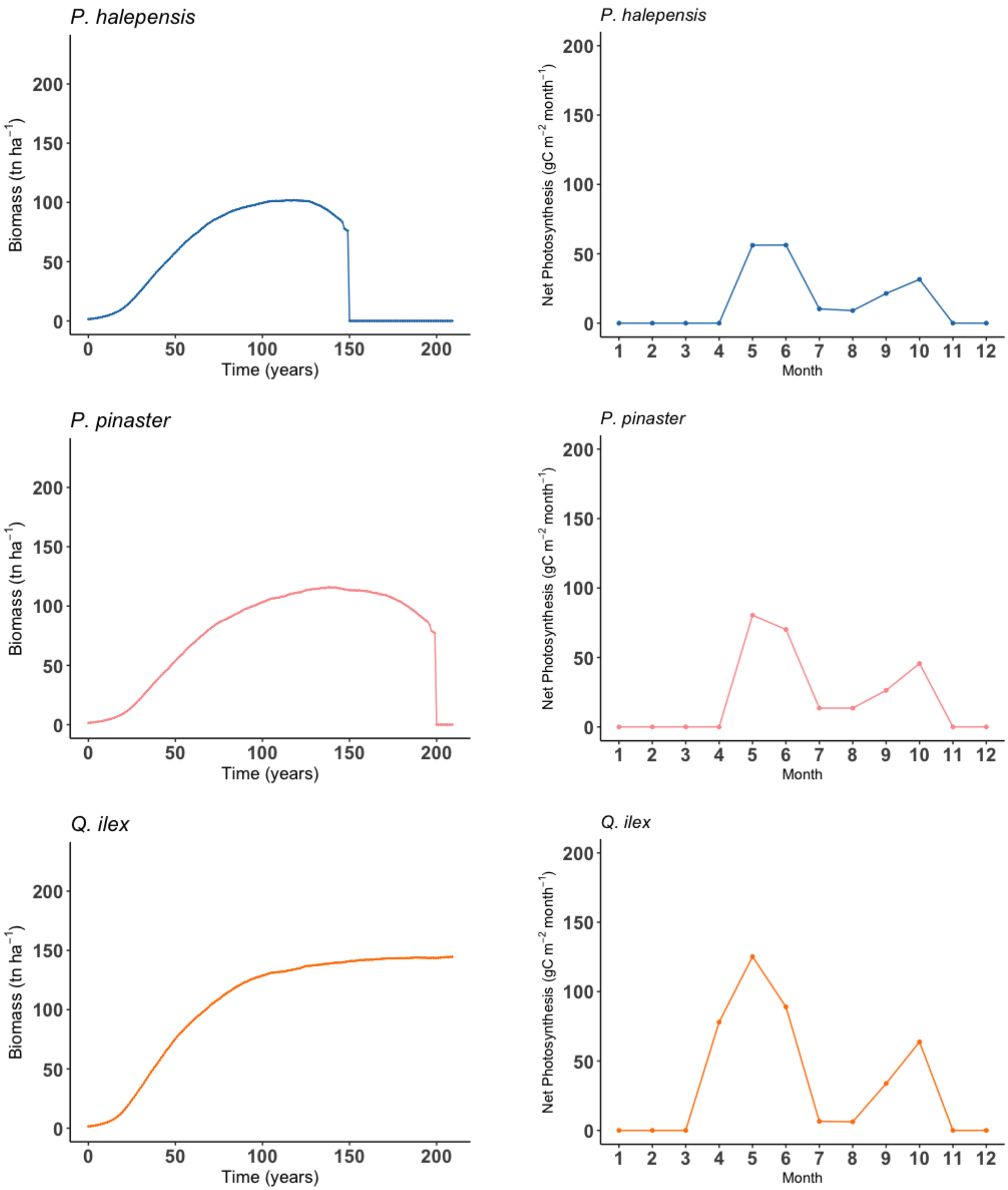
FracFol: Fraction of the amount of active woody biomass (above and belowground) that is allocated to foliage per year. Units: proportion per year. Source: default starting value for evergreen/deciduous species Gustafson and Miranda (2019). *Quercus* spp. subsequently adjusted during calibration to reduce differences in biomass estimations. Shrubs functional groups are assumed to behave as evergreen.

FracBelowG: Fraction of non-foliar biomass that is belowground (root pool). Allocations vary at each time step to maintain this fraction. Source: data from Montero et al. (2005) rescaled to recommended 0.3-0.4 range Gustafson and Miranda (2019). Shrubs functional groups are assumed to have an intermediate value.

2 Supplementary Figures

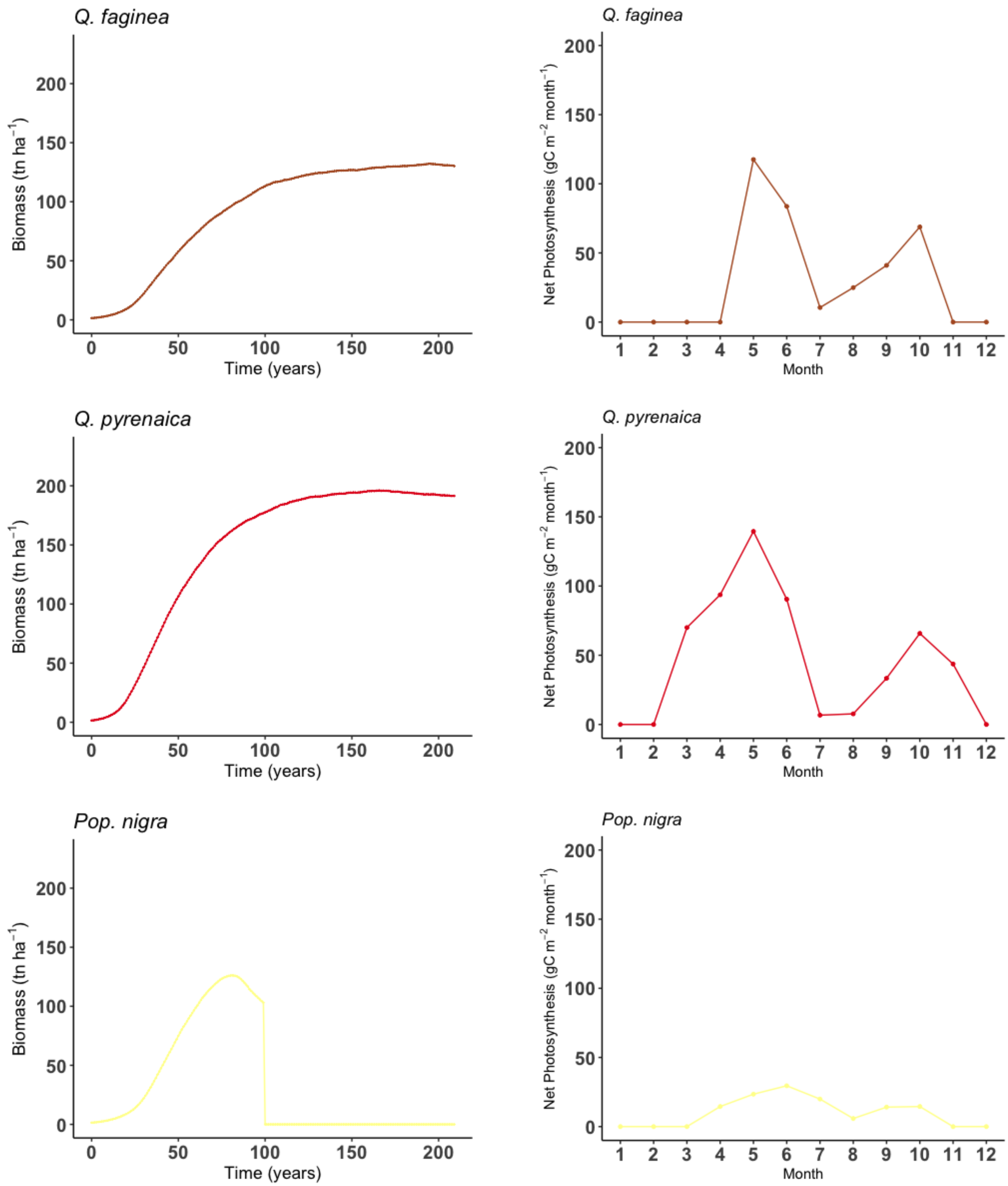
Figure S1. Single species simulations results: total biomass (left panels) and monthly photosynthesis (right panels). Each simulation consisted on a single cohort of the corresponding species growing on a single-cell landscape (1 ha) under average historical climate corresponding to climate region 1 (see below). Monthly photosynthesis is calculated as the monthly average among all months for which the species is alive.





P. halepensis
Biomass (tn ha^{-1})
Time (years)
P. halepensis
Net Photosynthesis (gC m^{-2} month^{-1})
Month
P. pinaster
Biomass (tn ha^{-1})
Time (years)
P. pinaster
Net Photosynthesis (gC m^{-2} month^{-1})
Month
Q. ilex
Biomass (tn ha^{-1})
Time (years)
Q. ilex
Net Photosynthesis (gC m^{-2} month^{-1})
Month

Supplementary Material



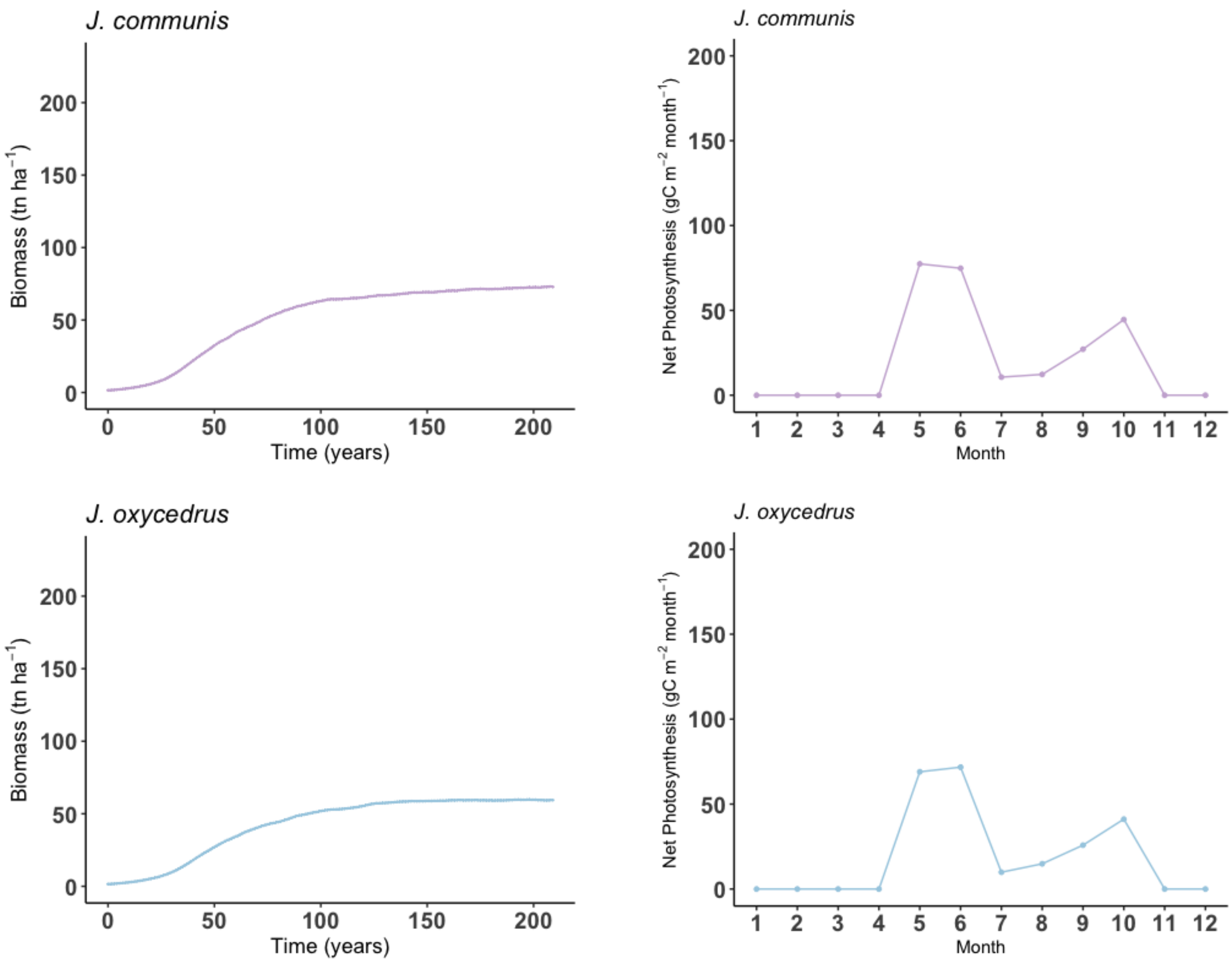
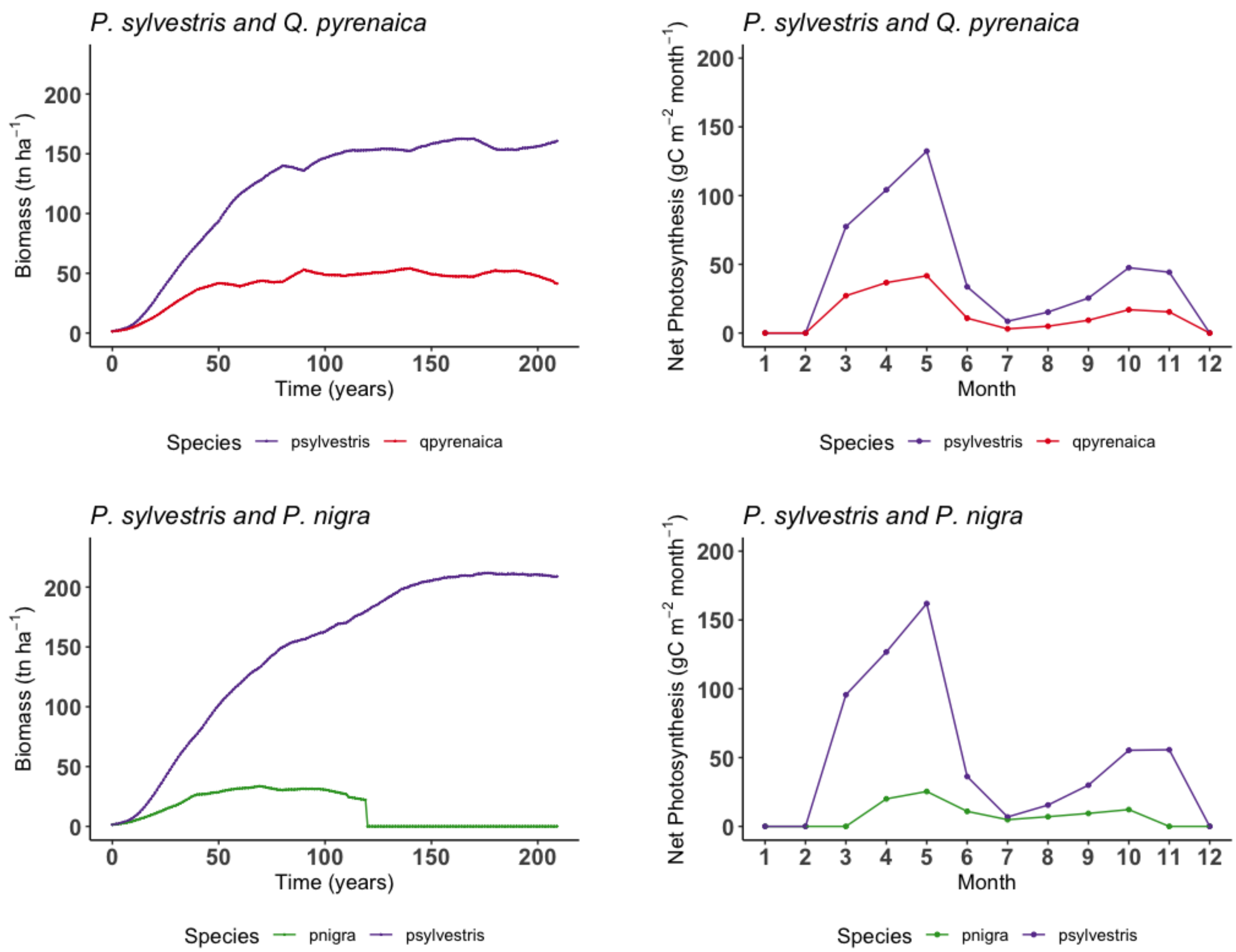
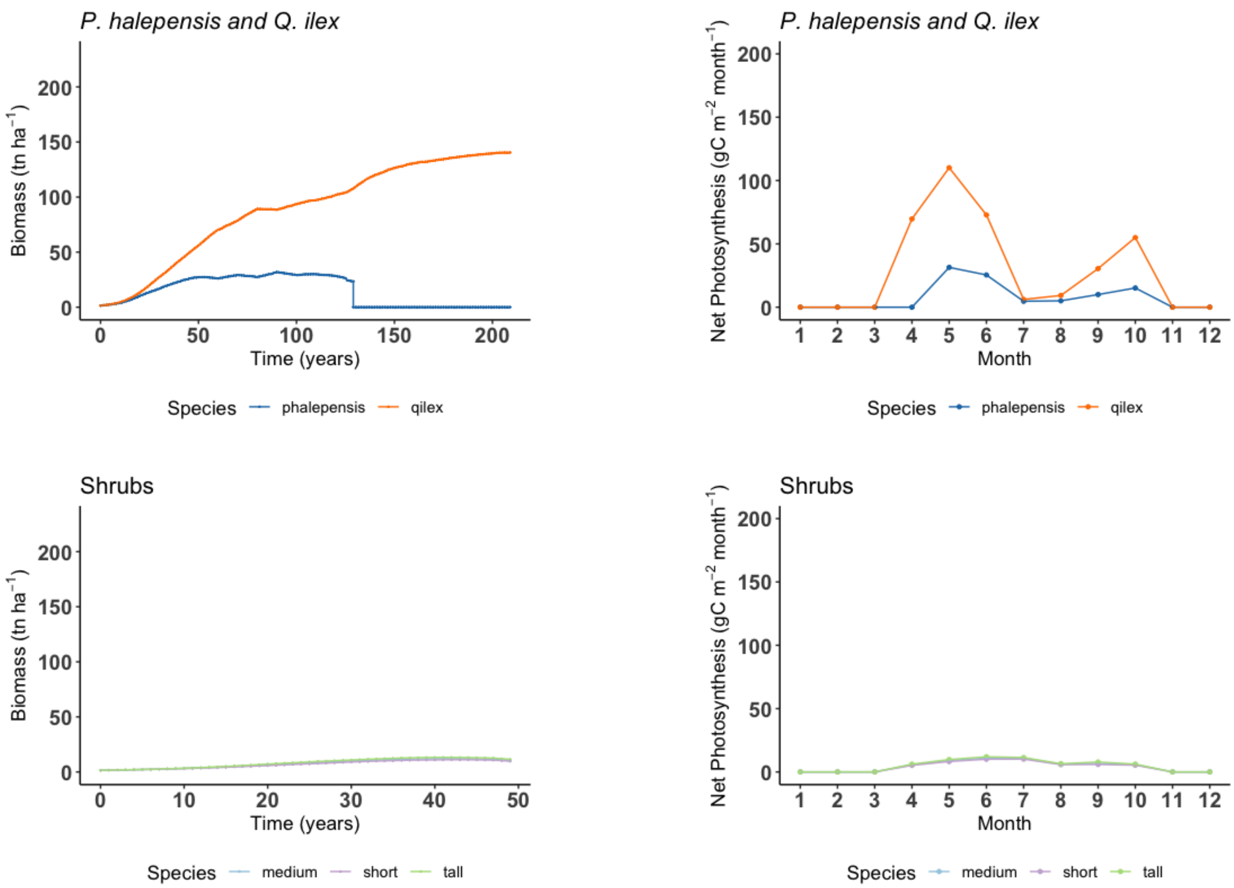

J. communis
Biomass (tn ha^{-1})
Time (years)
J. communis
Net Photosynthesis (gC m^{-2} month^{-1})
Month
J. oxycedrus
Biomass (tn ha^{-1})
Time (years)
J. oxycedrus
Net Photosynthesis (gC m^{-2} month^{-1})
Month

Figure S2. Groups of species simulation results: total biomass (left panels) and monthly photosynthesis (right panels). Each simulation consisted on one cohort of each of the corresponding species growing on a single-cell landscape (1 ha) under average historical climate corresponding to climate region 1 (see below). Monthly photosynthesis is calculated as the monthly average among all months for which the species is alive. Note that in the shrubs simulation (last two panels) short, medium and tall shrubs are present, with very similar values of biomass and photosynthesis rates.





P. halepensis and Q. ilex
Biomass (tn ha^{-1})
Time (years)
Species phalepensis qilex
P. halepensis and Q. ilex
Net Photosynthesis (gC m^{-2} month^{-1})
Month
Species phalepensis qilex
Shrubs
Biomass (tn ha^{-1})
Time (years)
Species medium short tall
Shrubs
Net Photosynthesis (gC m^{-2} month^{-1})
Month
Species medium short tall

Supplementary Material

Figure S3. Comparison of simulated (lines) versus observed (dots) Relative Growth Rates (RGR) relative to biomass. For the simulation results, the RGR corresponds to the slope coefficient in the linear model biomass as a function of age. The RGR observation data correspond to NFI data from single-species dominated plots within Sierra Nevada. Biomass was calculated from single-tree measurements using allometric equations from Montero et al. (2005). Observed RGR was calculated as:

$$\text{RGR} = \frac{ln(biomass_{NFI3}) - ln(biomass_{NFI2})}{time_{NFI3} - time_{NFI2}}$$

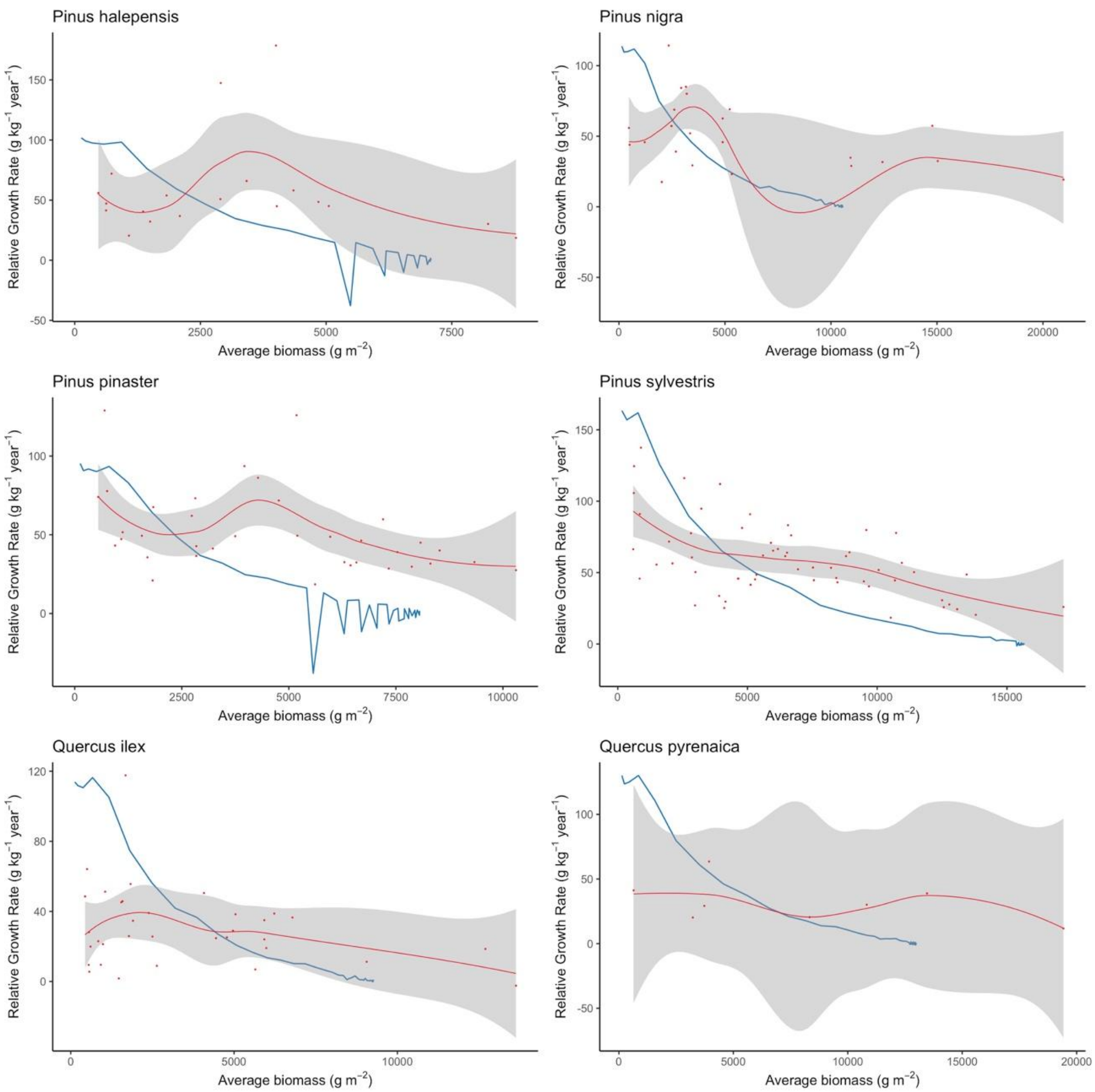


Figure S4. Temperature conditions for climate regions.

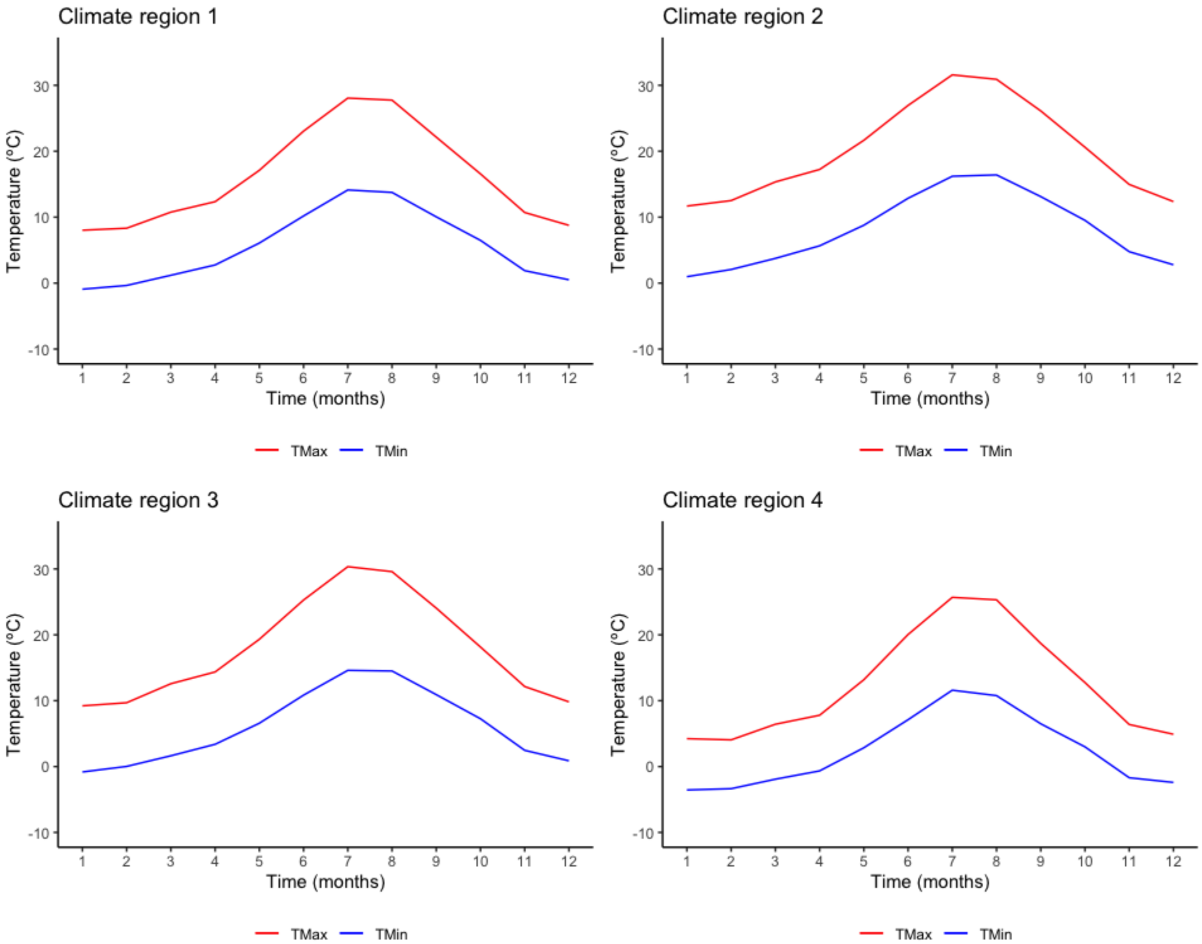


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Figure S5. Precipitation conditions for climate regions.

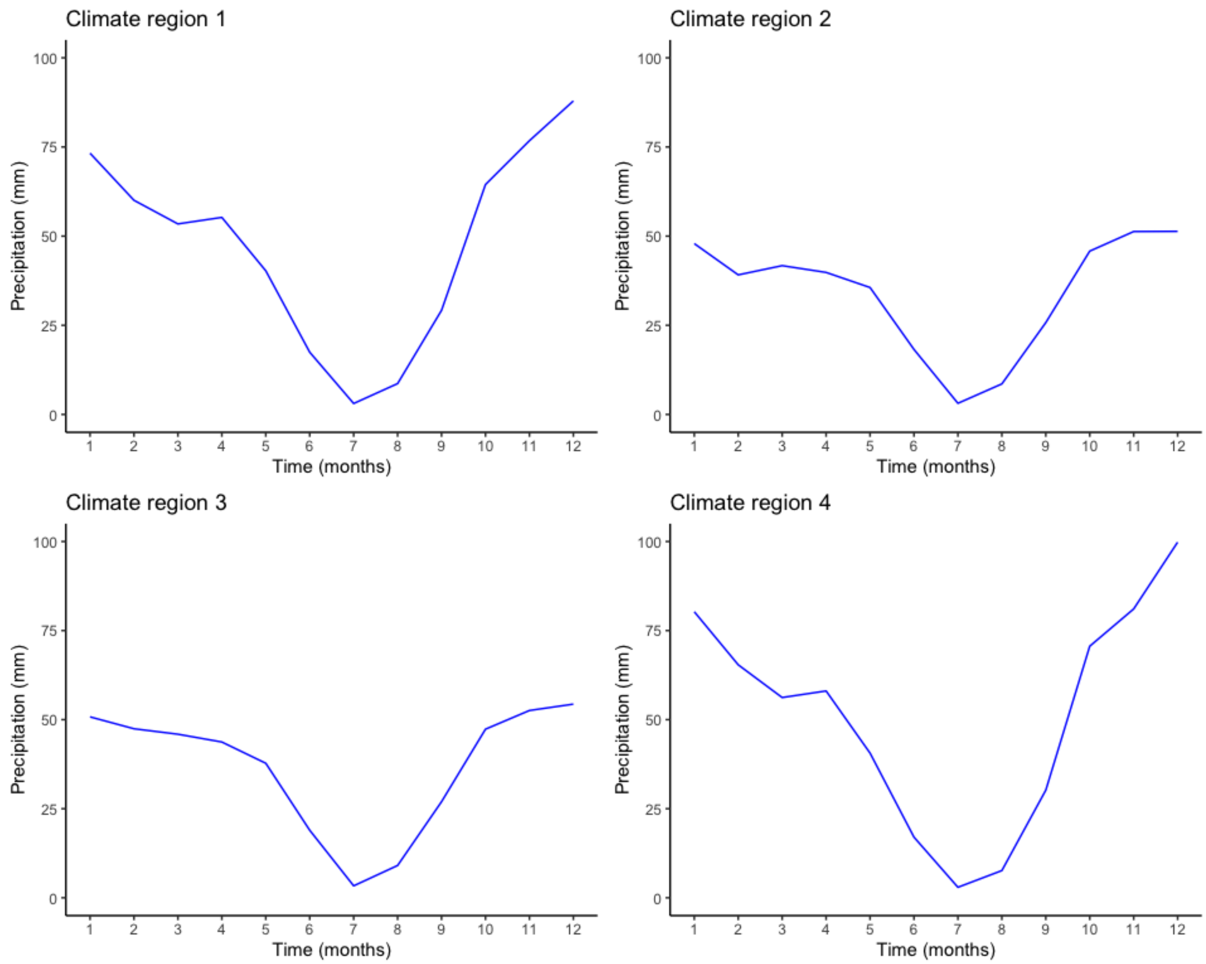


Figure S6. PAR conditions for climate regions.

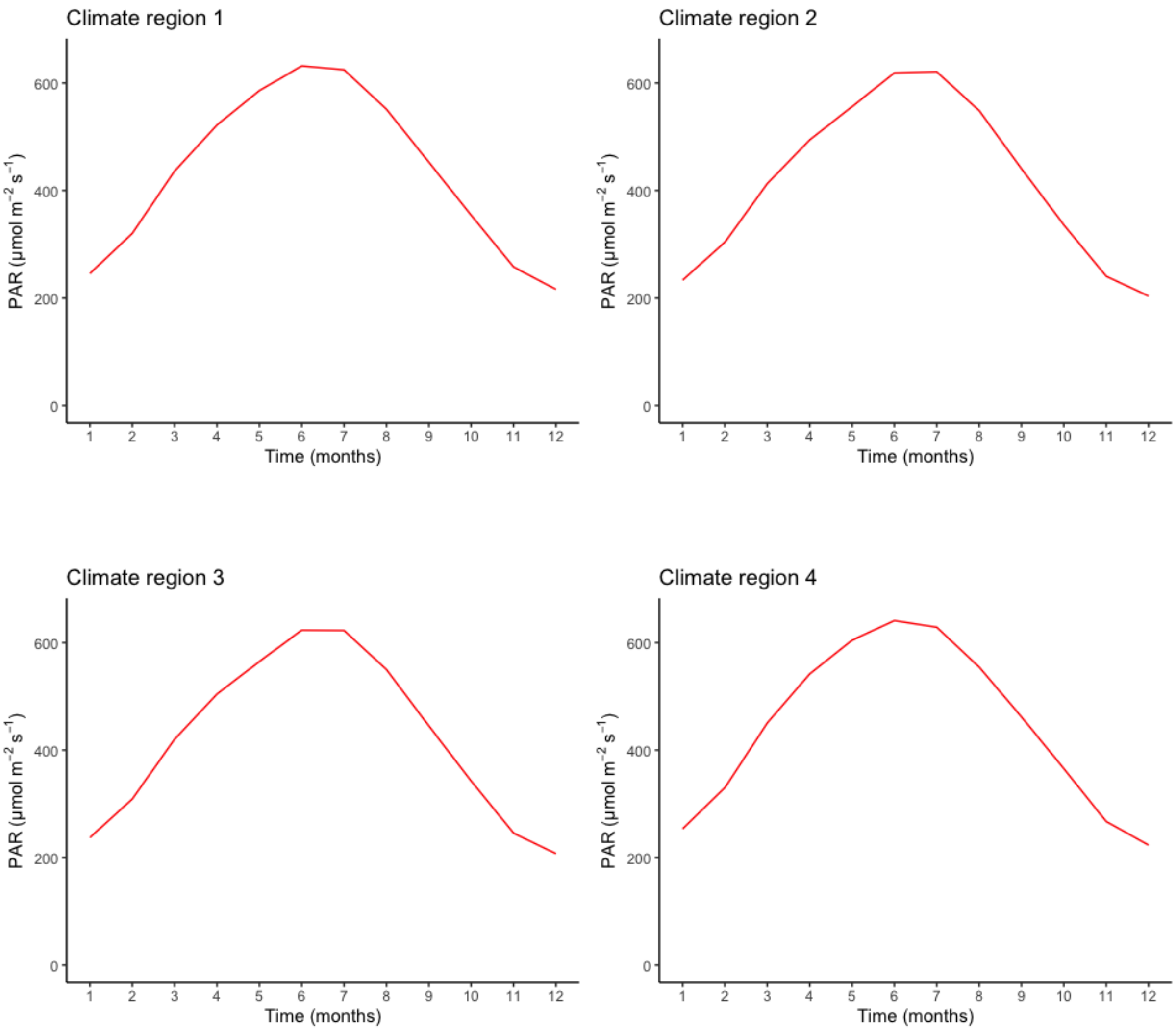
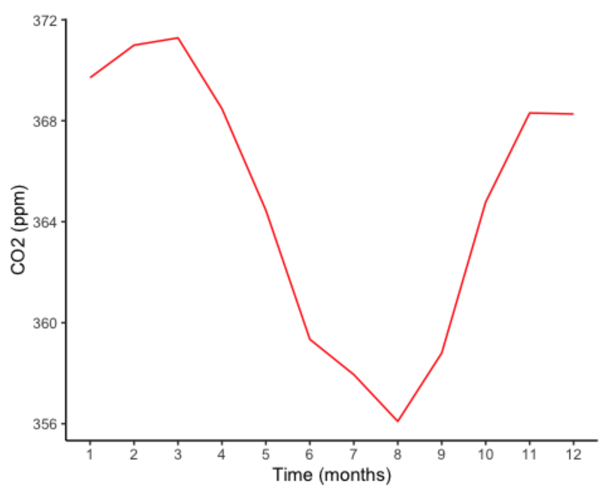


Figure S6. CO2 conditions for all climate regions.



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