SUPPLEMENTARY MATERIAL

The effect of fire on the carbon fluxes and productivity of Brazilian woodland savannas.

Authors: Francisco Navarro-Rosales[1,2,*], Maria Antonia Carniello[2], Wesley Jonatar Alves da Cruz [2,3], Flavio de Campos Oliveira[2,3], Huanyuan Zhang-Zheng[4], Valéria Lucélia de Oliveira Corrêa[2], Marcelo Leandro Feitosa de Andrade[5], Yadvinder Malhi[4], Andrew Hector[1], Immaculada Oliveras Menor[2,3,4].

Affiliations:

1. Department of Biology, University of Oxford, South Parks Road, Oxford, OX1 3RB, United Kingdom.
2. Programa de Pós-Graduação em Ciências Ambientais, UNEMAT – Universidade do Estado de Mato Grosso, Campus Cáceres Jane Vanini, Avenida São João, 563 – Cavalhada I – CEP 78216-060, Cáceres, Mato Grosso, Brazil.
3. AMAP – botAnique et Modélisation de l'Architecture des Plantes et des Végétations, Université de Montpellier, CIRAD, CNRS, INRAE, IRD, Montpellier CEDEX 5, France.
4. Environmental Change Institute, School of Geography and the Environment, University of Oxford, South Parks Road, Oxford, OX1 3QY, United Kingdom.
5. ICMBio – Instituto Chico Mendes de Conservação da Biodiversidade, – Estação Ecológica da Serra das Araras, CEP: 78.398-000, Porto Estrela, Mato Grosso, Brazil.

***Corresponding author:** francisco.navarrorosales@biology.ox.ac.uk

I. Methodology: estimation of leaf area index from fisheye lens canopy images

Leaf area index (LAI) of each plot was estimated from fisheye lens images of the canopy collected every month from December 2022 to November 2023. Images were taken with a Nikon D3200 camera and Samyang 8mm F3.5 UMC CS II Fisheye lens. Images were then processed using 'ilastik' (Berg *et al.*, 2019), matlab and 'CANEYE' (Weiss & Baret, 2017) software for pixel classification, image cropping and LAI calculations respectively. Ilastik was used to segment images into vegetation and sky pixels. Ilastik assigns labels to pixels based using a Random Forest classifier based on pixel labels and features (intensity, edge filters and textures) interactively set to enhance classification quality. Training was performed on a set of 10 images, indicating areas of sky and vegetation. All images were then processed and visually inspected. Inadequately segmented images were subsequently re-processed using a different training dataset and feature selection, and this process was repeated until all images were adequately segmented. Segmented images were then transformed to .tif format in matlab by changing pixel class values and applying a mask to pixels outside a 47º angle of view.

CANEYE was then used to obtain PAI (plant area index) estimates from segmented images. The software provides an estimate of PAI based on gap fraction and considering leaf distribution, inclination, and image projection function (Weiss & Baret, 2017). CANEYE reported one PAI value per plot per month, as a synthesis of the images of the 25 subplots. We used the 'CE V5.1 True PAI' method of PAI calculation, as our limited angle of view is not suitable for more recent calculation versions (requiring more than 60º angle of view). The following parameters were supplied to CANEYE based on image and camera characteristics:

1) CALIBRATION PARAMETERS

- **image size**: dimensions of the image (in landscape orientation) in terms of rows and columns of pixels (ROW: 4000, COLUMN: 6016, meaning 6016 x 4000 pixels).
- **angle of view**: 47º, where the vertical edge of the photo is the horizon, and the centroid is the zenith.
- **COI:** 45 degrees, defining the area of radius to be analysed, and incorporating a 2-degree buffer to account for edge imperfections.
- **Sub Sample Factor**: 1, using default value as reducing computational memory is not required.
- We created a projection function and inputted the optical centre characteristics:

- **Optical Centre:** the central pixel of the image defined as the midpoint pixel in the x and y direction (LINE: 2000, COLUMN 3008).
- **Polynomial order:** 1, as the projection is assumed to be equidistant/polar.
- **P1**: 0.013, representing the angle of view of the fisheye lens divided by the number of pixels from the centroid of the fisheye image to the image horizon.

2) ANGULAR RESOLUTION

- **Angular Resolution**: 2.5º in the zenith (θ) and azimuth (ϕ) directions, determining the angles for which the gap fraction is computed. It is set to the lowest value (highest resolution) for both angles.
- **FCover**: 20 degrees, used to calculate the percentage of black pixels within central 20-degree ring, not relevant to LAI.

3) CLUMPING PARAMETER

- **PAIsat**: 8, used to address the issue of mathematically calculated PAI being infinite in completely black pixels. To address this, we used a value of 8 in such cases. This value is the intermediate default value provided and based on the guess that the densest point in the sampled plots would have an PAI of 8.

4) FAPAR COMPUTATION

- **Latitude**: 15 degrees, based on the location of the plots.
- **Day Of Year:** 150, in this case it represents a random number as variations in radiation is not expected to be large in tropical areas, and because it is not relevant to the calculation of PAI.

Finally, we derived the true LAI values from the PAI estimates obtained from CANEYE by accounting for the percentage of PAI attributable to stems (stem area index – SAI). First, we used the percentage of PAI associated with stems and leaves of Cerrado trees provided by (Hoffmann *et al*., 2005) – where SAI and LAI account for 13.9% and 86.1% of PAI respectively – to calculate SAI and LAI proportions of PAI in each of the plots during the month with highest canopy cover. We also accounted for dead standing trees in each plot, by scaling the proportion of SAI in accordance with the proportion of standing dead trees (100% live trees means PAI = 0.139*PAI, and 100% dead standing trees means LAI = 1.000*PAI). We thus obtained the value of SAI for each plot, and since we assume that SAI does not vary seasonally, we subtracted SAI from all other PAI values to account for the stem fraction of the canopy cover in all other months, obtaining true green leaf LAI.

.

II. Monitoring plot characterisation

Table S1, description of the initial (2017 plot census) ecosystem characteristics of each monitoring plots at the Estação Ecológica da Serra das Araras fire experiment.

Aboveground dry biomass and aboveground carbon stocks were calculated using the equations provided by Rezende *et al*. (2006).

Plot	**ESA-04**	**ESA-05**	**ESA-06**	**ESA-07**	**ESA-08**	**ESA-09**
Fire regime	Unburnt	Biennial burns	Unburnt	Triennial burns	Unburnt	Annual burns
Number of stems (ha^{-1})	831	426	625	362	687	770
Basal area (m^2 ha^{-1})	5.45	2.50	3.83	2.32	4.43	5.47
Aboveground biomass (Mg ha^{-1})	11.55	4.41	6.68	4.31	8.55	10.85
Aboveground C stock (MgC ha^{-1})	5.78	2.21	3.34	2.16	4.27	5.43
Tree species richness	49	35	36	28	40	43
Most common species	*Curatella americana* *Pouteria ramiflora* *Myrcia bella* *Tachigali paniculata* *Hancornia speciosa* *Kielmeyera grandiflora* *Qualea grandiflora* *Vochysia haenkeana* *Qualea parviflora* *Eriotheca gracilipes*	*Tachigali paniculata* *Curatella americana* *Kielmeyera grandiflora* *Myrcia bella* *Pouteria ramiflora* *Vochysia haenkeana* *Byrsonima coccolobifolia* *Qualea multiflora* *Himatanthus obovatus* *Hymenaea stigonocarpa*	*Kielmeyera grandiflora* *Curatella americana* *Tachigali paniculata* *Pouteria ramiflora* *Myrcia bella* *Hancornia speciosa* *Vochysia haenkeana* *Byrsonima coccolobifolia* *Qualea grandiflora* *Xylopia aromatica*	*Pouteria ramiflora* *Tachigali paniculata* *Curatella americana* *Kielmeyera grandiflora* *Vochysia haenkeana* *Byrsonima coccolobifolia* *Hymenaea stigonocarpa* *Hancornia speciosa* *Myrcia bella* *Xylopia aromatica*	*Tachigali paniculata* *Pouteria ramiflora* *Kielmeyera grandiflora* *Curatella americana* *Myrcia bella* *Qualea grandiflora* *Xylopia aromatica* *Byrsonima coccolobifolia* *Byrsonima verbascifolia* *Vochysia haenkeana*	*Kielmeyera grandiflora* *Pouteria ramiflora* *Tachigali paniculata* *Vochysia haenkeana* *Curatella americana* *Dimorphandra mollis* *Hancornia speciosa* *Byrsonima coccolobifolia* *Byrsonima verbascifolia* *Qualea grandiflora*

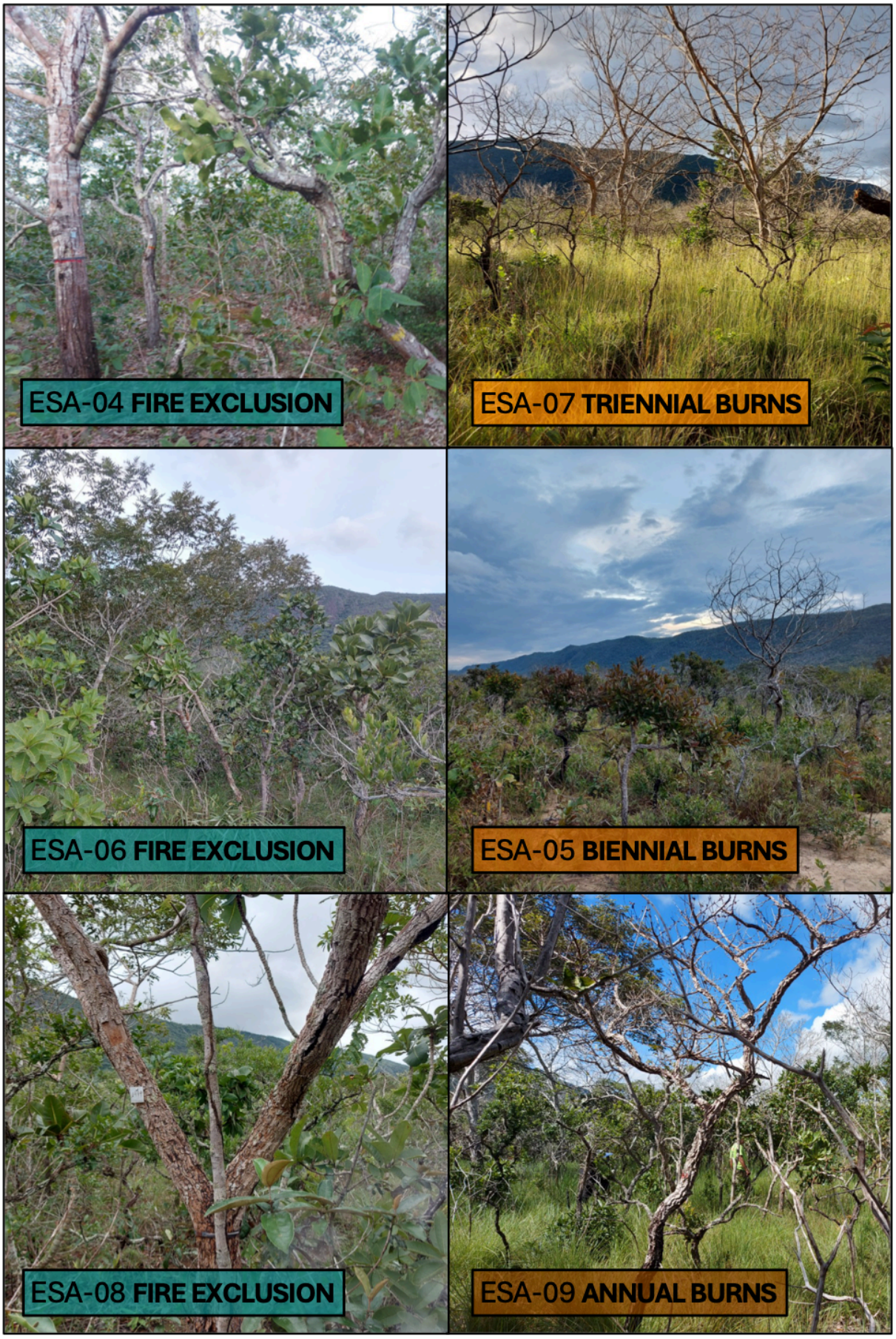

Fig. S1, images of the woodland savanna (*cerrado sensu stricto*) vegetation within the monitoring plots at the Estação Ecológica da Serra das Araras fire experiment, taken March to April 2023.

III. Statistical model outputs and pairwise comparisons

Table S2, summary statistics for the linear mixed model testing if litterfall net primary productivity ($\mathbf{NPP_{litterfall}}$) varies between fire regimes at the start (2018) and end (2023) monitoring periods. The model includes an interaction between fire regime and period. The response variable was transformed to meet statistical assumptions. The table includes fixed effect coefficients (in the transformed scale) and random effect variances. Plot and subplot identity were used as random effects to account for non-independence.

Formula: $\log_{10}(\mathbf{NPP_{litterfall}} + 0.1) \sim$ regime * year + (1 | plot) + (1 | subplot)				
Fixed effects	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)	0.12930	0.06095	2.121	0.162
regimeTriennial	-0.27915	0.12190	-2.290	0.143
regimeBiennial	-0.13072	0.12190	-1.072	0.391
regimeAnnual	0.14416	0.12190	1.183	0.354
period2023	0.00196	0.02992	0.065	0.948
regimeTriennial:period2023	**-0.45068**	0.05980	-7.537	**7.26e-14**
regimeBiennial:period2023	**-0.42377**	0.06009	-7.052	**2.42e-12**
regimeAnnual:period2023	**-0.50232**	0.05980	-8.401	**< 2e-16**

Random effects	**Variance**	**Groups**
subplot	0.049904	54
plot	0.004753	6
residual	0.198053	2049

Table S3, summary of the regime-level contrasts extracted from the linear mixed model testing if $\mathbf{NPP_{litterfall}}$ varies the start (2018) and end (2023) monitoring periods at each of the fire regimes (Table S2). The estimate values presented below represent the difference between the overall regime marginal mean, and 2018 and 2023 marginal means within that regime. Thus, contrast estimates are symmetrically opposite and correspond to half of the period2023 model coefficients. P-values under 0.05 indicate significant differences (Šídák method).

regime = Unburnt					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2018 effect	-0.00098	0.0150	1991	-0.065	0.9973
period2023 effect	0.00098	0.0150	1991	0.065	0.9973
regime = Triennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2018 effect	**0.22436**	0.0259	1991	8.667	**<.0001**
period2023 effect	**-0.22436**	0.0259	1991	-8.667	**<.0001**
regime = Biennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2018 effect	**0.21091**	0.0261	1991	8.095	**<.0001**
period2023 effect	**-0.21091**	0.0261	1991	-8.095	**<.0001**
regime = Annual					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2018 effect	**0.25018**	0.0259	1991	9.665	**<.0001**
period2023 effect	**-0.25018**	0.0259	1991	-9.665	**<.0001**

Table S4, summary statistics for the linear mixed model testing if positive values of stem DBH growth (from dendrometer data) vary between experimental fire regimes and at the start (2019) and end (2023) monitoring periods. The model includes an interaction between fire regime and period. Note the response variable was transformed to meet statistical assumptions. The table includes transformed-scale fixed effect coefficients and random effect variances. Plot, species and stem were used as random effects to account for non-independence.

Formula: $\log_{10}$(positive stem DBH growth) ~ regime * year + (1 | plot) + (1 | stem) + (1 | species)				
Fixed effects	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)	**-0.36561**	0.04002	-9.136	**2.01e-06**
regimeTriennial	0.14759	0.06383	2.312	0.0677
regimeBiennial	0.04234	0.07618	0.556	0.5902
regimeAnnual	0.07052	0.05850	1.205	0.3012
period2023	**-0.09093**	0.01820	-4.997	**6.50e-07**
regimeTriennial:period2023	-0.01979	0.07622	-0.260	0.7952
regimeBiennial:period2023	0.13584	0.08627	1.575	0.1156
regimeAnnual:period2023	0.08615	0.05537	1.556	0.1199

Random effects	**Variance**	**Groups**
stem	0.008108	349
species	0.011200	28
plot	0.001499	6
residual	0.103973	1656

Table S5, summary of the regime-level contrasts of marginal means extracted from the linear mixed model testing if positive values of stem DBH growth (from dendrometer data) vary between fire regimes and at the start (2019) and end (2023) monitoring periods (Table S4). The estimate values presented below represent the difference between the overall fire regime marginal mean, and the period-specific marginal mean within the fire regime. P-values below 0.05 indicate significant differences according to the Šídák method.

regime = Unburnt					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	**0.04547**	0.00911	1529	4.992	**<.0001**
period2023 effect	**-0.04547**	0.00911	1529	-4.992	**<.0001**
regime = Triennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	0.05536	0.03712	961	1.492	0.2538
period2023 effect	-0.05536	0.03712	961	-1.492	0.2538
regime = Biennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	-0.02246	0.04228	1460	-0.531	0.8363
period2023 effect	0.02246	0.04228	1460	0.531	0.8363
regime = Annual					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	0.00239	0.02617	1607	0.091	0.9947
period2023 effect	-0.00239	0.02617	1607	-0.091	0.9947

Table S6, summary statistics for the generalised linear mixed model testing if the proportion of stems sampled with dendrometer bands showing positive DBH growth varies between experimental fire regimes at the start (2019) and end (2023) monitoring periods. The model includes an interaction between fire regime and period. The table includes fixed effect coefficients (in the logit scale) and random effect variances. Stem identity was used as a random effect to account for non-independence.

Formula: binary stem DBH growth ~ regime * year + (1 | stem)				
Family: binomial (logit)				
logLik:1632.2 **deviance:** 3264.3 **df.resid:** 3236 **observations:** 3245				
Fixed effects	**Estimate**	**Std. Error**	**t-value**	**Pr(>|z|)**
(Intercept)	0.26288	0.17330	1.517	0.1293
regimeTriennial	-0.23115	0.52532	-0.440	0.6599
regimeBiennial	-0.92338	0.58663	-1.574	0.1155
regimeAnnual	0.31482	0.45026	0.699	0.4844
period2023	-0.06727	0.10920	-0.616	0.5378
regimeTriennial:period2023	0.19244	0.43994	0.437	0.6618
regimeBiennial:period2023	0.76883	0.45625	1.685	0.0920
regimeAnnual:period2023	-0.56550	0.33957	-1.685	0.0958

Random effects	**Variance**	**Groups**
stem	6.901	435

Table S7, summary of the regime-level contrasts of marginal means extracted from the generalised linear mixed model testing if the proportion of dendrometer stems with positive DBH growth varies between fire regimes at the start (2019) and end (2023) monitoring periods (Table S6). The estimate values presented below represent the difference between the overall fire regime marginal mean, and the period-specific marginal mean within the fire regime. P-values below 0.05 indicate significant differences according to the Šídák method.

regime = Unburnt					
contrast	**estimate**	**SE**	**df**	**z.ratio**	**p.value**
period2019 effect	0.0336	0.0546	Inf	0.616	0.7864
period2023 effect	-0.0336	0.0546	Inf	-0.616	0.7864
regime = Triennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	-0.0626	0.2215	Inf	-1.584	0.2136
period2023 effect	0.0626	0.2215	Inf	1.584	0.2136
regime = Biennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	-0.3508	0.2215	Inf	-1.584	0.2136
period2023 effect	0.3508	0.2215	Inf	1.584	0.2136
regime = Annual					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	0.3164	0.1608	Inf	1.968	0.0958
period2023 effect	-0.3164	0.1608	Inf	-1.968	0.0958

Table S8, summary statistics for the linear model testing if fine root net primary productivity ($\mathbf{NPP_{fine\ roots}}$) varies between fire regimes at the start (2018) and end (2023) monitoring periods. The model includes an interaction between fire regime and period. Note the response variable was transformed to meet statistical assumptions. The table includes fixed effect coefficients (in the transformed scale). Please note no random effects were used to avoid model overcomplexity.

Formula: $\log_{10}(\mathbf{NPP_{fine\ roots}} + 0.2) \sim$ regime * year				
Adjusted R-squared: 0.1987 **F-statistic:** 16.3 **DF:** 7,425 **p-value:** < 2.2e-16				
Fixed effects	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)	**0.321710**	0.038113	8.441	**5.01e-16**
regimeTriennial	-0.012090	0.076227	-0.159	0.8741
regimeBiennial	-0.125426	0.076227	-1.645	0.1006
regimeAnnual	-0.004198	0.076227	-0.055	0.9561
period2023	**-0.294563**	0.053777	-5.478	**7.40e-08**
regimeTriennial:period2023	**-0.212798**	0.107739	-1.975	**0.0489**
regimeBiennial:period2023	-0.029413	0.107739	-0.273	0.7850
regimeAnnual:period2023	**-0.230118**	0.107739	-2.136	**0.0333**

Table S9, summary of the regime-level contrasts of marginal means extracted from the linear model testing if fine root net primary productivity ($\mathbf{NPP_{fine\ roots}}$) varies between experimental fire regimes and between the start (2018) and end (2023) monitoring periods (Table S8). The estimate values presented below represent the difference between the overall fire regime marginal mean, and the period-specific marginal mean within the fire regime. P-values below 0.05 indicate significant differences according to the Šídák method.

regime = Unburnt					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	**0.147**	0.0269	425	5.478	**<.0001**
period2023 effect	**-0.147**	0.0269	425	-5.478	**<.0001**
regime = Triennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	**0.254**	0.0467	425	5.435	**<.0001**
period2023 effect	**-0.254**	0.0467	425	-5.435	**<.0001**
regime = Biennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	**0.162**	0.0467	425	-3.470	**0.0011**
period2023 effect	**-0.162**	0.0467	425	3.470	**0.0011**
regime = Annual					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period2019 effect	**-0.262**	0.0467	425	5.620	**<.0001**
period2023 effect	**0.262**	0.0467	425	-5.620	**<.0001**

Table S10, summary statistics for the linear mixed model testing if stem CO_2 efflux varies between fire regimes at the start (Sep 2018 to Aug 2019) and end (2023) monitoring periods. The model includes an interaction between fire regime and period. The table includes fixed effect coefficients and random effect variances. Plot, species and stem identity were used as random effects to account for non-independence. Please note that the start period data for plots ESA-05 and ESA-06 was taken from September 2019 to March 2020.

Formula: stem CO_2 efflux ~ regime * year + (1 | plot) + (1 | species) + (1 | stem)					
Fixed effects		**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)		**0.97911**	0.15874	6.168	**0.000410**
regimeTriennial		0.35463	0.21532	1.647	0.257029
regimeBiennial		0.36415	0.23451	1.553	0.236216
regimeAnnual		0.07337	0.22109	0.332	0.771980
period2023		0.03564	0.05820	0.612	0.540294
regimeTriennial:period2023		-0.14840	0.12685	-1.170	0.242218
regimeBiennial:period2023		**-0.41677**	0.12595	-3.309	**0.000954**
regimeAnnual:period2023		-0.07310	0.10906	-0.670	0.502746
Random effects	**Variance**	**Groups**			
stem	0.14859	100			
species	0.21570	21			
plot	0.02089	6			
residual	0.69510	1828			

Table S11, summary of the regime-level contrasts of marginal means extracted from the linear mixed model testing if stem CO_2 efflux varies between fire regimes at the start (Sep 2018 to Aug 2019) and end (2023) monitoring periods (Table S10). The estimate values presented below represent the difference between the overall fire regime marginal mean, and the period-specific marginal mean within the fire regime. P-values below 0.05 indicate significant differences according to the Šídák method.

regime = Unburnt					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	-0.0178	0.0292	1743	-0.611	0.7894
period2023 effect	0.0178	0.0292	1743	0.611	0.7894
regime = Triennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	0.0564	0.0566	1432	0.996	0.5369
period2023 effect	-0.0564	0.0566	1432	-0.996	0.5369
regime = Biennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	**0.1906**	0.0559	1800	3.409	**0.0013**
period2023 effect	**-0.1906**	0.0559	1800	-3.409	**0.0013**
regime = Annual					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	0.0187	0.0461	1725	0.406	0.9006
period2023 effect	-0.0187	0.0461	1725	-0.406	0.9006

Table S12, summary statistics for the linear mixed model testing if soil respiration ($\mathbf{R_{soil}}$) varies between fire regimes at the start (Sep 2018 to Aug 2019) and end (2023) monitoring periods. The model includes an interaction between fire regime and period. The table includes fixed effect coefficients and random effect variances. Plot and subplot identity were used as random effects to account for non-independence.

Formula: stem CO_2 efflux ~ regime * year + (1 | plot) + (1 | subplot)				
Fixed effects	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)	**8.3362**	0.3791	21.989	**7.82e-05**
regimeTriennial	1.5443	0.7610	2.029	0.12221
regimeBiennial	0.3896	0.7610	0.512	0.63918
regimeAnnual	1.3116	0.7757	1.691	0.17023
period2023	**-1.0747**	0.3527	-3.047	**0.00236**
regimeTriennial:period2023	**-1.5766**	0.7057	-1.170	**0.02566**
regimeBiennial:period2023	0.6952	0.6952	2.234	0.40690
regimeAnnual:period2023	-0.6904	0.7114	-0.971	0.33197

Random effects	**Variance**	**Groups**
subplot	1.1366	54
plot	0.1062	6
residual	18.2605	1194

Table S13, summary of the regime-level contrasts of marginal means extracted from the linear mixed model testing if soil respiration ($\mathbf{R_{soil}}$) varies between fire regimes at the start (Sep 2018 to Aug 2019) and end (2023) monitoring periods (Table S12). The estimate values presented below represent the difference between the overall fire regime marginal mean, and the period-specific marginal mean within the fire regime. P-values below 0.05 indicate significant differences according to the Šídák method.

regime = Unburnt					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	**0.537**	0.176	1143	3.046	**0.0047**
period2023 effect	**-0.537**	0.176	1143	-3.046	**0.0047**
regime = Triennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	**1.326**	0.306	1136	4.338	**<.0001**
period2023 effect	**-1.326**	0.306	1136	-4.338	**<.0001**
regime = Biennial					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	0.249	0.300	1136	0.831	0.6474
period2023 effect	-0.249	0.300	1136	-0.831	0.6474
regime = Annual					
contrast	**estimate**	**SE**	**df**	**t.ratio**	**p.value**
period(Sep 2018 - Aug 2019) effect	**0.883**	0.309	1137	2.857	**0.0087**
period2023 effect	**-0.883**	0.309	1137	-2.857	**0.0087**

Table S14, summary statistics for the linear mixed model testing if herbaceous net primary productivity ($\mathbf{NPP_{herbs}}$) varies between fire regimes. The table includes transformed fixed effect coefficients and random effect variances. Plot and subplot were used as random effects to account for non-independence.

Formula: $\log_{10}(\mathbf{NPP_{herbs}} + 0.05) \sim$ regime + (1 | plot) + (1 | subplot)					
Fixed effects			**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)			**-1.01880**	0.05485	-18.574	**0.0029**
regimeTriennial			0.38534	0.10970	3.513	0.0724
regimeBiennial			0.21803	0.10970	1.987	0.1852
regimeAnnual			0.08250	0.10970	0.752	0.5305
Random effects	**Variance**	**Groups**				
subplot	0.004291	72				
plot	0.007381	6				
residual	0.185449	864				

Table S15, summary statistics for the linear mixed model testing if live herbaceous biomass varies between fire regimes. The table includes transformed fixed effect coefficients and random effect variances. Plot was used as a random effect to account for non-independence.

Formula: $\log_{10}$(live herbaceous biomass + 1) ~ regime + (1 | plot)					
Fixed effects			**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)			**1.05406**	0.15306	6.887	**0.0204**
regimeTriennial			0.93808	0.30612	3.064	0.0920
regimeBiennial			0.39530	0.30612	1.291	0.3257
regimeAnnual			0.09873	0.30612	0.323	0.7777
Random effects	**Variance**	**Groups**				
plot	0.05759	6				
residual	0.15227	72				

Table S16, summary statistics for the linear mixed model testing if leaf area index (LAI) varies between fire regimes. The table includes fixed effect coefficients and random effect variances. LAI was calculated as a single value per plot and month, so plot was used as a random effect to account for non-independence.

Formula: LAI ~ regime + (1 | plot)					
Fixed effects			**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)			**1.7600**	0.1444	12.192	**0.00666**
regimeTriennial			**-1.5866**	0.2887	-5.495	**0.03156**
regimeBiennial			**-1.3121**	0.2900	-4.524	**0.04403**
regimeAnnual			-0.9362	0.2887	-3.242	0.08339
Random effects	**Variance**	**Groups**				
plot	0.05416	6				
residual	0.10035	71				

Table S17, comparison of AIC (Akaike's information criterion) values for models comparing variables at different fire regimes and monitoring periods with and without an additional fixed effect for basal area in 2017 (Table 4). Linear mixed models were fit using ML estimation rather than REML for adequate comparisons between different sets of fixed effects (Zuur *et al*., 2009).

Variable	**AIC(df) –** without initial basal area	**AIC(df) –** with initial basal area	**ΔAIC**
$NPP_{litterfall}$	2639.80 (11)	2640.46 (11)	0.66
positive DBH growth	1098.72 (12)	1099.45 (13)	0.73
binary DBH growth	3282.31 (9)	3282.29 (10)	-0.02
$NPP_{fine\ roots}$	436.70 (9)	436.92 (10)	0.22
Stem CO_2 efflux	4727.53 (12)	4725.60 (13)	-1.93
R_{soil}	6918.26 (11)	6919.35 (12)	1.09
NPP_{herbs}	1031.37 (7)	1024.18 (8)	**-7.19**
live herb biomass	84.49 (7)	77.64 (8)	**-6.85**
LAI	55.68 (6)	56.22 (7)	-0.46

Table S18, summary statistics for the linear mixed model testing if herbaceous net primary productivity (**NPP_{herbs}**) varies between fire regimes, including an additional fixed effect for plot-level basal area in 2017. Plot and subplot were used as random effects in order to maintain model structure (Table S15).

Formula: $\log_{10}(NPP_{herbs} + 0.05) \sim$ regime + initial_basal_area + (1 | plot) + (1 | subplot)

Fixed effects	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)	**-0.50434**	0.16134	-3.126	**0.00262**
initial_basal_area	**-0.11260**	0.03494	-3.223	**0.00196**
regimeTriennial	0.13209	0.09142	1.445	0.15318
regimeBiennial	-0.01456	0.08597	-0.169	0.86599
regimeAnnual	**0.18383**	0.05631	3.265	**0.00173**

Random effects	**Variance**	**Groups**
subplot	0.0042	72
plot	0.0000	6
residual	0.1854	504

Table S19, summary statistics for the linear mixed model testing if live herbaceous biomass varies between fire regimes, including an additional fixed effect for plot-level basal area in 2017. Plot was used as a random effect in order to maintain model structure (Table S16).

Formula: $\log_{10}$(live herbaceous biomass + 1) ~ regime + (1 | plot)

Fixed effects	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)	**2.46461**	0.43340	5.687	**2.59e-07**
initial_basal_area	**-0.30872**	0.09386	-3.289	**0.00156**
regimeTriennial	0.24371	0.24558	0.992	0.32434
regimeBiennial	-0.24242	0.23094	-1.050	0.29737
regimeAnnual	**0.37656**	0.15126	2.489	**0.01510**

Random effects	**Variance**	**Groups**
plot	0.0000	6
residual	0.1417	72

IV. Summaries of carbon fluxes and related variables

Table S20, summary of initial and final carbon flux estimates within the experimental fire regimes at the Estação Ecológica da Serra das Araras (MgC ha^{-1} $year^{-1}$).

START

Flux	$NPP_{litterfall}$	NPP_{stem}	NPP_{herbs}	$NPP_{coarse\ roots}$	$NPP_{fine\ roots}$	R_{canopy}	R_{stem}	R_{herbs}	R_{soil}	$C_{mortality}$
Period	Jan 2018 - Dec 2018	Jul 2017 - Sep 2019	-	Jul 2017 - Sep 2019	Jan 2018 - Dec 2018	-	Sep 2018 - Aug 2019	-	Sep 2018 - Aug 2019	Jul 2017 - Sep 2019
Unburnt	1.25 ± 0.19	0.49 ± 0.13	-	0.67 ± 0.48	1.90 ± 0.18	-	1.93 ± 0.36	-	8.34 ± 0.38	0.01 ± 0.00
Triennial	0.61± 0.17	0.29 ± 0.07	-	0.39 ± 0.29	1.84 ± 0.31	-	1.41 ± 0.26	-	9.88 ± 0.66	0.00 ± 0.00
Biennial	0.90 ± 0.24	0.24 ± 0.06	-	0.33 ± 0.24	1.37 ± 0.24	-	1.51 ± 0.29	-	8.73 ± 0.66	0.00 ± 0.00
Annual	1.78 ± 0.46	0.71 ± 0.18	-	0.97 ± 0.71	1.88 ± 0.32	-	2.35 ± 0.54	-	9.65 ± 0.68	0.03 ± 0.01

END

Flux	$NPP_{litterfall}$	NPP_{stem}	NPP_{herbs}	$NPP_{coarse\ roots}$	$NPP_{fine\ roots}$	R_{canopy}	R_{stem}	R_{herbs}	R_{soil}	$C_{mortality}$
Period	Jan 2023 - Dec 2023	Sep 2021 - Sep 2023	Nov 2023 - Oct 2024	Sep 2021 - Sep 2023	Jan 2023 - Dec 2023	Dec 2022 - Nov 2023	Jan 2023 - Dec 2023	Oct 2023	Jan 2023 - Dec 2023	Sep 2021 - Sep 2023
Unburnt	1.25 ± 0.20	0.66 ± 0.17	0.05 ± 0.01	0.90 ± 0.65	0.86 ± 0.09	4.32 ± 1.02	2.41 ± 0.48	0.58 ± 0.23	7.26 ± 0.37	0.08 ± 0.02
Triennial	0.15 ± 0.06	0.07 ± 0.02	0.18 ± 0.05	0.09 ± 0.07	0.43 ± 0.10	0.41 ± 0.61	0.82 ± 0.19	5.28 ± 3.31	7.23 ± 0.63	0.69 ± 0.18
Biennial	0.28 ± 0.10	0.16 ± 0.04	0.11 ± 0.03	0.21 ± 0.15	0.55 ± 0.11	1.10 ± 0.66	0.78 ± 0.22	1.44 ± 0.93	8.23 ± 0.62	0.76 ± 0.19
Annual	0.49 ± 0.15	0.60 ± 0.15	0.07 ± 0.03	0.82 ± 0.59	0.42 ± 0.09	2.01 ± 0.61	2.06 ± 0.49	0.77 ± 0.51	7.88 ± 0.62	1.22 ± 0.31

Table S21, summary of initial and final carbon fluxes within the experimental fire project at the Estação Ecológica da Serra das Araras (MgC ha^{-1} $year^{-1}$), separated by individual plot. Where flux estimates were derived from statistical models, plot was used as fixed effect instead of regime, and removed as a random effect.

START

Flux	$NPP_{litterfall}$	NPP_{stem}	NPP_{herbs}	$NPP_{coarse\ roots}$	$NPP_{fine\ roots}$	R_{canopy}	R_{stem}	R_{herbs}	R_{soil}	$C_{mortality}$
Period	Jan 2018 - Dec 2018	Jul 2017 - Sep 2019	-	Jul 2017 - Sep 2019	Jan 2018 - Dec 2018	-	Sep 2018 - Aug 2019	-	Sep 2018 - Aug 2019	Jul 2017 - Sep 2019
ESA-04	1.36 ± 0.27	0.62 ± 0.16	-	0.84 ± 0.61	2.33 ± 0.38	-	2.38 ± 0.46	-	8.82 ± 0.56	0.02 ± 0.01
ESA-05	0.90 ± 0.18	0.24 ± 0.06	-	0.33 ± 0.24	1.37 ± 0.24	-	1.51 ± 0.25	-	8.73 ± 0.57	0.00 ± 0.00
ESA-06	0.99 ± 0.20	0.33 ± 0.09	-	0.45 ± 0.33	1.61 ± 0.27	-	1.67 ± 0.35	-	7.47 ± 0.58	0.01 ± 0.00
ESA-07	0.61± 0.13	0.29 ± 0.07	-	0.39 ± 0.29	1.84 ± 0.31	-	1.39 ± 0.22	-	9.88 ± 0.57	0.00 ± 0.00
ESA-08	1.43 ± 0.28	0.51± 0.13	-	0.70 ± 0.51	1.82 ± 0.31	-	1.86 ± 0.37	-	8.68 ± 0.57	0.00 ± 0.00
ESA-09	1.78 ± 0.35	0.71 ± 0.18	-	0.97 ± 0.71	1.88 ± 0.32	-	2.33 ± 0.45	-	9.65 ± 0.59	0.23 ± 0.05

END

Flux	$NPP_{litterfall}$	NPP_{stem}	NPP_{herbs}	$NPP_{coarse\ roots}$	$NPP_{fine\ roots}$	R_{canopy}	R_{stem}	R_{herbs}	R_{soil}	$C_{mortality}$
Period	Jan 2023 - Dec 2023	Sep 2021 - Sep 2023	Nov 2023 - Oct 2024	Sep 2021 - Sep 2023	Jan 2023 - Dec 2023	Dec 2022 - Nov 2023	Jan 2023 - Dec 2023	Oct 2023	Jan 2023 - Dec 2023	Sep 2021 - Sep 2023
ESA-04	1.34 ± 0.28	0.94 ± 0.24	0.03 ± 0.01	1.29 ± 0.94	0.88 ± 0.16	4.60 ± 1.04	4.04 ± 0.64	0.37 ± 0.11	7.08 ± 0.54	0.06 ± 0.02
ESA-05	0.28 ± 0.07	0.16 ± 0.04	0.11 ± 0.03	0.21 ± 0.15	0.55 ± 0.11	1.10 ± 0.34	0.77 ± 0.15	1.49 ± 0.42	8.23 ± 0.53	0.76 ± 0.19
ESA-06	0.81 ± 0.18	0.38 ± 0.10	0.07 ± 0.01	0.52 ± 0.38	0.81 ± 0.15	3.60 ± 0.83	1.56 ± 0.37	1.15 ± 0.32	6.84 ± 0.56	0.15 ± 0.04
ESA-07	0.15 ± 0.05	0.07 ± 0.02	0.18 ± 0.02	0.09 ± 0.07	0.43 ± 0.10	0.42 ± 0.24	0.81 ± 0.14	5.33 ± 1.50	7.23 ± 0.54	0.69 ± 0.18
ESA-08	1.80 ± 0.38	0.65 ± 0.17	0.04 ± 0.01	0.87 ± 0.65	0.90 ± 0.17	4.77 ± 1.08	1.88 ± 0.43	0.57 ± 0.16	7.87 ± 0.54	0.04 ± 0.01
ESA-09	0.49 ± 0.12	0.60 ± 0.15	0.07 ± 0.01	0.82 ± 0.59	0.42 ± 0.09	2.01 ± 0.50	2.04 ± 0.40	0.82 ± 0.23	7.88 ± 0.53	1.22 ± 0.31

Table S22, summary of initial and final estimates of key flux-related variables within the experimental burning regimes at the Estação Ecológica da Serra das Araras.

START

Variable	**positive DBH growth**	**proportion of growing stems**	**leaf area index**	**Stem CO_2 efflux**	**stem surface area**	**live herbaceous biomass**
Units	cm $year^{-1}$	-	m^2m^{-2}	µmol m^{-2} s^{-1}	m^2 ha^{-1}	g m^{-2}
Period	Jan 2019 - Dec 2019	Jan 2019 - Dec 2019	-	Sep 2018 - Aug 2019	Jan 2018 - Dec 2018	-
Unburnt	0.43 ± 0.04	0.54 ± 0.02	-	1.00 ± 0.16	5096.38 ± 509.64	-
Triennial	0.61 ± 0.09	0.51 ± 0.07	-	1.34 ± 0.21	2770.75 ± 277.08	-
Biennial	0.48 ± 0.07	0.41 ± 0.07	-	1.35 ± 0.22	2962.50 ± 296.25	-
Annual	0.51 ± 0.07	0.58 ± 0.05	-	1.05 ± 0.22	5904.41 ± 590.44	-

END

Variable	**positive DBH growth**	**proportion of growing stems**	**leaf area index**	**Stem CO_2 efflux**	**stem surface area**	**live herbaceous biomass**
Units	cm $year^{-1}$	-	m^2m^{-2}	µmol m^{-2} s^{-1}	m^2 ha^{-1}	g m^{-2}
Period	Jan 2023 - Dec 2023	Jan 2023 - Dec 2023	Dec 2022 - Nov 2023	Jan 2023 - Dec 2023	Sep 2023	Oct 2023
Unburnt	0.35 ± 0.03	0.53 ± 0.03	1.76 ± 0.14	1.02 ± 0.15	6267.44 ± 626.74	10.33 ± 3.99
Triennial	0.47 ± 0.08	0.52 ± 0.07	0.17 ± 0.25	1.22 ± 0.21	1761.10 ± 176.11	97.21 ± 59.95
Biennial	0.53 ± 0.10	0.51 ± 0.07	0.45 ± 0.25	0.96 ± 0.21	2128.08 ± 212.81	27.14 ± 17.18
Annual	0.50 ± 0.08	0.50 ± 0.06	0.82 ± 0.25	1.01 ± 0.22	5370.34 ± 537.03	13.22 ± 8.68

Table S23, summary of initial and final estimates of key variables within the experimental fire project at the Estação Ecológica da Serra das Araras separated by individual plot. Where flux estimates were derived from statistical models, plot was used as fixed effect instead of regime, and removed as a random effect.

START

Variable	**positive DBH growth**	**proportion of growing stems**	**leaf area index**	**Stem CO_2 efflux**	**stem surface area**	**live herbaceous biomass**
Units	cm $year^{-1}$	-	m^2m^{-2}	µmol m^{-2} s^{-1}	m^2 ha^{-1}	g m^{-2}
Period	Jan 2019 - Dec 2019	Jan 2019 - Dec 2019	-	Sep 2018 - Aug 2019	Jan 2018 - Dec 2018	-
ESA-04	0.46 ± 0.04	0.60 ± 0.04	-	1.03 ± 0.17	6138.72 ± 613.87	-
ESA-05	0.47 ± 0.07	0.41 ± 0.07	-	1.34 ± 0.18	2962.50 ± 296.25	-
ESA-06	0.46 ± 0.04	0.51 ± 0.04	-	1.05 ± 0.19	4200.30 ± 420.03	-
ESA-07	0.60 ± 0.07	0.51 ± 0.07	-	1.33 ± 0.17	2770.75 ± 277.08	-
ESA-08	0.37 ± 0.03	0.49 ± 0.04	-	0.99 ± 0.17	4950.11 ± 485.01	-
ESA-09	0.50 ± 0.05	0.58 ± 0.05	-	1.04 ± 0.17	5904.41 ± 590.44	-

END

Variable	**positive DBH growth**	**proportion of growing stems**	**leaf area index**	**Stem CO_2 efflux**	**stem surface area**	**live herbaceous biomass**
Units	cm $year^{-1}$	-	m^2m^{-2}	µmol m^{-2} s^{-1}	m^2 ha^{-1}	g m^{-2}
Period	Jan 2023 - Dec 2023	Jan 2023 - Dec 2023	Dec 2022 - Nov 2023	Jan 2023 - Dec 2023	Sep 2023	Oct 2023
ESA-04	0.39 ± 0.03	0.56 ± 0.08	1.83 ± 0.09	1.40 ± 0.17	7648.15 ± 764.82	6.43 ± 1.69
ESA-05	0.53 ± 0.08	0.51 ± 0.08	0.45 ± 0.10	0.96 ± 0.17	2128.08 ± 212.81	28.04 ± 7.30
ESA-06	0.33 ± 0.03	0.51 ± 0.04	1.48 ± 0.09	0.82 ± 0.18	5020.68 ± 502.07	21.73 ± 5.66
ESA-07	0.47 ± 0.07	0.52 ± 0.07	0.17 ± 0.09	1.22 ± 0.17	1761.10 ± 176.11	98.11 ± 25.47
ESA-08	0.33 ± 0.03	0.52 ± 0.04	1.97 ± 0.09	0.81 ± 0.17	6133.49 ± 613.35	10.09 ± 2.64
ESA-09	0.50 ± 0.06	0.50 ± 0.06	0.82 ± 0.09	1.01 ± 0.17	5370.34 ± 537.03	14.12 ± 3.69

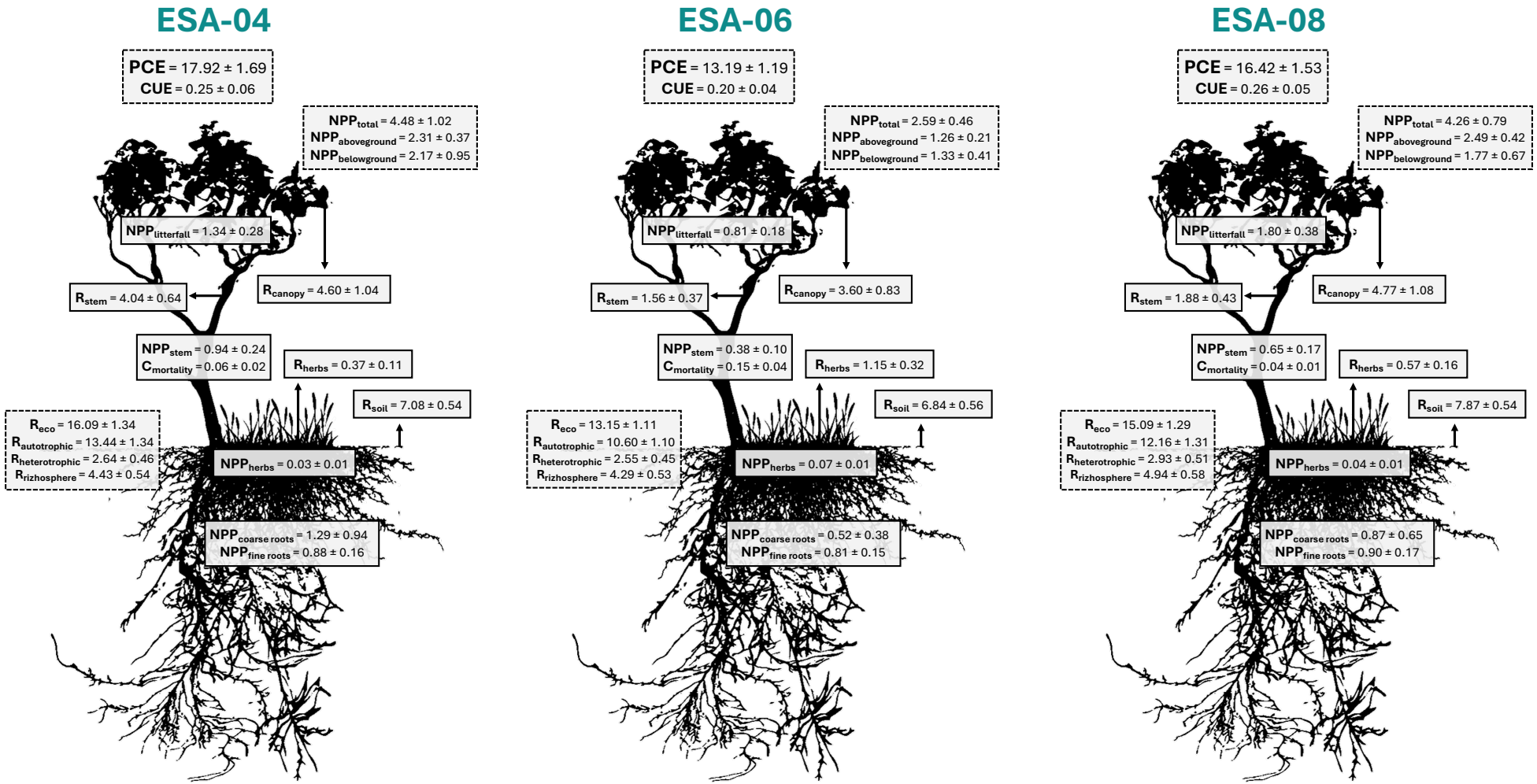

Fig. S2, main carbon fluxes (MgC ha^{-1} $year^{-1}$) within the unburnt fire regime at the Estação Ecológica da Serra das Araras, separated by plot. Fluxes were estimated approximately six years into the experimental fire regimes. Where flux estimates were derived from statistical models, plot was used as fixed effect instead of regime.

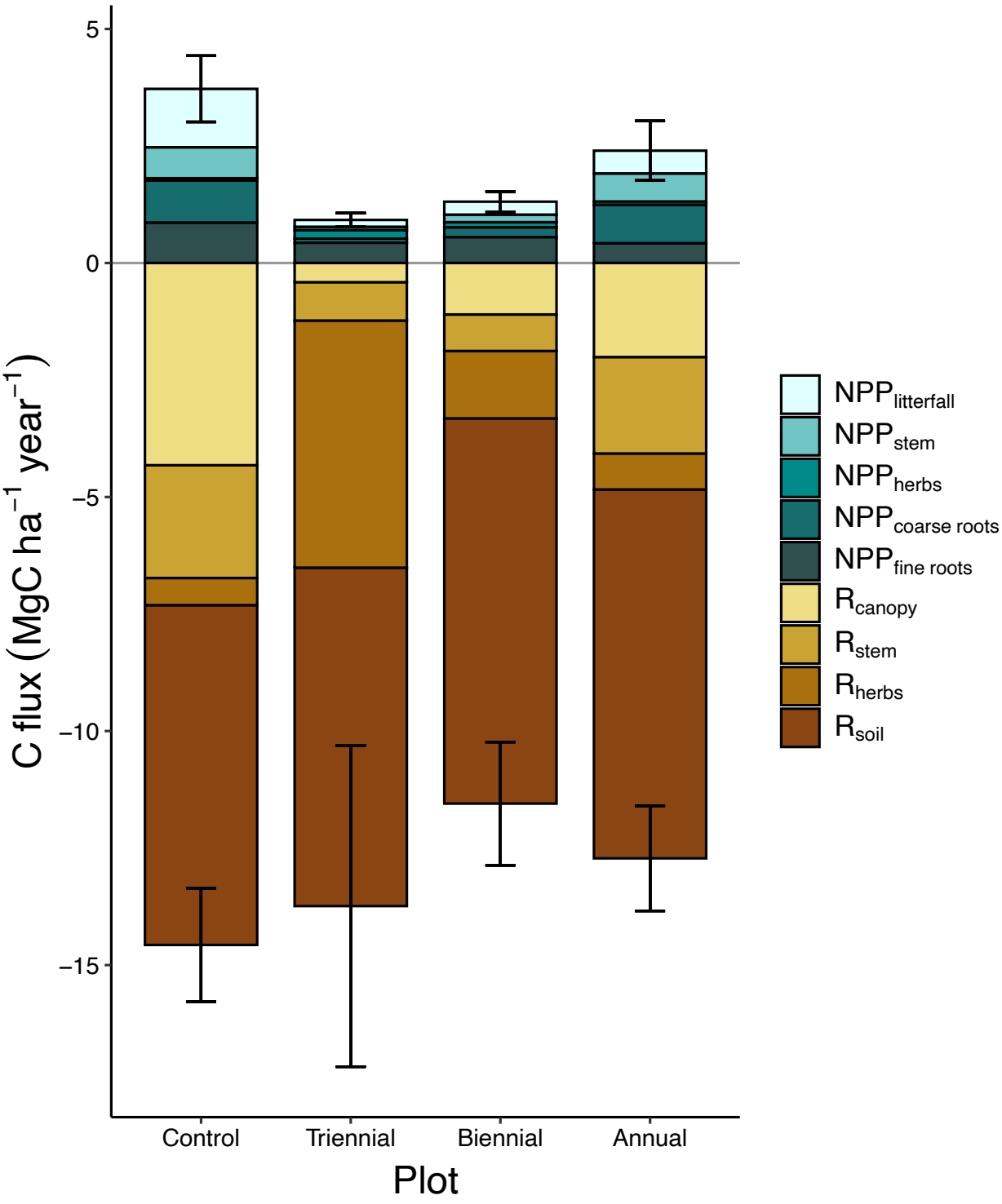

Fig. S3, graphical representation of the main carbon fluxes estimated within the experimental fire regimes at the Estação Ecológica da Serra das Araras (see Table S20). Positive fluxes represent components of net primary productivity (**NPP**), and negative fluxes represent components of ecosystem respiration ($\mathbf{R_{eco}}$).

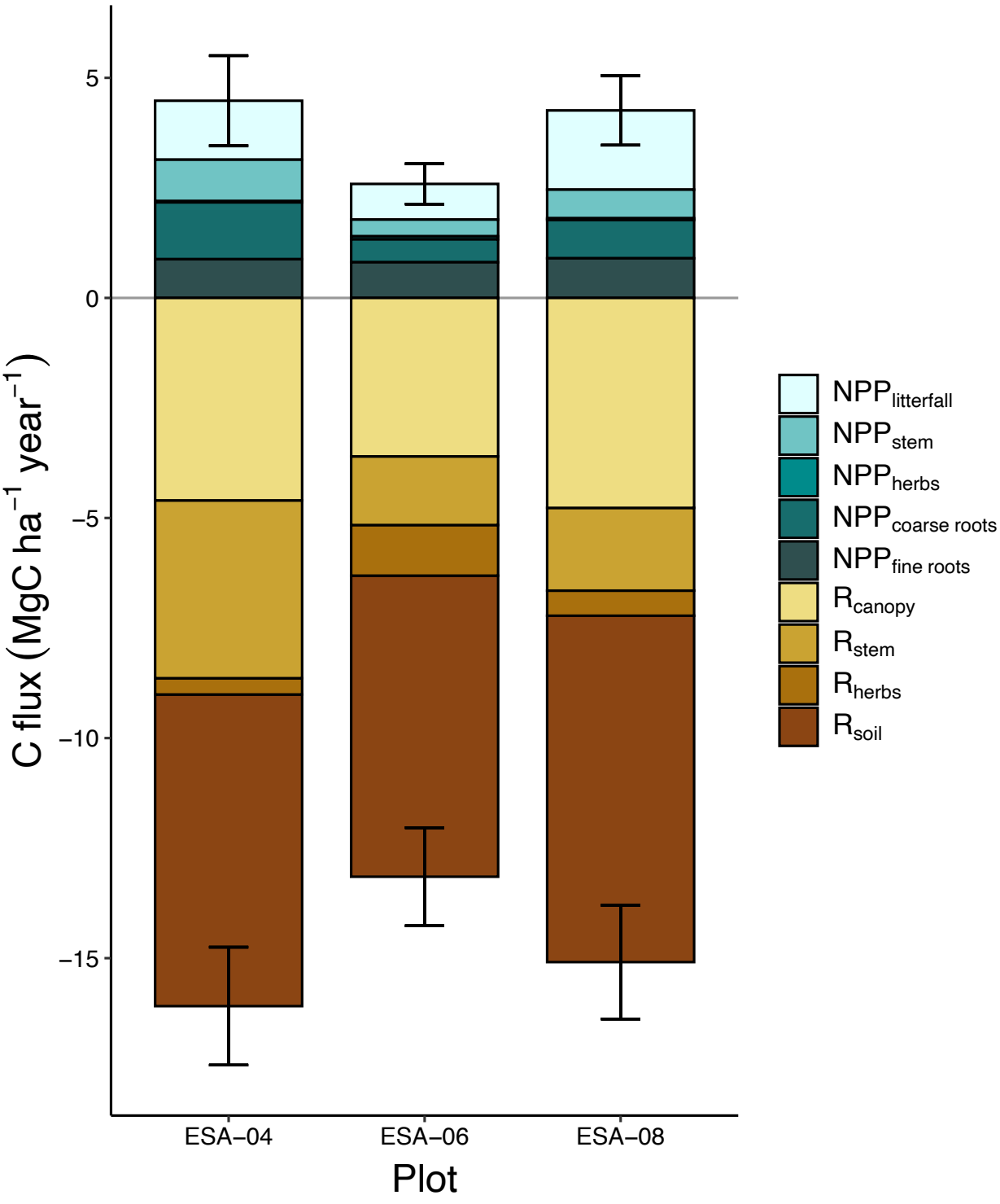

Fig. S4, graphical representation of the main carbon fluxes within the unburnt fire regime at the Estação Ecológica da Serra das Araras, separated by plot (see Table S21). Positive fluxes represent components of net primary productivity (**NPP**), and negative fluxes represent components of ecosystem respiration ($\mathbf{R_{eco}}$).

V. References

Berg, S., Kutra, D., Kroeger, T., Straehle, C. N., Kausler, B.X., Haubold, C., ... & Kreshuk, A. (2019). Ilastik: interactive machine learning for (bio) image analysis. *Nature methods*, *16*(12), 1226-1232.

Hoffmann, W.A., Da Silva, E.R., Machado, G.C., Bucci, S.J., Scholz, F.G., Goldstein, G. & Meinzer, F.C. (2005). Seasonal leaf dynamics across a tree density gradient in a Brazilian savanna. *Oecologia*, *145*, 306-315.

Rezende, A.V., Vale, A.D., Sanquetta, C.R., Figueiredo Filho, A. & Felfili, J.M. (2006). Comparação de modelos matemáticos para estimativa do volume, biomassa e estoque de carbono da vegetação lenhosa de um cerrado sensu stricto em Brasília, DF. *Scientia Forestalis*, *71*(2), 65-73.

Weiss, M. & Baret, F. (2017). CAN_EYE V6. 4.91 user manual.

Zuur, A.F., Ieno, E.N., Walker, N.J., Saveliev, A.A. & Smith, G.M. (2009). *Mixed effects models and extensions in ecology with R* (Vol. 574, p. 574). New York: Springer.