Estimating immediate post-fire carbon fluxes using the eddy-covariance technique

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Supplementary material

1. Supplementary Tables S1 to S4

Table S1. Summary of published eddy-covariance studies in woodland areas affected by wildfires

Reference	**Location**	**Climate Köppen–Geiger system**	**Dominant tree species before fire/disturbance**	**Stand observations**	**Measuring period**	**NEE** [g C m^{-2} y^{-1}]*
Present study	Central Portugal	Csb	*Pinus pinaster*	Stand replacing fire in Aug2017	Oct 2017-Oct2018	-290
Sun et al. (2016)	South Australia	Bsk	*Eucalyptus dumosa, E incrassata, E oleosa, E socialis*	1-y after fire May2014-Jul2015	May14	19 g C m^{-2} month^{-1}
					Jun14	16 g C m^{-2} month^{-1}
					Jul14	11 g C m^{-2} month^{-1}
					May15	-18 g C m^{-2} month^{-1}
					Jun15	-13 g C m^{-2} month^{-1}
					Jul15	-12 g C m^{-2} month^{-1}
Dadi et al. (2015)	Cuenca, Spain	Csb	*Pinus nigra*	High severity, stand-replacing fire in July 2009	Jun2011-Feb2013	180
Serrano-Ortiz et al. (2011)	SE Spain	Dsc	*Pinus sylvestris*	Burnt Sept 2005; Salvage logging (SL) vs no intervention (NI)	Jun-Dec 2009	BUR-SL 40 g C m^{-2} per 7-months
						BUR-NI -90 g C m^{-2} per 7-months
Mkhabela et al. (2009)	Saskatchewan, Canada	Dfb	*Pinus banksiana*	BUR 1998	2004 and 2005	20
				BUR 1989		-84
				BUR 1977		+58
				BUR 1929		-20

Dore et al. (2008)	Arizona, USA	Csa	*Pinus ponderosa*	High severity, stand-replacing fire 1996 vs Unburnt	Sep 2005 to Dec 2006	109±6
Amiro (2001)	NW Canada	Dfc	*Pinus banksiana*	Severely burnt in July 1997; Adjacent UNB with 80 years	7-15 Jul 1998	BUR 0.8 g C m^{-2} d^{-1}
				Burnt 1989 and aerially seeded in 1990; Adjacent UNB with 50 years	10-26 Aug1999	BUR = UNB -1.3 g C m^{-2} d^{-1}

*unless other units indicated

Table S2. Summary of published eddy-covariance studies in unburnt *Pinus pinaster Ait.* woodlands

Reference	**Location**	**Climate**	**Dominant tree species**	**Soil**	**Stand establishment**	**Tree age** [y]	**NEP** [g C m^{-2} y^{-1}]*
Berbigier et al. (2001)	Bordeaux, France	Cfb	*Pinus pinaster Ait*	sandy hydromorphic podzol	Planted in 1970	28	575
Kowalski et al. (2003)	Les Landes, France	Cfb	*Pinus pinaster Ait.*	sandy podzol	Clear-felled 50 y old plantation	1	-290
Jarosz et al. (2008)	Bordeaux, France	Cfb	*Pinus pinaster Ait.*	Sandy hydromorphic podzol	Planted in 1970	32	79 total -59 understory 138 tree layer
Moreaux et al. (2011)	Bordeaus, France	Cfb	*Pinus pinaster Ait.*	Sandy podzol	Clear cut 1999; ploughed and fertilized 2001; seeded 2004. A: without intervention B: removal of weed and thinning of trees in 2008/2009	A: 4 B: 5	243 65
Matteucci et al. (2015)	Tuscany, Italy	Csa (study year was atypically dry)	*Pinus pinaster Ait.*	93% sand, 3% silt; 4% clay. 43.8% SOM	Natural regeneration following a wildfire in 1944	64	(May'01-March'02) 21

*unless other units indicated

Table S3. Summary of the floristic composition on 10 September 2018 as determined by vegetation relevees at the 5 points along the transect in the targeted footprint area

Higher plant species	Average and standard deviation of projected ground cover (%)
Cistus psilosepalus	23 ± 18
Agrostis truncatula	15 ± 0
Cistus ladanifer	14± 10
Eucalyptus globulus	10 ± 0
Halimium ocymoides	7 ± 5
Calluna vulgaris	7 ± 6
Pterospartum tridentatum	7 ± 2
Erica spec.	5 ± 0
Arbutus unedo	5 ± 0
Phyllirea angustifolia	4 ± 4
Pinus pinaster	3 ± 2
Lavandula pedunculata	2 ± 0
Genista triachantos	2 ± 1
Conyza bonariensis	2 ± 1
Anarrhinum bellidifolium	1 ± 0
Pteridium aquilinum	1 ± 0
Jasione montana	1 ± 0
Hakea sericea	1 ± 0

2. Supplementary Figures

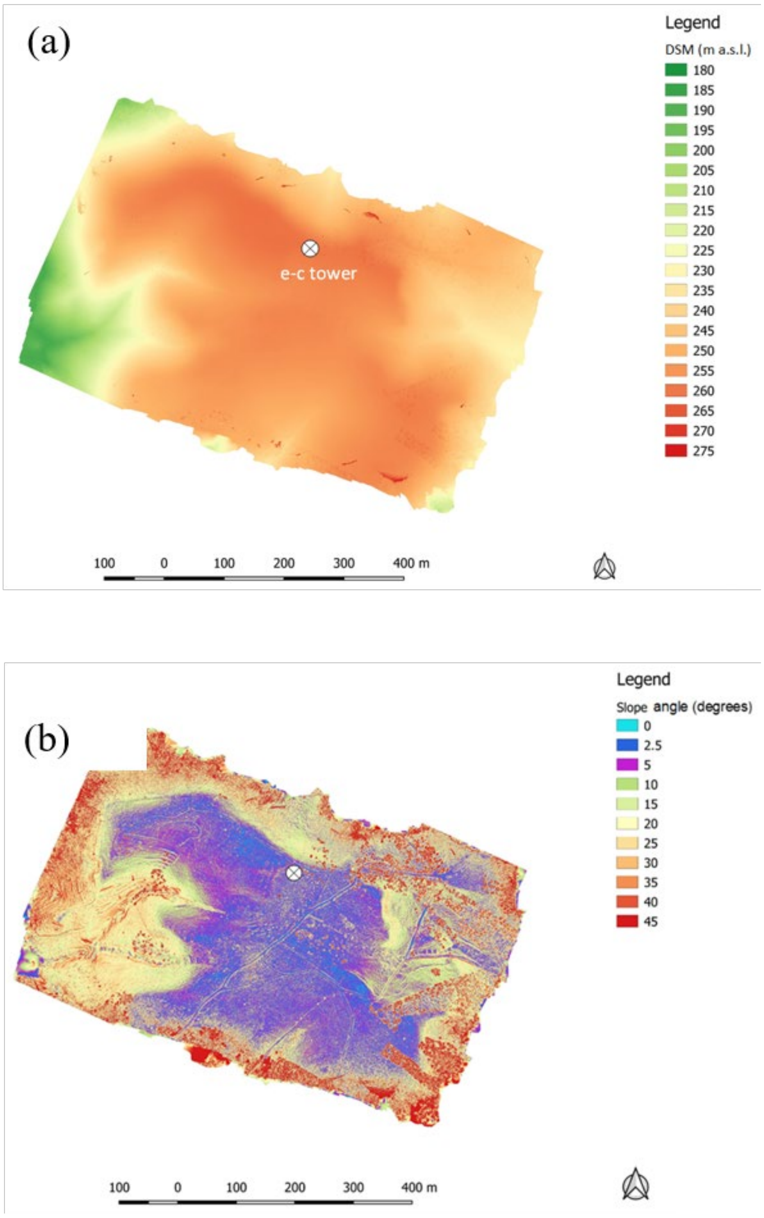

Figure S1. Digital surface model and associated slope angle map derived from aerial photography of the burnt area surrounding the flux tower that was acquired with a RGB camera mounted on a drone (DJI Phantom 3) on 18 July 2017. (tower: circle with cross)

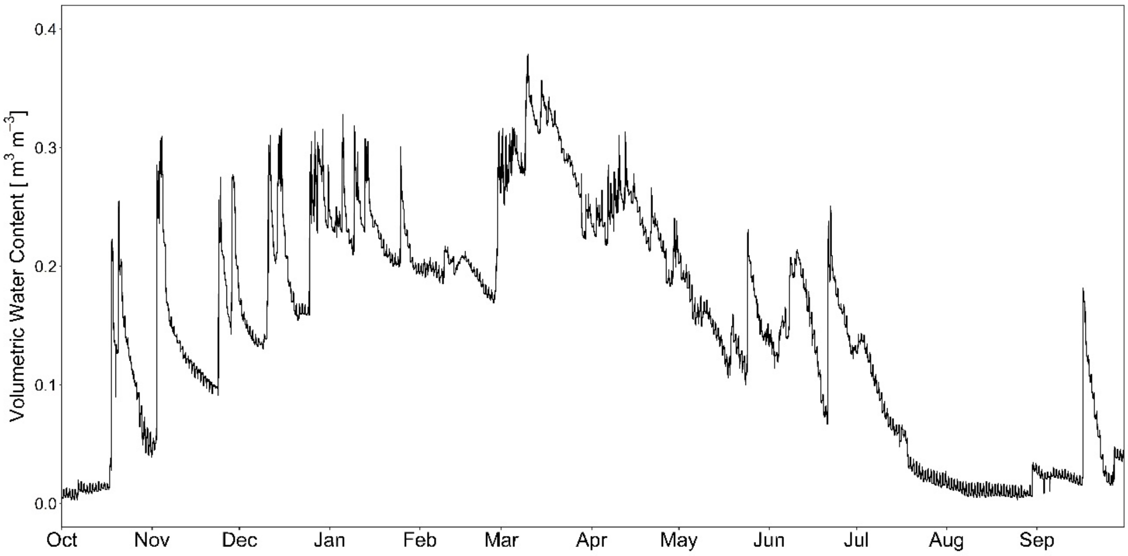

Figure S2. Median 30- minute volumetric soil water content during the 2017/18 hydrological year at 2.5 cm depth at five inter-patches along a transect laid out to the west of the flux tower in the Maritime pine footprint area.

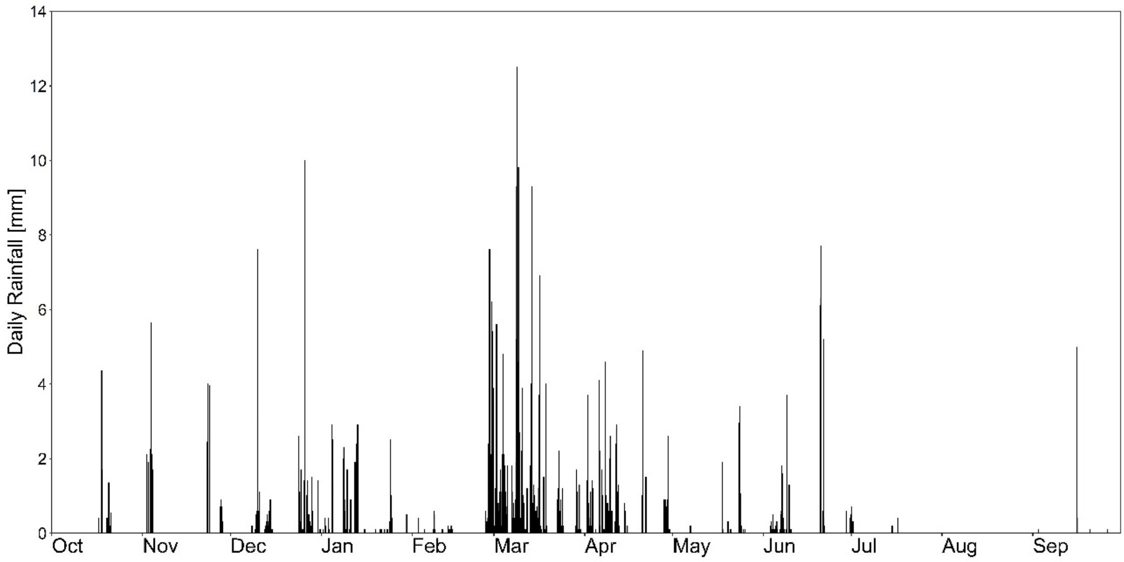

Figure S3: Daily rainfall during the 2017/18 hydrological year as recorded by the automatic gauges installed in the study area.

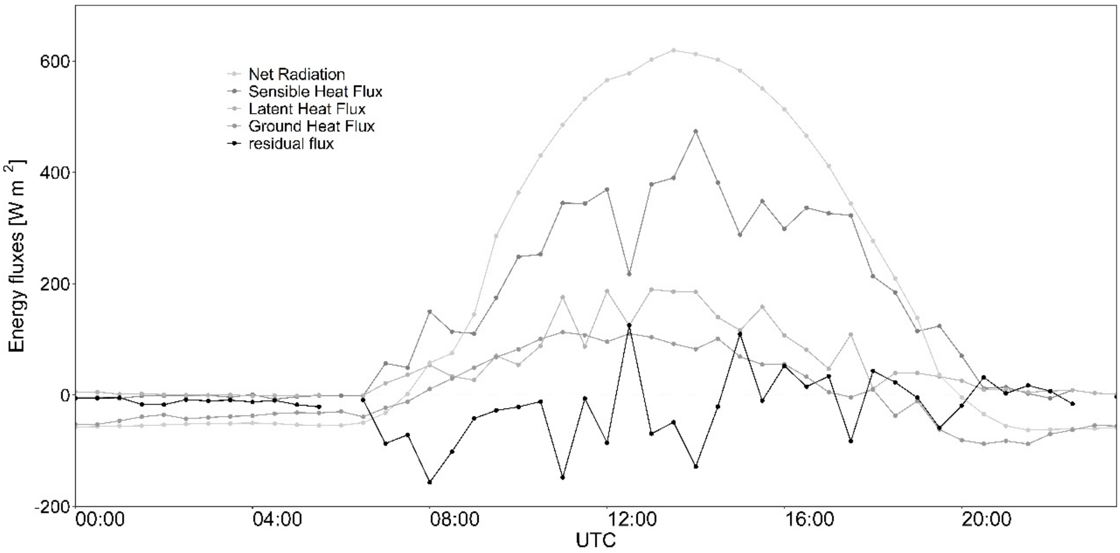

Figure S4. Daily cycle of energy fluxes and their residual on 24 June 2018, when the sky was predominantly clear, except for some high clouds around the local noon at 12:38 UTC. From 08:00 to 19:30 UTC, the footprint consisted for more than 80% of the Maritime pine woodland.

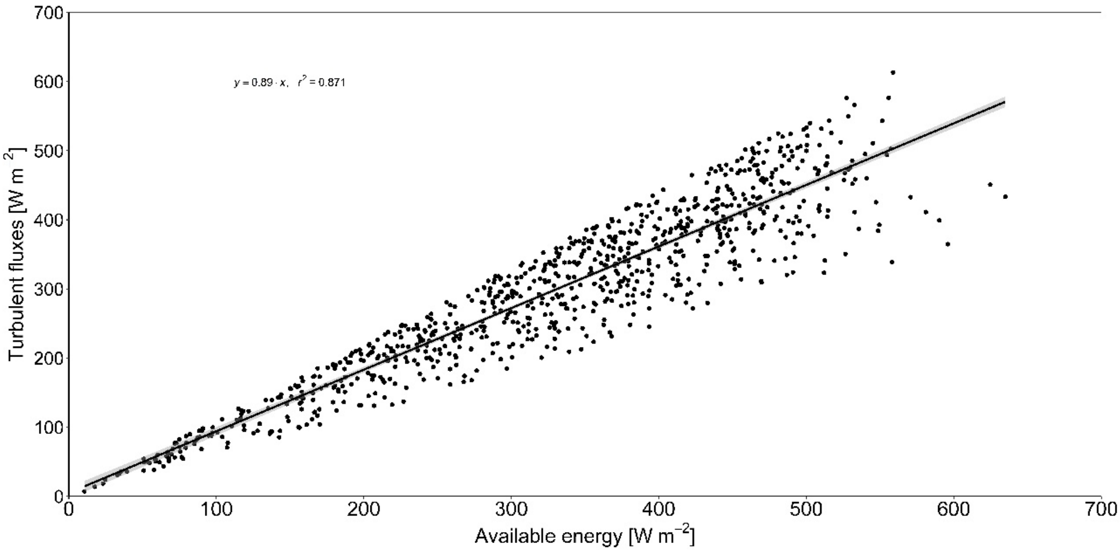

Figure S5. Relationship of turbulent fluxes with available energy for all 30-minute data records that met four conditions: (i) >80% of the footprint area corresponded to the burnt pine woodland; (ii) the quality flags for the turbulent fluxes ranged from 1 to 6; (iii) sensible and latent heat fluxes were larger than the detection limit of 10 W m^{-2}; the ration of latent to sensible heat fluxes passed a MAD-test with q=0.5.

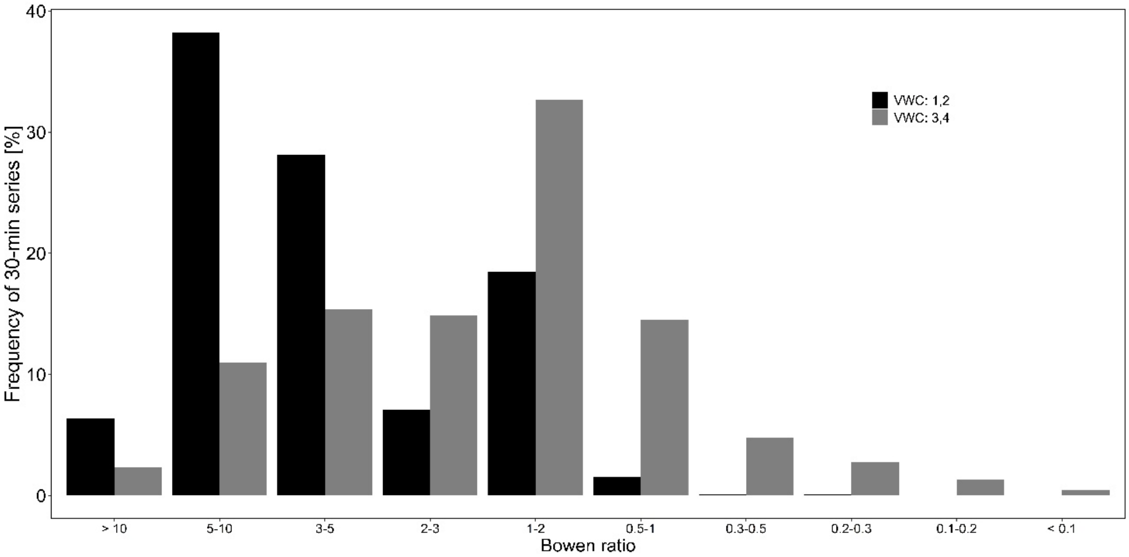

Figure S6. Frequency distribution of the ratio of sensible and latent heat fluxes (Bowen ratio) for two contrasting soil moisture conditions (Volumetric Water Content classes 1 and 2 vs. 3 and 4). The same 30-minute data records as used for Figure S5.

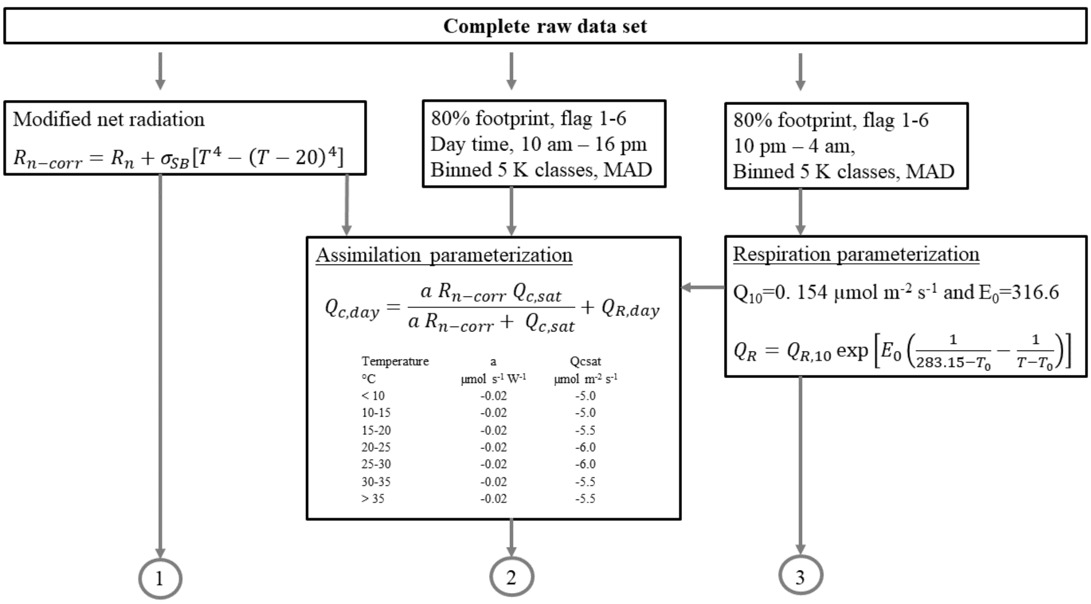

Figure S7. Flow chart of the calculation of the parameters for gap filling of 30-min assimilation and respiration fluxes.

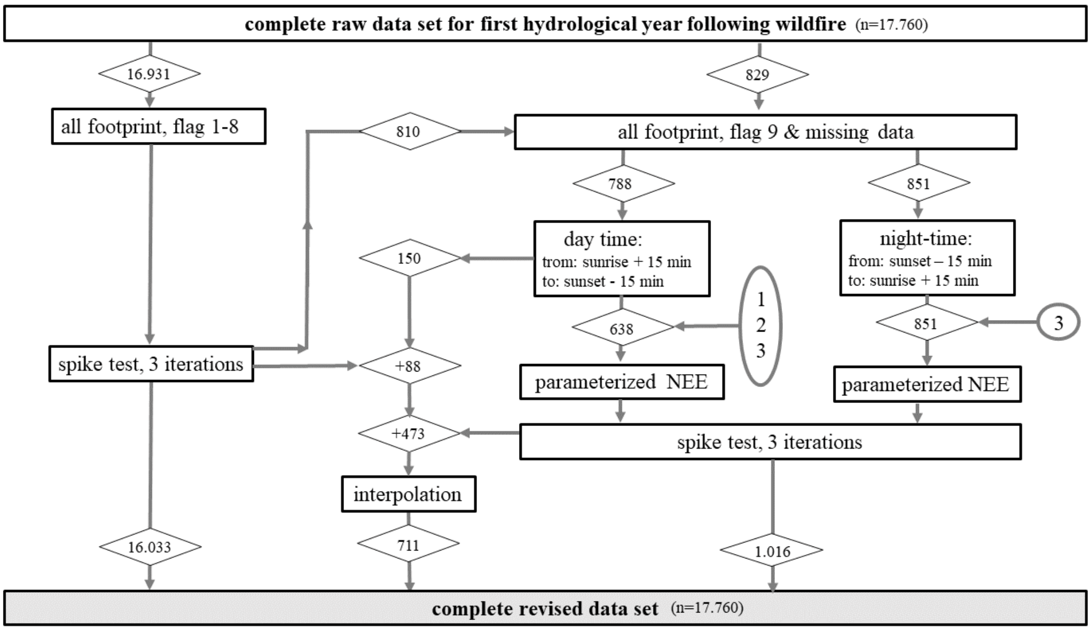

Figure S8. Flow chart of the revision of the raw 30-min data.

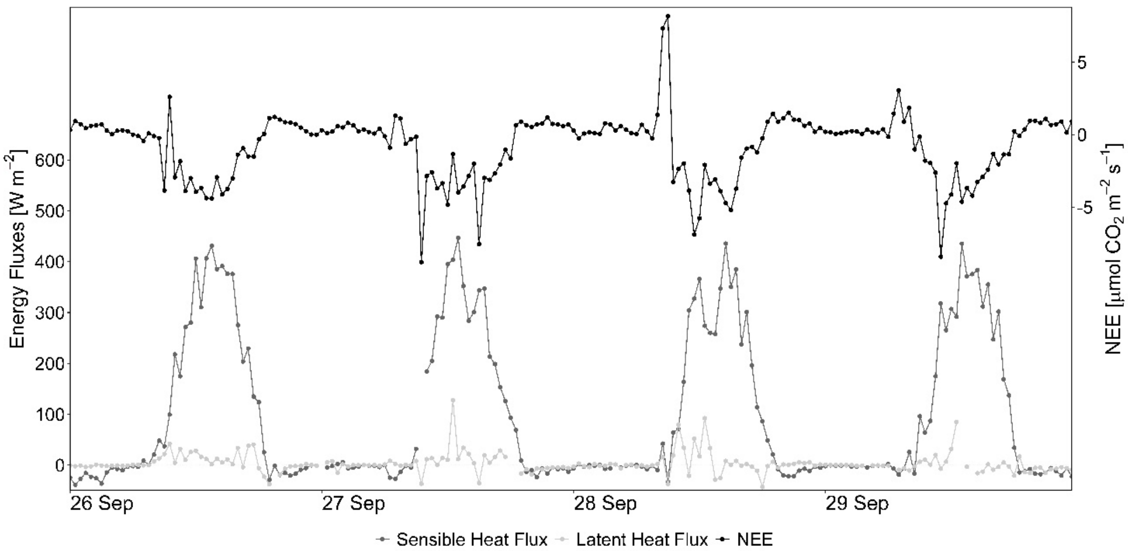

Figure S9. Daily cycles of 30-min sensible and latent heat fluxes and NEE fluxes for the immediate post-fire period from 26 to 29 September 2017. Figure S10 shows the daily cycles of relative humidity together with those of the NEE fluxes.

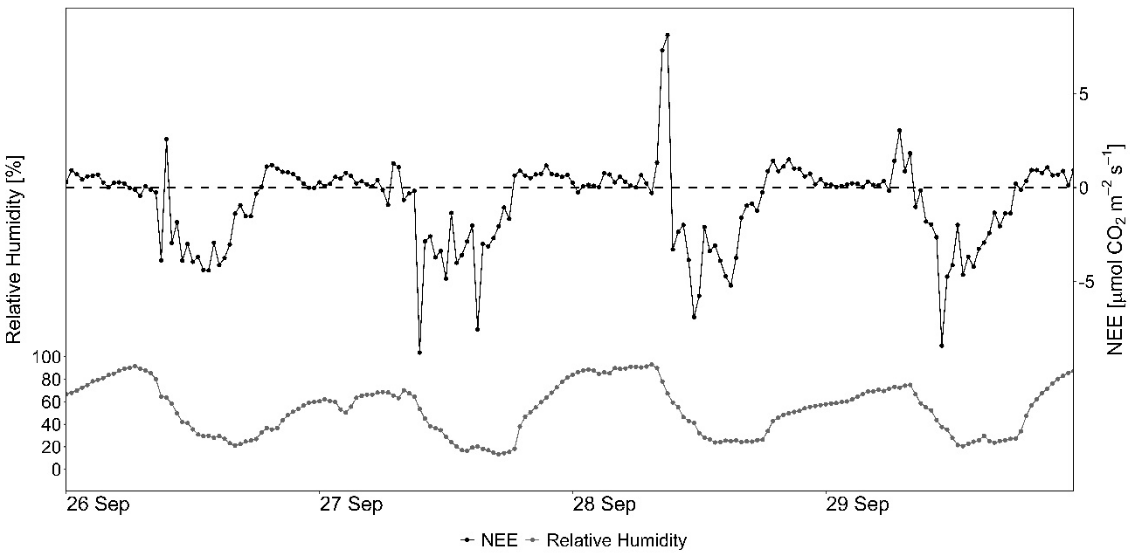

Figure S10. Daily cycles of 30-min relative humidity and NEE fluxes for the immediate post-fire period from 26 to 29 September 2017.

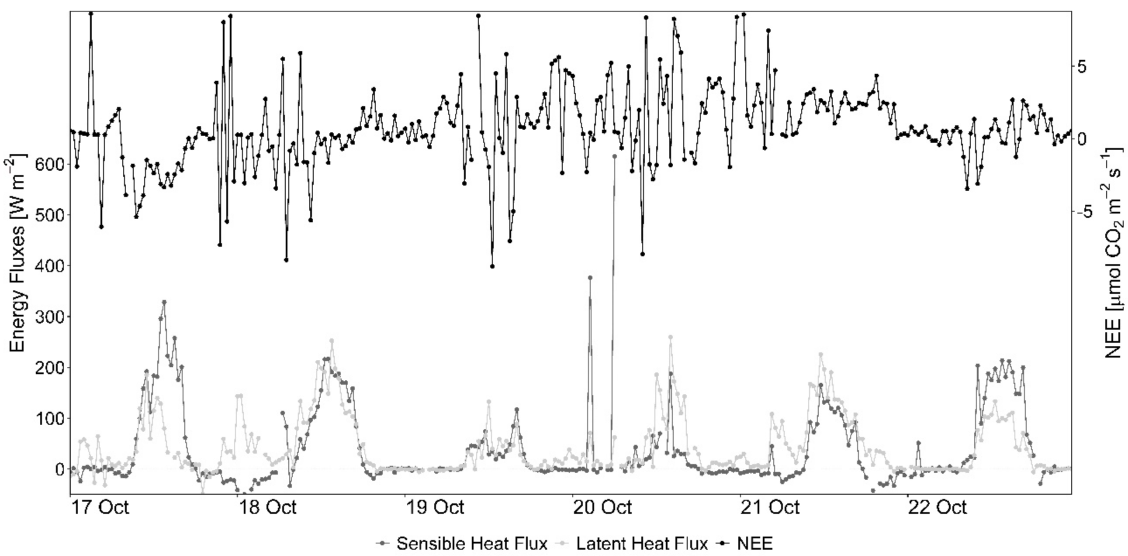

Figure S11. Daily cycles of 30-min sensible and latent heat fluxes and NEE fluxes following the first two significant post-fire rainfall events during the night from 17 to 18 October 2017 and around noon on 20 October 2017.

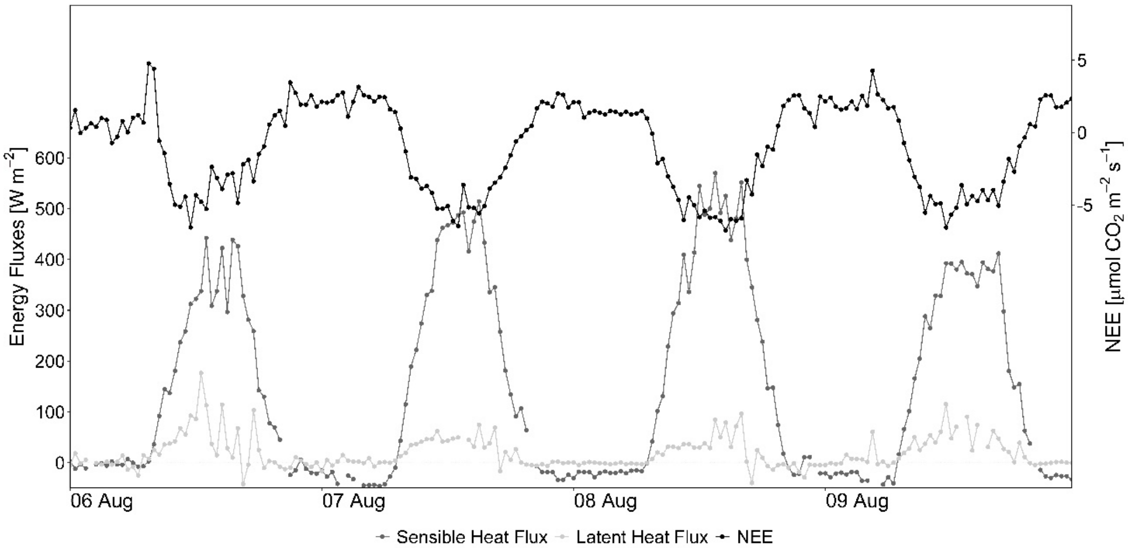

Figure S12. Daily cycles of 30-min sensible and latent heat fluxes and NEE fluxes during mid-summer 2018, from 6 to 9 August, when these fluxes originated from the eucalypt patches.

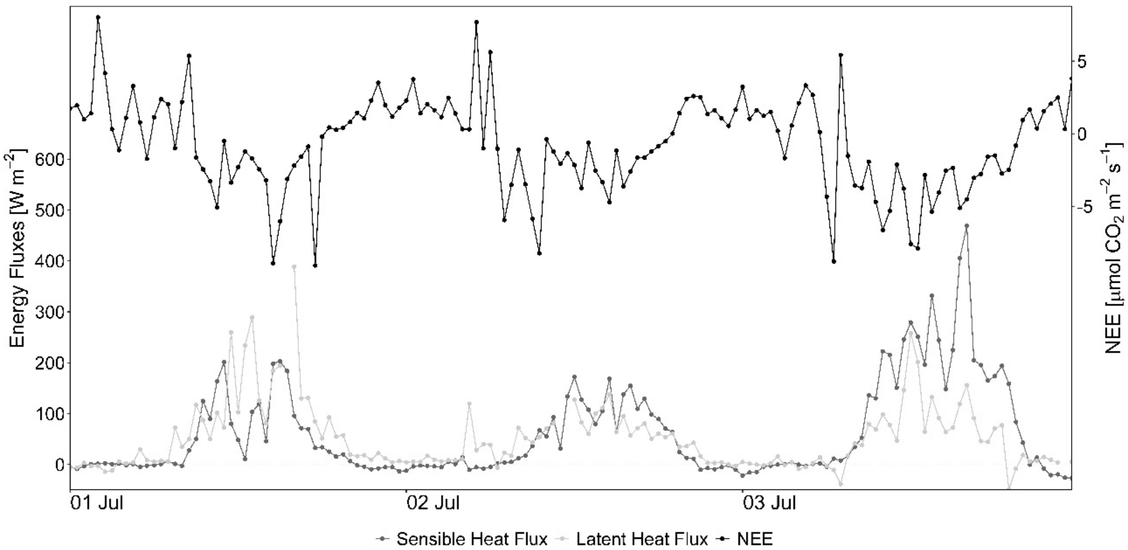

Figure S13. Daily cycles of 30-min sensible and latent heat fluxes and NEE fluxes during early summer 2018, from 1 to 3 July, when these fluxes originated from the Maritime pine woodlands.

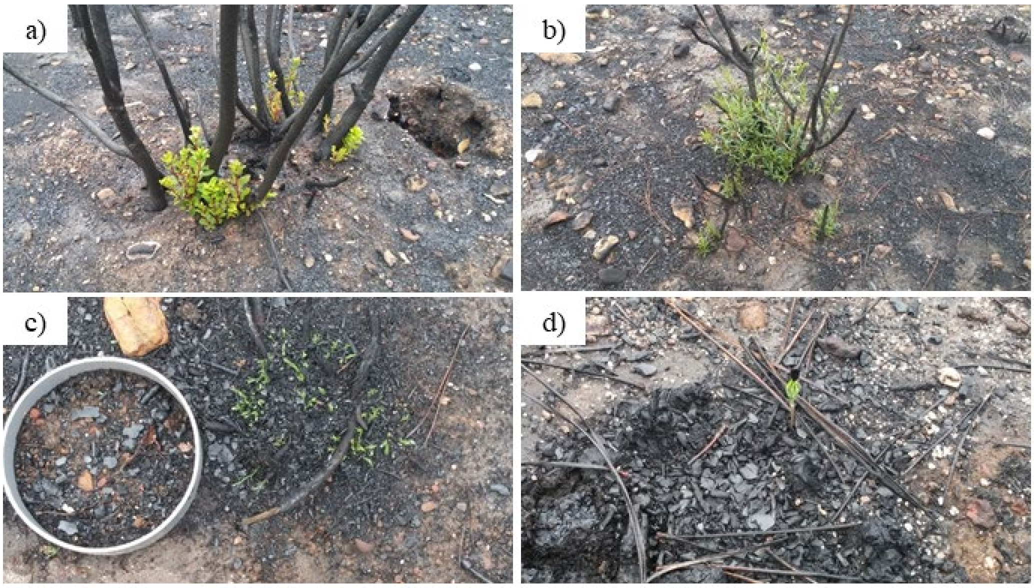

Figure S14. Illustration of post-fire vegetation recovery by 3 January 2018, showing three resprouter shrub species of the understory (a) *Arbutus unedo*; b) *Phillyrea angustifolia*; c) *Pterospartum tridentatum*; and d) Maritime pine seedling. (Pictures by J. Jacob Keizer)

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