

CO₂ fluxes before and after partial deforestation of a spruce forest

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Introduction and aim

- disturbances of forest ecosystems lead to changes in their functional characteristics, e. g., deforestation has a large impact on carbon dioxide (CO₂) exchange between forest ecosystem and the atmosphere: after clear-cutting, a former **forest sink** can become a **source** for CO₂
- measured net CO₂ exchange (NEE) is the balance between carbon fixed by photosynthesis (gross primary production, GPP) and release through ecosystem respiration (R_{eco}) → **NEE = -GPP + R_{eco}**

Our aim: quantifying the magnitude of the initial sink-source strength change of CO₂ and the pace of recovery during the first years after deforestation.

Test site and CO₂ flux measurements

- TERENO research site Wüstebach (50.5°N, 6.3°E, ~610 m a.s.l.):
- annual averaged temperature and precipitation: 8.2 °C, 1160 mm
- Wüstebach catchment: 38.5 ha of a 70-year-old spruce monoculture (*Picea abies* L.)
- 8.6 ha deforested → natural regeneration towards deciduous vegetation
- 1st year after clear-cutting: mainly grasses (*Deschampsia flexuosa* Trin.)
- 2nd year: young trees (mountain ash *Sorbus aucuparia* L.) and shrub vegetation

measurements in forest (since June 2010):

- meteorological tower (37.8 m a.g.l.),
- eddy covariance (EC) station: fluxes of CO₂, H₂O and heat (EC 1)

clearcut (since September 2013):

- second EC station (up to 3.0 m a.g.l., EC 2)
- soil respiration (R_s) measurements with portable soil CO₂ flux chambers at 25 x 3 transect locations (Fig.1)

EC site-years

	forest station	clearcut station
before clearcut	3	-
after clearcut	4	4

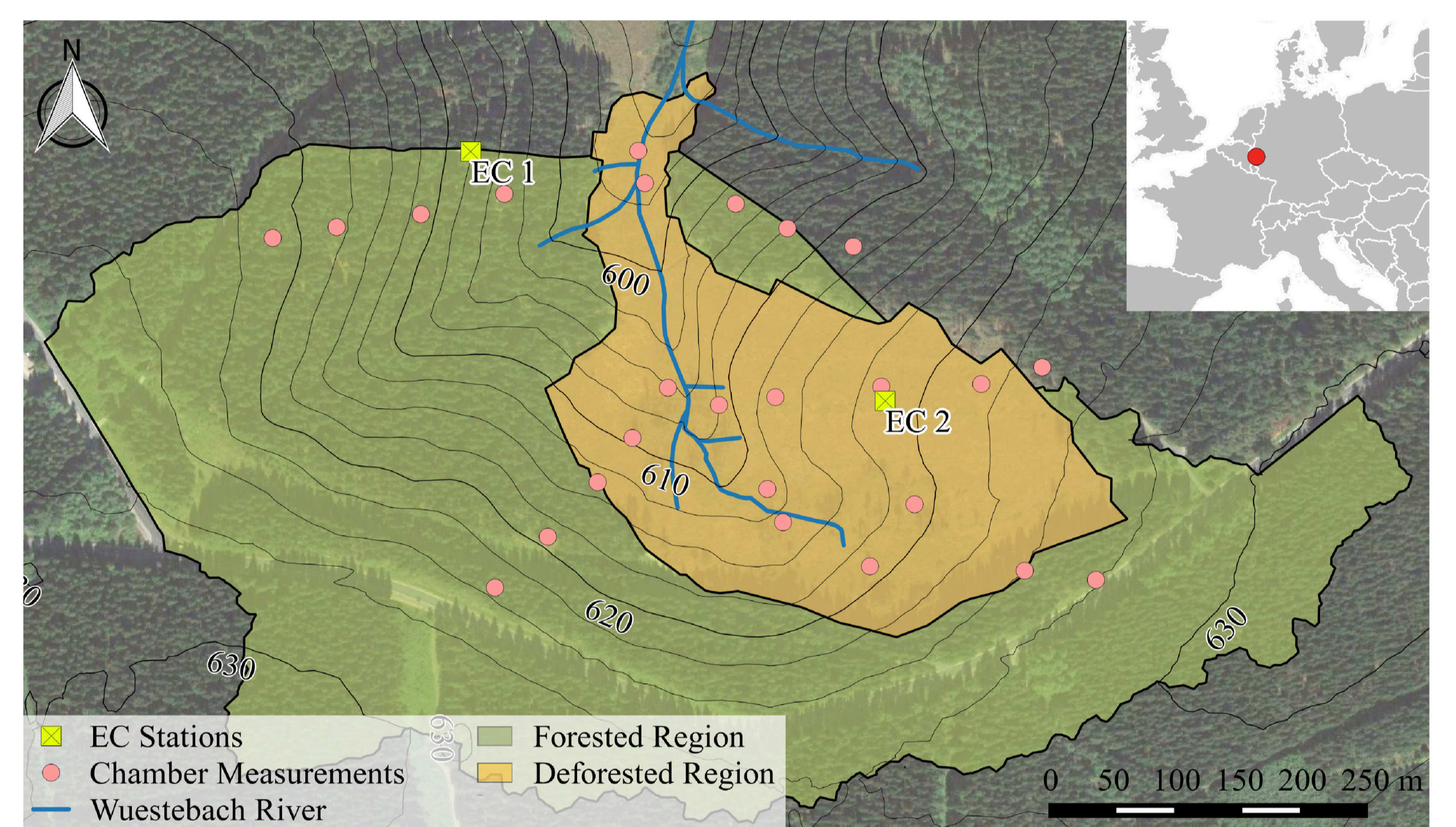


Fig. 1: Map of the Wüstebach catchment with locations of the measurements after partial deforestation in September 2013.

Results

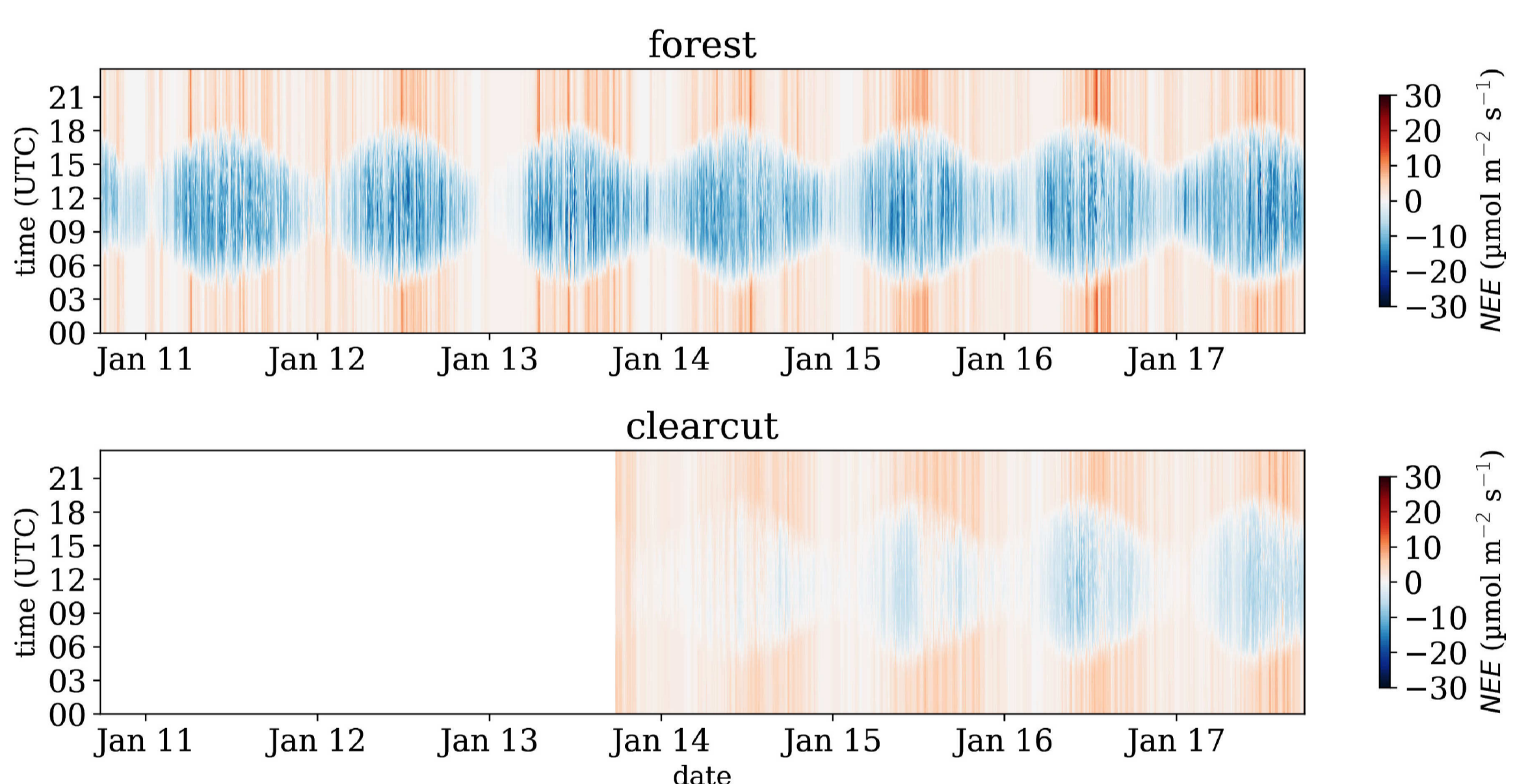


Fig.2: Half-hourly values of NEE (gap-filled after Lasslop, 2010). Positive (red) values indicate a release from the ecosystem to the atmosphere and vice versa. At the forest site, the amplitude between CO₂ uptake (blue, daytime) and release (night) was in general higher than in the deforested area due to higher amount of biomass. The amplitude of NEE in the deforested area increased year by year due to regrowing vegetation.

annual total carbon fluxes forest area

(g C m ⁻²)	y1	y2	y3	y4	y5	y6	y7
NEE	-587	-664	-680	-761	-759	-658	-530
GPP	1515	1622	1569	1738	1816	1738	1760
R _{eco}	928	958	889	997	1057	1080	1230

annual total carbon fluxes deforested area

NEE	-	-	-	521	283	95	83
GPP	-	-	-	385	670	923	892
R _{eco}	-	-	-	906	953	1018	975

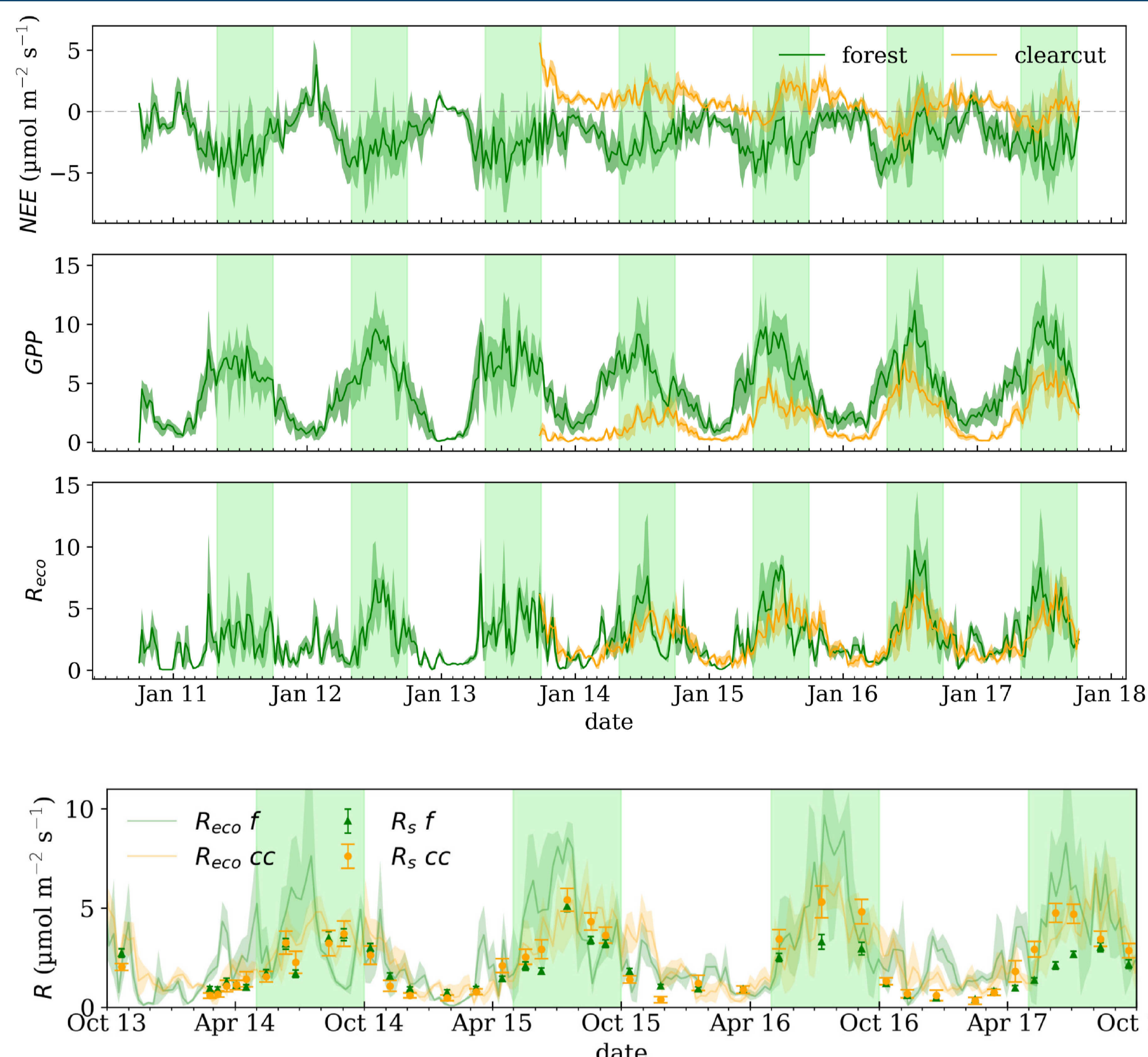


Fig.4: Significant differences in R_s in the last two years, clearcut R_s > forest R_s in the growing season. Contribution of R_s to R_{eco} higher on the clearcut (50%, forest 40%) due to less aboveground biomass.

Fig.3: Forest NEE mostly negative, uptake occurs even in winter due to conifers

Clearcut NEE mostly positive, negative in early growing season from its 2nd year on

Small inter-annual variability in forest GPP and R_{eco}.

Low clearcut GPP due to reduced photosynthetic uptake, tripled in the last year with recovering vegetation.

Clearcut R_{eco} was smaller in the first year, increasing trend over years, currently significantly larger than forest R_{eco}.

Radiative forcing (RF) estimated after Betts (2000), Myhre et al. (1998) and Rotenberg & Yakir (2010): cooling effect of ΔRF_{albedo} overrides warming effect of ΔRF_{NEE} of the increased NEE release. Decreasing albedo due to a higher proportion of woody vegetation will weaken the cooling effect in the future but not completely return to low spruce value, while ΔRF_{NEE} is expected to stop increasing or decrease.

radiative forcing of albedo and CO₂ effect (ΔRF and $\sum Forcing$ in 10⁻¹⁴ W m⁻² global m⁻² treated surface, $\Delta NEE_{f,cc}$ in g C m⁻²)

	y4	y5	y6	y7
albedo _f	0.07	0.07	0.07	0.07
albedo _{cc}	0.16	0.22	0.25	0.21
$\Delta NEE_{f,cc}$	1282	1042	753	613
ΔRF_{albedo}	-2.1	-3.56	-4.19	-3.23
ΔRF_{NEE}	0.4	0.73	0.96	1.16
$\sum Forcing$	-1.7	-2.83	-3.23	-2.08

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Reference

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