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A saturating response of photosynthesis to an increasing leaf area index allows selective harvest of trees without affecting forest productivity

Olivier Bouriaud et al.

Correspondence to: Olivier Bouriaud (obouriaud@usm.ro)

Supplementary material

Table S1. **Eddy covariance fluxes (NEE, GPP and Reco) for managed and unmanaged sites of temperate forests of the Northern Hemisphere.**
Flux errors were estimated using bootstrapping 200 times with different friction velocity values. LAI values were derived from ground measurements when available; otherwise, remote sensing observations were utilized. However, ground measurement of LAI is not standardized across all FLUXNET sites, which may result in their unavailability at some sites or measurements being conducted at varying temporal intervals (typically once per year under optimal conditions). For this data source, and when available, LAI is calculated as the yearly mean over the monitoring period. In case ground measurements are unavailable, LAI is obtained from the MCD15A3H Version 6.1 Moderate Resolution Imaging Spectroradiometer (MODIS) Level 4. This product offers a Leaf Area Index (LAI) dataset, which is a 4-day composite dataset with a 500-meter pixel size. LAIrs were estimations of the LAI obtained from remote-sensing (MODIS) for the same time-range as the fluxes. Since not all sites had such measurements, the LAI values used for the analysis were a mix (LAImix) of both, with priority to the ground measurements.
The description of these sites is provided in table S2. Eddy covariance observation accessed through https://fluxnet.org/. AmeriFlux Available online: data are available at https://ameriflux.lbl.gov/ (accessed on 26 November 2022).

SITE_ID	Monitoring time range	NEE (±SE) (gC m^{-2} y^{-1})	GPP (±SE) (gC m^{-2} y^{-1})	Reco (±SE) (gC m^{-2} y^{-1})	Source for Fluxes	LAIrs ± std (m^2 m^{-2})	LAImix (m^2 m^{-2})	Source for LAI
AU-Cum	2012 - 2014	-216.1 ± 107.1	1352.9 ± 14.7	1093.6 ± 14.3	(Elise Pendall, personal communication)	1.75 ± 0.14	1.75	https://doi.org/10.5067/MODIS/MCD15A3H.061
AU-Wac	2005 - 2008	-1515.6 ± 55.3	1916 ± 14.6	929.1 ± 26.4	(Beringer et al., 2016)	5.15 ± 0.49	5.15	https://doi.org/10.5067/MODIS/MCD15A3H.061
BE-Bra	1999 - 2014	-113.9 ± 18.6	1506.8 ± 3.4	1456.1 ± 5.7	(Luyssaert et al., 2007)	3.68 ± 0.48	1.9	https://doi.org/10.5194/bg-7-199-2010
BE-Vie	1996 - 2014	-500 ± 15.8	1843.4 ± 8.3	1328.7 ± 13.2	(Luyssaert et al., 2007)	3.72 ± 0.62	5.1	https://doi.org/10.1029/2008GB003233
CA-TP1	2003 - 2014	-26.8 ± 69.1	983.1 ± 23.1	922 ± 47	(Jian et al., 2021)	3.65 ± 0.20	0.45	https://doi.org/10.17190/AMF/1246009
CA-TP2	2003 - 2007	-819 ± 64.7	2274.8 ± 9.7	1467.7 ± 19.8	(Jian et al., 2021)	1.79 ± 0.07	12.8	https://doi.org/10.17190/AMF/1246010
CA-TP3	2003 - 2014	-469.1 ± 39.4	1555.3 ± 12.5	1130.4 ± 18.7	(Jian et al., 2021)	4.67 ± 0.08	5.9	https://doi.org/10.17190/AMF/1246011
CA-TP4	2002 - 2014	-91 ± 33.2	1376.2 ± 6.4	1133 ± 12.9	(Jian et al., 2021)	4.06 ± 0.67	8	https://doi.org/10.17190/AMF/1246012
CA-TPD	2012 - 2014	-298.6 ± 31.9	1423.3 ± 8.4	1084.5 ± 12.9	(Beamesderfer et al., 2020)	5.41 ± 0.46	5.41	https://doi.org/10.5067/MODIS/MCD15A3H.061
CH-Lae	2004 - 2014	-708.5 ± 224.2	2016.5 ± 31.3	1593.2 ± 75.9	(Etzold et al., 2011)	5.24 ± 0.55	4.1	https://www.swissfluxnet.ethz.ch/index.php/sites/ch-lae-laegeren/site-info-ch-lae/
CN-Cha	2003 - 2005	-267.6 ± 18.6	1428.3 ± 5.3	1061.3 ± 8.9	(Luyssaert et al., 2007)	4.64 ± 0.38	5.8	https://doi.org/10.1016/j.agrformet.2006.02.003
CN-Din	2003 - 2005	-520 ± 12.6	1600.5 ± 9.1	1288.8 ± 17.8	(Luyssaert et al., 2007)	4.52 ± 0.52	4	https://doi.org/10.1029/2018JG004482
CZ-BK1	2004 - 2014	-837.6 ± 20.6	1959.2 ± 10.2	941.2 ± 18.4	(Luyssaert et al., 2007)	3.6 ± 0.54	3.6	https://doi.org/10.5067/MODIS/MCD15A3H.061
DE-Hai	2000 - 2012	-557.2 ± 23.1	1652.8 ± 6.5	1155.1 ± 10.4	(Luyssaert et al., 2007)	4.78 ± 0.54	5	https://doi.org/10.5067/MODIS/MCD15A3H.061

DE-Lnf	2002 - 2012	-596.2 ± 27.4	1709.1 ± 6.3	1189.1 ± 9.1	(Luyssaert et al., 2007)	4.7 ± 0.54	4.73	https://doi.org/10.1016/S0168-1923(03)00115-1
DK-Sor	1996 - 2014	-209.9 ± 16.6	1977.7 ± 5.3	1766.5 ± 9.3	(Luyssaert et al., 2007)	4.41 ± 0.62	5	https://orbit.dtu.dk/en/publications/field-measurements-of-atmosphere-biosphere-interactions-in-a-dani
FR-Fon	2005 - 2014	-631.4 ± 26	1671.2 ± 6.6	1037.7 ± 10	(Jian et al., 2021)	4.61 ± 0.58	5.1	https://doi.org/10.1111/j.1365-3040.2010.02238.x
IT-La2	2000 - 2002	-1355.3 ± 84.8	2216.7 ± 30.6	1175 ± 34.3	(Luyssaert et al., 2007)	4.15 ± 0.58	4.15	https://doi.org/10.5067/MODIS/MCD15A3H.061
IT-Lav	2003 - 2014	-1843.6 ± 16.1	2458.1 ± 9.1	941.2 ± 15.6	(Luyssaert et al., 2007)	4.15 ± 0.55	8.1	https://pure.uva.nl/ws/files/1651610/139467_contribution_of_nitrogen_deposition_supporting_information1.pdf
IT-PT1	2002 - 2004	-551.1 ± 37	1828 ± 9.2	1354.1 ± 11.3	(Luyssaert et al., 2007)	1.74 ± 0.08	1.74	https://doi.org/10.5067/MODIS/MCD15A3H.061
JP-MBF	2004 - 2005	-420.5 ± 39.9	1067.1 ± 18.5	857.5 ± 21.5	(Toda et al., 2011)	4.22 ± 0.23	2.68	http://asiaflux.net/index.php?page_id=78
NL-Loo	1996 - 2014	-411.9 ± 23.3	1743.4 ± 4.6	1402.5 ± 8.9	(Luyssaert et al., 2007)	3.00 ± 0.68	1.9	https://doi.org/10.1016/S0168-1923(02)00024-2
US-Ha1	1991 - 2012	-211.7 ± 56	1519.9 ± 12.3	1279.5 ± 26.8	Ameriflux	5.23 ± 0.46	5.1	https://doi.org/10.1073/pnas.0810021105
US-MMS	1999 - 2014	-424.2 ± 19.2	1657.1 ± 11.4	1259.9 ± 20.5	(Luyssaert et al., 2007)	5.44 ± 0.47	4.9	https://doi.org/10.1046/j.1365-2486.2003.00624.x
US-Oho	2004 - 2013	-832.5 ± 25.5	1775.6 ± 8.2	1004.3 ± 16.4	Ameriflux	5.22 ± 0.48	4	https://doi.org/10.17190/AMF/1246089
US-PFa	1996 - 2014	-9.4 ± 18.1	912.8 ± 6.4	805.9 ± 9.8	Ameriflux	4.57 ± 0.43	3.74	https://doi.org/10.17190/AMF/1246090
US-Syv	2001 - 2014	-22.4 ± 34.5	1255 ± 11	1048.8 ± 14	(Luyssaert et al., 2007)	4.4 ± 0.45	4.02	https://doi.org/10.17190/AMF/1246106
US-UMB	2000 - 2014	-268.9 ± 10.2	1326.8 ± 3.3	1074 ± 5.7	Ameriflux	5.37 ± 0.45	3.68	https://doi.org/10.17190/AMF/1246107
US-UMd	2007 - 2014	-400.8 ± 14.3	1482.5 ± 5.9	1071.8 ± 8.1	(Luyssaert et al., 2007)	5.43 ± 0.43	3.49	https://doi.org/10.17190/AMF/1246134

Table S2. **Description of the sites equipped with eddy covariance system used for the comparison of managed versus unmanaged fluxes.**

Site ID	Country	Site name	Climate	Forest type	Management
AU-Cum	Australia	Cumberland Plain	Temperate	Evergreen	Unmanaged
AU-Wac	Australia	Wallaby Creek	Temperate	Evergreen	Unmanaged
BE-Bra	Belgium	Brasschaat	Temperate Humid	Mixed	Managed
BE-Vie	Belgium	Vielsalm	Temperate Humid	Mixed	Managed
CA-TP1	Canada	Ontario - Turkey Point 2002 Plantation White Pine	Temperate	Evergreen	Managed
CA-TP2	Canada	Ontario - Turkey Point 1989 Plantation White Pine	Temperate	Evergreen	Managed
CA-TP3	Canada	Ontario - Turkey Point 1974 Plantation White Pine	Temperate	Evergreen	Managed
CA-TP4	Canada	Ontario - Turkey Point 1939 Plantation White Pine	Temperate	Evergreen	Managed
CA-TPD	Canada	Ontario - Turkey Point Mature Deciduous	Temperate	Deciduous	Managed
CH-Lae	Switzerland	Laegern	Temperate	Mixed	Managed
CN-Cha	China	Changbaishan	Temperate	Mixed	Unmanaged
CN-Din	China	Dinghushan	Temperate	Evergreen	Unmanaged
CZ-BK1	Czech	Bily Kriz forest	Temperate	Evergreen	Managed
DE-Hai	Germany	Hainich	Temperate	Deciduous	Unmanaged
DE-Lnf	Germany	Leinefelde	Temperate	Deciduous	Managed
DK-Sor	Denmark	Soroe	Temperate Humid	Deciduous	Managed
FR-Fon	France	Fontainebleau-Barbeau	Temperate	Deciduous	Managed
IT-Col	Italy	Collelongo	Temperate Humid	Deciduous	Unmanaged
IT-La2	Italy	Lavarone2	Temperate Humid	Mixed	Managed
IT-Lav	Italy	Lavarone	Temperate Humid	Mixed	Managed
IT-PT1	Italy	Parco Ticino forest	Temperate Humid	Deciduous	Managed
JP-MBF	Japan	Moshiri Birch Forest Site	Cool Temperate	Deciduous	Unmanaged
NL-Loo	Netherlands	Loobos	Temperate Humid	Evergreen	Managed
US-Ha1	USA	Harvard Forest EMS Tower (HFR1)	Temperate Humid	Deciduous	Unmanaged
US-MMS	USA	Morgan Monroe State Forest	Temperate Humid	Deciduous	Managed
US-Oho	USA	Oak Openings	Temperate Humid	Deciduous	Managed
US-PFa	USA	Park Falls/WLEF	Temperate Humid	Deciduous	Managed
US-Syv	USA	Sylvania Wilderness Area	Temperate Humid	Mixed	Unmanaged
US-UMB	USA	Univ. of Mich. Biological Station	Temperate Humid	Deciduous	Unmanaged
US-UMd	USA	UMBS Disturbance	Temperate Humid	Deciduous	Managed

Table S3. **List of the eddy covariance monitoring sites that underwent selective harvest during the monitoring period.**

The intensity of the intervention is provided, depending on the study, either in terms of a reduction in the number of trees (N, n per ha), or LAI, or biomass.

Site ID	Country	Site name	Year of harvesting / value	Reference
BE-Bra	Belgium	Brasschaat	1999 / N: 30%	https://doi.org/10.1016/j.agrformet.2010.10.012
CA-TP1	Canada	Ontario - Turkey Point 2002 Plantation White Pine	2012 / N: 7%	https://doi.org/10.1016/j.foreco.2017.12.024
CA-TP4	Canada	Ontario - Turkey Point 1939 Plantation White Pine	2012 / N: 33%	https://bg.copernicus.org/preprints/bg-2019-457/bg-2019-457-manuscript-version2.pdf
CA-TPD	Canada	Ontario - Turkey Point Mature Deciduous	1984-86 / between 440 and 39.97 m^3	https://bg.copernicus.org/preprints/bg-2019-457/bg-2019-457-manuscript-version2.pdf
CZ-BK1	Czech	Bily Kriz forest	2005-2006 / N: 30%, LAI: 26%	doi: 10.2478/intag-2014-0013
DE-Lnf	Germany	Leinefelde	2002-2006 / Biomass: 23.1 tC/ha removed from 237 ~ 10%	
DK-Sor	Denmark	Soroe	2013 / N: 10%	https://doi.org/10.1016/j.agrformet.2013.07.012
FR-Fon	France	Fontainebleau-Barbeau	2010-2011 / LAI: 36%	https://doi.org/10.1111/nph.13771
US-UMd	USA	UMBS Disturbance	2008 / LAI: 35%	AmeriFlux FLUXNET-1F US-UMd UMBS Disturbance (Dataset) | OSTI.GOV

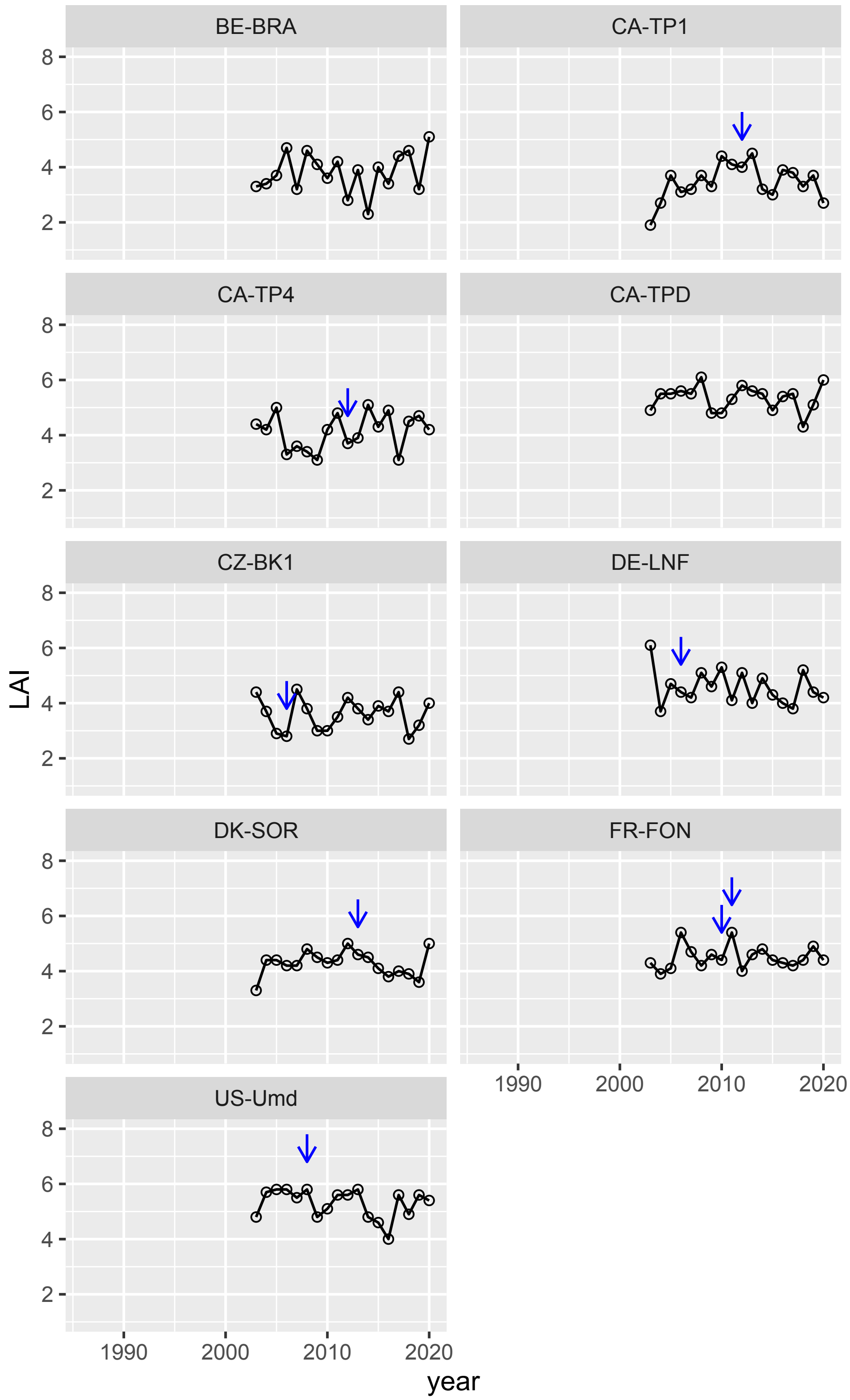

Figure SF1. **Time-dynamic of the Leaf Area Index (LAI, m^2 m^{-2}) over the monitoring sites for which cuttings occurred prior to or during the monitoring period.**

LAI data from MCD15A3H Version 6.1 Moderate Resolution Imaging Spectroradiometer (MODIS) Level 4. Blue arrows indicate the year during which the cuttings occurred.

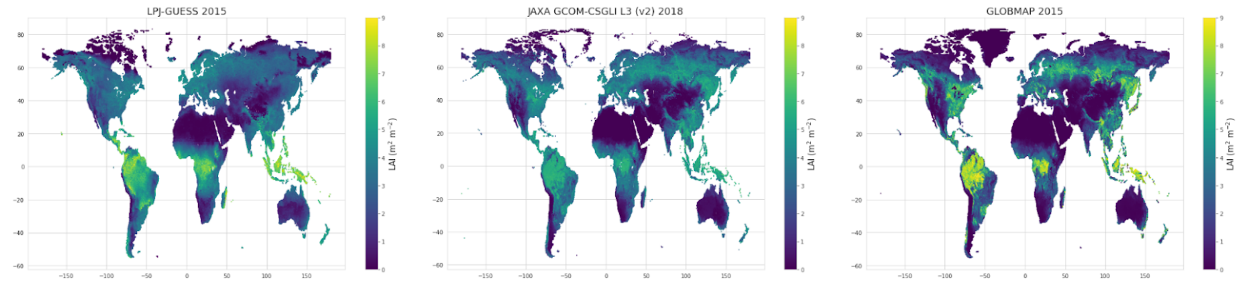

Figure SF2. LAI as estimated by LPJ-GUESS, Jaxa GCOM and GLOBMAP (https://zenodo.org/records/4700264). LAI values are the yearly maximum values, downscaled to 0.5 degrees to match the resolution of the LPJ-GUESS simulation using LPJ-GUESS v.4.1.1 with CRU-NCEP climate input (https://zenodo.org/records/8065737).

Simulated global LAI of LPJ-GUESS was within the range of satellite observations. Compared to GLOBMAP, LPJ-GUESS generally showed lower LAI values throughout the globe. LPJ-GUESS more closely resembled estimations of JAXA GCOM, but had higher values in the tropics.