README_Supplemental_information_for_ClarkClarkOberbauer

GENERAL INFORMATION

1. Title of Dataset:
Supplemental information for the manuscript "Annual tropical-rainforest productivity through two decades: complex responses to climatic factors, [CO2] and storm damage"

2. Author information

A. Principal Investigator, Contact Information

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3. Date of data collection: September 1997 – January 2019

4. Geographic location of data collection:
La Selva Biological Station, N.E. Costa Rica (10°26' N, 84°00' W)

5. Funding sources that supported the data collection:

- U.S. Department of Energy, award: TECO program, 1996-2003
- National Science Foundation, award: NSF DEB 9629245
- National Science Foundation, award: NSF BE/CBC 0421178
- Andrew W. Mellon Foundation: three successive awards, 1996-2004
- National Science Foundation, award: LTREB 0841872
- Conservation International – TEAM Initiative: one award
- National Science Foundation, award: LTREB 1357177
- Personal funds

SHARING/ACCESS INFORMATION

1. Licenses/restrictions placed on the data: None

2. Publications (with links) that cite or use the data:
(publication lists are provided in the prior CARBONO data depositions cited below [section 5])

3. Links to other publicly accessible locations of the data: none to the data provided here.

4. Links/relationships to ancillary data sets:

https://doi.org/10.5061/dryad.fn2z34tst (annual canopy-height distributions in the 18 CARBONO Project plots, 1999-2018)

https://doi.org/10.5061/dryad.d51c5b01q (the original field-sheets with the canopy-height data from the 18 CARBONO Project plots, 1999-2018)

5. Was data derived from another source?

The annual landscape-scale productivity data in this supplement are derived from the 21-year CARBONO data on tree growth and and dynamics and litterfall (prior CARBONO depositions: https://doi.org/10.5061/dryad.51c59zw8n and https://doi.org/10.5061/dryad.dfn2z351r). The annual soil-moisture metrics are based on the 21-yr CARBONO records of biweekly soil-moisture data (prior deposition: https://doi.org/10.5061/dryad.73n5tb2x5). The daily and annual climatic data were based on records from the Organization for Tropical Studies' La Selva met station (https://bixa.tropicalstudies.org/meteoro/detailed_view.php?mPageSize=&pfmin=20210710&pfmax=20210710&est=201&fecha=20210710&_ga=2.204852757.462048018.1625961289-461249506.1625961289, after qa/qc and further calculations by D.A. Clark. Monthly means of Mauna Loa atmospheric CO_2 concentration (http://www.esrl.noaa.gov/gmd/obop/mlo/) were averaged to produce annual averages of [CO_2] for each of the 21 CARBONO measurement-years. The annual data on newly dead trees in the CARBONO plots are based on the annual census data from the 18 CARBONO plots (prior deposition: https://doi.org/10.5061/dryad.51c59zw8n).

6. Recommended citation for this dataset:

Clark, Deborah A., David B. Clark, and S.F. Oberbauer. (2021) Supplemental information for the manuscript "Annual tropical-rainforest productivity through two decades: complex responses to climatic factors, [CO2] and storm damage"

DATA & FILE OVERVIEW

1. File List (6 files):

TableS1annual_environmentClarkClarkOberbauer.csv
(climatic factors and atmospheric [CO_2] for each of the 21 years of the CARBONO Project)

TableS2annualANPPClarkClarkOberbauer.csv
(the four components of landscape-scale field-estimated aboveground productivity [ANPP*] in each of the 21 years of the CARBONO Project)

TableS3daily_met_dataClarkClarkOberbauer.csv
(daily local met data for the analysed climatic factors during the 21 CARBONO years)

TableS4test _modelsClarkClarkOberbauer.xlsx
(the standard set of 66 models used to test for environmental responses of each of the productivity metrics [annual ANPP and its four components])

TableS5annual_deathsClarkClarkOberbauer.xlsx
(number of newly dead trees in the 18 CARBONO plots and associated potential lost growth in each of the 21 measurement-years of the CARBONO study)

README_Supplemental_information_for_ClarkClarkOberbauer.pdf
(this file)

2. Relationship between files:

While the prior data depositions from the CARBONO Project (listed in section 3, below) provide the data underlying the analyses in the manuscript, the four supplemental files in this deposition all contribute additional information useful for understanding those analyses. Tables S1 and S2 contain the annual (CARBONO-year) environmental and landscape-scale productivity data that were analyzed in the paper. The annual productivity metrics were derived from the CARBONO litterfall and tree-growth data in the prior data depositions. Table S3 provides the daily data for the analyzed meteorological factors. TableS4 lists the standardized set of 66 test models that were used to test each of the five productivity metrics for environmental responses. Table S5 provides annual numbers of newly dead trees in the 18 CARBONO plots and the associated potential lost wood production, based on the annual census data of all live stems in the 18 CARBONO plots, which are in the prior data deposition on tree growth and dynamics.

3. Additional related data collected that was not included in the current data package:

(the three below-listed data depositions provide all the productivity- and soil-moisture data underlying the analyses in the manuscript)

Clark, D.A., and D.B. Clark. 2021. Two decades of annual landscape-scale tree growth and dynamics in old-growth tropical rainforest in the CARBONO Project, La Selva Biological Station, 1997-2018. https://doi.org/10.5061/dryad.51c59zw8n

Clark, Deborah A. 2021. Biweekly fine litterfall in the 18 CARBONO Project plots, La Selva Biological Station, October 1997-October 2018. https://doi.org/10.5061/dryad.dfn2z351r

Clark, Deborah A. and Steven F. Oberbauer. 2021. Biweekly soil-moisture in the 18 CARBONO Project plots, La Selva Biological Station, March 1998-October 2018. https://doi.org/10.5061/dryad.73n5tb2x5

4. Are there multiple versions of the dataset? Not of the complete data sets

METHODOLOGICAL INFORMATION

1. Description of methods used for collection/generation of data:

The methods used in the productivity studies are detailed in the prior depositions of CARBONO-Project litterfall and tree data, and the soil-moisture methods are detailed in the prior CARBONO-Project soil-moisture deposition.

The daily local meteorological data are derived from the outputs from the Organization for Tropical Studies' (OTS) meteorological station at the La Selva Biological Station during the 21-year CARBONO Project. The automated system, which has been in operation since April 1992, records 30-min (or hourly in some prior years) data from sensors for air temperature, relative humidity, total radiation (pyranometer), and rainfall (tipping-bucket). OTS also maintains parallel daily manual measurements at the met station from maximum- and minimum-temperature thermometers (calibrated by the Instituto Meteorológico de Costa Rica) and from a pluviometer. The automated met station also logs daily summary data (e.g., maximum temperature, daily rainfall) based on the 24-hr period [7am (prior day) – 7am (current day)], to coincide with the 7am daily manual readings of the pluviometer and max/min thermometers. The daily data in Table S3 were generated by D.A. Clark from the met-station data after extensive qa/qc (screening for missing or anomalous values, then gap-filling by cross-record regressions [e.g., manual vs. automated data]) and after additional calculations as needed for the test metrics (e.g., hourly VPD, hours with $T_{mean} > 28°C$).

2. Methods for processing the data:

The landscape-scale annual productivity metrics were calculated by query in the CARBONO relational database as the across-plot (N=18 plots) averages of each productivity component as measured in each CARBONO measurement-year (1 October, Year 1 – 30 September, Year 2). The yearly plot-level calculations for these metrics are detailed in the respective data depositions cited above.

The daily meteorological data were calculated as described for each metric in the information provided below for the file **TableS3daily_met_dataClarkClarkOberbauer.csv.** The CARBONO-year annual data for the climatic metrics
(**TableS1annual_environmental_conditionsClarkClarkOberbauer.csv)**
were calculated directly from these daily data. Hourly VPD was calculated based on the 30- or 60-min logged averages for temperature and relative humidity. The landscape-scale CARBONO-year soil-moisture metrics were calculated from the biweekly soil-moisture readings in the 18 CARBONO plots as an average across edaphic types (the average of the three edaphic-type cross-plot averages, on dates with good readings from at least four plots in each edaphic type).

3. Instrument- or software-specific information needed to interpret the data: None

4. Standards and calibration information, if appropriate: None

5. Environmental/experimental conditions: None.

6. Describe any quality-assurance procedures performed on the data:

The yearly productivity metrics were cross-checked between different analysis platforms (in Excel vs. in the relational database later developed for these data in ACCESS).

The La Selva meteorological data for the period of the CARBONO Project were screened and gap-filled for missing or anomalous data by D.A. Clark using cross-record (e.g., automated vs. manual) checks and regressions.

The VPD calculations were checked each year by spot checks, using a standard set of sample data, and against a web-based VPD calculator.

7. People involved with sample collection, processing, analysis and/or submission:

D.A. Clark prepared the five included files and this README and submitted the data deposition.

DATA-SPECIFIC INFORMATION FOR:

TableS1annual_environmentClarkClarkOberbauer.csv
1. Number of variables: 18
2. Number of cases/rows: 21
3. Variable list:
Column 1 = **CARBONO_year1** (1997-2017) the first calendar year in each CARBONO measurement-year (1 Oct., Year 1 – 30 Sept., Year 2).
Column 2 = **DailyMeanT** (24.58 – 25.63 °C) annual mean of daily mean air temperature.
Column 3 = **DailyMaximumT** (30.15 – 32.25 °C) annual mean of daily maximum air temperature.
Column 4 = **DailyMinimumT** (21.34 – 22.27 °C) annual mean of daily minimum air temperature.
Column 5 = **DaytimeHoursGT28C** (0.33 – 0.49) annual average of the daily proportion of daytime hours (0600-1800; N=12) when hourly mean temperature was > 28°C.
Column 6 = **Dry-seasonHoursGT28C** (0.31 – 0.51) Jan-Apr. average of the daily proportion of daytime hours (0600-1800; N=12) when hourly mean temperature was > 28°C.
Column 7 = **DailyTsumGT28C** (7.92 – 15.65 °C) annual average of the daily sum of the hourly differences between hourly mean temperature and 28°C for all daytime hours (0600-1800) with mean hourly temperature > 28°C.

Column 8 = **Dry-seasonTsumGT28C** (6.62 – 16.13 °C)) Jan.-Apr. average of the daily sum of the hourly differences between hourly mean temperature and 28°C for all daytime hours (0600-1800) with mean hourly temperature > 28°C.

Column 9 = **DailyRadiation** (10.21 – 15.52 MJ/d) annual mean of daily total radiation (pyranometer).

Column 10 = **Dry-seasonRadiation** (10.86 – 16.55 MJ/d) the dry-season (Jan.-Apr.) average of daily total radiation (pyranometer).

Column 11 = **AnnualRainfall** (3282 – 6550 mm) total 12-mo rainfall.

Column 12 = **Dry-seasonRainfall** (396 – 1431 mm) total rainfall during the 4-mo dry season (Jan.-Apr.).

Column 13 = **AnnualSoil-MoistureDeficit** (-0.50 – 0.00, or blank) The annual deficit is the sum of the 26 biweekly landscape-scale soil-moisture deficits during the year. The upper limit of the lowest decile of all values of landscape-scale soil moisture (volumetric proportion water) was 0.43. For each biweekly sampling, when the landscape-scale soil moisture was < 0.43, the deficit was calculated as ([landscape-scale soil-moisture] – 0.43); when landscape-scale soil moisture was $\geq$ 0.43, the deficit was set to 0.0. Blanks indicate years with significant data gaps due to bad sensors.

Column 14 = **Dry-seasonSoil-MoistureDeficit** (-0.50 – 0.00, or blank) The dry-season deficit is the sum of the 8 latest biweekly landscape-scale soil-moisture deficits during Jan-Apr. The upper limit of the lowest decile of all values of landscape-scale soil moisture (volumetric proportion water) was 0.43. For each biweekly sampling, when the landscape-scale soil moisture was < 0.43, the deficit was calculated as ([landscape-scale soil-moisture] – 0.43); when landscape-scale soil moisture was $\geq$ 0.43, the deficit was set to 0.0. Blanks indicate years with significant data gaps due to bad sensors.

Column 15 = **MinimumSoilMoisture** (0.29-0.47, or blank) lowest biweekly landscape volumetric soil moisture in the CARBONO measurement-year. This is blank for years with significant data gaps due to bad sensors.

Column 16 = **DaytimeHighVPD** (0.17 – 0.49) annual mean of the daily proportion of the daytime hrs (0600-1800) with mean hourly vapor pressure deficit (VPD) > 1 kPa.

Column 17 = **Dry-seasonHighVPD** (0.19 – 0.56) Jan.-Apr. mean of the daily proportion of the daytime hrs (0600-1800) with mean hourly vapor pressure deficit (VPD) > 1 kPa.

Column 18 = **[CO2]** (365.92 – 407.88 ppmv) mean of the 12 monthly means of Mauna Loa atmospheric CO_2 concentration (http://www.esrl.noaa.gov/gmd/obop/mlo/) during each CARBONO measurement-year.

4. Missing data codes: blank
5. Specialized formats or other abbreviations used: none

TableS2annualANPPClarkClarkOberbauer.csv

1. Number of variables: 5
2. Number of cases/rows: 21
3. Variable list:

Column 1 = **CARBONO_year1** (1997-2017) the first calendar year in each 1-yr CARBONO measurement-year (1 Oct., Year1 – 30 Sept., Year 2).

Column 2 = **LeafLitterfall** (5.39 – 7.81 Mg/ha/yr) landscape-scale annual leaf litterfall, calculated as the 18-plot average of plot-level total leaf litterfall (leaves, including petioles) during that CARBONO measurement year.

Column 3 = **TwigLitterfall** (0.51 – 1.03 Mg/ha/yr) landscape-scale annual twig litterfall, calculated as the 18-plot average of plot-level total twig litterfall (twigs < 1 cm diameter) during that CARBONO measurement year.

Column 4 = **ReproLitterfall** (0.81 – 1.65 Mg/ha/yr) landscape-scale annual reproductive litterfall, calculated as the 18-plot average of plot-level total reproductive litterfall (fruits, flowers, seeds, inflorescences, infructescenses) during that CARBONO measurement year.

Column 5 = **WoodProduction** (3.53-4.99 Mg/ha/yr) landscape-scale annual estimated aboveground biomass increment (EABI = "wood production"), calculated as the 18-plot average of plot-level EABI during that CARBONO measurement year, based on the estimated biomass increments over the year by all surviving woody stems of diameter ≥ 10 cm and by all new recruits to that size in each plot.

4. Missing data codes: none
5. Specialized formats or other abbreviations used: none

TableS3daily_met_dataClarkClarkOberbauer.csv

1. Number of variables: 10
2. Number of cases/rows: 7670
3. Variable list:

Column 1 = **CARBONO_year1** (1997-2017) the first calendar year in each 1-yr CARBONO measurement-year (1 Oct., Year 1 – 30 Sept., Year 2).

Column 2 = **Date_of_met** (medium date variable: 01-Oct-97 – 30-Sep-18) the date of the daily meteorological data.

Column 3 = **DailyMeanT** (19.53 – 28.81 °C) mean daily air temperature (°C) from a T/RH sensor, averaged by the automated met station over the 24-hr period [7am (prior day) – 7am (current day)].

Column 4 = **DailyMaximumT** (20.17 – 37.46 °C) maximum daily air temperature (°C) from a T/RH sensor, the maximum logged by the automated met station over the 24-hr period [7am (prior day) – 7am (current day)].

Column 5 = **DailyMinimumT** (15.16 – 24.96 °C) minimum daily air temperature (°C) based on a T/RH sensor, the minimum logged by the automated met station over the 24-hr period [7am (prior day) – 7am (current day)].

Column 6 = **DaytimeNumHoursGT28C** (0 – 12) number of hours in each daytime period (0600-1800) when hourly mean air temperature was > 28°C. Note: this metric divided by 12 gives the daytime proportion when hourly mean air temperature was > 28°C.

Column 7 = **DaytimeTsumGT28C** (0 – 59.99 °C) the daily sum of the hourly differences between hourly mean temperature and 28°C for all daytime hours (0600-1800) with mean hourly temperature > 28°C.

Column 8 = **DailyRainfall** (0.0 – 229.0 mm) total rainfall (mm) over the 24-hr period [7am (prior day) – 7am (current day)], as manually measured from a pluviometer (at 7am).

Column 9 = **DailyRadiation** (0.44 – 27.50 MJ/d) daily total radiation (pyranometer) logged by the automated met station over each 24-hr period [1830, prior day – 1830, current day].

Column 10 = **DaytimeNumHoursHighVPD** (0 – 11) number of hours in each daytime period (0600-1800) when hourly average vapor pressure deficit (VPD) was greater than 1 kPa. Hourly VPD was calculated from the hourly averages of temperature and relative

humidity. Note: this metric divided by 12 gives the daytime proportion when hourly VPD was > 1 kPa.

4. Missing data codes: none
5. Specialized formats or other abbreviations used: none

(end of README)