NPP Tropical Forest: Consistent Worldwide Site Estimates, 1967-1999, R1

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Revision date: October 29, 2013

Summary:

This data set contains documented field measurements of NPP components for 39 old-growth tropical forests distributed worldwide between latitudes 23.58 N and 23.58 S. The data were compiled from published literature and other extant sources. The data are georeferenced to each intensive study site and include above- and below-ground biomass, fine root biomass, litterfall, branchfall, above-ground biomass increment, and herbivory estimates, where available. Other site characteristics are included, such as elevation, forest type and age, soil type, and climate summaries. Key references are provided.

Estimates of above-ground net primary productivity (ANPP) for the 39 sites were made based on the sum of (1) measured or estimated above-ground biomass increment, (2) measured or estimated fine litterfall accumulation, (3) estimated losses to consumers, and (4) estimated biogenic volatile organic compound emissions. Estimates of below-ground NPP were made based on professional judgment that below-ground production is 0.2 x ANPP (lower bounds) or 1.2 x ANPP (upper bounds). TNPP was calculated as the range between the low and high values of ANPP + BNPP. Average BNPP and TNPP estimates were also calculated.

Across the broad spectrum of the tropical forests studied (dry to wet, lowland to montane, nutrient-rich to nutrient-poor soils), the estimates of total NPP range from 3.4 to 34.4 Mg/ha/yr (lower bounds) and from 6.2 to 63.0 Mg/ha/yr (upper bounds).

There is one comma-separated data file (.csv) with this data set.

The ORNL DAAC [http://daac.ornl.gov] NPP Collection for tropical forests contains additional biomass and NPP component estimates and climate data for 28 of the intensive study sites in this data set.

Revision Notes: Only the documentation for this data set has been modified. The data files have been checked for accuracy and are identical to those originally published in 2001.

Additional Documentation:

The NPP data collection contains field measurements of biomass, estimated NPP, and climate data for terrestrial grassland, tropical forest, boreal forest, and tundra sites worldwide. Data were compiled from the published literature for intensively studied and well-documented individual field sites and from a number of previously compiled multi-site, multi-biome data sets of georeferenced NPP estimates. The principal compilation effort (Olson et al., 2001) was sponsored by the NASA Terrestrial Ecology Program. For more information, please visit the NPP web site at http://daac.ornl.gov/NPP/npp_home.html.

Data Citation:

Cite this data set as follows:

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Clark, D.A., S. Brown, D.W. Kicklighter, J.Q. Chambers, J.R. Thomlinson, J. Ni, and E.A. Holland. 2001. NPP Tropical Forest: Consistent Worldwide Site Estimates, 1967-1999. Data set. Available on-line [http://daac.ornl.gov] from the Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Table of Contents:

1. Data Set Overview:

Project: Net Primary Productivity (NPP)

The NPP measurement is the sum of measured and estimated above- and below-ground NPP components based on Clark et al. (2001a). The estimates of above-ground production (ANPP) are the sum of above-ground biomass increment + fine litterfall accumulation + estimated losses to consumers + estimated biogenic volatile organic compound (BVOC) emissions. Estimates of below-ground NPP are based on professional judgment that below-ground production = 0.2 x ANPP (lower bounds) or = 1.2 x ANPP (upper bounds). TNPP was calculated as the range between the low and high values of ANPP + BNPP. Average BNPP and TNPP estimates were also calculated by Clark et al. (2001a).

ANPP, BNPP, and TNPP estimates for these study sites are also reported in Olson et al. (2012a, b) based on Clark et al. (2001a). Some of these values differ from the values presented herein, due mainly to rounding.

This data set was compiled by the U.S. National Center for Ecological Analysis and Synthesis (NCEAS) Working Group on World NPP, Subgroup for Tropical Forests (Sandra Brown, Jeffrey Q. Chambers, Deborah A. Clark, David Kicklighter, Jian Ni, and John R. Thomlinson) based on review of the primary literature. The work was supported by NCEAS, a Center funded by NSF (Grant #DEB-94-21535), the University of California at Santa Barbara, and the State of California.

2. Data Description:

This data set is a synthesis of data in the primary literature on tropical forest NPP. The data file contains annotated field measurements and estimates of above- and below-ground biomass and NPP components for 39 old-growth tropical forests distributed worldwide between 23.58 N and 23.58 S latitude. Site longitudes and latitudes are provided in the data files.

Spatial Coverage

Site: Global (point)

Site Boundaries: (All latitude and longitude given in decimal degrees)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (m)
Global (point)	-180	180	23.58	-23.58	50-2,500

Site Information

The tropical forest locations are distributed worldwide between latitudes 23.58 N and 23.58 S and cover a broad rainfall, temperature, and elevation gradient. The sites are classified as: ‘‘tropical montane forests’’(elevation > 500 m); ‘‘tropical rain forests’’ (elevation < 500 m, annual rainfall > 2,000 mm); and ‘‘tropical seasonal forests’’ (elevation < 500 m, annual rainfall 2,000 mm).

The study sites are restricted to mature forest stands (i.e., no woodlands or savannas). All of the forests are considered "old growth" in structural/functional terms (sensu Clark, 1996). They include sites that are described in the NPP literature with terms such as ‘‘primary’’ or ‘‘virgin’’ as well as sites that the investigators were personally familiar with and judged to be at the old-growth end of the structure continuum [e.g., with a high basal area, wide range of tree diameters, large lianas, and a small-gap disturbance cycle (Clark, 1996)]. The investigators eliminated forests aged < 100 yr as well as a few specialized forest types (mangroves and dune forests). The investigators further restricted the sites to those for which there was estimates of above-ground biomass and at least one component of NPP, measured over at least a full year, and with the biomass and NPP components measured contemporaneously. Thirty-nine sites met these criteria.

Spatial Resolution

The area of the measured biomass plots was small. In 32 of the 39 studies, the total plot area assessed was < 1 ha (median = 0.25 ha). In a few studies (9 of 39) above-ground biomass estimates for a site were based on locally harvested plots; in six of these cases the plots were extremely small (0.04–0.16 ha).

Litterfall was collected from at least six litter traps sampled at least monthly through a full year. The size of the litterfall traps ranged from 0.2 m^2 to 2.0 m^2.

Leaf herbivory was quantified at only five sites based on tagged leaf studies or caterpillar frass in litter traps.

Below-ground biomass estimates are based on root biomass from cores or soil pits, roots from felled trees, and/or allometry. Only one direct measurement of fine root biomass is provided.

Temporal Coverage

Field measurements were made between 1967 and 1999.

Temporal Resolution

Above- and below-ground biomass estimates were derived from vegetation inventory, local harvest, harvest at another plot, and/or allometry, usually from one study carried out over the coarse of a year or more. Litterfall was sampled at least monthly through a full year. To measure leaf herbivory, lagged leaves were monitored monthly over 3-month or one-year periods. In one study, herbivory was estimated from caterpillar frass collected in litter traps. All NPP estimates are based on plant dry matter accumulation, expressed as Mg/ha/year (dry matter weight).

Data File Information

Table 1. Data files in this data set archive

FILE NAME	TEMPORAL COVERAGE	FILE CONTENTS
tropfornpp.csv	1967/01/01-1999/12/31	Annotated estimates of above- and below-ground biomass, biomass increment, litterfall, and herbivory, and ancillary information for 39 tropical forest sites

NPP Data. Biomass and NPP component estimates for 39 tropical forest sites are provided in one text file (.csv) (Table 1). Data records begin on row 7. #N/A is used to denote missing values. Biomass values and NPP units are in Mg/ha and Mg/ha/year (dry matter weight), respectively.

Table 2. Column headings in NPP files

Column Heading	Description	Units
Country/site	Location where data were measured	Text
Original Reference	Reference to full citation given in the bibliography in the data file	Text
Aboveground Biomass	Above-ground biomass estimates derived from vegetation inventory, local harvest, harvest at another plot, and/or allometry	Mg/ha
Comments	Annotations regarding above-ground biomass sampling methods	Text
Belowground Biomass	Below-ground biomass estimates based on root biomass from cores or soil pits, roots from felled trees, and/or allometry	Mg/ha
Comments	Annotations regarding below-ground biomass sampling methods	Text
Fine root Biomass	Only one direct measurement of fine root biomass provided	Mg/ha
Comments	Reference and annotation regarding fine root biomass sampling methods	Text
Litterfall	Annual leaf, fruit/flower, and small wood litterfall accumulation	Mg/ha/yr
Comments	Annotations regarding litterfall sampling methods and identification of litterfall components where known	Text
Branchfall	Annual wood litterfall accumulation not included in Litterfall above	Mg/ha/yr
Comments	Annotations regarding branchfall sampling methods and information about branch size where known	Text
Aboveground Biomass Increment	Annual tree growth based on dendrometer (diameter) measurements and/or allometry; in most cases, mortality not included	Mg/ha/yr
Comments	Annotations regarding above-ground biomass increment sampling methods	Text
Herbivory	Annual leaf consumption for five sites based on tagged leaf studies or caterpillar frass in litter traps	Mg/ha/yr
Comments	Annotations regarding herbivory sampling methods	Text

Latitude	Site latitude in decimal degrees (negative number = South latitude)	Numeric
Longitude	Site longitude in decimal degrees (negative number = West longitude)	Numeric
Elevation	Reported elevation of study site	m
Forest Type	Classification of forest type	Text
Forest Age	Age of forest in years or structural terms/classification	Numeric or Text
Soil type	Soil classification, texture class, or other information regarding soil type	Text
Mean Site Temp.	Mean annual air temperature at or near the study site	degrees C
Mean Site Precip.	Mean annual precipitation amount at or near the study site	mm
Plot size	Spatial area in sq m or ha except where not known	Numeric with explanatory text
Additional information	A few additional comments	Text
Notes	A few additional notes	Text

3. Data Application and Derivation:

Information on NPP in tropical forests is needed for the development of realistic global carbon budgets, for projecting how these ecosystems will be affected by climatic and atmospheric changes, and for evaluating eddy covariance measurements of tropical forest carbon flux. However, a review of the database commonly used to address these issues shows that it has serious flaws. For this data set, the investigators synthesized the data in the primary literature on NPP in old-growth tropical forests to produce a consistent data set on NPP for these forests. Studies in this biome have addressed only a few NPP components, all above-ground. Given the limited scope of the direct field measurements, the investigators sought relationships in the existing data that allow estimation of unmeasured aspects of production from those that are more easily assessed.

The NPP measurement presented here is sum of reported and estimated above- and below-ground NPP components. The estimates of above-ground production (ANPP) are the sum of above-ground biomass increment + fine litterfall accumulation + estimated losses to consumers + estimated biogenic volatile organic compound (BVOC) emissions. Estimates of below-ground NPP are based on professional judgment that below-ground production = 0.2 x ANPP (lower bounds) or = 1.2 x ANPP (upper bounds) (Clark et al., 2001a).

4. Quality Assessment:

Currently available data on NPP in tropical forests are limited. Even the best estimates for this biome must be thought of as rough approximations within wide bounds. Nevertheless, this study has provided a basis for evaluating the quality and utility of the data generated by past studies and of the NPP estimates that have been reported in the literature for tropical forests.

Sources of Error

Possible causes for overestimates and underestimates of NPP components are provided in Clark et al. (2001a, b). Some of these caveats include:

- Potential overestimation or unrepresentation of above-ground biomass and increment estimates due to the possible biases of small plot sizes and the influence of large trees.
- Data interpretation is problematic due to incomplete documentation of litterfall collection methods and variation in the types of material collected. Inter-site methodological differences were likely to have affected the relative values for litterfall. Another issue is the high spatial variance in litterfall in any tropical forest; most published litterfall numbers for tropical forests are highly uncertain because of the low number of traps. In addition, the data were uncorrected for precollection decomposition and may be underestimated, particularly the litterfall measured in lowland wet forests. None of the studies reported using special collection methods for the large items, such as large palm leaves.
- None of the 39 studies had adequate data for below-ground NPP components. Coarse root increment and mortality were not estimated by direct measurements, and coarse root biomass was measured at a very few sites. Fine roots were measured in a few sites, but with inadequate methods for estimating either net increment or losses.
- The two relationships that have been used previously for estimating NPP (the Bray-Gorham relationship based on leaf litterfall and the Miami model based on temperature or precipitation) are not valid for the tropical forest biome.

5. Data Acquisition Materials and Methods:

This data set is a synthesis of the data on NPP in tropical forests in the primary literature. It was compiled by the U.S. National Center for Ecological Analysis and Synthesis (NCEAS) Working Group on World NPP, Subgroup for Tropical Forests (Sandra Brown, Jeffrey Q. Chambers, Deborah A. Clark, David Kicklighter, Jian Ni, and John R. Thomlinson). The work was supported by NSF (Grant #DEB-94-21535), the University of California at Santa Barbara, and the State of California.

Given the limited scope of the direct field measurements, the investigators sought relationships in the existing data that allow estimation of unmeasured aspects of production from those that are more easily assessed. They found a predictive relationship between annual litterfall and above-ground biomass increment. For 39 diverse tropical forest sites, the investigators developed consistent, documented estimates of the upper and lower bounds around total NPP to serve as benchmarks for calibrating and validating biogeochemical models with respect to this biome. They developed these estimates based on existing field measurements, current understanding of above-ground consumption and biogenic volatile organic carbon emissions, and their judgment that below-ground production is bounded by the range 0.2–1.2 x ANPP (above-ground NPP) (Clark et al., 2001a, b).

Existing Data Related to Tropical Forest NPP

To synthesize research findings to date, the investigators intensively reviewed the primary literature, evaluating NPP data from > 70 tropical forest sites, including those cited in several past reviews (e.g., Bray and Gorham, 1964; Lugo, 1974; Murphy, 1975; Brown and Lugo, 1982; Raich et al., 1991; Vogt et al., 1996; Esser et al., 1997). They also included some data from recent, unpublished studies. In each case, the investigators evaluated the data and methods presented in the primary sources in light of current understanding of the total set of components of forest NPP and the appropriate methods for measuring them in the field (cf. Clark et al. 2001b). Thirty-nine sites met the investigators' criteria for inclusion in this data set.

Above-ground Biomass

In most studies, above-ground biomass was estimated by measuring the diameter of all woody stems above some minimum size (usually 3–10 cm in diameter) and calculating each stem's biomass based on allometric relations from trees harvested nearby or in previous studies elsewhere. The total plot area assessed was <1 ha (median = 0.25 ha). In a few studies (9 of 39) above-ground biomass estimates for a site were based on locally harvested plots; in six of these cases the plots were extremely small (0.04–0.16 ha).

Above-ground Biomass Increment

This NPP component was assessed at 33 of the 39 sites in a variety of ways, many of which were considered unacceptable for this analysis because of evident methodological problems (see Clark et al., 2001b) or lack of methods documentation. The investigators found 17 studies where above-ground increment was based on measurement of all trees in a plot at two censuses, with biomass estimated from empirical allometric relationships, and where the biomass increment appeared to have been ''accounted'' correctly (cf. Clark et al., 2001b). The total plot area measured in most of these studies, however, was on the order of those used in the above-ground biomass studies. When based on such small plots, biomass increment data are likely to be unrepresentative due to the same problems of plot bias and the influence of big trees that affect tropical forest biomass studies (see Clark et al., 2001b). It is probable that this bias is usually toward higher biomass increment due to an overrepresentation of big trees.

Fine Litterfall

Litterfall data were collected from at least six litter traps per site sampled, monthly through a full year. See Clark et al. (2001a) regarding how they handled woody litterfall data when no size was specified in the literature (i.e., variously called "branches," "wood," or "woody material").

Other Components of ANPP

From this sample of 39 tropical forest sites, there were almost no data on the other above-ground NPP components. Leaf herbivory was quantified at five sites. No measurements of BVOCs, organic leachates, or losses to other aboveground consumers (seed/fruit predators, sap-suckers/nectar-feeders) were reported.

Below-ground NPP Components

Coarse root increment and mortality were not estimated by direct measurements in any of the 39 studies. Coarse root biomass was measured at very few sites. Fine roots were measured in a few sites, but with inadequate methods for estimating either net increment or losses.

Updated Estimates of Tropical Forest NPP

Clark et al. (2001b) provide a detailed discussion on what methods and calculations should not be used to estimate missing NPP values for tropical forests. They concluded that estimated unmeasured components of ANPP for the sites in this data set could be estimated by the following rules:

When data existed either for litterfall or for above-ground biomass increment, they used the logarithmic relationship [$y = 1.13\ln(x) + 0.57$ or its converse] to estimate the missing parameter. This relationship provides a way to estimate above-ground biomass increment, a much more challenging quantity to measure than litterfall. The relatively high r^2 of this relationship (0.69) also increases confidence in the allometric methods used for estimating above-ground biomass increment for the 13 sites tested and indicates consistency in the litterfall data.

For five sites, leaf production losses to herbivory had been estimated on site (0.2–0.8 Mg/ha/yr) based on tracking area loss from marked leaves; for the remaining sites, the investigators estimated these losses as [0.10 x litterfall], on the assumption that litterfall averages ~ 75% leaves, and that there is a 12% herbivory loss from this material. They then estimated total losses to above-ground consumers as 1.2 x leaf herbivory, to account for the additional losses through fruit and seed consumption, phloem-feeding by sap-sucking insects, and nectar-feeding by vertebrates and insects.

Estimates of BVOC emissions were based on the estimates of Guenther et al. (1995): 0.62, 0.30, and 0.42 Mg/ha/yr for tropical rainforests, tropical montane forests, and tropical seasonal forests, respectively.

Given that direct measures of below-ground NPP components are lacking for tropical forests, the investigators judged there was no direct empirical basis for setting bounds on BNPP and therefore estimated a ''confidence interval'' of possible values. The lower limit estimate for BNPP is calculated as 0.2 x estimated ANPP, based on judgment that it is unlikely that the several components of below-ground production sum to < 20% of ANPP. They set the upper bound for BNPP to 1.2 x estimated ANPP.

Total NPP has frequently been estimated by assuming that BNPP equals ANPP (e.g., Esser et al., 1997); however a somewhat higher ceiling was used herein. The BNPP estimates were combined with the estimate of ANPP to generate upper and lower bounds for total NPP for the 39 sites in this data set. See Clark et al. (2001a) for these values.

6. Data Access:

This data set is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Data Archive:

Web Site: http://daac.ornl.gov/

Contact for Data Center Access Information:

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

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