# NPP Grassland: Charleville, Australia, 1973-1974

Get Data

Revision date: October 27, 2014

## Summary:

This data set contains three ASCII files (.txt format). One file provides above- and below-ground biomass, productivity, litterfall, and bioelement data for a native $C_3$ grassland near Charleville (-26.40 S, 146.27 E, Elevation 304 m) in southern Queensland, northeast Australia. The second file provides above- and below-ground biomass and productivity estimates for an introduced $C_4$ grassland near Charleville. The third file contains climate data (precipitation and maximum/minimum temperature) recorded a weather station located at the Charleville Airport for the period 1942-1994.

The NPP studies were carried out over a 12-month period from 1973 to 1974 using harvest techniques with a view to parameterizing a simulation model of primary production and livestock carrying capacity.

Peak above-ground standing crop at the end of the summer season was 122 g/m$^2$ and 154 g/m$^2$ for the native and introduced grasslands, respectively. Maximum below-ground standing crop was markedly different, at 110 g/m$^2$ and 400 g/m$^2$, respectively, suggesting a significant difference in shoot/root allocation. Annual net primary production was estimated as the sum of above-ground peak standing crop (live + dead) and root increment. These values were 182 and 319 g/m$^2$/yr for the native and introduced grasslands, respectively. Additional data on litter production and nutrient dynamics are available for the native grassland site. Data on soil moisture, determined gravimetrically with each biomass harvest, are available in the literature.

**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 1999.

## Additional Documentation

The Net Primary Productivity (NPP) data collection contains field measurements of biomass, estimated NPP, and climate data for terrestrial grassland, tropical forest, temperate 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.

**Cite this data set as follows:**

Christie, E.K. 2014. NPP Grassland: Charleville, Australia, 1973-1974, R1. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA. doi:10.3334/ORNLDAAC/468.

This data set was originally published as:
Christie, E.K. 1999. NPP Grassland: Charleville, Australia, 1973-1974. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

## Table of Contents:

## 1. Data Set Overview:

**Project:** Net Primary Production (NPP)

Above-ground and below-ground productivity of a native $C_3$ grassland and an introduced $C_4$ grassland were studied over a 12-month period from 1973 to 1974 near Charleville in southern Queensland, northeast Australia. Climate data for the Charleville grasslands were available from a weather station located at the Charleville Airport (elevation 306 m) for the period 1942-1994. The study was carried out with a view to parameterizing a simulation model of primary production and livestock carrying capacity.

Measurements of above-ground and below-ground standing crop (live + dead matter) were made every 2 weeks during the growing seasons - otherwise every 4 weeks - by clipping 1-$m^2$ quadrats and sampling 5-cm diameter soil cores to a depth of 40 cm. Shoot and root materials from the native $C_3$ grassland were analyzed for nutrient content. Both sites were mowed to a height of 4 cm at the beginning of the study (November, 1973) to remove senescent material.

The Charleville study sites, each of 0.7 ha, included a native perennial "mulga" grassland dominated by *Thyridolepis mitchelliana* ($C_3$) located within Charleville airport (-26.40 S, 146.27 E), about 1 km south of the town of Charleville, and a sown grassland dominated by *Cenchrus ciliaris* ($C_4$), about 25 km north of the town. Grazed mulga shrublands, containing *Acacia* shrubs together with a grass layer, comprise about 200,000 $km^2$ of south-western Queensland. They are usually associated with red earth soils which are characterized by very low nutrient concentrations and a narrow range of available soil water.

Peak above-ground standing crop at the end of the summer season was 122 $g/m^2$ and 154 $g/m^2$ for the native and the introduced grassland sites, respectively. Maximum below-ground standing crop was markedly different, at 110 $g/m^2$ and 400 $g/m^2$, respectively, suggesting a significant difference in shoot/root allocation. Annual net primary production was estimated as the sum of above-ground peak standing crop (live + dead) and root increment; the values were 182 and 319 $g/m^2$/yr for the native and introduced grass sites, respectively. Productivity data are derived from Christie (1978; 1979) and are also reported in Scurlock and Olson (2013) and Olson et al. (2013a; b). The productivity values reported in Olson et al. (2013a; b) do not agree with the values given here because different calculation and rounding methods were used.

Additional data on litter production and nutrient dynamics are available for the native grassland site. Data on soil moisture, determined gravimetrically with each biomass harvest, are available in the literature.

## 2. Data Description:

### Spatial Coverage

**Site:** Charleville, Queensland, Australia

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

| Site (Region) | Westernmost Longitude | Easternmost Longitude | Northernmost Latitude | Southernmost Latitude | Elevation (m) |
|---|---|---|---|---|---|
| Charleville, Queensland, Australia | 146.27 | 146.27 | -26.40 | -26.40 | 304 |

**Spatial Resolution**

Each study area covered 0.7 ha. Quadrats were 1 $m^2$.

### Temporal Coverage

Biomass measurements were made from 1973/11/30 through 1974/11/01. Climate data are available from 1942/04/01 through 1994/05/31.

**Temporal Resolution**

Measurements of above- and below-ground standing crop were made every 2 weeks during the growing seasons - otherwise every 4 weeks - over a 12 month period. Climate data are expressed as monthly and annual precipitation amounts (mm) and monthly and annual average maximum/minimum temperature (C). Monthly and annual climatic means are provided for the 1942-1994 period.

## Data File Information

Table 1. File names and descriptions

| FILE NAME | TEMPORAL COVERAGE | FILE CONTENTS |
|---|---|---|
| chr1_npp.txt | 1973/11/30-1974/11/01 | NPP data for a native $C_3$ grassland near Charleville in northeast Australia |
| chr2_npp.txt | 1973/11/30-1974/11/01 | NPP data for an introduced $C_4$ grassland near Charleville in northeast Australia |
| chr_cli.txt | 1942/04/01-1994/05/31 | Monthly and annual climate data from weather station near Charleville in northeast Australia |

**NPP Data.** NPP estimates for the Charleville sites are in two files: one for the native grassland and the other for the introduced grassland. The data sets are ASCII files (.txt format). The variable values are delimited by semicolons. The values -9.999 and -999.9 are used to denote missing values. File contents are shown in Tables 2 and 3. NOTE: the organization of these data files differs from that of other NPP data sets.

Table 2. Column headings for native grassland site (**chr1_npp.txt**). The data are for the years 1973-1974.

| PARAMETER | DEFINITION | UNITS | SOURCE / COMMENTS |
|---|---|---|---|
| ANPP | Peak standing above-ground biomass recorded at the end of the summer growing period | $g/m^2/yr$ | p. 778, Christie (1978) |
| BNPP | Annual root growth increment | $g/m^2/yr$ | Table 2, Christie (1978) |
| TNPP | Sum of ANPP + BNPP | $g/m^2/yr$ | by addition |
| N_use_efficiency | Efficiency of nitrogen utilization over the summer growing period | g/g | Table 1, Christie (1979) |
| P_use_efficiency | Efficiency of phosphorus utilization over the summer growing period | g/g | Table 1, Christie (1979) |
| Litterfall | Annual litter production rate | $g/m^2/yr$ | Christie (1979) (calculated from daily rate) |
| Litterfall | Daily litter production rate | $g/m^2/day$ | Figure 5, Christie (1979) (estimated from histogram) |
| AGbio_N | Nitrogen content of the green herbage compartment at the end of summer growth | $g/m^2$ | Table 2, Christie (1979) |
| stdead_N | Nitrogen content of the standing dead compartment at the end of summer growth | | |
| crown_N | Nitrogen content of the stubble (root crown) compartment at the end of summer growth | | |
| litter_N | Nitrogen content of the litter compartment at the end of summer growth | | |
| roots_N | Nitrogen content of the native grassland compartments at the end of summer growth | | |
| Totbio_N | Total nitrogen content of the green herbage compartment at the end of summer growth | | |
| AGbio_P | Phosphorus content of the green herbage compartment at the end of summer growth | | |
| stdead_P | Phosphorus content of the standing dead compartment at the end of summer growth | | |
| crown_P | Phosphorus content of the stubble (root crown) compartment at the end of summer growth | | |
| litter_P | Phosphorus content of the litter compartment at the end of summer growth | | |
| roots_P | Phosphorus content of the root compartment at the end of summer growth | | |
| Totbio_P | Total phosphorus content of the native grassland compartments at the end of summer growth | | |
| AGtotclip | Above-ground standing crop of native vegetation | $g/m^2$ | Figure 4, Christie (1978) |
| BGtotmatter | Below-ground root standing crop of native vegetation | $g/m^2$ | Figure 4, Christie (1978) |

Table 3. Column headings for introduced grassland site (**chr2_npp.txt**). The data are for the years 1973-1974.

| PARAMETER | DEFINITION | UNITS | SOURCE / COMMENTS |
|---|---|---|---|
| ANPP | Peak standing above-ground biomass recorded at the end of the summer growing period | $g/m^2/yr$ | p. 778, Christie (1978) |
| BNPP | Annual root growth increment | $g/m^2/yr$ | Table 2, Christie (1978) |
| TNPP | Sum of ANPP + BNPP | $g/m^2/yr$ | by addition |
| N_use_efficiency | Efficiency of nitrogen utilization over the summer growing period | g/g | Table 1, Christie (1979) |
| P_use_efficiency | Efficiency of phosphorus utilization over the summer growing period | g/g | Table 1, Christie (1979) |
| AGtotclip | Above-ground standing crop of native vegetation | $g/m^2$ | Figure 4, Christie (1978) |
| BGtotmatter | Below-ground root standing crop of introduced vegetation | $g/m^2$ | Figure 4, Christie (1978) |

**Climate Data**. The climate data set is an ASCII file (.txt format). The first 18 lines are metadata; data records begin on line 19. The variable values are delimited by semicolons. The value -999.9 is used to denote missing values.

| COLUMN HEADINGS | DEFINITION |
|---|---|
| Site | Unique 3-character code for each site based on the first three consonants in the site name (e.g., chr for Charleville) |
| Temp (Temporal) | Indicates whether the values in that row are either long-term (i.e, mulit-year) or annual data for the specified parameter.<br><br>For multi-year, the values are:<br>mean=mean values (monthly and annual) calculated for the years of data as noted in the documentation<br>numb=number of years of data included in a reported mean value<br>stdv=standard deviation of a mean value<br><br>Annual data: 19XX=monthly and annual parameter values for the specified year (e.g., 1972) |
| Parm | Parameter, indicates the meteorological data reported in that row.<br>prec-total precipitation for the month or year<br>tmax=maximum temperature for the month or year reported in degrees C<br>tmin=minimum temperature for the month or year reported in degrees C |

**Description of specific Temp and Parm data values:**

Long-term data:

site;mean;prec;
Multi-year mean of total precipitation for each month [Jan, Feb, Mar, …, Dec] and mean of total annual precipitation across all years [Year] (mm)

site;mean;tmax;
Multi-year mean of maximum temperature for each month [Jan, Feb, Mar, …, Dec] and mean of annual maximum temperature across all years [Year] (C)

site;mean;tmin;
Multi-year mean of minimum temperature for each month [Jan, Feb, Mar, …, Dec] and mean of annual minimum temperature across all years [Year] (C)

… site; numb and stdv; repeat for prec, tmax, and tmin;

Annual data:

site;19XX;prec;
Total precipitation for each month [Jan, Feb, Mar,.....Dec] and total precipitation for the year 19XX [Year] (mm)

site;19XX;tmax;
Maximum temperature for each month [Jan, Feb, Mar,.....Dec] and maximum for the year 19XX [Year] (C)

site;19XX;tmin;
Minimum temperature for each month [Jan, Feb, Mar,.....Dec] and minimum for the year 19XX [Year] (C)

… site;19XX;(prec, tmax, and tmin); repeat for reported years.

Annual data missing value note: If a monthly parm value is missing, the parm value for [Year] is also set to missing (-999.9).

**Sample Climate Data Record**

```
Site;Temp;Parm; Jan; Feb; Mar; Apr; May; Jun; Jul; Aug; Sep; Oct; Nov; Dec; Year

chr ;mean;prec; 70.1; 67.7; 61.8; 34.4; 35.3; 20.1; 26.6; 21.2; 21.2; 38.0; 38.3; 53.1; 483.2
chr ;mean;tmax; 34.9; 33.8; 31.8; 27.9; 23.0; 19.7; 19.3; 21.5; 25.6; 29.6; 32.7; 34.8; 36.2
chr ;mean;tmin; 21.5; 21.3; 18.7; 13.8; 8.9; 5.3; 4.0; 5.8; 9.5; 14.2; 17.7; 20.2; 3.4
chr ;numb;prec; 52; 52; 52; 52; 53; 52; 52; 52; 52; 52; 52; 52; 51
chr ;numb;tmax; 50; 50; 50; 51; 51; 51; 51; 51; 51; 51; 51; 50; 49
chr ;numb;tmin; 50; 50; 50; 51; 51; 51; 51; 51; 51; 51; 51; 50; 49
chr ;stdv;prec; 60.1; 58.4; 72.2; 48.0; 40.9; 20.6; 30.7; 22.5; 25.3; 40.2; 39.2; 45.0; 346.5
chr ;stdv;tmax; 2.3; 1.9; 1.6; 1.6; 1.5; 1.5; 1.2; 1.4; 1.5; 1.7; 1.8; 1.6; 1.3
chr ;stdv;tmin; 1.4; 1.5; 1.3; 1.6; 2.0; 1.8; 2.0; 1.8; 1.6; 1.3; 1.5; 1.4; 1.6
chr ;1942;prec; -999.9; -999.9; -999.9; -999.9; 57.4; 24.7; 55.7; 0.5; 4.6; 65.5; 48.8; 219.7; -999.9
chr ;1942;tmax; -999.9; -999.9; -999.9; 28.1; 24.6; 21.4; 19.4; 24.2; 27.0; 28.7; 32.1; 31.5; -999.9
chr ;1942;tmin; -999.9; -999.9; -999.9; 15.7; 12.1; 8.5; 7.2; 7.5; 11.1; 15.1; 17.9; 20.6; -999.9
chr ;1943;prec; 90.7; 12.4; 16.3; 20.8; 13.5; 37.6; 5.1; 36.1; 69.5; 37.4; 59.7; 15.3; 414.4
chr ;1943;tmax; 34.2; 34.2; 34.6; 29.0; 22.8; 18.0; 19.7; 19.4; 24.5; 29.5; 31.1; 35.9; 35.9
chr ;1943;tmin; 20.1; 20.9; 19.6; 14.2; 8.9; 3.5; 3.9; 5.3; 10.3; 13.9; 16.5; 20.0; 3.5
…
Where,
Temp (temporal) - specific year or long-term statistic:
  mean = mean based on all years
  numb = number of years
  stdv = standard deviation based on all years
Parm (parameter):
  prec = precipitation for month or year (mm)
  tmax = mean maximum temperature for month or year (C)
  tmin = mean minimum temperature for month or year (C)
```

## 3. Data Application and Derivation:

The accumulation of biomass, or NPP, is the net gain of carbon by photosynthesis that remains after plant respiration. While there are many fates for this carbon, this data set accounts for above-ground peak standing crop (live + dead) and root increment. These are considered the major components of NPP.

The Charleville grassland study was carried out with a view to parameterizing a simulation model of primary production and livestock carrying capacity. Apart from the studies of Beale (1973), quantitative information on the productivity of semiarid grasslands in southwestern Queensland was sparse prior to this study. Most prior available data on herbage production referred to yields at isolated points in time rather than to actual production rates.

Biomass data are provided for comparison with models and estimation of NPP. The data also have implications for the agronomic and ecological management of these grasslands. Climate data are provided for use in driving ecosystem/NPP models.

## 4. Quality Assessment:

The sampling procedure resulted in the standard error of the mean weight for herbage or root being less than 10% of the mean for almost all harvests. The maximum values derived for grassland community biomass production rates for the native and buffel grasslands in this study were similar to values for other Australian grasslands. Root crop values also agree with results of other studies described in Christie (1979). However, the investigator cautions that the results of this study are site-specific and possibly may not be generally extrapolated to all situations.

**Sources of Error**

Information not available.

## 5. Data Acquisition Materials and Methods:

**Site Information**

The grassland study sites are located near Charleville in southern Queensland, northeast Australia, at an elevation of 304 m. They included a native perennial $C_3$ "mulga" grassland located within Charleville Airport (-26.40 S, 146.27 E), about 1-km south of the town of Charleville, and a sown $C_4$

"buffel" grassland community, about 25-km north of the town. Grazed mulga shrublands, containing *Acacia* shrubs together with a grass layer, comprise about 200,000 $km^2$ of southwestern Queensland. They are usually associated with red earth soils which are characterized by very low nutrient concentrations and a narrow range of available soil water.

The Charleville grassland sites are classified as semi-arid grassland (modified Bailey ecoregion Savanna, #411/416) with mean annual precipitation of 489 mm. The predominant perennial grass species in the native grassland were *Thyridolepis mitchelliana* (mulga Mitchell grass), *Monachather paradoxa* (mulga oats grass), and *Themeda australis* (kangaroo grass). The introduced grassland was dominated by the buffel grass, *Cenchrus ciliaris* ($C_4$).

Soils at both study sites is sandy red earth. Sandy red earth soils in arid and semiarid ecosystems are characterized by having much of the biologically mobile nitrogen and phosphorus capital concentrated towards the soil surface. In this study, the soil nitrogen content at the native grassland was 165 $gN/m^2$ at 0-20 cm and and 110 $gN/m^2$ at 20-40 cm depths. At the introduced grassland, soil nitrogen content was 200 $gN/m^2$ at 0-20 cm and and 125 $gN/m^2$ at 20-40 cm depths. Soil carbon content is not available for either site.

Climate data for the Charleville grasslands are available from a weather station located at the Charleville Airport (elevation 306 m) for the period 1942-1994. The climate of southwestern Queensland is characterized by high levels of irradiance and high maximum summer temperatures. In addition, drought periods of 1-2 months occur frequently.

**Methods**

**Primary Production** (Christie, 1978). Measurements of above- and below-ground standing crop (live + dead matter) were made every 2 weeks during the continuous growing periods of 12 weeks and 8 weeks occurring in summer and winter, respectively. At all other times the interval was 28 days. All vegetation sampling was done on a random stratified grid pattern, no one point being resampled at any time throughout the year. This sampling procedure resulted in the standard error of the mean weight for herbage or root being less than 10% of the mean for almost all harvests. Harvests of both sites, on each sampling occasion, were staggered at 2 day intervals.

Sampling of above-ground material at each site on each occasion was by harvesting 12 blocks of 4 by 1-$m^2$ contiguous quadrats, each 1-$m^2$ being harvested separately. Root cores (5-cm diameter) were taken in all of the quadrats to a depth of 40 cm, alternately in the interspaces between tussocks or directly over tussocks. Bare quadrats were sampled in the center of the quadrat. All cut herbage was sorted into green shoot and dead material by hand separation for the first eight harvest occasions and by colorimetric method for the 10 final harvests. The green shoot material was further subdivided into the predominant perennial grasses recorded at each site.

Forty core samples were also taken to determine the vertical root distribution in both communities at the end of the summer growing season (harvest 6). The soil profile was sampled in 20 cm intervals to the maximum soil depth, viz. 120 cm and 80 cm for the native and buffel community, respectively. The non-rhizomatous root material was separated from the soil mass. Because of difficulty in differentiating between new and old growth or live and dead portions in these perennial grassland root systems, only data on the total non-rhizomatous root crop at any time are given. All shoot and root material was oven-dried for 24-36 hr at 80 degrees C, weighed, and retained for chemical analysis.

**Nutrient Dynamics** (Christie, 1979). This experiment complemented the 12 month study of primary production of the native and introduced grassland communities; the harvest sequence corresponds exactly with the sequence described above. Above- and below-ground vegetation was harvested sequentially at 14-d intervals on six occasions in summer and four occasions in winter following major rainfall events which initiated growth. Green shoot material of each predominant species was analyzed for nitrogen, phosphorus, and sulfur. Root and standing dead material was analyzed for nitrogen and phosphorus.

Because of the mobility of the phosphorus ion, the uppermost expanded leaf would represent the maximum concentration in the plant at any one time. Consequently, the uppermost expanded leaves of each of the four species were sampled after 8 and 10 weeks growth of the community in summer. Two hundred leaves of each species were sampled and duplicate analyses for nitrogen and phosphorus were undertaken on subsamples of the composite. Soil samples were taken in 20-cm increments to the full soil profile depth, viz. 120 cm for the native grassland and 80 cm for the buffel grassland, respectively. Duplicate analyses were carried out on soil subsamples for total nitrogen, total (and available) phosphorus and total sulfur. The absolute content of nitrogen and phosphorus of the above-ground biomass, standing dead, and root compartments was calculated from the data on chemical composition and the yield values from the production study.

**Litter Production** (Christie, 1979). The study area was a 0.4-ha ungrazed native grassland growing on cleared mulga shrubland adjacent to and similar to the native grassland used in the primary production study (based on basal area and species composition). The study was carried out over an identical period in time. At 6-week intervals, over a 48-week experimental period, herbaceous litter was estimated by harvesting 40 quadrats (1-$m^2$) on each occasion, on a random stratified sampling grid pattern. The instantaneous rate of litter disappearance of herbaceous litter was estimated by a modification of the paired-plot technique (Wiegert and Evans, 1964) following Hughes (1970). Litter was collected by sweeping the soil surface and collecting and bagging the litter. The litter samples were then washed on a 200 micron mesh sieve to remove all adhering soil. The litter material was oven-dried at 80 degrees C for 24-30 h, weighed, and retained for nitrogen and phosphorus analyses.

Litter production (P) was calculated following Medwecka-Kornas (1970) as

$P = (S_l - S_o) + D,$

where $S_o$, $S_l$, refer to the standing crop of litter at the beginning and end of each time interval respectively, and D the amount of litter which disappeared during the time interval. Litter accumulation can be seen to be dependent on relative differences in litter production and disappearance rates.

Data on soil moisture, determined gravimetrically with each biomass harvest, and litter production in grazed situations are available in the literature (Christie, 1979).

**Climate Data.**

The climate data accompanying this NPP data set was compiled from daily observations of Tmax, Tmin, and precip amount.

For a given month, the maximum value of the daily Tmax for that month and the minimum value of the Tmin for that month is provided. For the year, the maximum value of the monthly Tmax is the annual Tmax and for the year the minimum value of the monthly Tmin values is the annual Tmin. Daily precipitation amount is summed to yield a monthly precipitation amount and the monthly precipitation is summed to provide an annual precipitation amount.

The multi-year mean monthly Tmax is the average of the Tmax values for that month for each year of the record. For example the mean monthly Tmax for April is the mean of each April's Tmax for the observation period of record. Mean monthly Tmin and Mean monthly precip amount are calculated similarly.

## 6. Data Access:

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

### Data Archive Center:

**Contact for Data Center Access Information:**
E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

## 7. References:

Christie, E.K. 1978. Ecosystem processes in semi-arid grasslands. I. Primary production and water use of two communities possessing different photosynthetic pathways. Australian J. Agricultural Research 29: 773-787.

Christie, E.K. 1979. Ecosystem processes in semi-arid grasslands. II. Litter production, decomposition and nutrient dynamics. Australian J. Agricultural Research 30: 29-42.

Olson, R.J., K.R. Johnson, D.L. Zheng, and J.M.O. Scurlock. 2001. Global and Regional Ecosystem Modeling: Databases of Model Drivers and Validation Measurements. ORNL Technical Memorandum TM-2001/196. Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A.

**Additional Sources of Information:**

Beale, I.F. 1973. Tree density effects on yields of herbage and tree components in south west Queensland mulga (Acacia aneura F. Muell.) scrub. Trop. Grassl. 7: 135-42.

Hughes, M.K. 1970. Ground vegetation and forest litter production. In: J. Phillipson (ed.). Methods of Study in Soil Ecology, pp. 145-50. UNESCO, Paris.

Hunter, R.F., and S.A. Grant. 1961. The estimation of 'green dry matter' in a sample by methanol-soluble pigments. J. Br. Grassl. Soc. 16, 43-8.

Medwecka-Kornas, A. 1970. Litter production. In: J. Phillipson (ed.). Methods of Study in Soil Ecology, pp. 139-43. UNESCO, Paris.

Olson, R.J., J.M.O. Scurlock, S.D. Prince, D.L. Zheng, and K.R. Johnson (eds.). 2013a. NPP Multi-Biome: Global Primary Production Data Initiative Products, R2. Data set. Available on-line [http://daac.ornl.gov] from the Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA. doi:10.3334/ORNLDAAC/617

Olson, R.J., J.M.O. Scurlock, S.D. Prince, D.L. Zheng, and K.R. Johnson (eds.). 2013b. NPP Multi-Biome: NPP and Driver Data for Ecosystem Model-Data Intercomparison, R2. 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. doi:10.3334/ORNLDAAC/615

Schuurman, J.J., and M.A.J. Goedewaagen. 1965. Methods for the examination of root systems and roots. Centre Agric. Publ. Documentation, Wageningen.

Scurlock, J.M.O., and R.J. Olson. 2002. Terrestrial net primary productivity - A brief history and a new worldwide database. Environ. Rev. 10(2): 91-109. doi:10.1139/a02-002

Scurlock, J.M.O., and R.J. Olson. 2013. NPP Multi-Biome: Grassland, Boreal Forest, and Tropical Forest Sites, 1939-1996, R1. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/653

Scurlock, J.M.O., K. Johnson, and R.J. Olson. 2002. Estimating net primary productivity from grassland biomass dynamics measurements. Global Change Biology 8(8): 736-753. DOI: 10.1046/j.1365-2486.2002.00512.x

Wiegert, R.G., and F.C. Evans, F. C. 1964. Primary production and the disappearance of dead vegetation on an old-field in south-eastern Michigan. Ecology 45: 49-63.

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