NPP Grassland: Central Plains Experimental Range (SGS), USA, 1939-1990, R1

Get Data

Revision date: April 15, 2015

Summary:

This data set records the productivity of a semiarid shortgrass prairie steppe located in the Central Plains Experimental Reserve (CPER)/Pawnee National Grassland in north-central Colorado. There are nine data files (.txt). Four files contain measurements of monthly dynamics of harvested above-ground plant biomass, one file each for untreated, irrigated, fertilized, and irrigated + fertilized plots for the period 1970 to 1975. The fifth file contains annual above-ground NPP estimates for the untreated plot for the period 1970-1974. The sixth file contains long-term ANPP estimated from field harvest measurements made between 1970 and 1990 and by correlation with forage production measurements made between 1939 and 1990. Two additional files provide estimates of above- and below-ground NPP based on peak growing season harvests; one record covers 1970-1972 from the Pawnee site and the other covers 1985-1988 from CPER. The ninth file contains climate data for 1912-1990 from a weather station located at CPER.

Depending on the study, location, and methods, ANPP ranged from a mean of 78 g/m^2/yr (grasses + forbs + succulents) to 172 g/m^2/yr (grasses + forbs + succulents + shrubs) on untreated plots. In treated areas, production (grasses + forbs + succulents + shrubs) peaked at approximately 240 g/m^2/yr on fertilized plots, 420 g/m^2/yr on irrigated plots, and 1,000 g/m^2/yr on irrigated + fertilized plots. BNPP on untreated plots ranged from 185 g/m^2/yr for root production to 568 g/m^2/yr for root + crown production.

Revision Notes: This data set has been revised to correct the study site elevation, extend the temporal coverage, and add four data files containing estimates of NPP. Please see the Data Set Revisions section of this document for detailed information.

Figure 1. General view of the CPER grassland site, Colorado, USA. (Mark Lindquist, Colorado State University, demonstrates moderate [foreground] and light [background] grazing regimes. Photograph taken July 1996 by Dr. J.M.O. Scurlock, ORNL).

Additional Documentation

The 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.shtml

Data Citation:

Cite this data set as follows:

Uresk, D., P.L. Sims, and J.L. Dodd. 2015. NPP Grassland: Central Plains Experimental Range (SGS), USA, 1939-1990, R1. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA. http://dx.doi.org/10.3334/ORNLDAAC/145

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Table of Contents:

1. Data Set Overview:

Project: Net Primary Productivity (NPP)

This data set contains records of the productivity of a semi-arid shortgrass prairie steppe located in the piedmont of north-central Colorado (40.82 N -104.77 W Elevation 1,652 m). Productivity was monitored at the Central Plains Experimental Reserve (CPER) and the Pawnee National Grassland at various times from

1939 to 1990.

There are nine files (.txt) in this data set. Four files contain biweekly to monthly measurements of harvested above-ground plant biomass, one file for each treatment (untreated, irrigated, fertilized, and irrigated + fertilized) for the period 1970 to 1975 (Dodd and Lauenroth, 1979). The fifth file contains annual above-ground NPP estimates for the untreated plot for the period 1970-1974 (Dodd and Lauenroth, 1979). The sixth file contains long-term ANPP estimated from field biomass measurements made between 1970 and 1990 and by correlation with forage production measurements made between 1939 and 1990 (Lauenroth and Sala, 1992). Two additional files provide estimates of above- and below-ground NPP based on peak growing season harvests; one record covers 1970-1972 at Pawnee (Sims and Singh, 1978) and the other record covers 1985-1988 at CPER (Milchunas and Lauenroth, 1992). The ninth file contains climate data for 1912-1990 recorded at CPER.

Depending on the study, location, and methods, ANPP ranged from a mean of 78 g/m^2/yr (grasses + forbs + succulents) to 172 g/m^2/yr (grasses + forbs + succulents + shrubs) on untreated plots. In treated areas, production (grasses + forbs + succulents + shrubs) peaked at approximately 240 g/m^2/yr on fertilized plots, 420 g/m^2/yr on irrigated plots, and 1,000 g/m^2/yr on irrigated + fertilized plots. BNPP on untreated plots ranged from 185 g/m^2/yr for root production to 568 g/m^2/yr for root + crown production. ANPP, BNPP, and TNPP estimates are also reported in Esser (2013), Olson et al. (2013a, b), and Scurlock and Olson (2013). These values are comparable to the values reported by Sims and Singh (1978) (Table 1).

Earlier work was originally carried out by the U.S. Agricultural Research Service and under the U.S. Grassland Biome Project of the International Biological Programme (IBP). Research has continued under the U.S. Long-Term Ecological Research (LTER) program at the Shortgrass Steppe (SGS) site. Data on soil dynamics at CPER were used in the development of the CENTURY plant/soil organic matter model.

Table 1. ANPP, BNPP, and TNPP values for untreated CPER/Pawnee plots reported by various published data sources.

File Name or Description	Data Source(s)	Sub-Site	Temporal Coverage	ANPP	BNPP	TNPP
		alphanumeric	yyyy-yyyy	gC/m2/year		
cpr5_npp.txt	Dodd and Lauenroth (1979)	cpr5 (with shrubs)	1970-1974	57.5	NA	NA
cpr5 (without shrubs)				35.1	NA	NA
cpr6_npp.txt	Lauenroth and Sala (1992)	cpr6 (field measurements; without shrubs)	1970-1990	42.3	NA	NA
		cpr6 (calculation based on forage production measurements; without shrubs)	1939-1990	43.7	NA	NA
cpr7_npp.txt	Sims and Singh (1978)	cpr7 (with shrubs)	1970-1972	77.4	255.6	333
cpr8_npp.txt	Milchunas and Lauenroth (1992)	cpr8 (harvest method with shrubs)	1985-1998	47.3	106.2	NA
		cpr8 (harvest method without shrubs)		40.95		
		cpr8 (14C turnover method)		49.1	104.4	
NPP_Multibiome_EnvReview_Table_A1_R1.csv	Scurlock and Olson (2013) based on Sims and Singh (1978)	cpr	1970-1972	77	256	333
ods_npp.csv	Esser et al. (2013)	2075				
GPPDI_ClassA_NPP_162_R2.csv	Olson et al. (2013a)	Class A 87 (MI 86)				
EMDI_ClassA_NPP_81_R1.xls	Olson et al. (2013b)	Class A 87				

Notes: NA = Not available. MI = Measurement identification number. The differences in NPP values reported in this table are mainly due to differences in plot locations, harvest methods, and calculation methods. Please consult original references for details.

For this table, NPP data from the original data sources were converted from grams of dry weight per meter square per year to grams of carbon per meter square per year using a conversion factor of 0.45.

ANPP and BNPP estimates are mean values based on field measurements and/or calculations based on forage production measurements. TNPP = ANPP + BNPP. Please consult original references for details.

NPP estimates in cpr7_npp.txt and in Scurlock and Olson (2013), Esser et al. (2013), and Olson et al. (2013a; b) come from studies at the Pawnee site; the other data come from CPER.

NPP estimates were not calculated in data files **cpr1_npp_r1.txt, cpr2_npp_r1.txt, cpr3_npp_r1.txt, or cpr4_npp_r1.txt**.

Please see the Data Set Revisions section of this document for detailed information on the revised data sets (R1, R2, etc.)

Figure 2. Dr. George Van Dyne (Director 1970-73, Natural Resource Ecology Laboratory, Colorado State University, and Director of the US/IBP Grassland Biome Programme) with Dr. Norman French (Field Validation Studies Director, Grassland Biome Programme) and two visitors at the CPER/Pawnee grassland site, Colorado, USA. (Photograph taken early 1970s: reproduced by kind permission of NREL).

2. Data Description:

Spatial Coverage

Site: Central Plains Experimental Range (CPER)/Pawnee National Grassland, USA

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

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (m)
Central Plains Experimental Range (CPER)/Pawnee National Grassland, USA	-104.77	-104.77	40.82	40.82	1,652

Spatial Resolution

The CPER grassland site is about 6,280 ha. The western division of the Pawnee National Grassland is about 42,492 ha. The spatial resolution of the study plots included in this data set is shown in Table 2.

Table 2. Spatial resolution of study plots.

STUDY	FILE NAMES	LOCATION	REPLICATES	PLOT SIZE	TEMPORAL RESOLUTION	TEMPORAL COVERAGE
Dodd and Lauenroth (1979)	cpr1_npp, cpr2_npp, cpr3_npp, cpr4_npp	CPER	Two one-hectare replicates of each treatment (control, irrigated, fertilized, and irrigated + fertilized); ungrazed the year prior to and during the six year study	10 to 12 circular 0.5-m2 plots for each treatment	Harvests made several times each year during growing season (biweekly, monthly, or every other month; see data files for details)	1970-1975
Dodd and			Two one-hectare replicates of control treatment (above);	10 to 12 circular 0.5-	Annual estimates of ANPP and BNPP based on	

Lauenroth (1979)	cpr5_npp	CPER	ungrazed the year prior to and during the six year study	m2 plots for control replicates	harvests made during growing season (see above)	1970-1974
Lauenroth and Sala (1992)	cpr6_npp	CPER	Average of eleven locations per year (range: 3 to 35 locations)	0.19-m2 quadrats	Harvests made at the end of the growing season	1939-1990
Sims and Singh (1978)	cpr7_npp	Pawnee	Two replicates; ungrazed since 1939	0.25 to 0.5-m2 square or rectangular plots (1970); 0.5-m2 circular quadrats (1971-1972)	Harvests made every two weeks during growing season	1970-1972 /td>
Milchunas and Lauenroth (1992)	cpr8_npp	CPER	Control plots: 15 above-ground harvest plots and 80 cores of crown and root biomass each sampling period. 14C labeled treatment plots: eight long-term replicates (9-m2 each) and eight short-term replicates (4-m2 each); ungrazed since 1969	Control plots: 0.25-m2 above-ground plots and cores with 66.5-mm inside diameter for crown and root (0-20 cm) biomass. 14C treatment: two adjacent cores from the center of each of five 0.11-m2 squares per plot and five 0.14-m2 squares per plot = 2 cores x 5 squares x 8 plots = 80 cores per date per treatment (long- and short-term experiments, respectively).	Harvests made of peak above-ground standing crops of current-year biomass; crown and root cores taken on the same date. Samples using 14C method taken 5, 35, 85, 267, 381, and 485 days after labeling (short-term plots) and 267, 485, 632, 846, and 1,013 days after labeling (long-term plots)./td>	1985-1988

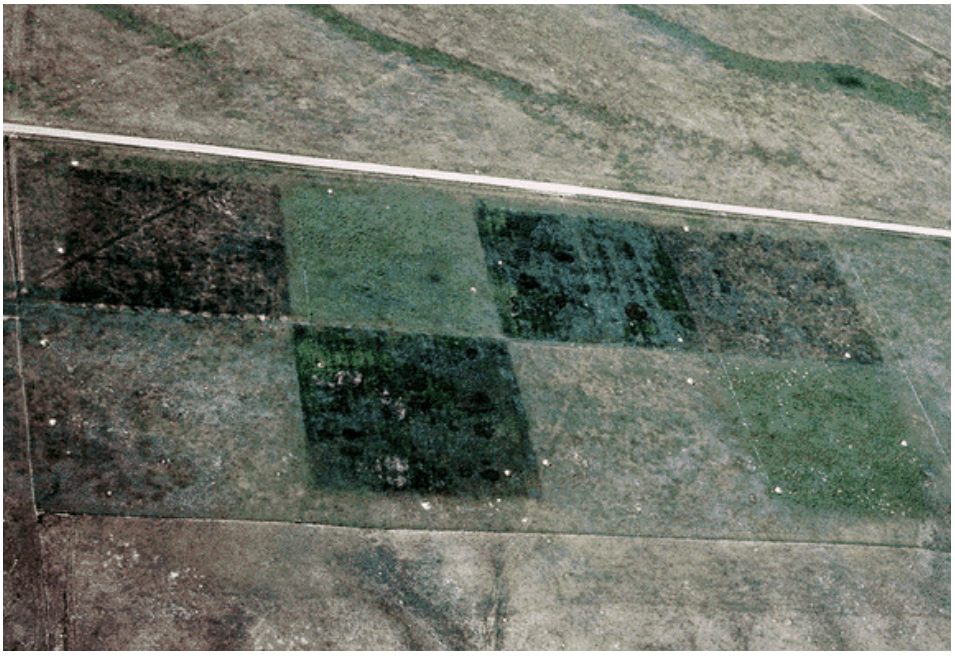

Figure 3. Aerial view of the Dodd and Lauenroth (1979) Ecological Stress Analysis (ESA) experimental area at the CPER/Pawnee grassland site, Colorado, USA. Differences between the 4 treatments, each with two replicates, are quite obvious. Photograph taken July 1975.

Temporal Coverage

All measurements were made between 1939 and 1990. Temporal coverage of each data file varies. See Table 3.

Temporal Resolution

Biomass measurements were made at different sampling intervals for each study, ranging from biweekly to monthly to once at the end of the growing season to seasonal "days after treatment." See Table 4. Biomass measurements are expressed as g/m^2 per sampling date. All NPP measurements are expressed on a annual basis ($g/m^2/yr$).

Data File Information

Table 3. Data file descriptions.

FILE NAME	TEMPORAL COVERAGE	FILE CONTENTS
cpr1_npp_r1.txt, cpr2_npp_r1.txt, cpr3_npp_r1.txt, cpr4_npp_r1.txt	1970/04/26-1975/08/18	Biweekly and monthly above-ground biomass measurements of live and standing dead grass, forbs, succulents, and shrubs from CPER plots with four treatments: control, irrigated, fertilized, and irrigated + fertilized
cpr5_npp.txt	1970/04/26-1975/08/18	ANPP estimates for control plot in CPER based on peak biomass (see above)
cpr6_npp.txt	1939/01/01-1990/12/31	Annual estimates of above-ground forage biomass and ANPP for live and attached dead grasses, forbs, and sedges in CPER
cpr7_npp.txt	1970/01/01-1972/12/31	ANPP estimates based on sum of harvested peak live weights of individual species during the growing season and BNPP estimates based on sum of harvested crown biomass and positive increments of root biomass by depth (0-20 cm) during growing season at Pawnee
cpr8_npp.txt	1985/01/01-1988/12/31	ANPP and BNPP estimates from two methods: harvest clips and cores and 14C turnover in CPER
cpr_cli.txt	1912/01/01-1990/12/31	Monthly and annual precipitation amount and maximum/minimum temperatures plus long-term means from weather station located at CPER

NPP Data. NPP estimates are provided in eight text files (.txt format) (Table 3). The variable values are tab delimited. The first 18 lines are metadata; data records begin on line 19. The value -999 is used to denote missing values. All biomass units are expressed in g/m^2 (dry matter weight) and NPP units are expressed in $g/m^2/yr$ (dry matter weight).

Table 4. Column headings in NPP files cpr1_npp_r1.txt, cpr2_npp_r1.txt, cpr3_npp_r1.txt, and cpr4_npp_r1.txt.

COLUMN HEADING	DEFINITION	UNITS
Site	Site where data were gathered (code refers to site identification)	alphnumeric
Treatmt	Long term management of site (code refers to treatment in the Ecological Stress Analysis (ESA) experimental area: esa_c = control (none); esa_i = irrigated; esa_f = fertilized; esa_if = irrigated + fertilized). All plots were ungrazed one year prior to and during the study.	text
Year	Year in which data were collected	yyyy
Mn	Month in which data were collected	MM
Dy	Day on which data were collected	dd
Tyear	Date in decimal year (year plus the Julian date divided by 365)	numeric
AGbioherb	Above-ground live biomass of herbaceous layer	g/m2
forbs	Above-ground live biomass of forbs	
grass	Above-ground live biomass of grasses	
Deadherb	Dead herbaceous matter	
Deadforb	Dead forb matter	
Deadgras	Dead grass matter	
AGherbclip	Total clipped matter for herbaceous layer	
ShrSuc	Above-ground live biomass of shrubs and succulents	
Deadshrsuc	Dead shrubs and succulents	
AGbiomass	Above-ground biomass	
Stdead	Standing dead	
AGTotclip	Total above-ground clipped matter	

Sample NPP Data Record: cpr1_npp_r1.txt

```
Site Treatmt Year Mn Dy Jdate Tyear AGbioherb forbs grass Deadherb Deadforb Deadgras AGherbclip
ShrSuc Deadshrsuc AGbiomass Stdead AGTotclip [units g/m2]
```

```
cpr esa_c 1970 4 26 116 1970.318 32.96 0.2 32.76 9.62 0 9.62 42.58 49.6 0 82.56 9.62 92.18
cpr esa_c 1970 5 12 132 1970.362 53.87 1.22 52.65 0 0 0 53.87 38.46 0 92.33 0 92.33
...
```

Table 5. Column headings in NPP file: cpr5_npp.txt.

COLUMN HEADING	DEFINITION	UNITS
Site	Site where data were gathered (code refers to site identification). This site is also known as esa_c = control (no fertilization or water treatment) and ungrazed one year prior to and during the study.	alphnumeric
Year	Year in which data were collected	yyyy
ANPP_w_shrubs	Above-ground net primary production = sum of peak standing crop of current-year grasses + forbs + succulents + shrubs	g/m2/yr
ANPP_wo_shrubs	Above-ground net primary production = sum of peak standing crop of current-year grasses + forbs + succulents (without shrubs)	
Precip	Total annual precipitation	mm

Sample NPP Data Record: cpr5_npp.txt

```
Site Year ANPP_w_shrubs ANPP_wo_shrubs Precip
alphanumeric yyyy g/m2/yr g/m2/yr mm

cpr5 1970 182 115 172
cpr5 1971 114 82 254
...
```

Table 6. Column headings in NPP file: cpr6_npp.txt.

COLUMN HEADING	DEFINITION	UNITS
Site	Site where data were gathered (code refers to site identification).	alphnumeric
Year	Year in which data were collected	yyyy
AGbiomass	Live and attached-dead biomass of grasses, sedges, and forbs reported as air-dry forage production	g/m2
AGbiomass_SD	Standard deviation of AGbiomass	
field_samples	Number of plots sampled each year	numeric
ANPP_FE	Oven-dry ANPP based on field estimates of forage production	g/m2/yr
ANPP_OD	Air-dry forage production converted to oven-dry ANPP using the equation ANPP_OD = 46 + 0.76 (forage production)	
Precip	Total annual precipitation	mm
Temp	Annual mean air temperature	degrees C

Sample NPP Data Record: cpr6_npp.txt

```
Site Year AGbiomass Agbiomass_SD field_samples ANPP_FE
ANPP_OD Precip Temp
alphanumeric yyyy g/m2 g/m2 numeric g/m2/yr g/m2/yr mm
degrees_C

cpr6 1939 50 12.1 11 -999 84 117 9.3
cpr6 1940 -999 -999 0 -999 -999 339 8.85
cpr6 1941 74 11.3 10 -999 102 325 8.43
cpr6 1942 123 33.3 7 -999 139 371 8.07
cpr6 1943 123 32.6 13 -999 140 790 8.8
. ...
```

Table 7. Column headings in NPP file: cpr7_npp.txt.

COLUMN HEADING	DEFINITION	UNITS
Site	Site where data were gathered (code refers to site identification).	alphnumeric
Year	Year in which data were collected	yyyy
ANPP	Sum of oven-dried harvested peak live weights of individual species	g/m2/yr
BNPP	Sum of oven-dried harvested crown biomass and positive increments of root biomass by depth (0-20 cm) during growing season	
TNPP	ANPP + BNPP	

Sample NPP Data Record: cpr7_npp.txt

```
Site Year ANPP BNPP TNPP
alphanumeric yyyy g/m2/yr g/m2/yr g/m2/yr

cpr7 1970 160 411 571
cpr7 1971 218 686 904
...
```

Table 8. Column headings in NPP file: cpr8_npp.txt.

COLUMN HEADING	DEFINITION	UNITS
Site	Site where data were gathered (code refers to site identification).	alphnumeric
Year	Year in which data were collected	yyyy
ANPP_w_shrubs_harvest	Sum of harvested peak standing crop current-year biomass with shrubs	g/m2/yr
ANPP_wo_shrubs_harvest	Sum of harvested peak standing crop current-year biomass without shrubs	
BNPP_harvest	Sum of harvested positive increments of root biomass (0-20 cm)	
ANPP_14C_method[1]	Sum of green tissue + dead + litter production based on 14C turnover. See note.	
Crown_NPP_14C_method[1]	Crown production based on 14C turnover. See note.	
Root_NPP_14C_method[1]	Root production by depth (0-20 cm) based on 14C turnover. See note.	
Precip_Apr_Sept	Precipitation amount during growing season	mm

Note: [1]NPP estimates from 14C turnover method described in Milchunas and Lauenroth (1992). 1985 data = Mean biomass from short-term experiment plots divided by number of years for complete turnover. 1987 and 1988 data = Mean biomass from long-term experiment plots divided by number of years for complete turnover. 1986 data = Mean biomass from short-term + long-term plots.

Sample NPP Data Record: cpr8_npp.txt

```
Site Year ANPP_w_shrubs_harvest ANPP_wo_shrubs_harvest BNPP_harvest ANPP_14C_method
Crown_NPP_14C_method Root_NPP_14C_method Precip_Apr_Sep
alphanumeric yyyy g/m2/yr g/m2/yr g/m2/yr g/m2/yr g/m2/yr g/m2/yr mm

cpr8 1985 128 112 162 159 74 188 237
cpr8 1986 119 94 182 103 56 183 195
...
```

Climate Data. The climate data are provided in one file (.txt format) (Table 4). The variable values are delimited by semicolons. The first 18 lines are metadata;

data records begin on line 19. There are no missing values.

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

cpr;mean;prec; 6.6; 8.4; 15.4; 28.1; 50.4; 49.8; 48.6; 40.2; 28.5; 16.7; 9.1; 7.7; 309.5
cpr;mean;tmax; 5.0; 6.8; 9.9; 15.4; 20.5; 26.5; 30.6; 29.6; 25.0; 18.6; 10.7; 5.9; 31.0
cpr;mean;tmin;-10.9; -9.0; -5.9; -0.9; 4.4; 9.3; 12.6; 11.8; 6.9; 0.9; -5.3; -9.4; -12.3
cpr;numb;prec; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0
cpr;numb;tmax; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0
cpr;numb;tmin; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0; 79.0
cpr;stdv;prec; 6.4; 9.1; 14.0; 19.8; 30.9; 33.6; 28.8; 28.8; 22.5; 16.8; 7.6; 10.1; 87.7
cpr;stdv;tmax; 3.3; 3.4; 3.1; 2.7; 2.1; 2.8; 2.0; 1.8; 2.6; 2.7; 2.7; 3.0; 1.8
cpr;stdv;tmin; 3.2; 3.0; 2.5; 2.1; 1.8; 1.8; 1.6; 1.7; 1.9; 1.9; 2.2; 2.6; 2.8
cpr;1912;prec; 12.1; 32.7; 37.2; 43.3; 35.3; 57.6; 30.2; 40.0; 45.4; 39.0; 4.1; 9.8; 386.7
cpr;1912;tmax; 2.9; 4.9; 1.9; 12.1; 20.1; 24.2; 27.9; 27.9; 19.2; 16.5; 11.4; 4.8; 27.9
cpr;1912;tmin;-11.2;-10.0;-10.7; -1.6; 3.1; 7.0; 11.4; 10.7; 3.6; -0.7; -4.7;-11.1; -11.2
cpr;1913;prec; 6.1; 43.9; 17.4; 15.3; 59.7; 26.8; 56.6; 15.9; 50.3; 7.8; 0.4; 64.4; 364.6
cpr;1913;tmax; 3.1; -0.9; 8.6; 16.7; 20.8; 26.5; 29.4; 31.4; 22.1; 14.9; 13.6; -0.9; 31.4
cpr;1913;tmin;-13.8;-16.3; -7.6; -1.7; 4.1; 7.9; 10.2; 11.0; 4.3; -3.2; -5.9;-13.5; -16.3
…

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)
```

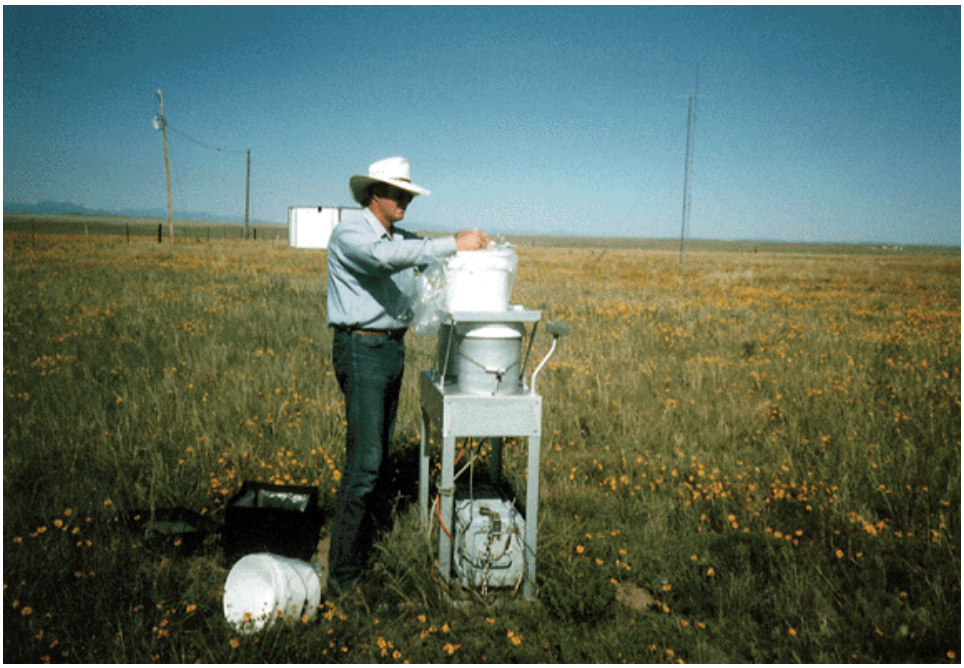

Figure 4. Weather station in grazing exclosure within the CPER grassland site, Colorado, USA. (Mark Lindquist, Colorado State University, is checking a wet/dry deposition gauge. Photograph taken July 1996 by Dr. J.M.O. Scurlock, ORNL).

3. Data Application and Derivation:

The accumulation of biomass, or NPP, is the net gain of carbon by photosynthesis that remains after plant respiration. In this data set, NPP for the shortgrass prairie at CPER/Pawnee was estimated in several ways.

Dodd and Lauenroth (1979) assessed the effects of four different treatments (control (none), irrigated, fertilized, and irrigated + fertilized) on above-ground biomass production. They estimated ANPP as being the sum of seasonal peaks of total standing crops of current-year live + dead above-ground vegetation for six functional plant groups (warm-season grasses, cool-season grasses, warm-season forbs, cool-season forbs, shrubs, and succulents). Lauenroth and Sala

(1992) evaluated the relationship between annual forage production and annual and seasonal precipitation and temperature using a long-term data set (52 yr) and constructed a relationship between forage production and ANPP. The Sims and Singh (1978) study was part of the International Biological Programme's (IBP) coordinated comparative research on the structure and function of ten central and western U.S. grasslands. Their estimates of NPP are based on the sum of above-ground peak live + dead weights of individual species harvested during the growing season (=ANPP) and the sum of crown biomass + positive increments of root biomass by depth (0-20 cm) harvested during the growing season (=BNPP). Milchunas and Lauenroth (1992) assessed short-term patterns of carbon allocation and the long-term process of herbivory, death, and decomposition, and compared estimates of above-ground, crown, and root NPP using ^{14}C dilution, ^{14}C turnover, and traditional harvest methods.

Grassland biomass dynamics data are provided for comparison with models and estimation of NPP. Climate data are provided for use in driving ecosystem/NPP models.

4. Quality Assessment:

Net primary production of grasslands is subject to a number of different methods of estimation from biomass data, some of which may be inappropriate for particular biome types. Methodology of estimation/calculation needs to be taken into account, as well as methodology of measurement, when making comparisons between different regions. Errors in biomass measurement may also occur between different study sites. For short time series of data it may be assumed that measurement methodology remains consistent; however, over very long time series changes in staff, tools, etc. may lead to "calibration" errors.

See published literature for each of the studies cited herein for discussions of data quality.

5. Data Acquisition Materials and Methods:

Site Information

Central Plains Experimental Range (CPER), which is administered by the USDA Agricultural Research Service, is located in the north-central Colorado piedmont of North America in the precipitation shadow of the Rocky Mountains, about 40-km south of Cheyenne, Wyoming and 56-km northeast of Fort Collins, Colorado. CPER is located at the western edge of the Pawnee National Grassland which is administered by the USDA Forest Service. Intensive studies requiring careful experimental design are conducted on CPER; more extensive studies requiring larger area but less control are conducted on the Pawnee National Grassland. Collectively, the two administrative units are often referred to as the Pawnee Site.

Figure 5. Main entrance from U.S. Highway 85 to the CPER/Pawnee grassland site, Colorado, USA, pictured in the early 1970s. (Sign reads: "Cooperating agencies: International Biological Program, Central Plains Experimental Range, Pawnee National Grassland." Photograph taken by Don Peden, Colorado State University).

The study site is a mid continental semiarid shortgrass prairie with an average annual precipitation of 310 mm (79-year mean). More than 70% of the precipitation occurs as rain from late April through early August, with the largest quantities occurring in May and June. Year-to-year fluctuations in quantity and seasonal distribution are great. Average monthly air temperatures range from -4 degrees C in January to 21 degrees C in July (52-year means).

The soils of this area are derived from granitic outwash from the Rocky Mountains and are weakly developed zonal soils of loam to sandy-loam texture and relatively low fertility. The vegetation is representative of the northern portion of the shortgrass steppe (Lauenroth and Milchunas, 1991). The vegetation, regardless of past grazing history, is dominated by shortgrasses, succulants, and half-shrubs (e.g., *Bouteloua gracilis*, *Opuntia polyacantha*, and *Artemisia*

frigida, respectively). About 90 % of the total above-ground biomass is about equally divided between these three major groups of plants. Cool-season grasses and sedges and cool- and warm-season forbs collectively account for less than 10% of the total standing crop (Dodd and Lauenroth, 1979). Studies of this grassland have shown that primary production is limited mainly by spring and summer precipitation and to a lesser extent by the availability of soil mineral nitrogen during shorter periods of the season when soil water is at or near optimal levels for plant growth (Hyder et al., 1975). The shortgrass prairie is typically grazed annually by domestic animals, and would have been grazed by wild buffalo prior to the mid 19th century. Some of the region has been converted to arable crops, and some has subsequently been restored to grassland under the U.S. Conservation Reserve Program (Dodd and Lauenroth, 1979; Lauenroth and Sala, 1992).

Table 9. Site characteristics

Description	Values
mean annual precipitation	310 mm
mean monthly minimum temperature	-10.9 (C) (Jan)
mean monthly maximum temperature	30.6 (C) (July)
vegetation type	shortgrass prairie
dominant species	Bouteloua gracilis (C4)
historical long-term management regime	annual grazing
max above-ground live biomass (typical month)	75 g/m2 (July)
soil type	sandy loam
soil pH	6.2
soil texture (sand/ silt/ clay)	0.70 / 0.15 / 0.15
soil carbon content	0.8-1.0% OM (0-20 cm)
soil nitrogen content	0.07-0.08% (0-20 cm)

Figure 6. Grazing strip experiment at the CPER grassland site, Colorado, USA. (Photograph taken July 1996 by Andy Bean, Colorado State University: reproduced by kind permission of Chris Wasser, SGS LTER site data manager).

In this data set, biomass production and NPP for the shortgrass prairie at the CPER/Pawnee grassland site were estimated by several different studies using somewhat similar methods. These studies are briefly described below. This data set also includes climate data monitored from 1912 through 1990 at a weather station located at CPER. Measurements included precipitation, minimum temperature, and maximum temperature. Monthly and annual means are reported in the climate file.

Dodd and Lauenroth (1979). Data files: **cpr1_npp_r1.txt, cpr2_npp_r1.txt, cpr3_npp_r1.txt, cpr4_npp_r1.txt, and cpr5_npp.txt.** The CPER experimental design was a factorial combination of two replications for each treatment: control (no treatment), irrigation, nitrogen fertilization, and water + nitrogen treatment. Each of the eight contiguous cells (see Figure 5) was a one-hectare plot and had a long history of light summer grazing by cattle. For this study, livestock were

excluded the year prior to and during the six year study. Estimates of standing above-ground plant biomass were made by harvesting 10 to 12 circular plots of 0.5-m^2 each per treatment area at 2-3 week intervals or monthly during the growing season. Total standing crop was determined by species and ANPP was derived from seasonal peaks of total standing crop of current year's production (live + dead).

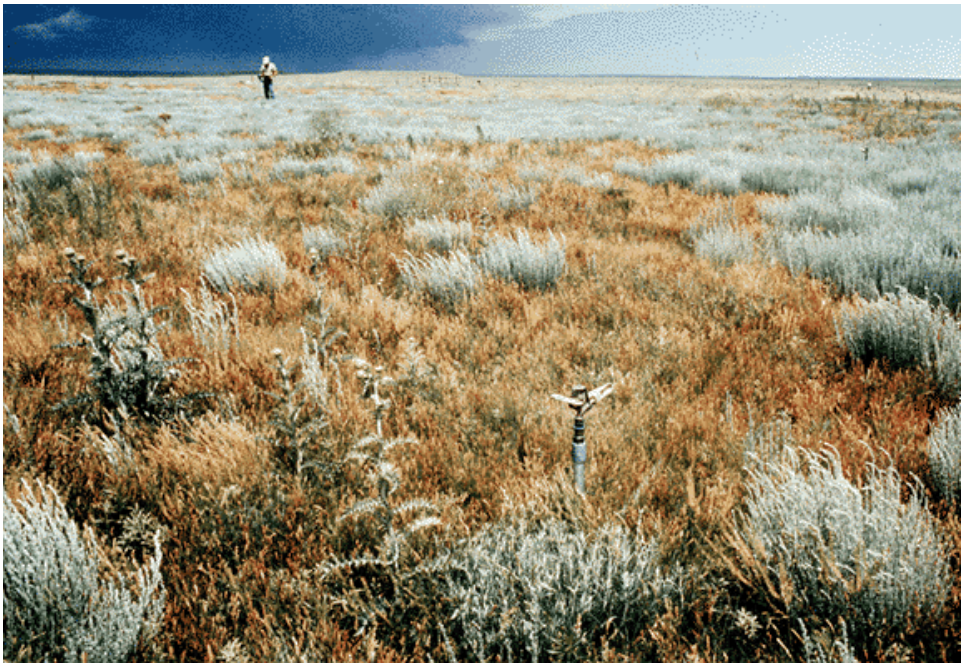

Figure 7. Close-up view of an irrigated plot within the Dodd and Lauenroth (1979) Ecological Stress Analysis (ESA) experimental area at the CPER/Pawnee grassland site, Colorado, USA. (Enhanced growth of the native species *Artemisia frigida*, *V*ulpia *octoflora* and *Circium undulatum* is evident. A sprinkler is shown in the foreground. Photograph taken 1971 by Larry Nell, Colorado State University).

Lauenroth and Sala (1992). Data file: **cpr6_npp.txt.** Forage production was estimated annually in CPER from 1939 to 1990 (except 1940 and 1980). The same pastures were not sampled every year; however, most locations were similar in species composition. Samples were collected by harvesting live and attached-dead biomass of grasses, sedges, and forbs from 0.19 m^2 quadrats at the end of the growing season. Succulents and shrubs were not harvested. An exception occurred in the years 1969-1972 when masses were visually estimated but not harvested. The average number of locations sampled per year was 11 with a range of three in 1967 to 35 in 1977; no sampling was done in 1940 or 1980. The biomass data presented in the data file represent annual average forage production expressed on an air-dry basis. These data were converted to oven-dry ANPP by the equation ANPP = 46 + 0.76 (Forage Production). Field estimates of oven-dry ANPP are also provided, but for shorter time periods (1970-1975 and 1983-1990).

Sims and Singh (1978). Data file: **cpr7_npp.txt.** Above- and below-ground biomass was sampled in two ungrazed microwatersheds with similar soil and vegetative characteristics in the Pawnee National Grassland as part of the US/IBP Grassland Biome Programme. The study area had been protected from grazing by large herbivores by exclosure for at least 31 years prior to commencement of the study. Biomass was estimated by harvest methods once each in the pre-growing and post-growing seasons and biweekly during the season of rapid vegetative growth and flowering. Eight plots were harvested in each study area on each sampling date. Non-destructive biomass estimations were also made on a larger number of plots in the same study area on the same sampling date. In 1970, square 0.25-m^2 harvest plots were used; in 1971-1972, 0.5-m^2 circular harvest quadrats were used. Aerial plant material was clipped at the soil surface, sorted and weighed by species in the field, oven dried in the laboratory, and composited to determine total standing crop. Below-ground biomass was sampled to a depth sufficient to include at least 90% of the root mass. Crown and root samples were collected on eight 0.25-m^2 plots located randomly within the same area as above-ground biomass was harvested. Cores 7.5-cm in diameter were taken at a depth of 10 cm at two week intervals during the growing season and 5.0-cm diameter cores were taken twice to a depth of 80 cm. Soil cores containing root samples were separated into 10-cm increments, washed over a 32-mesh screen, dried at 60 degrees C, weighed, and then ashed. ANPP (or shoot production) for each year was determined by the summation of peak live weights of individual species. Crown production was estimated by summing the statistically significant positive increases in crown biomass within a growing season. Root production was estimated by the summation of the significant positive increases in root biomass by depth. BNPP was estimated as annual crown + root production.

Milchunas and Lauenroth (1992). Data file: **cpr8_npp.txt**. Eight long-term and eight short-term plots (9 m^2 and 4 m^2, respectively) were located in a level upland site in CPER that had been ungrazed since 1969. Both short- and long-term plots had a 30-cm wide border. The remainder of each plot was divided into 64 squares for long-term plots or 36 squares for short-term plots. Plots were tented and labeled with ^{14}C. Five randomly chosen squares in each of the eight plots were sampled on days after treatment representing early spring, peak live biomass, and late fall production. Above-ground biomass, including litter, and 2 adjacent cores were removed from the center of each of 5 squares per plot (2 cores x 5 squares x 8 plots = 80 cores/date) for each of the short- and long-term groups of plots. The cores were 66.5-mm inside diameter, with one driven to 20 cm and one to 40 cm depth. Sample categories on short-term plots were above-ground green tissue, dead plus litter, crowns, roots, and soil, and for long-term plots were above-ground plus litter, crowns, roots, and soil. ANPP and BNPP (crown + root production) were estimated by both harvest and plant part turnover of ^{14}C mass (^{14}C turnover). See source for details on treatment, sampling, and data calculation methods.

Figure 8. Measurement of above-ground biomass at the CPER/Pawnee grassland site, Colorado, USA. (Dan Uresk, Colorado State University, is scoring the ground cover of key species within the quadrat. Photograph taken 1970-1972 by Dale Bartos, Colorado State University).

Figure 9. Measurement of below-ground biomass at the CPER/Pawnee grassland site, Colorado, USA. (Dale Bartos, Colorado State University, is using a root core sampler fitted with a slide-hammer. Photograph taken 1970-1972 by Dan Uresk, Colorado State University).

Figure 10. Soil coring apparatus mounted on the back of a pick-up truck at the CPER/Pawnee grassland site, Colorado, USA. (John Leetham, Research Technician, Colorado State University, is operating the soil corer; other persons not identified. Photograph taken April/May 1971 by Larry Nell, Colorado State University).

Figure 11. Close-up view of a soil core root sample at the CPER/Pawnee grassland site, Colorado, USA. (Photograph taken 1970 by Dale Bartos, Colorado State University).

Figure 12. Processing of replicate biomass samples, ready for drying and weighing, in the field laboratory at the CPER/Pawnee grassland site, Colorado, USA. (Photograph taken July 1971 by Larry Nell, Colorado State University).

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

7. References:

Dodd, J.L., and W.K. Lauenroth. 1979. Analysis of the response of a shortgrass ecosystem to stress, pp. 43-58. IN: French, N.R. (ed.). 1979. Perspectives in Grassland Ecology: Results and Applications of the US/IBP Grassland Biome Study. Springer-Verlag, New York. 204 pp.

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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.

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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, USA. doi:10.3334/ORNLDAAC/615.

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Sims, P.L., and J.S. Singh. 1978. The structure and function of ten western North American grasslands. III. Net primary production, turnover and efficiencies of energy capture and water use. Journal of Ecology 66: 573-597. doi:10.2307/2259152

Additional Sources of Information:

Bartos, D., and J. Hughes. 1969. Preliminary methodology and results ofroot biomass sampling on the Pawnee Site. US/IBP Grassland Biome Technical Report No. 2. Colorado State University, Fort Collins, Colorado.

Jameson, D.A. 1969. General description of the Pawnee site. US/IBP Grassland Biome Technical Report No. 1. Colorado State University, Fort Collins, Colorado.

Lauenroth, W.K., and P.L. Sims. 1973. Effects of water and nitrogen stresses on a shortgrass prairie ecosystem. US/IBP Grassland Biome Technical Report No. 232. Colorado State University, Fort Collins, Colorado.

Lauenroth, W.K., J.L. Dodd, and P.L. Sims. 1978. The effects of water-and nitrogen-induced stresses on plant community structure in a semiarid grassland. Oecologia 36(2): 211-222. doi:10.1007/BF00349810

Sims, P.L., J.S. Singh, and W.K. Lauenroth. 1978. The structure and function of ten western North American grasslands. I. Abiotic and vegetational characteristics. Journal of Ecology 66: 251-285. doi:10.2307/2259192

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Swift, D.M., and N.R. French. 1973. Basic field data collection procedures for the grassland biome. US/IBP Grassland Biome Technical Report No. 145. Colorado State University, Fort Collins, Colorado.

Uresk, D.W., and P.L. Sims. 1969. Preliminary methodology and results for aboveground herbage biomass sampling on the Pawnee Site. US/IBP Grassland Biome Technical Report No. 33. Colorado State University, Fort Collins, Colorado.

8. Data Set Revisions:

Revision Summary:

Data files (cpr1_npp.txt, cpr2_npp.txt, cpr3_npp.txt, and cpr4_npp.txt) have been revised to correct the elevation where above-ground biomass samples were collected. Four new data files have been added. The temporal coverage of this data set has been extended from 1970-1975 to 1939-1990.

Data File Changes:

The elevation where above-ground biomass samples were collected has been corrected to agree with Table 1 in Sims et al. (1978). The data values in **cpr1_npp_r1.txt**, **cpr2_npp_r1.txt**, **cpr3_npp_r1.txt**, and **cpr4_npp_r1**.txt are now correct.

ELEVATION (m)	
Uncorrected in cpr1_npp.txt, cpr2_npp.txt, cpr3_npp.txt, cpr4_npp.txt	**Corrected in cpr1_npp_r1.txt, cpr2_npp_r1.txt, cpr3_npp_r1.txt, cpr4_npp_r1.txt**
1,625	1,652

Data File Additions:

Four new data files have been added to this data set:

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FILE NAME	TEMPORAL COVERAGE	FILE CONTENTS	SOURCE
cpr5_npp.txt	1970/04/26-1975/08/18	Annual estimates of above-ground net primary production for control plot in CPER	Dodd and Lauenroth (1979)
cpr6_npp.txt	1939-1990	Annual estimates of above-ground forage biomass and ANPP for live and attached dead grasses, forbs, and sedges in CPER	Lauenroth and Sala (1992)
cpr7_npp.txt	1970-1972	ANPP estimates based on sum of harvested peak live weights of individual species during the growing season and BNPP estimates based on sum of harvested crown biomass and positive increments of root biomass by depth (0-20 cm)	Sims and Singh (1978)

		during growing season at Pawnee	
cpr8_npp.txt	1985-1988	ANPP and BNPP estimates from two methods: harvest clips and cores and 14C turnover in CPER	Milchunas and Lauenroth (1992)

Data User Action: If you downloaded the referenced data set from the ORNL DAAC on-line archive before 04-17-2015, you should download it again from the ORNL DAAC.

Revision History:

Original Citation:

Uresk, D., P. L. Sims, and J. L. Dodd. 1996. NPP Grassland: Central Plains Experimental Range (SGS), U.S.A., 1970-1975. 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/204