The Climates of the Long-Term Ecological Research Sites

Prepared by

The Climatology Committee
of the Long-Term Ecological Research Program
Editor: David Greenland

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PREFACE

The Long-Term Ecological Research (LTER) Program funded by the National Science Foundation (NSF), Division of Biotic Systems, is mandated to pursue ecological research over long time periods at a variety of sites throughout the United States. The program is overseen by a coordinating committee formed of the principal investigators of each site and by normal NSF peer and panel review procedures.

The LTER Climate Committee was established by the Coordinating Committee to produce a) the document *Standardization of Meteorological Measurements for Long-Term Ecological Sites* which was issued in June 1986, b) the present monograph *The Climates of Long-Term Ecological Sites,* and c) to stimulate studies in bioclimatology in the LTER program. This monograph thus represents the completion of the second task of the LTER Climate Committee. It has been reviewed by all members of the LTER Climate Committee. Dr. Lloyd Swift, in particular, made extensive editorial comments and I am also grateful to Ms. Kathleen Salzberg for copy editing the whole manuscript and Ms. Wendy Stout for drafting the diagrams. The monograph represents the official baseline description of the climates of the sites.

David Greenland.
Niwot Ridge/Green Lakes Valley Site
University of Colorado

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CHAPTER 5

COWEETA HYDROLOGIC LABORATORY, NORTH CAROLINA

Lloyd W. Swift

SITE DESCRIPTION

The Coweeta Hydrologic Laboratory covers two adjacent, east-facing, bowl-shaped valleys in the Nantahala Mountain chain of the Southern Appalachian Mountains in western North Carolina (Fig. 5.1). Streams drain into headwaters of the Little Tennessee River. Most research activity and all climatic data collection are centered on the larger, 1625 ha upper Coweeta Creek drainage. Elevations range from 675 m at the lower boundary to 1592 m at Albert Mountain on the dividing ridge between the Upper Nantahala and Little Tennessee rivers. Coweeta Creek divides near the lower research area boundary into Ball Creek and Shope Fork, two subdrainages of about equal size. Gaged experimental watersheds are located along the north-facing boundary of the Ball Creek drainage and the south-facing boundary of Shope Fork drainage with six additional watersheds in the headwaters of the east-facing, high elevation slope.

Climatic data in this chapter are collected primarily at station CS01 on the valley floor at elevation 685 m, latitude 35° 04'N, longitude 83° 26'W (Fig. 5.2). Data from this station is published monthly as "Coweeta Exp. Station", North Carolina Cooperative Observer No 2102, by the National Climatic Data Center. Data collection began in August 1934. CS01 is shielded by adjacent topography from north-northeast to southwest and opens only on the east to terrain of the same elevation. The vertical angle from the climatic station to ridgelines is 15 degrees to the south and north and 12 degrees to the west. The station is in a large grassy field, about 65 m from the nearest forest edge and 20 m from Shope Fork. CS01 experiences the usual phenomenon for a valley bottom site, i.e. diurnal cool air drainage and frequent fall morning fog cover. Solar radiation input is blocked by surrounding topography only during the beginning and ending hours of daylight when the solar altitude and intensity are least. Wind speed and direction are expected to be considerably different from conditions on the exposed high slopes or ridges. High humidities persist longer at CS01 than on the south-facing slopes. Thus, CS01 probably best represents the local climate along the streams and on the north-facing watersheds. Other climatic stations at Coweeta are at 820 m on the south-facing slope, 890 m on the north-facing slope, and 1190 m on the east-facing slope.

VEGETATION

The vegetation of the Coweeta Basin historically is in the oak-chestnut forest association but *Castanea dentata,* the dominant species, was lost from the overstory through chestnut blight in the 1930s and the forest is now classified as oak-hickory association. The plant communities are still changing, typically diverse, and distributed over highly varied topography in relation to temperature and moisture. Throughout the four major forest types, the predominant species composition is a mix of deciduous oaks and other species with abundant patches of evergreen undergrowth of *Rhododendron maximum* and *Kalmia latifolia.* The Northern Hardwood Type, characterized by *Betula lutea, Quercus rubra,* and other cooler climate species, occurs at higher elevations, mainly above 1200 m. The Cove Hardwood Type, found in moist coves and stream bottoms, is dominated by *Liriodendron* and *Tsuga canadensis* and other mesic species. The Oak Type is widely distributed over all slopes. *Quercus prinus* is the predominant species with *Q. coccinea* on drier slopes, *Q. alba* and *Q. velutina* at lower elevations and Carya on the moister north-facing slopes. *Pinus rigida* is a significant component in the Oak-Pine Type on ridges and drier slopes at low elevations. The natural deciduous forest is interrupted by three plantations of *Pinus strobus.*

SYNOPTIC CLIMATOLOGY

The climate of the Appalachian Mountains is distinguished from that of surrounding lowlands by characteristics of high precipitation, moderate temperatures and sustained evaporation rates. Under Köppen's system, Coweeta's climate is classed as Marine, Humid Temperate (Cfb). The lower elevations of the Coweeta Basin, including station CS01, are borderline between Marine and Humid Subtropical because the mean monthly temperatures in June and July are near 22 deg. C. According to Thornthwaite's classification, Coweeta is in the wet, mesothermal, adequate rainfall (AB'r) climate whereas his modified classification is perhumid, mesothermal with water surplus in all seasons.

Moist marine air masses are uplifted by the Appalachian mountains and annual rainfalls regularly exceed those for other locations in the eastern United States. Typically, storm fronts approach from the northwest, and winter storms tend to have longer durations if the cold air masses meet moist ones at the southern edge and movement is slowed by passage over the mountains. Short duration thundershowers are typical for mid-summer and fall with random occurrences of large rainfalls stimulated by hurricane disturbances near the Atlantic or Gulf coasts. Forty-nine percent of the 133 storms each year have total precipitation amount less than 5 mm, and 69 percent of the annual precipitation falls with an intensity less than 10 mm/h. Coweeta does not experience a distinct dry or low rain season; the probability of measurable precipitation for any date is 30 to 40 percent.

Temperatures are moderate because of the combination of low latitude and high (for the eastern United States) elevations. Snow is a minor part of the annual precipitation, averaging 2 to 5 percent depending upon elevation. Snow cover rarely lasts for more than 3 or 4 days, even on the upper slopes. Compared with other mountain sites, wind speeds at Coweeta appear to be low and even imperceptible in the valley bottom at CS01. The majority of precipitation falls when wind speed is less than 2.2 m/s and over 90 percent falls when wind is low or blowing from the south. Even so, wind action seems to cause precipitation catches to be reduced on or near ridgelines but greater on the north-facing slopes. Climatic data are presented in Table 5.1 and Figs. 5.3 and 5.4.

WATER BALANCE

Coweeta receives relatively large quantities of precipitation throughout the year which allows the values of potential evapotranspiration to be met in all seasons in most years. Lower values of actual evapotranspiration in the dormant season lead to a considerable soil moisture surplus which is realized primarily as streamflow. In summer, values of both potential and actual evapotranspiration are close to precipitation values suggesting that in some years localized soil moisture deficits will occur. Water balance data are given in Table 5.2 and Fig. 5.5.

CLIMATIC FACTORS AFFECTING FLORA AND FAUNA

In most years, winter precipitation totally recharges soil water storage so that growing seasons begin in May with an adequate moisture supply. Although high evapotranspiration rates exceed summer rainfall, soil moisture stress in plants typically does not appear until late summer. On warm sunny days in the dormant season, evapotranspiration continues and this is a significant factor in the greater water use by conifer over deciduous forest. Fifty-year mean annual precipitation ranges from 1812 mm at CS01 to 2386 mm at Mooney Gap near the Appalachian Trail (1364 m elevation). The 30-year moving average for CS01 ranges between 1775 and 1872 mm for the total period of record. Solar radiation intensity in mid summer is nearly equivalent on north- and south-facing slopes but in mid winter, the radiant energy received by a south slope does not fall below that for a horizontal surface in March. Winter ice damage of forest vegetation occurs in some years. Streams may be bridged by ice for a few days in some winters. Due to the southern latitude, stream temperatures are near the upper limit for a cold-water mountain aquatic habitat ranging from a mean minimum 6-8 deg. C in winter to a mean maximum of 16-18 deg. C on a south-facing slope in midsummer. Within the forest, soils are rarely frozen. For example, on the coldest day from the 50 year record at Coweeta, soil temperature at 10 cm stayed above 1 degree C even on the cold north-facing slope.

Fig. 5.1. Aerial view of Coweeta Hydrologic Laboratory looking west toward the Nantahala Mountains from the Little Tennessee River.

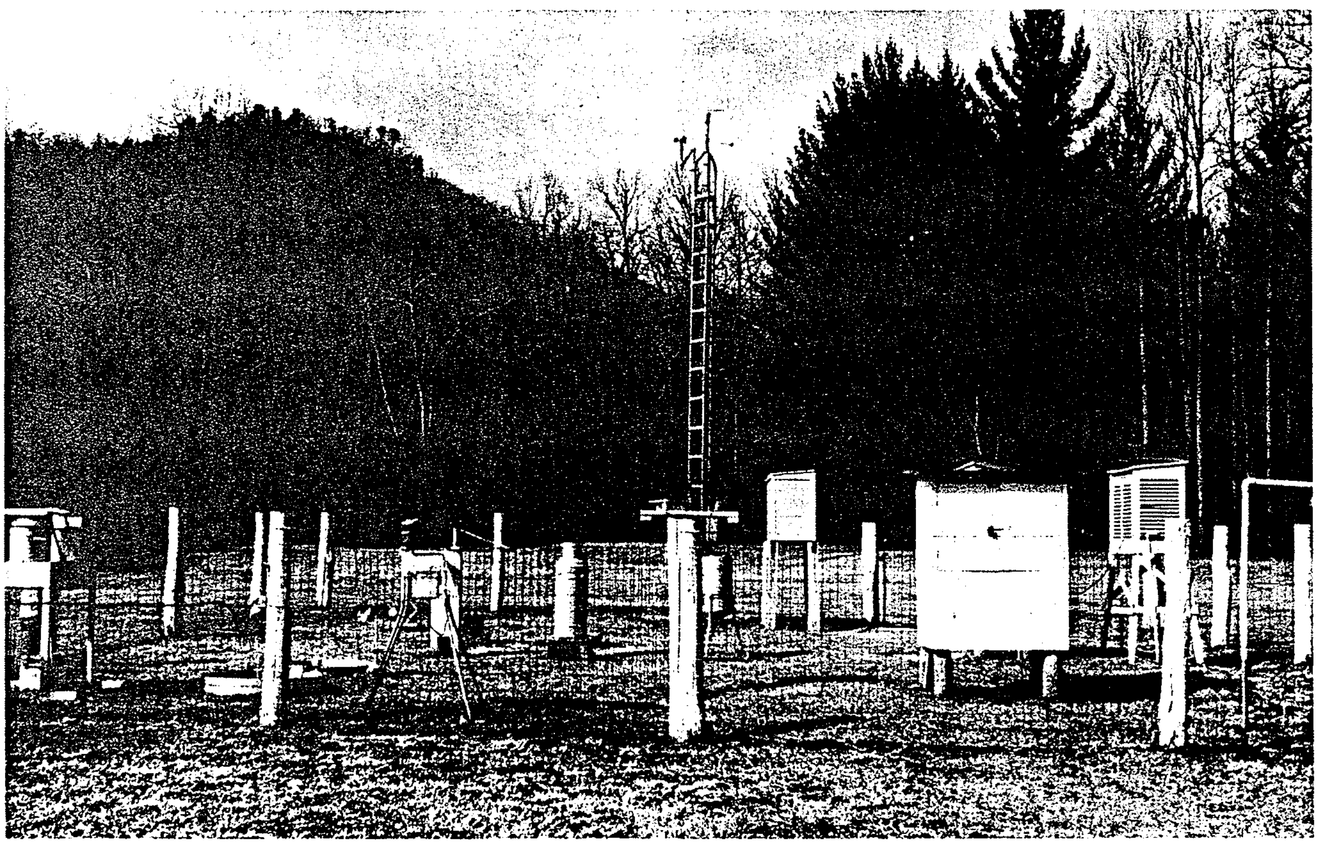

Fig. 5.2. The main climatic station CS01. Instrumentation includes samplers for atmospheric chemistry studies.

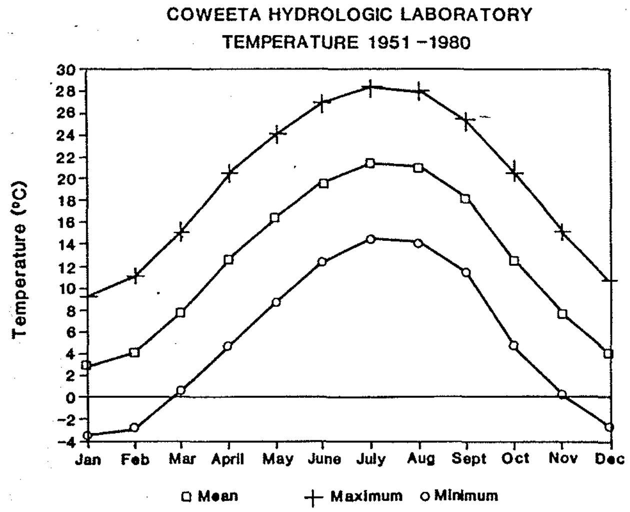

Fig. 5.3. Average annual temperature values at Coweeta Hydrologic Laboratory.

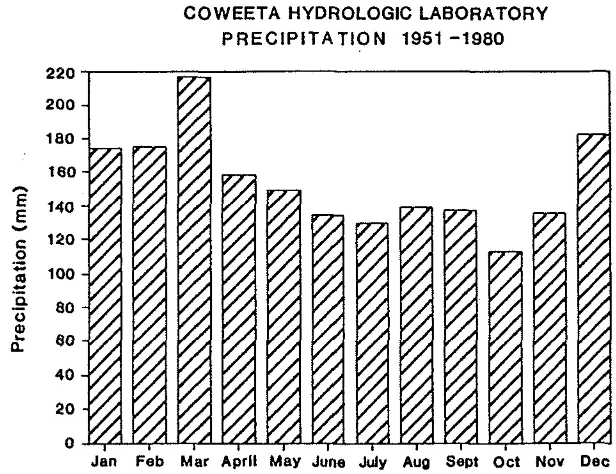

Fig. 5.4. Average annual precipitation totals at Coweeta Hydrologic Laboratory.

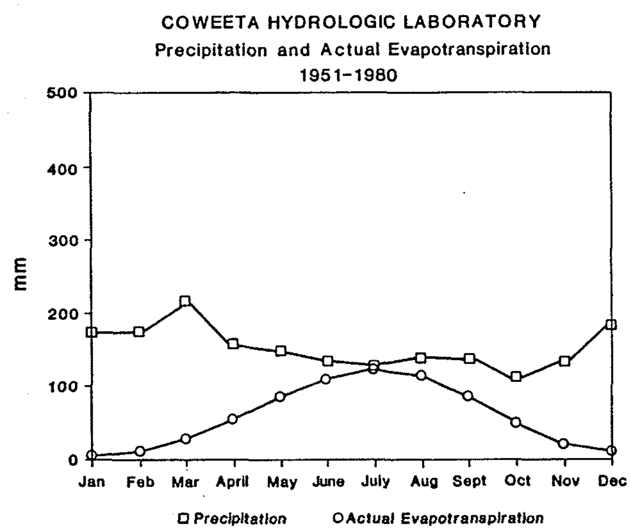

Fig. 5.5. Monthly water budget values at Coweeta Hydrologic . Laboratory.

Table 5.1

SUMMARY STATISTICS COWEETA HYDROLOGIC LABORATORY

TEMPERATURE
Deg. C.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mon Mean	2.95	4.22	7.89	12.70	16.41	19.75	21.50	21.24	18.46	12.74	7.74	4.13
An Mean	12.48	St Dev	0.47									
Mean Mx T	9.26	11.18	15.07	20.56	24.06	27.00	28.45	28.23	25.37	20.72	15.27	10.76
Mean Mi T	-3.38	-2.75	0.71	4.84	8.76	12.49	14.57	14.27	11.55	4.78	0.26	-2.51

Mean Temp Warmest Month	21.65	St Dev	0.75	
Mean Temp Coldest Month	1.87	St Dev	1.84	
Annual Range of Monthly Mean Temps		19.78		
Num months with mean temp >0		12		
Num months with mean temp >15		5		
Highest monthly mean		23.09		
Lowest monthly mean		-3.02		

PRECIPITATION
mm

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mon mean	174.0	175.0	217.0	159.0	149.0	135.0	130.0	139.0	137.0	113.0	136.0	183.0
Mean annual total		1848.0										
Wettest year in period			2315									
Driest year in period			1392									

Monthly totals during wettest year in period — Year 1979

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
246	164	279	253	229	77	229	161	245	95	281	57

Monthly totals during driest year in period — Year 1978

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
258	30	152	72	146	68	83	203	28	7	111	234

Total precip in months with temp >0   1848

Table 5.2

WATER BALANCE FOR COWEETA HYDROLOGIC LABORATORY

Water budget for Latitude 35.0 N, Longitude 83.5 W
Field capacity 70.0 mm Resistance curve C

MON	TEMP	UPE	APE	PREC	DIFF	ST	DST	AE	DEF	SURP	SMT	SST
Jan	3.0	7	6	174	168	70	0	6	0	168	0	0
Feb	4.2	12	10	175	165	70	0	10	0	165	0	0
Mar	7.9	27	28	217	189	70	0	28	0	189	0	0
Apr	12.7	51	55	159	104	70	0	55	0	104	0	0
May	16.4	71	86	149	63	70	0	86	0	63	0	0
Jun	19.8	91	110	135	25	70	0	110	0	25	0	0
Jul	21.5	102	125	130	5	70	0	125	0	5	0	0
Aug	21.2	100	116	139	23	70	0	116	0	23	0	0
Sep	18.5	83	86	137	51	70	0	86	0	51	0	0
Oct	12.7	51	49	113	64	70	0	49	0	64	0	0
Nov	7.7	26	22	136	114	70	0	22	0	114	0	0
Dec	4.1	11	10	183	173	70	0	10	0	173	0	0
	Yearly Totals:		702	1847				702	0	1145		

Explanation for Water Balance Columns. (All units are millimeters depth of water unless otherwise specified.)

MON	Month of the year
TEMP	Mean monthly air temperature in deg. C.
UPE	Unadjusted potential evapotranspiration
APE	Adjusted potential evapotranspiration
PREC	Precipitation
DIFF	PREC minus APE
ST	Soil moisture storage
DST	Change in storage from preceeding month
AE	Actual evapotranspiration
DEF	Soil moisture deficit
SURP	Soil moisture surplus
SMT	Snowmelt
SST	Water equivalent held in snowpack.