



Eighteen Years (1990–2007) of Climatological Data on NMSU’s Corona Range and Livestock Research Center

Research Report 761

L. Allen Torell, Kirk C. McDaniel, Shad Cox, Suman Majumdar¹

Agricultural Experiment Station • College of Agriculture and Home Economics

INTRODUCTION

Range forage production on the Corona Range and Livestock Research Center (CRLRC) is tied closely to climate and weather conditions, especially seasonal rainfall amounts. Range and livestock management decisions are dependent on weather information and informed judgment about what those weather conditions will be in the near and distant future. Further, numerous research projects conducted at the CRLRC are influenced by climatological factors and require historical and current data about weather conditions.

The objectives of this research report are to describe the climatic data of the CRLRC over the 18-year period for which detailed climate data exist, and to provide a baseline method by which these data can be updated and made available online for use by CRLRC researchers and others interested in weather conditions near Corona, New Mexico. These weather data are updated regularly and are available from the Corona Ranch web site (NMSU-CRLRC, 2007) at <http://agecon.nmsu.edu/corona>. The charts and tables provided in this report link the reader to appropriate spreadsheets and databases available online. Many of these charts are presented as pivot charts and pivot tables in Access and Excel. The knowledgeable user can download, query, and extract updated data for their specific use. Additional daily and hourly data not reported in this research report are available at the web site. An intermediate knowledge of Access and Excel is assumed for electronic data access.

WEATHER DATA AVAILABLE FOR THE CORONA RANCH

The weather data reported for the CRLRC were accumulated from multiple sources, including four instrumented weather stations located on the ranch and eight rainfall gauges scattered at various locations across the ranch (Figure 1). The data are available for various temporal scales, from long-term averages down to seasonal, monthly, daily, and hourly averages. Daily and hourly weather observations are not reported in this research report but are available in spreadsheets and databases maintained at the Corona Ranch web site. The data are in varying degrees of completeness, especially at the hourly level.

Weather observations have been made on the Corona Ranch since 1990, at instrumented research sites referred to as *South House* (SH) (Latitude: 34° 16' 43" N, Longitude: 105° 23' 35" W, Elevation: 6,032 feet) and *Oil Well* (OW) (Latitude: 34° 17' 9" N, Longitude: 105° 21' 37" W, Elevation: 5,924 feet). Recorded data include hourly measurements of precipitation, air temperature, soil temperature at 10 cm (4 inches) and 50 cm (20 inches), relative humidity, wind speed and direction, and soil moisture at 10 cm (4 inches) and between 10 cm and 30 cm (4–12 inches). Approximately 88% of the elapsed hours over the July 1990 through 2007 period recorded a reading that appeared correct and was not clearly a missing or invalid recording.

Missing data for selected variables were substituted in the database from other automated weather stations located on the ranch, primarily the other research site (SH or OW) when available, and the NMSU New Mexico Climate Center automated weather station located at the North Camp facility on the Corona Ranch (NMCC, 2007). A paired t-test of all annual rainfall totals at SH and OW, excluding replaced data, indicated that rainfall totals were not statistically different between the two sites.

Table of Contents _____ Page

Introduction	1
Weather Data Available For The Corona Ranch	1
Results.....	3
Rainfall	3
Soil Moisture.....	4
Air Temperature	13
Soil Temperature	20
Relative Humidity.....	20
Wind Speed and Direction.....	20
Updated Data Access	20
References	20

¹ Respectively, Professor, Department of Agricultural Economics and Agricultural Business; Professor, Department of Animal and Range Sciences; Superintendent, Corona Range and Livestock Research Center; and former Graduate Research Assistant, Department of Agricultural Economics and Agricultural Business, all of New Mexico State University, Las Cruces.

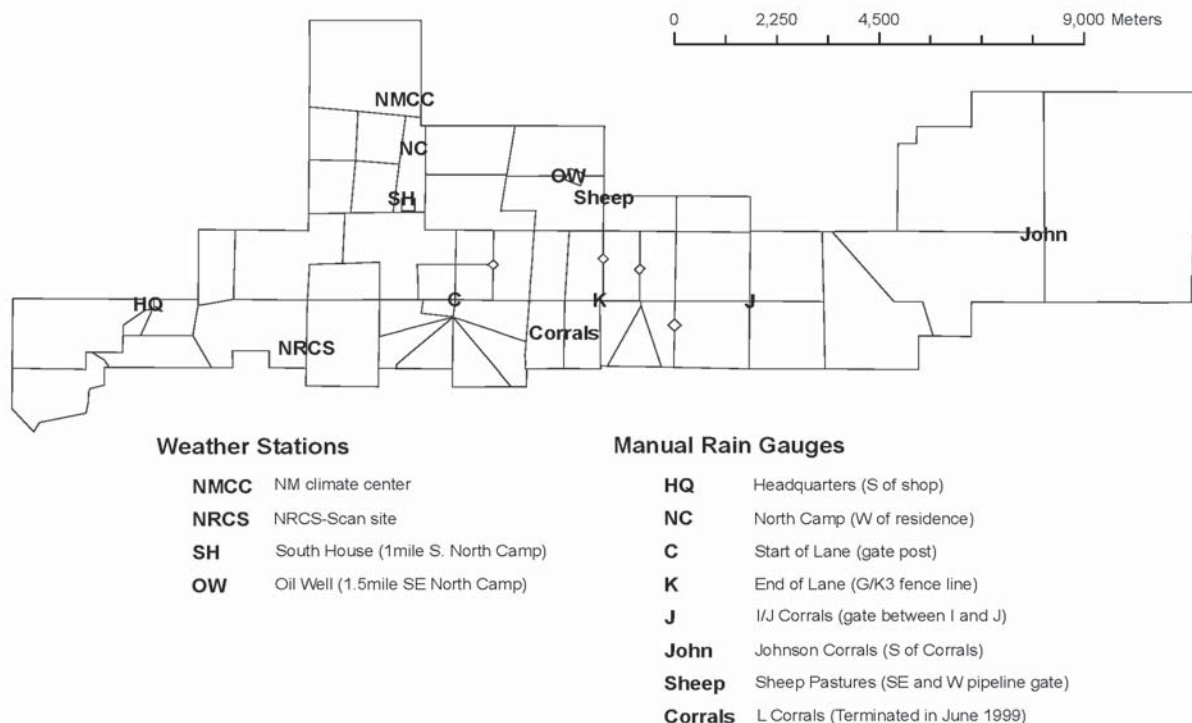


Figure 1. Weather monitoring locations on the Corona Ranch.

National Oceanic and Atmospheric Administration (NOAA) data from the Ramon and Corona 10 SW sites (WRCC, 2007) were also used to fill in missing data from 1990 through 1992. Variables are included in the Access database that identify which records were replaced from alternative sources and from where the data came. With these substitutions, the Access file titled “Corona_SH_and_OW_Weather_Data.mdb” includes a complete daily record for rainfall amounts over the period July 17, 1990 through December 31, 2007. Hourly estimates are provided over most days for both research sites.

Located at the North Camp facility (Latitude: 34° 17’ 47.98” N, Longitude: 105° 23’ 44.74” W, Elevation: 6,155 feet) on the Corona Ranch is another automated weather station included in the NMSU Climate Network, with weather observations made since 1993. Reported data include daily measurements of temperature, humidity, precipitation, wind speed and direction, solar radiation, and soil temperature (NMCC, 2007). These data are available online at <http://weather.nmsu.edu> and are not reported here.

Historical weather data, recorded prior to 1990, are not available on the Corona Ranch, but various estimates from nearby cooperating weather sites linked from the New Mexico Climate Center (NMCC, 2007) and from other Western Regional cooperator weather stations (NMCC, 2007; UCC, 2007) are available.

Relevant cooperator sites include the Corona site (1914–1977; WRCC, 2007; inactive station), Corona 11 SW (December 1977–September 1992; WRCC, 2007; inactive station), Corona 10 SW (October 1992–May 2006; UCC, 2007; active station), and Ramon 8 SW (March 1957–May 2006; UCC 2007; active station).

Soil volumetric water content (volume of water per volume of soil) at the SH and OW sites was recorded starting in 2001, using time domain reflectory (TDR) moisture probes (CS 615-L, Campbell Scientific Inc., Logan, UT, 1996). The two TDR probes are buried in the same configuration at each site, with one placed horizontally into the soil profile at a 10 cm depth and with the second probe positioned vertically at a 10 to 30 cm depth. All instrument readings are taken at one-minute intervals and averaged hourly.

The Natural Resources Conservation Service (NRCS) maintains a Soil Climate Analysis Network (SCAN) site on the Corona Ranch referred to as the “Adams site” (Figure 1) (Latitude: 34° 15’ N, Longitude: 105° 25’ W, Elevation: 6,175 feet). Automated SCAN sites collect soil moisture and soil temperature data along with precipitation, wind, and solar radiation data. SCAN sites are located throughout the United States and other global locations, and the data are used for the management and prediction of climatic issues affecting natural resources. The Adams site facility records hourly with soil moisture measured at 2, 4, 8, 20, and

40 inches (NRCS, 2007). Soil moisture data recorded at the NRCS Adams site use a TDR Hydra Probe II (Stevens Water Monitoring Systems, 2007). Though the Adams site was initiated in 1994, rainfall measurements appear to be complete and accurate only after October 2003. Apparently, valid soil moisture measurements begin at the Adams site in 1997. The Adams site data are downloaded monthly and maintained on the Corona web site in a database called “Adams_Weather.mdb.”

RESULTS

Rainfall

Long-term average rainfall for the Corona, New Mexico, area recorded between 1914 and 2006 was 14.6 inches with a standard deviation of 4.7 inches (Table 1). The minimum annual rainfall over the 1914–2007 period occurred in 1917 (5.81 inches) and the maximum occurred in 1941 (36 inches) (Figure 2). A similar extreme was recorded in many parts of New Mexico during 1941.

Table 1. Average, Minimum, Maximum, and Median Precipitation (in inches with mm in parentheses) Recorded by Month At or Near the Corona Ranch, 1914–2006

Month	Average	Standard Deviation	Minimum	Maximum	Median	<i>n</i>
Jan	0.64 (15.9)	0.71 (16.3)	0.00 (0.0)	4.84 (92.0)	0.51 (12.8)	92
Feb	0.70 (17.5)	0.72 (17.4)	0.00 (0.0)	3.83 (88.1)	0.52 (13.8)	92
Mar	0.74 (18.9)	0.73 (18.4)	0.00 (0.0)	3.30 (83.8)	0.54 (13.7)	92
Apr	0.73 (18.5)	0.95 (24.2)	0.00 (0.0)	5.81 (147.6)	0.40 (10.3)	92
May	1.11 (28.3)	1.13 (28.7)	0.00 (0.0)	5.91 (150.1)	0.82 (20.8)	92
Jun	1.27 (32.2)	1.06 (26.7)	0.00 (0.0)	5.40 (137.2)	0.99 (25.1)	92
Jul	2.45 (62.4)	1.36 (34.3)	0.10 (2.5)	5.56 (141.2)	2.19 (57.1)	92
Aug	2.75 (69.9)	1.55 (39.4)	0.00 (0.0)	7.68 (195.1)	2.45 (62.2)	92
Sep	1.70 (43.2)	1.48 (37.7)	0.00 (0.0)	9.08 (230.6)	1.47 (37.3)	92
Oct	1.13 (28.8)	1.02 (25.9)	0.00 (0.0)	4.54 (115.3)	0.86 (21.8)	92
Nov	0.59 (15.0)	0.62 (15.8)	0.00 (0.0)	3.04 (77.2)	0.45 (11.4)	92
Dec	0.77 (19.5)	0.76 (19.2)	0.00 (0.0)	3.30 (83.8)	0.51 (13.0)	92
Annual	14.59 (370.1)	4.68 (118.6)	5.81 (147.6)	36.11 (917.2)	14.36 (364.8)	92

Period: 1914–2006 (excluding 1977, when data was very incomplete). Weather Stations: Corona (1914–1976), NOAA Corona 11W (1976–1989), Oil Well and South House with some data from NOAA (1990–2006).

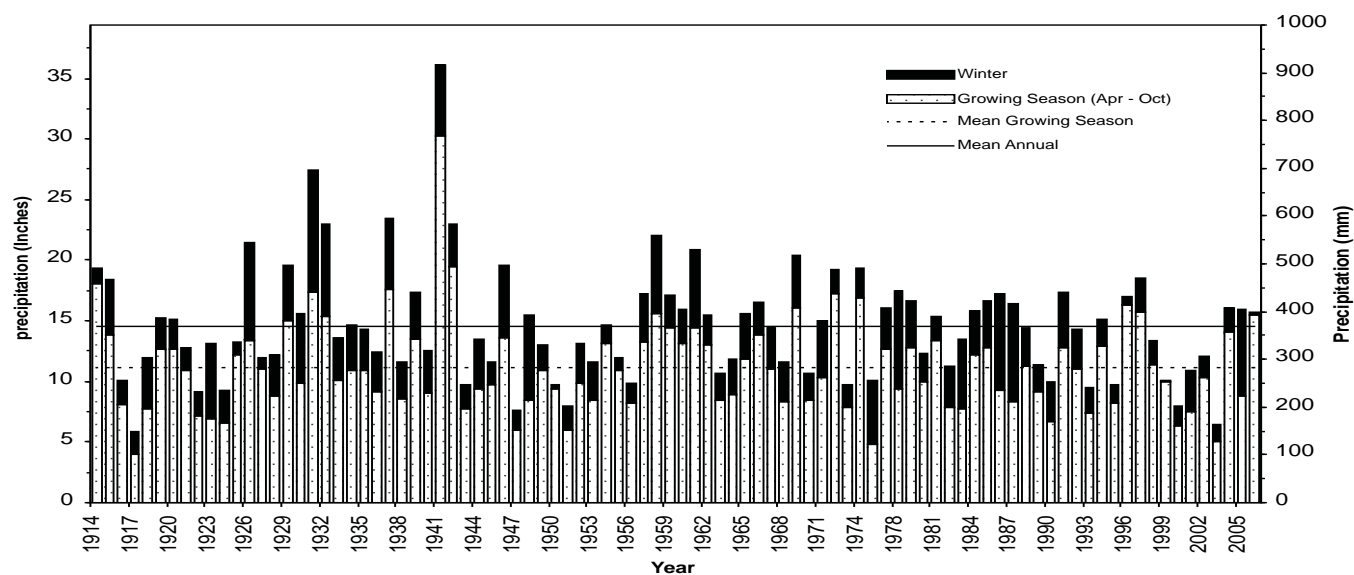


Figure 2. Historical Corona area seasonal and annual rainfall amounts.

Tables 2 through 4 show monthly rainfall amounts recorded at automated weather stations located at the SH, OW, and Adams sites (inches, mm, and combined averages across sites). Table 5 (inches) and Table 6 (mm) show monthly rainfall totals recorded at rain gauges scattered across the ranch (Figure 1). Figure 3 graphs average annual amounts recorded at the SH and OW sites. The 6-month growing season rainfall (considered to be April–October) usually made up well over half of the annual total rainfall amount. Seasonal extremes were realized in both 2005 and 2006. The winter of 2004–2005 was one of the wettest on record, whereas no daily rainfall total exceeded 6 mm (0.25 inches) on the ranch from mid-October 2005 until May 2006. This is not unlike many areas in New Mexico where drought conditions that started in the late 1990s were interrupted in late 2004 with one of the wettest winters on record, followed by a normal to above-average moisture year once the monsoon season started in June 2006. For some locations in the state, November 2005 to May 2006 precipitation was the lowest historically recorded amount.

New Mexico is influenced by the North American monsoon and gets 40 to 50% of annual rainfall during the monsoon season (late June through early October). One-third of the days during quarter 3 had measurable rainfall events as compared to 15 to 18% of days during the other quarters. There are many dry and sunny days on the Corona Ranch. As shown in Figure 4, on 79% of the days in the year (290 days) it typically does not rain or snow. Dry days occurred only 66% of the time during quarter 3.

On the 75 days a year that it does typically rain, it rains less than 0.25 inch (6.4 mm) 64% of the time.

These small rainfall events are most common during quarter 1 and quarter 4 (Figure 4). Rain events over the day exceeded 0.50 inch (12.7 mm) about 20% of the time. When it does rain, it rains over 1 inch about 9% of the time. These large storms rarely occur during the winter period (< 5% of days) (Figure 4).

Soil Moisture

Soil moisture data are available from the Adams site starting in 1997 and from the OW and SH sites starting in 2001. As noted earlier, data were recorded at two depths at the OW and SH sites (4 inches and from 4 to 12 inches) and at five depths at the Adams site (2, 4, 8, 20, and 40 inches). Soil moisture levels for the Adams site are not detailed in this report but are available at the Corona Ranch web site.

Figures 5 and 6 plot midnight recorded soil moisture at 10 cm (4 inches) at the SH and OW site from 2002 through 2007. Also shown on the graphs are daily rainfall amounts in mm. At the 10 cm (4 inch) depth, the OW data logger consistently recorded about 20% higher than the SH data logger. At the 10–30 cm depth, soil moisture recorded at the SH site was about 6% higher than at the OW site. The Adams site had a consistently lower recording and the range of data was much less. This is likely due to differences in how the probes were calibrated.

The change in daily soil moisture was tied closely to the size of the recorded rainfall event, as would be expected. For those days when valid soil moisture recordings were made, average daily changes in soil moisture increased with the amount of rainfall recorded. It took

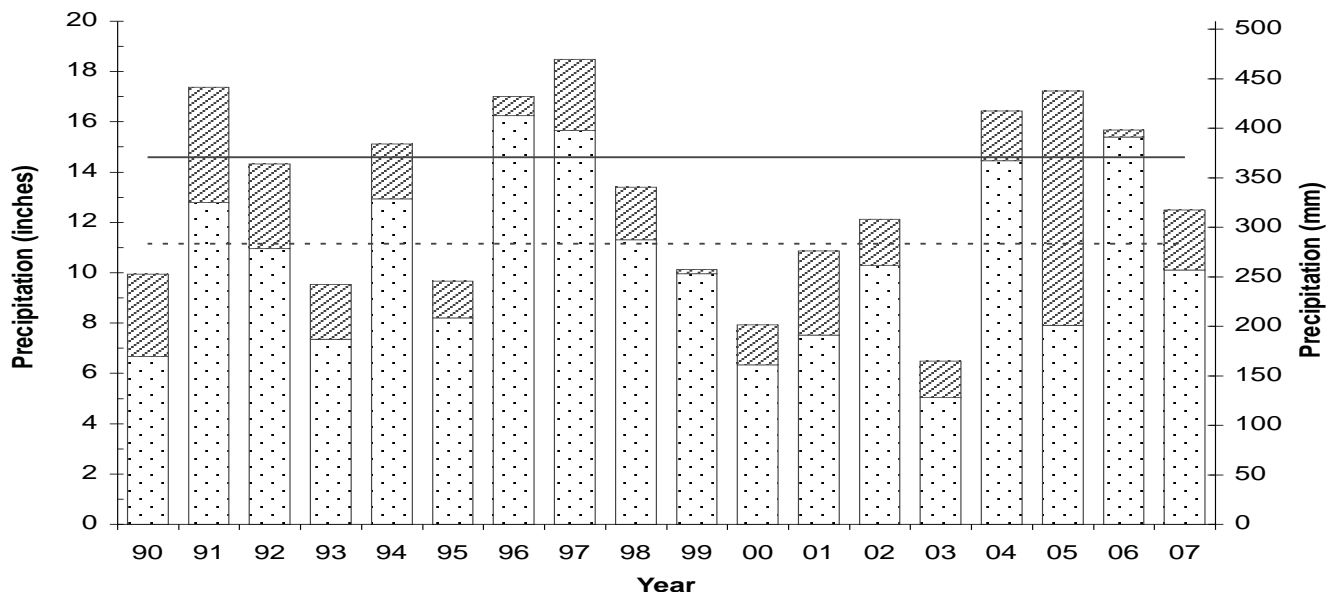


Figure 3. Average annual and growing season (April–October) (bottom bar and dotted line) rainfall recorded at the SH and OW research sites (1990–2007) as compared to 1914–2006 long-term averages.

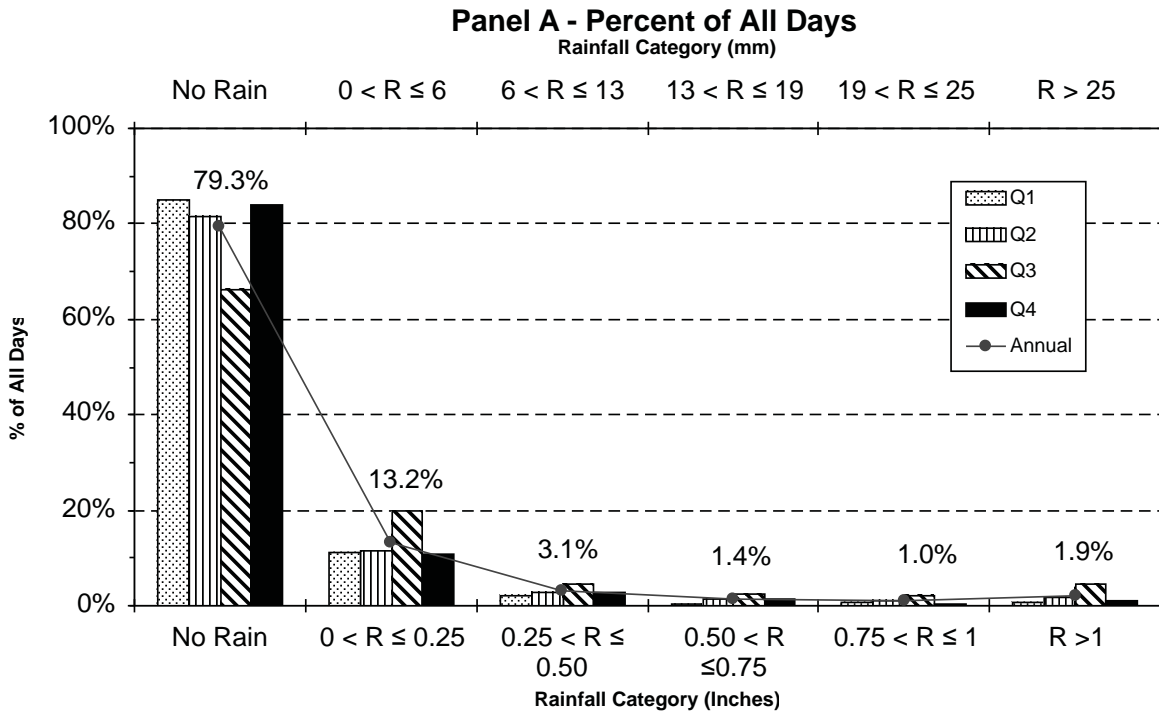


Figure 4a. Rainfall frequency by amount category, Sept. 24, 1989 to July 3, 2007, at SH and OW sites.

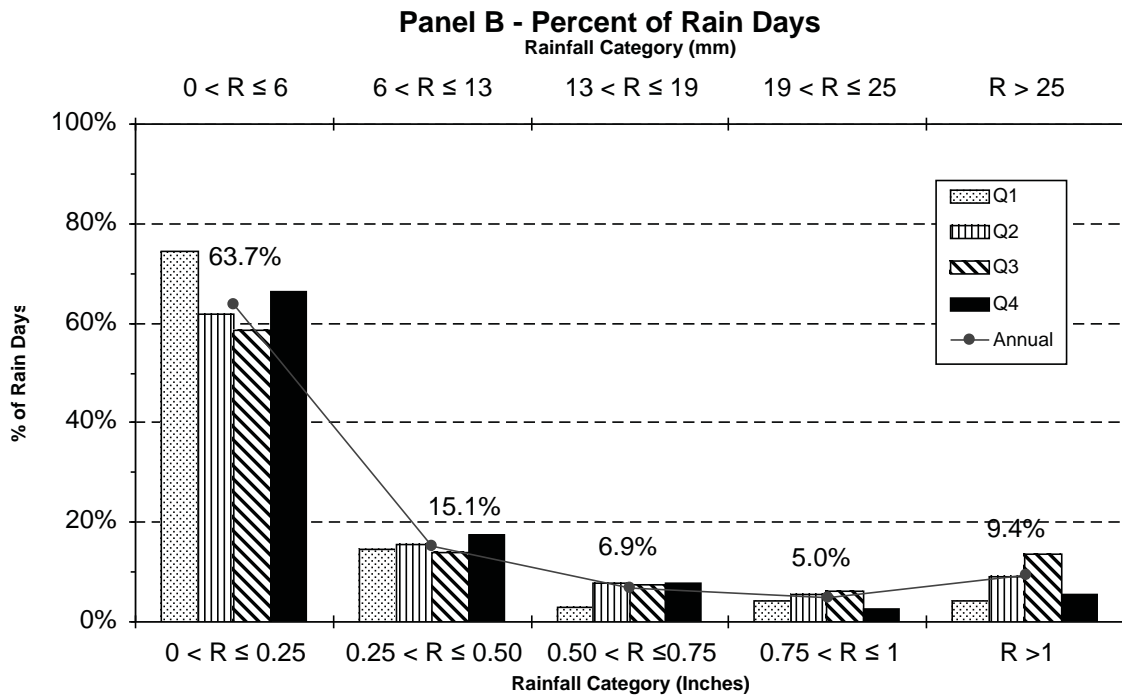


Figure 4b. Rainfall frequency by amount category, Sept. 24, 1989 to July 3, 2007, at SH and OW sites.

Table 2. Total Monthly Precipitation (inches) Recorded at OW, SH, and Adams Weather Stations, 1990–2007*

Site OW													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1990	0.57	0.89	1.12	0.86	0.70	0.24	3.07	0.00	1.63	0.56	0.40	0.30	10.34
1991	0.20	0.17	0.45	0.00	1.34	0.93	3.58	2.69	2.63	0.69	1.40	2.42	16.50
1992	1.28	0.44	1.12	0.58	5.37	0.97	2.46	2.68	0.46	0.70	0.18	0.30	16.54
1993	0.68	0.48	0.19	0.23	0.78	1.59	1.65	1.66	0.31	1.65	0.55	0.15	9.92
1994	0.10	0.08	0.54	0.52	4.24	0.83	2.08	3.79	1.64	1.19	0.76	0.73	16.50
1995	0.31	0.28	0.61	0.41	0.59	0.96	2.07	2.10	1.71	0.00	0.06	0.25	9.35
1996	0.13	0.26	0.07	0.03	0.00	3.01	4.80	5.05	2.08	1.28	0.32	0.00	17.03
1997	0.15	1.12	0.11	2.18	1.13	3.34	1.52	4.17	2.51	0.65	0.52	0.94	18.34
1998	0.06	0.52	1.24	0.53	0.00	0.01	2.46	3.97	1.28	3.12	0.21	0.38	13.78
1999	0.00	0.00	0.00	0.65	1.20	1.48	3.41	1.69	1.16	0.35	0.00	0.17	10.11
2000	0.00	0.01	1.01	0.28	0.01	2.16	0.41	0.50	0.04	2.81	0.41	0.25	7.89
2001	0.42	0.70	0.75	0.18	1.11	0.70	1.45	2.78	0.93	0.20	1.22	0.20	10.64
2002	0.10	0.37	0.13	0.02	0.00	0.69	3.75	1.50	2.83	1.16	0.23	0.80	11.59
2003	0.00	0.25	0.36	0.30	0.41	0.31	1.73	0.82	0.44	1.07	0.54	0.24	6.47
2004	0.30	0.49	0.12	4.54	0.12	1.90	2.36	2.71	0.87	2.11	0.73	0.36	16.61
2005	4.84	3.83	0.62	0.26	2.55	0.00	0.00	1.19	1.38	1.19	0.01	0.00	15.86
2006	0.00	0.00	0.10	0.21	0.35	0.82	2.82	5.85	1.99	2.62	0.00	0.16	14.92
2007	0.00	0.17	1.51	0.41	2.87	1.65	1.37	1.03	2.03	0.49	0.55	0.42	12.50
Average	0.51	0.56	0.56	0.68	1.27	1.20	2.28	2.45	1.44	1.21	0.45	0.45	13.05

Site SH													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1990	0.57	0.89	1.12	0.86	0.70	0.24	2.28	0.00	1.63	0.56	0.41	0.29	9.55
1991	0.18	0.17	0.41	0.00	1.34	1.17	3.58	4.32	2.63	0.69	1.35	2.42	18.26
1992	1.28	0.44	1.30	0.53	5.36	0.62	0.04	0.77	0.67	0.73	0.16	0.21	12.11
1993	0.74	0.53	0.30	0.08	0.66	1.30	1.90	1.66	0.25	0.98	0.58	0.17	9.15
1994	0.09	0.09	0.50	0.39	3.79	0.74	1.82	2.22	1.53	1.10	0.74	0.74	13.75
1995	0.30	0.26	0.61	0.33	0.77	0.89	1.86	2.81	1.89	0.01	0.06	0.20	9.99
1996	0.16	0.20	0.06	0.02	0.00	3.01	4.80	5.05	2.08	1.28	0.32	0.00	16.98
1997	0.19	1.07	0.10	2.09	1.25	3.63	1.52	4.17	2.51	0.65	0.52	0.94	18.64
1998	0.00	0.20	1.02	0.48	0.03	0.01	2.71	3.75	1.47	2.81	0.20	0.33	13.01
1999	0.00	0.00	0.00	0.55	1.63	1.44	3.27	1.53	1.30	0.28	0.00	0.14	10.14
2000	0.00	0.00	0.92	0.28	0.05	2.04	0.41	0.50	0.04	3.15	0.40	0.19	7.98
2001	0.36	0.72	0.60	0.25	1.55	0.64	1.76	1.77	1.47	0.27	1.50	0.22	11.11
2002	0.19	0.34	0.21	0.02	0.00	0.69	3.50	1.83	3.46	1.13	0.40	0.89	12.67
2003	0.00	0.24	0.40	0.30	0.67	0.47	0.96	1.21	0.30	1.09	0.55	0.30	6.49
2004	0.26	0.52	0.15	4.12	0.24	1.18	1.98	3.96	0.92	1.90	0.68	0.36	16.27
2005	4.84	3.83	0.68	0.26	2.17	0.94	0.91	2.65	1.21	1.10	0.01	0.00	18.59
2006	0.00	0.00	0.12	0.15	0.26	0.89	3.55	6.74	2.03	2.52	0.00	0.16	16.42
2007	0.00	0.08	1.10	0.39	3.18	1.63	1.73	0.58	2.85	0.00	0.55	0.42	12.51
Average	0.51	0.53	0.53	0.62	1.31	1.20	2.14	2.53	1.57	1.12	0.47	0.44	12.98

Site Adams													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
2004	0.30	0.64	0.17	4.33	0.48	1.23	2.49	2.49	0.77	1.65	0.63	0.15	15.33
2005	1.19	1.08	0.62	0.26	2.44	1.13	1.11	3.15	1.20	1.13	0.00	0.00	13.31
2006	0.00	0.00	0.09	0.27	0.32	1.33	2.79	6.02	2.24	2.65	0.00	0.02	15.73
2007	0.35	0.09	0.92	0.76	2.73	1.43	1.54	1.25	2.39	0.48	0.04	0.88	12.86
Average	0.46	0.45	0.45	1.41	1.49	1.28	1.98	3.23	1.65	1.48	0.17	0.26	14.31

*Bold number is highest recorded monthly precipitation over the period. Rows with incomplete data are not included in the average.

Table 3. Total Monthly Precipitation (mm) Recorded at OW, SH and Adams Weather Stations, 1990–2007*

Site OW													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1990	14	23	28	22	18	6	78	0	41	14	10	8	263
1991	5	4	11	0	34	24	91	68	67	18	36	61	419
1992	33	11	28	15	136	25	62	68	12	18	5	8	420
1993	17	12	5	6	20	40	42	42	8	42	14	4	252
1994	3	2	14	13	108	21	53	96	42	30	19	19	419
1995	8	7	15	10	15	24	53	53	43	0	2	6	237
1996	3	7	2	1	0	76	122	128	53	33	8	0	433
1997	4	28	3	55	29	85	39	106	64	17	13	24	466
1998	2	13	31	13	0	0	62	101	33	79	5	10	350
1999	0	0	0	17	30	38	87	43	29	9	0	4	257
2000	0	0	26	7	0	55	10	13	1	71	10	6	200
2001	11	18	19	5	28	18	37	71	24	5	31	5	270
2002	3	9	3	1	0	18	95	38	72	29	6	20	294
2003	0	6	9	8	10	8	44	21	11	27	14	6	164
2004	8	12	3	115	3	48	60	69	22	54	19	9	422
2005	123	97	16	7	65	0	0	30	35	30	0	0	403
2006	0	0	3	5	9	21	72	149	51	67	0	4	379
2007	0	4	38	10	73	42	35	26	52	12	14	11	317
Average	13	14	14	17	32	30	58	62	37	31	11	11	331

Site SH													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1990	14	23	28	22	18	6	58	0	41	14	10	7	243
1991	5	4	10	0	34	30	91	110	67	18	34	61	464
1992	33	11	33	13	136	16	1	20	17	19	4	5	308
1993	19	13	8	2	17	33	48	42	6	25	15	4	232
1994	2	2	13	10	96	19	46	56	39	28	19	19	349
1995	8	7	15	8	20	23	47	71	48	0	2	5	254
1996	4	5	2	1	0	76	122	128	53	33	8	0	431
1997	5	27	3	53	32	92	39	106	64	17	13	24	473
1998	0	5	26	12	1	0	69	95	37	71	5	8	330
1999	0	0	0	14	41	37	83	39	33	7	0	4	258
2000	0	0	23	7	1	52	10	13	1	80	10	5	203
2001	9	18	15	6	39	16	45	45	37	7	38	6	282
2002	5	9	5	1	0	18	89	46	88	29	10	23	322
2003	0	6	10	8	17	12	24	31	8	28	14	8	165
2004	7	13	4	105	6	30	50	101	23	48	17	9	413
2005	123	97	17	7	55	24	23	67	31	28	0	0	472
2006	0	0	3	4	7	23	90	171	52	64	0	4	417
2007	0	2	28	10	81	41	44	15	72	0	14	11	318
Average	13	14	14	16	33	30	54	64	40	29	12	11	330

Site Adams													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
2004	8	16	4	110	12	31	63	63	20	42	16	4	389
2005	30	27	16	7	62	29	28	80	30	29	0	0	338
2006	0	0	2	7	8	34	71	153	57	67	0	1	400
2007	9	2	23	19	69	36	39	32	61	12	1	22	327
Average	12	11	11	36	38	33	50	82	42	38	4	7	363

*Bold number is highest recorded monthly precipitation over the period. Rows with incomplete data are not included in the average.

Table 4a. Average Total Monthly Precipitation (inches) Averaged Across OW and SH Weather Stations.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct Total	Winter Total	Annual Total
1990	0.57	0.89	1.12	0.86	0.70	0.24	2.67	0.00	1.63	0.56	0.40	0.29	6.66	3.28	9.94
1991	0.19	0.17	0.43	0.00	1.34	1.05	3.58	3.50	2.63	0.69	1.37	2.42	12.79	4.59	17.38
1992	1.28	0.44	1.21	0.56	5.36	0.79	1.25	1.73	0.56	0.71	0.17	0.25	10.97	3.35	14.32
1993	0.71	0.50	0.24	0.15	0.72	1.44	1.77	1.66	0.28	1.32	0.56	0.16	7.35	2.18	9.53
1994	0.09	0.08	0.52	0.45	4.02	0.79	1.95	3.01	1.58	1.14	0.75	0.73	12.94	2.18	15.13
1995	0.30	0.27	0.61	0.37	0.68	0.92	1.97	2.45	1.80	0.00	0.06	0.22	8.20	1.47	9.67
1996	0.14	0.23	0.06	0.02	0.00	3.01	4.80	5.05	2.08	1.28	0.32	0.00	16.25	0.76	17.01
1997	0.17	1.09	0.10	2.14	1.19	3.49	1.52	4.17	2.51	0.65	0.52	0.94	15.66	2.83	18.49
1998	0.03	0.36	1.13	0.50	0.01	0.01	2.59	3.86	1.37	2.96	0.20	0.35	11.32	2.08	13.40
1999	0.00	0.00	0.00	0.60	1.41	1.46	3.34	1.61	1.23	0.31	0.00	0.15	9.97	0.15	10.13
2000	0.00	0.00	0.97	0.28	0.03	2.10	0.41	0.50	0.04	2.98	0.40	0.22	6.34	1.60	7.93
2001	0.39	0.71	0.67	0.21	1.33	0.67	1.60	2.28	1.20	0.23	1.36	0.21	7.53	3.34	10.87
2002	0.14	0.35	0.17	0.02	0.00	0.69	3.62	1.66	3.14	1.14	0.31	0.84	10.29	1.83	12.13
2003	0.00	0.24	0.38	0.30	0.54	0.39	1.34	1.02	0.37	1.08	0.54	0.27	5.04	1.44	6.48
2004	0.28	0.50	0.13	4.33	0.18	1.54	2.17	3.33	0.89	2.00	0.70	0.36	14.46	1.98	16.44
2005	4.84	3.83	0.65	0.26	2.36	0.47	0.45	1.92	1.29	1.14	0.01	0.00	7.90	9.32	17.23
2006	0.00	0.00	0.11	0.18	0.30	0.85	3.18	6.30	2.01	2.57	0.00	0.16	15.40	0.27	15.67
2007	0.00	0.12	1.31	0.40	3.03	1.64	1.55	0.80	2.44	0.24	0.55	0.42	10.10	2.40	12.50
Average	0.51	0.55	0.55	0.65	1.29	1.20	2.21	2.49	1.50	1.17	0.46	0.45	10.51	2.50	13.01

Table 4b. Average Total Monthly Precipitation (mm) Averaged Across OW and SH Weather Stations.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct Total	Winter Total	Annual Total
1990	14	23	28	22	18	6	68	0	41	14	10	7	169	83	253
1991	5	4	11	0	34	27	91	89	67	18	35	61	325	116	441
1992	33	11	31	14	136	20	32	44	14	18	4	6	279	85	364
1993	18	13	6	4	18	37	45	42	7	33	14	4	187	55	242
1994	2	2	13	12	102	20	50	76	40	29	19	19	329	55	384
1995	8	7	15	9	17	23	50	62	46	0	2	6	208	37	246
1996	4	6	2	1	0	76	122	128	53	33	8	0	413	19	432
1997	4	28	3	54	30	89	39	106	64	17	13	24	398	72	470
1998	1	9	29	13	0	0	66	98	35	75	5	9	287	53	340
1999	0	0	0	15	36	37	85	41	31	8	0	4	253	4	257
2000	0	0	25	7	1	53	10	13	1	76	10	6	161	41	202
2001	10	18	17	5	34	17	41	58	30	6	35	5	191	85	276
2002	4	9	4	1	0	18	92	42	80	29	8	21	261	47	308
2003	0	6	10	8	14	10	34	26	9	27	14	7	128	37	165
2004	7	13	3	110	5	39	55	85	23	51	18	9	367	50	418
2005	123	97	17	7	60	12	12	49	33	29	0	0	201	237	438
2006	0	0	3	5	8	22	81	160	51	65	0	4	391	7	398
2007	0	3	33	10	77	42	39	20	62	6	14	11	257	61	318
Average	13	14	14	16	33	30	56	63	38	30	12	11	267	64	331

*Bold number is highest recorded monthly precipitation over the period. Rows with incomplete data are not included in the average.

Table 5. Total Monthly Precipitation (inches) Recorded at Various Rain Gauges, 1994–2007

Site HQ													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994	0.00	0.00	0.95	0.97	3.27	1.13	2.79	2.36	1.17	0.92	1.00	0.75	15.31
1995	0.29	0.00	1.25	0.00	0.65	0.82	2.28	3.17	2.21	0.00	0.00	0.13	10.81
1996	0.00	0.82	0.00	0.00	0.00	1.98	4.79	5.00	3.03	2.16	0.15	0.00	17.94
1997	0.83	0.63	0.49	0.94	1.36	5.60	2.19	4.96	3.84	0.70	0.70	2.48	24.73
1998	0.00	0.20	1.62	0.70	0.10	0.00	2.55	3.45	0.61	3.39	1.32	0.47	14.41
1999	0.48	0.00	1.21	0.68	2.01	2.38	2.83	4.23	0.68	0.33	0.00	0.57	15.40
2000	0.01	0.00	1.17	0.62	0.01	1.29	1.11	1.06	0.19	2.85	1.69	1.09	11.09
2001	1.60	0.73	1.22	0.26	1.41	0.86	5.03	1.86	4.01	0.30	1.55	0.19	19.03
2002	0.58	0.00	0.40	0.04	0.00	0.21	4.36	1.97	3.58	1.33	0.60	2.32	15.39
2003	0.00	0.30	0.00	0.95	0.18	0.37	0.96	3.53	0.36	1.24	1.37	0.31	9.57
2004	1.30	1.98	0.58	6.18	0.11	1.55	2.41	3.49	1.22	2.94	2.04	0.56	24.37
2005	1.11	0.85	0.90	0.14	3.62	1.14	0.41	2.60	1.54	1.39	0.00	0.00	13.70
2006	0.00	0.00	0.12	0.02	0.50	0.78	2.96	6.09	1.31	1.43	0.28	0.70	14.19
2007	0.73	0.46	1.33	0.32	3.99	1.56	1.22	1.23	2.87	0.34	0.00	0.90	14.95
Average	0.50	0.43	0.80	0.84	1.23	1.41	2.56	3.22	1.90	1.38	0.76	0.75	15.78
Site NC													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994							1.22	3.13	1.38	0.87	0.59	0.61	
1995	0.23	0.00	0.80	0.00	0.59	0.79	2.73	2.80	2.01	0.00	0.00	0.14	10.10
1996	0.00	0.48	0.02	0.00	0.00	2.37	4.93	5.66	2.35	2.27	0.12	0.00	18.21
1997	1.01	0.68	0.36	1.32	1.31	4.24	1.86	3.95	4.40	1.04	0.00	1.13	21.30
1998	0.00	0.33	1.29	0.53	0.03	0.02	3.41	3.45	1.40	2.25	1.22	0.46	14.39
1999	0.35	0.00	0.95	0.34	1.70	1.40	3.43	2.53	1.89	0.21	0.00	0.40	13.20
2000	0.02	0.00	0.91	0.49	0.01	1.19	2.03	0.88	0.25	4.06	1.26	0.64	11.74
2001	1.54	0.66	0.68	0.20	1.78	0.89	2.98	2.43	1.37	0.27	2.76	0.13	15.70
2002	0.59	0.00	0.70	0.16	0.00	0.37	3.12	1.28	4.19	1.33	0.42	2.10	14.26
2003	0.00	0.26	0.46	0.32	0.00	0.47	1.14	2.16	0.28	1.83	0.60	0.14	7.66
2004	1.43	2.20	0.50	4.69	0.02	1.53	1.35	3.15	1.16	2.36	0.55	0.06	19.00
2005	1.01	0.79	0.59	0.08	4.00	1.35	0.94	2.97	1.35	1.26	0.00	0.00	14.34
2006	0.00	0.00	0.05	0.22	0.38	0.88	3.35	7.75	1.94	2.62	0.21	0.60	18.00
2007	1.65	0.28	1.23	0.45	3.41	1.94	2.53	0.45	2.97	0.60	0.40	0.53	16.44
Average	0.60	0.44	0.66	0.68	1.02	1.34	2.50	3.04	1.92	1.50	0.58	0.50	14.95
Site C													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1999							2.88	2.34	1.65	0.42			
2000				0.17	0.00	0.52	1.05	0.34	0.18	2.91			
2001				0.14	1.77	0.92	1.71	1.96	1.54	0.32			
2002				0.17	0.00	0.81	3.34	1.62	2.91	1.36	0.34	1.96	
2003	0.00	0.17	0.15	0.34	0.00	0.65	0.64	2.19	0.16	1.06	0.60	0.14	6.10
2004	1.41	1.42	0.41	4.54	0.01	2.01	2.60	4.57	1.14	2.29	0.62	0.08	21.10
2005	1.07	1.10	0.87	0.07	1.88	0.95	1.34	3.32	2.09	1.08	0.00	0.00	13.77
2006	0.00	0.00	0.04	0.16	0.36	0.93	3.53	7.02	2.06	2.77	0.22	0.64	17.73
2007	0.88	0.21	1.31	0.37	2.61	1.20	1.99	0.27	2.30	0.51	0.45	0.50	12.60
Average	0.67	0.58	0.56	0.75	0.83	1.00	2.12	2.63	1.56	1.41	0.37	0.55	14.26
Site Corrals/K													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994						0.00	1.16	2.01	2.68	0.90	0.70	0.70	
1995	0.26	0.00	0.60	0.00	0.55	1.25	2.02	2.78	1.83	0.00	0.00	0.20	9.49
1996	0.00	0.66	0.05	0.00	0.00	3.11	4.56	3.97	1.96	0.89	0.00	0.00	15.21
1997	0.70	0.66	0.34	2.55	1.42	3.55	1.67	3.52	2.00	0.69	0.14	0.99	18.23

Table 5. Total Monthly Precipitation (inches) Recorded at Various Rain Gauges, 1994–2007 (Continued)

Site Corral/K													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1998	0.00	0.28	1.08	0.48	0.00	0.03	3.42	5.40	0.34	3.37	1.48	0.54	16.42
1999	0.33	0.00	0.94	0.48	1.81	1.63	3.78	2.18	2.06	0.28			
2000				0.19	0.00	0.23	2.77	1.03	0.16	2.93			
2001				0.13	1.91	0.99	1.54	1.98	2.39	0.34			
2002				0.15	0.00	0.67	3.10	1.98	4.31	1.37	0.28	1.95	
2003	0.00	0.12	0.19	0.36	0.00	0.89	0.83	1.92	0.27	1.02	0.62	0.13	6.35
2004	0.73	1.13	0.18	4.69	0.00	1.40	2.28	3.33	1.29	2.01	0.69	0.07	17.81
2005	1.14	1.13	0.73	0.09	1.71	0.35	1.55	3.67	3.55	1.32	0.00	0.00	15.24
2006	0.00	0.00	0.05	0.16	0.36	0.54	3.68	8.06	2.47	2.90	0.24	0.55	19.01
2007	0.51	0.22	1.40	0.26	2.57	1.14	1.05	0.24	1.92	0.60	0.39	0.47	10.77
Average	0.37	0.42	0.56	0.73	0.79	1.13	2.39	3.01	1.95	1.33	0.41	0.51	14.28

Site J													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1999							4.07	2.41	1.37	0.43	0.00		
2000				0.14	0.00	0.28	1.01	0.59	0.28	3.25			
2001				0.24	1.36	0.42	2.32	3.04	2.38	0.32			
2002				0.10	0.00	0.44	3.97	2.04	3.38	1.51	0.21	1.86	
2003	0.00	0.17	0.01	0.27	0.00	1.82	0.95	1.22	0.26	1.08	0.64	0.07	6.49
2004	0.24	1.01	0.29	6.09	0.00	1.52	2.12	2.61	1.59	2.34	0.84	0.07	18.72
2005	1.16	1.20	0.99	0.30	1.52	0.26	0.91	4.03	3.29	1.57	0.00	0.00	15.23
2006	0.00	0.00	0.06	0.20	0.45	0.76	4.52	6.85	3.53	3.05	0.15	0.57	20.14
2007	0.16	0.19	1.25	0.28	3.88	0.92	0.26	0.00	2.54	0.60	0.43	0.44	10.95
Average	0.31	0.51	0.52	0.95	0.90	0.80	2.24	2.53	2.07	1.57	0.32	0.50	14.31

Site Johnson													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994						0.00	1.20	2.62	0.98	0.70	0.55	0.25	
1995	0.08	0.00	0.75	0.00	0.40	1.39	1.56	1.17	0.93	0.00	0.00	0.32	6.61
1996	0.00	0.58	0.02	0.00	0.00	3.01	3.17	2.14	3.85	0.40	0.00	0.00	13.18
1997	0.70	0.40	0.19	2.00	0.47	3.11	1.39	5.12	2.01	0.37	0.00	1.75	17.52
1998	0.00	0.28	1.75	0.81	0.00	0.05	2.62	3.69	0.66	2.03	1.19	0.52	13.60
1999	0.13	0.00	0.79	1.69	1.35	2.91	2.30	1.05	1.32	0.28			
2000				0.16	0.00	0.27	2.25	0.54	0.14	2.92			
2001				0.35	1.08	0.87	1.54	2.20	0.98	0.37			
2002				0.04	0.00	0.42	3.37	2.22	2.93	1.40	0.17	1.71	
2003	0.00	0.00	0.05	0.37	0.00	1.70	0.29	3.13	0.39	1.01	0.62	0.03	7.59
2004	0.38	0.91	0.00	3.43	0.00	0.98	1.93	2.73	1.51	3.53	0.48	0.04	15.93
2005	0.85	0.87	0.53	0.16	1.78	0.21	1.33	3.50	3.83	1.40	0.00	0.00	14.46
2006	0.00	0.00	0.05	0.19	0.45	0.33	4.04	6.17	4.23	2.65	0.13	0.49	18.73
2007	0.03	0.24	0.66	0.13	2.39	0.72	0.00	0.00	3.15	0.85	0.00	0.40	8.58
Average	0.22	0.33	0.48	0.72	0.61	1.14	1.93	2.59	1.92	1.28	0.29	0.50	12.91

Site Sheep													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1999							3.38	2.17	1.22	0.16	0.00		
2000				0.20	0.01	0.82	4.20	0.58	0.18	2.99			
2001				0.22	1.62	0.82	2.33	3.16	2.09	0.29			
2002				0.00	0.00	0.43	3.30	1.50	2.77	1.24	0.39	2.05	
2003	0.00	0.16	0.32	0.44	0.00	0.31	1.10	1.97	0.38	1.03	0.58	0.08	6.37
2004	1.07	1.04	0.27	4.71	0.00	1.68	1.47	2.75	1.20	2.30	0.56	0.06	17.12
2005	1.06	0.83	0.41	0.06	2.41	0.47	1.61	3.43	1.51	1.26	0.00	0.00	13.05
2006	0.00	0.00	0.02	0.12	0.38	0.62	3.13	6.57	2.22	2.71	0.17	0.53	16.47
2007	0.22	0.14	1.05	0.16	3.06	1.41	0.89	0.32	2.50	0.56	0.38	0.45	11.14
Average	0.47	0.43	0.41	0.74	0.94	0.82	2.38	2.49	1.56	1.39	0.30	0.53	12.83

Table 6. Total Monthly Precipitation (mm) Recorded at Various Rain Gauges, 1994–2007

Site Q													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994	0	0	24	25	83	29	71	60	30	23	25	19	389
1995	7	0	32	0	17	21	58	81	56	0	0	3	275
1996	0	21	0	0	0	50	122	127	77	55	4	0	456
1997	21	16	12	24	35	142	56	126	98	18	18	63	628
1998	0	5	41	18	3	0	65	88	15	86	34	12	366
1999	12	0	31	17	51	60	72	107	17	8	0	14	391
2000	0	0	30	16	0	33	28	27	5	72	43	28	282
2001	41	19	31	7	36	22	128	47	102	8	39	5	483
2002	15	0	10	1	0	5	111	50	91	34	15	59	391
2003	0	8	0	24	5	9	24	90	9	31	35	8	243
2004	33	50	15	157	3	39	61	89	31	75	52	14	619
2005	28	22	23	4	92	29	10	66	39	35	0	0	348
2006	0	0	3	1	13	20	75	155	33	36	7	18	360
2007	19	12	34	8	101	40	31	31	73	9	0	23	380
Average	13	11	20	21	31	36	65	82	48	35	19	19	401

Site NC													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994	0	0	0	0	0	0	31	80	35	22	15	15	198
1995	6	0	20	0	15	20	69	71	51	0	0	4	256
1996	0	12	1	0	0	60	125	144	60	58	3	0	462
1997	26	17	9	34	33	108	47	100	112	26	0	29	541
1998	0	8	33	13	1	1	87	88	36	57	31	12	366
1999	9	0	24	9	43	36	87	64	48	5	0	10	335
2000	1	0	23	12	0	30	52	22	6	103	32	16	298
2001	39	17	17	5	45	23	76	62	35	7	70	3	399
2002	15	0	18	4	0	9	79	33	106	34	11	53	362
2003	0	7	12	8	0	12	29	55	7	46	15	4	195
2004	36	56	13	119	1	39	34	80	29	60	14	2	483
2005	26	20	15	2	102	34	24	75	34	32	0	0	364
2006	0	0	1	6	10	22	85	197	49	67	5	15	457
2007	42	7	31	11	87	49	64	11	75	15	10	13	418
Average	14	10	15	16	24	32	64	77	49	38	15	13	367

Site C													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1999	0	0	0	0	0	0	73	59	42	11	0	0	185
2000	0	0	0	4	0	13	27	9	5	74	0	0	131
2001	0	0	0	4	45	23	43	50	39	8	0	0	212
2002	0	0	0	4	0	21	85	41	74	35	9	50	318
2003	0	4	4	9	0	17	16	56	4	27	15	4	155
2004	36	36	10	115	0	51	66	116	29	58	16	2	536
2005	27	28	22	2	48	24	34	84	53	27	0	0	350
2006	0	0	1	4	9	24	90	178	52	70	6	16	450
2007	22	5	33	9	66	30	51	7	58	13	11	13	320
Average	9	8	8	17	19	23	54	67	40	36	6	9	295

Site Corrals/K													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994	0	0	0	0	0	0	29	51	68	23	18	18	207
1995	7	0	15	0	14	32	51	71	47	0	0	5	241
1996	0	17	1	0	0	79	116	101	50	23	0	0	386
1997	18	17	9	65	36	90	42	89	51	18	4	25	463
1998	0	7	27	12	0	1	87	137	9	86	38	14	417

Table 6. Total Monthly Precipitation (mm) Recorded at Various Rain Gauges, 1994–2007 (Continued)

Site Corrals/k													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1999	8	0	24	12	46	41	96	55	52	7	0	0	343
2000	0	0	0	5	0	6	70	26	4	74	0	0	186
2001	0	0	0	3	49	25	39	50	61	9	0	0	236
2002	0	0	0	4	0	17	79	50	109	35	7	50	351
2003	0	3	5	9	0	23	21	49	7	26	16	3	161
2004	19	29	5	119	0	36	58	85	33	51	18	2	452
2005	29	29	19	2	43	9	39	93	90	34	0	0	387
2006	0	0	1	4	9	14	93	205	63	74	6	14	483
2007	13	6	36	7	65	29	27	6	49	15	10	12	274
Average	7	8	10	17	19	29	61	76	49	34	8	10	328

Site J													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1999	0	0	0	0	0	0	103	61	35	11	0	0	210
2000	0	0	0	4	0	7	26	15	7	83	0	0	141
2001	0	0	0	6	35	11	59	77	60	8	0	0	256
2002	0	0	0	3	0	11	101	52	86	38	5	47	343
2003	0	4	0	7	0	46	24	31	7	27	16	2	165
2004	6	26	7	155	0	39	54	66	40	59	21	2	476
2005	29	30	25	8	39	7	23	102	84	40	0	0	387
2006	0	0	2	5	11	19	115	174	90	77	4	14	512
2007	4	5	32	7	99	23	7	0	65	15	11	11	278
Average	4	7	7	22	20	18	57	64	53	40	6	8	308

Site Johnson													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1994	0	0	0	0	0	0	30	67	25	18	14	6	160
1995	2	0	19	0	10	35	40	30	24	0	0	8	168
1996	0	15	1	0	0	76	81	54	98	10	0	0	335
1997	18	10	5	51	12	79	35	130	51	9	0	44	445
1998	0	7	44	21	0	1	67	94	17	52	30	13	346
1999	3	0	20	43	34	74	58	27	34	7	0	0	300
2000	0	0	0	4	0	7	57	14	4	74	0	0	160
2001	0	0	0	9	27	22	39	56	25	9	0	0	188
2002	0	0	0	1	0	11	86	56	74	36	4	43	312
2003	0	0	1	9	0	43	7	80	10	26	16	1	193
2004	10	23	0	87	0	25	49	69	38	90	12	1	404
2005	22	22	13	4	45	5	34	89	97	36	0	0	367
2006	0	0	1	5	11	8	103	157	107	67	3	12	476
2007	1	6	17	3	61	18	0	0	80	22	0	10	218
Average	4	6	9	17	14	29	49	66	49	32	6	10	291

Site Sheep													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1999	0	0	0	0	0	0	86	55	31	4	0	0	176
2000	0	0	0	5	0	21	107	15	5	76	0	0	228
2001	0	0	0	6	41	21	59	80	53	7	0	0	268
2002	0	0	0	0	0	11	84	38	70	31	10	52	297
2003	0	4	8	11	0	8	28	50	10	26	15	2	162
2004	27	26	7	120	0	43	37	70	30	58	14	2	435
2005	27	21	10	2	61	12	41	87	38	32	0	0	331
2006	0	0	1	3	10	16	80	167	56	69	4	13	418
2007	6	4	27	4	78	36	23	8	64	14	10	11	283
Average	7	6	6	17	21	19	60	63	40	35	6	9	289

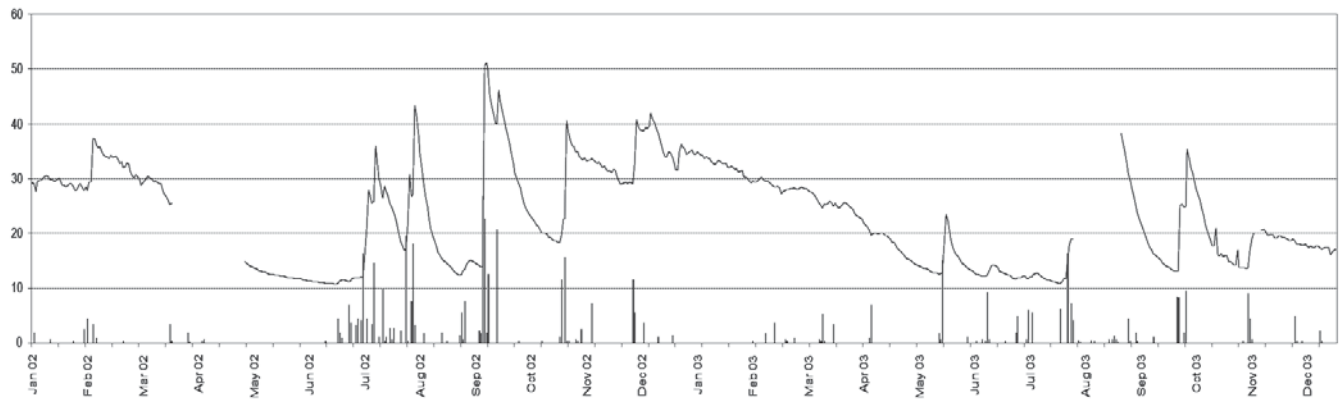


Figure 5a. Soil moisture measured at 10 cm (line) and daily rainfall (bars, in mm), SH site, 2002–2003.

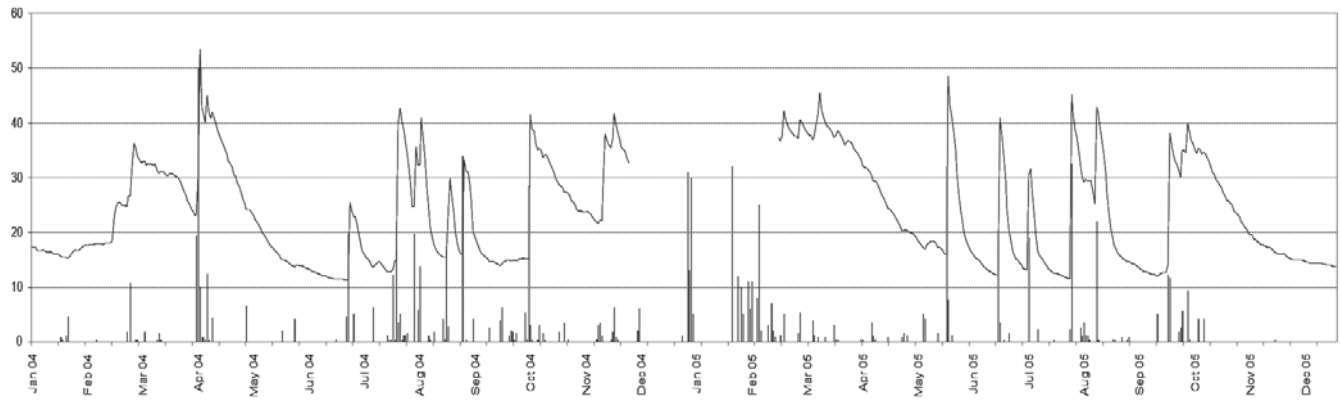


Figure 5b. Soil moisture measured at 10 cm (line) and daily rainfall (bars, in mm), SH site, 2004–2005.

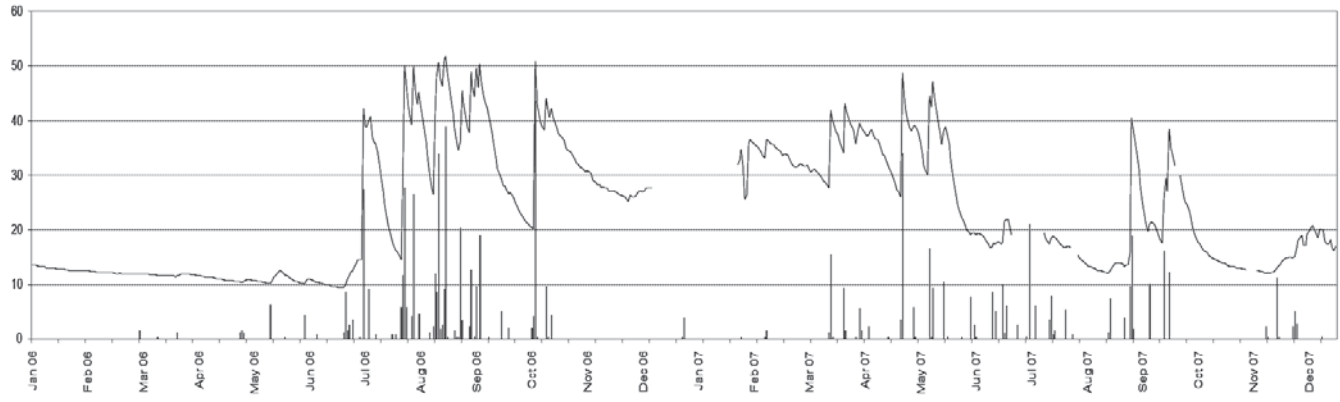


Figure 5c. Soil moisture measured at 10 cm (line) and daily rainfall (bars, in mm), SH site, 2006–2007.

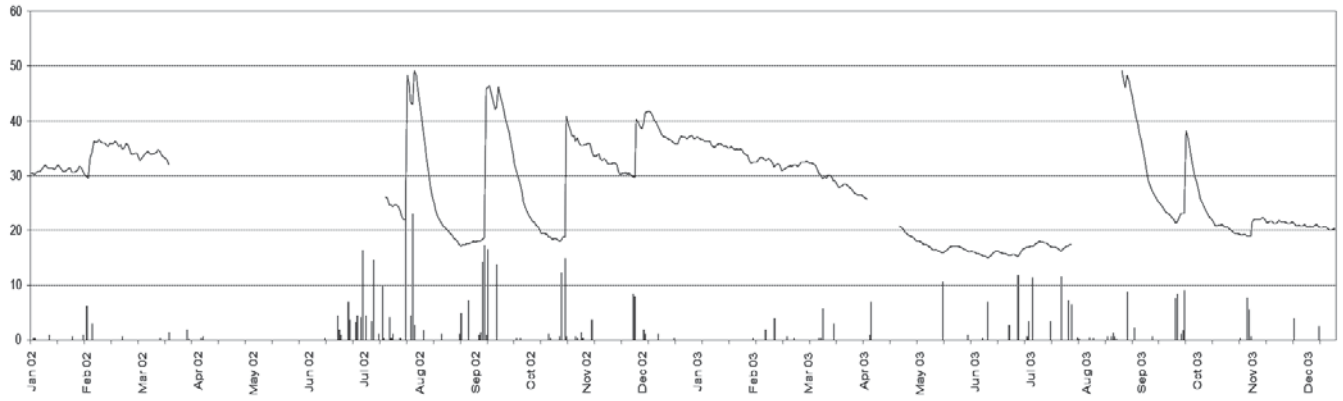


Figure 6a. Soil moisture measured at 10 cm (line) and daily rainfall (bars, in mm), OW site, 2002–2003.

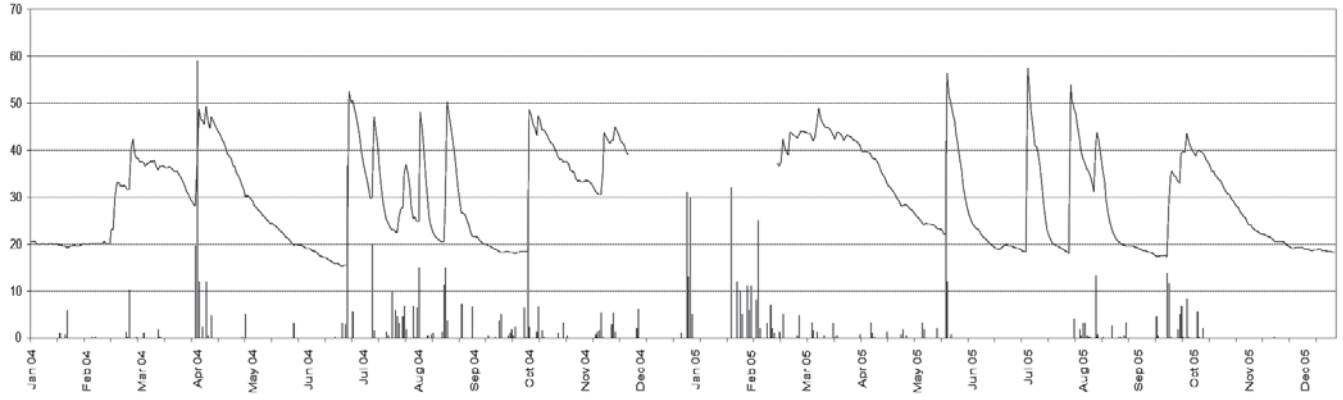


Figure 6b. Soil moisture measured at 10 cm (line) and daily rainfall (bars, in mm), OW site, 2004–2005.

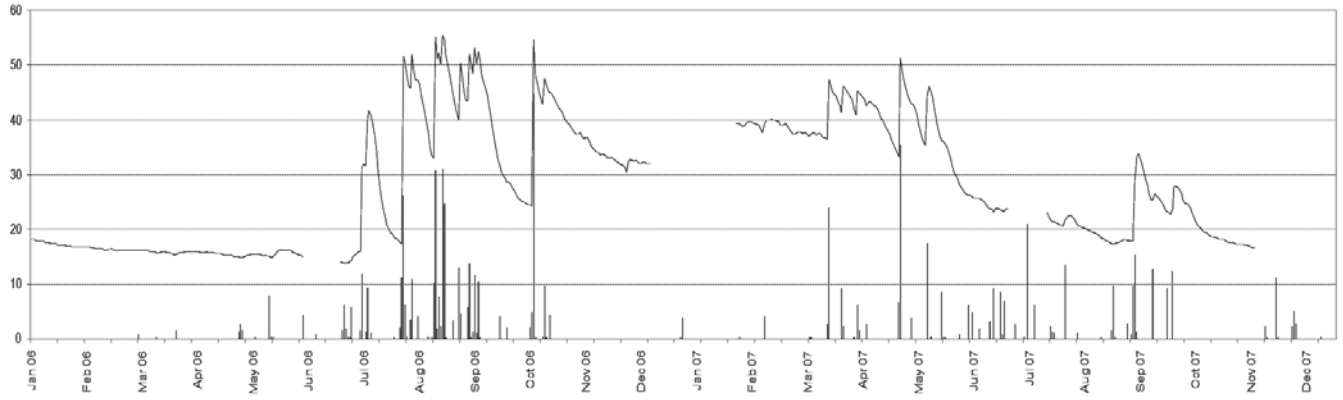


Figure 6c. Soil moisture measured at 10 cm (line) and daily rainfall (bars, in mm), OW site, 2006–2007.

at least 5 mm (0.2 inches) of rainfall to substantially increase soil moisture levels over the day. When it did not rain on a given day, soil moisture decreased on average by 0.2%. For the dry climate of the Corona Ranch, soil moisture is largely built rainfall events > 5 mm, by which were recorded on about 20 days of the year (Figure 4). The rate of decline in soil moisture was much more rapid during the heat of the summer and when plants were growing. Soil moisture moved from the high levels realized following a large rainfall event to low levels in as little as two weeks from June to September, whereas during the winter months soil moisture without additional rainfall declined at a gradual, slow pace (Figures 5 and 6).

Both soil moisture probe depths placed at the OW and SH sites recorded a similar pattern, but the deeper probe (data not shown) remained at a slightly higher level. Over the 2001–2006 period during quarters 1 and 4, the 10–30 cm probe recorded soil moisture levels that averaged 3.5% more than the 10 cm probe. The difference increased to 7.6% during quarter 2 and 5.6% during quarter 3.

Air Temperature

Average daily maximum air temperature at the OW and SH study sites was 50°F during December–January and 84°F in July. Average daily minimum air temperature

was 25°F during December–January and 57°F in July. The average frost-free period (consecutive days above 32°F) was about 164 days, from April 30 to October 11. The interval between killing frosts (28°F or less) averaged 186 days (Table 7). Average minimum daily temperatures were above freezing from April 1 to October 31 (Figure 7). Perhaps more important for range forage production, an approximate 50°F is considered a minimum temperature for growth of blue grama grass (Stubendieck & Burzlaff, 1970), the predominant forage species found on the Corona Ranch. As shown in Figure 7, average daily daytime air temperatures begin to exceed 50°F near the first of April and remain above this threshold until late October. This suggests a maximum April through October growing season for warm-season grass growth, similar to the frost-free period (214 days).

Table 8 summarizes the number of accumulated degree days over the growing season for the SH and OW sites. This variable was computed by taking the average daily daytime temperature (6 a.m. to 6 p.m.), subtracting 10°C from it and summing this difference for a defined maximum 214-day growing season (April–October). The average number of degree days over the study period, averaged across both sites, was 2,308 with a standard deviation of 152. The years 2000, 2001, and 2003 had degree day values that were 1 standard deviation or more above the average (Table 8), with rainfall

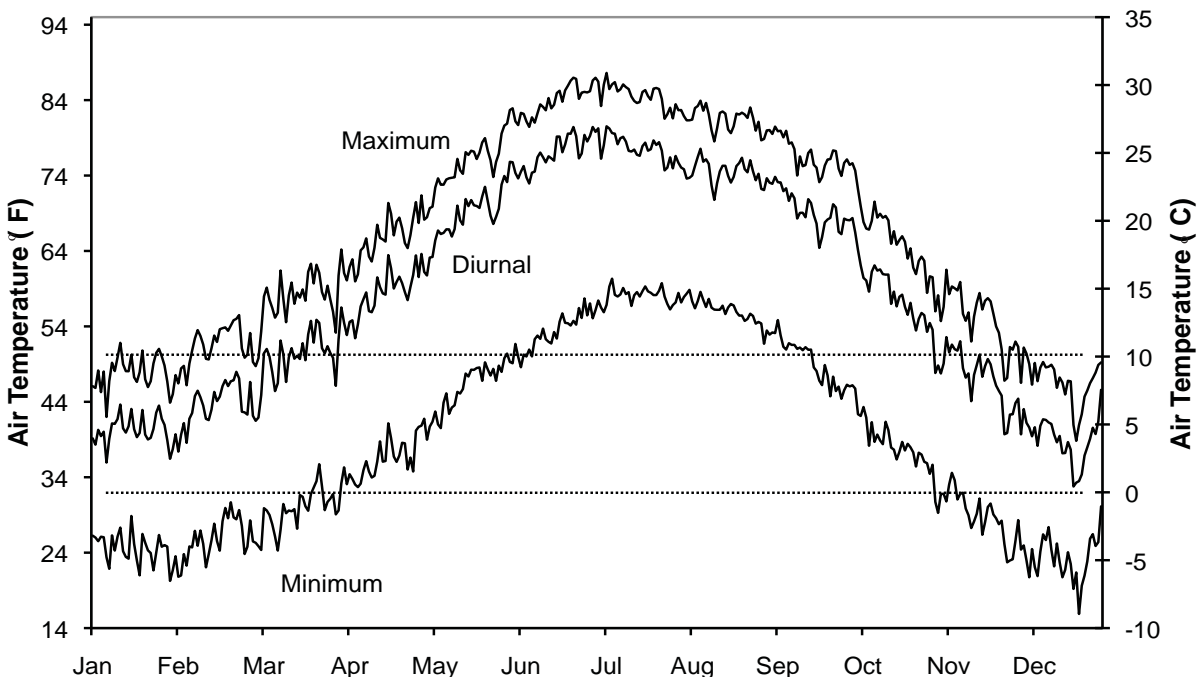


Figure 7. Daily average minimum and maximum air temperature and average diurnal air temperature recorded at the OW and SH study sites (July 17, 1990–July 3, 2007).

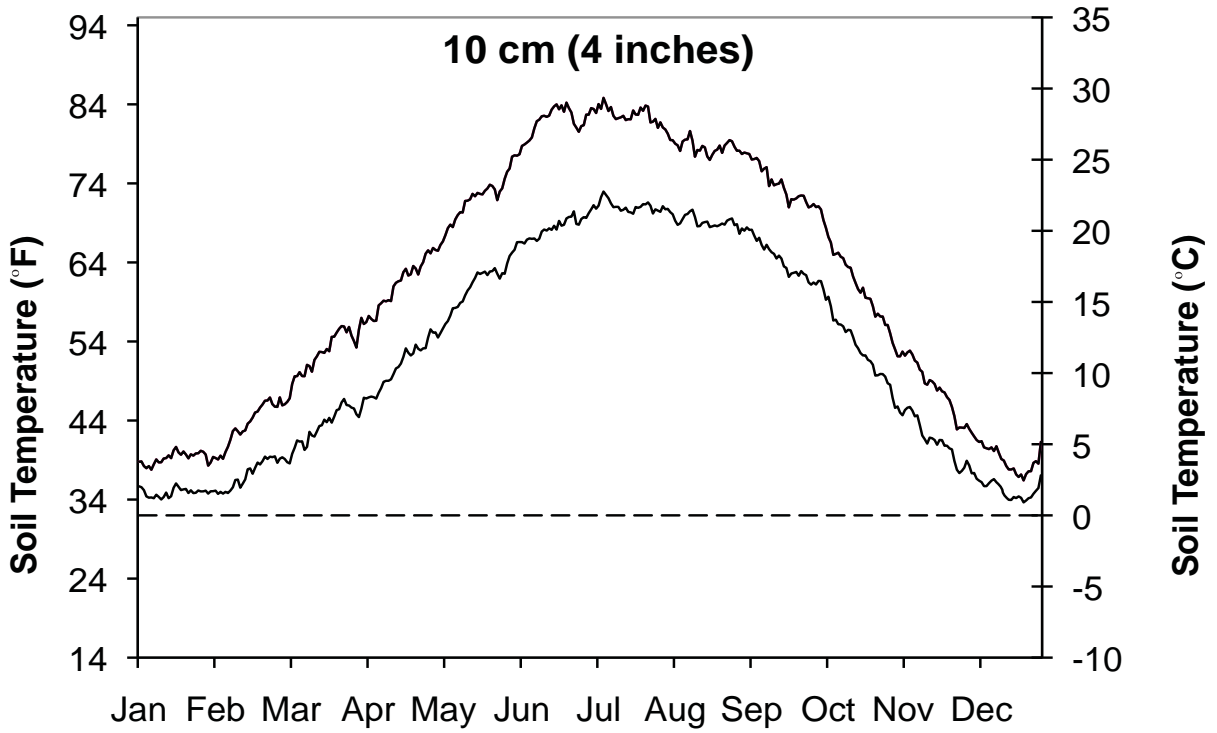


Figure 8a. Daily average minimum and maximum soil temperature (10 cm and 50 cm) measured at the SH and OW sites (July 17, 1990–July 3, 2007).

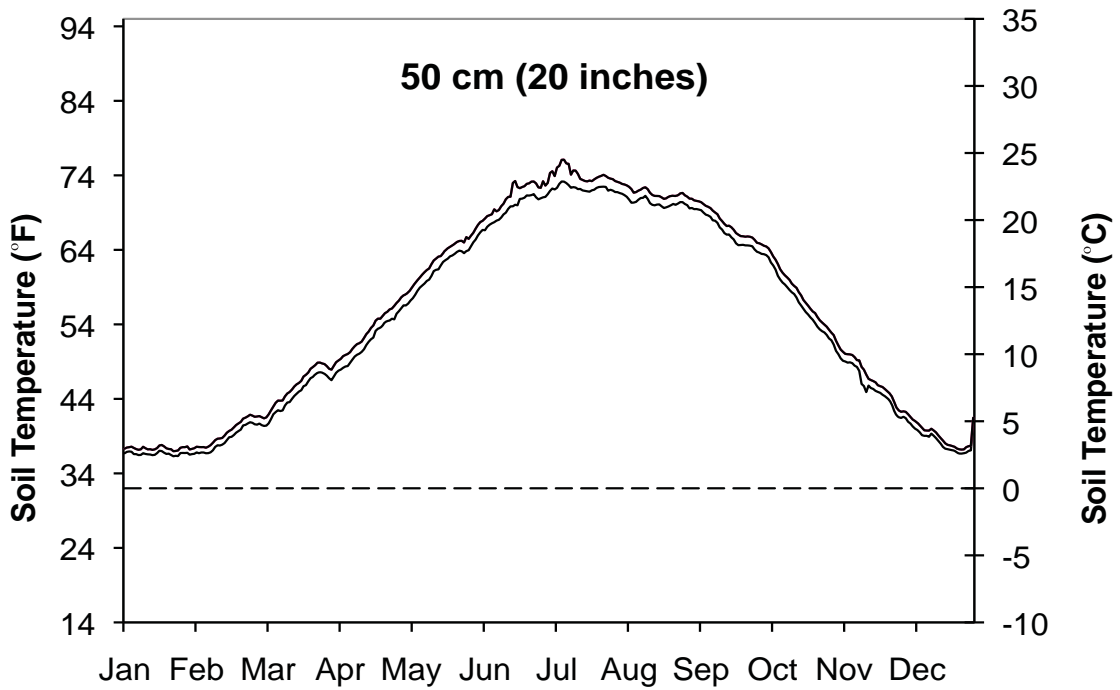


Figure 8b. Daily average minimum and maximum soil temperature (10 cm and 50 cm) measured at the SH and OW sites (July 17, 1990–July 3, 2007).

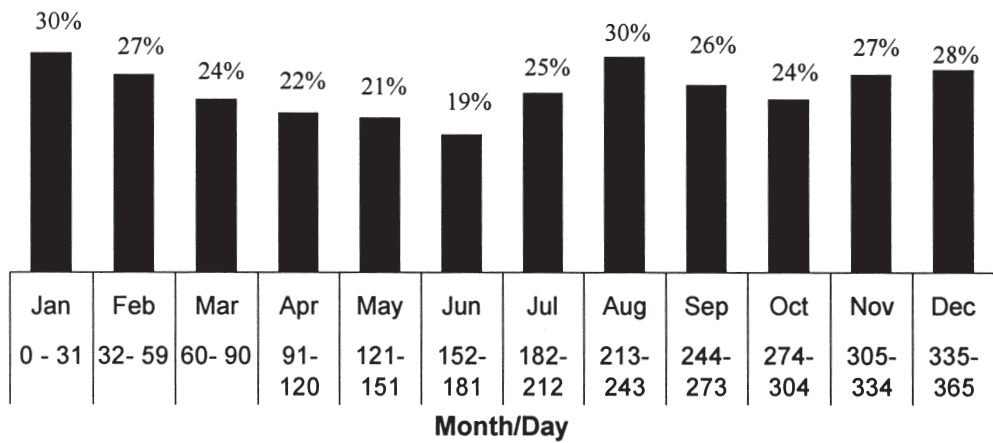
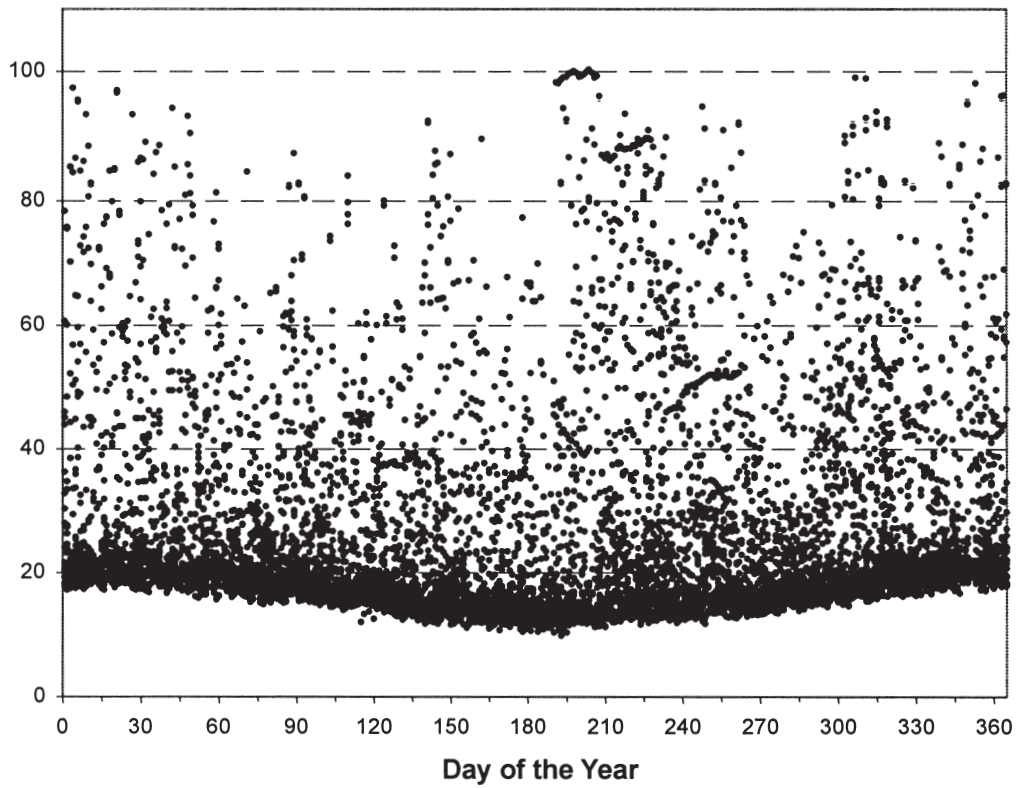


Figure 9. Daily average relative humidity (July 17, 1990–Sept. 3, 2007).

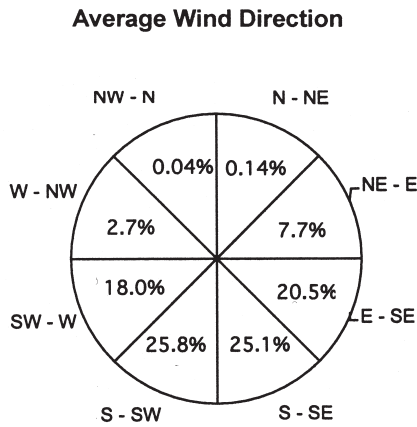
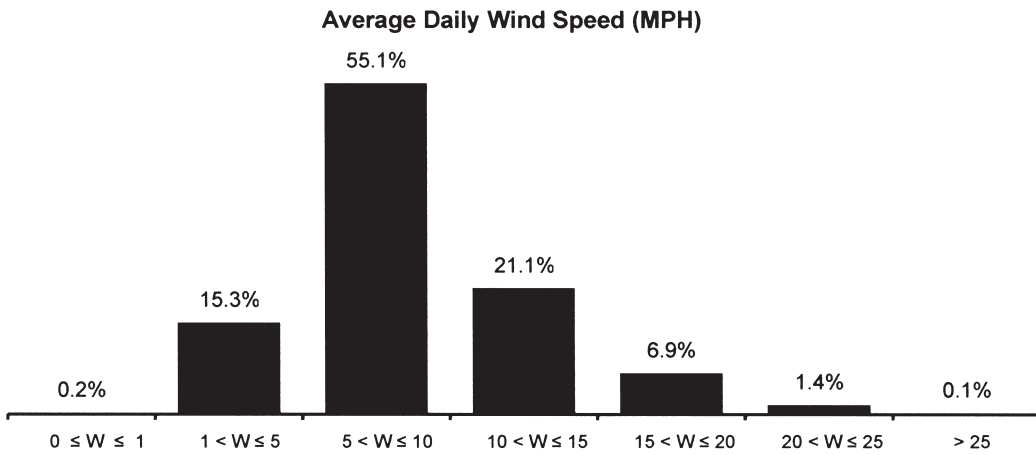
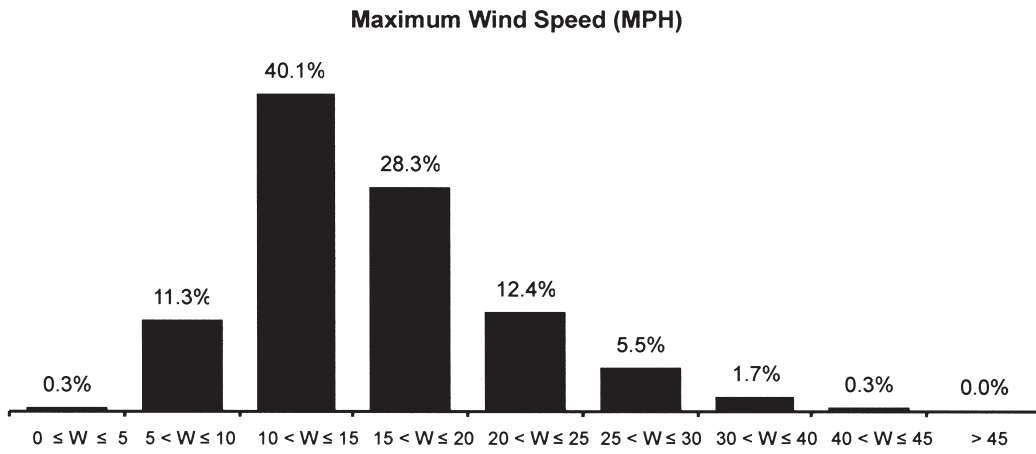


Figure 10. Percentage of hours with different maximum and average wind speeds, and the hourly average wind direction (July 17, 1990–July 3, 2007).

Table 7. Frost dates and number of consecutive frost-free days at NMSU's Corona Ranch (1991 - 2007).

Year	Less than or equal to 32° F			Less than or equal to 28° F		
	Last Spring Frost (date)	First Fall Frost (date)	Frost-Free Period (days)	Last Spring Killing Frost (date)	First Fall Killing Frost (date)	Killing Frost-free-period (days)
1991	May 5	Oct 28	176	May 1	Oct 29	181
1992	Apr 21	Oct 8	170	Apr 4*	Oct 9	188
1993	May 11	Oct 21	163	Apr 21	Oct 29	191
1994	Apr 30	Oct 8	161	Apr 6	Nov 10	218
1995	Apr 27	Sep 22*	148	Apr 27	Oct 6	162
1996	Apr 30	Oct 19	172	Apr 30	Oct 19	172
1997	May 3	Oct 13	163	Apr 14	Oct 13	182
1998	Apr 28	Oct 7	162	Apr 21	Oct 18	180
1999	May 6	Sep 29	146	Apr 17	Sep 29	165
2000	May 14	Sep 26	135	Apr 9	Sep 26*	170
2001	Apr 24	Oct 6	165	Apr 24	Oct 16	175
2002	Apr 27	Oct 13	169	Apr 3*	Oct 20	200
2003	May 11	Oct 25	167	May 11**	Oct 25	167
2004	May 15**	Oct 15	153	Apr 13	Nov 2	203
2005	Apr 13*	Oct 31**	201	Apr 11	Nov 13**	216
2006	Apr 25	Oct 19	177	Apr 8	Nov 1	207
2007	May 7	Oct 8	154	Apr 16	Oct 21	188
Average	Apr 30	Oct 11	164	Apr 16	Oct 19	186

* Earliest date

** Latest date

Italicized number is shortest or longest frost free period

Table 8. Degree Days Over the Growing Season at the OW and SH Sites, 1990–2007

Year	OW								SH								Average
	Apr	May	Jun	Jul	Aug	Sep	Oct	OW Total	Apr	May	Jun	Jul	Aug	Sep	Oct	SH Total	
1990	137	314	445	445	385	313	188	2,226	137	314	445	445	385	313	188	2,226	2,226
1991	163	344	398	371	371	238	164	2,049	160	344	397	371	395	238	164	2,069	2,059
1992	191	212	398	461	439	363	234	2,298	188	204	391	456	438	359	227	2,261	2,280
1993	163	292	450	505	424	366	136	2,336	129	254	417	472	390	331	112	2,105	2,220
1994	145	280	535	532	479	356	154	2,481	111	250	502	498	450	328	129	2,267	2,374
1995	112	270	415	524	493	322	255	2,392	73	231	379	486	449	288	220	2,127	2,259
1996	176	416	436	442	383	265	118	2,237	152	416	436	442	383	265	118	2,212	2,225
1997	0	246	391	468	425	347	147	2,023	-4	236	378	449	414	339	137	1,949	1,986
1998	62	359	476	472	428	391	151	2,339	76	371	484	473	436	402	156	2,398	2,368
1999	84	255	405	446	444	305	199	2,137	96	264	411	452	450	314	205	2,191	2,164
2000	182	428	452	490	416	415	90	2,473	192	439	453	490	416	418	96	2,503	2,488
2001	186	317	484	528	428	374	224	2,540	191	325	490	531	425	377	204	2,543	2,542
2002	223	327	495	452	469	305	98	2,370	223	327	495	448	466	302	92	2,352	2,361
2003	166	342	398	559	451	338	223	2,476	176	363	414	591	456	353	237	2,590	2,533
2004	91	371	458	471	399	333	139	2,262	88	367	451	474	386	318	128	2,213	2,238
2005	156	302	486	541	415	401	151	2,453	145	294	474	529	408	388	142	2,380	2,416
2006	137	372	510	517	397	260	149	2,342	230	411	507	505	385	252	144	2,433	2,387
2007	118	256	441	462	538	394	250	2,458	113	242	427	454	520	375	227	2,359	2,409
Average	139	317	448	482	433	338	170	2,327	138	314	442	476	425	331	162	2,288	2,308
S.D.	54	59	43	46	42	50	50	150	59	71	43	47	37	51	48	172	152

See text for a description of degree days calculation.

totals that were below average (Table 2). The years 1991, 1993, 1997, and 1999 were exceptionally cool years with relatively low calculated degree days.

Soil Temperature

The daily average soil temperature recorded at 10 cm (4 inches) and 50 cm (20 inches) at the SH and OW sites is shown in Figure 8. Soil temperatures fluctuated annually and daily with variation in air temperature and solar radiation. At 50 cm (20 inches) the daily range in soil temperature was only about 1°C, as compared to 9°C for the 10-cm (4-inch) probe.

Relative Humidity

Relative humidity varies widely on the Corona Ranch, ranging from nearly 100% on wet, rainy days to a dry 10% a sunny June day (Figure 9). Daily average on relative humidity was frequently in a narrow range from 12% to 25%. Average relative humidity was 25% with monthly averages ranging from 19% during June to 30% during January. Average relative humidity varied from about 30% in the early morning and evening hours to less than 20% by mid-day.

Wind Speed and Direction

Figure 10 shows the frequency of different hourly maximum and average daily wind speeds at the SH and OW sites, and the average wind direction (in degrees) over the day. As shown, wind has a southerly component 90% of the time, and it blows nearly every day.

UPDATED DATA ACCESS

The interested reader is referred to the Corona Range and Livestock Research Center web site (<http://cahe.nmsu.edu/aes/corona>) for links to updated weather data for the ranch. These data are stored in two Access databases and numerous spreadsheets. One database is maintained for weather data collected by the South House (SH) and Oil Well (OW) data loggers and recorders. The second database is for the Natural Resources Conservation Service (NRCS) Soil Climate Analysis Network (SCAN) site (Adams site) (NRCS, 2007).

From the web page link, updated tables and figures presented in this report will be available in spreadsheet form. The spreadsheets are linked to the Access database files, and you may be asked whether you would like to enable or disable automatic refresh as you open the file. You should disable the refresh because the data was refreshed before it was saved to the server.

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