8. AIR QUALITY

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Air quality is monitored continuously at GLEES. Air pollutants are considered an important component of the atmosphere that can have an effect on terrestrial and aquatic ecosystems. Atmospheric deposition of gases, wet deposition of chemicals in precipitation including snow and rain, and dry deposition of chemicals are all monitored at GLEES. Although GLEES is a relatively remote and unpolluted site, deposition of pollutants can be important. The effects of ozone on native vegetation in alpine and subalpine ecosystems is generally unknown, but relatively high concentrations of ozone have been recorded at GLEES. Wet and dry deposition is important in snowmelt chemistry and subsequent input to aquatic ecosystems at GLEES.

Wet deposition is monitored at the GLEES Snowy Range National Atmospheric Deposition Program (NADP) site on the west shore of West Glacier Lake. The station has been in operation since 1986, and was initially installed and operated by the University of Wyoming. It has been operated by the Rocky Mountain Station since 1990. Wet precipitation is collected every Tuesday at the site and sent to the NADP Central Analytical Laboratory (CAL) in Illinois. Protocols allow collection on Wednesdays if necessary. The Snowy Range site is one of about 200 wet deposition sites in the network. Precipitation is also recorded at the NADP site with a standard Alter-shielded Belfort rain gage. Precipitation collection in winter is low since snow tends to blow out of the buckets used for water chemistry samples. Research on better snow collection methods is being conducted. Weekly data from the Snowy Range NADP site and from the entire network is available from NADP. A summary of data output from the NADP site is listed in table 8.1.

Table 8.1.—Summary data from Snowy Range NADP site, 1987–1991.

			Precipitation-weighted mean concentrations									Totals[1]			
			m/g/Liter									µS/cm	c/a	mL	cm
Year	Dates		Ca	Mg	K	Na	NH_4	NO_3	Cl	SO_4	pH	Cond.	Ratio	Svol	Ppt
Annual															
1986	860422	861230	0.20	0.024	0.021	0.104	0.06	0.51	0.08	0.53	5.27	5.8	1.18	12708.4	65.08
1987	861230	871229	0.20	0.029	0.019	0.149	0.09	0.63	0.13	0.60	5.20	6.6	1.16	22374.6	87.07
1988	871229	890103	0.19	0.025	0.018	0.116	0.05	0.51	0.11	0.72	5.18	6.8	0.99	8575.9	119.48
1989	890103	900102	0.19	0.028	0.013	0.206	0.15	0.77	0.16	0.77	5.67	6.8	0.97	12986.1	126.70
1990	900102	910102	0.19	0.027	0.014	0.089	0.12	0.76	0.13	0.49	5.43	5.8	0.99	15906.7	130.39
1991	910102	911231	0.14	0.018	0.014	0.089	0.09	0.67	0.10	0.51	5.29	6.2	0.94	21802.6	125.05
Winter															
1987	861202	870303	0.15	0.027	0.020	0.219	0.10	0.49	0.18	0.53	5.47	5.7	1.19	1592.2	18.11
1988	871201	880301	0.17	0.028	0.019	0.157	0.02	0.41	0.14	0.53	5.27	5.6	1.14	1203.9	44.36
1989	881129	890228	0.10	0.017	0.007	0.467	0.21	0.81	0.20	0.95	6.14	8.4	1.03	480.3	48.29
1990	891129	900227	0.14	0.025	0.009	0.075	0.07	0.68	0.12	0.46	5.50	5.1	0.82	1333.1	45.37
1991	901204	910226	0.12	0.017	0.007	0.079	0.02	0.51	0.08	0.28	5.45	4.9	0.95	1079.4	34.85
Spring															
1986	860422	860603	0.74	0.060	0.029	0.126	0.01	0.27	0.11	0.66	5.89	7.5	2.36	2172.6	6.07
1987	870303	870602	0.39	0.044	0.030	0.163	0.11	0.96	0.18	0.79	5.10	8.9	1.21	5266.7	21.21
1988	880301	880531	0.21	0.025	0.013	0.101	0.08	0.37	0.10	0.78	5.47	5.8	1.01	1969.3	44.46
1989	890228	890530	0.27	0.038	0.015	0.195	0.15	0.68	0.15	0.88	5.85	6.8	1.04	1833.0	39.99
1990	900227	900529	0.25	0.033	0.017	0.144	0.22	0.88	0.21	0.57	5.86	6.3	1.10	1657.9	41.81
1991	910226	910604	0.22	0.025	0.017	0.091	0.12	0.72	0.09	0.61	5.37	6.7	1.07	9486.3	55.96
Summer															
1986	860603	860902	0.19	0.029	0.032	0.056	0.10	0.75	0.09	0.68	5.13	7.1	0.97	6396.3	15.93
1987	870602	870901	0.12	0.018	0.015	0.051	0.13	0.75	0.08	0.63	4.99	7.4	1.00	11485.4	21.31
1988	880531	880830	0.29	0.038	0.028	0.093	0.12	1.48	0.14	1.30	4.80	12.5	0.81	3988.6	6.32
1989	890530	890829	0.19	0.027	0.017	0.064	0.22	0.94	0.09	0.80	5.16	7.8	0.99	6824.5	13.35
1990	900529	900904	0.13	0.018	0.020	0.046	0.15	0.75	0.10	0.56	5.17	6.3	0.97	8087.5	22.06
1991	910604	910903	0.22	0.030	0.026	0.052	0.19	1.21	0.10	0.94	4.95	9.6	0.90	7841.9	12.86
Fall															
1986	860902	861202	0.07	0.010	0.012	0.131	0.04	0.40	0.06	0.40	5.31	4.4	1.05	4007.6	41.55
1987	870901	871201	0.06	0.014	0.010	0.114	0.06	0.39	0.08	0.51	5.17	6.1	1.04	3780.7	12.98
1988	880830	881129	0.18	0.027	0.015	0.126	0.01	0.68	0.10	0.69	4.99	8.0	1.01	1795.6	23.07
1989	890829	891129	0.22	0.029	0.015	0.168	0.12	0.84	0.17	0.65	5.70	6.5	0.92	3476.4	26.90
1990	900904	901204	0.10	0.016	0.006	0.040	0.06	0.65	0.09	0.38	5.30	5.0	0.79	4913.3	24.33
1991	910903	911203	0.04	0.007	0.010	0.106	0.06	0.60	0.15	0.34	5.21	5.1	0.80	3587.3	28.70

[1] *Cond. - Conductivity; µS/cm - microsiemens per centimeter; c/a Ratio - ratio of cations to anions; ml Svol - sample volume in milliliters; cm Ppt - centimeters of precipitation.*

Dry deposition is monitored at the Brooklyn Lake monitoring site with two samplers using filter pack technology, the Stacked Filter Unit (SFU) Network from University of California at Davis and the National Dry Deposition Network (NDDN) operated for the U.S. Environmental Protection Agency. The SFU filter pack is sent to the University of California at Davis for analysis. The analysis measures concentrations of elements from sodium to lead by particle-induced x-ray emission (PIXE), using the Crocker Nuclear Laboratory cyclotron. Also measured by the network are optical absorption (by laser integrating plate method, LIRM), fine mass and coarse mass particles (by gravimetric measurement), and hydrogen (by proton elastic scattering analysis, PESA). A sample of data output is listed in table 8.2.

The National Dry Deposition Network (NDDN) is a network of dry deposition monitoring sites in the United States operated for the U.S. EPA. An NDDN site located at GLEES is designated as the Centennial site, CNT169. The Centennial NDDN site is one of only 12 NDDN sites in the western United States. NDDN protocols collect dry deposition on a three-stage filter pack. Teflon, nylon, and paper filters each absorb different chemical species. All samples are analyzed in a central analytical lab located in Florida. NDDN filters are changed every Tuesday and sent to the lab for processing. NDDN sites also monitor meteorological conditions and ozone continuously. Data available from the NDDN site includes meteorological measurements of wind speed, wind direction, relative humidity, solar radiation, precipitation, and ambient temperature. Filter pack flow rate is also recorded at the site. Filter pack chemical analyses include sulfate, nitrate, ammonium, sodium, potassium, and nitric acid. Typical ozone data from the site for winter and summer is shown in figure 8.1.

A carbon dioxide monitor has been installed at the Brooklyn site for monitoring of ambient carbon dioxide. Measurements of carbon dioxide in the snowpack and soil at the Brooklyn site are also made at infrequent intervals.

Table 8.2.—Arithmetic mean values, December 1, 1990–February 28, 1991, Stacked Filter Unit (SFU) Particulate Network, Brooklyn Lakes SFU Site.

Particulate measurement	24-hour concentration nanograms/cubic meter
H	57.6
S	132.00
Al	15.30
Si	48.00
K	11.60
Ca	16.10
Ti	1.84
Mn	0.39
Fe	13.50
KNON	3.49
Na	6.47
Cl	3.07
V	0.84
Ni	0.44
Cu	0.79
Zn	0.87
As	0.13
Se	0.17
Br	0.62
Pb	0.68
Fine mass particles (<2.5 um)	1.95
Coarse mass particles (>2.5 and <15 um)	2.49
Reconstructed mass particles	1.21
SOIL (Sum of Al, Si, Ca, Ti, and Fe)	0.22
Ammonium sulfate (calculated)	0.54
Organic mass from hydrogen	0.34
Optical absorption	1.86

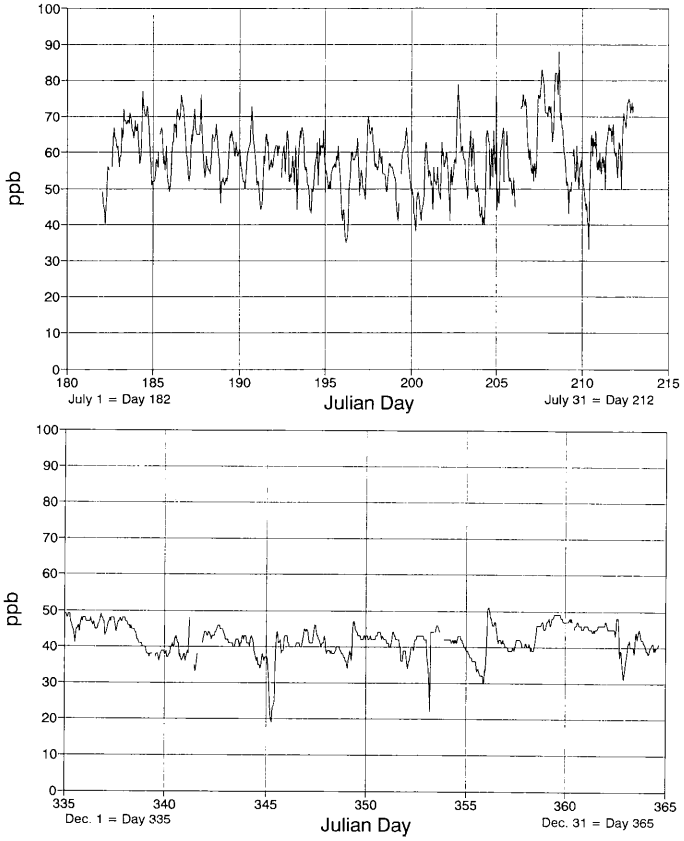

Figure 8.1.—Ozone concentrations in summer and winter from Centennial NDDN site, Brooklyn Lake, GLEES.