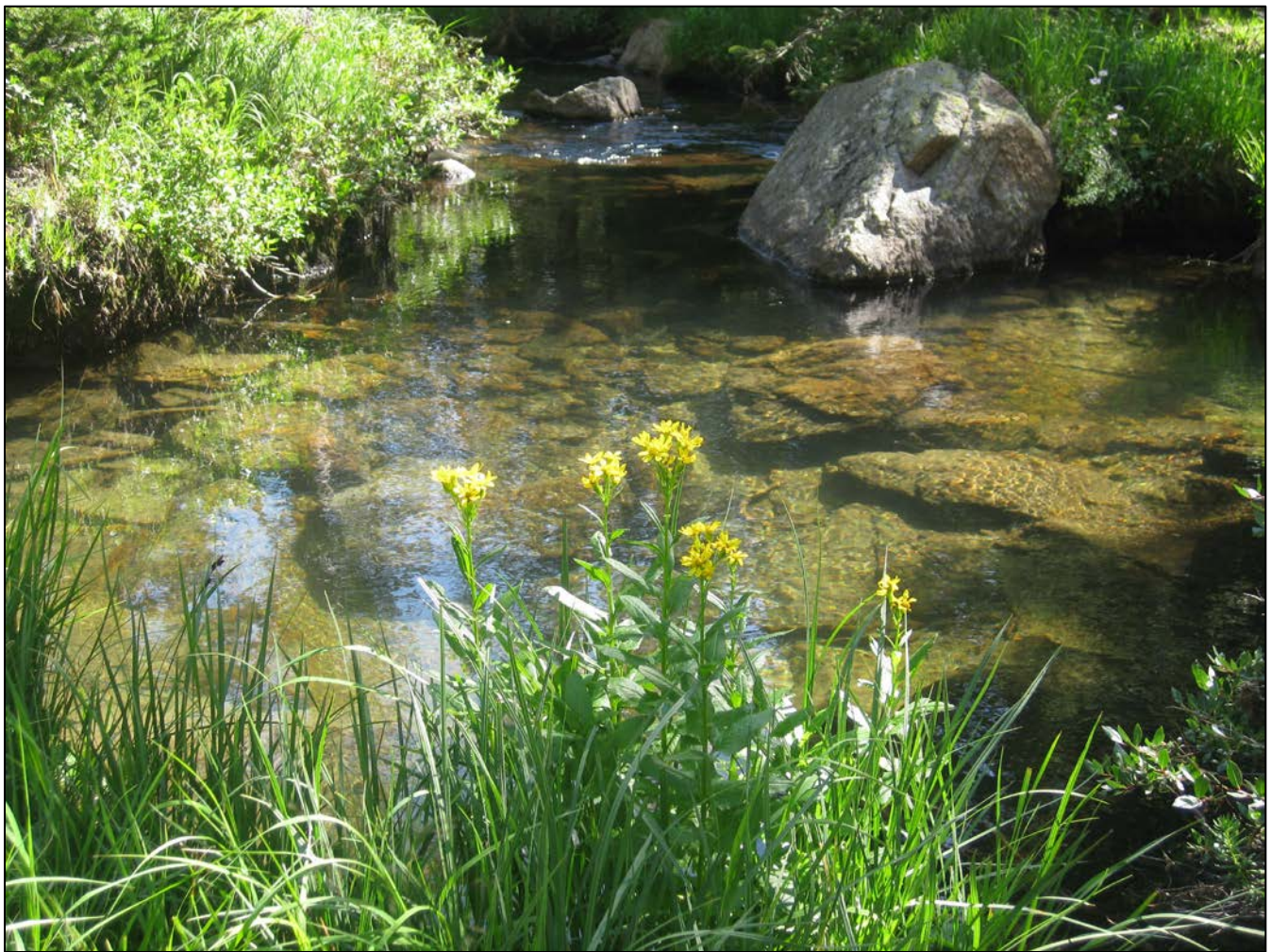




2015 Data Summary of Wet Nitrogen Deposition at Rocky Mountain National Park

Natural Resource Report NPS/NRSS/ARD/NRR—2017/1454



ON THE COVER

Photograph of the Loch in Rocky Mountain National Park
Photograph courtesy of Kristi Morris

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Introduction

The annual Monitoring and Tracking Wet Nitrogen Deposition at Rocky Mountain National Park (RMNP) reports were peer reviewed and published from 2009 to 2013. Reports will continue to undergo rigorous peer-reviewed and published for milestone years including 2017, 2022, 2027, and 2032. However, in 2014, it was decided that a summary of the data would be compiled and distributed annually between milestone years.

The purpose of this data summary is the same as the full reports, which is to inform the Memorandum of Understanding (MOU) agencies, stakeholders, and the public about the current status and trends of wet nitrogen (N) deposition in accordance with the Nitrogen Deposition Reduction Plan for RMNP.

Several analyses are used to track nitrogen deposition at RMNP, including:

1. assessment of progress along the glidepath,
2. long-term (>25 years) trend analyses for RMNP and other regional sites, and
3. short-term (5 and 7 years) trend analyses for RMNP and other regional sites.

Wet N deposition data through 2015 are presented in this summary (Figures 1-7 and Tables 1-8) and are available on the National Atmospheric Deposition Program website (<http://nadp.sws.uiuc.edu>). A complete overview of the issue and description of the methods are available in the last full report (Morris et al. 2015) at https://www.colorado.gov/pacific/sites/default/files/AP_RMNP_2013-Monitoring-and-Tracking-Wet-Nitrogen-Deposition.pdf.

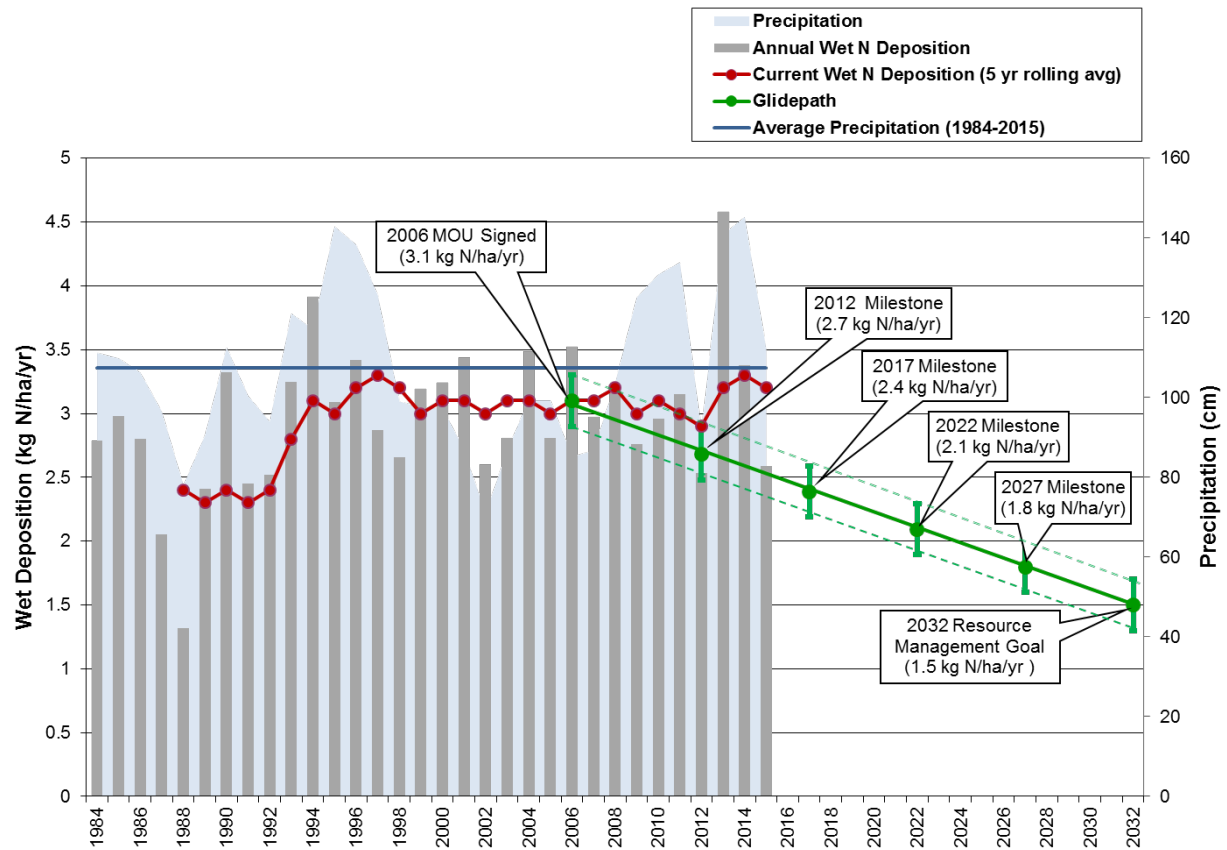


Figure 1. The glidepath compared to annual and 5-year average of wet N deposition. Annual wet N deposition in 2015 dropped further from the spike that was observed in 2013. However, the 5-year rolling average remains above the glidepath. Error bars are based on the analysis of co-located sites by Wetherbee (2016; $\alpha = 0.10$).

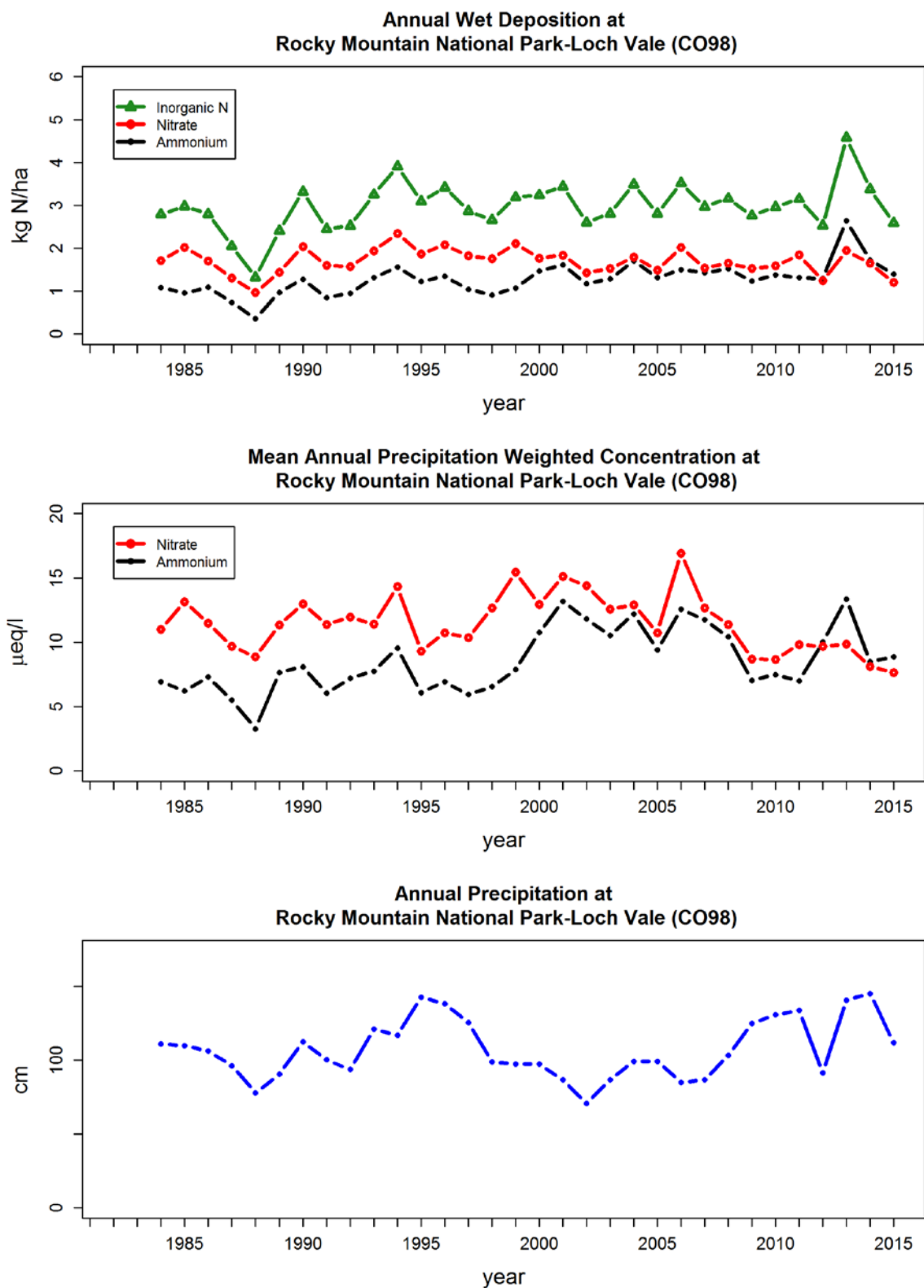


Figure 2. Precipitation in 2015 was lower than 2014, but still above average at Loch Vale, RMNP. Concentrations of nitrate and ammonium in 2015 were similar to 2014. Therefore deposition decreased.

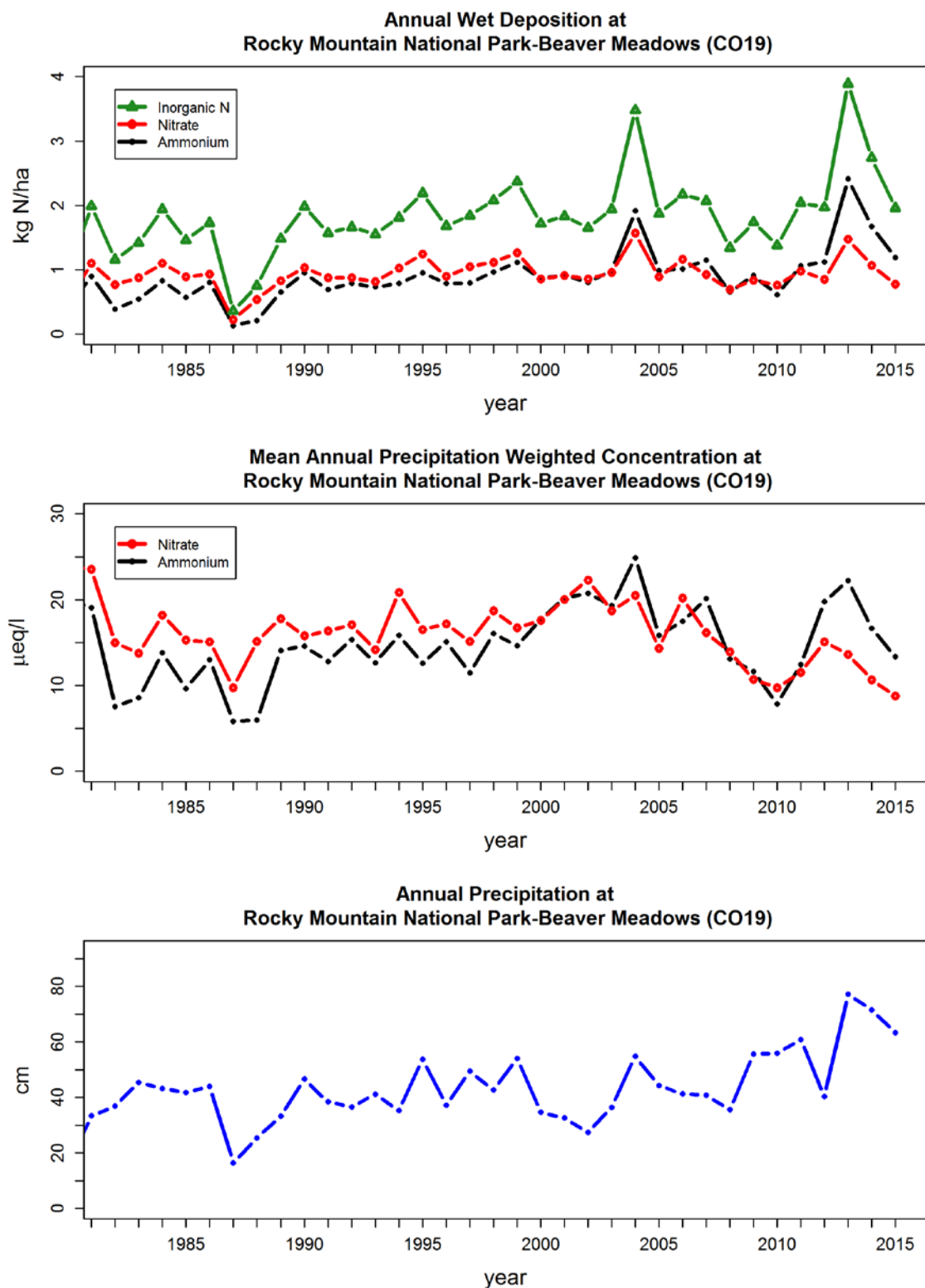


Figure 3. Precipitation and concentrations decreased in 2015, resulting in less wet N deposition at Beaver Meadows, RMNP.

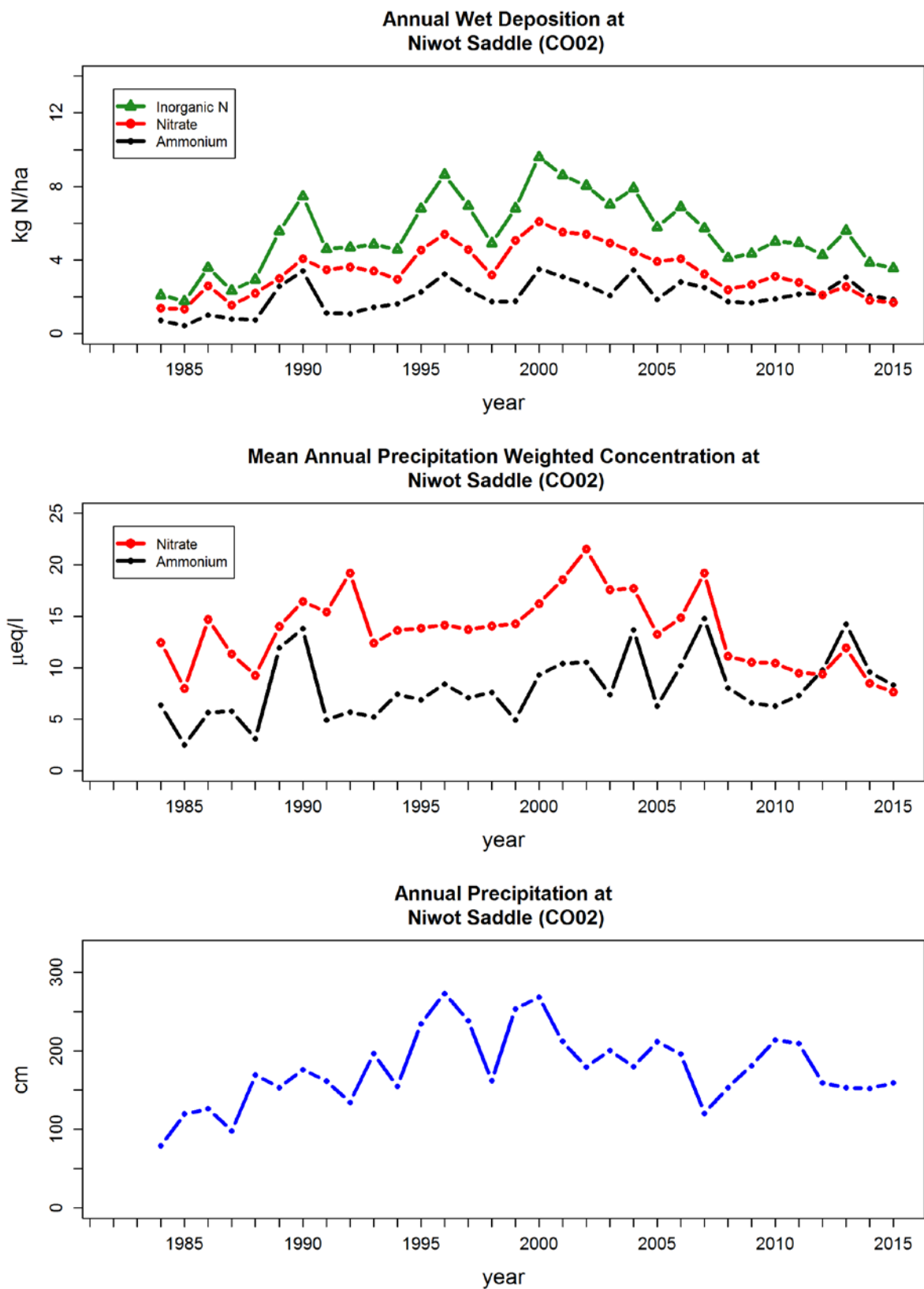


Figure 4. Precipitation and concentrations were similar in 2015 to 2014.

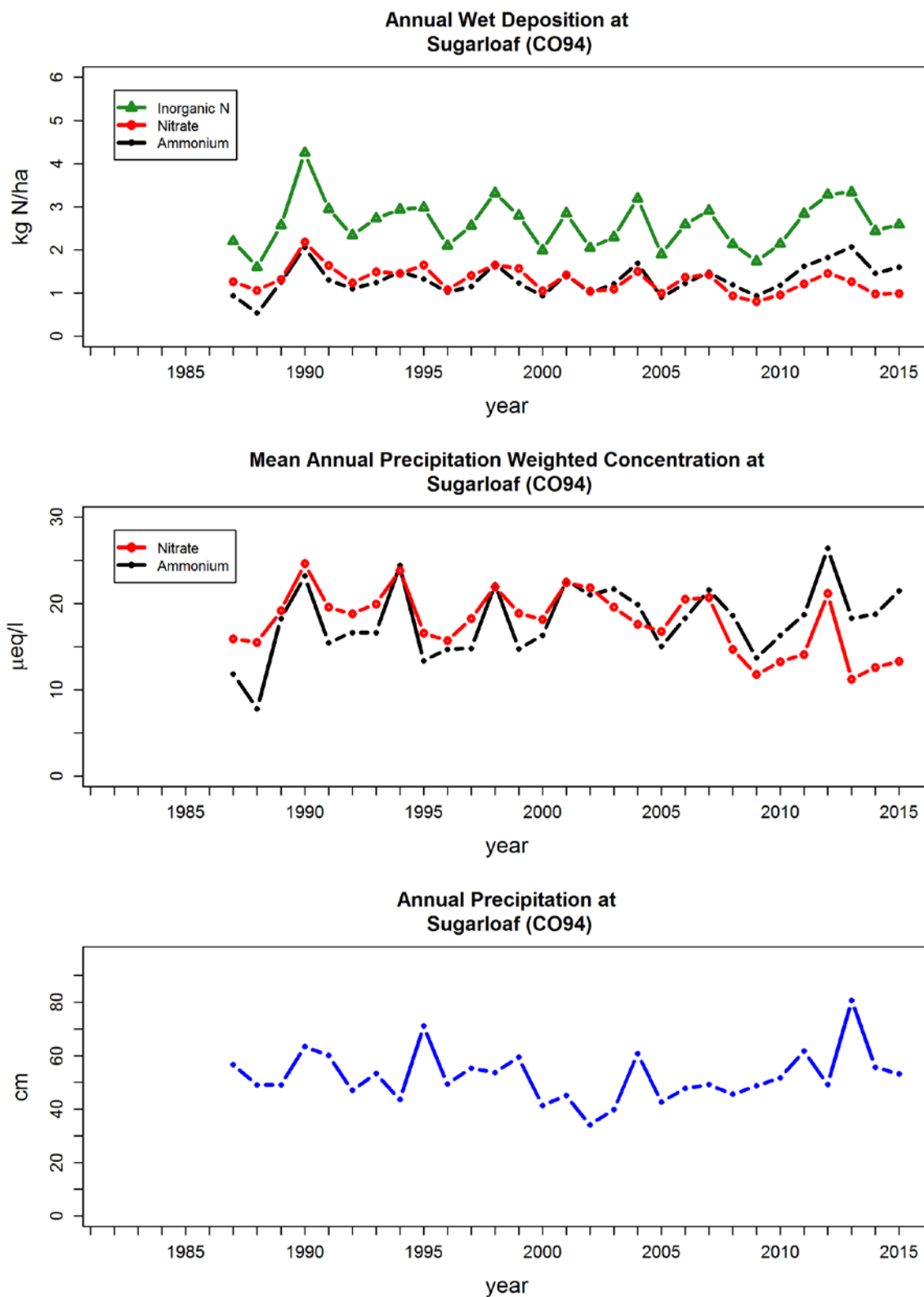


Figure 5. Precipitation decreased slightly in 2015 and concentrations increased slightly, resulting in a slight increase in wet N deposition.

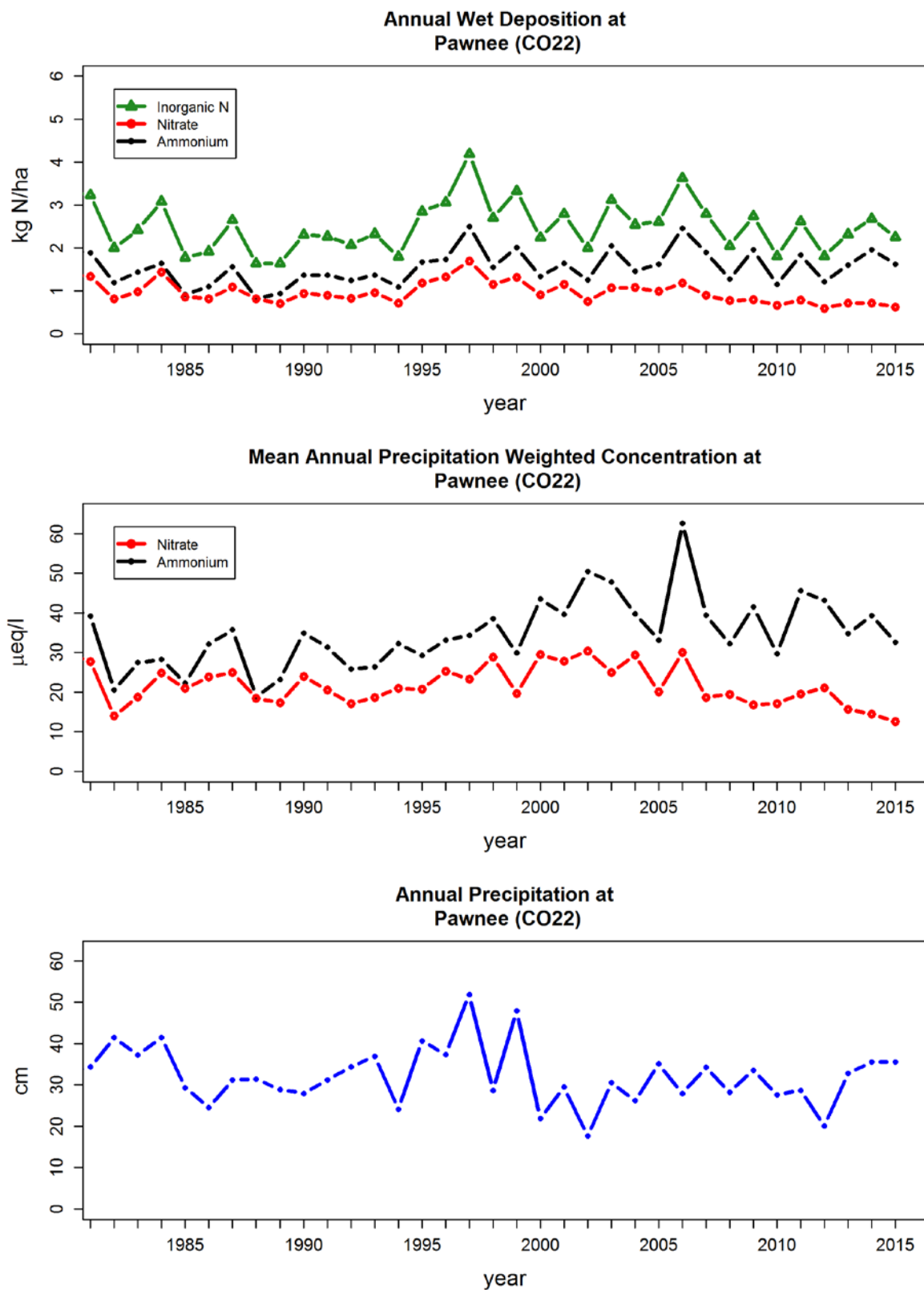


Figure 6. Precipitation in 2015 was similar to 2014, slight decreases in concentrations resulted in a slight decrease in wet N deposition at Pawnee.

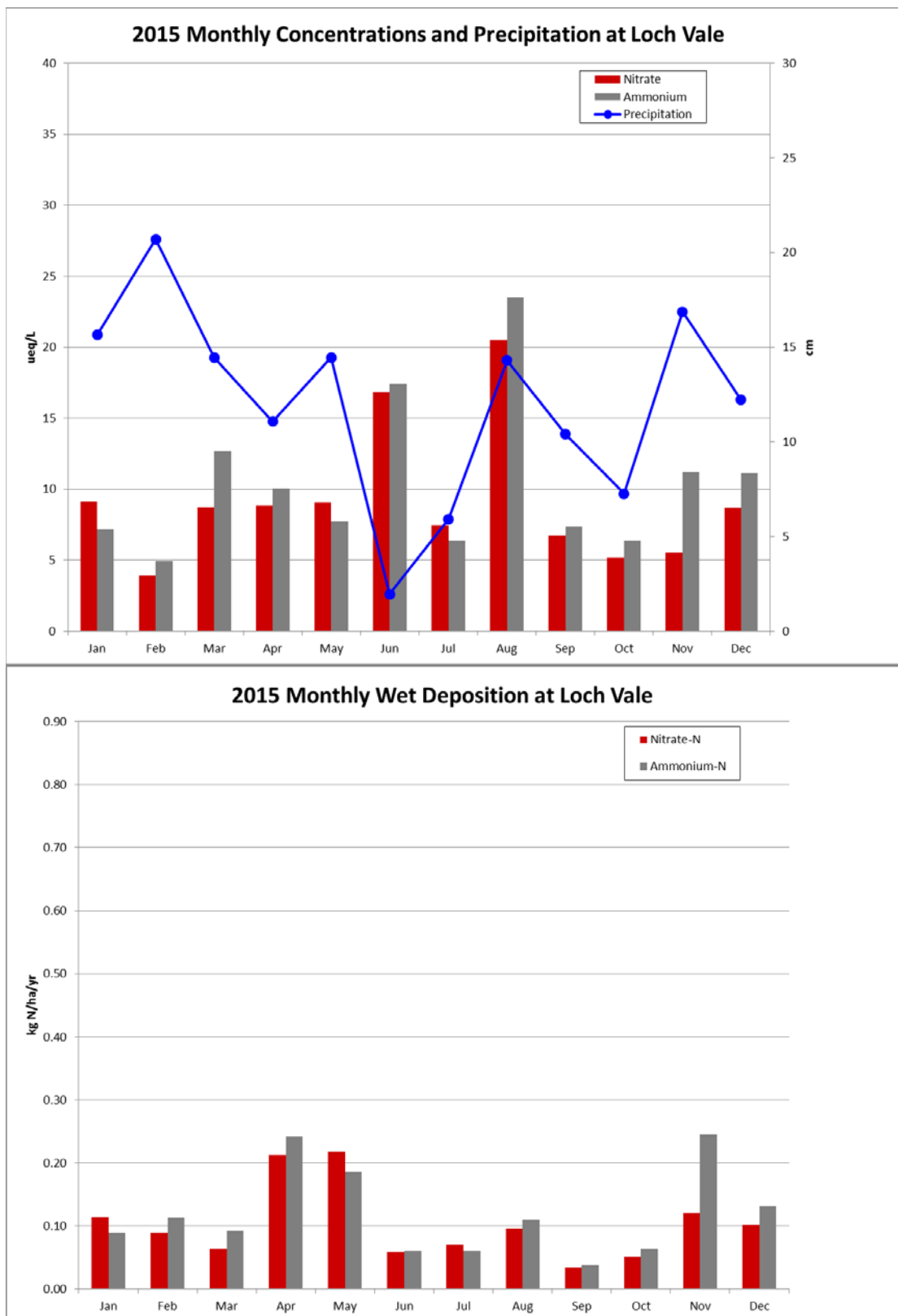


Figure 7. 2015 monthly data at Loch Vale. Wet N deposition in 2015 was fairly evenly distributed over all 12 months, with the highest amounts being deposited in April, May and November.

Table 1. Long-term trends in **wet nitrogen deposition** over the period of record (through 2015). Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

Site Name	Start Year	Trend (kg N/ha/yr)	P-value	Significant Trends
Loch Vale	1984	0.016	0.119	no trend
Beaver Meadows	1981	0.020	0.006	increasing
Niwot Saddle	1985	-0.038	0.453	no trend
Sugarloaf	1987	0.002	0.881	no trend
Pawnee	1980	0.001	0.924	no trend

Table 2. Long-term trends in **precipitation-weighted mean ammonium concentrations** over the period of record (through 2015). Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

Site Name	Start Year	Trend ($\mu\text{eq/L/yr}$)	P-value	Significant Trends
Loch Vale	1984	0.129	<0.001	increasing
Beaver Meadows	1981	0.194	<0.001	increasing
Niwot Saddle	1985	0.125	0.004	increasing
Sugarloaf	1987	0.166	0.022	increasing
Pawnee	1980	0.360	0.001	increasing

Table 3. Long-term trends in **precipitation-weighted mean nitrate concentrations** over the period of record (through 2015). Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

Site Name	Start Year	Trend ($\mu\text{eq/L/yr}$)	P-value	Significant Trends
Loch Vale	1984	-0.046	0.217	no trend
Beaver Meadows	1981	-0.113	0.015	decreasing
Niwot Saddle	1985	-0.097	0.218	no trend
Sugarloaf	1987	-0.203	0.008	decreasing
Pawnee	1980	-0.143	0.067	no trend

Table 4. Long-term trends of **precipitation** over the period of record (through 2015). Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

Site Name	Start Year	Trend (cm/yr)	P-value	Significant Trends
Loch Vale	1984	0.445	0.408	no trend
Beaver Meadows	1981	0.597	0.005	increasing
Niwot Saddle	1985	0.256	0.775	no trend
Sugarloaf	1987	0.008	0.925	no trend
Pawnee	1980	-0.108	0.258	no trend

Table 5. Short-term trends of **wet nitrogen deposition** for 5 year (2011–2015) and 7 year (2009–2015) time periods. Significant trends were determined at the 95 percent confidence level (p-value $\leq$ 0.05).

Site Name	5 year			7 year		
	Trend (kg N/ha/yr)	P-value	Significant Trends	Trend (kg N/ha/yr)	P-value	Significant Trends
Loch Vale	-0.060	1.000	no trend	0.077	0.764	no trend
Beaver Meadows	-0.012	0.807	no trend	0.150	0.368	no trend
Niwot Saddle	-0.323	0.221	no trend	-0.210	0.230	no trend
Sugarloaf	-0.098	0.807	no trend	0.142	0.230	no trend
Pawnee	-0.008	1.000	no trend	-0.012	0.879	no trend

Table 6. Short-term trends for **precipitation-weighted mean ammonium concentrations** for 5 year (2011–2015) and 7 year (2009–2015) time periods. Significant trends were determined at the 95 percent confidence level (p-value $\leq$ 0.05).

Site Name	5 year			7 year		
	Trend (μ eq/L/yr)	P-value	Significant Trends	Trend (μ eq/L/yr)	P-value	Significant Trends
Loch Vale	0.146	0.713	no trend	0.342	0.050	increasing
Beaver Meadows	-0.157	0.713	no trend	0.711	0.154	no trend
Niwot Saddle	0.028	1.000	no trend	0.715	0.027	increasing
Sugarloaf	1.23	0.178	no trend	1.13	0.029	increasing
Pawnee	-4.72	0.111	no trend	-0.046	1.000	no trend

Table 7. Short-term trends for **precipitation-weighted mean nitrate concentrations** for 5 year (2011–2015) and 7 year (2009–2015) time periods. Significant trends were determined at the 95 percent confidence level (p-value $\leq$ 0.05).

Site Name	5 year			7 year		
	Trend (μ eq/L/yr))	P-value	Significant Trends	Trend (μ eq/L/yr)	P-value	Significant Trends
Loch Vale	-0.537	0.217	no trend	0.058	0.763	no trend
Beaver Meadows	-0.649	0.066	no trend	-0.028	0.822	no trend
Niwot Saddle	-0.680	0.111	no trend	-0.288	0.181	no trend
Sugarloaf	0.284	0.639	no trend	0.244	0.329	no trend
Pawnee	-1.87	0.020	decreasing	-0.520	0.084	no trend

Table 8. Short-term trends for **precipitation** for 5 year (2011–2015) and 7 year (2009–2015) time periods. Significant trends were determined at the 95 percent confidence level ($p\text{-value} \leq 0.05$).

Site Name	5 year			7 year		
	Trend (cm/yr)	P-value	Significant Trends	Trend (cm/yr)	P-value	Significant Trends
Loch Vale	3.64	0.807	no trend	3.47	0.548	no trend
Beaver Meadows	2.11	0.807	no trend	2.56	0.230	no trend
Niwot Saddle	-5.03	0.221	no trend	-6.42	0.072	no trend
Sugarloaf	-2.08	0.807	no trend	1.00	0.368	no trend
Pawnee	2.16	0.086	no trend	1.40	0.230	no trend

Summary

1. Is current wet nitrogen deposition in RMNP on or below the NDRP glidepath?

Current wet N deposition (5-year rolling average) at Loch Vale in RMNP was 3.2 kg/ha/yr, which is 0.7 kg/ha/yr above the glidepath.

2. Has wet nitrogen deposition decreased at RMNP and other sites in the region?

Wet N deposition has not decreased at RMNP or other sites in the region over the long-term. Over the entire period of record, the trend in wet N deposition at Loch Vale in RMNP has gone from increasing (1984-2000) to no trend (1984-2015). Data from Beaver Meadows in RMNP, however, indicate an increase in wet N deposition and precipitation for the period of record. Ammonium concentration data show an increase at all five sites in the region over the long-term. Nitrate concentration data show a decreasing trend at two sites over the long-term.

3. Has wet nitrogen deposition *recently* decreased at RMNP and at other sites in the region?

Wet N deposition has not recently decreased at RMNP or other sites in the region (2009-2015). Concentrations of ammonium increased at 3 of the 5 sites over the most recent 7 year time period and concentrations of nitrate decreased at one site over the most recent 5 year period.

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