



2016 Data Summary of Wet Nitrogen Deposition at Rocky Mountain National Park

Natural Resource Report NPS/NRSS/ARD/NRR—2018/1610



ON THE COVER

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

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Kristi Morris

National Park Service
Air Resources Division
P.O. Box 25287
Denver, Colorado 80225-0287

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Abstract

The NPS is working with the Colorado Department of Public Health and Environment and the Environmental Protection Agency to reduce atmospheric nitrogen (N) deposition at Rocky Mountain National Park (RMNP) due to its deleterious effects on park ecosystems. The data summarized in this report informs these agencies, stakeholders, and the public about the current status and trends of N deposition in accordance with the Nitrogen Deposition Reduction Plan for RMNP. Analyses include assessment of progress along the glidepath, long-term (>25 years) trend analyses for RMNP and other regional sites, and short-term (5 and 7 years) trend analyses for RMNP and other regional sites.

Introduction and Results

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 external peer-review and be 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. This data summary is peer-reviewed by the Memorandum of Understanding (MOU) agencies including the National Park Service, the Environmental Protection Agency and the Colorado Department of Public Health and Environment.

The purpose of this data summary is the same as the full reports, which is to inform the 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 2016 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.

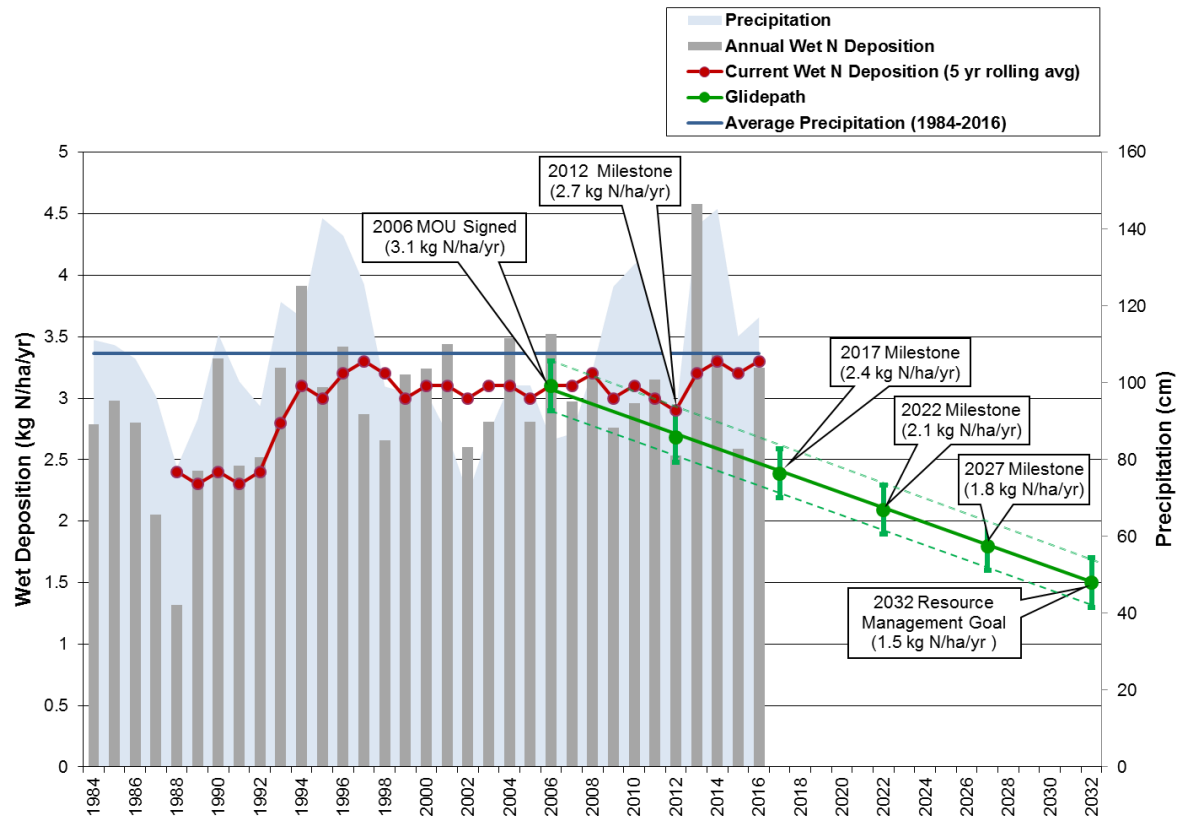


Figure 1. The glidepath compared to annual and 5-year average of wet N deposition. Annual wet N deposition in 2016 increased from 2015. The 5-year rolling average remains above the glidepath. Error bars are based on the analysis of co-located sites by Wetherbee (2016; alpha = 0.10).

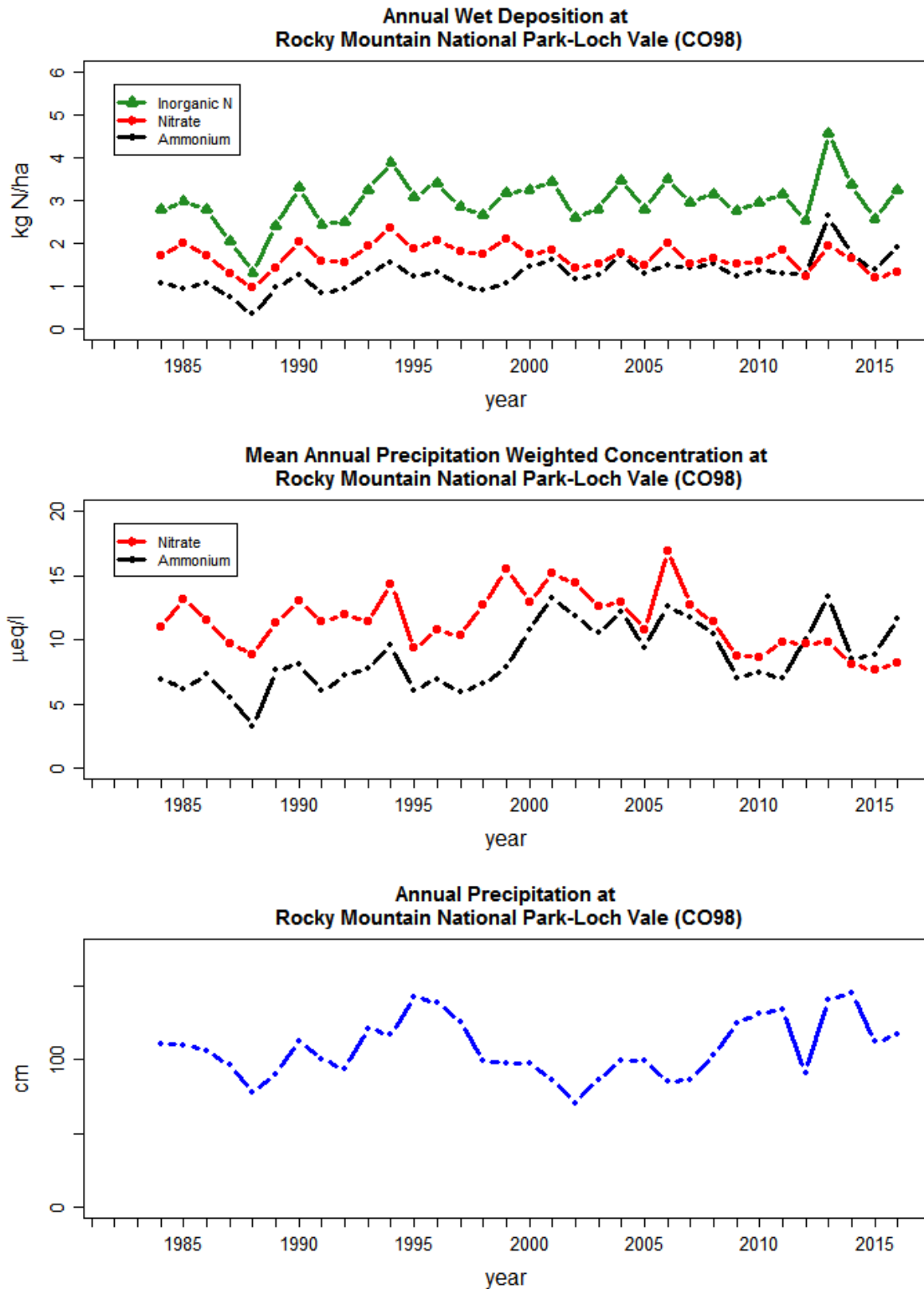


Figure 2. Precipitation in 2016 was slightly higher than 2015 and still above average at Loch Vale, RMNP. Concentrations of nitrate in 2015 were increased slightly, and concentrations of ammonium also increased. Therefore, wet N deposition increased.

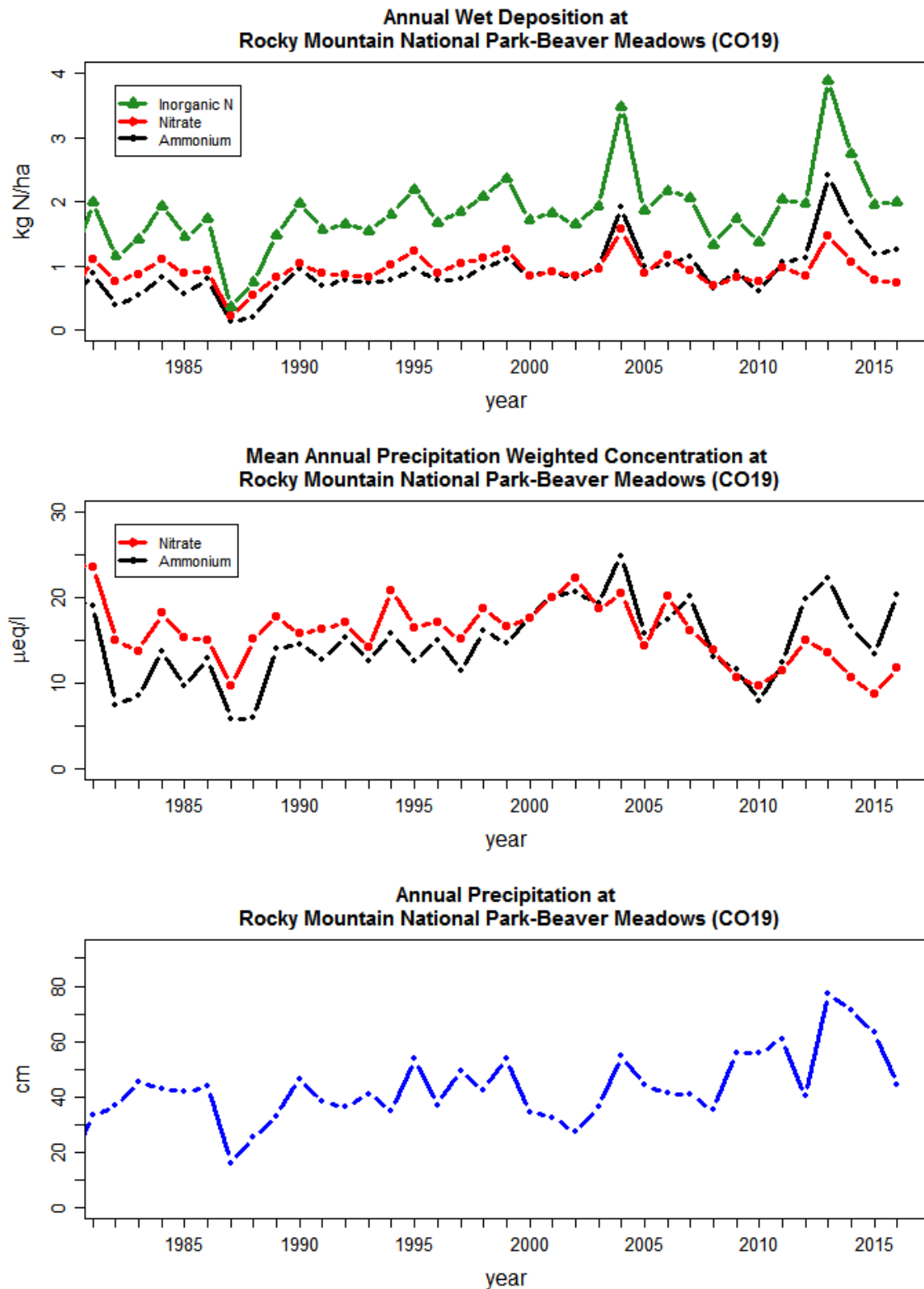


Figure 3. Precipitation decreased in 2016, while concentrations of nitrate and ammonium increased, resulting in similar wet N deposition in 2015 and 2016 at Beaver Meadows, RMNP.

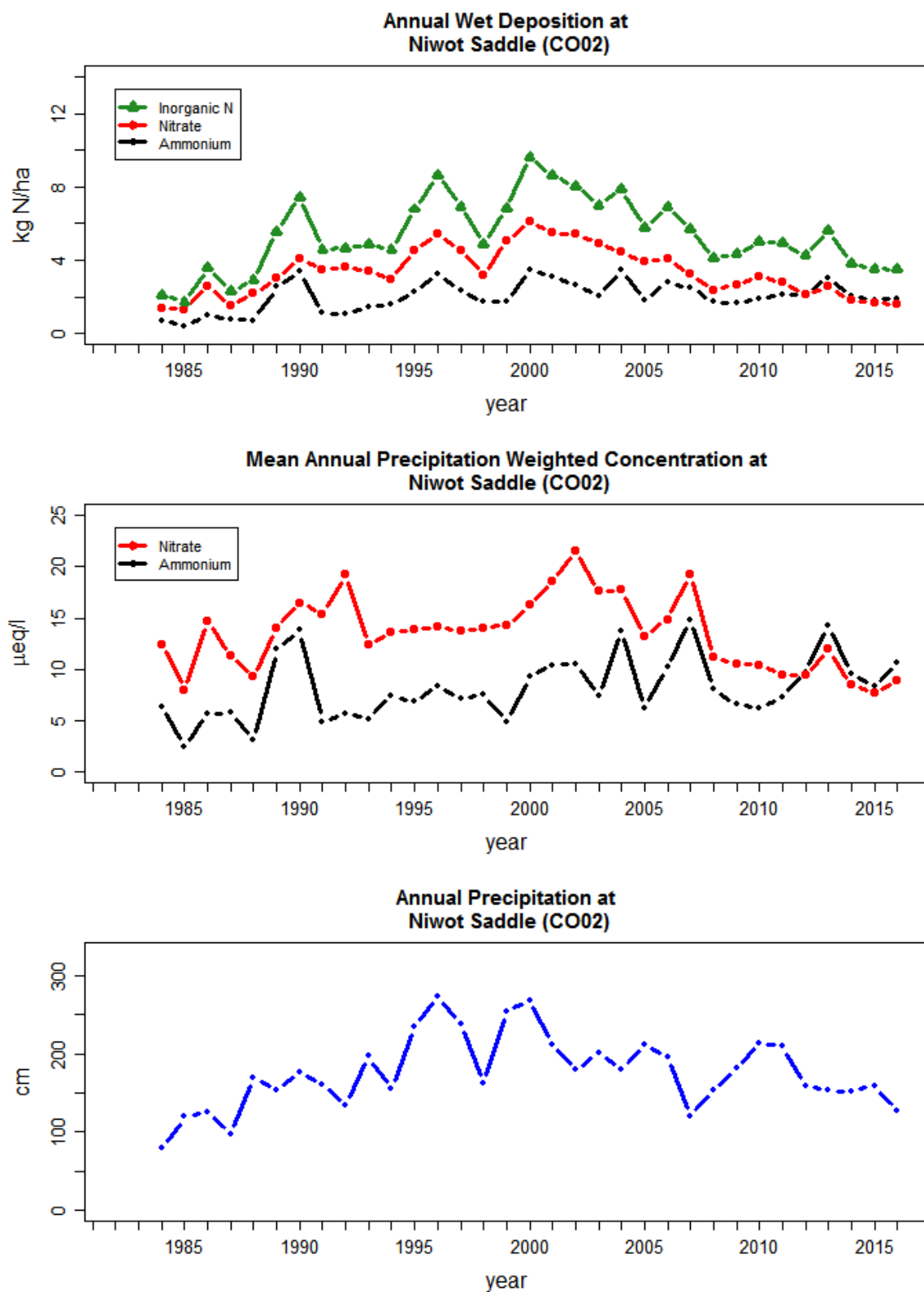


Figure 4. Precipitation decreased slightly in 2016 while concentrations increased slightly, resulting in similar wet N deposition in 2015 and 2016 at Niwot Saddle.

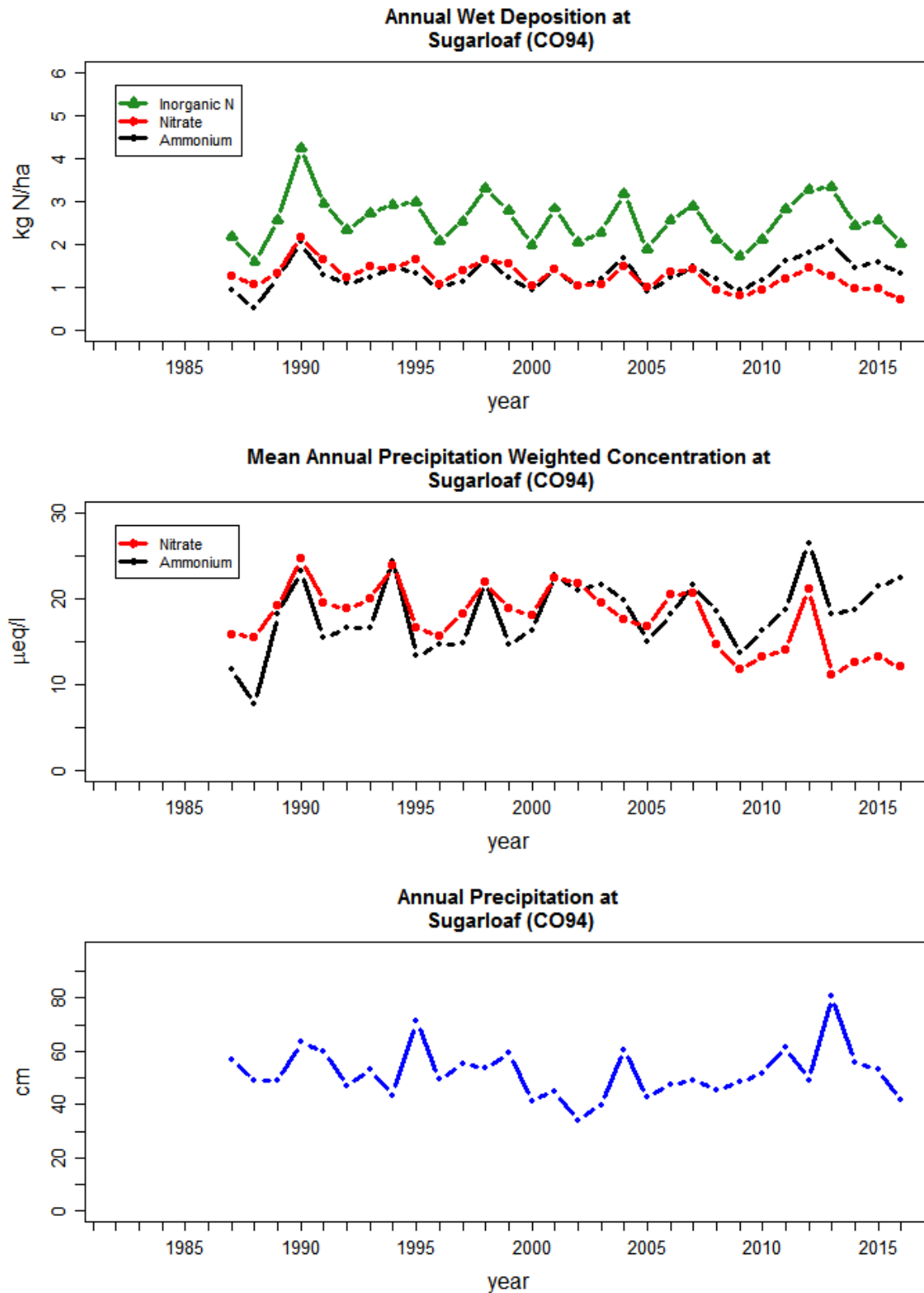


Figure 5. Precipitation decreased in 2016. Concentrations of nitrate decreased slightly while concentrations of ammonium increased, resulting in a decrease in wet N deposition at Sugarloaf.

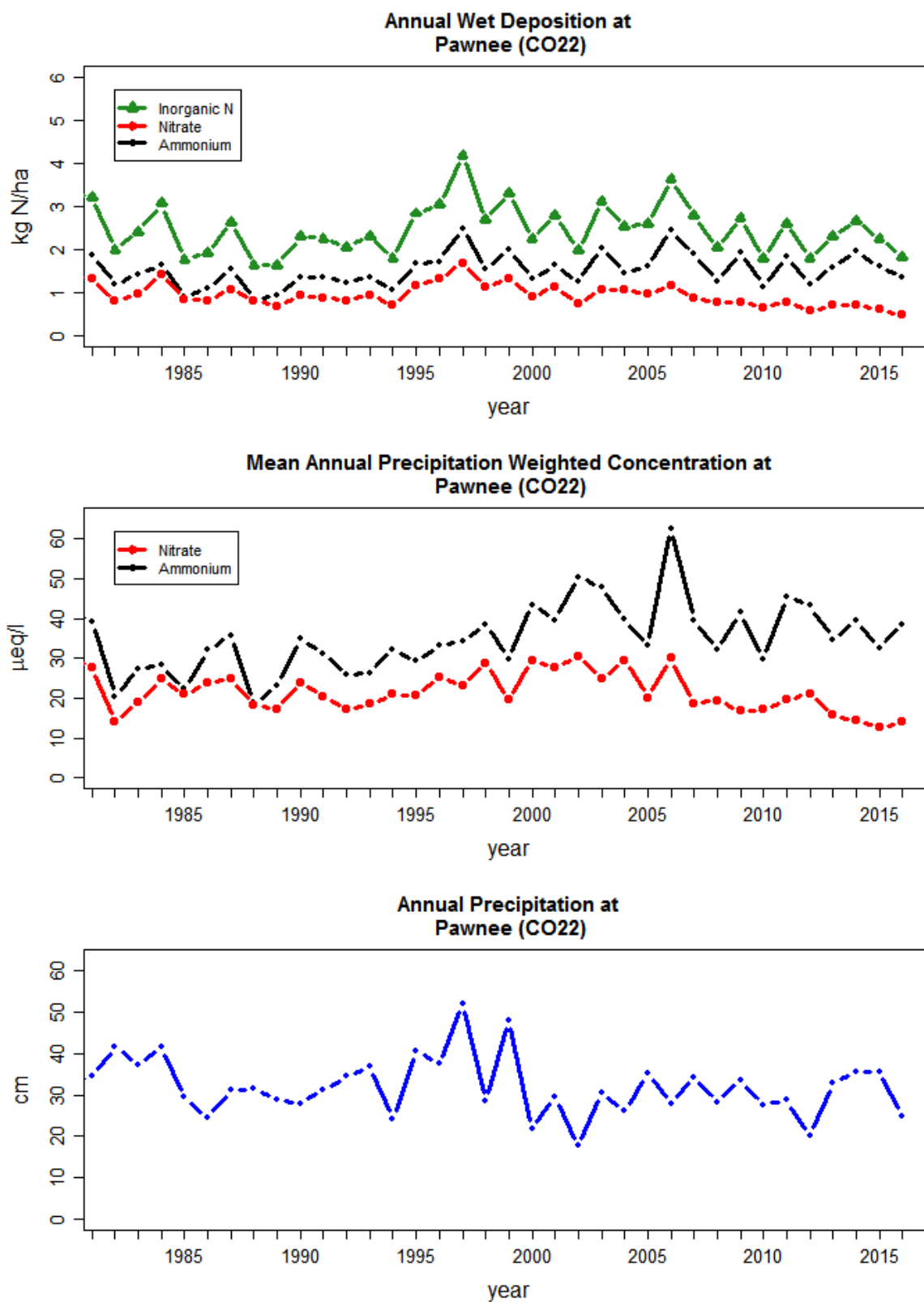


Figure 6. Precipitation decreased in 2016. Concentrations of nitrate and ammonium increased slightly, resulting in a decrease in wet N deposition at Pawnee.

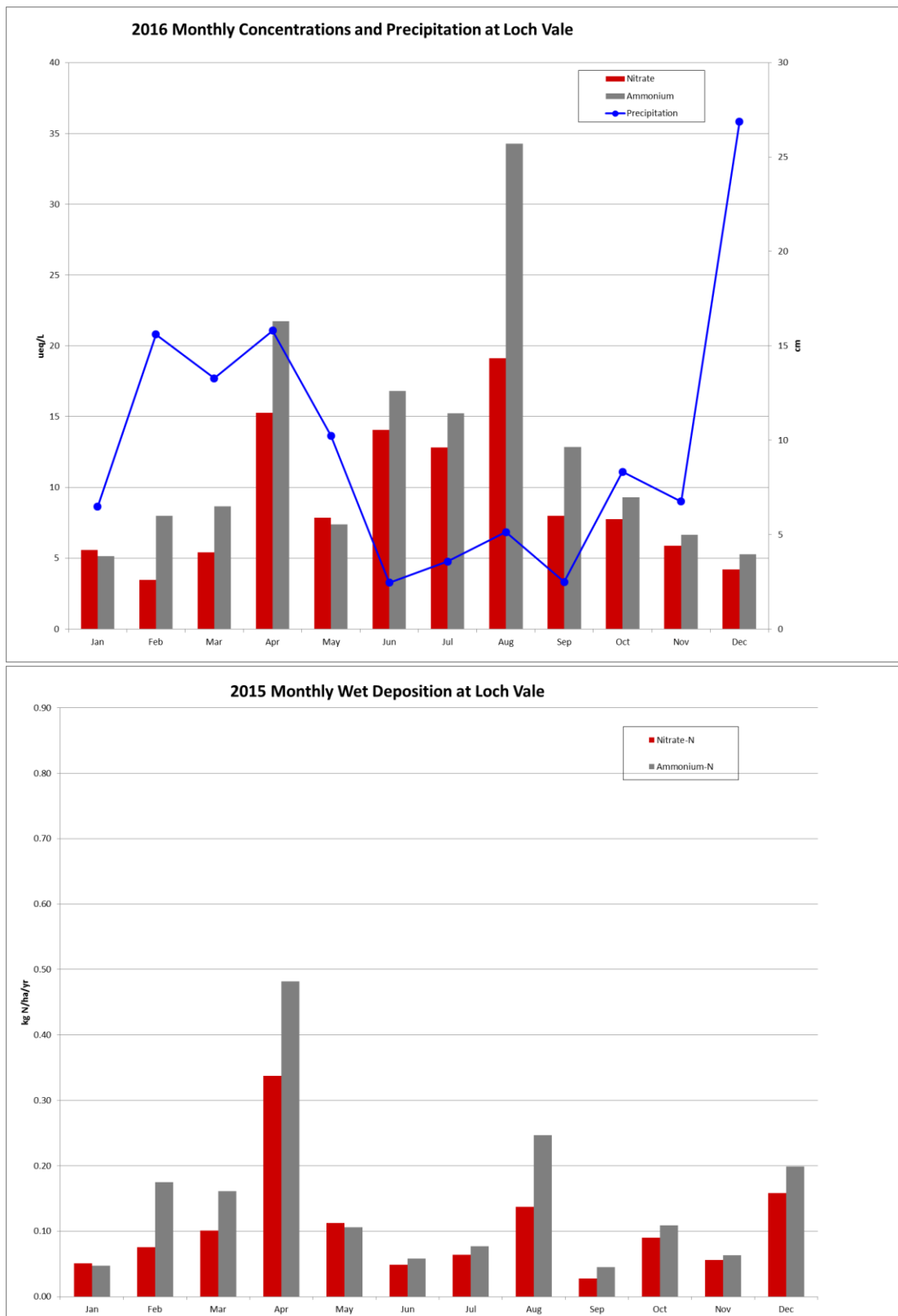


Figure 7. 2016 monthly data at Loch Vale. Wet N deposition in 2016 was highest in April, August and December.

Table 1. Long-term trends in **wet nitrogen deposition** over the period of record (through 2016). Significant trends were determined at the 95 percent confidence level (p-value $\leq$ 0.05).

Site Name	Start Year	Trend (kg N/ha/yr)	P-value	Significant Trends
Loch Vale	1984	0.017	0.085	no trend
Beaver Meadows	1981	0.018	0.004	increasing
Niwot Saddle	1986	-0.014	0.887	no trend
Sugarloaf	1987	-0.003	0.844	no trend
Pawnee	1980	-0.002	0.844	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 $\leq$ 0.05).

Site Name	Start Year	Trend ($\mu\text{eq/L/yr}$)	P-value	Significant Trends
Loch Vale	1984	0.139	<0.001	increasing
Beaver Meadows	1981	0.209	<0.001	increasing
Niwot Saddle	1986	0.153	0.001	increasing
Sugarloaf	1987	0.189	0.026	increasing
Pawnee	1980	0.354	0.003	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 $\leq$ 0.05).

Site Name	Start Year	Trend ($\mu\text{eq/L/yr}$)	P-value	Significant Trends
Loch Vale	1984	-0.055	0.151	no trend
Beaver Meadows	1981	-0.115	0.020	decreasing
Niwot Saddle	1986	-0.069	0.321	no trend
Sugarloaf	1987	-0.211	0.005	decreasing
Pawnee	1980	-0.167	0.040	decreasing

Table 4. Long-term trends of **precipitation** over the period of record (through 2016). 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	0.456	0.329	no trend
Beaver Meadows	1981	0.500	0.008	increasing
Niwot Saddle	1986	0.256	0.775	no trend
Sugarloaf	1987	-0.057	0.775	no trend
Pawnee	1980	-0.148	0.154	no trend

Table 5. Short-term trends of **wet nitrogen deposition** for 5 year (2012–2016) and 7 year (2010–2016) time periods. Significant trends were determined at the 95 percent confidence level (p-value ≤ 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	-0.023	1.000	no trend	0.020	0.764	no trend
Beaver Meadows	-0.187	0.807	no trend	0.040	0.764	no trend
Niwot Saddle	-0.270	0.308	no trend	-0.286	0.036	decreasing
Sugarloaf	-0.344	0.221	no trend	-0.063	0.764	no trend
Pawnee	-0.014	1.000	no trend	0.005	0.879	no trend

Table 6. Short-term trends for **precipitation-weighted mean ammonium concentrations** for 5 year (2012–2016) and 7 year (2010–2016) time periods. Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

Site Name	5 year			7 year		
	Trend ($\mu\text{eq/L/yr}$)	P-value	Significant Trends	Trend ($\mu\text{eq/L/yr}$)	P-value	Significant Trends
Loch Vale	0.111	0.622	no trend	0.715	0.016	increasing
Beaver Meadows	-0.277	0.540	no trend	1.03	0.084	no trend
Niwot Saddle	-1.00	0.554	no trend	1.12	0.037	increasing
Sugarloaf	0.476	0.514	no trend	1.57	0.098	no trend
Pawnee	-1.54	0.270	no trend	-0.946	0.499	no trend

Table 7. Short-term trends for **precipitation-weighted mean nitrate concentrations** for 5 year (2012–2016) and 7 year (2010–2016) 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 ($\mu\text{eq/L/yr}$)	P-value	Significant Trends	Trend ($\mu\text{eq/L/yr}$)	P-value	Significant Trends
Loch Vale	-0.429	0.139	no trend	-0.270	0.451	no trend
Beaver Meadows	-0.415	0.111	no trend	-0.028	0.822	no trend
Niwot Saddle	-0.726	0.554	no trend	<0.001	1.000	no trend
Sugarloaf	-0.495	0.151	no trend	-0.061	0.937	no trend
Pawnee	-1.59	0.010	decreasing	-1.27	0.009	decreasing

Table 8. Short-term trends for **precipitation** for 5 year (2012–2016) and 7 year (2010–2016) 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	4.70	0.807	no trend	3.03	1.000	no trend
Beaver Meadows	-6.36	0.807	no trend	0.64	1.000	no trend
Niwot Saddle	-0.455	0.734	no trend	-12.14	0.016	decreasing
Sugarloaf	-4.72	0.462	no trend	-1.81	0.548	no trend
Pawnee	1.31	0.462	no trend	1.40	0.368	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 3.3 kg/ha/yr, which is 0.85 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. An increasing trend was reported by Burns 2003 for the period 1984-2000. Trend analyses since then (for 1984-2008 and beyond) show no trend. 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 three 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 (2010-2016), except at Niwot Saddle. Concentrations of ammonium increased at 2 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 and 7 year period.

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1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525