National Park Service
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Natural Resource Stewardship and Science

2014 Data Summary of Wet Nitrogen Deposition at Rocky Mountain National Park

Natural Resource Data Series NPS/NRSS/ARD/NRDS—2016/1036

ON THE COVER
Photograph of Loch Vale in Rocky Mountain National Park
Photograph courtesy of Kristi Morris

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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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 be 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 2014 are presented in this summary 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.

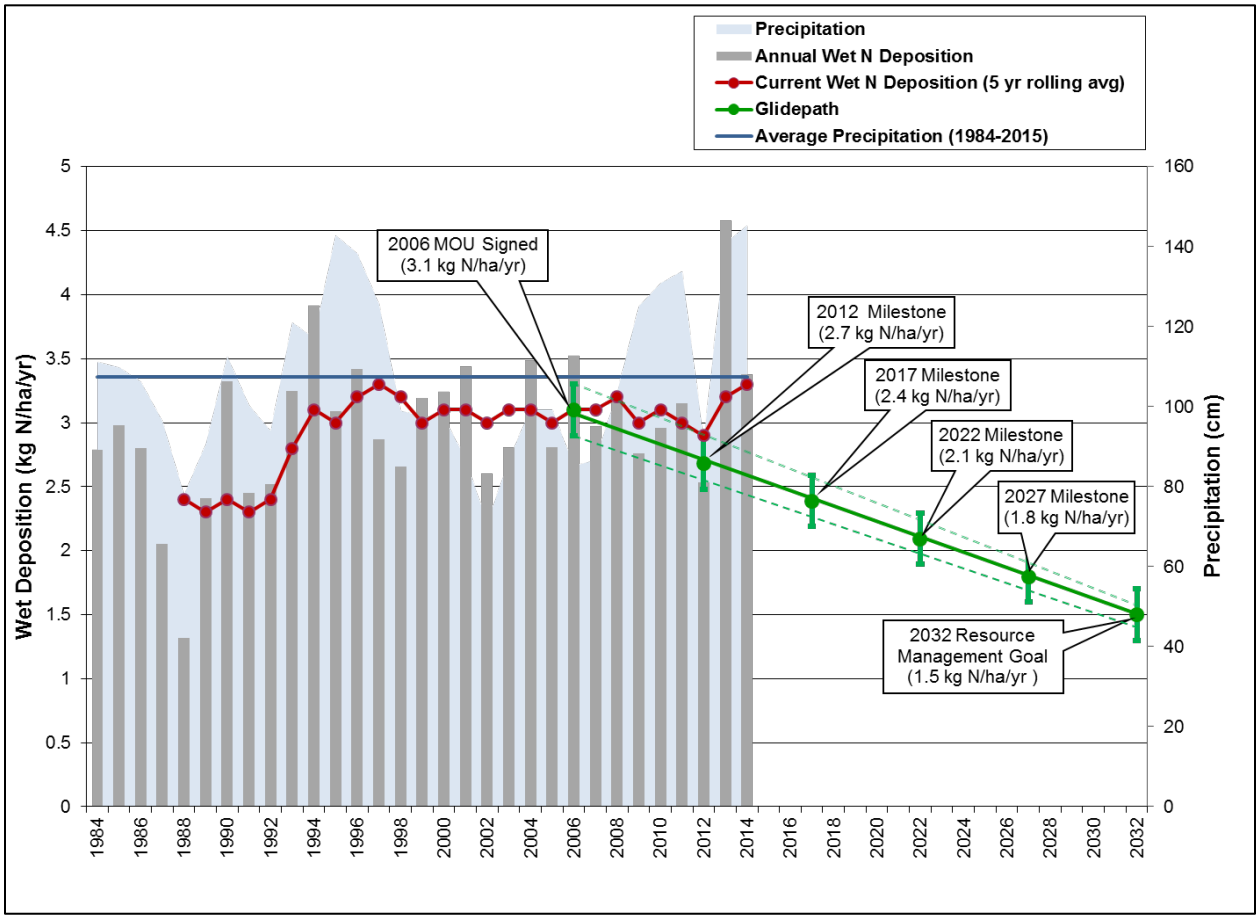


Figure 1. The glidepath compared to annual and 5-year average of wet N deposition. Annual wet N deposition in 2014 dropped from the spike that was observed in 2013. However, the 5-year rolling average remains above the glidepath. Error bars were added to the glidepath in 2014 based on the analysis of co-located sites by Wetherbee (2016; alpha = 0.10). When the measured value equals the glidepath, there is a 90% chance that N deposition will exceed the lower bound and 10% chance that the true deposition is greater than the upper bound.

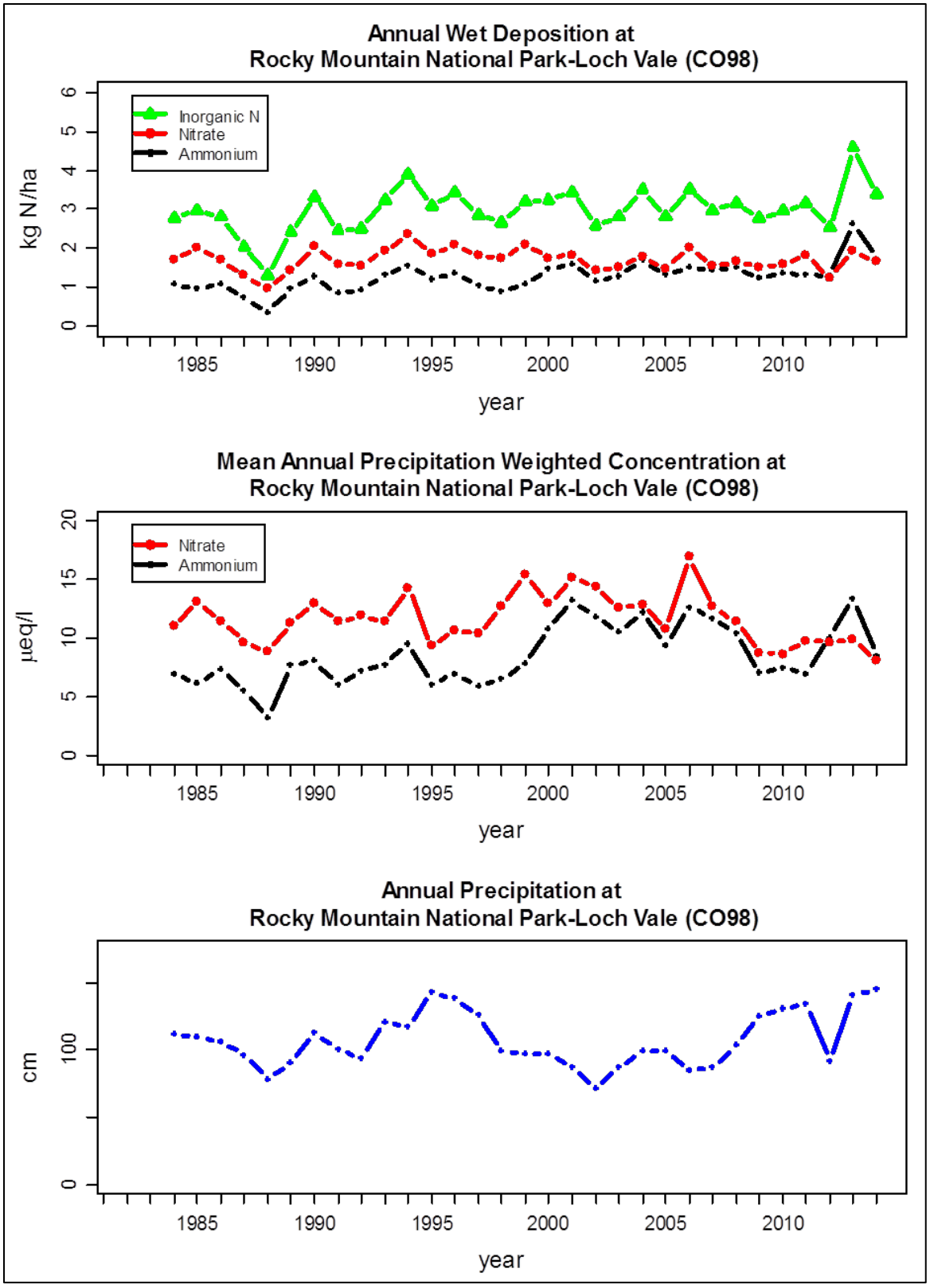


Figure 2. 2014 was another wet year at Loch Vale, RMNP. However, because concentrations of nitrate and ammonium decreased in 2014, so did N wet deposition.

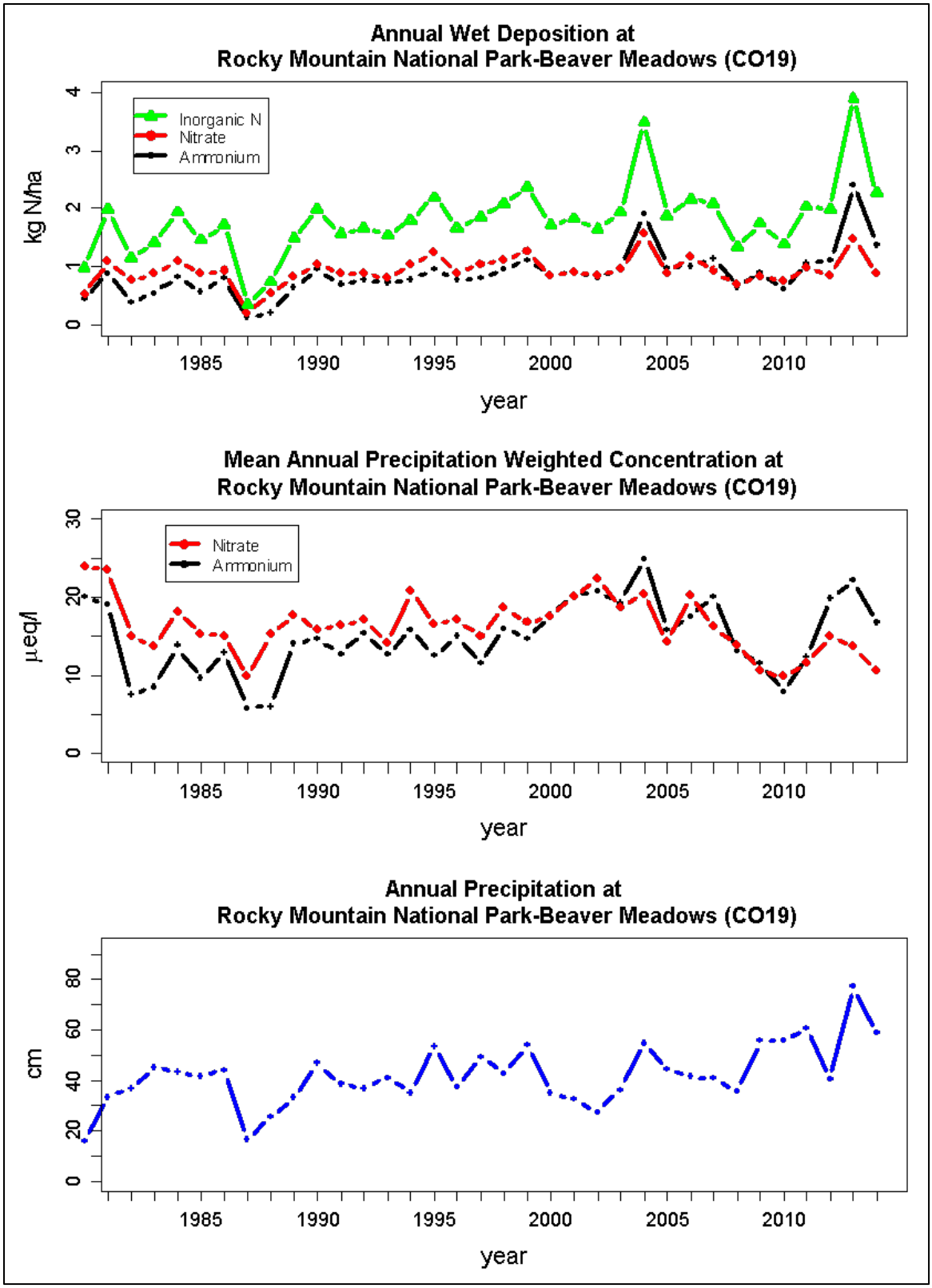


Figure 3. Precipitation and concentrations decreased in 2014, resulting in less wet N deposition at Beaver Meadows, RMNP.

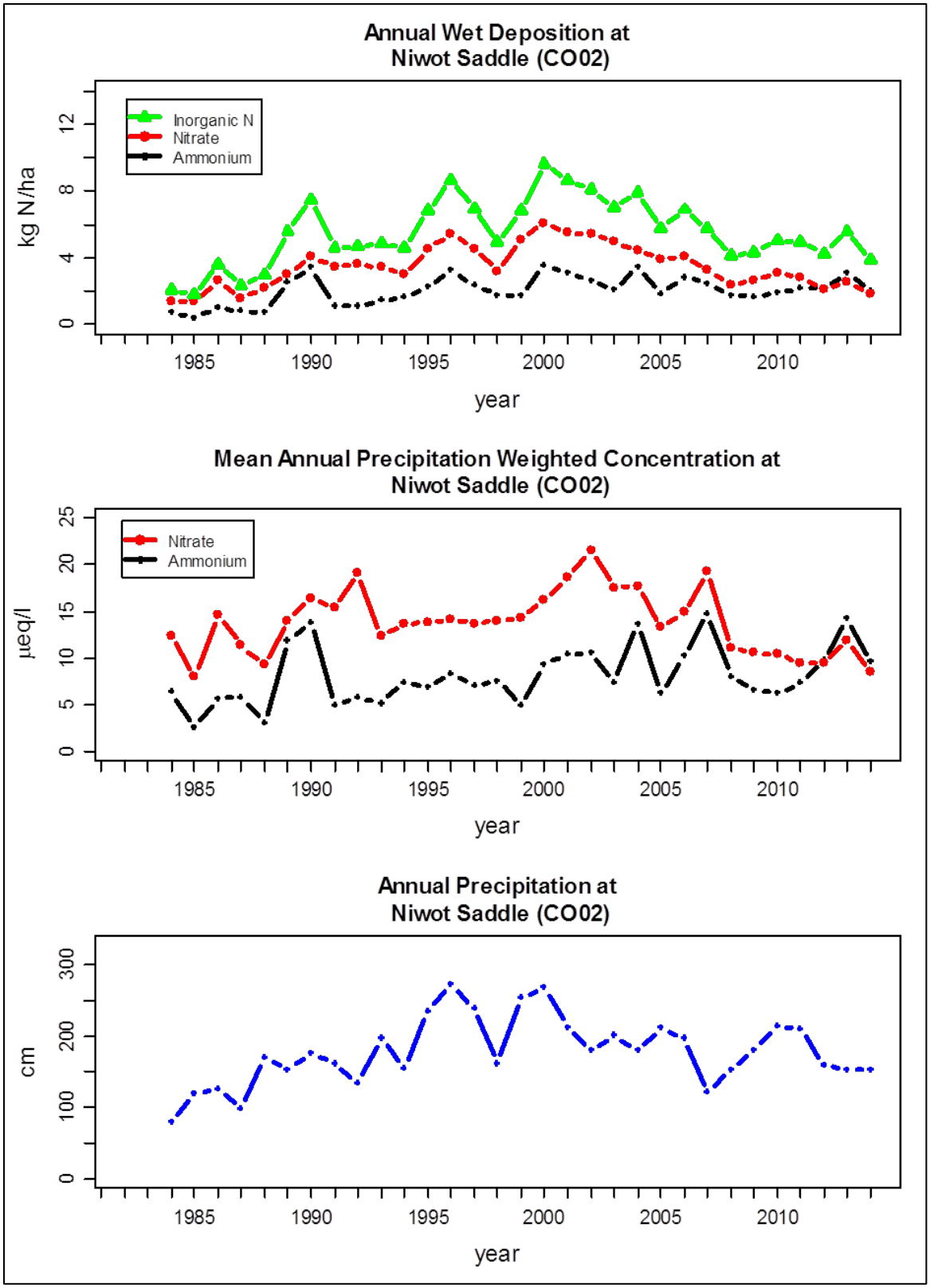


Figure 4. Precipitation was similar in 2014, however concentrations decreased, resulting in less wet N deposition at Niwot Saddle.

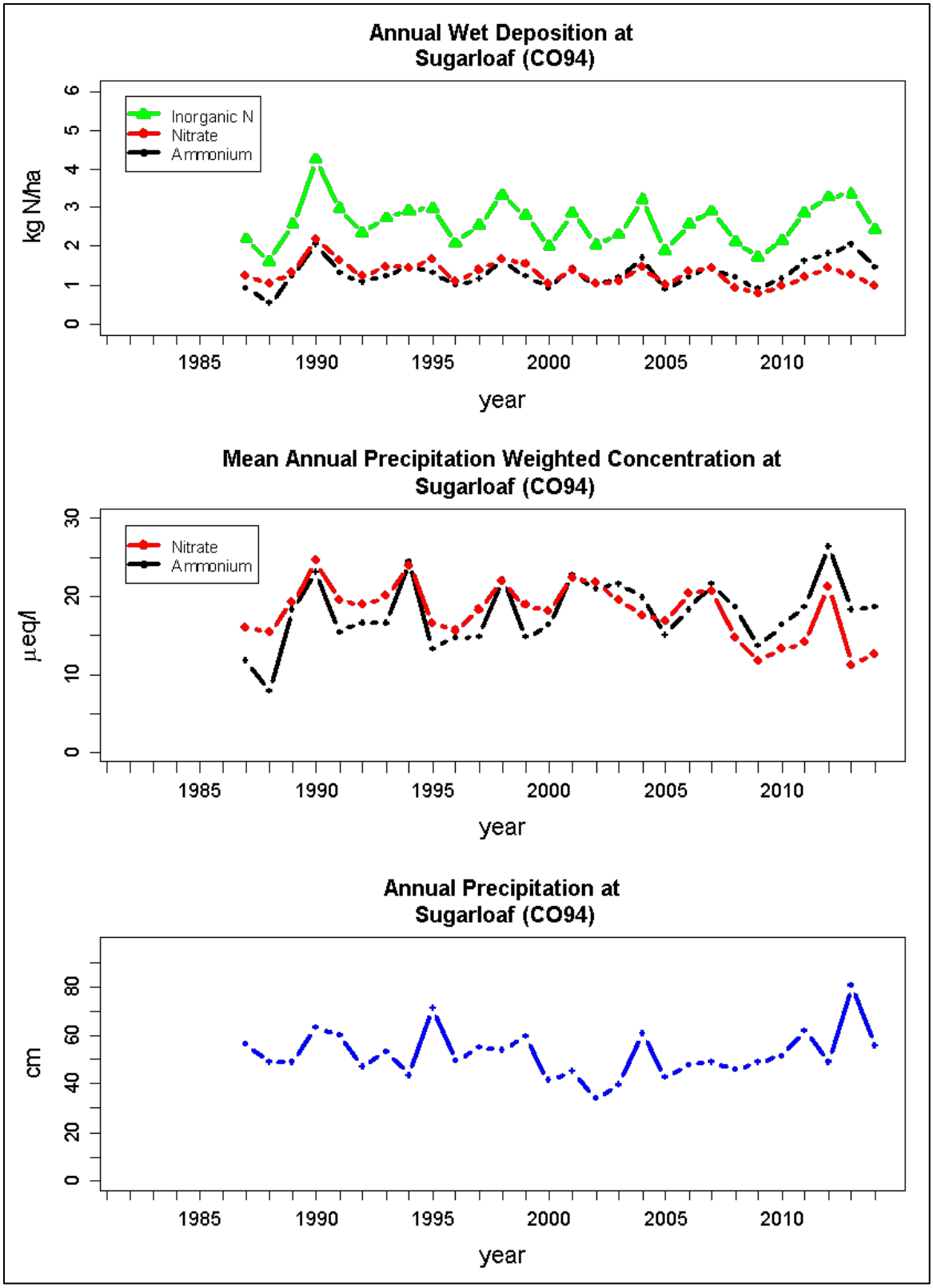


Figure 5. Precipitation decreased in 2014, so even though concentrations increased slightly, wet N deposition decreased in 2014 at Sugar Loaf.

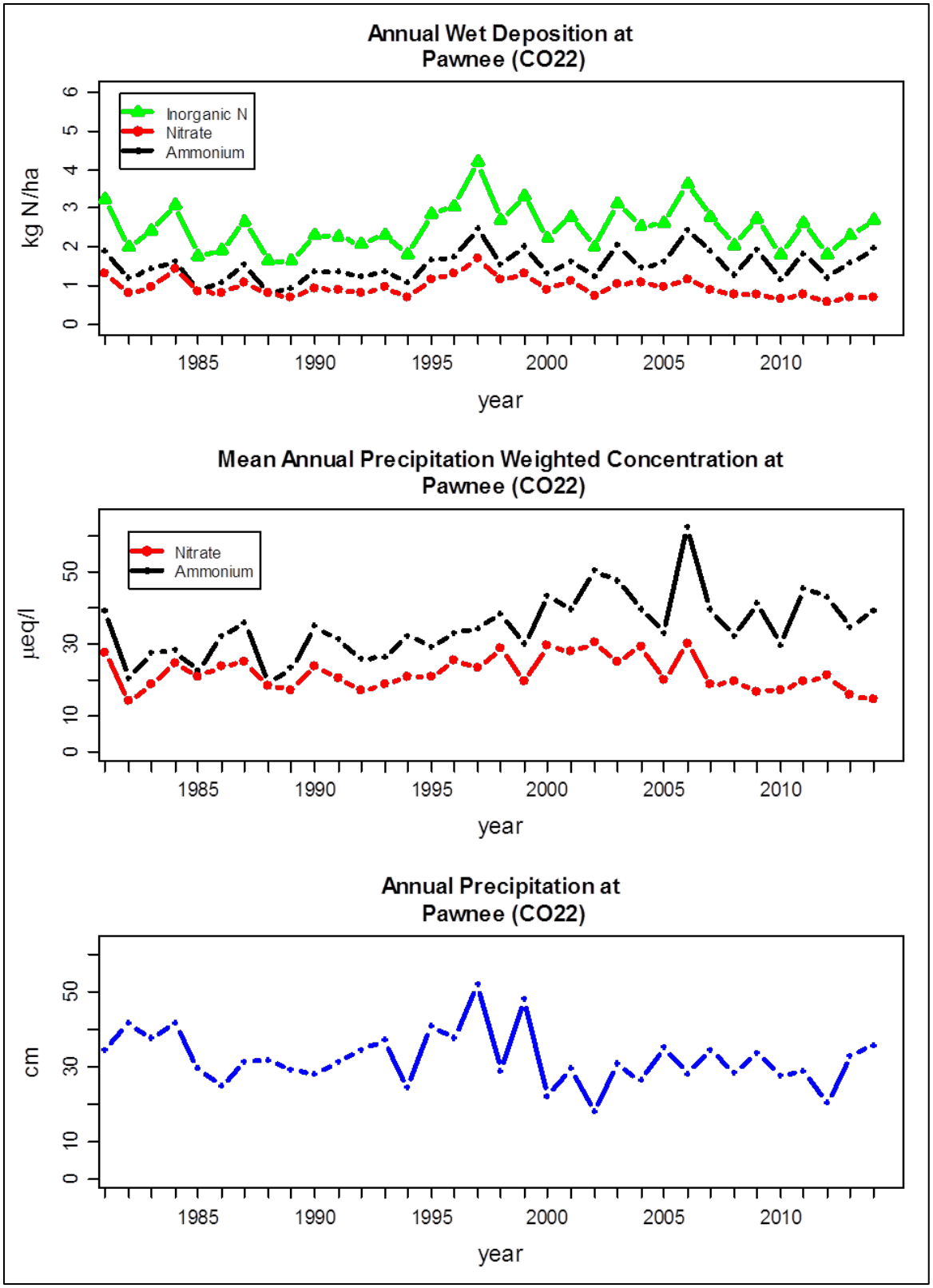
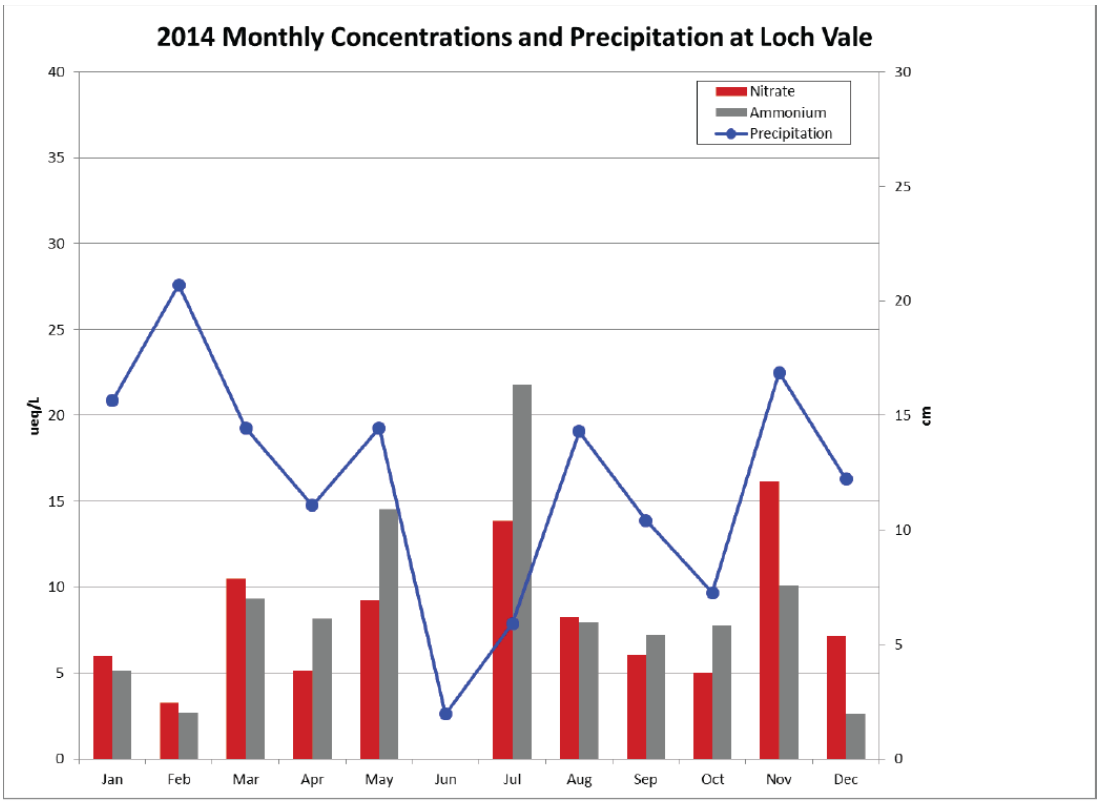


Figure 6. A slight increase in precipitation and ammonium concentration resulted in a slight increase in wet N deposition at Pawnee.



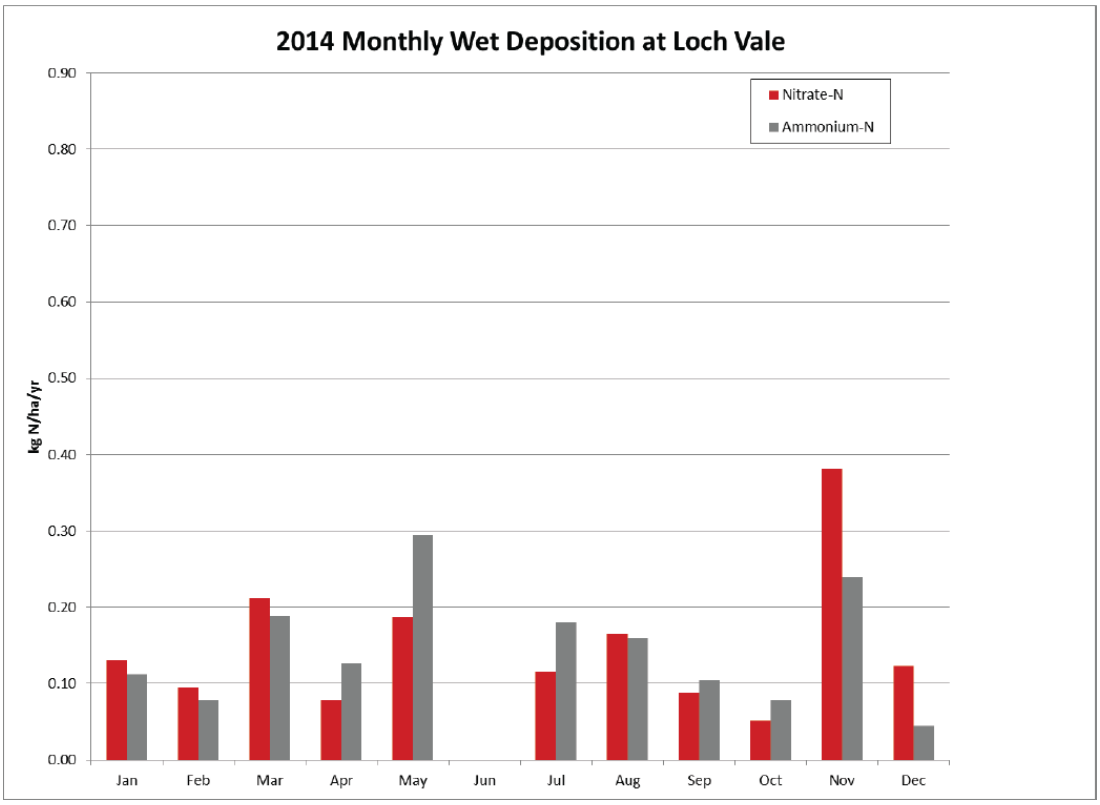


Figure 7. 2014 monthly data at Loch Vale. Wet N deposition in 2014 was fairly evenly distributed over all 12 months, in contrast to 2013, when the majority of N was deposited in April and May.

Table 1. Long-term trends in wet nitrogen deposition over the period of record (through 2014). 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	0.02	0.051	no trend
Beaver Meadows	1981	0.02	0.007	increasing
Niwot Saddle	1985	0.03	0.432	no trend
Sugarloaf	1987	< 0.01	0.890	no trend
Pawnee	1980	< 0.01	0.798	no trend

Table 2. Long-term trends in precipitation-weighted mean ammonium concentrations over the period of record (through 2014). Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

Site Name	Start Year	Trend (µeq/L/yr)	P-value	Significant Trends
Loch Vale	1984	0.13	< 0.001	increasing
Beaver Meadows	1981	0.21	< 0.001	increasing
Niwot Saddle	1985	0.14	0.005	increasing
Sugarloaf	1987	0.15	0.085	no trend
Pawnee	1980	0.43	0.002	increasing

Table 3. Long-term trends in precipitation-weighted mean nitrate concentrations over the period of record (through 2014). Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

Site Name	Start Year	Trend (µeq/L/yr)	P-value	Significant Trends
Loch Vale	1984	-0.03	0.453	no trend
Beaver Meadows	1981	-0.09	0.094	no trend
Niwot Saddle	1985	-0.03	0.559	no trend
Sugarloaf	1987	-0.18	0.025	decreasing
Pawnee	1980	-0.09	0.238	no trend

Table 4. Long-term trends of precipitation over the period of record (through 2014). 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	0.42	0.475	no trend
Beaver Meadows	1981	0.46	0.024	increasing
Niwot Saddle	1985	1.12	0.335	no trend
Sugarloaf	1987	< 0.01	0.984	no trend
Pawnee	1980	-0.15	0.147	no trend

Table 5. Short-term trends of wet nitrogen deposition for 5 year (2010–2014) and 7 year (2008–2014) time periods. Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

	5 year			7 year		
Site Name	**Trend (kg N/ha/yr)**	**P-value**	**Significant Trends**	**Trend (kg N/ha/yr)**	**P-value**	**Significant Trends**
Loch Vale	0.15	0.462	no trend	0.11	0.548	no trend
Beaver Meadows	0.26	0.221	no trend	0.16	0.035	increasing
Niwot Saddle	-0.25	0.462	no trend	0.04	1.000	no trend
Sugarloaf	0.16	0.462	no trend	0.24	0.072	no trend
Pawnee	0.19	0.312	no trend	0.02	0.879	no trend

Table 6. Short-term trends for precipitation-weighted mean ammonium concentrations for 5 year (2010–2014) and 7 year (2008–2014) time periods. Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

	5 year			7 year		
Site Name	**Trend (µeq/L/yr)**	**P-value**	**Significant Trends**	**Trend (µeq/L/yr)**	**P-value**	**Significant Trends**
Loch Vale	0.53	0.270	no trend	0.35	0.228	no trend
Beaver Meadows	-0.06	1.000	no trend	0.88	0.084	no trend
Niwot Saddle	1.03	0.391	no trend	0.94	0.058	no trend
Sugarloaf	1.33	0.270	no trend	0.68	0.084	no trend
Pawnee	4.88	0.178	no trend	1.02	0.409	no trend

Table 7. Short-term trends for precipitation-weighted mean nitrate concentrations for 5 year (2010–2014) and 7 year (2008–2014) time periods. Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

	5 year			7 year		
Site Name	**Trend (µeq/L/yr))**	**P-value**	**Significant Trends**	**Trend (µeq/L/yr)**	**P-value**	**Significant Trends**
Loch Vale	-0.03	0.902	no trend	-0.12	1.000	no trend
Beaver Meadows	0.68	0.622	no trend	0.08	0.660	no trend
Niwot Saddle	0.31	0.902	no trend	-0.13	0.660	no trend
Sugarloaf	0.42	0.713	no trend	< 0.01	0.660	no trend
Pawnee	1.91	0.178	no trend	-0.20	0.499	no trend

Table 8. Short-term trends for precipitation for 5 year (2010–2014) and 7 year (2008–2014) time periods. Significant trends were determined at the 95 percent confidence level (p-value ≤ 0.05).

	5 year			7 year		
Site Name	**Trend (cm/yr)**	**P-value**	**Significant Trends**	**Trend (cm/yr)**	**P-value**	**Significant Trends**
Loch Vale	0.15	0.462	no trend	0.11	0.548	no trend
Beaver Meadows	0.26	0.221	no trend	0.16	0.035	increasing
Niwot Saddle	-0.25	0.462	no trend	0.04	1.000	no trend
Sugarloaf	0.16	0.462	no trend	0.24	0.072	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 0.7 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 (1984-2014). 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 four of the five sites in the region over the long-term. Nitrate concentration data show a decreasing trend at one site over the long-term.

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

   In more recent years (2008-2014), wet N deposition showed no trend at Loch Vale in RMNP, however, wet N deposition increased at Beaver Meadows, RMNP. Concentrations showed no trends over the 5 or 7 year time periods for any regional sites.

Literature Cited

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