

Estimation of Nitrogen Deposition in Precipitation from Historical Studies, 1958 - 1984

Amy Ludtke & Jo Ann Gronberg 10/22/2014

USGS National Water Quality Assessment (NAWQA) Program Long Term Trends Team

- GOAL → Analyzing long-term changes in nitrogen deposition for surface and ground water studies on a national basis
 - The USGS NAWQA Trends Team is looking at trends that cover the years of 1972-2012 (40 years!) for ~ 70 constituents
 - Wanted to include atmospheric deposition as one of the components in the nitrogen trend analysis. Other components are fertilizer and manure.
- PROBLEM → NADP NTN nitrogen loads maps date from 1985 to current, so we needed to find studies pre-dating the NADP

NOAA Technical Memorandum ERL ARL-135

AN ANALYSIS AND ASSESSMENT OF US-WMO
MEASUREMENTS (1972-1982), A SUBSET OF

R. S. Artz
J. M. Miller

Air Resources Laboratory
Silver Spring, Maryland
February 1985

noaa NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION



✓
**CHEMISTRY OF
UNITED STATES
PRECIPITATION.**

**Final Report on the
National Precipitation
Sampling Network**

J.P. LODGE, Jr. K.C. HILL
J.B. PATE E. LORANGE
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G.S. SWANSON

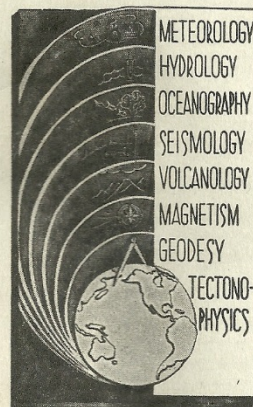
August 1968

LABORATORY OF
NATIONAL CENTER FOR A

Ernest T. Anderson

VOLUME 39 • NUMBER 2 • April 1958

Transactions American Geophysical Union



THE AMERICAN GEOPHYSICAL UNION
of the
NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL



Literature Search for Past Studies

National Coverage

- Air Force Cambridge Research Center's study from 1955-1956, by Junge
- Public Health Service and the National Center for Atmospheric Research from 1960-1966, by Lodge
- NOAA-EPA-WMO study from 1972-1982
- National Atmospheric Deposition Program from 1978-1984

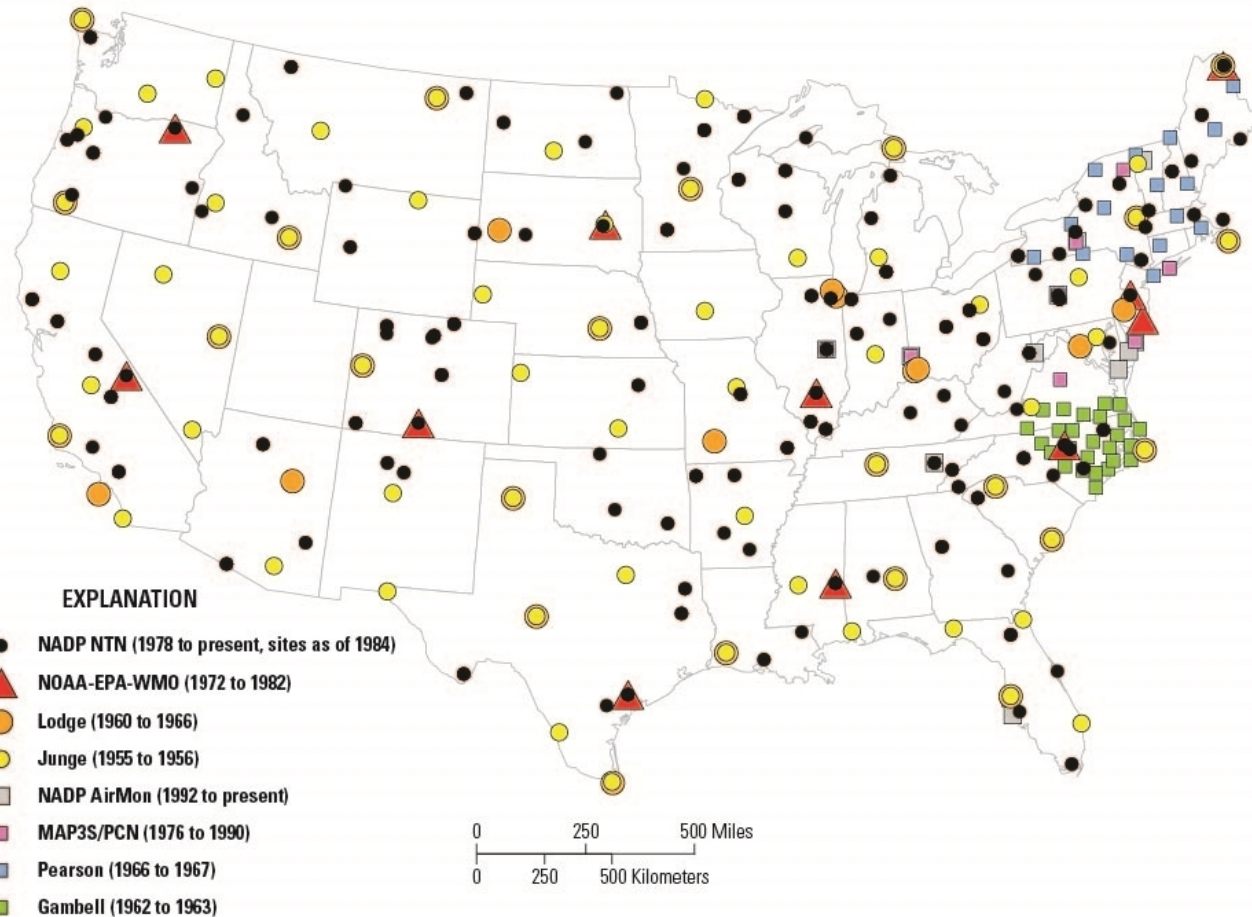
Regional Coverage

- USGS North Carolina and Virginia, 1962-1963
- USGS Northeastern US, 1966-1968
- Multistate Atmospheric Power Production Pollution Study (MAP₃S) 1976-1992
- NADP AirMoN, 1992-2012

Old Studies Did Not Include Latitude, Longitude, or Precipitation Volumes

- We knew that both Junge and Lodge sites were located at NOAA NWS stations, usually near small municipal airports
- Junge study announcement listed abbreviations for sites, for example, “GI” translates to Grand Island.
- We estimated and interpolated latitude and longitude based on the most probable National Weather Service station operational during study period

Location of Network Sites



Then the messy job of transcribing data sets ...

RESEARCH TRIANGLE PARK, NORTH CAROLINA

ALL IONS ARE IN MILLIGRAMS PER LITER PRECIP IS IN CENTIMETERS

MMDDYY	P COLL	P ST'D	LBCOND	LAB HH	FLD HH	CA	MC	K	NA	NH ₄	NO ₃	CL	SO ₄
10172	6.20	5.00	74.00	4.66	999.00	0.16	0.06	0.14	0.47	0.10	0.00	2.10	1.60
20172	14.40	10.49	12.00	4.57	999.00	0.33	0.00	0.34	0.21	0.20	0.00	2.00	1.80
30172	7.30	6.35	2.00	4.67	999.00	0.63	0.08	0.13	0.46	0.00	0.00	4.00	1.20
40172	6.60	4.87	53.00	4.21	999.00	0.27	0.05	0.13	0.26	0.00	0.00	2.70	0.00
50172	19.60	13.56	163.00	4.42	999.00	0.08	0.04	0.07	0.31	0.60	0.00	1.10	0.00
60172	999.00	10.56	16.00	4.52	999.00	0.09	0.04	0.19	0.26	0.00	0.00	0.00	0.00
70172	22.70	17.27	66.00	4.29	999.00	0.13	0.03	0.00	0.46	0.00	1.80	0.00	3.90
80172	15.70	10.57	71.00	4.11	999.00	0.12	0.02	0.18	0.00	0.00	0.00	0.00	5.30
90172	20.00	14.73	23.00	4.25	999.00	0.07	0.02	0.21	0.00	0.00	0.00	0.00	2.40
100172	13.60	10.05	14.00	4.45	999.00	0.08	0.05	0.16	0.37	0.00	0.60	0.80	0.00
110172	17.80	15.18	12.00	4.72	999.00	0.03	0.02	0.14	0.29	0.00	0.00	0.40	1.00
120172	16.70	12.72	12.00	4.68	999.00	0.06	0.03	0.15	0.31	0.00	0.00	0.30	1.10
10173	8.50	6.78	16.00	4.55	999.00	0.12	0.05	0.12	0.71	0.00	0.00	0.60	2.20
20173	13.50	13.97	19.00	4.28	999.00	0.09	0.05	0.00	0.48	0.00	0.00	0.40	2.70
30173	14.60	10.31	14.00	4.73	999.00	0.11	0.06	0.12	1.02	0.00	0.05	0.50	2.40
40173	12.90	11.17	8.00	5.31	999.00	0.47	0.03	0.00	0.28	0.00	0.02	0.05	1.60
50173	13.90	10.13	22.00	6.00	999.00	0.21	0.05	0.00	0.44	0.60	1.10	0.40	2.50
60173	33.60	23.82	21.00	4.10	999.00	0.04	0.01	0.00	0.32	0.70	0.03	0.40	2.70
70173	11.40	7.92	44.00	4.01	999.00	0.08	0.02	0.00	0.16	0.50	1.30	0.10	4.60
80173	16.00	11.68	13.00	4.72	999.00	0.13	0.08	0.00	0.45	0.05	0.30	0.30	1.20
90173	0.10	2.87	999.00	4.32	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00
100173	1.70	1.52	25.00	4.80	999.00	0.43	0.09	0.15	2.64	0.30	1.52	0.70	6.76
110173	1.40	1.54	999.00	4.01	999.00	0.34	0.12	0.52	1.32	0.49	2.53	1.80	8.14
120173	21.80	16.20	22.00	4.20	999.00	0.12	0.05	0.05	0.49	0.07	0.53	0.76	1.77
10174	9.00	11.15	999.00	7.00	999.00	0.28	0.28	0.08	3.11	5.60	1.10	0.90	2.90
20174	0.10	7.28	999.00	6.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00
30174	9.60	8.48	19.00	4.09	999.00	0.18	0.05	0.09	0.95	0.40	1.50	0.30	3.50
40174	3.50	3.35	24.00	4.41	999.00	0.36	0.00	0.13	1.17	0.50	1.80	1.50	2.80
50174	29.20	19.48	23.00	3.72	999.00	0.09	0.00	0.00	0.30	0.30	1.10	0.20	1.60
60174	15.10	10.21	21.00	4.11	999.00	0.13	0.00	0.00	0.66	0.30	1.40	0.11	3.10
70174	5.40	3.96	40.00	3.90	999.00	0.11	0.03	0.03	0.24	0.20	2.00	0.10	4.10
80174	12.30	12.24	6.00	5.20	999.00	0.00	0.00	0.00	0.34	0.00	0.40	0.10	1.20
90174	2.70	9.42	30.00	4.15	999.00	0.62	0.09	0.39	0.31	0.40	1.70	0.80	5.20
100174	4.80	3.12	27.00	4.34	999.00	0.46	0.01	0.85	0.63	0.30	2.60	0.50	2.90
110174	9.20	4.54	22.00	3.79	999.00	0.19	0.01	0.03	0.06	0.10	1.30	0.60	2.20
120174	5.90	10.21	21.00	3.63	999.00	0.08	0.00	0.08	0.71	0.10	1.30	0.50	2.40
10175	13.80	15.46	13.00	4.00	999.00	0.14	0.06	0.05	0.18	0.10	0.60	0.70	1.90
20175	3.20	7.23	24.00	4.60	999.00	0.40	0.12	0.45	0.73	0.30	1.40	2.50	2.80
30175	9.70	15.90	16.00	4.90	999.00	0.21	0.07	0.04	0.31	0.20	0.90	0.70	1.60
40175	2.10	4.16	42.00	4.50	999.00	1.03	0.25	0.41	0.60	0.90	4.60	0.80	6.00
50175	7.80	9.75	23.00	4.30	999.00	0.09	0.04	0.08	0.11	0.20	1.70	0.20	2.70
60175	0.90	4.21	999.00	3.90	999.00	0.75	0.21	0.39	0.60	0.80	4.50	1.10	4.80
70175	6.20	17.11	47.00	4.00	999.00	0.37	0.04	0.07	999.00	0.50	2.10	0.30	4.10
80175	4.10	5.35	25.00	4.20	999.00	0.13	0.03	999.00	0.01	0.30	1.60	0.20	3.10
90175	1.50	14.65	21.00	4.70	999.00	0.24	0.10	0.22	0.72	0.70	1.50	1.50	2.70
100175	2.20	3.12	18.00	4.60	999.00	0.20	0.03	0.58	0.11	0.10	1.30	0.50	2.10
110175	5.50	11.60	17.00	4.40	999.00	0.18	0.04	0.06	0.14	0.10	0.80	0.20	2.20
120175	18.80	18.80	18.80	4.30	999.00	0.07	0.05	0.07	0.01	0.20	1.10	0.60	2.50

D-14



Old Studies Did Not Include Precipitation Volumes, Critical for Loads Calculation

- Retrieved monthly precipitation volumes from the NOAA National Climatic Data Center (NCDC)
- We searched the NCDC data for the NWS station data
- When not available, we made substitutions, all of which is noted in the data tables
- NOAA-EPA-WMO data had latitudes/ longitudes and precipitation volumes reported with the data

Final Inorganic N Loads Calculations from Wet Deposition

- Concentration Data from data sets
- Monthly Precipitation Volumes from data sets of NCDC (Junge & Lodge)
- Reviewed and screened data. NADP NTN data had to meet completeness criteria adopted by network
- Calculated Monthly Precipitation Weighted Concentrations
- PRISM - Parameter-Elevation Regression on Independent Slopes Model Climate Group
- Calculated Annual Inorganic N loads from wet deposition

At this point we removed the following data sets:

- All “Regional” Studies:
 - USGS North Carolina and Virginia, 1962-1963
 - USGS Northeastern US, 1966-1968
 - Multistate Atmospheric Power Production Pollution Study (MAP3S) 1976-1992 (lot of overlap w/ NADP)
 - NADP AirMoN, 1992-2012 (overlap of NADP)
- NOAA-EPA-WMO Study:
 - Sparse national coverage with only 9-11 sites
 - Pre-1980 data had higher deposition values noted that were attributed to sample evaporation and poor sample collector efficiency
 - Post-1980 data overlapped with NADP data, so redundant
- NADP NTN 1978-1980:
 - Sparse national coverage

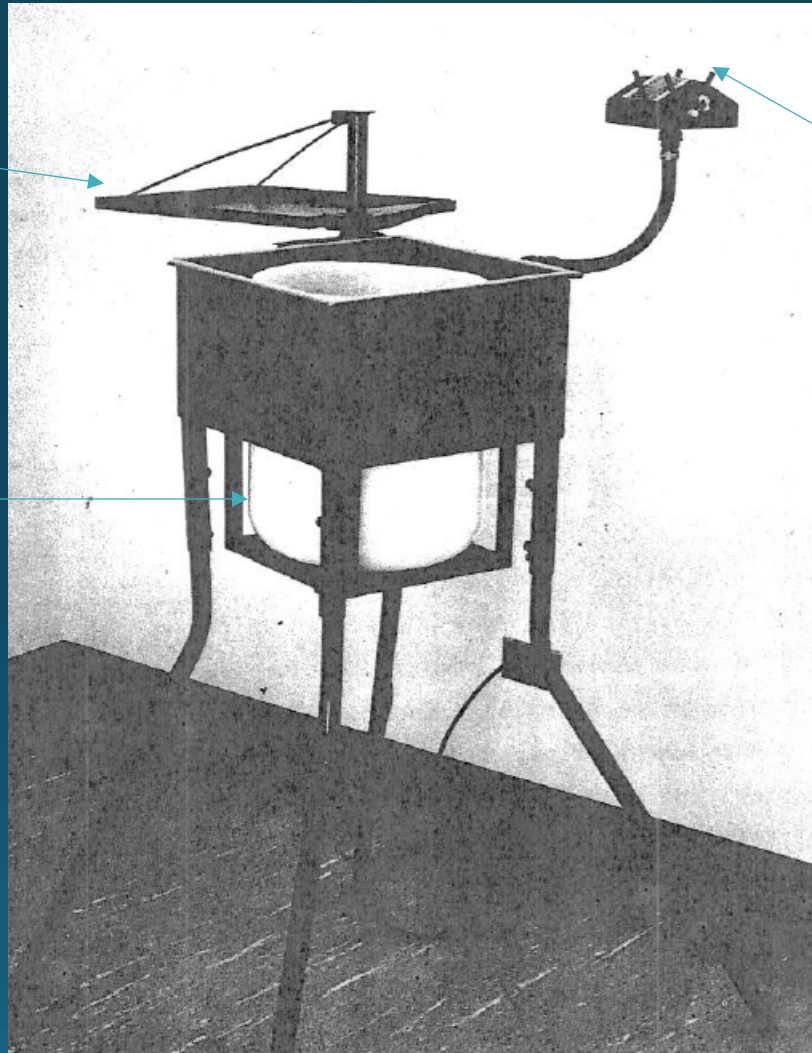
3 National Studies in Final Analysis

Study	Sites	Collection Method	Chemistry	Preserv.
Junge '55-'56	67	Event Based (Manual) Monthly	NO ₃ NH ₄	Toluene
Lodge '60-'66	33	Event Based (Automatic) Monthly	Inorganic N	Toluene
NADP '78-'14	18 (1979) – 236 (2012)	Event Based (Automatic) Weekly	NO ₃ NH ₄	None

Sampler Picture from Lodge, 1960

Lid cover

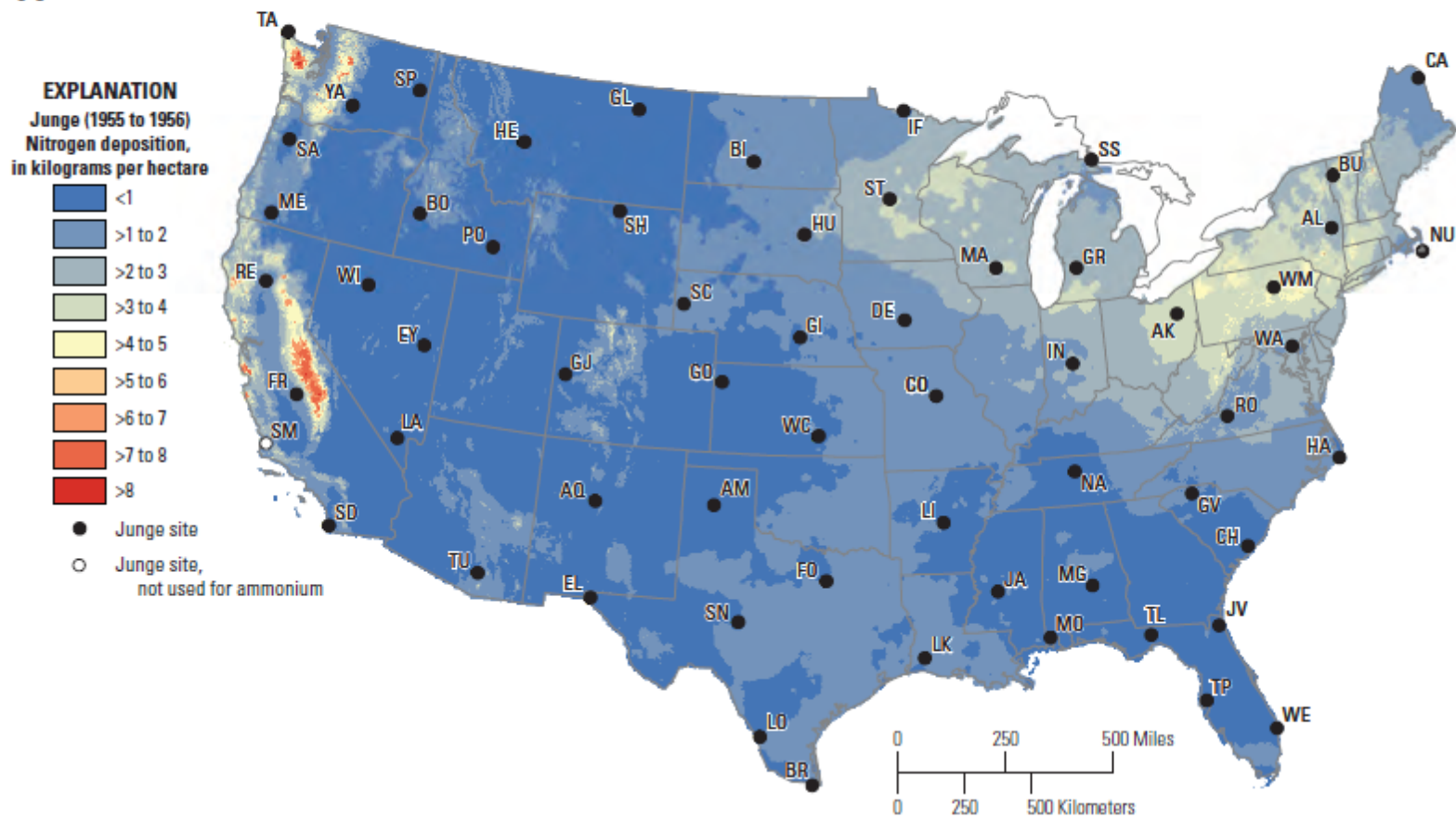
Polyethylene bucket



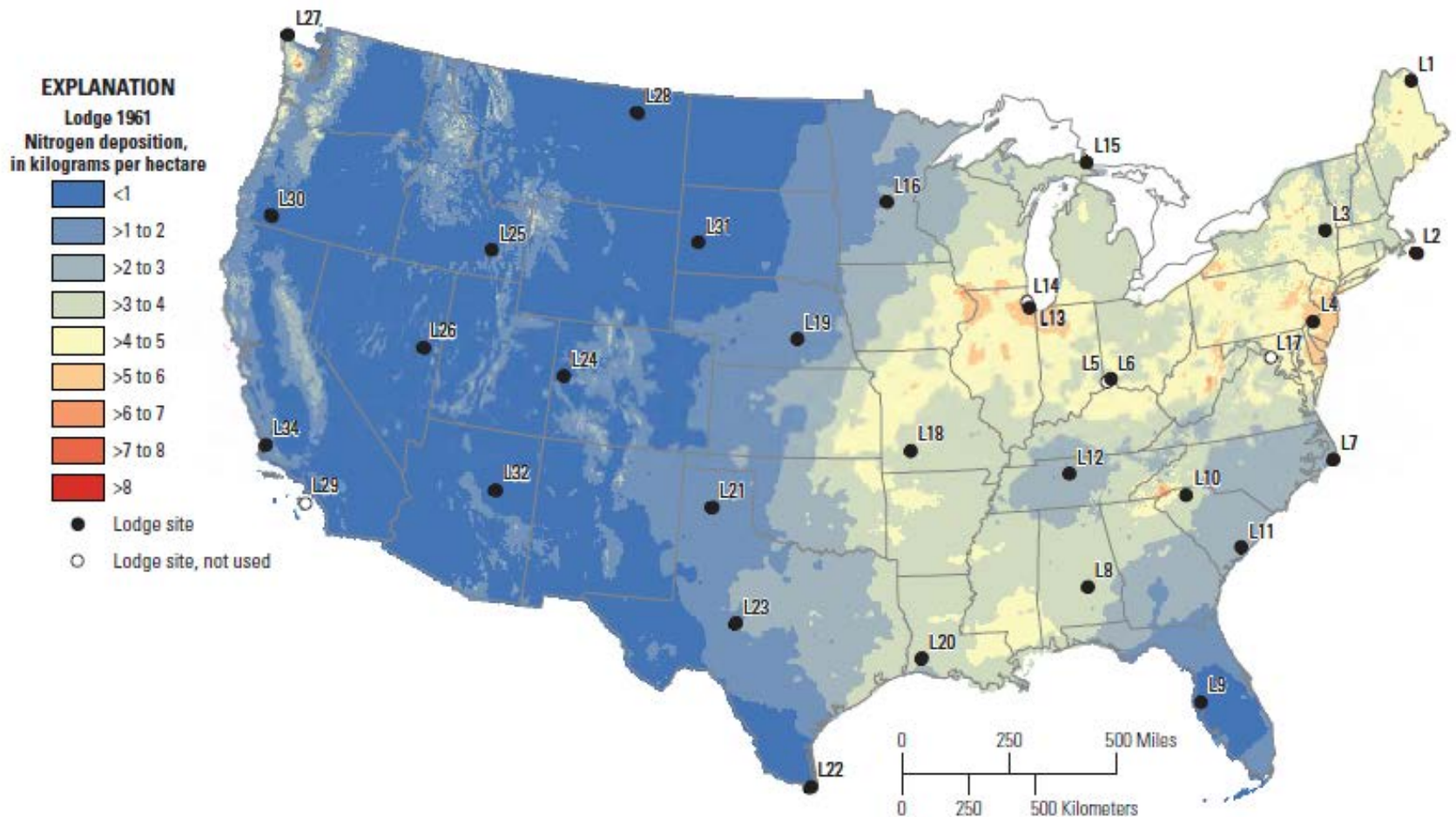
Thermostatically controlled precipitation sensing grid

12 Estimates of Inorganic Nitrogen Wet Deposition from Precipitation for the Conterminous United States, 1955–84

A

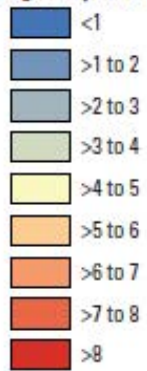


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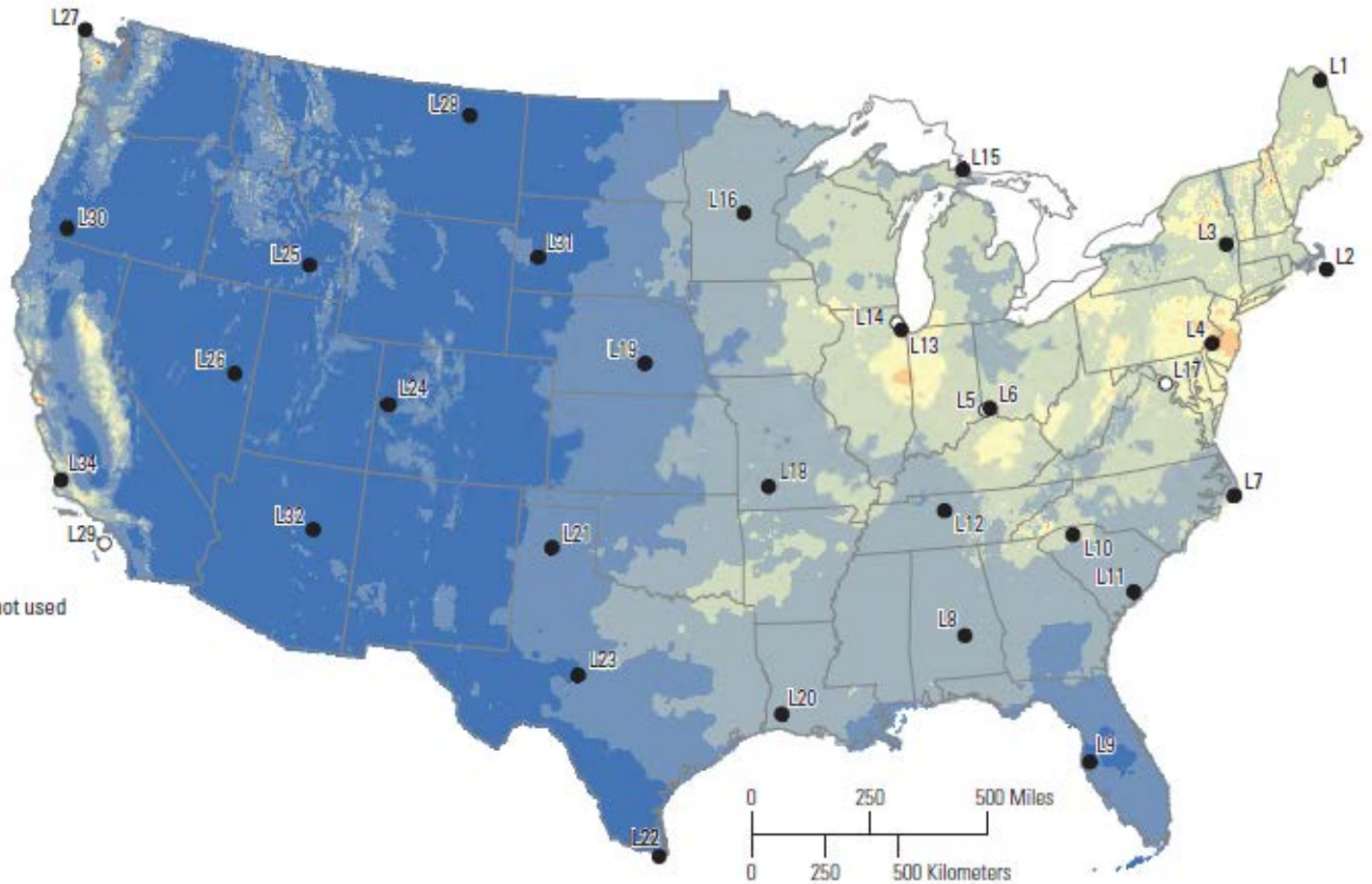


C

EXPLANATION
Lodge 1962
Nitrogen deposition,
in kilograms per hectare

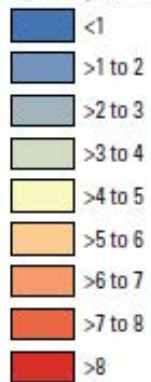


- Lodge site
- Lodge site, not used

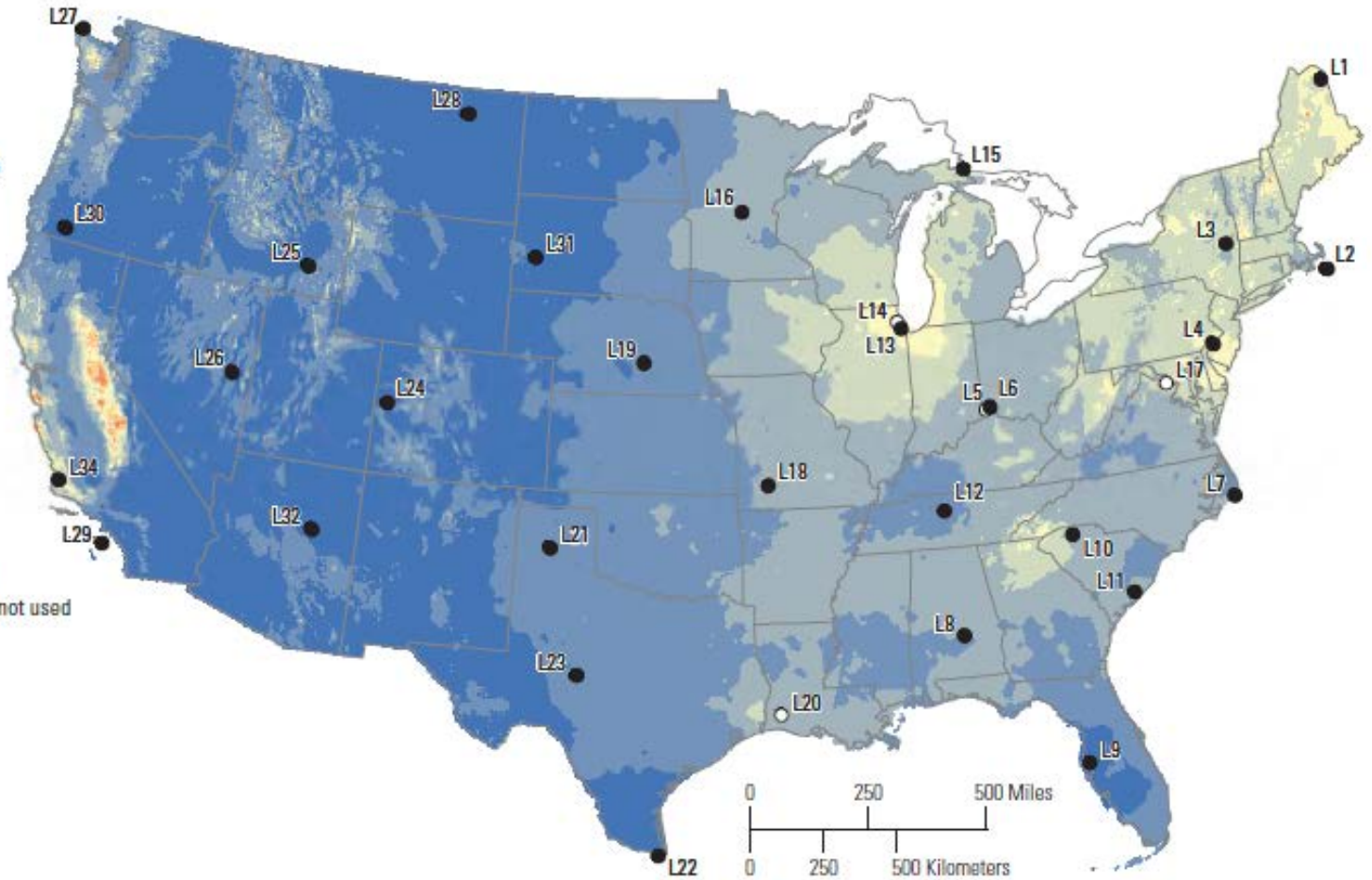


D

EXPLANATION
Lodge 1963
Nitrogen deposition,
in kilograms per hectare

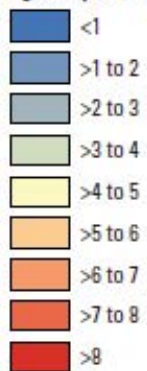


- Lodge site
- Lodge site, not used

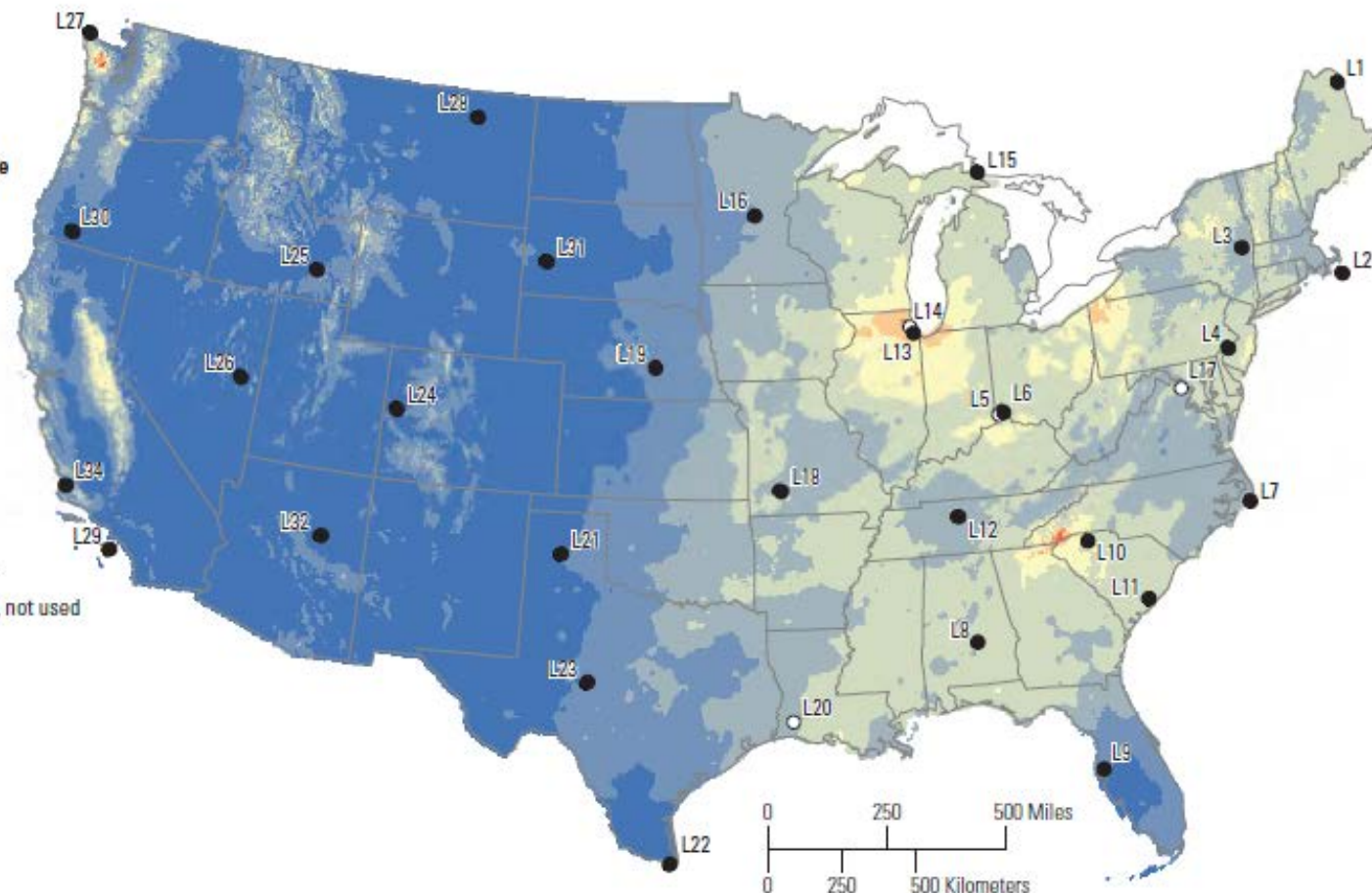


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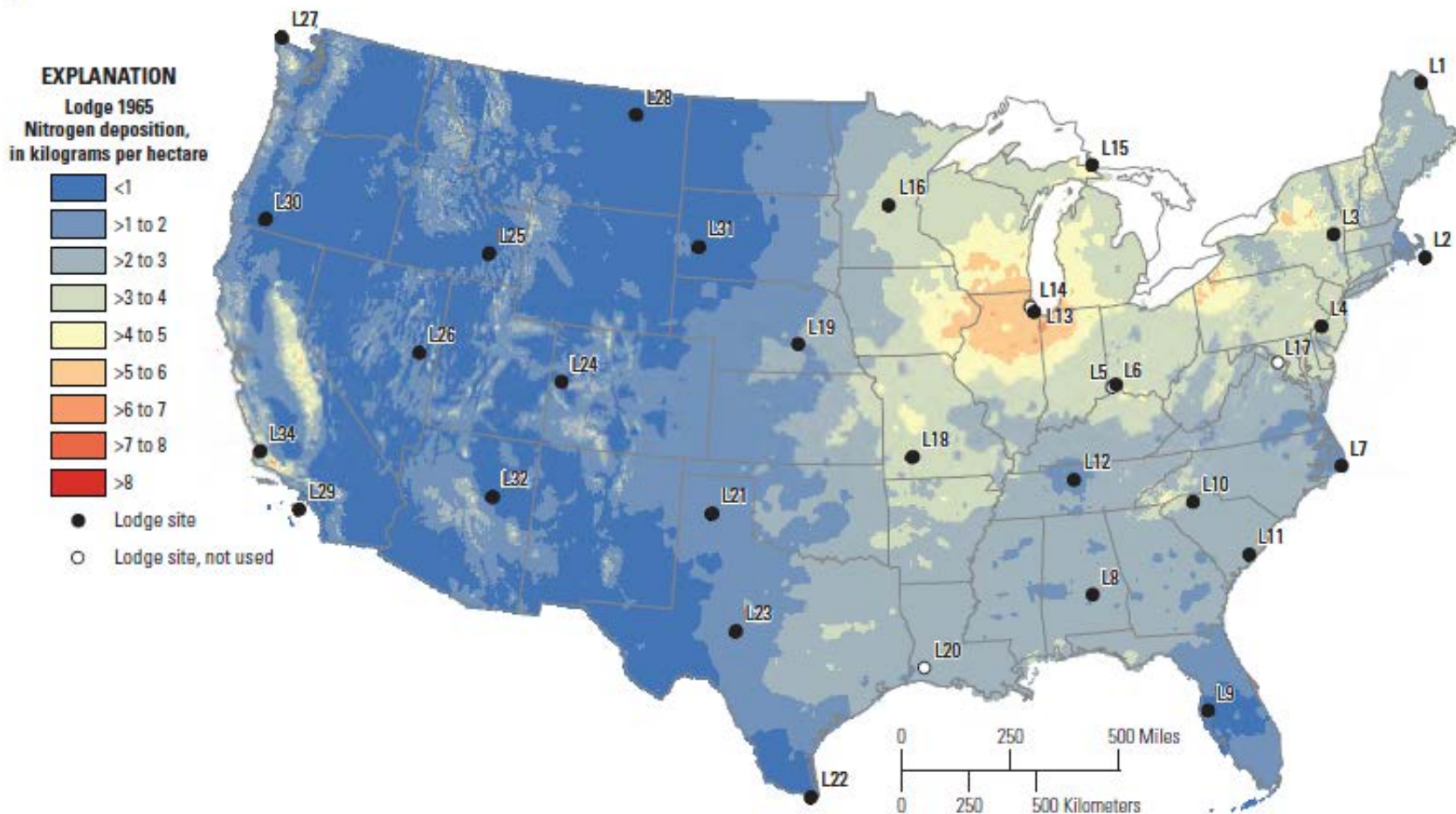
EXPLANATION
Lodge 1964
Nitrogen deposition,
in kilograms per hectare



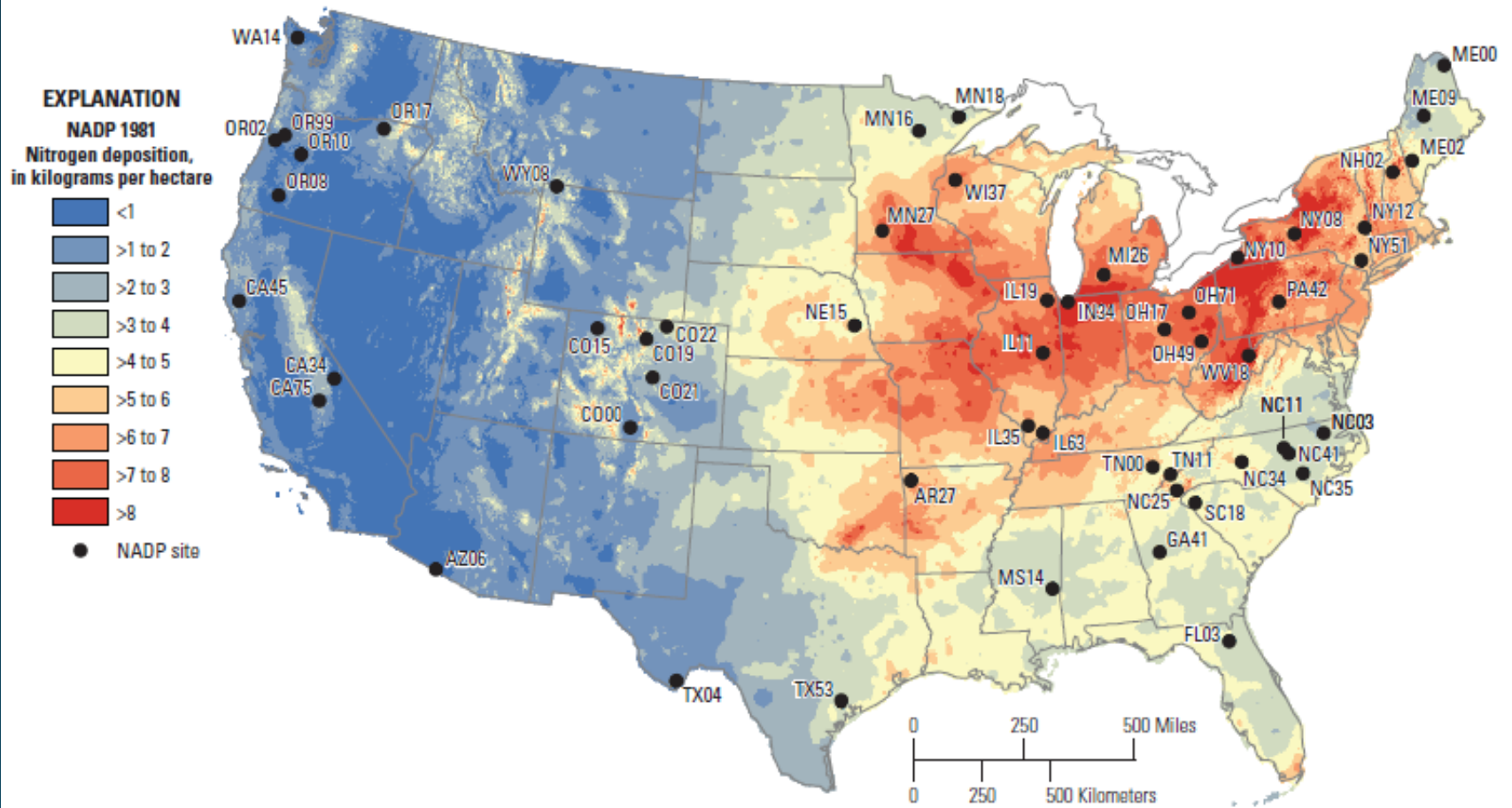
- Lodge site
- Lodge site, not used



F

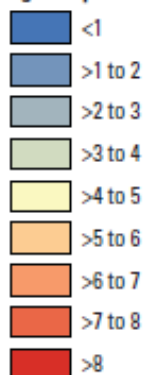


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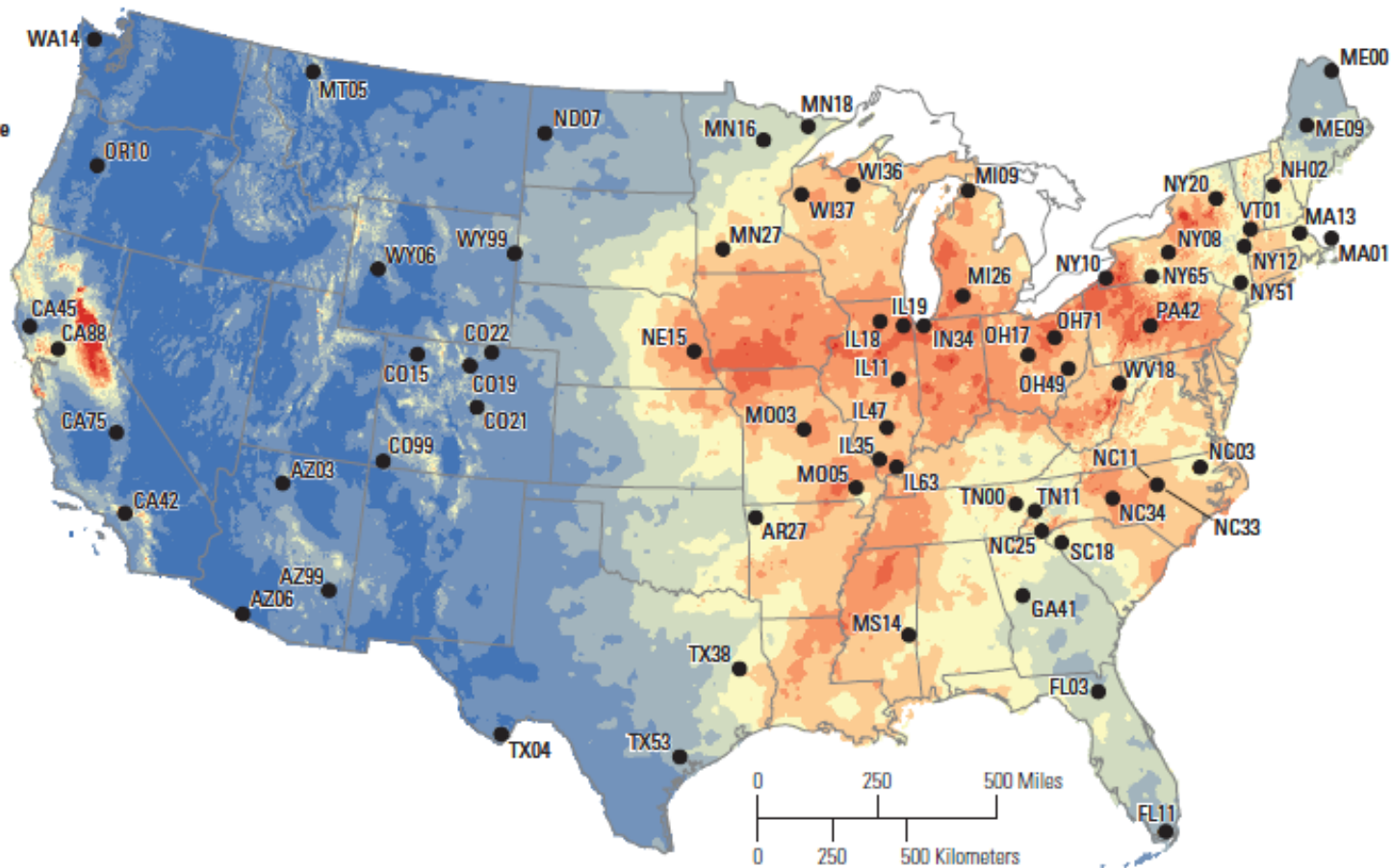


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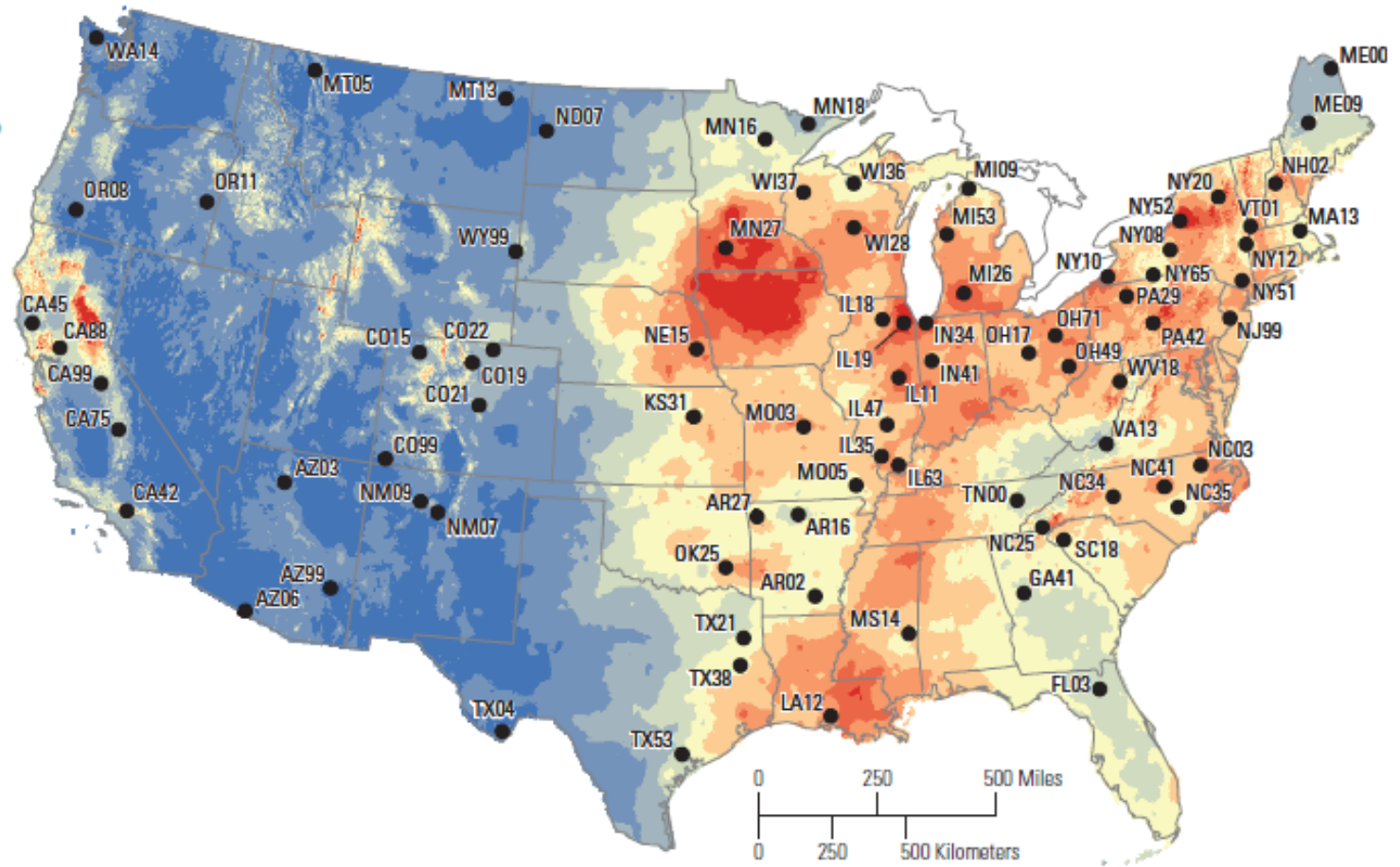
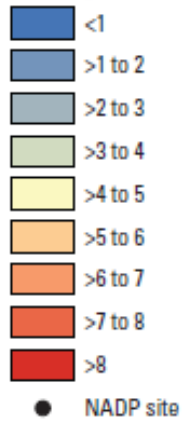
EXPLANATION
NADP 1982
Nitrogen deposition,
in kilograms per hectare



● NADP site

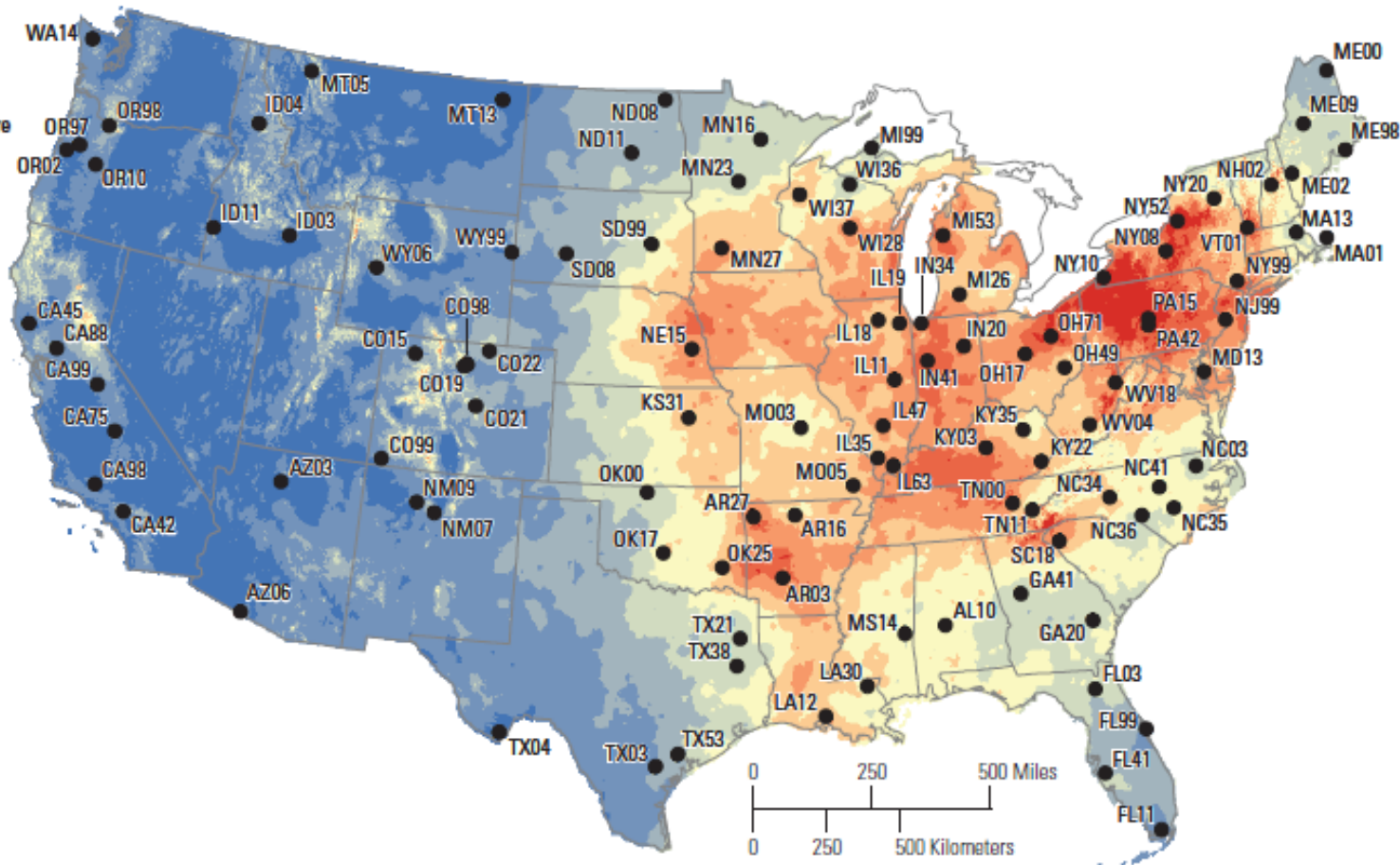
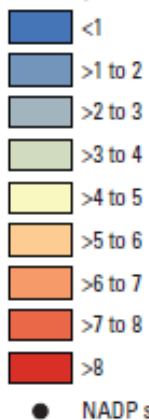


EXPLANATION
NADP 1983
Nitrogen deposition,
in kilograms per hectare



J

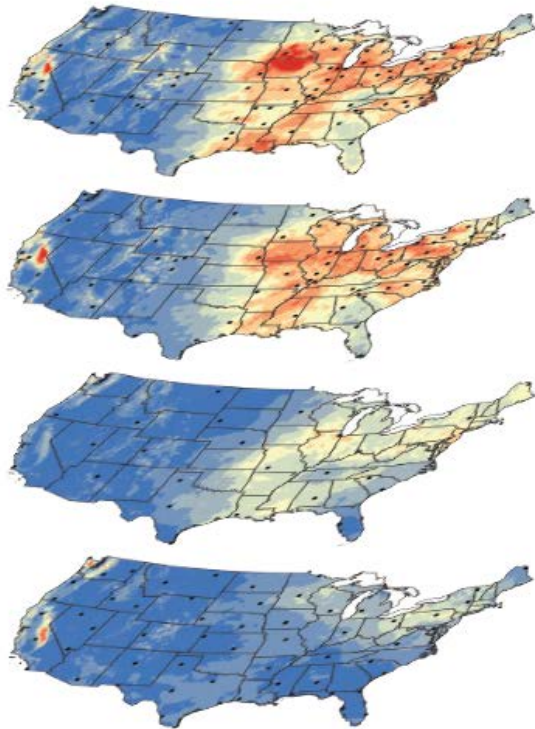
EXPLANATION
NADP 1984
Nitrogen deposition,
in kilograms per hectare



All chemistry, precipitation, and map data available online

Study	Tabular Dataset	Raster Map Datasets
Junge (1955-1956)	NH ₄ , NO ₃ , Cl, Na, SO ₄ , Ca, & K	1955-1956
Lodge (1961-1965)	Inorganic N, Cl, Na, SO ₄ , Ca, & K	1961, 1962, 1963, 1964, 1965
NOAA-EPA- WMO (1972-1982)	NH ₄ , NO ₃ , Cl, Na, SO ₄ , Ca, K, Cond., & H ⁺	NA
NADP NTN (1981-1984)	Find at NADP	1981, 1982, 1983, 1984
USGS Pearson(1971)	NH ₄ , NO ₃ , Cl, Na, SO ₄ , Ca, K, Bicarb, Cond., & H ⁺	NA

Estimates of Inorganic Nitrogen Wet Deposition from Precipitation for the Conterminous United States, 1955–84



Scientific Investigations Report 2014–5067

Full Report and appendices
available:

<http://pubs.usgs.gov/sir/2014/5067/pdf/sir2014-5067.pdf>

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