Comprehensive Assessment of Deposition Monitoring for Class I Areas

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Objectives and background

In many ways NADP was the creation of Forest Service employees when acid rain was first recognized as a threat to forest health. The establishment of NADP monitoring within the Forest Service began with the very first acid rain monitoring initiatives in an effort to understand the geographic and temporal trends in acidified precipitation. All eight of the original monitoring sites established in 1978 by the Forest Service are still running, providing over 30 years of continuous wet deposition data. What began as an acid rain monitoring network in the late 1970s has grown into a more general nutrient deposition network. While acidification effects continue to be of concern, deposition of nitrogen, sulfur, and other ions are often the focus of managers' and researchers' application of NADP data. As the value of the network data in answering nitrogen deposition questions, in particular, increased, several new sites were installed specifically to monitor changes in nitrogen deposition from increased pressure from urbanization. The need for monitoring continues to evolve for all land managers, but especially as the Forest Service works to improve and restore resiliency in watersheds that are being affected by many stressors, including air pollution and changing climate.

There were two separate questions driving this project:

1.) How well does the NADP data represent deposition in Class I wilderness areas managed by the Forest Service?

The Clean Air Act gives Federal Land managers purview over air quality on lands set aside for unique ecosystem characteristics, designated as Class I Areas. A significant amount of thinking and planning has gone into identification of Air Quality Related Values (AQRV) that enable assessment of pollution effects on the landscape, but in many cases the relationship between AQRVs and a quantitative measure of air pollution or deposition is poorly developed. One of the main scientific gaps in developing a rigorous relationship is the lack of air and deposition monitoring data in the wilderness areas. NADP offers the best and most widely available wet deposition data, but it is not always clear to land managers which monitoring stations are most relevant to a specific location of interest such as a wilderness area, district, or forest, particularly when the NADP station is managed by a non-Forest Service entity. To that end, a relatively simple approach of quantifying the distance between each of the Forest Service Class I Wilderness areas and the nearest NADP station was used. The original thought was that a more detailed geospatial evaluation of a subset of sites would follow. As will be shown, the study revealed that overall most of the Class I areas are seriously under-represented and that subsequent detailed evaluation would not be very useful.

2.) Which agencies or organizations, or entities within the Forest Service, are funding and operating NADP sites affiliated with the Forest Service.

Although it might seem odd that the Forest Service did not have a clear record of how NADP sites were being funded, or even which group was operating them, in many ways the lack of a centralized system within the Forest Service is consistent with how NADP itself operates. Anyone, or any group, can join the Program. There are only three requirements: 1.) purchase of the specified monitoring equipment, 2.) follow the siting criteria for installation of the equipment. 3.) Pay the annual analytical fee to the Program Office at the University of Illinois. Although the NADP Program Office contracts and oversees the laboratory analysis and is responsible for quality control and distribution of the data, all operating decisions are in the hands of an Executive Committee, which is made-up of volunteers who simply have an interest in the Network. No single agency or entity controls the Program or the Network.

Likewise, the Forest Service participation has grown from several independent groups each with specific need for monitoring data. All of the Forest Service Research and Development stations operate at least two NADP monitors. Many are associated with Experimental Forests, but not all. Many of the monitoring sites were initiated by NFS managers who were concerned about acid rain, originally, and more recently by nutrient deposition. There are also examples of sites that were set-up as cooperative ventures between private organizations such a municipal water district or a permit holder and the Forest Service. State agencies and the Forest Service have established cooperative agreements for operating NADP stations and there are several examples of cooperative operations between two Federal agencies.

In almost all cases, maintaining the funding stream has been an on-going concern for site supervisors. One of the goals in this project was to inform, not only NF staff with budget authority, but all NADP participants, of how, who, what, where, and when these sites were being managed. In addition, the project seeks to provide network sponsors, supervisors, and operators, with more insight into how other NADP stations are being managed to assist in solving ongoing management and funding issues. In the end, building an internal network of Forest Service NADP partners is critical to keeping long term monitoring strong within the Agency.

Methods

1.) Class I wilderness representativeness study

Shape files for the Class I Wilderness Areas were acquired from the online data resource provided by the National Forest System (see App B). Latitude and longitude lists for NADP sites managed by the Forest Service, and for all other NADP sites was graciously provided by the NADP Program Office. Please refer to Appendix B for the details of the ArcView analysis. Breifly, 20km, 50km, and 100km boundaries were drawn around each of the wilderness areas and each of the NADP monitoring stations falling within these boundaries were identified. The resulting data produced a series of maps and tables derived from an Excel spreadsheet of the exported data.

There are several ways to evaluate the resulting data. The full dataset is available in a spreadsheet, PDF versions of the maps, and GIS shape files on the O drive displayed in the footer. For this report each wilderness area was classified and segregated by distance to the nearest NADP station, 0 – 20km, 20 – 50km, 50 – 100km and greater than 100km. Each wilderness is identified once in any of the four resulting tables

(tables 1 through 4). Tables 5 through 8 identify all NADP monitoring stations associated with each of the wilderness within the 3 boundaries.

All NADP monitoring stations were grouped into one of two categories: Sites own or operated by the Forest Service, or sites owned and operated by all other entities (not Forest Service sites). The Forest Service stations are shown in turquoise on the maps and all other owners are shown in purple. Several wilderness areas had historic monitoring data available from stations that are now closed. The deposition data are still available on the NADP website. There were also wilderness areas with a MDN (mercury monitoring) station closest. While this may not answer a nitrogen deposition question, it may provide other information such as precipitation amounts that may inform a landscape analysis query. These are indicated on tables 1 through 4 as "sites with limited data".

2.) Funding and operations

The method used to understand funding and operations at each of the Forest Service affiliated NADP stations was interviews of the listed site supervisors. Each supervisor of a Forest Service affiliated station listed in the NADP record was contacted over the phone and asked a series of questions (appendix A).

In addition to the interviews, the NADP information sheet was collected from the website and a KMZ file for most sites was filed. The KMZ files for a few locations, particularly Alaska were of too poor quality to be of any use. The KMZ files and the NADP information sheets are archived on the O drive for quick reference. These files were quite useful for understanding the geographic position of each of the stations. The interview data was summarized into a spread sheet, which is available electronically on the O drive. The most significant columns were separated and presented as tables in this report.

3.) Data availability and storage

Processed data and analytical results are housed on the Forest Service's O drive
O:\NFS\WOWatershedFishWildlife\Program\2500Air\Wilderness.net\FARM Teams\Deposition\PadgettRepresentProject

Findings

1.) Class I Wilderness Proximity.

The Forest Service manages 88 wildernesses that are designated Class I areas (Figure 1). Of these, 17 have monitoring sites within 20 km, 36 have monitoring 20-50 km away, 22 have monitoring 50-100 km from the wilderness, and 5 sites have no monitoring within 100 km.

Figure 1. Location of Forest Service Class I wilderness area, with 20k, 50k, and 100k buffers. Individual dots are locations of NADP monitoring stations. Blue dots are stations with Forest Service affiliation, and red dots are stations managed by other entities. A full sized version is available on the Odrive

Seventeen wilderness areas have current NADP monitoring within 20 km, and an additional 3 have either historic data or data associated with a mercury monitoring station (Table 1). Bridger wilderness has 4 stations – 2 managed by the Forest Service and 2 managed by BLM from which to derive deposition data. Maroon Bells, Mt Zirkel and Weminuche all have 2 stations available. In the case of Maroon Bells, the second station is operated by EPA; the others have double FS coverage.

Table 1. Class I wilderness areas with NADP monitoring stations within 20 km,

Wilderness Name	Wilderness State	Wilderness Region	NADP Site ID	Site Name	Owner	
Maroon Bells-Snowmass Wilderness	CO	R2	CO08	Four Mile Park	Forest Service	
	CO	R2	CO10	Gothic	EPA	
Mount Zirkel Wilderness	CO	R2	CO93	Buffalo Pass Dry lake	Forest Service	
	CO	R2	CO97	Buffalo Pass Summit lake	Forest Service	
Weminuche Wilderness	CO	R2	CO91	Wolf Creek Pass	Forest Service	
	CO	R2	CO96	Molas Pass	Forest Service	
West Elk Wilderness	CO	R2	CO10	Gothic	EPA	
Chiricahua Wilderness	AZ	R3	AZ98	Chiricahua	EPA	
Gila Wilderness	NM	R3	NM01	Gila Cliff Dwellings	NM DEP	
Bridger Wilderness	WY	R4	WY02	Sinks Canyon	BLM	
	WY	R4	WY06	Pinedale	BLM	
	WY	R4	WY97	South Pass City	Forest Service	
	WY	R4	WY98	Gypsum Creek	Forest Service	
	CA	R5	CA42	Tanbark Flat	Forest Service	
John Muir Wilderness	CA	R5	CA28	Kings River Exp Watershed	Forest Service	
San Gabriel Wilderness	CA	R5	CA42	Tanbark Flat	Forest Service	
San Gorgonio Wilderness	CA	R5	CA94	Converse Flats	Forest Service	
Thousand Lakes Wilderness	CA	R5	CA96	Lassen Volcanic National Park	NPS	
Yolla Bolly-Middle Eel Wilderness	CA	R5	CA97	Buffalo Pass summit lake	Forest Service	
Glacier Peak Wilderness	WA	R6	WA19	N. Cascades National Park	NPS/USGS	
Three Sisters Wilderness	OR	R6	OR10	HJ Andrews	Forest Service	
James River Face Wilderness	VA	R8	VA99	Natural Bridge	Forest Service	
Boundary Waters Canoe Area Wilderness	MN	R9	MN18	Fernberg	Forest Service	
Otter Creek Wilderness	WV	R9	WV18	Parsons	Forest Service	
Sites with limited data within 20km						**Inactive Sites end dates**
San Pedro Parks Wilderness	NM	R3	NM09	Cuba	*inactive*	2004
Sycamore Canyon Wilderness	AZ	R3	AZ02	Sycamore Canyon	MDN (Hg)	
Jarbidge Wilderness	NV	R4	NV99	Gibb's Ranch	MDN (Hg)	

Thirty-five wilderness areas have current NADP monitoring at 20 to 50 Km distance and an additional 2 have historic data. Ansel Adams, Boundary Waters, Bradwell Bay, Fitzpatrick, Flat Tops, Great Gulf, La Garita, Presidential Range-Dry River, Rawah and San Jacinto (10 total) all have 2 or more stations with the 20 to 50 km range. It should be noted, however, that this may not actually represent a duplication of monitoring efforts. In most cases it appears that one of the stations is either at a very different elevation or not in the same air shed.

Table 2. Class I wilderness areas with NADP monitoring stations between 20 and 50 km distant.

Wilderness Name	Wilderness State	Wilderness Region	NADP Site ID	Site Name	Owner/Sponsor
Anaconda Pintler Wilderness	MT	R1	MT97	Lost Trail Pass	Forest Service
Gates of the Mountains Wilderness	MT	R1	MT07	Clancy	USGS
Selway-Bitterroot Wilderness	MT-ID	R1	MT97	Lost Trail Pass	Forest Service
Fitzpatrick Wilderness	WY	R2	WY06	Pinedale	Forest Service
	WY	R2	WY98	Gypsum Creek	Forest Service
Flat Tops Wilderness	CO	R2	CO08	Four Mile Park	EPA/CAMD
	CO	R2	CO92	Sunlight Peak	EPA/CAMD
La Garita Wilderness	CO	R2	CO91	Wolf Creek Pass	Forest Service
	CO	R2	CO96	Molas Pass	Forest Service
Maroon Bells-Snowmass Wilderness	CO	R2	CO92	Sunlight Peak	EPA/CAMD
North Absaroka Wilderness	WY	R2	WY08	Yellowstone National Park	NPS
Rawah Wilderness	CO	R2	CO19	Rocky Mt. National Park-Beaver Meadows	NPS
	CO	R2	CO89	Rocky Mt. National Park-Lock Vale	NPS
	CO	R2	CO98	Rocky Mt. National Park - Lock Vale	NPS
Pecos Wilderness	NM	R3	NM07	Bandelier National Monument	NPS/Los Alamos
Ansel Adams Wilderness	CA	R5	CA28	King River Exp. Watershed	Forest Service
	CA	R5	CA99	Yosemite National Park	NPS
Caribou Wilderness	CA	R5	CA96	Lassen Volcanic Park	NPS
Desolation Wilderness	CA	R5	CA50	Sagehen Creek	Forest Service
Emigrant Wilderness	CA	R5	CA99	Yosemite National Park	NPS
Hoover Wilderness	CA	R5	CA99	Yosemite National Park	NPS
John Muir Wilderness	CA	R5	CA75	Sequoia National Park	NPS
Kaiser Wilderness	CA	R5	CA28	King River Exp. Watershed	Forest Service
Marble Mountain Wilderness	CA	R5	CA76	Montague	USGS
Mokelumne Wilderness	CA	R5	NV03	Smith Valley	USGS
San Gorgonio Wilderness	CA	R5	CA67	Joshua Tree National Park	NPS
San Jacinto Wilderness	CA	R5	CA67	Joshua Tree National Park	NPS
	CA	R5	CA68	Palomar Mountain	inactive
	CA	R5	CA94	Converse Flats	Forest Service
Ventana Wilderness	CA	R5	CA66	Pinnacles National Monument	NPS
Goat Rocks Wilderness	WA	R6	WA99	Mount Rainier National Park	NPS
Mount Hood Wilderness	OR	R6	WA98	Columbia River Gorge	Forest Service
Mount Jefferson Wilderness	OR	R6	OR10	H.J. Andrews Exp. Forest	Forest Service
Mount Washington Wilderness	OR	R6	OR10	H.J. Andrews Exp. Forest	Forest Service
Pasayten Wilderness	WA	R6	WA19	N. Cascades National Park	USGS
Bradwell Bay Wilderness	FL	R8	FL14	Quincy	NPS
	FL	R8	FL23	Sumatra	EPA/CAMD
Joyce Kilmer-Slickrock Wilderness	TN-NC	R8	TN11	Great Smokey MT's National Park	NPS
Linville Gorge Wilderness	NC	R8	NC45	Mt. Mitchell	EPA/ NC State
Boundary Waters Canoe Area Wilderness	MN	R9	MN08	Hovland	Minn. Pollution Control
Boundary Waters Canoe Area Wilderness	MN	R9	MN08	Hovland	Minn. Pollution Control
	MN	R9	MN32	Voyageurs National Park	NPS
	MN	R9	MN99	Wolf Ridge	Minn. Pollution Control
Dolly Sods Wilderness	WV	R9	WV18	Parsons	Forest Service
Great Gulf Wilderness	NH	R9	ME02	Bridgton	Maine DEP
	NH	R9	ME08	Gilead	USGS
	NH	R9	NH02	Hubbard Brook	Forest Service
Lye Brook Wilderness	VT	R9	VT01	Bennington	USGS
Presidential Range-Dry River Wilderness	NH	R9	ME02	Bridgton	Maine DEP
	NH	R9	ME08	Gilead	USGS
	NH	R9	NH02	Hubbard Brook	Forest Service

Sites with other data available						Inactive sites end date
Hells Canyon Wilderness	ID-OR	R1-R6	ID99	McCall	MDN - inactive	2010
	MT-ID	R1	ID04	Headquarters	inactive	1991
Rainbow Lake Wilderness	WI	R9	WI97	Lac Courte Oreilles Reserve	inactive	2005

Table 3 lists the wilderness areas with NADP monitoring more than 50 km away, but less that 100km. For all practical purposes these stations are not representative of the wilderness area's air shed. The table is intended as more of a caution on what not to use, rather than a positive recommendation. There were 22 wilderness areas that fell into this category and an additional 6 with limited data available.

Table 3. Class I wilderness areas with NADP monitoring stations between 50 and 100 km distant.

Wilderness Name	Wilderness State	Wilderness Region	NADP Site ID	Site Name	Owner/Sponsor
Bob Marshall Wilderness	MT	R1	MT05	Glacier National Park	NPS
Cabinet Mountains Wilderness	MT	R1	ID02	Priest River Experimental Forest	Forest Service
Mission Mountains Wilderness	MT	R1	MT05	Glacier National Park	NPS
Scapegoat Wilderness	MT	R1	MT07	Clancy	USGS
Eagles Nest Wilderness	CO	R2	CO02	Niwot Saddle	Niwot LTER
	CO	R2	CO08	Four Mile Park	Forest Service
	CO	R2	CO10	Gothic	EPA/CAMD
	CO	R2	CO19	Rocky Mt. National Park - Beaver Meadows	NPS
	CO	R2	CO21	Manitou	Forest Service
	CO	R2	CO89	Rocky Mt. National Park - Loch Vale	NPS
	CO	R2	CO90	Niwot Ridge - Southeast	Niwot LTER
	CO	R2	CO92	Sunlight Peak	EPA/CAMD
	CO	R2	CO93	Buffalo Pass - Dry Lake	Forest Service
	CO	R2	CO94	Sugarloaf	EPA/CAMD
	CO	R2	CO97	Buffalo Pass - Summit Lake	Forest Service
	CO	R2	CO98	Rocky Mt. National Park - Loch Vale	NPS
Washakie Wilderness	WY	R2	WY06	Pinedale	Forest Service
Galiuro Wilderness	AZ	R3	AZ98	Chiricahua	EPA/CAMD
	AZ	R3	AZ99	Oliver Knoll	BLM/USGS
Teton Wilderness	WY	R4	WY08	Yellowstone National Park	NPS
	WY	R4	WY98	Gypsum Creek	Forest Service
Agua Tibia Wilderness	CA	R5	CA67	Joshua Tree National Park	NPS
	CA	R5	CA94	Converse Flats	Forest Service
Cucamonga Wilderness	CA	R5	CA94	Converse Flats	Forest Service
Domeland Wilderness	CA	R5	CA75	Sequoia National Park	NPS
Alpine Lakes Wilderness	WA	R6	WA19	N. Cascades National Park	NPS
	WA	R6	WA21	La Grande	EPA/CAMD
	WA	R6	WA99	Mount Rainier National Park	NPS
Diamond Peak Wilderness	OR	R6	OR09	Silverlake Ranger District	USGS/Forest Service
	OR	R6	OR10	H.J. Andrews Experimental Forest	Forest Service
Eagle Cap Wilderness	OR	R6	OR18	Starkey Experimental Forest	Forest Service
Gearhart Mountain Wilderness	OR	R6	OR09	Silverlake Ranger District	USGS/Forest Service
Mount Adams Wilderness	WA	R6	WA21	La Grande	EPA/CAMD
	WA	R6	WA98	Columbia River Gorge	Forest Service
	WA	R6	WA99	Mount Rainier National Park	NPS
Mountain Lakes Wilderness	OR	R6	CA76	Montague	USGS
Caney Creek Wilderness	AR	R8	AR03	Caddo Valley	USGS
Cohutta Wilderness	TN-GA	R8	NC25	Coweeta	Forest Service

Shining Rock Wilderness	NC	R8	NC25	Coweeta	Forest Service	
	NC	R8	NC45	Mt. Mitchell	EPA/NC State	
	NC	R8	TN11	Great Smokey National Park	NPS	
Upper Buffalo Wilderness	AR	R8	AR16	Buffalo National River	NPS	
	AR	R8	AR27	Fayetteville	Univ Ark/USGS	
Hercules-Glades Wilderness	MO	R9	AR16	Buffalo National River	NPS	
Sites with other data available						Site end date
Mazatzal Wilderness	AZ	R3	AZ02	Sycamore Canyon	MDN	
Pine Mountain Wilderness	AZ	R3	AZ02	Sycamore Canyon	MDN	
Sawtooth Wilderness	ID	R4	ID15	Smiths Ferry	inactive	2006
San Rafael Wilderness	CA	R5	CA85	Channel Islands National Park	inactive	1982
	CA	R5	CA98	Chuchupate Ranger Station	inactive	1996
Kalmiopsis Wilderness	OR	R6	OR08	Lost Creek Dam	inactive	1983
	OR	R6	CA20	Yurok Tribe	MDN	
Strawberry Mountain Wilderness	OR	R6	OR11	Vines Hill	inactive	1993
Sipsey Wilderness	AL	R8	TN98	Wilburn Chapel	inactive	1996

Five wilderness areas managed by the Forest Service have no deposition monitoring within 100 km (Table 4). All but one is in Region 3 in the Southwestern part of the country. The fifth wilderness without monitoring is the South Warner in northeast California on the Nevada border, an area with a big monitoring gap, but few wilderness areas to the east.

Table 4. Class I wilderness areas with no NADP monitoring with 100 Km.

Wilderness Name	Wilderness ID	Wilderness State	Wilderness Region
Mount Baldy Wilderness	moba	AZ	R3
Sierra Ancha Wilderness	sian	AZ	R3
Superstition Wilderness	supe	AZ	R3
Wheeler Peak Wilderness	whpe	NM	R3
South Warner Wilderness	sowa	CA	R5

In summary, 33 of the 88 wilderness areas evaluated have no suitable deposition monitoring data available. Thirty-six may have some information available, but each area would need to be carefully evaluated for geographic position (see the section below). Only 18 of the Class I wilderness areas managed by the Forest Service have suitable deposition data for evaluating AQRVs in these areas.

Application to Class I AQRV, Critical loads and other assessments.

How to use the data.

The overall intent of this study was to provide wilderness managers with information and a tool for assessing the available deposition data. NADP monitors only wet deposition, leaving dry deposition to the EPA's CASTNET monitoring network and visibility and particulate concentration to IMPROVE. Many of the CASTNET sites are collocated with NADP stations. All of the collocated CASTNET sites can be accessed from the NADP website from the individual monitoring site's page.

One conclusion that can be drawn from this study is that the monitoring data available for assessing air pollution and deposition in the Forest Service's Class I Wilderness areas are seriously lacking. One might be

tempted to use the nearest monitoring station, but geography and physiography limits the application. Below are a few rules:

- Any NADP station within 20 km of a wilderness area can be assumed to reasonably represent that area
- Beyond 20 km, the representativeness of any NADP station is terrain dependent.
  - High elevation areas in the western mountain ranges and other areas of complex terrain are limited to NADP data within 20 km.
  - Areas in flat, open terrain with less than 1000 ft of relief difference can use NADP data up to 50 km away.
- In general, airsheds follow watersheds (roughly HUC 6 level). It may be better to use a monitoring station further away, but in the same watershed, than a station closer, but not geographically related.

Alternatives to monitoring data

The majority of the wilderness areas do not have wet deposition monitoring close enough to provide reliable data. The next best data source is the extrapolated maps generated by NADP (for example Fig 2). The new modeling protocol uses the PRISM precipitation model as the rain and snow data, which greatly improves the elevation-based calculations of deposition. But users need to be aware that these modeled/calculated values are best used as relative values of deposition or a range of deposition values, rather than one specific value. These maps are created annually by the NADP Program office and published in October of the following year. Current and historical maps can be downloaded for free from http://nadp.sws.uiuc.edu/ as can all of the site-specific monitoring data.

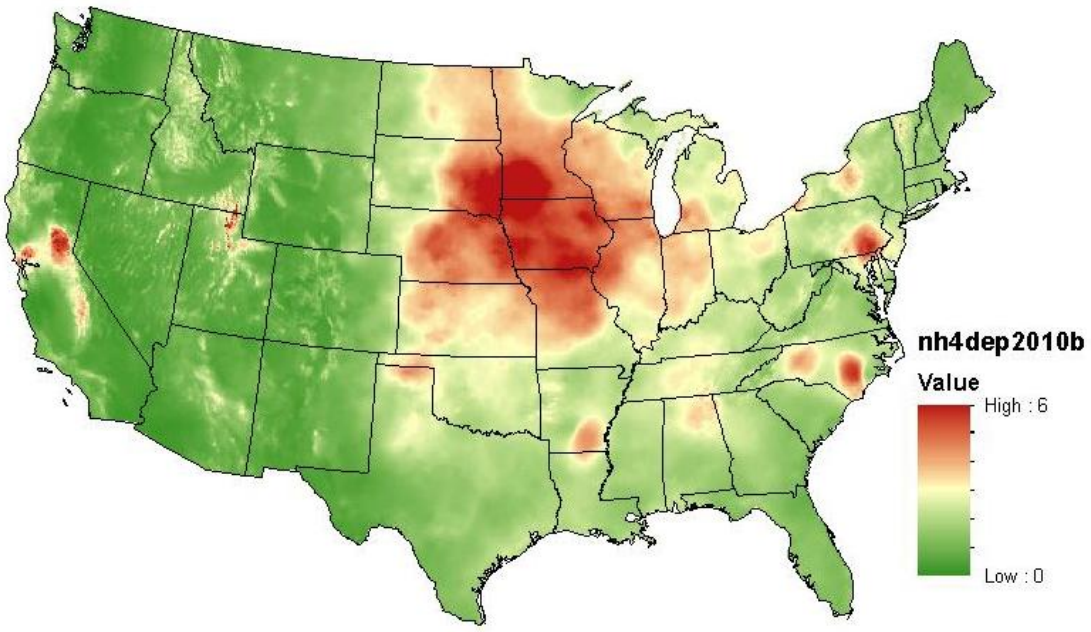

Figure 2. Annual deposition of NH_4^+ calculated use the PRISM models for precipitation.

Improving the network for Class I wilderness areas

Below are five regional maps graphically showing the proximity of NADP monitoring to individual wilderness areas. Each of the wilderness areas are color coded by distance to the closest NADP monitoring station. Most of the northeast and southeast, east of the Mississippi River, are reasonably well represented by monitoring within 50km. The three wilderness areas just west of the Mississippi River have no deposition data available (Figure 3). The upper Midwest section is dominated by the Boundary Waters Canoe Area Wilderness which is well represented by several monitoring stations (Figure 4). However, the Rainbow Lake Wilderness in Wisconsin is poorly covered; the closest monitoring station is an MDN station more than 50 km away.

Many of the wilderness areas in the Colorado Rockies and the California Sierras are also reasonably well covered, but large gaps in monitoring data exist in the northeastern part of the west, Wyoming, Montana, Idaho and eastern Oregon (Figure 5). Data gaps also exist in Arizona (as noted earlier), coastal California and Oregon as well as all of Nevada.

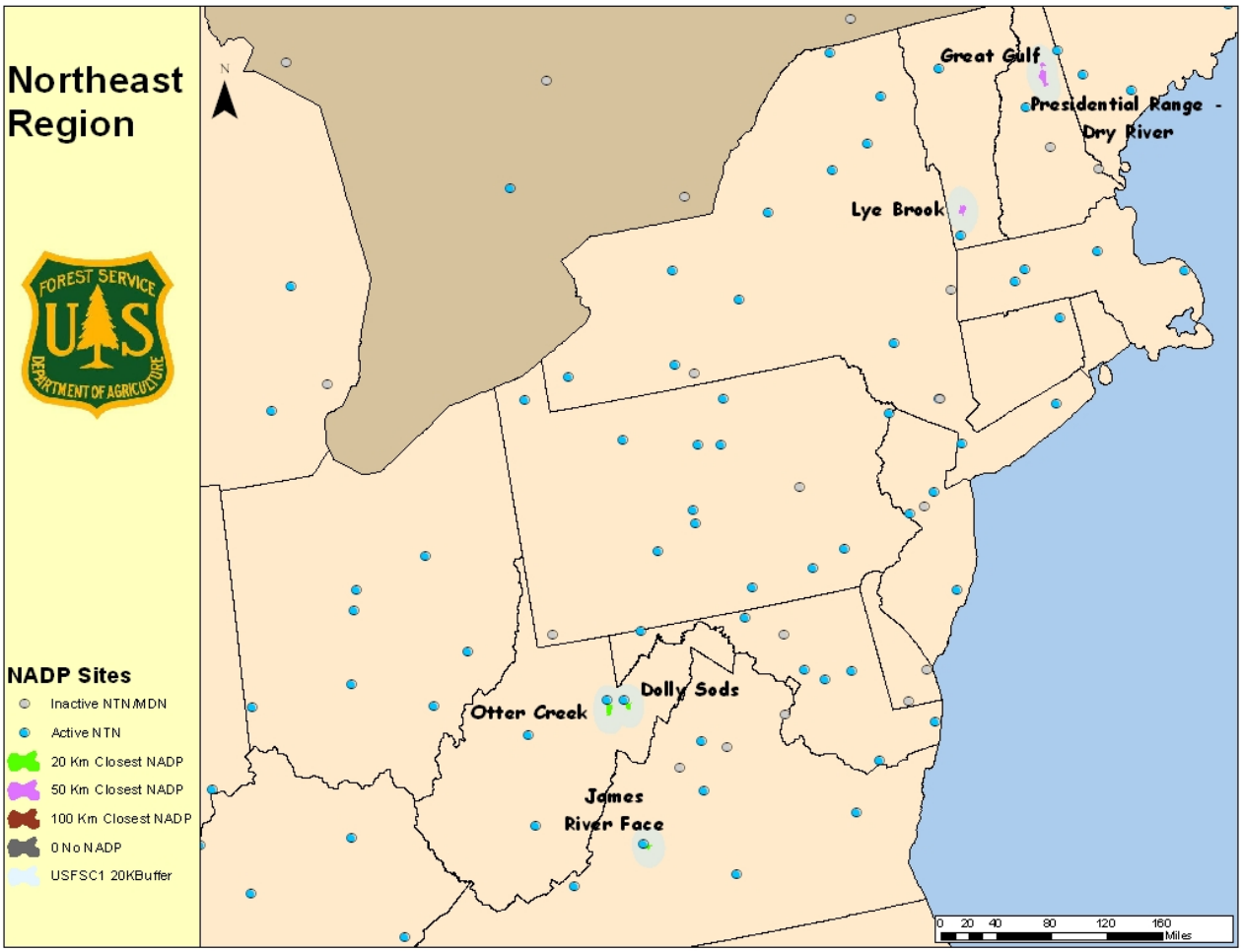

Figure 3. Wilderness areas in the Northeast region. Each wilderness is color coded indicating monitoring stations within 20, 50, 100km. For example Dolly Sods is shown in green indicating monitoring data available with in 20km.

Northeast Wilderness Areas	Distance to NADP collector		
	0-20 km	20-50 km	50-100 km
Dolly Sods	WV99	**WV18**	MD08, VA28, WV99, VA27
Great Gulf		ME02, **NH02**, ME08	NH00
James River Face	**VA99**		VA00, VA13, VA27
Lye Brook		VT01	MA99, MA08, NY12
Otter Creek	WV99, **WV18**		MD08, WV05
Presidential Range - Dry River		ME02, **NH02**, ME08	ME96, NH00

Table 5. NADP monitoring stations within 0 - 20km, 20 - 50km, 50 – 100km of the wilderness area boundary. Bold face station are Forest Service affiliated stations.

Figure 4. Proximity of NADP monitoring to Class I Wilderness areas in the southeastern US. Each wilderness is color coded indicating monitoring stations within 20, 50, 100km. For example Cohutta is coded magenta indicating the closest station is between 50 and 100km away.

Southeast Wilderness Areas	Distance to nearest NADP collector		
	0-20 km	20-50 km	50-100 km
Bradwell Bay		FL14, FL23	
Cohutta			**NC25**
Carey Creek			AR03
Hercules-glades			AR16, MO50
James River Face	**VA99**		VA00, VA13, VA27
Joyce Kilmer-Slickrock		TN11	**NC25**, TN00
Linville Gorge		NC45	VA29, VA33
Shining Rock			TN11, **NC25**, NC45, SC18
Sipsey wilderness			TN98
Upper Buffalo			AR16, AR27

Table 6. NADP monitoring stations within 0-20km, 20-50km, 50-100km of the wilderness area boundary. Bold face station are Forest Service affiliated stations.

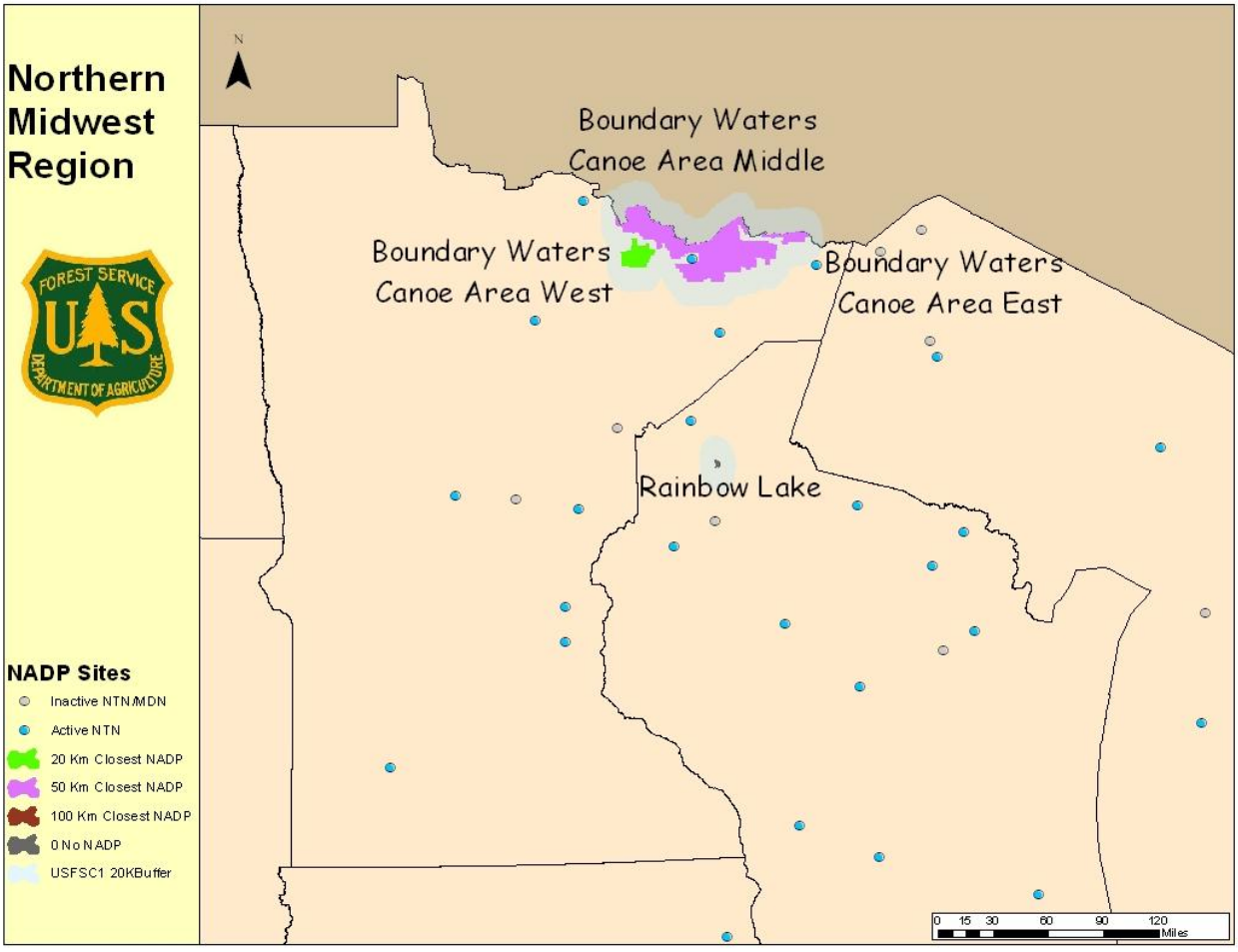

Figure 5 Proximity of NADP monitoring to Class I Wilderness areas in the upper Midwest. Each wilderness is color coded indicating monitoring stations within 20, 50, 100km. For example Boundary Waters is shown in purple indicating monitoring data available within 20 - 50km.

Upper Midwest Area Wilderness Area	Distance to nearest NADP collector		
	0-20 km	20-50 km	50-100 km
Boundary Waters Canoe Area Middle	**MN18**	MN08, MN32, MN99	MI25
Boundary Waters Canoe Area West		**MN18**	**MN16**, MN32, MN99
Boundary Waters Canoe Area East		MN08	**MN18**, MI25, MI97, MN99
Rainbow Lake		WI08, WI97	MN05, WI37

Table 7. NADP monitoring stations within 0-20km, 20-50km, 50-100km of the wilderness area boundary. Bold face station are Forest Service affiliated stations.

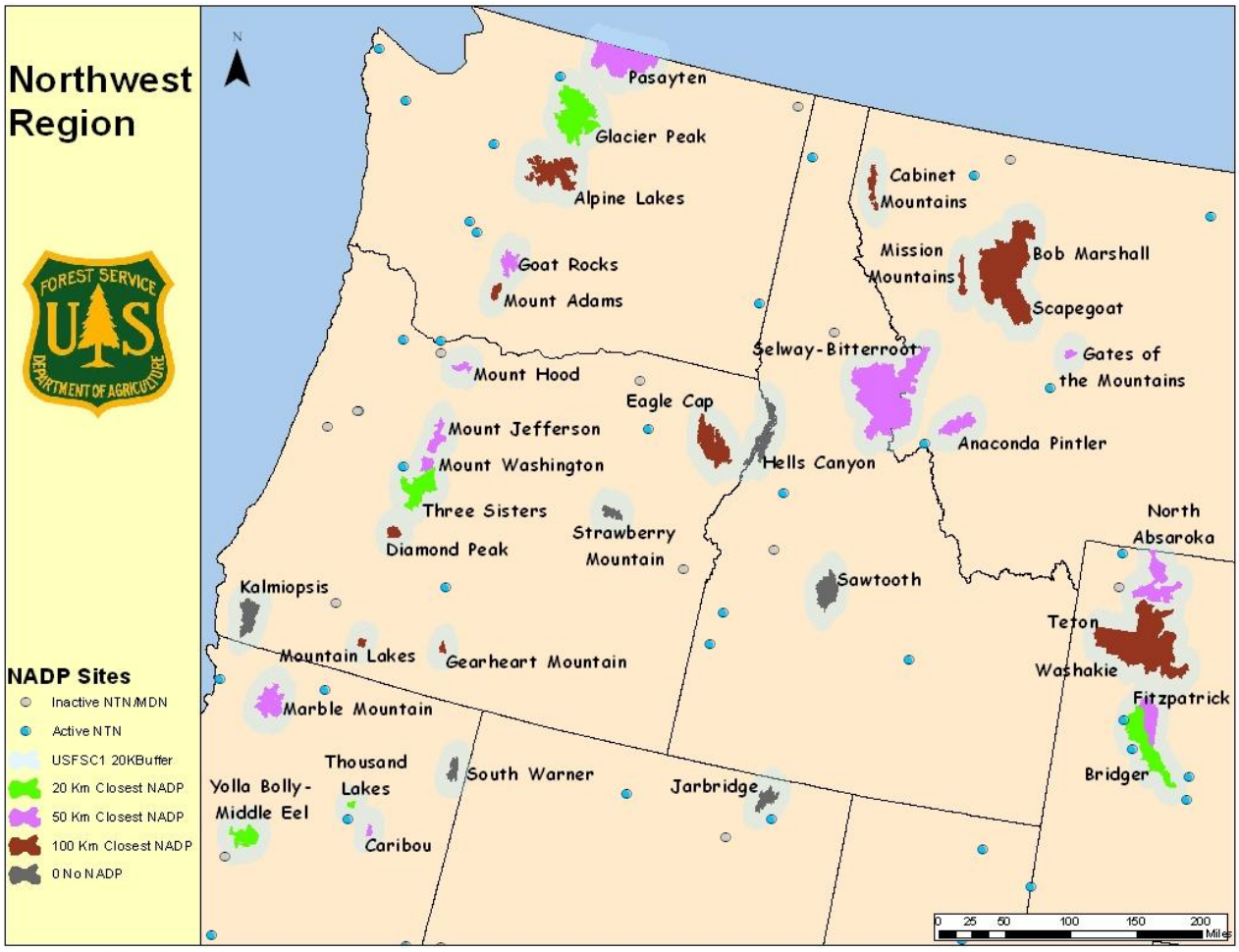

Figure 6. Proximity of NADP monitoring to Class I Wilderness areas in the upper Midwest. Each wilderness is color coded indicating monitoring stations within 20, 50, 100km. For example Three Sisters is shown in green indicating monitoring data available within 20km.

Northwest Wilderness Areas	Distance from the nearest NADP collector		
	0-20 km	20-50 km	50-100 km
Alpine Lakes		WA18	WA19, WA21, WA99
Anaconda Pintler		**MT97**	MT07
Bob Marshal			MT05, MT99
Bridger	WY02, WY06, **WY97**, **WY98**		
Cabinet Mountains			**ID02**
Caribou		CA96	
Diamond Peak			**OR10**, **OR09**
Eagle Cap			**ID99**, OR17, **OR18**
Fitzpatrick		WY06, **WY98**	WY02, **WY97**
Gates of the Mountains		MT07	
Gearheart Mountain			**OR09**
Glacier Peak	WA19		WA18
Goat Rocks		WA99	WA21
Hells Canyon		**ID99**	**ID99**
Jarbidge	NV99	NV01	
Kalmiopsis			CA20, OR08
Marble Mountain		CA76	CA20
Mission Mountains			MT05
Mount Adams			OR98, WA21, **WA98**, WA99
Mount Hood		OR98, **WA98**	OR01
Mount Jefferson		**OR10**	OR97, OR98, OR99, **WA98**
Mount Washington		**OR10**	OR97, OR99
Mountain Lakes			CA76, OR08
North Absaroka	WY07	WY08	
Pasayten	WA19		WA18
Sawtooth			ID15
Scapegoat			MT07
Selway-Bitterroot		ID04, **MT97**	
South Warner			
Strawberry Mountain			OR11
Teton		WY07	WY08, **WY98**
Thousand Lakes	CA96		
Three sisters	**OR10**		OR97, OR99
Washakie		WY07	WY08, WY06, **WY98**
Yolla Bolly-Middle Eel	CA97		

Table 8. NADP monitoring stations within 0-20km, 20-50km, 50-100km of the wilderness area boundary. Bold face station are Forest Service affiliated stations.

Figure 7. Proximity of NADP monitoring to Class I Wilderness areas in the Southwestern region. Each wilderness is color coded indicating monitoring stations within 20, 50, 100km, on none. For example Gila is shown in green indicating monitoring data available within 20km.

Southwest Wilderness Areas	Distance from nearest NADP collector		
	0-20 km	**20-50 km**	**50-100 km**
Ansel Adams		CA28, CA34, CA99	CA75
Aqua Tibia	CA68		**CA94**, CA67
Chiricahua	AZ98		AZ01
Cucamonga	**CA42**		**CA94**
Desolation		**CA50**	NV98, NV03
Domeland			CA75
Eagles Nest			**CO97**, **CO02**, **CO08**, CO10, CO18, CO19, **CO21**, CO89, **CO90**, **CO92**, **CO93**, CO94, CO98
Emigrant		CA99	NV03
Galiuro			AZ01, AZ98, AZ99
Gila	**OR09**	NM01	

Hoover		CA99	NV03
John Muir	**CA28**	CA75, CA34	CA34, CA95, CA99
Kaiser		**CA28**	CA75, CA34, CA99
La Garita		**CO96**, **CO91**	CO00, CO95
Maroon Bells-Snowmass	**CO08**, CO10	**CO92**	CO18
Mazatzal			AZ02
Mokelumne		NV03	NV98, **CA50**, CA99
Mount Baldy			
Mount Zirkel	**CO97**, **CO93**		CO15, CO18, CO19, CO89, CO98, **WY00**, **WY95**, WY96
Pecos		WA19	
Pine Mountain			**AZ02**
Rawah		CO19, CO89, CO98	**CO97**, **CO02**, CO22, **CO90**, **CO93**, CO94, **WY00**, **WY95**, WY96
San Gabriel	**CA42**		**CA94**
San Gorgonio	**CA94**	CA67	**CA42**, CA68
San Jacinto		**CA94**, CA67, CA68	**CA42**,
San Pedro Parks	NM09	NM97	NM98, NM07
San Rafael			CA85, CA98
Sierra Ancha			
Superstition			
Sycamore Canyon	**AZ02**		
Ventana		CA66	
Weminuche	**CO96**, **CO91**, CO95		CO99, NM98, CO00
West Elk	CO10		**CO96**, **CO08**,**CO92**
Wheeler Peak			
White Mountain			**NM08**

Table 9. NADP monitoring stations within 0 - 20km, 20 - 50km, 50 – 100km of the wilderness area boundary. Bold face station are Forest Service affiliated stations.

Investing in new monitoring

As severely under monitored as many of the wilderness areas are, strategic planning indicates investment in additional monitoring is more critical in some areas than others. One approach to identifying key locations for new investment is to look at change and trends in population growth (Figure 8), and in historical trends in deposition patterns, because increases in population are accompanied by increases in automobile emissions, thus oxidized nitrogen sources.

Figure 8 is the change in population from the 2000 and 2010 census data. It is depicted by county, where red tones indicate declines in county populations, and blue tones indicate increases in population. Growth in the southwest part of the country (Figure 8) is reflected in the higher nitrate concentrations in rain around the Phoenix and Salt Lake City metropolitan areas (Figure 9). This growth in human activity, and the subsequent increase in deposition, suggests that the southwest would be a high priority zone for new monitoring. In

comparison, deposition values and population growth in Idaho, Montana, and western Oregon (Figures 8 and 9) remain low suggesting that monitoring in this area might be a lower priority.

Changes in deposition of specific analytes over time can also provide guidance in locating new monitoring stations. For example, historical trends indicate that sulfate deposition is continuing to decline, oxidized nitrogen is trending downward in many parts of the region, but ammonia is increasing. Ammonia "hotspots" are appearing in areas of concentrated animal production, and especially in the upper Midwest (Figure 2), largely independent of population changes. The central US is particularly lacking in deposition monitoring, thus the three wilderness areas in Missouri and Arkansas which have no monitoring within 50km.

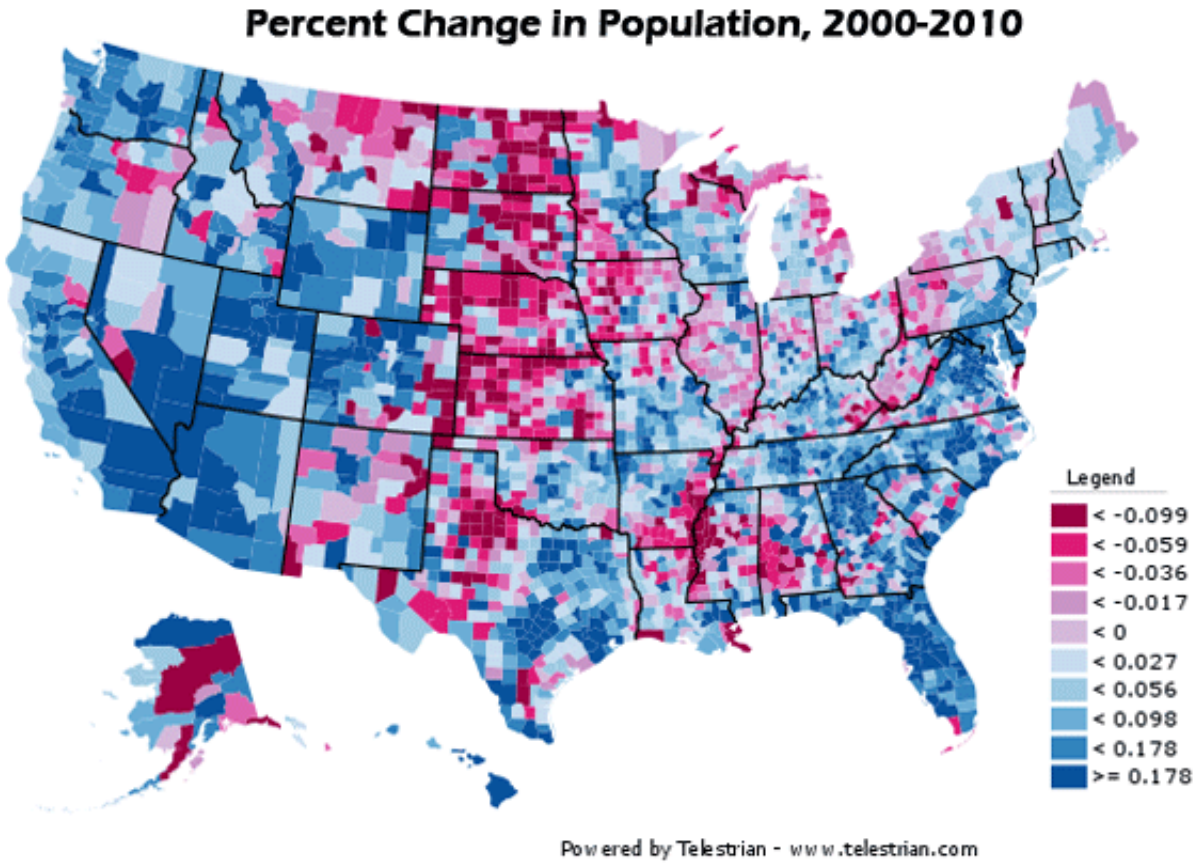

Figure 8. Change in population over the last 10 years. US Census data

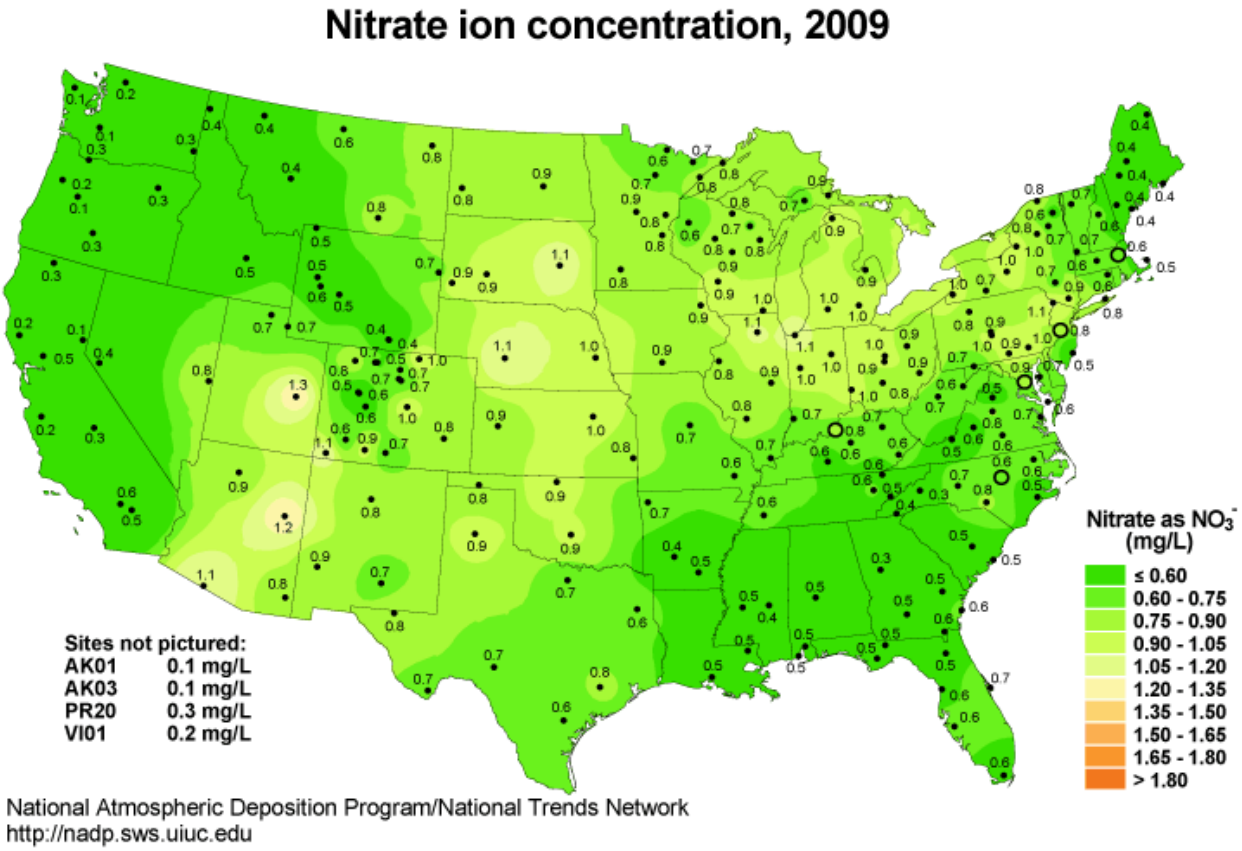

Figure 9. Nitrate concentration in rain taken from the NADP 2009 annual report.

2.) Funding and operations

The 36 supervisors interviewed had a wide array of knowledge and interest in the Network. The exact funding mechanism was unknown to roughly a third of the supervisors. In most cases those were sites that were being paid for by the Washington Office and had a long history of being paid by the WO. In at least 2 cases, the supervisors were unaware that there were any fees associated with NADP. Some were very actively engaged in using the NAPD data for research and management questions, while a few merely made sure the samples were collected. Very few were actively participating in the Network programs, but many expressed interest in attending meetings if funding was available. Most of the FS supervisors were also interested in creating a FS based contact and information sheet so that supervisors and operators could get in touch with other operators.

Tables 10, 11, and 12 are rearrangements of the same information, but in different order to address different questions. Table 10 is the alphabetical listing of the 41 sites found to have any affiliation with the Forest Service. The Forest Service maintains NTN monitoring stations in 21 states, and with the exception of

Colorado, they are fairly well distributed over the continental US with an additional two sites in Alaska and one in Puerto Rico. There are no Forest Service monitoring sites in Hawaii, and the Park Service discontinued that last monitoring station in Hawaii in 2005. Hawaii has no National Forests, but it does have Experimental Forest Units or the equivalent. Two of the Colorado sites are paid for and managed by the Niwot Ridge LTER – but are on Forest Service land. And two other Colorado stations are supported by EPA, Clean Air Markets Division. The remaining 4 sites were established in a proactive effort to ensure that land managers would have the data necessary to evaluate changes in land use on nature ecosystems.

Table 10. Alphabetical listing of all NADP sites owned, operated or supervised by the Forest Service

	Site Name	Year Est.	NADP Funding source 2011	Operating agency or entity	Forest or landowner	National Forest
AK01	Poker Creek	1992	WO	Univ. Alaska Fairbanks	Bonanza Creek LTER/Experimental Forest	Alaska State Land
AK02	Juneau	2004	WO	Univ. Alaska Juneau	Univ. Alaska Juneau	None
CA28	Kings River Exp. Watershed	2007	WO	PSW Research	Kings River Exp. Watershed	Sierra National Forest
CA42	Tanbark Flat	1982	WO	PSW Research	San Dimas Exp Forest	Angeles National Forest
CA50	Sagehen Creek	2001	USGS	UC Berkeley	Sagehen UC Reserve/Sagehen Exp. Forest	Tahoe National Forest
CA94	Converse Flats	2006	WO	PSW Research	San Bernardino NF	San Bernardino NF
CO02	Niwot Saddle	1984	Niwot Ridge LTER	Univ. of Colorado, Boulder	Niwot LTER	Roosevelt National Forest
CO08	Four Mile Park	1987	EPA/CAMD	R2	White River National Forest	White River National Forest
CO21	Manitou	1978	WO	RMRS Research	Manitou Experimental Forest	Pike and San Isabel National Forest
CO90	Niwot Ridge-Southeast	2006	Niwot Ridge LTER	Univ. of Colorado, Boulder	Niwot LTER	Roosevelt National Forest
CO91	Wolf Creek Pass	1992	WO	Contract with ski area	San Juan National Forest	San Juan National Forest
CO92	Sunlight Peak	1988	EPA/CAMD	R2	White River National Forest	White River National Forest
CO93	Buffalo Pass - Dry Lake	1986	WO/R2	R2	Routt/Medicine Bow National Forest	Routt National Forest
CO96	Molas Pass	1986	WO	R2	San Juan National Forest	San Juan National Forest
CO97	Buffalo Pass - Summit Lake	1984	WO/R2	R2	Routt/Medicine Bow National Forest	Routt National Forest
ID02	Priest River Experimental Forest	2002	WO	RMRS	Priest River Exp Forest	Idaho Panhandle National Forest
KY99	Mulberry Flat	1994	TVA/Murray State Univ.	Murray State	Land Between the Lakes National Recreation Area	Land Between the Lakes National Recreation Area
MI53	Wellston	1978	WO	NRS	Wellston Field Lab	Huron-Manistee National Forest
MI98	Raco	1984	EPA/CAMD	Hiawatha NF	Hiawatha NF	Hiawatha NF
MN16	Marcell Experimental Forest	1978	WO	NRS	Marcell EF&R	Chippewa National Forest
MN18	Fernberg	1980	EPA/CAMD	R9	Boundary Waters Canoe Area Wilderness	Superior National Forest
MS30	Coffeeville	1984	TVA	USGS	Tallahatchie Experimental Forest (SRS)	Holly Springs National Forest
MT97	Lost Trail Pass	1990	WO	R1	Bitterroot National Forest	Bitterroot National Forest
NC25	Coweeta	1978	WO/ MACTEC shares ops costs	SRS	Coweeta Experimental Forest and Hydrological Lab	Nantahala National Forest
NH02	Hubbard Brook	1978	WO	NRS	Hubbard Brook Experimental Forest	White Mountain National Forest
NM08	Mayhill	1984	USGS	Contract FS	Lincoln National Forest	Lincoln National Forest

OH17	Delaware	1978	WO	NRS	NRS/ Delaware Research Station	None
OR09	Silver Lake Ranger Station	1983	USGS	Contract FS	Fremont-Winema NF	Fremont-Winema National Forest
OR10	H. J. Andrews Experimental Forest	1980	WO	Oregon St. Univ.	H.J. Andrews LTER	Willamette National Forest
OR18	Starkey Experimental Forest	1984	USGS	PNW	Starkey Experimental Forest	None
PA29	Kane Experimental Forest	1978	WO	NRS	Kane Experimental Forest	Allegheny National Forest
PA72	Milford	1983	WO	NRS	Grey Towers Historical Site	
PR20	El Verde	1985	WO	Univ. Puerto Rico	El Verde Field Station/International LTER	El Yunque National Forest
TX56	L.B.J. National Grasslands	1983	USGS	Contract FS	LBJ National Grasslands	Caddo-LBJ National Grassland
VA99	Natural Bridge Station	2002	R8/ GWJ NF	GW&Jefferson NF	GW &Jefferson NF	George Washington & Jefferson National Forests
WA98	Columbia River Gorge	2002	R6	R6	National Scenic Area	Columbia River Gorge National Scenic Area
WV18	Parsons	1978	WO	NRS	Fernow Experimental Forest	Monongahela National Forest
WY00	Snowy Range	1986	WO	RMRS	Glacier Lakes Study Area	Medicine Bow National Forest
WY95	Brooklyn Lake	1992	WO	RMRS	Glacier Lakes Study Area	Medicine Bow National Forest
WY97	South Pass City	1985	Exxon-Mobile	R4	Shoshone National Forest	Shoshone National Forest
WY98	Gypsum Creek	1984	Exxon-Mobile	R4	Pinedale Ranger District	Bridger-Teton National Forest

Almost all of the monitoring stations have some unique story surrounding their establishment or adoption by the Forest Service. Several were not originally part of the Forest Service network such as VA99 and KY99 but were “adopted” when the original sponsors were no longer able to support them. Many stations have physical challenges such as the high elevation monitors. These stations are very difficult to maintain during the winter, and the data doesn’t always meet the NADP “completeness criteria” due to the difficulty of catching and retaining snow in an open bucket. The dedication of the operators and supervisors is a testament to the dedication to the Network. Several sites are unique cooperatives between 3 organizations such as Sagehen. This station is on a University of California Reserve, and UC personnel do the weekly operations. The reserve is housed on a Forest Service Experimental Forest which maintains the roads and lands, and is paid for by USGS which is interested in a variety of hydrologic questions at this location.

Table 11 is sorted in order of year established. NADP was born out of a Forest Service sponsored symposium in 1975. Subsequent workshops shaped the original concept of “establishment of a permanent network of precipitation chemistry monitoring stations throughout the United States.” In 1977 funding and an organizational structure was created that lead the way establishing the first set of monitoring stations in 1978. The Forest Service continues to maintain 8 of the 24 existing original stations. In 1980, the National Acid Precipitation Assessment Program (NAPAP) was established as an interagency initiative to monitor and coordinate research on acid rain. The biggest growth in the NADP Network and in Forest Service participation occurred during this time. Sites continue to be added through the 1990s and into the 2000s. Most of the later monitoring sites were established in an effort to improve the understanding of nitrogen deposition on natural ecosystems.

Table 11. Forest Service affiliated sites organized by year established.

Site ID	Site Name	Year Est.	Funding source 2011	Operating agency or entity	Forest or landowner	National Forest
CO21	Manitou	1978	WO	RMRS Research	Manitou Experimental Forest	Pike and San Isabel National Forest
MI53	Wellston	1978	WO	NRS	Wellston Field Lab	Huron-Manistee National Forest
MN16	Marcell Experimental Forest	1978	WO	NRS	Marcell EF&R	Chippewa National Forest
NC25	Coweeta	1978	WO/ MACTEC shares ops costs	SRS	Coweeta Experimental Forest and Hydrological Lab	Nantahala National Forest
NH02	Hubbard Brook	1978	WO	NRS	Hubbard Brook Experimental Forest	White Mountain National Forest
OH17	Delaware	1978	WO	NRS	NRS/ Delaware Research Station	None
PA29	Kane Experimental Forest	1978	WO	NRS	Kane Experimental Forest	Allegheny National Forest
WV18	Parsons	1978	WO	NRS	Fernow Experimental Forest	Monongahela National Forest
MN18	Fernberg	1980	EPA/CAMD	R9	Boundary Waters Canoe Area Wilderness	Superior National Forest
OR10	H. J. Andrews Experimental Forest	1980	WO	Oregon St. Univ.	H.J. Andrews LTER	Willamette National Forest
CA42	Tanbark Flat	1982	WO	PSW Research	San Dimas Exp Forest	Angeles National Forest
OR09	Silver Lake Ranger Station	1983	USGS	Contract FS	Fremont-Winema NF	Fremont-Winema National Forest
PA72	Milford	1983	WO	NRS	Grey Towers Historical Site	
TX56	L.B.J. National Grasslands	1983	USGS	Contract FS	LBJ National Grasslands	Caddo-LBJ National Grassland
CO02	Niwot Saddle	1984	Niwot Ridge LTER	Univ. of Colorado, Boulder	Niwot LTER	Roosevelt National Forest
CO97	Buffalo Pass - Summit Lake	1984	WO/R2	R2	Routt/Medicine Bow National Forest	Routt National Forest
MI98	Raco	1984	EPA/CAMD	Hiawatha NF	Hiawatha NF	Hiawatha NF
MS30	Coffeeville	1984	TVA	USGS	Tallahatchie Experimental Forest (SRS)	Holly Springs National Forest
NM08	Mayhill	1984	USGS	Contract FS	Lincoln National Forest	Lincoln National Forest
OR18	Starkey Experimental Forest	1984	USGS	PNW	Starkey Experimental Forest	None
WY98	Gypsum Creek	1984	Exxon-Mobile	R4	Pinedale Ranger District	Bridger-Teton National Forest
PR20	El Verde	1985	WO	Univ. Puerto Rico	El Verde Field Station/International LTER	El Yunque National Forest
WY97	South Pass City	1985	Exxon-Mobile	R4	Shoshone National Forest	Shoshone National Forest
CO93	Buffalo Pass - Dry Lake	1986	WO/R2	R2	Routt/Medicine Bow National Forest	Routt National Forest
CO96	Molas Pass	1986	WO	R2	San Juan National Forest	San Juan National Forest
WY00	Snowy Range	1986	WO	RMRS	Glacier Lakes Study Area	Medicine Bow National Forest
CO08	Four Mile Park	1987	EPA/CAMD	R2	White River National Forest	White River National Forest
CO92	Sunlight Peak	1988	EPA/CAMD	R2	White River National Forest	White River National Forest
MT97	Lost Trail Pass	1990	WO	R1	Bitterroot National Forest	Bitterroot National Forest
AK01	Poker Creek	1992	WO	Univ. Alaska Fairbanks	Bonanza Creek LTER/Experimental Forest	Alaska State Land
CO91	Wolf Creek Pass	1992	WO	Contract with ski area	San Juan National Forest	San Juan National Forest
WY95	Brooklyn Lake	1992	WO	RMRS	Glacier Lakes Study Area	Medicine Bow National Forest

KY99	Mulberry Flat	1994	TVA/Murray State Univ.	Murray State	Land Between the Lakes National Recreation Area	Land Between the Lakes National Recreation Area
CA50	Sagehen Creek	2001	USGS	UC Berkeley	Sagehen UC Reserve/Sagehen Exp. Forest	Tahoe National Forest
ID02	Priest River Experimental Forest	2002	WO	RMRS	Priest River Exp Forest	Idaho Panhandle National Forest
VA99	Natural Bridge Station	2002	R8/GWJ NFs	GW&Jefferson NFs	GW &Jefferson NF	George Washington & Jefferson National Forests
WA98	Columbia River Gorge	2002	R6	R6	National Scenic Area	Columbia River Gorge National Scenic Area
AK02	Juneau	2004	WO	Univ. Alaska Juneau	Univ. Alaska Juneau	None
CA94	Converse Flats	2006	WO	PSW Research	San Bernardino NF	San Bernardino NF
CO90	Niwot Ridge-Southeast	2006	Niwot Ridge LTER	Univ. of Colorado, Boulder	Niwot LTER	Roosevelt National Forest
CA28	Kings River Exp. Watershed	2007	WO	PSW Research	Kings River Exp. Watershed	Sierra National Forest

Table 12 is organized by funding source. As noted earlier, continuity of funding is a major source of stress for supervisors. Many sites were established by other organizations and later assumed by the Forest Service. As far as is known, the reverse has not happened. By far the majority of sites are supported directly by the Washington Office through a contract with USDA National Institute of Food and Agriculture, (formally CSREES). All of the original 1978 sites are in this category, as are most of the NADP stations on the Experimental Forests. Several sites currently supported by the WO were originally supported by other organizations, but when those organizations either fulfilled their need for the data, or ran into budget problems, the sites were important enough to Forest Service goals that funds were made available to keep those stations open.

Table 12. Forest Service affiliated sites organized by funding agency.

Site ID	Site Name	Year Est.	Funding source 2011	Operating agency or entity	Forest or landowner	National Forest
CO08	Four Mile Park	1987	EPA/CAMD	R2	White River National Forest	White River National Forest
CO92	Sunlight Peak	1988	EPA/CAMD	R2	White River National Forest	White River National Forest
MI98	Raco	1984	EPA/CAMD	Hiawatha NF	Hiawatha NF	Hiawatha NF
MN18	Fernberg	1980	EPA/CAMD	R9	Boundary Waters Canoe Area Wilderness	Superior National Forest
WY97	South Pass City	1985	Exxon-Mobile	R4	Shoshone National Forest	Shoshone National Forest
WY98	Gypsum Creek	1984	Exxon-Mobile	R4	Pinedale Ranger District	Bridger-Teton National Forest
CO02	Niwot Saddle	1984	Niwot Ridge LTER	Univ. of Colorado, Boulder	Niwot LTER	Roosevelt National Forest
CO90	Niwot Ridge-Southeast	2006	Niwot Ridge LTER	Univ. of Colorado, Boulder	Niwot LTER	Roosevelt National Forest
WA98	Columbia River Gorge	2002	R6	R6	National Scenic Area	Columbia River Gorge National Scenic Area
MS30	Coffeeville	1984	TVA	USGS	Tallahatchie Experimental Forest (SRS)	Holly Springs National Forest
KY99	Mulberry Flat	1994	TVA/Murray State Univ.	Murray State	Land Between the Lakes National Recreation Area	Land Between the Lakes National Recreation Area
CA50	Sagehen Creek	2001	USGS	UC Berkeley	Sagehen UC Reserve/Sagehen Exp. Forest	Tahoe National Forest
NM08	Mayhill	1984	USGS	Contract FS	Lincoln National Forest	Lincoln National Forest
OR09	Silver Lake Ranger	1983	USGS	Contract FS	Fremont-Winema NF	Fremont-Winema National

	Station					Forest
OR18	Starkey Experimental Forest	1984	USGS	PNW	Starkey Experimental Forest	None
TX56	L.B.J. National Grasslands	1983	USGS	Contract FS	LBJ National Grasslands	Caddo-LBJ National Grassland
AK01	Poker Creek	1992	WO	Univ. Alaska Fairbanks	Bonanza Creek LTER/Experimental Forest	Alaska State Land
AK02	Juneau	2004	WO	Univ. Alaska Juneau	Univ. Alaska Juneau	None
CA28	Kings River Exp. Watershed	2007	WO	PSW Research	Kings River Exp. Watershed	Sierra National Forest
CA42	Tanbark Flat	1982	WO	PSW Research	San Dimas Exp Forest	Angeles National Forest
CA94	Converse Flats	2006	WO	PSW Research	San Bernardino NF	San Bernardino NF
CO21	Manitou	1978	WO	RMRS Research	Manitou Experimental Forest	Pike and San Isabel National Forest
CO91	Wolf Creek Pass	1992	WO	Contract with ski area	San Juan National Forest	San Juan National Forest
CO96	Molas Pass	1986	WO	R2	San Juan National Forest	San Juan National Forest
ID02	Priest River Experimental Forest	2002	WO	RMRS	Priest River Exp Forest	Idaho Panhandle National Forest
MI53	Wellston	1978	WO	NRS	Wellston Field Lab	Huron-Manistee National Forest
MN16	Marcell Experimental Forest	1978	WO	NRS	Marcell EF&R	Chippewa National Forest
MT97	Lost Trail Pass	1990	WO	R1	Bitterroot National Forest	Bitterroot National Forest
NH02	Hubbard Brook	1978	WO	NRS	Hubbard Brook Experimental Forest	White Mountain National Forest
OH17	Delaware	1978	WO	NRS	NRS/ Delaware Research Station	None
OR10	H. J. Andrews Experimental Forest	1980	WO	Oregon St. Univ.	H.J. Andrews LTER	Willamette National Forest
PA29	Kane Experimental Forest	1978	WO	NRS	Kane Experimental Forest	Allegheny National Forest
PA72	Milford	1983	WO	NRS	Grey Towers Historical Site	
PR20	El Verde	1985	WO	Univ. Puerto Rico	El Verde Field Station/International LTER	El Yunque National Forest
WV18	Parsons	1978	WO	NRS	Fernow Experimental Forest	Monongahela National Forest
WY00	Snowy Range	1986	WO	RMRS	Glacier Lakes Study Area	Medicine Bow National Forest
WY95	Brooklyn Lake	1992	WO	RMRS	Glacier Lakes Study Area	Medicine Bow National Forest
VA99	Natural Bridge Station	2002	R8/GWJ NFs	GW&Jefferson NFs	GW &Jefferson NF	George Washington & Jefferson National Forests
NC25	Coweeta	1978	WO/ MACTEC shares ops costs	SRS	Coweeta Experimental Forest and Hydrological Lab	Nantahala National Forest
CO93	Buffalo Pass - Dry Lake	1986	WO/R2	R2	Routt/Medicine Bow National Forest	Routt National Forest
CO97	Buffalo Pass - Summit Lake	1984	WO/R2	R2	Routt/Medicine Bow National Forest	Routt National Forest

USGS supports 5 monitoring stations all on Forest Service lands. Three of those stations are operated by Forest Service personnel under contract from the USGS. EPA, Clean Air Markets Division (CAMD) pays the analytical and operational costs for 4 stations that are operated by the Forest Service. There are 7 other stations funded by a combination of sources including the Niwot Ridge LTER, the TVA, and Exxon-Mobile.

Conclusions

This study had two goals:

1.) How well does the NADP data represent deposition in Class I wilderness areas managed by the Forest Service
2.) Which agencies, organizations, or entities with the Forest Service are funding and operating NADP sites affiliated with the Forest Service.

Very few of the Class I wildernesses managed by the Forest Service have sufficient deposition monitoring data available to be able to make any reliable deposition assessments within the borders. In part, this is because most of the NADP monitoring stations were established with other needs in mind. And in part, because many Class I areas are in remote locations where weekly access to collect samples has not been feasible or not cost effective. That being said, the paucity of air quality and deposition data for the majority of the wilderness areas makes site-specific assessment of ecosystem effects of deposition difficult. Alternatives such as the annual maps generated by the NADP program office and posted on their websites, or the use of regional models such as CMAQ (EPA: Community Multi-scale Air Quality) can provide valuable information, particularly on a comparative basis, but neither are designed to address site specific deposition.

The addition of many new NADP monitoring stations seem unlikely in the near future, but strategic placement of three or four new monitoring stations would improve the data and information available to natural resource assessments. The cluster of wilderness areas in Arizona and New Mexico has virtually no data available, but a rapidly growing population. There is a lack of data available for the wilderness areas in the Great Basin region of California, Nevada, Eastern Oregon and Idaho. While the population density remains relatively sparse in this area, agricultural activity continues to be source of ammonia.

The study found that over all there is very little duplication of monitoring stations except in Colorado. Two supervisors and operators indicated that the Wolf Creek Pass station had ongoing management problems and that the data was not used much as a result. It might be a candidate for relocation.

Money is an issue for all projects, especially for long term monitoring projects. While the Forest Service has a commitment and obligation to monitor existing conditions, status and trends, and effects of management activities on ecosystems, there is always the temptation to eliminate long term monitoring to save money. In point of fact, there is no substitution for site-specific data collected from on the ground. All of our atmospheric deposition models are built, validated, and continually updated from empirical data. It may be possible, sometime in the future, to predict accurately deposition from a model. But currently no models are fine-tuned enough to provide detailed data required for accurate assessment of atmospheric deposition at the landscape level.

The study found that 61% of the Forest Service stations are paid for directly by the Washington Office, and 37% by other agencies or entities, leaving only one or two (depending on the definition) covered by “local” budgets. A general recommendation has been made that all Forest Service stations be supported through a single funding mechanism. This would help stabilize the often shaky support many of the non-WO sites experience. However, history suggests that this may not be the best option. One of the reasons why NADP has been able to persevere in the face of some serious budget problems is that no single entity can kill the

Network. Given the budget uncertainties within the Forest Service it is difficult to support of a single fund model (although that is what currently exists, fundamentally). Should the budget cuts be serious enoughall of the Forest Service stations could be eliminated with a single action. A dispersed funding model where regional, forest, or research funds are combined with WO funds has two benefits. The first is like NADP itself, multiple lines of support mean that no single action can close all of the Forest Service stations. Secondly, the more stations being supported by the WO, the larger that pool of money appears and the more tempting it becomes for application to other priorities.

Historically many of the Forest Service stations were initiated by other entities. There have been precedents within the Forest Service as well as other agencies for shifting funding responsibilities back and forth. Several National Parks stations have been picked up by the states when the Federal budgets were threatened and then returned to NPS when the states budgets were in trouble. An alternative to funding is already in place in Region 4 where the permittee is being asked to fund the monitoring effort. There may be other regions and stations where at least a temporary shift in sponsoring organization could be affected. Although clearly pie-in-the-sky, the best funding mechanism allows for fluidity. WO funds for stations that have no other options, but sincere efforts on the part of Research stations, regional office and forests to find support for the individual monitoring stations.

In short, NADP is invaluable to natural resource management. The Forest Service was critical to its establishment in 1978, and continues to fund a significant portion of the total network. Participation in NADP is arguably the most cost effective use of limited funds. Not only does it provide site-specific deposition data for research and management, it enables the Forest Service to make decisions within a national context. No other monitoring network, internal or external, can offer such benefits as such a modest cost.

Appendix A

NADP Forest Service site Query

Site Number:	Date contacted
Forest Service Contact:	
Telephone number:	
Who established the site:	
Why was the site established:	
Is this site near a Wilderness area either FS or other	
Has the site changed ownership, sponsorship or operator	
Who is paying for the chemical analysis right now	
Who has paid for the analysis in the past	
Contact for the sponsor	
Is anyone using the data	
Does anyone participate in NADP organizational activities	
Other information	

Appendix B

GIS analytical approach

wilderness.mxd ArcMap project name

nfs_land.shp
Source: FTP2 (Cindy Huber) nfs_proclaimed_boundaries
Description: seems to be polygons of all FS lands
Projection: Geographic
Datum: NAD 1927

USFSC1_gcsnad1983.shp
Source: FTP2 (Cindy Huber) fs_class_1_boundaries
Description: polygons Class I wilderness
Projection: Geographic
Datum: NAD 1983

USFSC1_gcsnad1983_Albers.shp
Source: geographic to Albers Equal Area Conic projection
Description: polygons Class I wilderness
Projection: Albers Equal Area Conic
Datum: NAD 1983

USFSC1_gcsnad1983_Albers_MultiBuffer.shp
Source: USFSC1_gcsnad1983_Albers.shp
Description: 20k, 50k, 100k buffered polygons
Projection: Albers Equal Area Conic
Datum: NAD 1983

USFSC1_Albers_Buffer_Join.shp
Source: USFSC1_gcsnad1983_Albers_MultiBuffer.shp
Description: 20k, 50k, 100k buffered polygons spatial join with ALL_NADP points
Projection: Albers Equal Area Conic
Datum: NAD 1983

wilderness.shp
Source: From FTP2 (Cindy Huber) fs_boundaries_asof2009
Description: polygons of all wilderness
Projection: Geographic
Datum: NAD 1983

site_list_txtEvents_Albers.shp
Source: Event file of site list conv. to shape file and projected to Albers Equal Area.
I went through the binder and entered each sheet as a record into Excel. A couple were missing coordinates. I found them at the NADP site (I think). The list was exported to a text file for import into ArcMap. [site_list.txt]. A shape file was created from the text file [site_list_txt Events.shp]. It was projected to Albers [site_list_txtEvents_Albers.shp]

Deposition monitoring in Class I Wilderness

Description: point file of FS NADP sites in binder
Projection: Albers Equal Area Conic
Datum: NAD1983

NTN_MDN_ALL_txtEvents_ALBERS.shp
Source: text file list of sites converted to shape file and projected to Albers
From NADP web site, downloaded list of ntn sites. This list was same as NTNlatlong.xls sent 9/21/10. I used NTNlatlong.xls. Downloaded list of mdn sites from NADP web site. 2 sets were merged, dups labeled as "both". This list was exported to a text file for import into ArcMap.[ntn_mdn_all.txt]. A shape file was created from the text file [NTM_MDN_ALL_TXT Events.shp]. It was projected to Albers [NTN_MDN_ALL_txtEvents_Albers.shp]
Description: point file of all NADP sites
Projection: L Albers Equal Area Conic
Datum: L NAD19833

C:\aamaps\wilderness_nadp\forest_boundaries_from_intern\
allEF_v3.shp
Source: From FTP2 (Cindy Huber)
Description: polygons of all Experimental Forests
Projection: Albers Equal Area Conic
Datum: NAD 198
Note: used query to exclude small triangular EF in Texas with no name or size from subsequent analysis

C:\aamaps\wilderness_nadp\forest_boundaries_from_intern\
allEF_v3_MultipleRingBuffer7.shp
Source: output of multi-ring buffer tool using allEF_v3.shp
Description: 20k, 50k, 100k buffered polygons
Projection: Albers Equal Area Conic
Datum: NAD 1983

C:\aamaps\wilderness_nadp\forest_boundaries_from_intern\
allEF_v3_Mul7_join3.shp
Source: from allEF_v3.shp
Description: output of spatial join (Analysis Tools – overlay – Spatial Join)between Target:
allEF_v3_MultipleRingBuffer7.shp and Join Feature: ALL_NADP
Projection: Albers Equal Area Conic
Datum: NAD 1983

C:\Documents and Settings\sschilling\My Documents\shared\WILDERNESS_NADP\
efr_buffer_join_export.txt table export from allEF_v3_Mul7_join3.shp
efr_buffer_join_export.xlsx table export from allEF_v3_Mul7_join3.shp

Castnet sites:
Downloaded a list of Castnet sites. These were associated with NADP sites that were already on the merged list (except for one in NY, and 3 not associated). I didn't do anything more with this list.

ArcMap Project: [wilderness.mxd]

The primary shape files I used are **usfsc1_gcsnad83.shp**, and **allEF_v3.shp**. I also generated point shape files of FS NADP sites and ALL NADP sites. I projected everything to Albers Equal Area Conic (allEF_v3 was already projected). Albers is pretty good for calculating distances in the middle latitudes at less that continental scale.

When I compared **usfsc1_gcsnad83.shp** to **wilderness.shp**, the 2 shapefile did not quite match. They are offset about 90m east and 40m north. Wilderness.shp includes all the wildernesses not just Class I. Usfsc1 has the same number of wildernesses as the min-max-elevation spreadsheet Cindy sent.

Near Tool:
In ArcMap I used a Tool named "Near" which will calculate the distance between the features in 2 shape files. The id and distance to the closest feature in the 2nd file are added to the attribute table of the 1st shape file attribute table.

What is closest FS NADP site to each wilderness and what is the distance?

Input feature: USFSC1_gcsnad1983_Albers.shp
Near feature: site_list_txtEvents_Albers.shp (FS NADP only)
Added ID and Distance (in meters) to USFSC1_gcsnad1983_Albers table. Distance is actually the distance squared (don't know why).

Export:
WILDERNESS_NADP\nearest_site_join.xlsx

What is closest NADP site to each wilderness and what is the distance?

Input feature: USFSC1_gcsnad1983_Albers.shp
Near feature: NTN_MDN_ALL_txtEvents_Albers.shp (ALL NADP)
Added ID and Distance (in meters) to USFSC1_gcsnad1983_Albers table. Distance is actually the distance squared. Overwrote first "near" done with FS only NADP.
Used field calculator to get sqrt dist

Export:
WILDERNESS_NADP\wilder_allnadp_near_export.xxx

What is closest FS NADP site to each Experimental Forest and what is the distance?

Input feature: allEF_v3.shp
Near feature: site_list_txtEvents_Albers.shp (FS NADP only)
Added ID and Distance (in meters) to allEF_v3.shp table. Distance is actually the distance squared.

Export:
\WILDERNESS_NADP\FS_NADP_near_EF.xlsx

Multi-ring buffer tool:
The Buffer tool is used to define an area within a specified distance around a feature (C1 Wilderness/Exp. Forest). It creates a new coverage of buffer polygons. This coverage will be used to select NADP sites within a specified distance of an C1 Wilderness/Exp. Forest.

Experimental Forests:

Input Feature: allEF_v3.shp
Output Feature Class: \forest_boundaries_from_intern\allEF_v3_MultipleRingBuffer7.shp
Distances: 20,000, 50,000, 100,000
Buffer Unit: meters
Dissolve option: NONE

Class I Wildernesses:

Input Feature: USFSC1_gcsnad1983_Albers.shp
Output Feature Class: \fs_class_1_boundaries\USFSC1_gcsnad1983_Albers_MultiBuffer.shp
Distances: 20,000, 50,000, 100,000
Buffer Unit: meters
Dissolve option: NONE

Spatial Join Tool
This tool creates a table join in which fields from one layer's attribute table are appended to another layer's attribute table based on the relative locations of the features in the two layers. The purpose is to create a field in the Wilderness/EFR coverage table with an aggregate list of NADP sites that fall within a particular buffer ring. Attribute tables were exported to text files and imported into Excel.

Class I Wildernesses:

Target: \fs_class_1_boundaries\USFSC1_gcsnad1983_Albers_MultiBuffer.shp
Join Features: \NTN_MDN_ALL_txtEvents_ALBERS.shp
Output Feature Class: \fs_class_1_boundaries\USFSC1_Albers_Buffer_Join.shp
Join Operation: one to one
Match Option: Intersects
Field Map:
Deleted extra fields from target table, kept only site_id from Join feature table.
Properties of Site_Id: Merge rule -> join
Delimeter-> ,

Export: WILDERNESS_NADP\buffer_spatial_join_all.xlsx

Experimental Forests:

Target: \forest_boundaries_from_intern\allEF_v3_MultipleRingBuffer7.shp
Join Features: \NTN_MDN_ALL_txtEvents_ALBERS.shp
Output Feature Class: \forest_boundaries_from_intern\allEF_v3_Mul7_join3.shp
Join Operation: one to one
Match Option: Intersects
Field Map:
Deleted extra fields from target table, kept only site_id from Join feature table.
Properties of Site_Id: Merge rule -> join
Delimeter-> ,

Export: aamaps\wilderness_nadp\efr_buffer_join_export.txt,
WILDERNESS_NADP\efr_buffer_join_export.xlsx