AIR QUALITY

AND

AIR QUALITY RELATED VALUES

IN

CHASSAHOWITZKA NATIONAL WILDLIFE REFUGE

AND WILDERNESS AREA

Air Quality Branch
U.S. Fish and Wildlife Service
Denver, Colorado

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TABLE OF CONTENTS

SUMMARY i

1.0 INTRODUCTION AND PURPOSE 1

2.0 LEGAL RESPONSIBILITIES 3

2.1 The Wilderness Act 3
2.2 The Clean Air Act 3
2.2.1 The Prevention of Significant Deterioration Program 4

3.0 PHYSICAL ENVIRONMENT 7

3.1 Introduction 7
3.2 Habitat Types 10

4.0 AIR POLLUTANT EMISSIONS FROM AREA SOURCES 11

4.1 Introduction 11
4.2 Stationary Sources 11
4.2.1 Sulfur Dioxide 11
4.2.2 Nitrogen Oxides 11
4.2.3 Volatile Organic Compounds 14
4.2.4 Particulate Matter 14

4.3 Mobile Sources 17
4.4 Stationary vs. Mobile Sources 17
4.5 Wildfires and Prescribed Burning in Chassahowitzka 19

5.0 AMBIENT AIR QUALITY MONITORING 20

5.1 Introduction 20
5.2 Ambient Air Quality Monitoring in Chassahowitzka 20
5.2.1 IMPROVE PM-2.5 Components 20
5.2.2 IMPROVE PM-10 Components 21
5.3 Ambient Air Quality Monitoring Near Chassahowitzka 21
5.3.1 Sulfur Dioxide 24
5.3.2 Ozone 24
5.3.3 Nitrogen Dioxide 25
5.4 Atmospheric Deposition Chemistry in Central and Northern Florida . . . 25
5.4.1 Wet Deposition 25
5.4.2 Dry Deposition 28
5.4.3 Total Deposition 28

6.0 AIR QUALITY RELATED VALUES AT CHASSAHOWITZKA; DOCUMENTED AND POTENTIAL EFFECTS FROM AIR POLLUTANTS 29

6.1 Introduction 29
6.2 Vegetation 29
6.2.1 Vascular Plants 29
6.2.2 Non-Vascular Plants (Lichens) 29
6.2.3 Sensitive Plant Species 30
6.2.4 Ozone Effects 30
6.2.5 Sulfur Dioxide Effects 32
6.2.6 Nitrogen Effects 33
6.3 Wildlife 34
6.4 Soils 35
6.5 Water Quality 36
6.6 Visibility 37
6.6.1 IMPROVE Program 37
6.6.2 Standard Visual Range and the Deciview Index 37

7.0 RECOMMENDATIONS 39

REFERENCES 40

APPENDICES

A. Wetland Types in Chassahowitzka National Wildlife Refuge
B. Seasonal Summaries of IMPROVE Fine Particle Data, April 1993 - May 1994
C. Vegetation Species Lists
C-1. Plants in Chassahowitzka National Wildlife Refuge (updated 1982-1983)
C-2. Lichens in Chassahowitzka National Wildlife Refuge (collected and identified 1994)
D. Wildlife Species Lists
D-1. Mammals in Chassahowitzka National Wildlife Refuge
D-2. Amphibians and Reptiles in Chassahowitzka National Wildlife Refuge
D-3. Birds in Chassahowitzka National Wildlife Refuge (1983)
E. Soils Types in Chassahowitzka National Wildlife Refuge

LIST OF TABLES

Table 2.2-1	Class I Wilderness Areas under FWS Jurisdiction	5
Table 4.4-1	NO_x Emissions From Stationary and Mobile Sources Near Chassahowitzka	17
Table 4.4-2	VOC Emissions From Stationary and Mobile Sources Near Chassahowitzka	18
Table 4.5-1	Chassahowitzka National Wildlife Refuge Fire History, 1990-1995	19
Table 5.2-1	PM-10 at Chassahowitzka	21
Table 5.3-1	National Ambient Air Quality Standards for Criteria Pollutants	22
Table 5.3-2	Sulfur Dioxide at Brooksville, Hernando County	24
Table 5.3-3	Ozone at Holiday, Pasco County	24
Table 5.3-4	Nitrogen Dioxide at Azalea Park, Pinellas County	25
Table 5.4-1	NADP/NTN Wet Precipitation and Deposition Data, Florida, 1991-1993	26
Table 6.2-1	Vascular Vegetation Sensitive to Ambient Concentrations of Air Pollutants at Chassahowitzka	31
Table 6.2-2	"Sensitive" Lichen Species at Chassahowitzka (according to Wetmore 1983) and Associated Substrates	33
Table 6.5-1	Chemical and Physical Conditions of Chassahowitzka and Homosassa Springs	36
Table 6.6-1	Standard Visual Range and Deciview Value at Chassahowitzka NWR	38

LIST OF FIGURES

Fig. 1-1	Chassahowitzka National Wildlife Refuge and Wilderness Area	2
Fig. 3.1-1	Wind Roses From Tampa International Airport, 1985 - 1992	8-9
Fig. 4.2-1	Total SO_2 Emissions by County in Tons Per Year (TPY) Near Chassahowitzka	12
Fig. 4.2-2	Total NO_x Emissions by County in Tons Per Year (TPY) Near Chassahowitzka	13
Fig. 4.2-3	Total VOC Emissions by County in Tons Per Year (TPY) Near Chassahowitzka	15
Fig. 4.2-4	Total PM Emissions by County in Tons Per Year (TPY) Near Chassahowitzka	16
Fig. 5.3-1	FDEP, County, and IMPROVE monitors within 100 km of Chassahowitzka	23
Fig. 5.4-1	NADP/NTN sites in northern and central Florida	27

SUMMARY

Chassahowitzka Wilderness Area is a Class I air quality area administered by the U.S. Fish and Wildlife Service. Despite the special protection mandated for Chassahowitzka by the Wilderness Act and the Clean Air Act, resources in the area are affected by poor air quality. This report presents available information on the air quality and on the resources sensitive to air quality in Chassahowitzka. It also identifies the need for additional inventory, monitoring, and research.

Air quality in Chassahowitzka is affected by many nearby stationary, mobile, and area sources. The largest stationary sources of sulfur dioxide, nitrogen oxides, and particulate matter in Florida are located within 100 km of Chassahowitzka. In addition, the Tampa metropolitan area, approximately 60 km south of the wilderness area, contributes significant mobile and area emissions.

Resources in Chassahowitzka potentially sensitive to air quality include vegetation, wildlife, water, soils, and visibility. For example, several species of plants and lichens found in Chassahowitzka are sensitive to ozone or sulfur dioxide pollution. As a result, these species may experience leaf injury and reduced growth and productivity. Shallow saltwater ecosystems in Chassahowitzka are sensitive to nitrogen deposition from the atmosphere. This additional nitrogen may fertilize these waters, causing algal blooms, reduced water quality, and loss of seagrass beds important to many species of fish and wildlife. In addition, visibility in Chassahowitzka is reduced by haze resulting from high concentrations of pollutant particles in the air.

1.0 INTRODUCTION AND PURPOSE

The U.S. Fish and Wildlife Service (FWS) has legal responsibility for the protection, preservation, and enhancement of "trust" resources. Trust resources include FWS lands and associated biota, threatened and endangered plant and animal species, migratory birds, certain marine mammals, and some anadromous and interjurisdictional fish species and their habitats.

Many FWS trust resources are being affected or have the potential to be affected by air pollutants. Of particular importance is air quality in areas designated Class I by the Clean Air Act. Congress granted Class I areas the greatest degree of air quality protection, and very little deterioration of air quality is allowed in these areas. The FWS manages 21 Class I areas, all wilderness areas. Included is the Chassahowitzka Wilderness Area, part of the Chassahowitzka National Wildlife Refuge (NWR).

The Chassahowitzka NWR was established on June 15, 1943, under the authority of the Migratory Bird Conservation Act. The 30,466-acre refuge is located in the southwest corner of Citrus County and the northwest corner of Hernando County, Florida, along the Gulf of Mexico (fig. 1-1). In 1976, approximately 23,360 acres of Chassahowitzka NWR were designated as wilderness (Public Law 94-557); in 1978, the Chassahowitzka Wilderness Area was designated a mandatory Class I air quality area under the provisions of the Clean Air Act amendments of 1977. Subsequent land acquisition has increased the size of the wilderness area to 23,579 acres.

Congress mandated for Class I Federal Land Managers "an affirmative responsibility to protect all those air quality related values (including visibility) of such lands...." These air quality related values (AQRVs) include vegetation, wildlife, soils, water quality, odor, visibility, and cultural and historical resources.

The purpose of this report is to provide information to help assess the potential for air pollutant impacts to AQRVs at Chassahowitzka. Included in this document are:

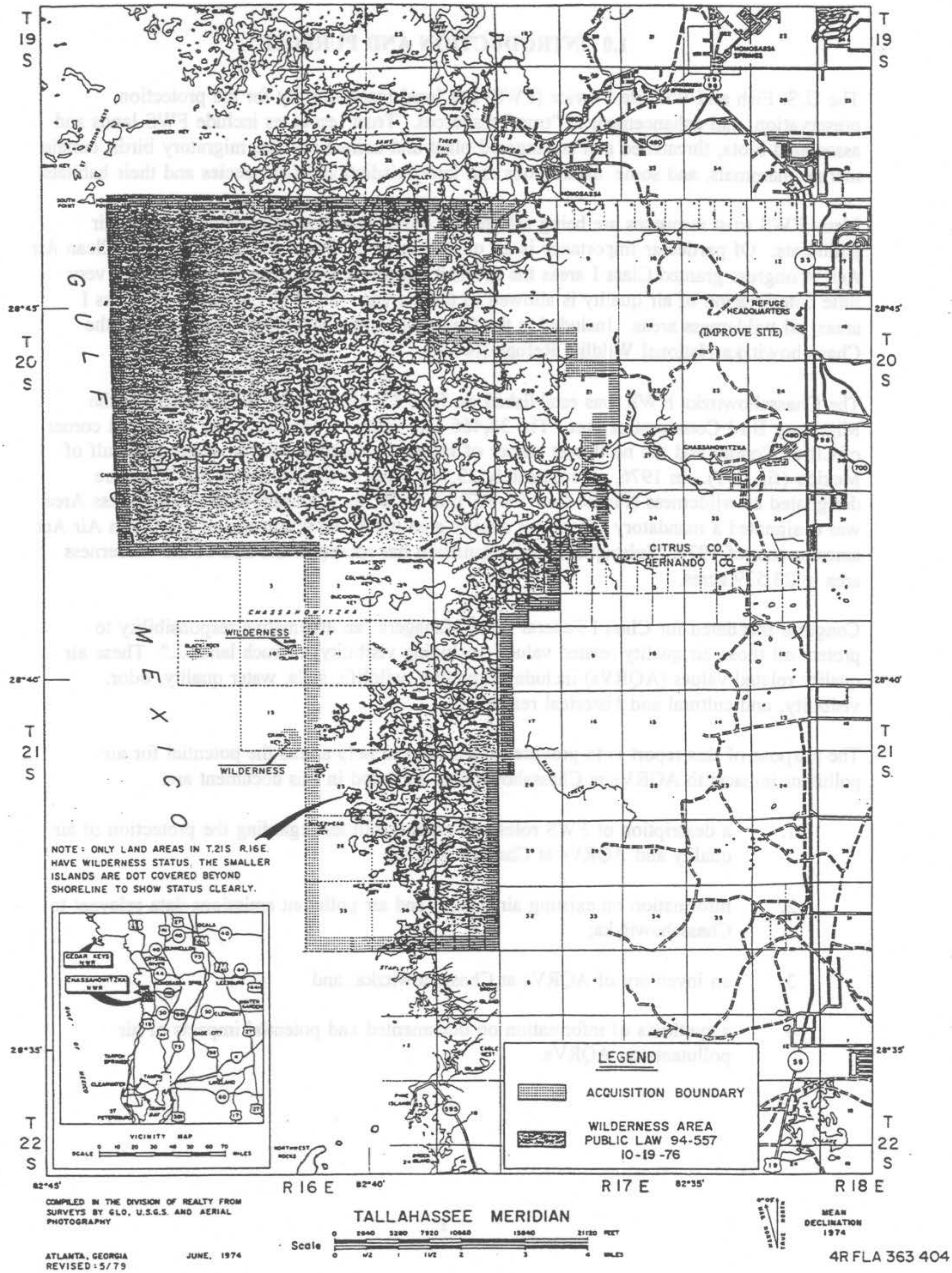
1. a description of FWS roles and responsibilities regarding the protection of air quality and AQRVs at Chassahowitzka;

2. information on existing air quality and air pollutant emissions data relevant to Chassahowitzka;

3. an inventory of AQRVs at Chassahowitzka; and

4. a synthesis of information on documented and potential impacts of air pollutants on AQRVs.

Figure 1-1. Chassahowitzka National Wildlife Refuge and Wilderness Area.



2.0 LEGAL RESPONSIBILITIES

The FWS's air quality management responsibilities are mandated by several laws enacted by Congress. Some of these laws contain general language requiring the FWS to protect, preserve, and enhance natural resources; others set forth specific responsibilities. The most specific mandates to manage air resources are contained in the Wilderness Act of 1964 and the Clean Air Act (as amended in 1977 and 1990).

2.1 THE WILDERNESS ACT

The Wilderness Act of 1964 defines a wilderness area as:

> "... an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is managed so as to preserve its natural conditions...."

The Act goes on to state that:

> "... each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and shall so administer such area for such other purposes for which it may have established as also to preserve its wilderness character."

The FWS manages 20.6 million acres in 75 wilderness areas. The Wilderness Act permits certain activities in wilderness areas so long as they do not permanently alter the natural processes that interact with the land. The "Wilderness Area Management Policy" chapter of the FWS Refuge Manual contains specific guidelines for wilderness management, including the FWS's responsibilities for air quality management in its 21 Class I wilderness areas totalling 721,119 acres.

2.2 THE CLEAN AIR ACT

Under the Clean Air Act, including the amendments of 1977 and 1990, Congress requires the use of specific substantive and procedural tools to protect the nation's air quality. Several sections of the Clean Air Act directly affect FWS management of air quality:

Section 109. National Ambient Air Quality Standards (NAAQS) have been established for six air pollutants: particulate matter less than 10 microns in diameter (PM_{10}), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), and lead (Pb). All areas must meet these standards, or the State must develop plans to do so.

Sections 160-169. The fundamental principle of the Prevention of Significant Deterioration (PSD) program is that air quality in areas meeting NAAQS may not be significantly degraded.

Section 169A. This section requires "the prevention of any future, and the remedying of any existing impairment of visibility in mandatory Class I areas which impairment results from man-made pollution."

2.2.1 The Prevention of Significant Deterioration Program

Of particular importance to the FWS is the Prevention of Significant Deterioration (PSD) Program. Among the purposes of the PSD Program are:

> " to preserve, protect and enhance the air quality in national parks, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic or historic value" and
>
> " to assure that any decision to permit increased air pollution in any area to which this section applies is made only after careful evaluation of all the consequences of such a decision and after adequate procedural opportunities for informed public participation in the decision-making process." (42 U.S.C. 7470 (2) and (5)).

Under the PSD Program, three air quality classes (I, II, and III) were established for areas with air quality meeting the NAAQS (i.e., attainment areas). Class I areas, which are given the highest level of protection from air pollutants, include the following areas that were in existence on August 7, 1977: National Parks exceeding 6,000 acres; National Wilderness Areas exceeding 5,000 acres; National Memorial Parks exceeding 5,000 acres; and International Parks. Of the 158 Class I areas, the FWS is responsible for managing air quality in 21, all of which are wilderness areas (table 2.2-1).

Congress mandated for Class I Federal Land Managers (FLM) "an affirmative responsibility to protect all those air quality related values (including visibility) of such lands...." Air quality related values (AQRVs) are any resources that may be affected by air quality including vegetation, wildlife, soils, water, visibility, odor, and cultural and historical resources.

In attainment areas a preconstruction PSD permit is required for any "major" new stationary source or modification. The Clean Air Act defines "major" as any facility with the potential to emit 250 tons per year of a regulated pollutant. For certain types of facilities, such as fossil fuel-fired steam electric power plants, petroleum refineries, and ore smelters, the threshold is 100 tons per year. Major modifications are defined as those changes to a facility or its methods of operation that increase emissions by more than certain minimal levels, which vary by pollutant. Facilities emitting less than the threshold amounts are considered minor sources and need not obtain PSD permits.

Table 2.2-1. Class I Wilderness Areas under FWS Jurisdiction (Annual Report of Lands Under Control of the FWS as of September 30, 1993).

Wilderness Area	National Wildlife Refuge	Wilderness Acres
Bering Sea	Alaska Maritime	81,340
Simeonof	Alaska Maritime	25,855
Tuxedni	Alaska Maritime	5,566
Chassahowitzka	Chassahowitzka	23,579
St. Marks	St. Marks	17,350
Okefenokee	Okefenokee	353,981
Wolf Island	Savannah Coastal	5,126
Breton	Bogue Chitto	5,000
Moosehorn	Moosehorn	7,386
Seney	Seney	25,150
Mingo	Mingo	7,730
Medicine Lake	Medicine Lake	11,366
Red Rock Lakes	Red Rock Lakes	32,350
UL Bend	Charles M. Russell	20,819
Brigantine	Edwin B. Forsythe	6,681
Bosque del Apache	Bosque del Apache	30,287
Salt Creek	Salt Creek	9,621
Swanquarter	Mattamuskeet	8,785
Lostwood	Lostwood	5,577
Wichita Mountains	Wichita Mountains	8,570
Cape Romain	Cape Romain	29,000

Section 165 of the Clean Air Act requires the Environmental Protection Agency or delegated State authority to notify the responsible FLM of any permit application from a source that may affect a Class I area. Any facility in an attainment area (Class I, II, or III) seeking a PSD permit must (1) use Best Available Control Technology (BACT) for each pollutant, and (2) demonstrate that emissions will not cause or contribute to violations of the NAAQS or Class I PSD increments. (A PSD increment, as defined by the Clean Air Act, is the maximum allowable increase in a pollutant.)

If the FLM can demonstrate, to the satisfaction of the permitting authority, that the emissions would have an adverse impact on an AQRV, the permitting authority cannot authorize the permit. The "adverse impact" determination is site-specific and is a critical test for a proposed facility seeking to locate near a Class I area. If the owner or operator of the proposed facility can demonstrate to the FLM that the emissions will have no adverse impact on the AQRVs of the Class I area and the FLM so certifies, then the State may issue a permit even if the Class I increment would be violated.

The Assistant Secretary for Fish and Wildlife and Parks, as FLM for Class I areas managed by the National Park Service and the FWS, has stated that air pollution effects on resources in Class I areas constitute an unacceptable adverse impact if such effects diminish the national significance of the area, impair the quality of the visitor experience, or impair the structure and functioning of ecosystems.

3.0 PHYSICAL ENVIRONMENT

3.1 INTRODUCTION

Chassahowitzka is located in the southwest corner of Citrus County and the northwest corner of Hernando County, Florida, along the Gulf of Mexico. The 30,466-acre refuge comprises saltwater bays, estuaries, and brackish marsh, with a fringe of hardwood swamps along the eastern border. The northern boundary parallels and includes much of the Homosassa River. The refuge extends southward across the Chassahowitzka River for 12 miles to its southern boundary at Raccoon Point. The 23,579-acre wilderness area includes most of the refuge, excluding the eastern portion of the refuge north of the Chassahowitzka River (figure 1-1).

Chassahowitzka sits atop a flat, surficial limestone deposit of Eocene age (Vernon and Puri 1964). In many places the limestone is covered by a thin layer of organic sediment; in other places the limestone is exposed. Refuge elevations range from sea level to 10 feet above mean sea level. The tidal range in the area is approximately 75 cm (30 in); relative sea level rise is 25 cm (9.8 in) per century; and wave energy is very low except during hurricanes or storm events (Montague and Weigert 1990).

The high permeability of the limestone, low topographic gradient, and high evapotranspiration combine to cause little surficial drainage. As a result, the dominant surface-water influences on the refuge are from two first-magnitude springs: Homosassa to the north and Chassahowitzka to the east, both at the headwaters of rivers of the same names. The average discharges for Homosassa and Chassahowitzka springs are 4.96 and 3.94 cubic meters per second, respectively (Rosenau et al. 1977).

The climate of Chassahowitzka is characterized by long, warm summers and mild, dry winters. Average monthly temperatures range from 15°C (59°F) in January to 28°C (82°F) in August. On average, there are nine days each year with below-freezing temperatures. Average rainfall is approximately 147 cm/yr (58 in/yr) with a range of 94 to 203 cm/yr (37 to 80 in/yr). Evapotranspiration is approximately 83 cm/yr (33 in/yr)(Fernald and Patton 1984). Over 50 percent of the annual rainfall occurs between June and September, whereas only 10 percent occurs between November and February. The greater rainfall during the summer is caused by localized afternoon thunderstorms that form as moisture from the Gulf of Mexico moves inland. These storms can result in large amounts of rainfall. For example, in July 1964, the refuge recorded 57 cm (22.6 in) of rainfall.

The wind roses in figure 3.1-1 summarize wind direction and wind speed data from the National Weather Service meteorological station at Tampa International Airport from 1985 to 1992. In Tampa, winds are generally from the east-northeast; winds from the west are a strong secondary influence. Wind conditions at Chassahowitzka are believed to be similar to those in Tampa. Chassahowitzka also experiences the diurnal variation in wind direction typical of coastal areas: during daytime, wind tends to blow onshore; during nighttime, wind tends to blow offshore.

Figure 3.1-1. Wind Roses from Tampa International Airport, 1985-1992.

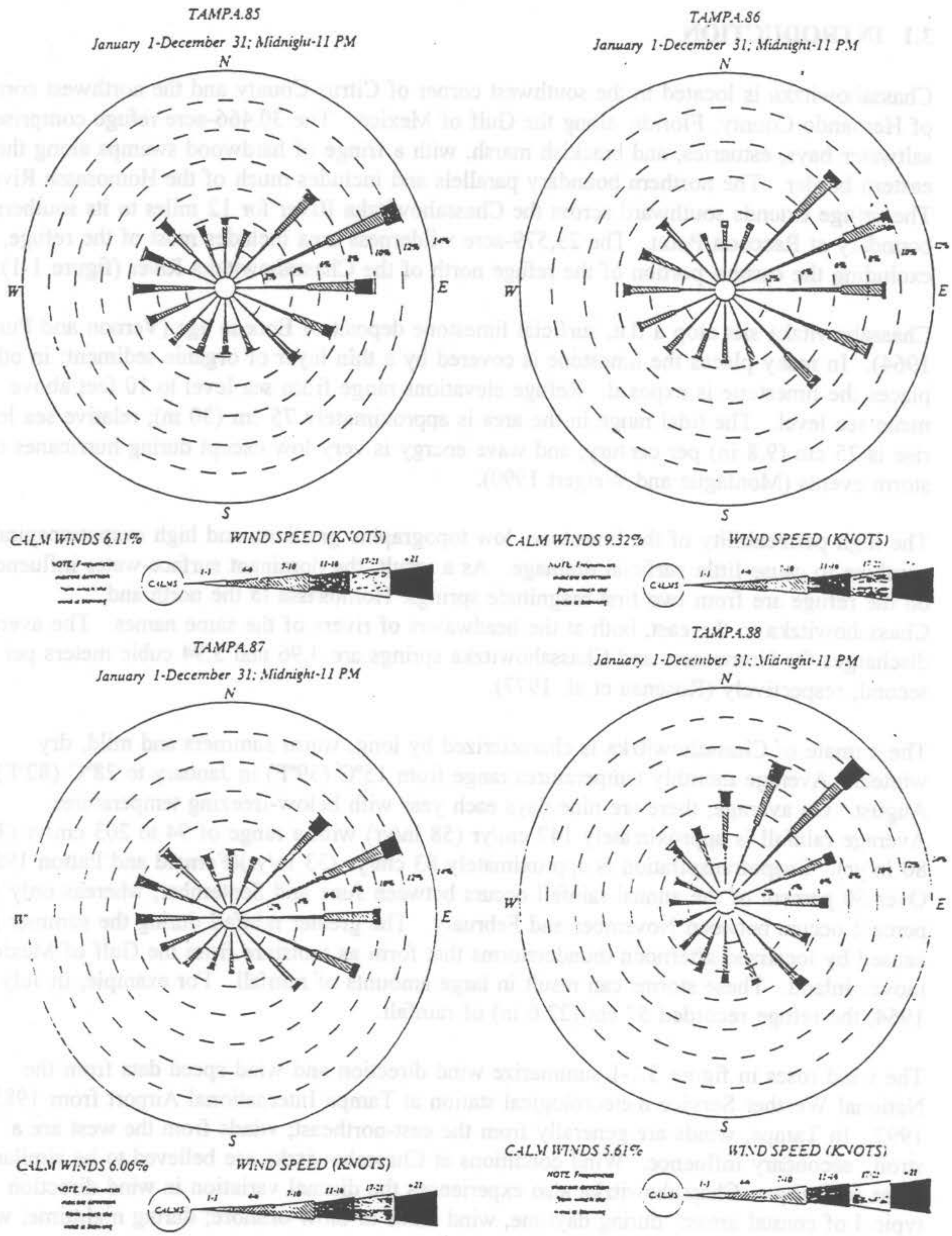
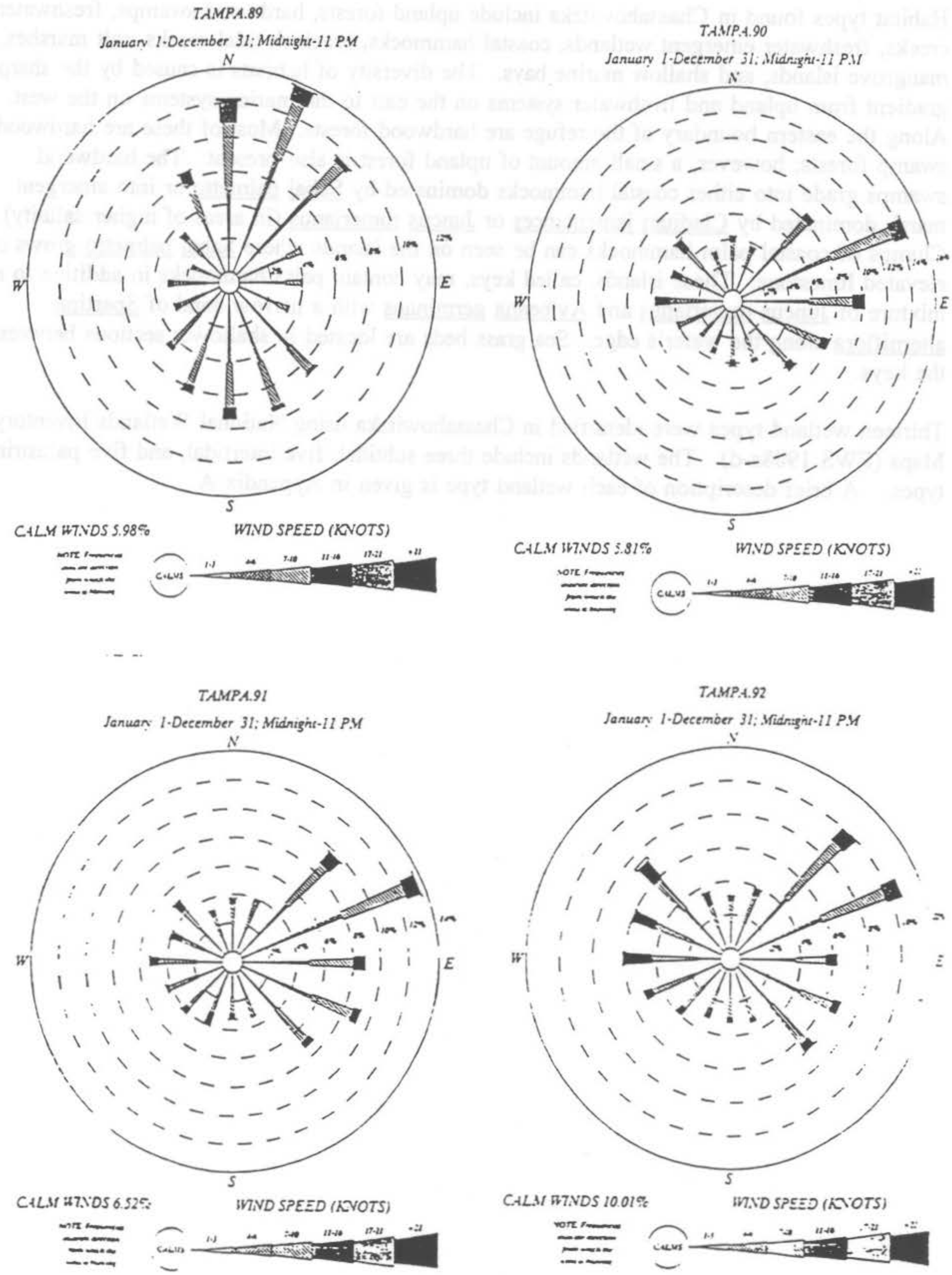


Figure 3.1-1 (cont'd). Wind Roses from Tampa International Airport, 1985-1992.



3.2 HABITAT TYPES

Habitat types found in Chassahowitzka include upland forests, hardwood swamps, freshwater creeks, freshwater emergent wetlands, coastal hammocks, brackish tidal creeks, salt marshes, mangrove islands, and shallow marine bays. The diversity of habitats is caused by the sharp gradient from upland and freshwater systems on the east to the marine systems on the west. Along the eastern boundary of the refuge are hardwood forests. Most of these are hardwood swamp forests; however, a small amount of upland forest is also present. The hardwood swamps grade into either coastal hammocks dominated by Sabal palmetto or into emergent marsh dominated by Cladium jamencinces or Juncus romerianus (in areas of higher salinity). Clumps of coastal palm hammocks can be seen on the islands where Sabal palmetto grows on elevated limestone. These islands, called keys, may contain palm hammocks in addition to a mixture of Juncus romerianus and Avicenna germinans with a narrow band of Spartina alterniflora along the water's edge. Sea grass beds are located in shallower sections between the keys.

Thirteen wetland types were identified in Chassahowitzka using National Wetlands Inventory Maps (FWS 1988a-d). The wetlands include three subtidal, five intertidal, and five palustrine types. A brief description of each wetland type is given in Appendix A.

4.0 AIR POLLUTANT EMISSIONS FROM AREA SOURCES

4.1 INTRODUCTION

Major sources of atmospheric pollutants include both stationary sources, such as power plants and industrial facilities, and mobile sources, such as automobiles and diesel-powered vehicles. The following sections describe emissions from both stationary and mobile sources near Chassahowitzka. In addition, emissions from wildfires and prescribed burning in Chassahowitzka are discussed.

4.2 STATIONARY SOURCES

Information on stationary source emissions near Chassahowitzka was obtained from EPA's Aerometric Information Retrieval System (AIRS). The Florida Department of Environmental Protection (FDEP) last updated this information in 1990; therefore, sources that obtained permits since 1990 are not included. A 13-county area around Chassahowitzka was selected for study because portions of these counties are within a 100-km radius of the refuge. However, emissions from sources outside this area may also affect the refuge and wilderness area.

4.2.1 Sulfur Dioxide

Figure 4.2-1 shows total emissions, by county, from facilities with sulfur dioxide (SO_2) emissions of 100 tons per year (tpy) or more near Chassahowitzka. Electric power production accounts for most SO_2 emissions in the area, contributing approximately 340,000 tpy of the total 372,000 tpy SO_2. The Tampa Electric Company (TECO)-Big Bend Station in Hillsborough County, 90 km south of Chassahowitzka, is the largest emitter of SO_2 in Florida, with emissions of 149,000 tpy. Florida Power's facility in Citrus County, 21 km north of Chassahowitzka, is the third largest emitter of SO_2 in the state, with emissions of 87,000 tpy. (Gulf Power Company's facility in Escambia County, near Pensacola, is the second largest emitter of SO_2 in the state.)

Phosphate fertilizer production, primarily in Polk and Hillsborough counties, also contributes significantly to SO_2 emissions in the area, emitting approximately 27,000 tpy.

4.2.2 Nitrogen Oxides

Figure 4.2-2 shows total emissions from facilities with nitrogen oxides (NO_x) emissions of 100 tpy or more near Chassahowitzka. Electric power production accounts for most stationary source NO_x emissions in the area, contributing approximately 159,000 tpy of the total 165,000 tpy NO_x. Florida Power's facility in Citrus County, 21 km north of Chassahowitzka, is the top NO_x emitter in the state, with emissions of 53,000 tpy. TECO-Big Bend Station is the state's second highest NO_x emitter, with 44,000 tpy. The TECO-Gannon Station is the state's fourth highest NO_x emitter, with 38,000 tpy.

Figure 4.2- 1. Total SO_2 Emissions by County in Tons Per Year (tpy) Near Chassahowitzka NWR (includes only facilities having SO_2 emissions $\geq$ 100 tpy).

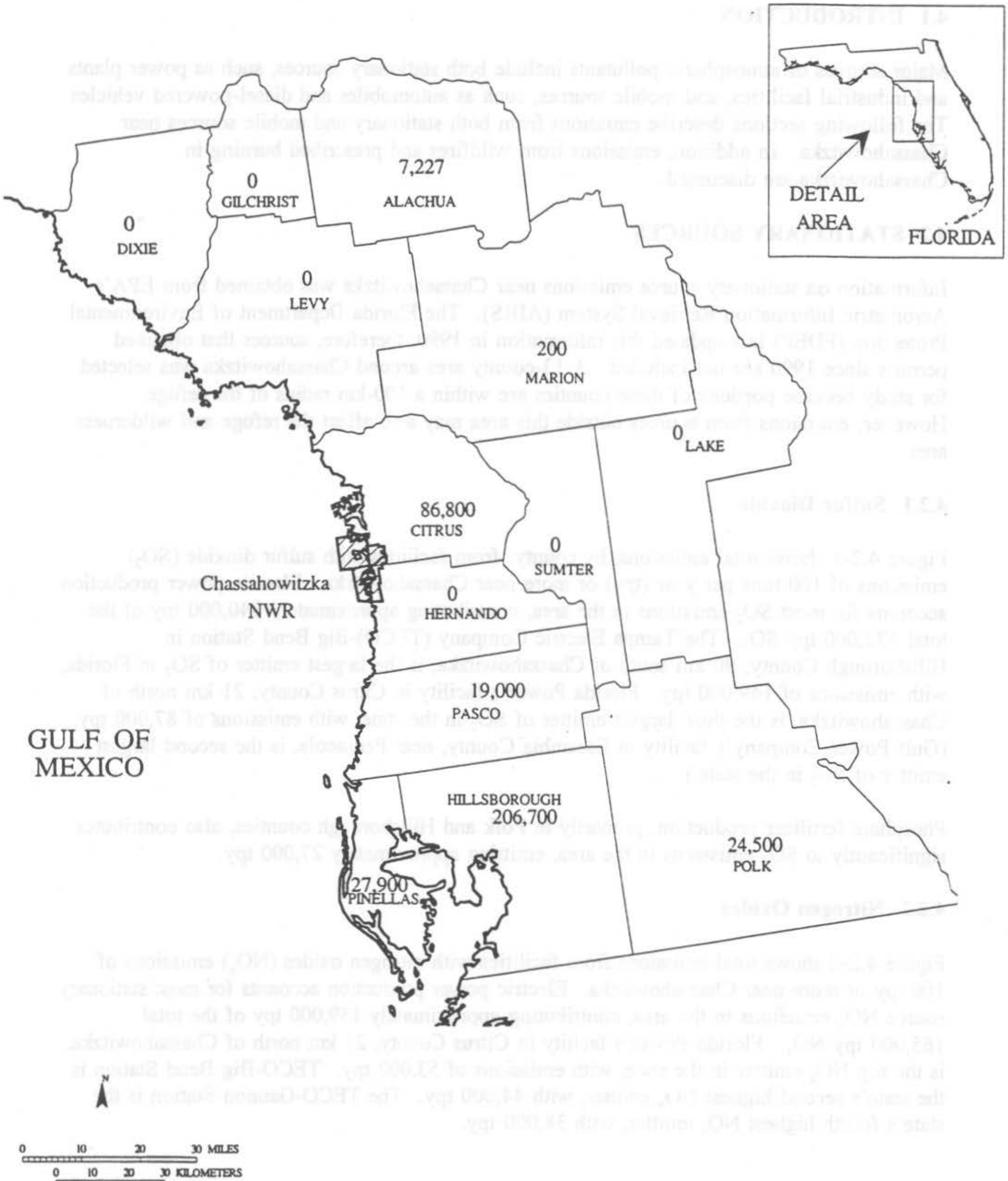
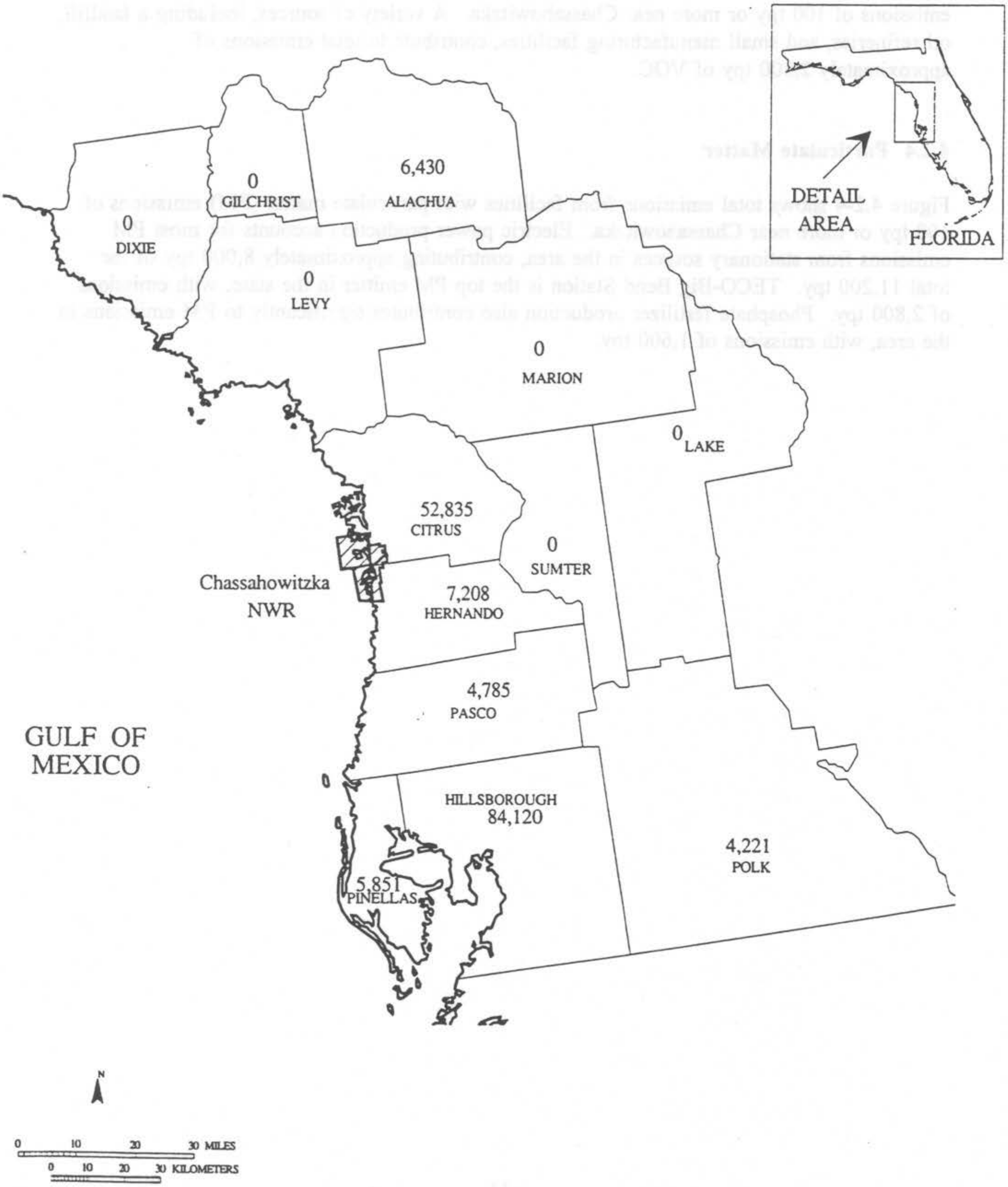


Figure 4.2- 2. Total NOX Emissions by County in Tons Per Year (tpy) Near Chassahowitzka NWR (includes only facilities having NOX emissions ≥ 100 tpy).



4.2.3 Volatile Organic Compounds

Figure 4.2-3 shows total emissions from facilities with Volatile Organic Compounds (VOC) emissions of 100 tpy or more near Chassahowitzka. A variety of sources, including a landfill, oil refineries, and small manufacturing facilities, contribute to total emissions of approximately 2,500 tpy of VOC.

4.2.4 Particulate Matter

Figure 4.2-4 shows total emissions from facilities with particulate matter (PM) emissions of 100 tpy or more near Chassahowitzka. Electric power production accounts for most PM emissions from stationary sources in the area, contributing approximately 8,000 tpy of the total 11,200 tpy. TECO-Big Bend Station is the top PM emitter in the state, with emissions of 2,800 tpy. Phosphate fertilizer production also contributes significantly to PM emissions in the area, with emissions of 1,600 tpy.

Figure 4.2- 3. Total VOC Emissions by County in Tons Per Year (tpy) near Chassahowitzka NWR (includes only facilities having VOC emissions ≥ 100 tpy).

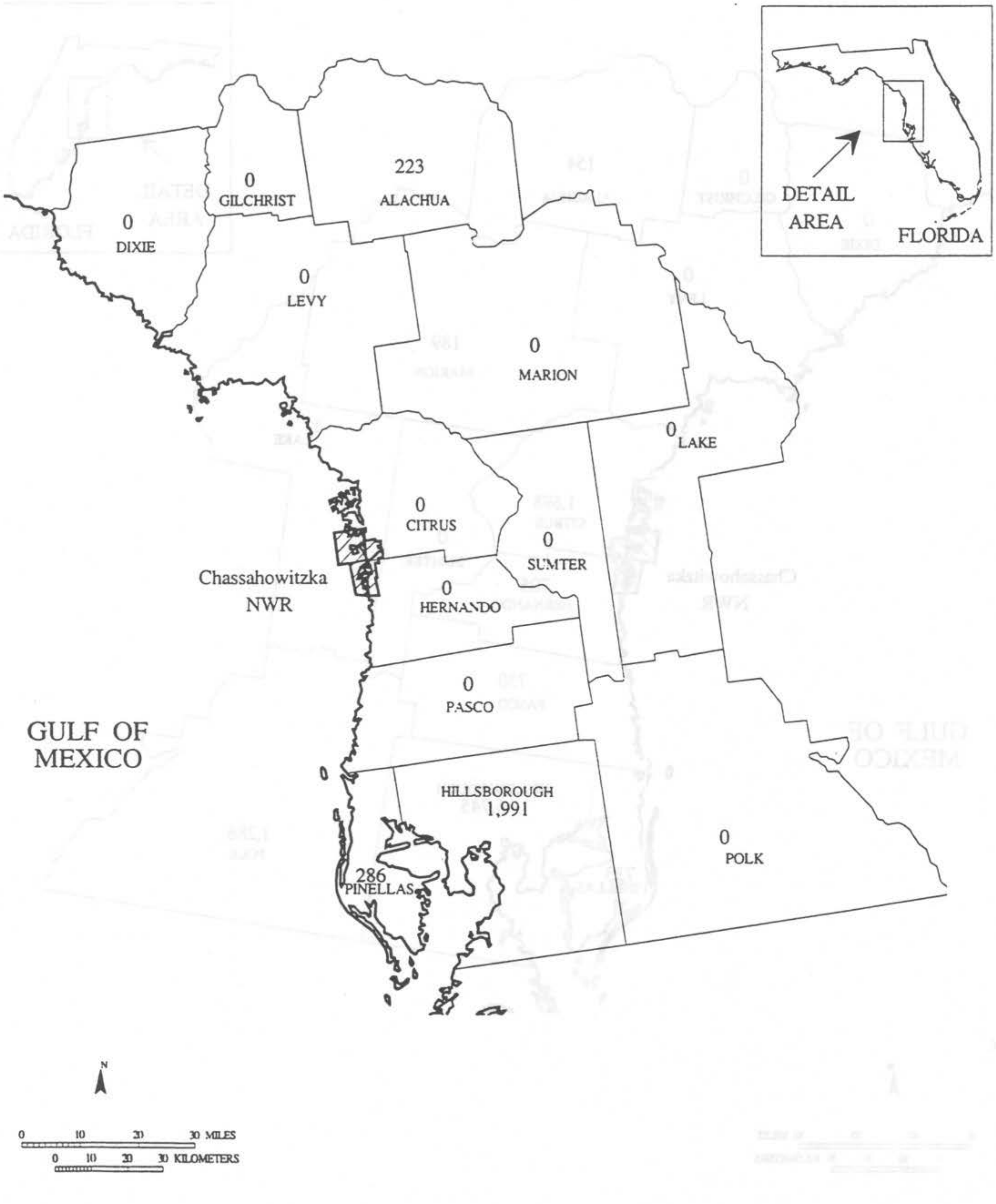
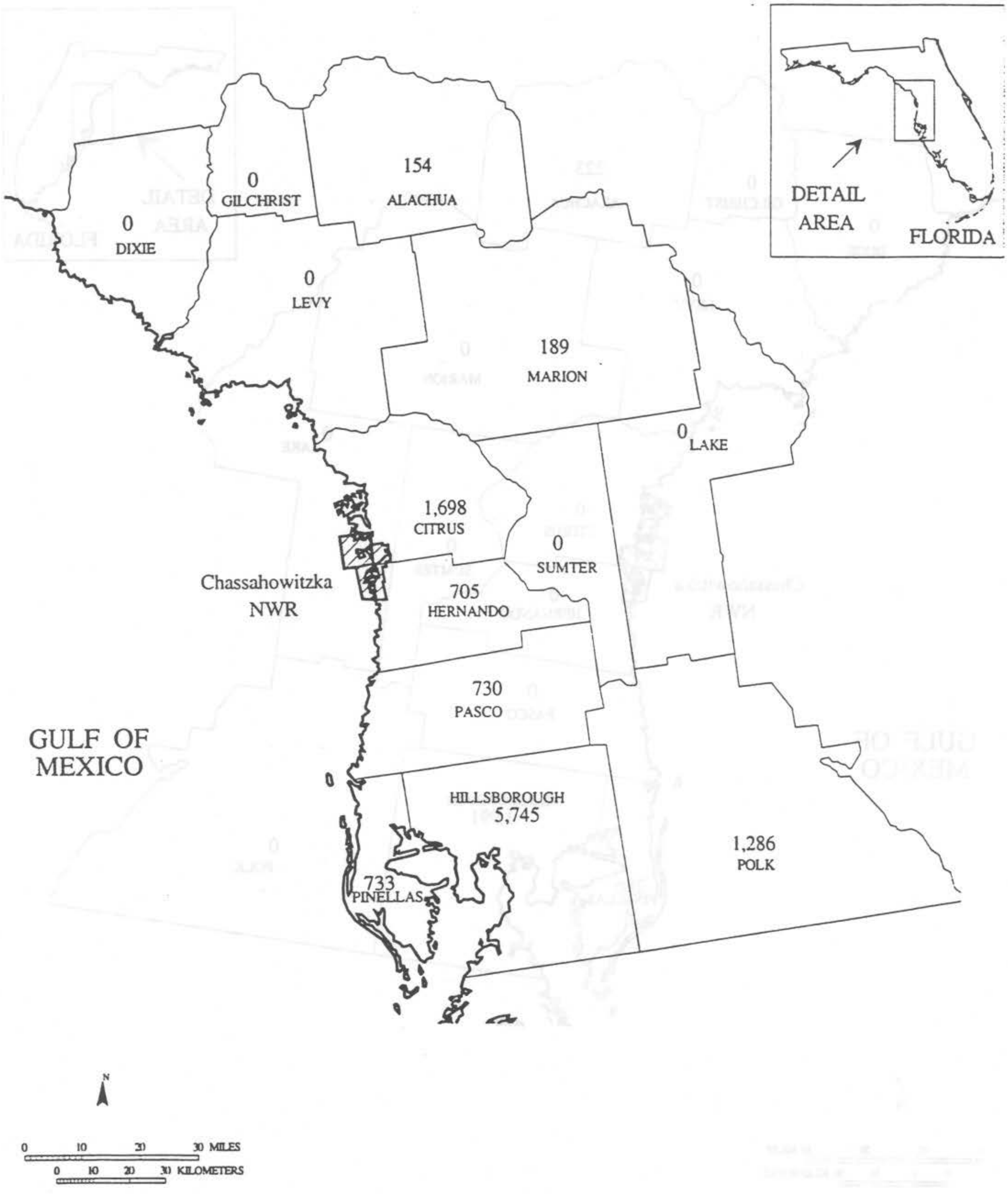


Figure 4.2- 4. Total PM Emissions by County in Tons Per Year (tpy) Near Chassahowitzka NWR (includes only facilities having PM emissions ≥ 100 tpy).



4.3 MOBILE SOURCES

In 1990, FDEP compiled information on mobile-source emissions of NO_x, VOC, and carbon monoxide for four counties in the Tampa Bay area south of Chassahowitzka: Hernando, Pasco, Hillsborough, and Pinellas. Currently, only emissions of NO_x and VOC are considered important to Chassahowitzka because carbon monoxide is primarily a concern only in urban environments.

The mobile-source inventory includes emissions from on-road vehicles (e.g., autos, trucks), non-road engines (e.g., lawnmowers, farm equipment), aircraft, trains, and commercial vessels. On-road engines contribute approximately 75 percent of the total mobile-source emissions of NO_x and VOC for the area. Non-road engines contribute most of the remainder; aircraft, trains, and commercial vessels contribute minor amounts. Mobile-source emissions of NO_x and VOC are highest near Tampa Bay, in Hillsborough and Pinellas counties.

4.4 STATIONARY VS. MOBILE SOURCES

Table 4.4-1 compares NO_x emissions from stationary and mobile sources in the four-county area.

Table 4.4-1. NO_x Emissions From Stationary and Mobile Sources Near Chassahowitzka (1990 Inventory).

NO_x EMISSIONS (tpy)		
COUNTY	**STATIONARY SOURCES**	**MOBILE SOURCES**
Hernando	7,208	3,526
Hillsborough	84,120	34,551
Pasco	4,785	8,158
Pinellas	5,851	24,984
TOTAL	**101,964**	**71,219**

Stationary sources contribute approximately 60 percent of total NO_x emissions in the area; mobile sources contribute 40 percent.

Table 4.4-2 compares VOC emissions from stationary and mobile sources in the four-county area.

Table 4.4-2. VOC Emissions From Stationary and Mobile Sources Near Chassahowitzka (1990 Inventory).

VOC EMISSIONS (tpy)		
COUNTY	**STATIONARY SOURCES**	**MOBILE SOURCES**
Hernando	0	4,095
Hillsborough	1991	42,322
Pasco	0	10,132
Pinellas	286	37,340
TOTAL	**2,277**	**93,889**

Mobile sources contribute 98 percent of total VOC emissions in the area; stationary sources contribute only 2 percent of the total.

These comparisons demonstrate that mobile sources are significant contributors to emissions in the area, contributing 40 percent of total NO_x emissions and 98 percent of total VOC emissions.

4.5 WILDFIRES AND PRESCRIBED BURNING IN CHASSAHOWITZKA

Table 4.5-1 summarizes the fire history of Chassahowitzka NWR from 1990 to 1995 and shows approximate particulate matter (PM) emissions from fires. (Note: Although other pollutants are emitted by fires, PM is the primary pollutant of concern.) At Chassahowitzka, PM emissions from fires have been low (average 11 tons per year, 1990-1995) compared with PM emissions from stationary sources.

Table 4.5-1. Chassahowitzka National Wildlife Refuge Fire History, 1990 - 1995.

YEAR	WILDFIRE (acres burned)	PRESCRIBED FIRES (acres burned)	TOTAL (acres burned)	PM EMISSIONS (tpy)[a]
1990	135	225	360	20
1991	50	0	50	3
1992	0	35	35	2
1993	0	0	0	0
1994	0	0	0	0
1995	30	725	755	42
			Avg. emissions = 11 tpy	

[a] Particulate emissions calculated using PM emission factor of 111 pounds/acre (National Fire-Danger Rating System Fuel Model N for tallgrass/sawgrass).

Although fires produce air pollutants, FWS recognizes that fire is integral to many ecosystems, including Chassahowitzka. Fire maintains healthy plant communities by removing dead vegetation, recycling nutrients, and encouraging new plant growth. Historically, wildfires occurred regularly in Chassahowitzka; it is FWS policy to suppress wildfires (which are by definition uncontrolled) and, instead, conduct prescribed burns. Prescribed burns are those conducted for specific management objectives (e.g., habitat improvement and fuel reduction) using a "prescription" that dictates location, time, and meteorological conditions.

During prescribed burns, FWS smoke-management techniques minimize the amount of smoke, and therefore particulates, released to the atmosphere. Consequently, over the long term, prescribed burns are expected to result in the release of less PM emissions than the amount that would be released if uncontrolled wildfires occur. Therefore, prescribed burning is considered consistent with the FWS goal of improving air quality in Chassahowitzka.

5.0 AMBIENT AIR QUALITY MONITORING

5.1 INTRODUCTION

The following subsections describe ambient air quality and its monitoring in and near Chassahowitzka. In Chassahowitzka, FWS monitors the fine particles and aerosols found in ambient air. Near Chassahowitzka, the State of Florida Department of Environmental Protection (FDEP) and certain industries monitor gaseous pollutants and particulate matter. The FDEP data are EPA-approved and can be used in conjunction with the FWS data to characterize air quality that may affect Chassahowitzka. However, the FDEP data must be used with caution because the closest FDEP monitor is 40 km south of Chassahowitzka. This monitor and others further away may not adequately represent air quality in Chassahowitzka. For instance, a major influence on Chassahowitzka air quality is Florida Power Corporation's Crystal River Plant, 21 km north of Chassahowitzka. The Crystal River Plant is the largest emitter of nitrogen oxides in Florida (52,835 tpy) and the third largest sulfur dioxide emitter (86,773 tpy). Air pollutant concentrations resulting from this plant's emissions will be significantly higher at Chassahowitzka than at the FDEP monitors further south.

5.2 AMBIENT AIR QUALITY MONITORING IN CHASSAHOWITZKA

FWS conducts monitoring of ambient air quality, specifically to assess visibility, in Chassahowitzka as part of the national Interagency Monitoring of Protected Visual Environments (IMPROVE) network. Three primary monitoring objectives of IMPROVE support the visibility protection regulations for Class I areas: (1) to establish present visibility levels; (2) to identify sources of existing anthropogenic impairment; and (3) to document long-term trends to track progress toward meeting the goal of no anthropogenic impairment of protected areas.

An IMPROVE sampler was installed in April 1993 adjacent to Chassahowitzka refuge headquarters (fig. 1-1). The sampler is designed primarily to collect PM-2.5 (fine particles less than 2.5 micrometers (µm) in diameter) that contribute to visibility impairment. (Visibility is discussed in more detail in sect. 6.6.) The sampler filters a known volume of air over a 24-hour period twice a week. The filters are analyzed for fine particles including hydrogen, sulfur, soil elements, trace elements, nitrate, chloride, organic carbon, and elemental carbon. Data on several composite parameters are derived from data on the measured parameters. Composite parameters include ammonium sulfate, ammonium nitrate, organic mass, light-absorbing carbon, and soil. The filters are also analyzed for PM-10 (particles less than 10 µm in diameter).

5.2.1 IMPROVE PM-2.5 Components

IMPROVE data from Chassahowitzka collected April 1993 to May 1994 are summarized by season in Appendix B on maps that display data from the entire IMPROVE network. Because only 14 months of data have been summarized for the Chassahowitzka site, extensive data analysis would be premature. However, some trends are evident. For most measured parameters (e.g., total and fine mass, ammonium sulfate, ammonium nitrate, organic carbon), eastern sites have higher concentrations than western sites. This reflects the pattern of greater air pollution and lower visibility in the east. The concentration of soil in the atmosphere is an exception; it is sometimes higher in the west. Concentrations of PM-2.5 components at Chassahowitzka conform to these patterns. Section 6.6 discusses the impact of PM-2.5 on visibility in Chassahowitzka. As the data record lengthens, attributing visibility impairment at the refuge and adjacent Class I wilderness area to specific source types and regions will be more accurate.

5.2.2. IMPROVE PM-10

The IMPROVE sampler uses an EPA-certified sampler head for measuring PM-10. The data from April 1993 to May 1994 are summarized in table 5.2-1. Caution should be used in interpreting this data because it represents a relatively short sampling period.

Table 5.2-1. PM-10 at Chassahowitzka.

PM-10 (μg/m³)		
Year	Max. 24-hr[a]	Annual Mean[b]
1993 (April-Dec)	68	19
1994 (Jan-May)	36	18

[a] 24-hour PM-10 NAAQS = 150 μg/m³.
[b] annual PM-10 NAAQS = 50 μg/m³.

5.3 AMBIENT AIR QUALITY MONITORING NEAR CHASSAHOWITZKA

FDEP and county agencies monitor ambient air near Chassahowitzka as part of the statewide program to verify compliance, or progress toward compliance, with the National Ambient Air Quality Standards (NAAQS) for criteria pollutants. These standards are shown in table 5.3-1.

Table 5.3-1. National Ambient Air Quality Standards for Criteria Pollutants.

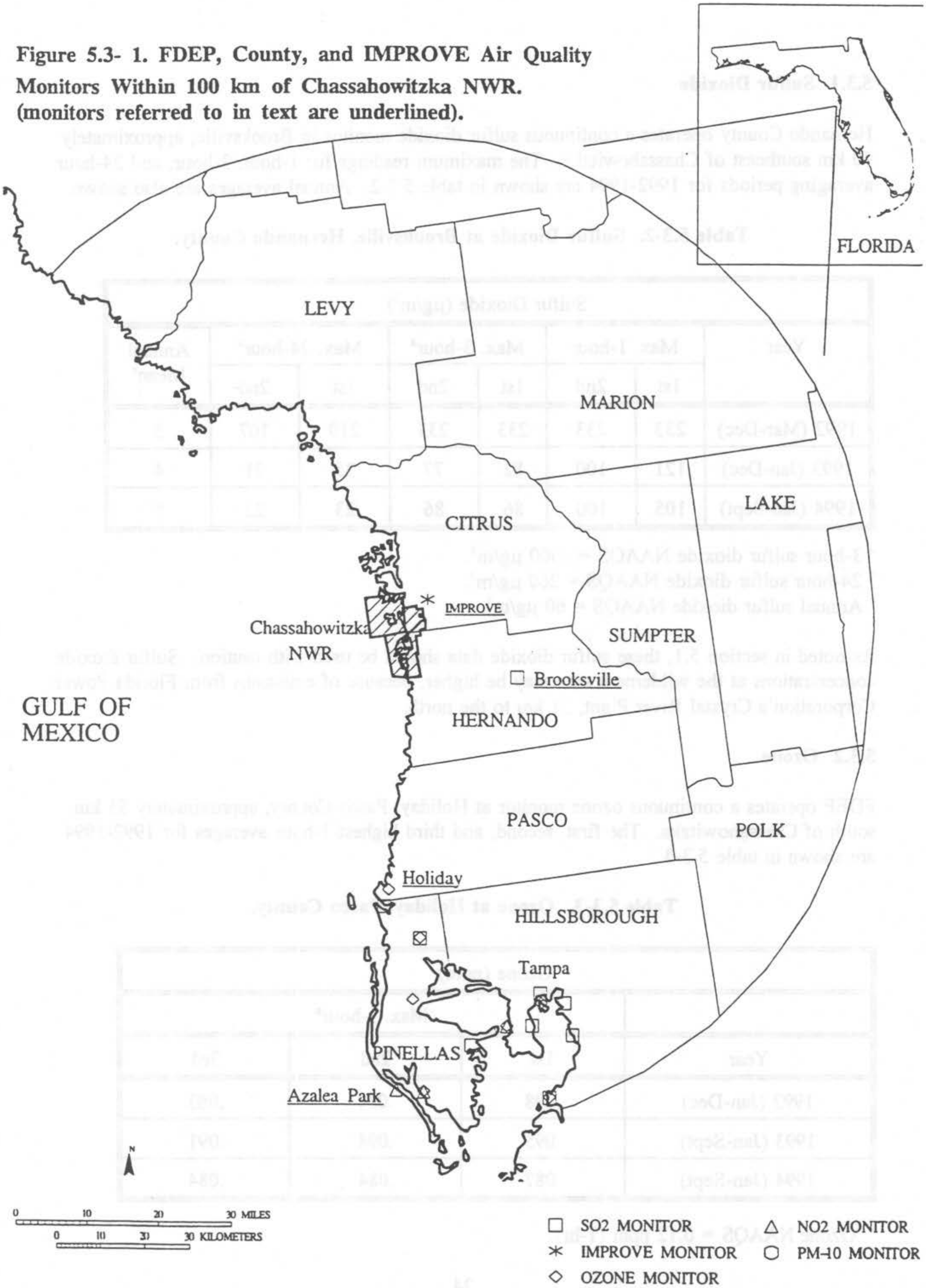
NATIONAL AMBIENT AIR QUALITY STANDARDS μg/m³[ppm]			
POLLUTANT	AVERAGING TIME	PRIMARY[a]	SECONDARY[b]
SULFUR DIOXIDE	Annual Arithmetic Mean	80 [0.03]	none
	24-hr [c]	365 [0.14]	none
	3-hr [c]	none	1300 [0.5]
PM-10	Annual Arithmetic Mean	50	same
	24-hr	150	same
CARBON MONOXIDE	8-hr [c]	10000 [9]	same
	1-hr [c]	40000 [35]	same
OZONE	1-hr [c]	235 [0.12]	same
NITROGEN DIOXIDE	Annual Arithmetic Mean	100 [0.05]	same
LEAD	Calendar Qtr.	1.5	same

[a] Primary standards were established to protect human health.
[b] Secondary standards were established to protect welfare (e.g., the environment).
[c] Maximum concentration not to be exceeded more than once a year.

An area (e.g., county) having air quality better than the NAAQS for a particular pollutant is designated an attainment area for that pollutant. An area having air quality worse than the NAAQS is designated a nonattainment area, requiring the state to develop a plan to bring the area into compliance. Pinellas and Hillsborough counties, 50 km south of Chassahowitzka, are designated nonattainment for ozone (sect. 5.3.2). In addition, a small part of Hillsborough County is designated nonattainment for lead. All other areas within 200 km of Chassahowitzka are in attainment of the NAAQS.

Figure 5.3-1 shows the location of FDEP, county, and IMPROVE monitors within 100 km of Chassahowitzka. The following sections summarize data from several of these monitors.

Figure 5.3- 1. FDEP, County, and IMPROVE Air Quality Monitors Within 100 km of Chassahowitzka NWR. (monitors referred to in text are underlined).



5.3.1 Sulfur Dioxide

Hernando County operates a continuous sulfur dioxide monitor in Brooksville, approximately 40 km southeast of Chassahowitzka. The maximum readings for 1-hour, 3-hour, and 24-hour averaging periods for 1992-1994 are shown in table 5.3-2. Annual averages are also shown.

Table 5.3-2. Sulfur Dioxide at Brooksville, Hernando County.

Sulfur Dioxide (µg/m³)							
Year	Max. 1-hour		Max. 3-hour[a]		Max. 24-hour[b]		Annual Mean[c]
	1st	2nd	1st	2nd	1st	2nd	
1992 (Mar-Dec)	233	233	233	233	219	107	5
1993 (Jan-Dec)	121	100	82	77	25	21	4
1994 (Jan-Sept)	105	100	86	86	23	23	5

[a] 3-hour sulfur dioxide NAAQS = 1300 µg/m³.
[b] 24-hour sulfur dioxide NAAQS = 260 µg/m³.
[c] Annual sulfur dioxide NAAQS = 60 µg/m³.

As noted in section 5.1, these sulfur dioxide data should be used with caution. Sulfur dioxide concentrations at the wilderness area may be higher, because of emissions from Florida Power Corporation's Crystal River Plant, 21 km to the north.

5.3.2 Ozone

FDEP operates a continuous ozone monitor at Holiday, Pasco County, approximately 53 km south of Chassahowitzka. The first, second, and third highest 1-hour averages for 1992-1994 are shown in table 5.3-3.

Table 5.3-3. Ozone at Holiday, Pasco County.

Ozone (ppm)			
	Max. 1-hour[a]		
Year	1st	2nd	3rd
1992 (Jan-Dec)	.098	.084	.083
1993 (Jan-Sept)	.095	.094	.091
1994 (Jan-Sept)	.087	.084	.084

[a] Ozone NAAQS = 0.12 ppm (1-hr).

Pinellas and Hillsborough counties, located 50 km south of Chassahowitzka, are designated nonattainment for ozone. However, neither county has recorded an ozone NAAQS violation since 1990. Both counties are applying for redesignation as attainment areas.

5.3.3 Nitrogen Dioxide

FDEP operates a continuous nitrogen dioxide monitor in Azalea Park, St. Petersburg, Pinellas County, approximately 90 km south of Chassahowitzka. Table 5.3-4 shows the maximum 1-hr values and the annual means from 1992 to 1994.

Table 5.3-4. Nitrogen Dioxide at Azalea Park, Pinellas County.

Nitrogen Dioxide (ppm)		
Year	Max. 1-hr	Annual Mean[a]
1992	.067	.012
1993	.065	.012
1994 (Jan-Sept)	.056	.010

[a] Nitrogen dioxide NAAQS = 0.05 ppm (annual mean).

Because of the considerable distance of this monitor from Chassahowitzka, it cannot be used to represent conditions at the wilderness area. However, it provides information on air quality in Tampa, a large area-source of emissions to Chassahowitzka. Nitrogen dioxide concentrations in Chassahowitzka are probably significantly influenced by Florida Power Corporation's Crystal River Plant, 21 km to the north, which is the largest nitrogen oxides emitter in Florida.

5.4. ATMOSPHERIC DEPOSITION CHEMISTRY IN CENTRAL AND NORTHERN FLORIDA

The following sections summarize information on the chemistry of atmospheric deposition in northern and central Florida and discuss how this information can be used to describe atmospheric deposition at Chassahowitzka.

5.4.1 Wet Deposition

Wet deposition flux (loading) of a pollutant is expressed in kilograms per hectare per year (kg/ha/yr). It is calculated by multiplying the pollutant's concentration in wet deposition by total measured wet deposition. Wet deposition is not monitored at Chassahowitzka; however, wet deposition data is available from other monitoring efforts in northern and central Florida .

Wet deposition throughout the state has been studied by the Florida Electric Power Coordinating Group (FCG) and the National Atmospheric Deposition Program/National Trends Network (NADP/NTN).

There are five NADP/NTN sites in Florida, including four in northern and central Florida and one in southern Florida. The four sites in northern and central Florida (fig. 5.4-1) were selected as being most likely to represent conditions at Chassahowitzka. Monitoring by both FCG and NADP/NTN has demonstrated certain trends. For instance, wet deposition is approximately 2 to 4 times more acidic in northern Florida than in southern Florida. In addition, sulfate and nitrate deposition is greater in northern Florida than in southern Florida.

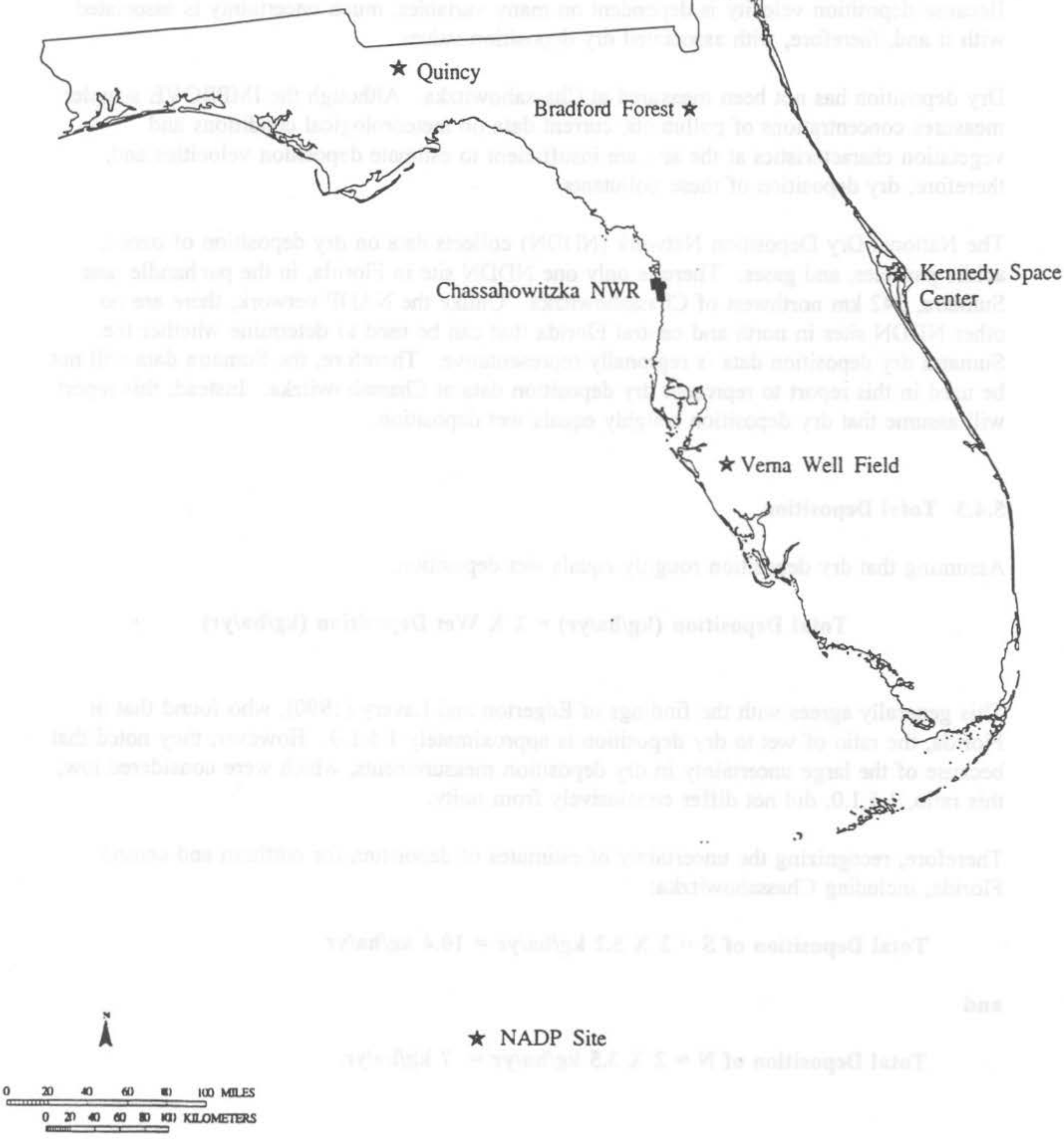
Data from the four NADP/NTN sites in northern and central Florida are summarized in table 5.4-1. Parameters include precipitation, sulfate (SO_4), total sulfur (S) from SO_4, nitrate (NO_3), ammonia (NH_4), total nitrogen (N) from NO_3 and NH_4, and pH (measured in the field).

Table 5.4-1. NADP/NTN Wet Precipitation and Deposition Data, Florida, 1991-1993.

SITE	ANNUAL PRECIP (cm)	WET DEPOSITION (kg/ha/yr)					pH (field)
		SO_4	TOTAL S	NO_3	NH_4	TOTAL N	
Bradford	144	16.6	5.5	11.0	1.4	3.6	4.6
Kennedy	117	16.1	5.4	9.2	1.2	3.0	4.6
Quincy	164	15.1	5.0	9.7	1.4	3.2	4.7
Verna	152	14.7	4.9	11.4	1.9	4.1	4.7
MEAN	144	15.6	5.2	10.3	1.5	3.5	4.7

The data indicate that wet deposition chemistry is similar over a widespread region of northern and central Florida. Wet deposition of total S is 5 to 6 kg/ha/yr; wet deposition of total N is 3 to 4 kg/ha/yr. Wet deposition pH is 4.6 to 4.7 and therefore considered acidic ("natural" deposition has a pH of 5.2 to 6.0).

Figure 5.4- 1. NADP sites in northern and central Florida.



5.4.2 Dry Deposition

Dry deposition of a pollutant is also usually expressed in kilograms per hectare per year. It is calculated by multiplying the ambient concentration (ug/m^3) by the deposition velocity (cm/sec) of that pollutant. Deposition velocity is dependent upon many site-specific variables, including meteorological conditions (e.g., wind speed, temperature, solar radiation, relative humidity, precipitation, surface wetness) and vegetation characteristics (e.g., stomatal resistance, light response coefficient, plant response temperature, vertical profile of biomass). Because deposition velocity is dependent on many variables, much uncertainty is associated with it and, therefore, with associated dry deposition values.

Dry deposition has not been measured at Chassahowitzka. Although the IMPROVE sampler measures concentrations of pollutants, current data on meteorological conditions and vegetation characteristics at the site are insufficient to estimate deposition velocities and, therefore, dry deposition of these pollutants.

The National Dry Deposition Network (NDDN) collects data on dry deposition of ozone, acidic particles, and gases. There is only one NDDN site in Florida, in the panhandle near Sumatra, 242 km northwest of Chassahowitzka. Unlike the NADP network, there are no other NDDN sites in north and central Florida that can be used to determine whether the Sumatra dry deposition data is regionally representative. Therefore, the Sumatra data will not be used in this report to represent dry deposition data at Chassahowitzka. Instead, this report will assume that dry deposition roughly equals wet deposition.

5.4.3 Total Deposition

Assuming that dry deposition roughly equals wet deposition,

Total Deposition (kg/ha/yr) = 2 X Wet Deposition (kg/ha/yr)

This generally agrees with the findings of Edgerton and Lavery (1990), who found that in Florida, the ratio of wet to dry deposition is approximately 1.5:1.0. However, they noted that because of the large uncertainty in dry deposition measurements, which were considered low, this ratio, 1.5:1.0, did not differ conclusively from unity.

Therefore, recognizing the uncertainty of estimates of deposition for northern and central Florida, including Chassahowitzka:

Total Deposition of S = 2 X 5.2 kg/ha/yr = 10.4 kg/ha/yr

and

Total Deposition of N = 2 X 3.5 kg/ha/yr = 7 kg/ha/yr.

6.0 AIR QUALITY RELATED VALUES AT CHASSAHOWITZKA; DOCUMENTED AND POTENTIAL EFFECTS FROM AIR POLLUTANTS

6.1 INTRODUCTION

Air quality related values (AQRVs) are resources that may be affected by air quality. The discussion below focuses on the documented and potential effects of air pollution on the following AQRVs at Chassahowitzka: vegetation, wildlife, soils, water quality, and visibility at Chassahowitzka. Cultural and archeological resources, which are also AQRVs, are not in the scope of this report.

Effects from air pollution to visibility in Chassahowitzka has been documented by on-site monitoring, as described in sect. 6.6. Other AQRVs in Chassahowitzka, including vegetation, wildlife, soils, and water quality, have not been evaluated for air pollution effects. Therefore, potential effects to these resources were identified by comparing information on Chassahowitzka resources with the scientific literature on air pollution effects.

6.2 VEGETATION

6.2.1 Vascular Plants

A list of vascular plant species is maintained by Chassahowitzka NWR staff. Additional species were identified by Dr. Wade Bryant during his field reconnaissance in 1994. The comprehensive list of 396 vascular plant species is given in appendix C-1. The great variety of vascular plant species is caused by the sharp change of habitat types in Chassahowitzka, from the upland and freshwater systems in the east to the marine systems in the west.

6.2.2 Non-Vascular Plants (Lichens)

Some species of lichens are sensitive to air pollutants, particularly sulfur dioxide. Therefore, this report attempted to identify lichen species at Chassahowitzka and determine their sensitivity to air pollutants. A survey of the area established that the most diverse assemblage of lichens was found in the freshwater swamps, particularly the areas bordering the creeks that flow into the Chassahowitzka River. In these areas the tree canopy is somewhat open, providing considerable light penetration and moisture, which are conducive to the growth of foliose and fruticose lichens. Foliose and fruticose lichens were rare in areas of closed canopy.

Because of the abundance of downed trees and limbs, Dr. Wade Bryant was able to collect lichen species in the canopy. Most of the lichens within 5 feet of the ground showed signs of stress (e.g., chlorosis), probably because they were submerged by salt water during the "storm of the century" in March 1993. Trees that tend to shed bark easily (e.g., Sabal palmetto, Pinus taeda) supported fewer numbers and species of lichens than trees that provide a stable substrate (e.g., Carpinus caroliniana, Magnolia grandiflora, Ilex cassine, Tilia floridana, Celtis laevigata, Acer rubrum, Quercus virginiana). Few lichens were found in estuarine environments, probably because of the frequency of inundation by salt water coupled with the effects of salt spray. No lichens were found on exposed limestone.

Lichens were collected by removing the outer layer of bark from trees or by peeling lichens from their substrate. Field notations on the relative health and diversity of lichen species were made. Dr. Dana Griffin, curator of the Bryophyte and Lichen Herbarium, University of Florida, identified lichen species in the laboratory. The complete list is in appendix C-2. Voucher specimens for all species have been deposited in the Lichen Herbarium at the Florida Museum of Natural History in Gainesville, Florida.

6.2.3 Sensitive Plant Species

After the vegetation list was compiled, the scientific literature was searched to determine which, if any, Chassahowitzka species have been identified as sensitive to air pollutants. The search used bibliographic databases, including Agricola (1984-1994), Biological Abstracts (1986 - 1994), and the National Park Service BIOLEFF. In addition, the lichen species list was cross-referenced with the list of air pollution-sensitive lichens compiled by Dr. Clifford Wetmore (Wetmore 1983).

It should be noted that most research on air pollutant effects on vegetation has been done on species of commercial interest, i.e., crops and timber. In addition, there is a substantial body of research on wildland plants, primarily upland species. Little research has been conducted on the coastal wetland species typical of Chassahowitzka. Therefore, although this report identifies several pollution-sensitive species, many more may exist at Chassahowitzka.

The gaseous pollutants that can injure vegetation at ambient concentrations (i.e., concentrations likely to occur at Chassahowitzka) include ozone and sulfur dioxide. The particulate pollutants that may affect plants at ambient loadings include nitrogen compounds (e.g., nitrates, ammonia). Other gases (e.g., nitrogen oxides) and particles (e.g., fluoride) occur in Chassahowitzka in concentrations believed to be too low to injure vegetation.

6.2.4 Ozone Effects

Ambient levels of ozone in the lower atmosphere are known to injure a large variety of plant species, including both crop and wildland species. Short-term effects include foliar injury and altered leaf metabolism, whereas longer-term changes may include alteration of stand structure, alteration of plant community composition, reduced productivity, and genetic selection toward pollution-tolerant individuals and clones.

A literature search identified vascular plant species at Chassahowitzka (see table 6.2-1) known to be sensitive at ozone concentrations comparable with those found near the wilderness area. Documented effects to these species from ozone include visible injury (including leaf stipple and chlorosis) and decreased photosynthesis and biomass.

Table 6.2-1. Vascular Vegetation Sensitive to Ambient Concentrations of Ozone at Chassahowitzka.

LATIN NAME	COMMON NAME	O3 CONCENTRATION	DURATION	EFFECT	REF
Alnus serrulata	Hazel alder	0.12 ppm	27 d (164 h)	Decrease in photosynthetic rate at 0.12 ppm	DuBay
Lepidium virginicum	Virginia pepperweed	0.05 - 0.07; 0.15;0.30 ppm	3h/d x 5d/wk	Significant reduction in total plant weight even at 0.05-0.07 ppm	Harward
Liquidambar styraciflua	Sweetgum	0.10 ppm	6 h/d for 28 d	27% reduction in height growth; 50% leaf area affected by stipple	Kress
Liquidambar styraciflua	Sweetgum	0.05; 0.10; 0.15 ppm	28 d	8%; 19%; 29% reduction in biomass	Kress
Pinus elliotti	Slash pine	0.05; 0.15 ppm	5 - 18 wk	Photosynthesis depressed, respiration stimulated	Barnes
Pinus elliotti	Slash pine	0.08 ppm mean (0.094 peak); 0.10 ppm mean (0.126 peak)	7 h/d for 112 d	Slight visible injury; all growth parameters decreased significantly w/time and conc.; root growth most impacted	Hogsett
Pinus taeda	Loblolly pine	0.050; 0.150 ppm	5 - 18 wk	Photosynthesis depressed, respiration stimulated	Barnes
Prunus serotina	Black cherry	0.040; 0.080 ppm	8 wk	Visible injury (at 0.080 ppm 61% of leaf injured); decreased biomass	Davis
Toxicodendron radicans	Poison-ivy	ambient	episodes	Early senescence and premature onset of fall coloration	Chevone

In addition to these six species, recent evidence suggests that Spartina alterniflora (smooth cordgrass), a dominant saltmarsh species in Chassahowitzka, is affected by ozone. When fumigated in the laboratory at 0.10 ppm, S. alterniflora exhibited progressively worsening foliar injury (i.e., chlorosis) over time. In addition, the shoot-to-root ratio was significantly higher for ozone-treated plants (Brondyke 1995). The long-term effects of these responses are uncertain.

The literature search did not identify any non-vascular plants at Chassahowitzka as sensitive to ozone at ambient levels.

6.2.5 Sulfur Dioxide Effects

Several lichen species at Chassahowitzka were identified as sensitive to SO_2. Because of the number, proximity, and size of SO_2 sources in the area, these lichen species are at risk. Sensitive lichens at Chassahowitzka and the substrates on which they were found are listed in table 6.2-2.

The identification of these species as sensitive was adapted from the classification system developed by Dr. Clifford Wetmore (Wetmore 1983). Dr. Wetmore classified "sensitive" lichens as those absent when the annual average concentration of SO_2 is greater than 50 ug/m^3; "intermediate" lichens are those present only at SO_2 concentrations up to 100 ug/m^3; and "tolerant" lichens are those present at SO_2 concentrations over 100 ug/m^3 (Wetmore 1983). The fact that sensitive lichens are absent at SO_2 concentrations above 50 ug/m^3 suggests that at concentrations below 50 ug/m^3, sensitive lichens experience effects (e.g., reduced growth, productivity, and reproduction) that can lead to their deaths.

Besides injury from long-term, relatively low-concentration SO_2 exposure, lichens, like vascular plants, are also affected by short-term, higher concentration exposures. Both types of exposures are possible at Chassahowitzka.

No vascular plant species at Chassahowitzka were identified as sensitive to ambient concentrations of sulfur dioxide (SO_2).

Table 6.2-2. "Sensitive" Lichen Species at Chassahowitzka (according to Wetmore 1983) and Associated Substrates.

Lichen	Substrate(s)
Parmotrema reticulatum (formerly Parmelia reticulata)	Acer rubrum Quercus virginiana
Ramalina americana	unidentified dead branch Quercus virginiana
Usnea strigosa (formerly Usnea florida)	Quercus virginiana downed twig Juniperus silicicola unidentified dead branch

6.2.6 Nitrogen Effects

The third atmospheric pollutant of concern to plants, both aquatic and terrestrial, at Chassahowitzka WA is nitrogen. Nitrogen enters ecosystems through groundwater, surface run-off, and the atmosphere. For example, nitrogen oxides and ammonia are released into the air by various emissions sources (e.g., power plants, industries, fertilizer producers, automobiles) and deposited on land or water as nitrate-nitrogen or ammonium-nitrogen.

The relative contributions of groundwater, surface run-off, and the atmosphere to nitrogen loading varies with the area. For example, as much as 67 percent of the total nitrogen loading into Tampa Bay (70 km south of Chassahowitzka) originates from atmospheric deposition, either directly into the bay or onto the watershed (Tampa Bay National Estuary Program 1994); whereas, in other areas (e.g., areas of excessive nitrogen-fertilizer use or faulty septic systems), surface run-off and groundwater contribute most of the added nitrogen.

In aquatic ecosystems, particularly coastal waters that are generally nitrogen-limited, nitrogen additions can result in fertilization and potential disruption of normal nutrient cycling. For example, in Tampa Bay, excess nitrogen loadings have stimulated growth of algae, causing algal "blooms." These algal blooms have outcompeted seagrasses for nutrients and light, causing their decline. In addition, when the blooms die, their decomposition depletes dissolved oxygen in the water. Both the loss of seagrasses and decrease of oxygen have reduced the quality of the habitat for many organisms (e.g., fish and invertebrates), causing a decline in species diversity. This process, characterized by excessive productivity, decreased species diversity, and increased instability, is known as eutrophication.

Nitrogen loadings from atmospheric deposition are relatively uniform across central and northern Florida (tab. 5.4-1). Therefore, nitrogen fertilization and eutrophication, similar to that in Tampa Bay, may be occurring in Chassahowitzka and Homosassa bays.

Nitrogen also fertilizes terrestrial ecosystems. Plants that are able to rapidly assimilate nitrogen will outcompete other species, causing changes in species composition and abundance. For instance, a forest in the Nikiski region of Alaska experienced fertilization and changes in plant composition because of high loadings of atmospheric nitrogen from an adjacent industrial complex. As a result, the local forest ecosystem was being gradually converted to a grass prairie (Sullivan 1990). The effect of excess nitrogen deposition on Chassahowitzka is, at present, unknown.

6.3 WILDLIFE

Appendix D contains lists of species of mammals, reptiles, amphibians, and birds found at Chassahowitzka, as well as a list of the threatened and endangered species present. This section evaluates the potential for air pollution effects on the wildlife of the area.

Although there is little information on the effect of gaseous pollutants on wildlife, laboratory test animals have experienced reduced respiratory function at ozone levels below the National Ambient Air Quality Standard of 0.12 ppm (1-hour average). Similar effects may occur in wildlife.

Fluoride effects on wildlife have been well documented. Fluoride is toxic to animals (e.g., white-tailed deer) grazing on vegetation upon which fluoride has been deposited. Malformation and pitting of bones and teeth (fluorosis) of grazing animals has been observed and documented. Although symptoms of fluorosis have not been observed at Chassahowitzka, the presence of nearby fluoride emission sources (power plants and phosphate fertilizer plants) is cause for concern.

The effects of heavy metals and toxic organic compounds on wildlife, including neurological and reproductive effects, are also well documented. Adverse effects on wildlife from these pollutants have not been identified at Chassahowitzka, but the proximity of numerous sources (power plants, industrial sources, agriculture, and urban areas) suggests that contamination is possible.

Mercury, a heavy metal emitted by power plants, waste incinerators, and certain industries, is of particular concern. Because of its volatility, mercury can be carried long distances in the atmosphere and deposited far from its source. Even remote, seemingly pristine lakes have been found contaminated with mercury from the atmosphere. Mercury bioaccumulates in the aquatic food chain, particularly in fish. Animals (including humans) that eat mercury-contaminated fish, in turn, accumulate the mercury, which can cause damage to the nervous system and birth defects.

In Florida, human-caused emissions (e.g., combustion of municipal solid waste, fossil fuel, and medical waste; paint application; electrical apparatus disposal) account for 60 to 65 percent of the total mercury emissions. Natural sources (e.g., soil degassing) account for 35 to 40 percent of the total. Approximately half of the many lakes and rivers in Florida contain fish with elevated mercury levels (more than 0.5 parts per million). Therefore, the Florida Department of Health and Rehabilitative Services has issued health advisories for consumption of certain fish species from many areas. The Tampa Bay area (Hillsborough and Pinellas counties) is the largest source of mercury emissions in Florida; Citrus County is also a large source of mercury emissions (Florida Department of Environmental Regulation 1992). There is an advisory to limit consumption of largemouth bass (no more than one meal per week) taken from the Crystal River, 10 km north of Chassahowitzka. In addition, there are advisories for the Suwannee and Waccasassa rivers north of Crystal River, as well as the rivers in the Tampa Bay area. And although the fish of the Chassahowitzka and Homosassa rivers have not been tested, they, too, are probably contaminated to some degree by mercury.

Mercury has been recognized as a problem primarily in freshwater systems. However, in October, 1995, the Florida Department of Health and Rehabilitative Services issued a health advisory urging limitations on consumption of several species of fish from portions of Florida's coastal waters, including Tampa Bay. Evidence is mounting that mercury is also a growing problem in marine environments.

In addition to the direct effects of air pollutants on wildlife mentioned above, there is a potential for indirect and more subtle effects on wildlife. For example, air pollutants may affect the wildlife habitat or food supply by injuring some vegetation species and favoring others. As discussed in sect. 6.2.6, nitrogen fertilization of Chassahowitzka waters would cause algal blooms and subsequent reduction of the seagrass beds that provide habitat and food to many species, including the endangered West Indian manatee and many fish and invertebrates. Bird species dependent on these small fish and invertebrates would, in turn, be affected.

6.4 SOILS

Soil maps of Citrus and Hernando counties (Hyde et al. 1977; Pilney et. al 1988) were used to determine soil types found within the Chassahowitzka Wilderness Area. Nine soil complexes are present: Aripeka fine sand, Aripeka-Okeelanta-Lauderhill, Hallendale-Rock outcrop, Homosassa mucky fine sandy loam, Lacooche, Okeelanta mucks, Okeelanta-Lauderdale-Terra Ceia mucks, Rock outcrop-Homosassa-Lacoochee, and Weekiwachee-Durbin mucks. A description of each complex is found in appendix E.

The soils at Chassahowitzka formed in a coastal environment. They are inundated by tidal waters: on a daily basis for some soils, during storm events for others. The tidal influence may overshadow any atmospheric influence (i.e., deposition of sulfur) in regularly flooded soils. However, the freshwater mucks Terra Ceia, Okeelanta, and Lauderdale may be at risk from atmospheric sulfur deposition. These soils, found in the freshwater swamps along the eastern border of the wilderness area, support a rich freshwater plant community. Increased sulfate deposition on these wetland soils could stimulate sulfate reduction, with the subsequent production of hydrogen sulfide ("rotten egg") gas. This gas is toxic to many freshwater plants not adapted to living in estuarine environments.

A 1994 field assessment performed by Dr. Wade Bryant indicated that although hydrogen sulfide was present in all the soils regularly inundated by the tide, it was not present in the freshwater mucks. However, it is uncertain what effect long-term deposition of sulfate would have on these soils.

6.5 WATER QUALITY

The dominant surface water influences on Chassahowitzka are two first-magnitude freshwater springs: Homosassa to the north and Chassahowitzka to the east. Each of these springs is at the headwaters of a river of the same name. According to Rosenau et al. (1977), the average discharges for Homosassa and Chassahowitzka springs are 4.96 and 3.94 cubic meters per second, respectively. Selected physical and chemical parameters for both springs are listed in table 6.5-1.

Table 6.5-1. Chemical and Physical Conditions of Chassahowitzka and Homosassa Springs (Rosenau et al. 1977).

PARAMETER	CHASSAHOWITZKA	HOMOSASSA
Calcium (mg/kg)[a]	46-55	48-65
Magnesium (mg/kg)	11-29	48-86
Sodium (mg/kg)	29-180	340-600
Bicarbonate (mg/kg)	160-180	130-140
Chloride (mg/kg)	53-320	640-1100
Sulfate (mg/kg)	13-56	84-150
Hardness (mg/kg $CaCO_3$[b])	160-260	320-480
pH	7.5-8.2	6.9-8.2
Specific Conductance (uS/cm at 25°C[c])	470-1370	2370-3740
Color (Pt-Co units[d])	8-10	0-10
Temperature (°C)	22.2-26.0	23.5

[a] milligrams per kilogram.
[b] milligrams per kilogram as Calcium carbonate.
[c] microsiemens per centimeter at 25 degrees Celsius.
[d] Platinum-Cobalt units.

Air pollutants can affect water quality in several ways. Common effects include acidification and eutrophication. Acidification occurs when acidic deposition (wet or dry) falls on a body of water with low acid-neutralizing capacity ("buffering" capacity), decreasing the pH of the water. Water with low acid-neutralizing capacity contains few carbonates and bicarbonates, compounds that neutralize acids.

Data from NADP sites in Florida indicate that rainfall in the area is acidic, with an average pH of approximately 4.7 (table 5.4-1). Normal rainfall has a pH of approximately 5.5.

However, at Chassahowitzka, both the fresh water and salt water are well-buffered. The fresh water in the area lies on limestone (calcium carbonate), whereas the salt water is buffered with a variety of ions. Therefore, acidification is not likely in Chassahowitzka waters even though the area receives acidic deposition.

Eutrophication caused by atmospheric deposition of nitrogen may, however, be occurring at Chassahowitzka (sect. 6.2.6). The subsequent loss of seagrass beds may result in habitat unfavorable for many species of fish, birds, and other wildlife now found in Chassahowitzka.

6.6 VISIBILITY

Visibility is an air quality related value of Chassahowitzka. In the 1977 amendments to the Clean Air Act, Congress established as a national goal the prevention of any future and the remedying of any existing impairment in visibility resulting from anthropogenic air pollution in Class I areas. Visibility involves not only how far one can see (visual range), but also how well scenic landscape features can be seen and appreciated. That is, image contrast, color, and textures are also important.

Particles and gas molecules are responsible for visibility impairment. Some of these come from natural sources such as forest fires; however, anthropogenic emissions, especially sulfates and organic carbon, are the largest contributors to reduced visibility. Sulfates are formed from sulfur dioxide emissions from fossil fuel-fired powerplants, smelting, oil extraction, and refining activities. Carbon is emitted directly from prescribed burns, agricultural burning, and diesel engines. Other contributors to visibility impairment include organic compounds, nitrates, and dust.

6.6.1 IMPROVE Program

Section 5.2 describes visibility monitoring at Chassahowitzka. The IMPROVE sampler collects the fine particles in the air that contribute to visibility impairment at the refuge and wilderness area. The data from the sampler indicate that in Chassahowitzka, as in most of the eastern U.S., fine particle concentrations are high and, therefore, visibility is affected. This agrees with the conclusion of the National Research Council, who found that in most of the East the average visual range is less than 30 km, or about one-fifth of the natural visual range, because of anthropogenic air pollution (National Research Council 1993).

The following section describes visibility measurements that can be derived from the IMPROVE data.

6.6.2 Standard Visual Range and the Deciview Index

Visual range is the distance at which an object can be seen against the horizon. Standard Visual Range (SVR) is an estimate of visual range standardized to certain atmospheric conditions to compare visibility at different sites. However, visual range and SVR are not linear with respect to perceived changes in visibility. For example, in a clean atmosphere with a visual range of 180 km, a 5-km decrease in visual range would be imperceptible to most observers. On the other hand, in a polluted atmosphere with a visual range of just 15 km, a 5-km decrease in visual range would be very noticeable. This limitation of the SVR can be circumvented by using the recently developed haziness index (Pitchford and Malm, 1994). This measurement system uses a deciview (dv) scale, which is linear with respect to perceived changes in visibility.

Haziness (in dv) = 10 ln (391 km/SVR in km),

where 391 km is the theoretical upper limit of visibility.

The deciview (dv) scale, near zero for a pristine atmosphere, increases with visibility impairment. A 1-dv change represents a perceptible change in visibility independent of baseline conditions. Using the previous example, a decrease in visual range from 180 km to 175 km represents a 0.2 dv increase, which would generally be imperceptible. However, a decrease in visual range from 15 km to 10 km represents a 4.1 dv increase and would be very noticeable.

Both the SVR and the dv scale can be used to quantify improvement or degradation of visibility. Estimates of the SVR and the dv value for Chassahowitzka were derived from the IMPROVE particle data from April 1993 to May 1994. The SVR and the dv value were calculated for (1) the 10 percent of the sampling period having the best visibility, (2) the median visibility condition, and (3) the 90 percent of the sampling period having the worst visibility. These data are shown in table 6.6-1.

Table 6.6-1. Standard Visual Range and Deciview Value at Chassahowitzka NWR.

Visibility Measure	Best 10% Days	Median	Worst 90% Days
Standard Visual Range (SVR)	65 km	40 km	26 km
Deciview Index (dv)	17.9	22.8	27.1

FWS policy is to protect those days having the best visibility: in this case, the 10 percent of the sampling period having a SVR of 65 km or greater and a dv index of 17.9 or less. Therefore, major sources of air pollution proposing to locate or expand near Chassahowitzka must demonstrate that they will not cause a perceptible decrease in visibility on these days; i.e., they will not cause a 1-dv increase.

7.0 RECOMMENDATIONS

Additional information is needed to better understand air quality and its effects on resources in Chassahowitzka. The following needs were identified as a result of this report:

Expanded on-site monitoring of pollutant concentrations and loadings in Chassahowitzka. The IMPROVE fine-particle sampler measures concentrations of air pollutant particles in Chassahowitzka, but does not measure concentrations of gaseous pollutants or loadings (i.e., deposition) of pollutants. A wet deposition sampler installed in September 1996 will facilitate estimates of pollutant loadings from wet deposition. However, samplers are also needed to measure gaseous pollutant concentrations and to estimate pollutant loadings from dry deposition.

Direct measurements of light scattering to assess visibility conditions. Estimates of light scattering (and the associated visibility impairment) for Chassahowitzka are currently derived from the IMPROVE fine-particle data. These estimates are based on certain assumptions regarding relative humidity and the light-scattering efficiencies of particles. Errors in these assumptions may result in errors in light-scattering estimates. Direct measurement of light scattering by a nephelometer, on the other hand, does not require the use of such assumptions and would provide more accurate data.

Comprehensive Air Quality Related Values (AQRV) information. Additional information is needed regarding resources and, in particular, AQRVs in Chassahowitzka. Information on location, distribution, abundance, and condition of resources is needed to create a comprehensive inventory to support management decisions in Chassahowitzka.

The responses of these resources to air pollution also should be more thoroughly characterized. For instance, the pollutant concentrations and loadings at which resource effects occur should be determined before informed decisions can be made regarding resource protection.

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APPENDIX A
WETLAND TYPES IN CHASSAHOWITZKA NATIONAL WILDLIFE REFUGE
(Wetland types and nomenclature taken from National Wetland Inventory Maps.)

Estuarine Subtidal Aquatic Bed Rooted Vascular - Subtidal(E1AB3L)

Commonly called sea grass beds. Extensive areas of seagrasses found below the low-tide level. Vegetation may include Thalassia testudinum, Halodule wrightii, Halophila engelmannii, and Ruppia maritima.

Estuarine Subtidal Unconsolidated Bottom - Subtidal (E1UBL)

Due to the unconsolidated nature of the substrate most areas are not vegetated. If vegetated will have sparse sea grasses listed above.

Estuarine Intertidal Emergent Persistent Irregularly Flooded (E2EMIP)

Commonly called irregularly flooded salt marsh. This wetland type contains extensive areas dominated by Juncus roemarianus. At Chassahowitzka many small areas within this wetland type will be unvegetated or sparsely vegetated limestone outcroppings. Panicum virgatum and Distichlis spicata dominate smaller patches. Some young Avicennia nitida (germinans) were noted along some of the transects. These are the result of regrowth following recent freezes that damaged above ground portions of Avicennia germinans. Narrow bands of Spartina alterniflora form along drainage channels that are subject to tidal action. Soils are generally Homosassa, Durbin, or Weeikiwachee.

Estuarine Intertidal Shrub Scrub (E2SS)

Commonly called mangrove islands. Dominant vegetation is Avicennia germinans. Other salt marsh species are common but do not form extensive patches. Lacoochee is the dominant soil type with some Homosassa, Durbin, and Weeikiwachee.

Estuarine Intertidal Shrub Scrub Broad Leaved Evergreen (E2SS3U)

Same as E2SS but soils tend to be more unconsolidated.

Estuarine Intertidal Unconsolidated Shore Irregularly Exposed (E2USM)

Unvegetated to sparsely vegetated (less 40% cover) of unconsolidated sediment found on points of salt marshes and mangrove islands. Avicennia nitida (germinans) and Spartina alterniflora are common.

Estuarine Intertidal Forested Evergreen Irregularly Flooded
Estuarine Intertidal Forested Evergreen Seasonal Tidal

These two wetlands are commonly called coastal palm hammocks. These wetlands are located on elevated limestone in intertidal emergent marshes. The dominant canopy species are Sabal palmetto, Juniperus silicicola, and Quercus virginiana. Myrica cerifera and Juncus romerianus were are also common. These areas showed evidence of fire and contained debris deposited during the "storm of the century". Lacoochee and Aripeka soils are dominant.

Palustrine Emergent Persistent Semipermanent Tidal

Areas dominated by Cladium jamaicense located upslope from salt marshes. These areas maintain lower salinities due to less frequent flooding and increased freshwater inputs from creeks. A tidal signal is evident. Soils types include Hallendale, Lauderdale, Okeelanta, Weeikiwachee, and Terra Ceia.

Palustrine Forested Evergreen Seasonal Tidal/Palustrine Forested Evergreen Temporarily Flooded/Palustrine Forested Evergreen Seasonally Flooded

These three wetlands types are similar in vegetation composition and are commonly called coastal hammocks. They differ in the position in the landscape and flooding regime. The coastal hammocks at Chassahowitzka belong to the largest contiguous stand of hydric hammocks known as the Gulf Hammock (Vince et al 1989). Dominant canopy species are Sabal palmetto, Juniperus silicicola, and Quercus virginiana.

Palustrine Forested Broad Leaved Evergreen/Broad Leaved Deciduous Coastal Hardwood Hammocks

Most common inland wetland type found at Chassahowitzka. Deciduous trees dominate. This wetland type has the greatest diversity of plant species found at Chassahowitzka. Common species include: Sabal palmetto, Juniperus silicicola, Quercus virginiana, Magnolia virginiana, Tilia floridana, Pinus taeda, Ilex cassine, and Celtis sp. These areas are inundated by saline water only during very high tides associated with tropical depressions. The Aripeka-Okeelanta-Lauderdale or Okeelanta-Terra Ceia soil associations are found in this wetland type.

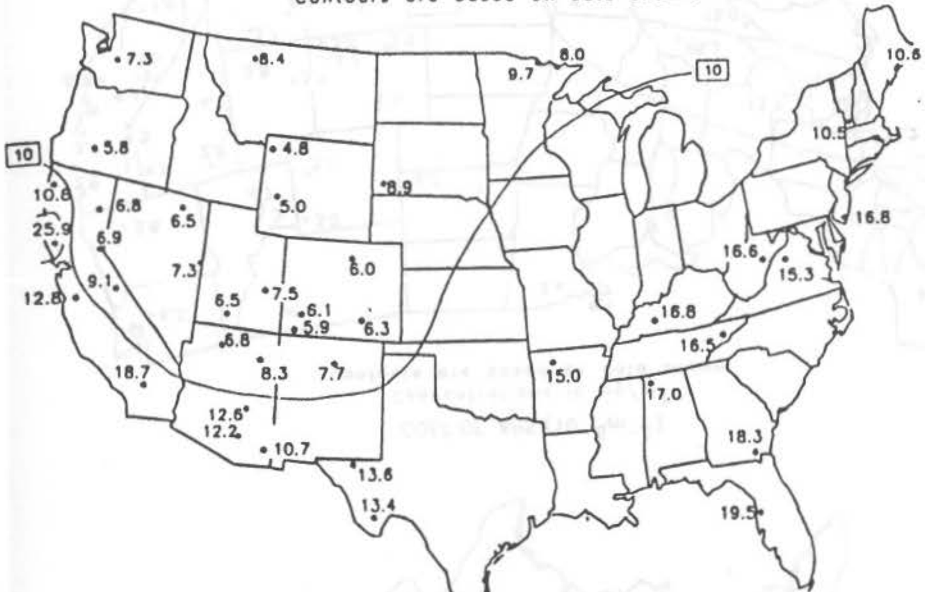
APPENDIX B

SEASONAL SUMMARIES OF IMPROVE FINE PARTICLE DATA

APRIL 1993 - MAY 1994

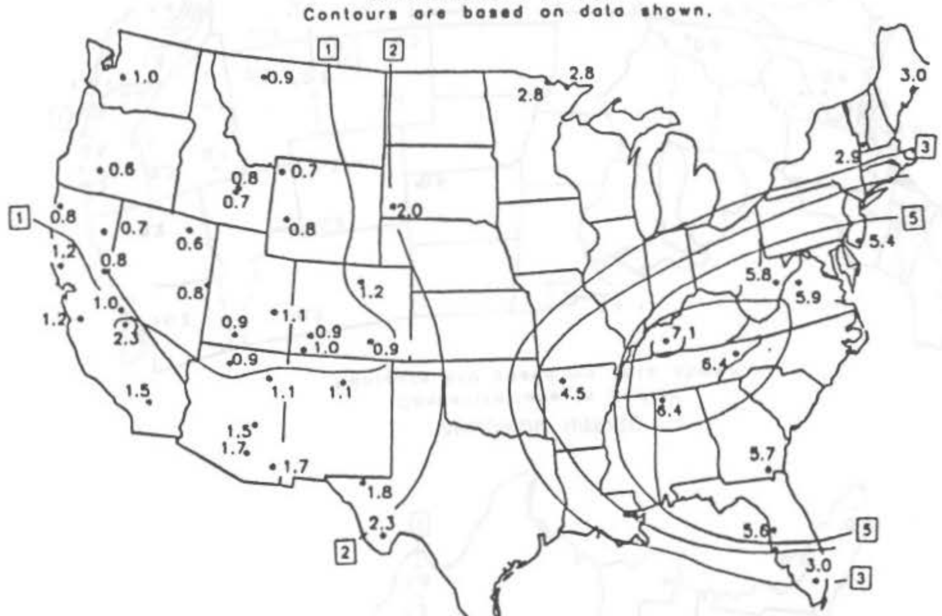
IMPROVE PARTICULATE NETWORK
MAR 1993–MAY 1993

TOTAL MASS
Concentrations in $\mu g/m^3$
Contours are based on data shown.

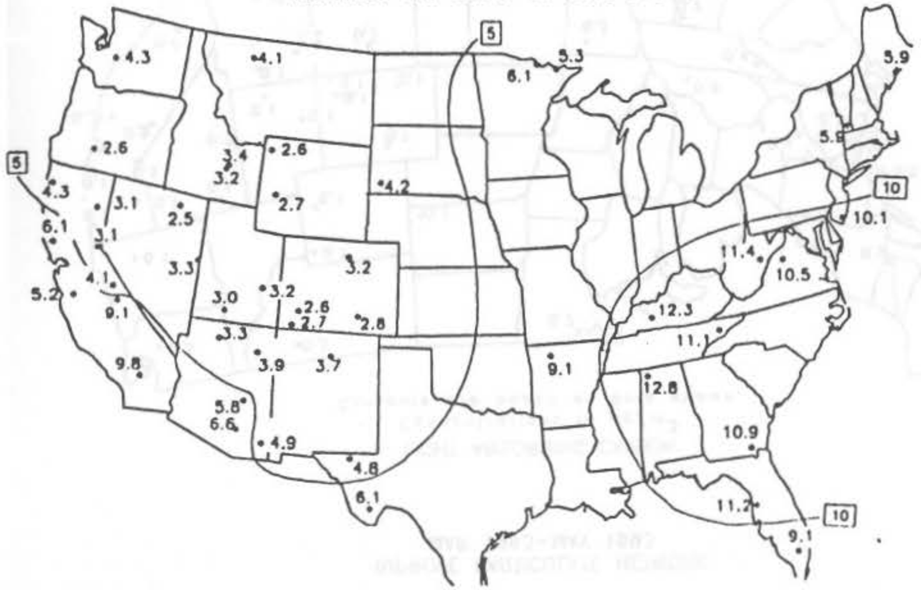


IMPROVE PARTICULATE NETWORK
MAR 1993–MAY 1993

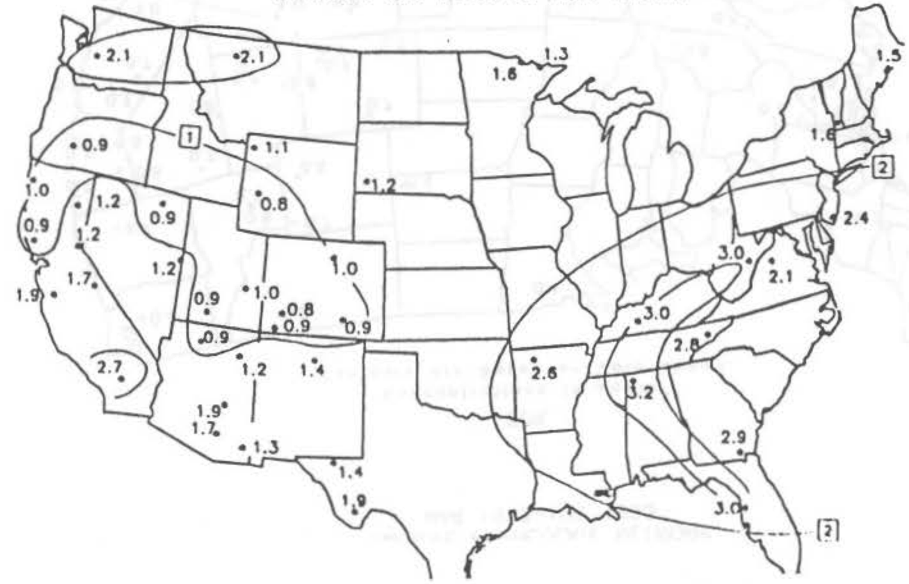
AMMONIUM SULFATE
Concentrations in $\mu g/m^3$
Contours are based on data shown.



FINE MASS
Concentrations in $\mu g/m^3$
Contours are based on data shown.

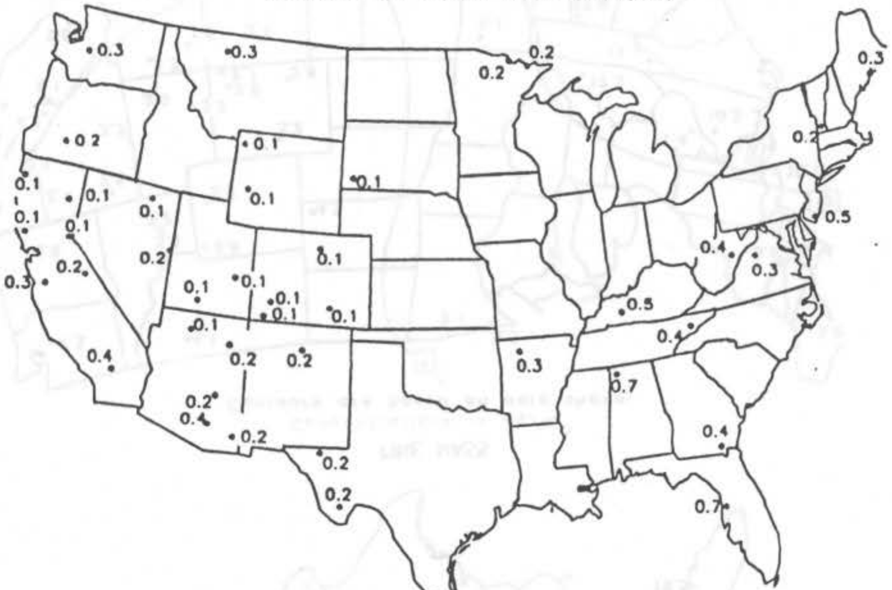


ORGANIC MASS FROM CARBON
Concentrations in $\mu g/m^3$
Contours are based on data shown.

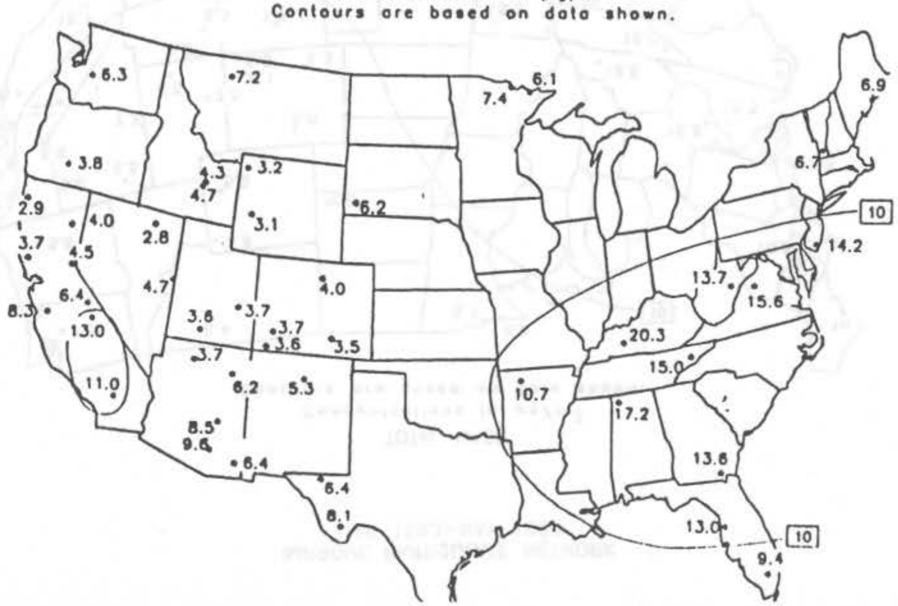


IMPROVE PARTICULATE NETWORK
MAR 1993–MAY 1993

LIGHT ABSORBING CARBON
Concentrations in $\mu g/m^3$
Contours are based on data shown.

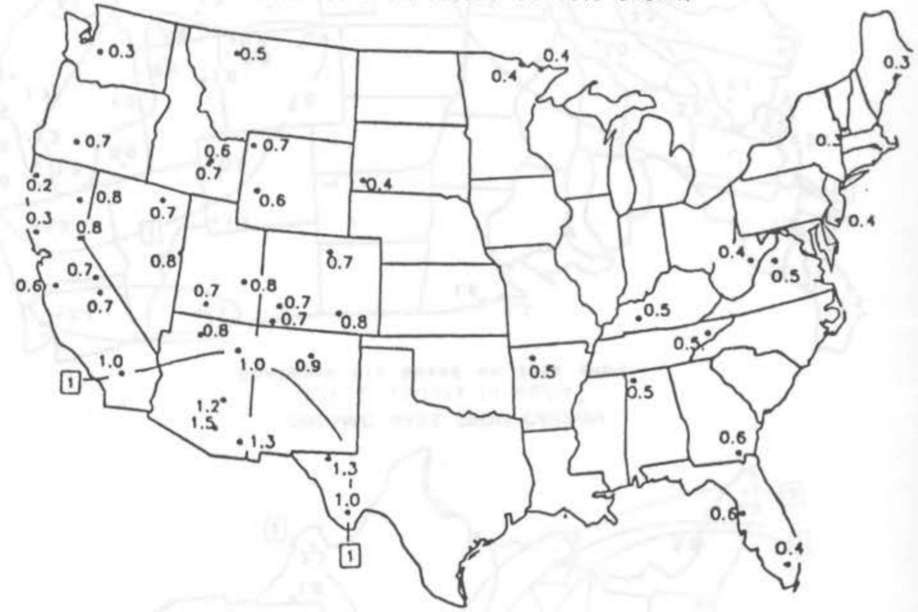


COEF.OF ABS.($10^{-6}m^{-1}$)
Concentrations in $\mu g/m^3$
Contours are based on data shown.

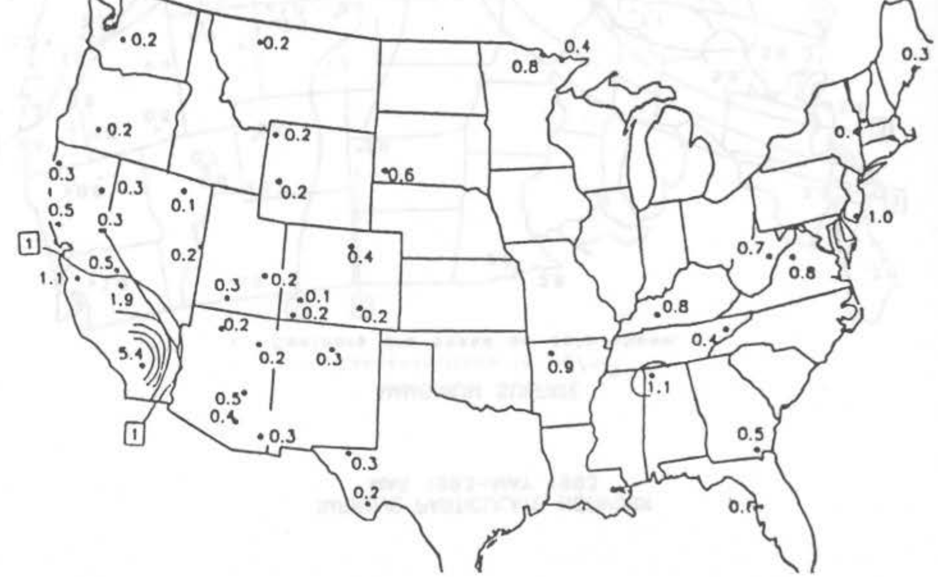


IMPROVE PARTICULATE NETWORK
MAR 1993–MAY 1993

SOIL
Concentrations in $\mu g/m^3$
Contours are based on data shown.

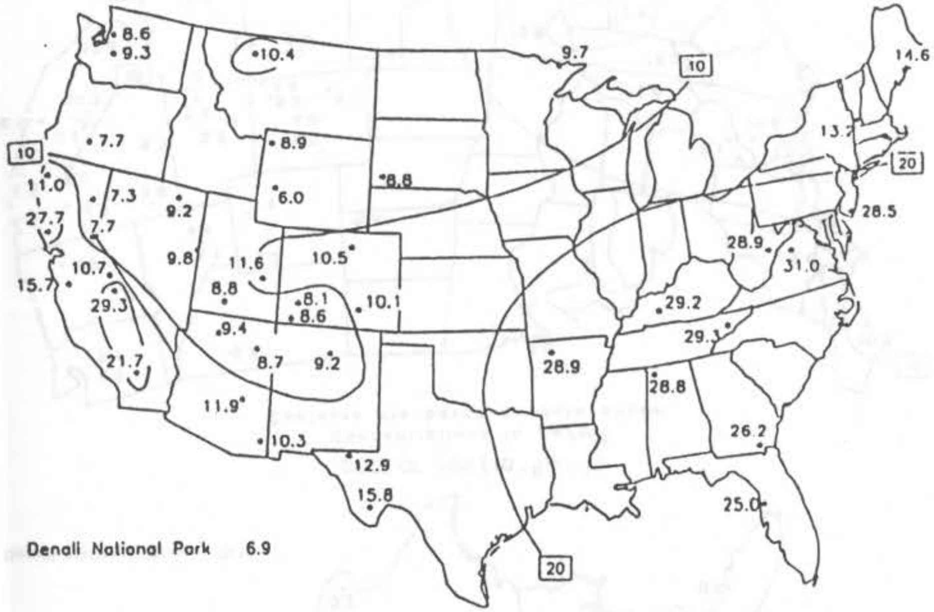


AMMONIUM NITRATE
Concentrations in $\mu g/m^3$
Contours are based on data shown.



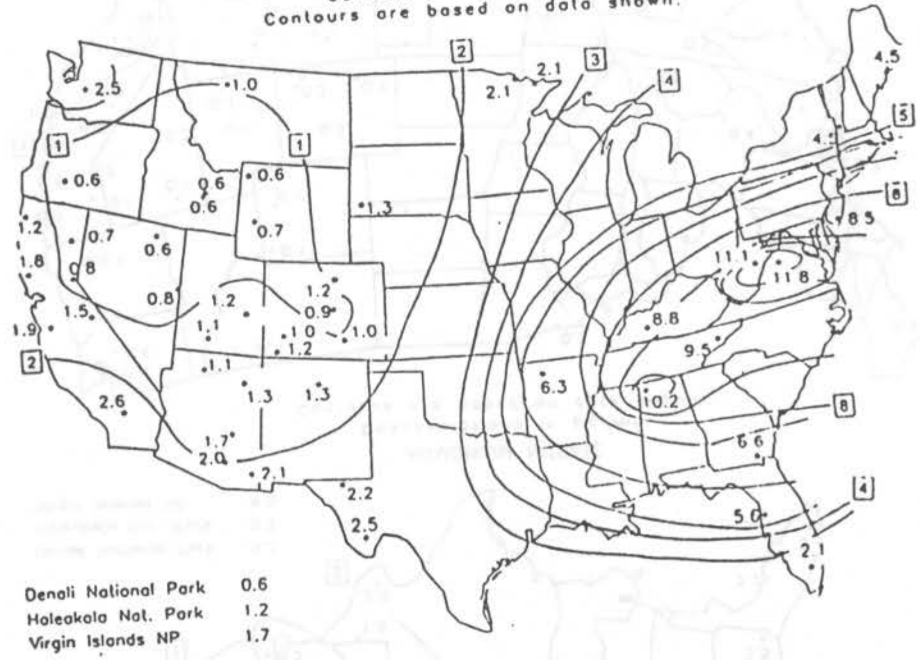
IMPROVE PARTICULATE NETWORK
JUN 1993-AUG 1993

TOTAL MASS
Concentrations in $\mu g/m^3$
Contours are based on data shown.

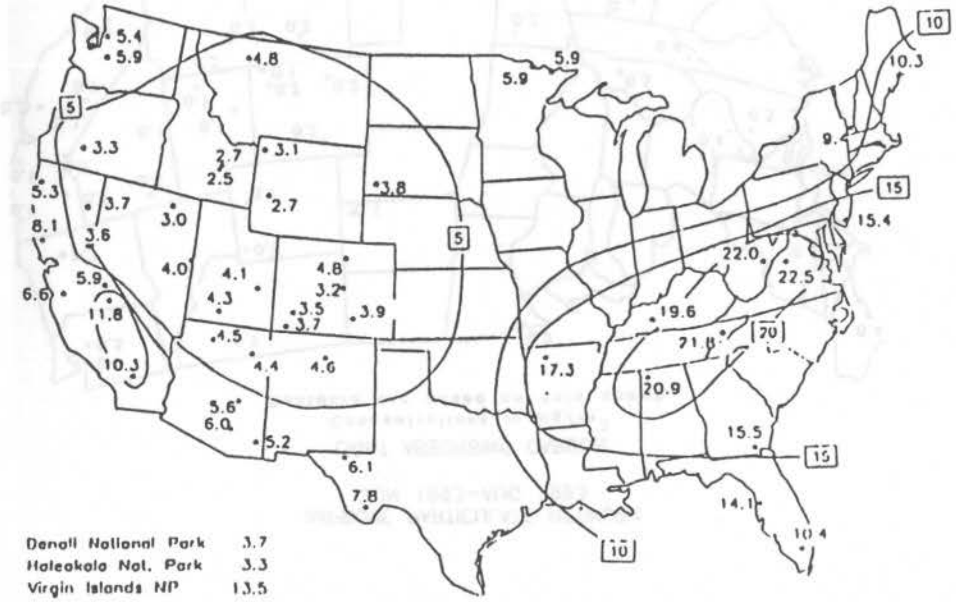


IMPROVE PARTICULATE NETWORK
JUN 1993-AUG 1993

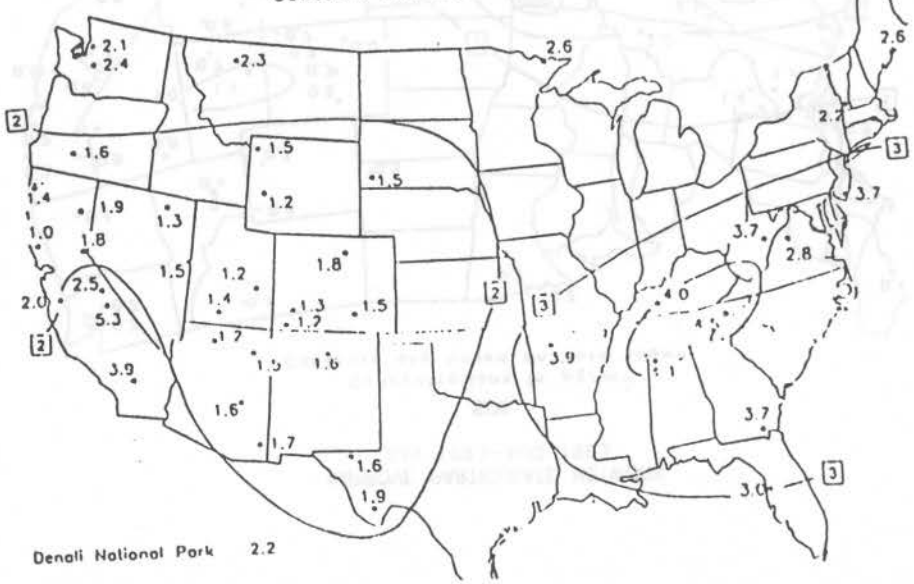
AMMONIUM SULFATE
Concentrations in $\mu g/m^3$
Contours are based on data shown.



FINE MASS
Concentrations in $\mu g/m^3$
Contours are based on data shown.

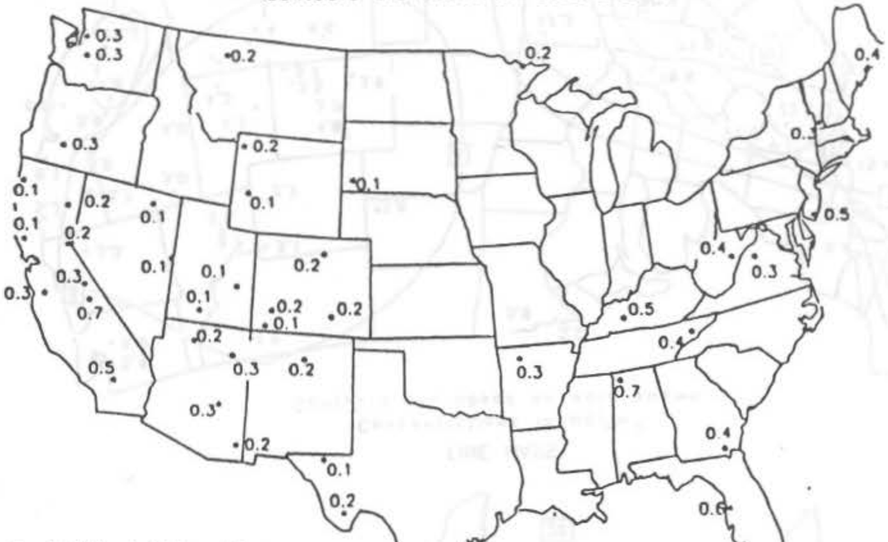


ORGANIC MASS FROM CARBON
Concentrations in $\mu g/m^3$
Contours are based on data shown.



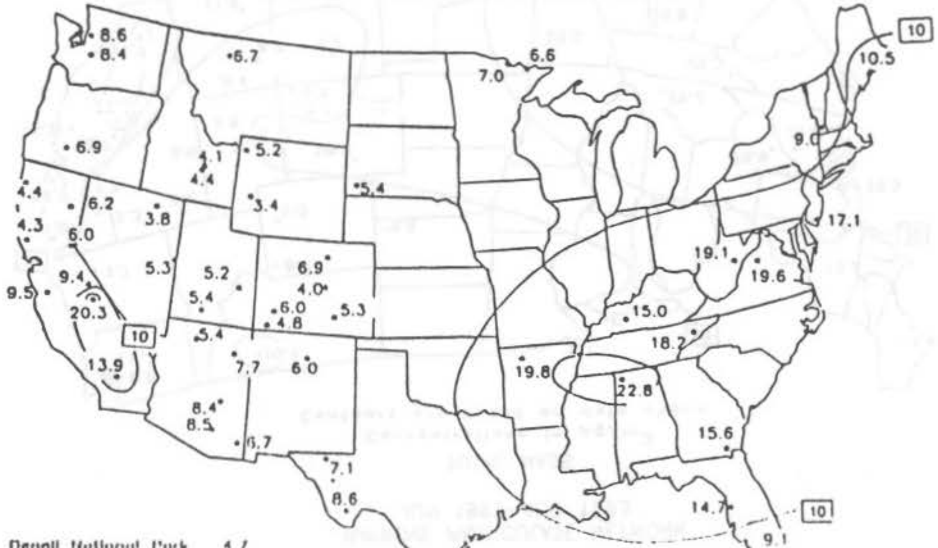
IMPROVE PARTICULATE NETWORK
JUN 1993–AUG 1993

LIGHT ABSORBING CARBON
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 0.1

COEF.OF ABS.($10^{-6}m^{-1}$)
Concentrations in $\mu g/m^3$
Contours are based on data shown.



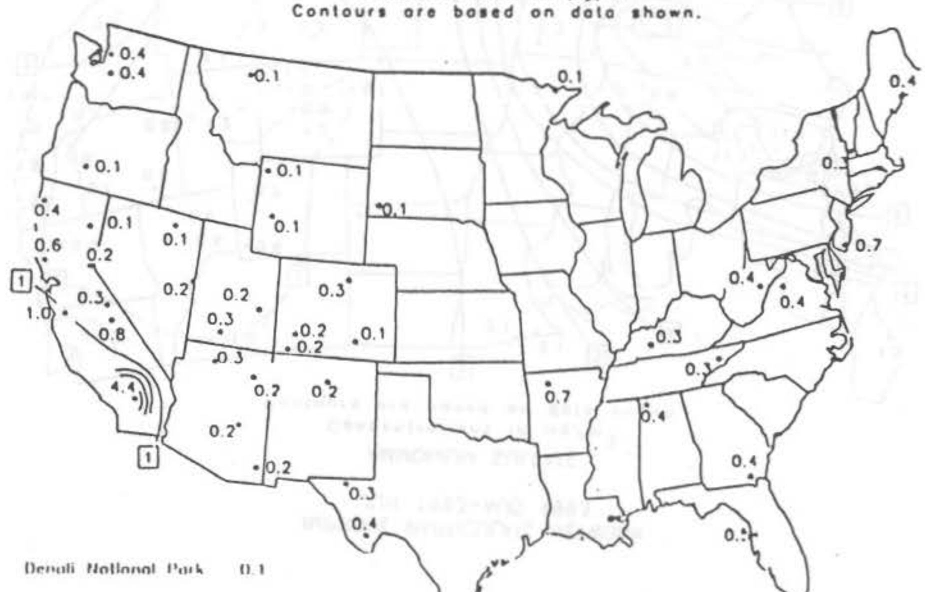
Denali National Park 4.7
Haleakala Nat. Park 4.7
Virgin Islands NP 8.8

IMPROVE PARTICULATE NETWORK
JUN 1993–AUG 1993

SOIL
Concentrations in $\mu g/m^3$
Contours are based on data shown.

Denali National Park 0.3
Haleakala Nat. Park 0.2
Virgin Islands NP 8.5

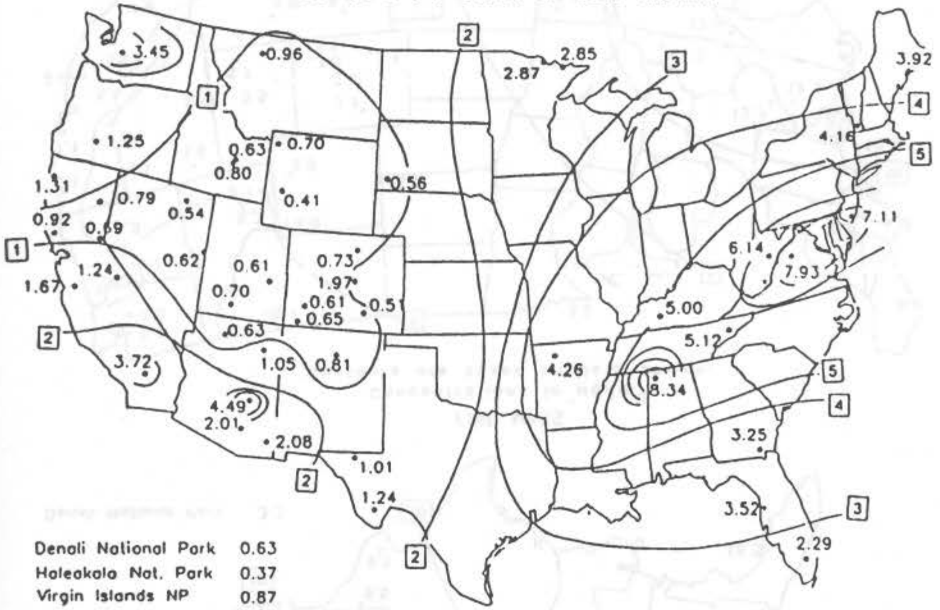
AMMONIUM NITRATE
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 0.1

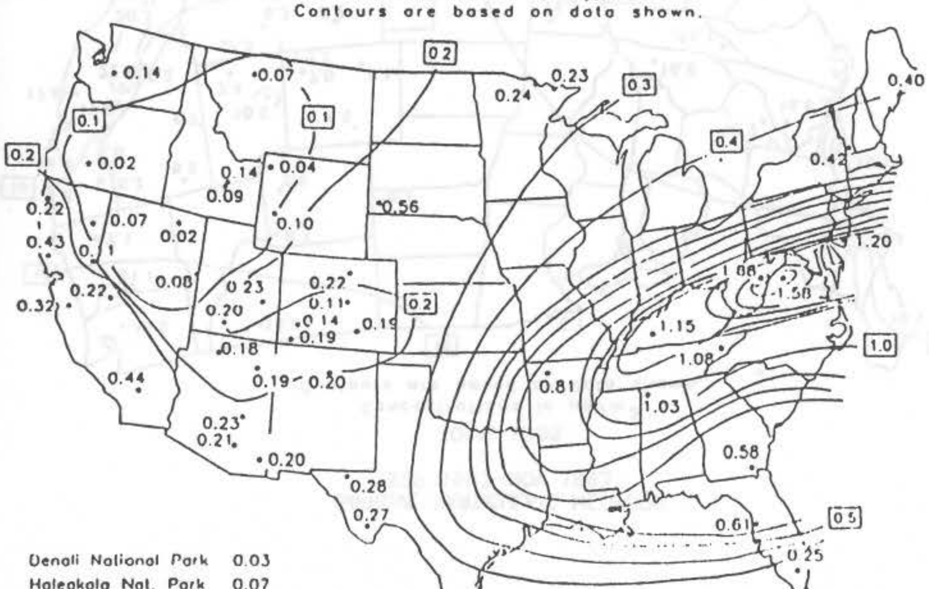
IMPROVE PARTICULATE NETWORK
JUN 1993-AUG 1993

ZINC
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.63
Haleakala Nat. Park	0.37
Virgin Islands NP	0.87

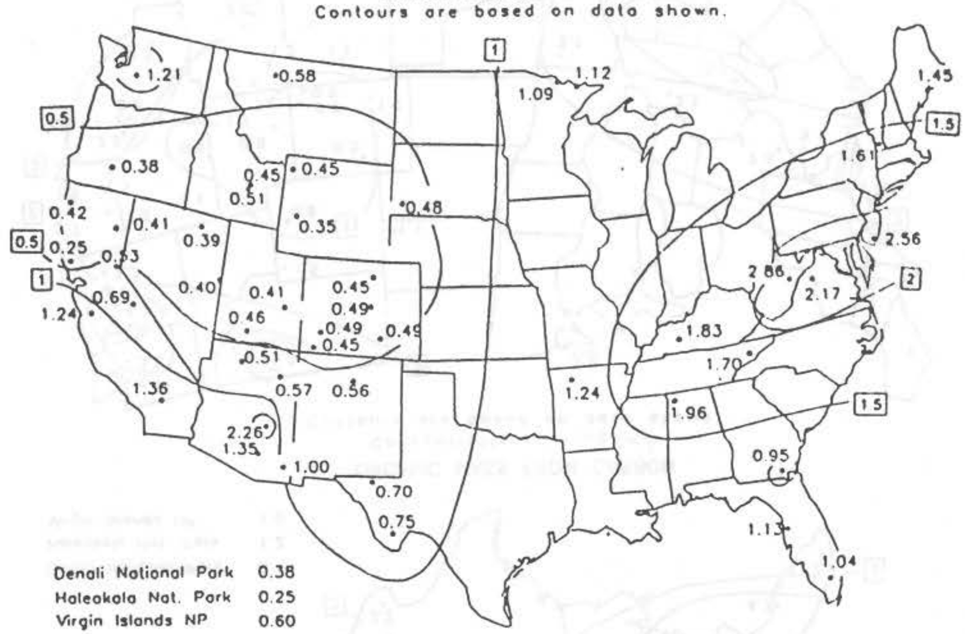
SELENIUM
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.03
Haleakala Nat. Park	0.07

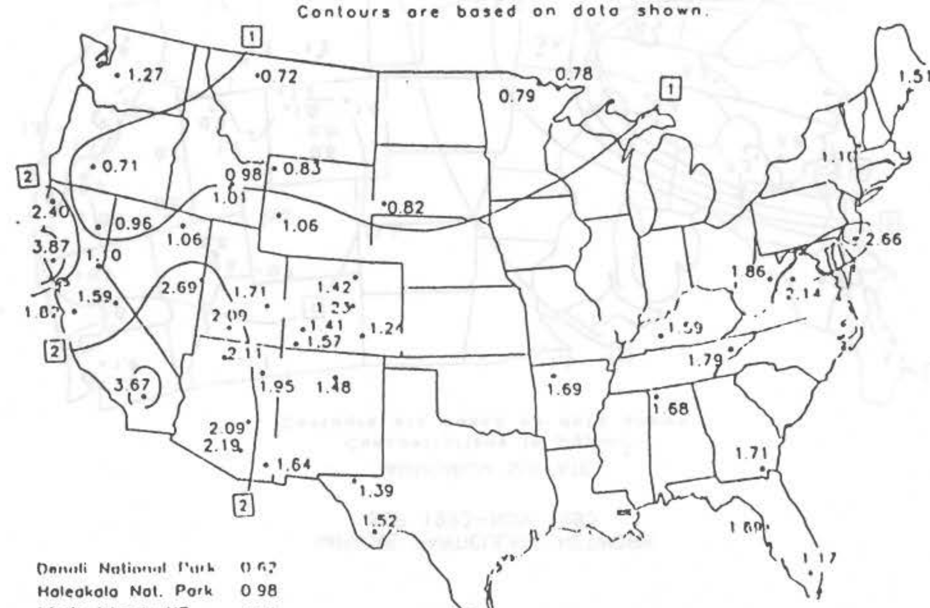
IMPROVE PARTICULATE NETWORK
JUN 1993-AUG 1993

LEAD
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.38
Haleakala Nat. Park	0.25
Virgin Islands NP	0.60

BROMINE
Concentrations in ng/m^3
Contours are based on data shown.

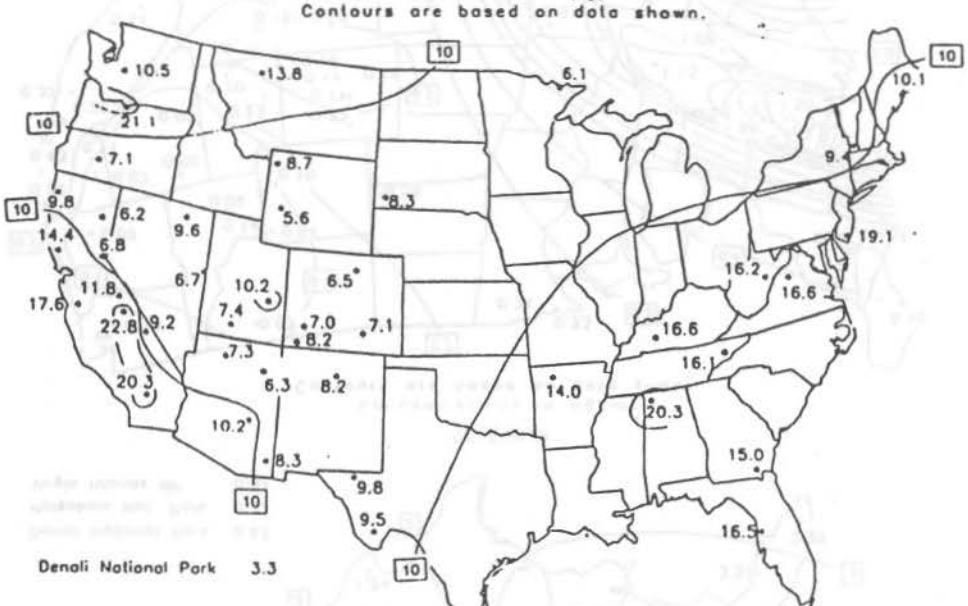


Denali National Park	0.62
Haleakala Nat. Park	0.98
Virgin Islands NP	1.11

IMPROVE PARTICULATE NETWORK
SEP 1993-NOV 1993

TOTAL MASS

Concentrations in $\mu g/m^3$
Contours are based on data shown.

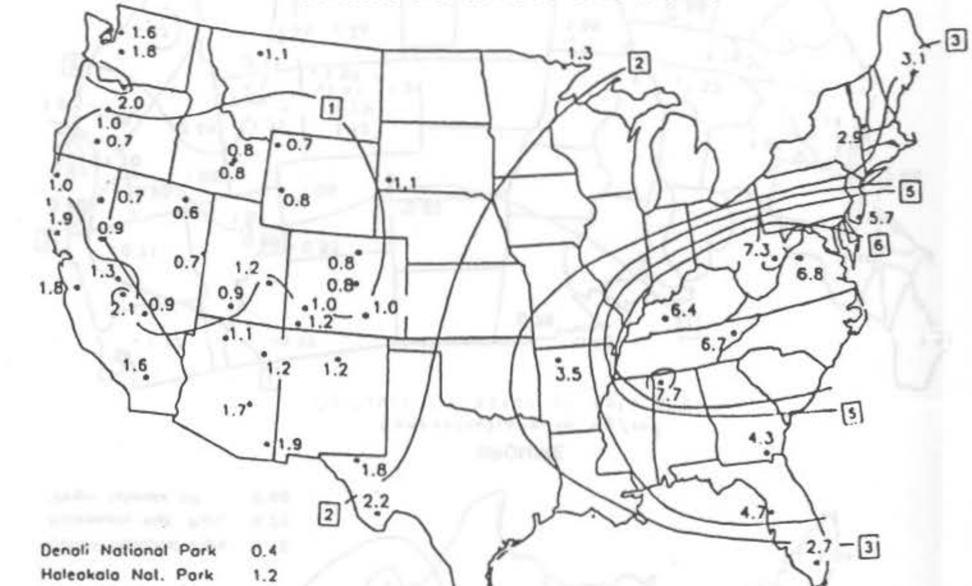


Denali National Park 3.3

IMPROVE PARTICULATE NETWORK
SEP 1993-NOV 1993

AMMONIUM SULFATE

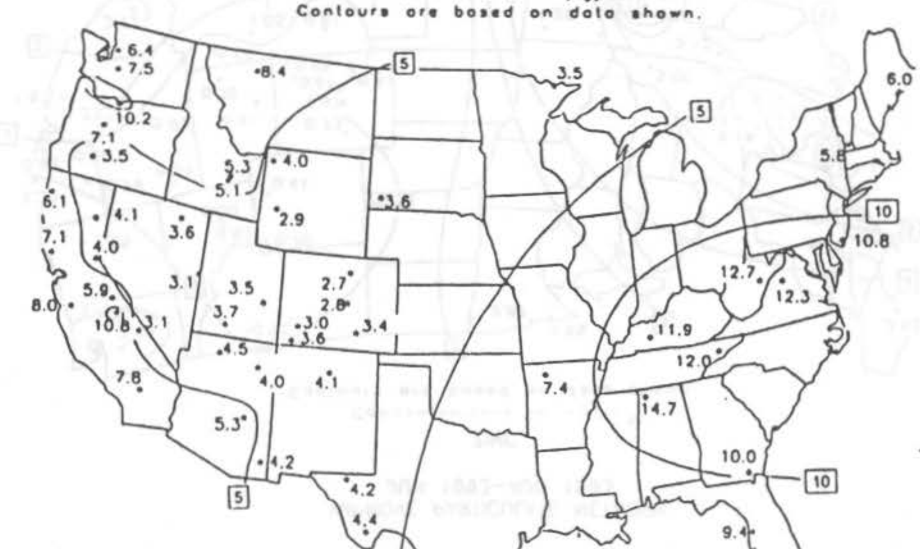
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 0.4
Haleakala Nat. Park 1.2
Virgin Islands NP 1.0

FINE MASS

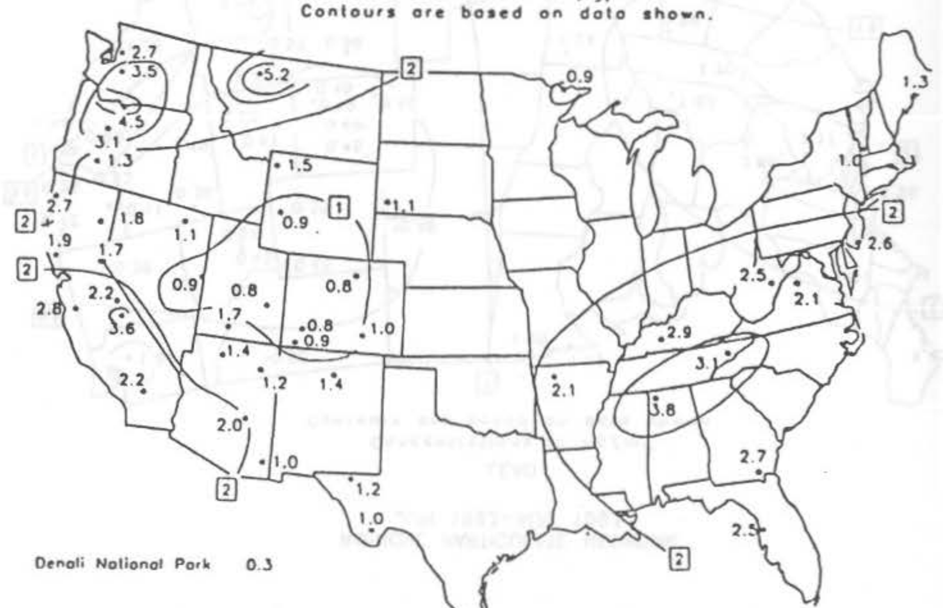
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 1.5
Haleakala Nat. Park 2.8

ORGANIC MASS FROM CARBON

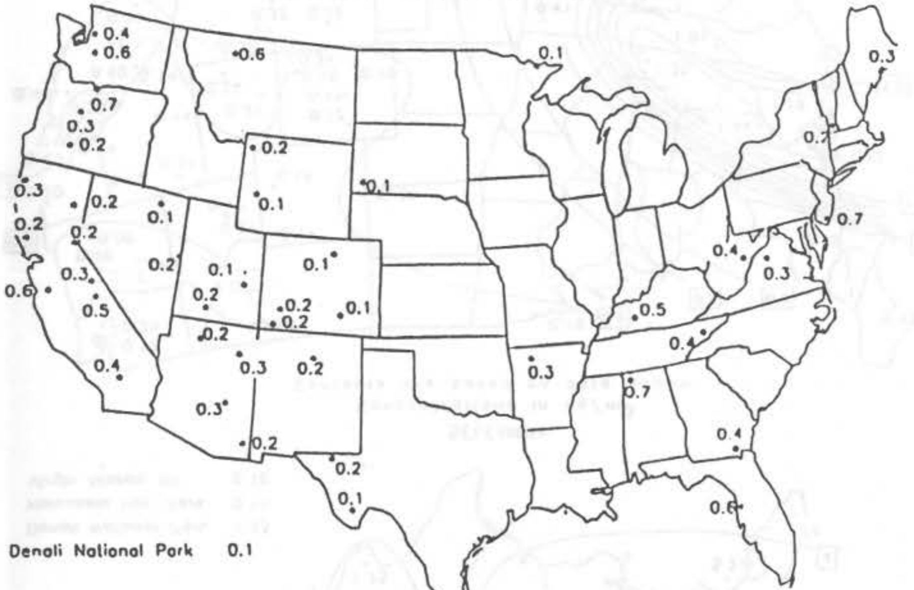
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 0.3

IMPROVE PARTICULATE NETWORK
SEP 1993–NOV 1993

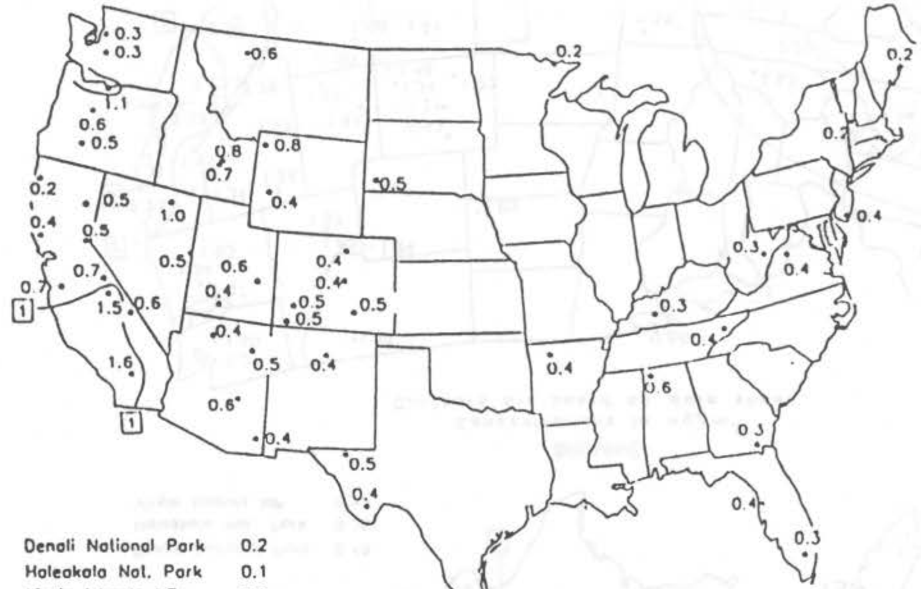
LIGHT ABSORBING CARBON
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 0.1

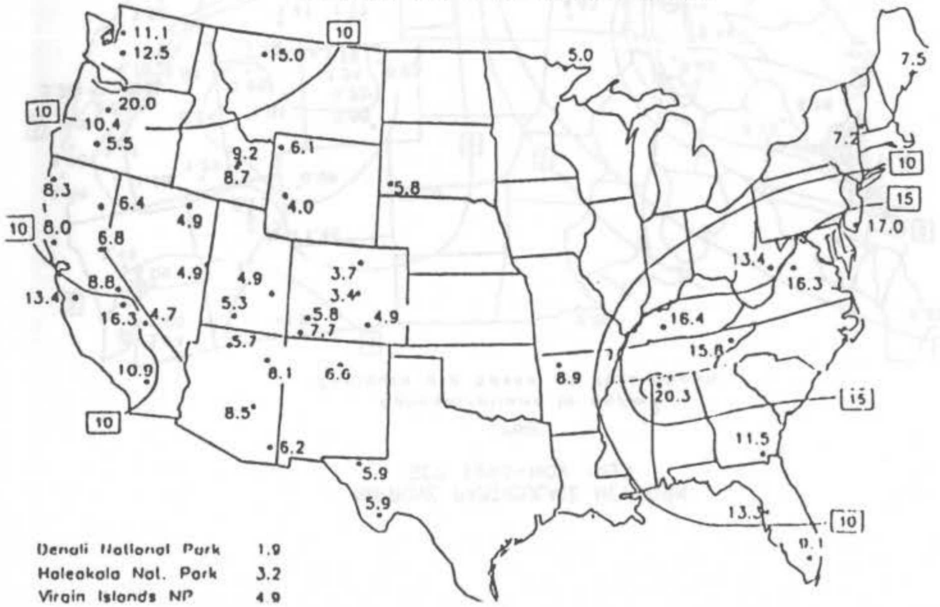
IMPROVE PARTICULATE NETWORK
SEP 1993–NOV 1993

SOIL
Concentrations in $\mu g/m^3$
Contours are based on data shown.



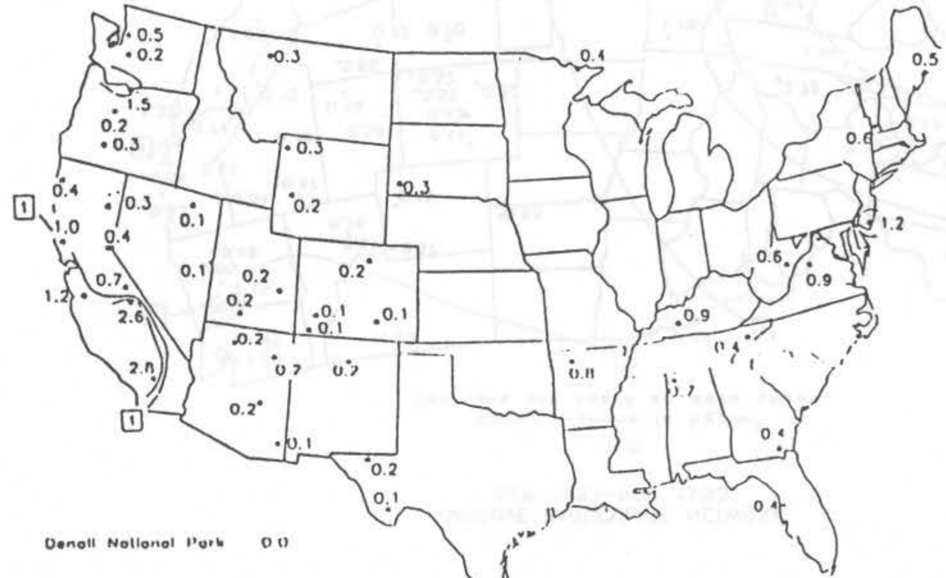
Denali National Park 0.2
Haleakala Nat. Park 0.1
Virgin Islands NP 3.0

COEF.OF ABS.($10^{-6}m^{-1}$)
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 1.9
Haleakala Nat. Park 3.2
Virgin Islands NP 4.9

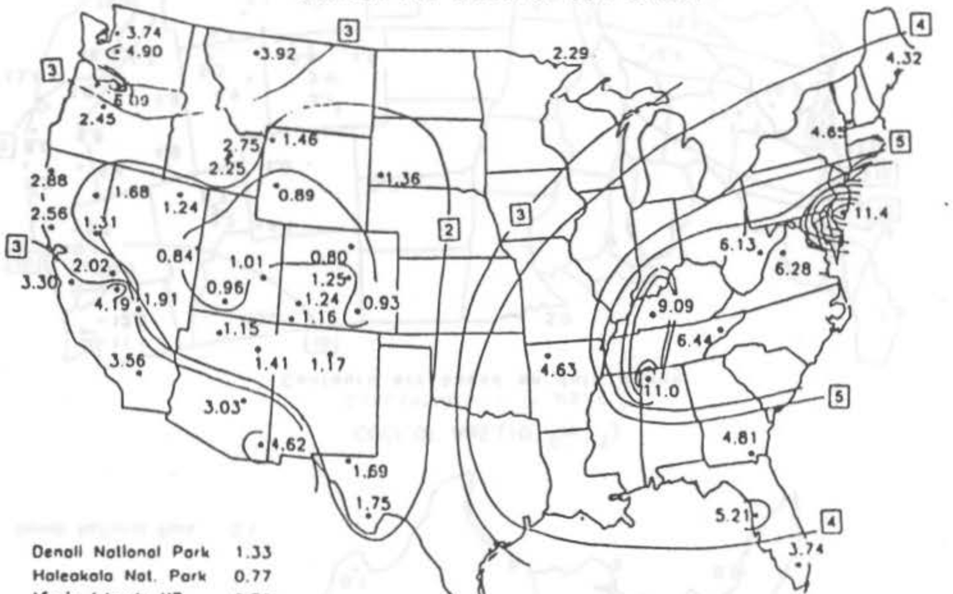
AMMONIUM NITRATE
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 0.0

IMPROVE PARTICULATE NETWORK
SEP 1993–NOV 1993

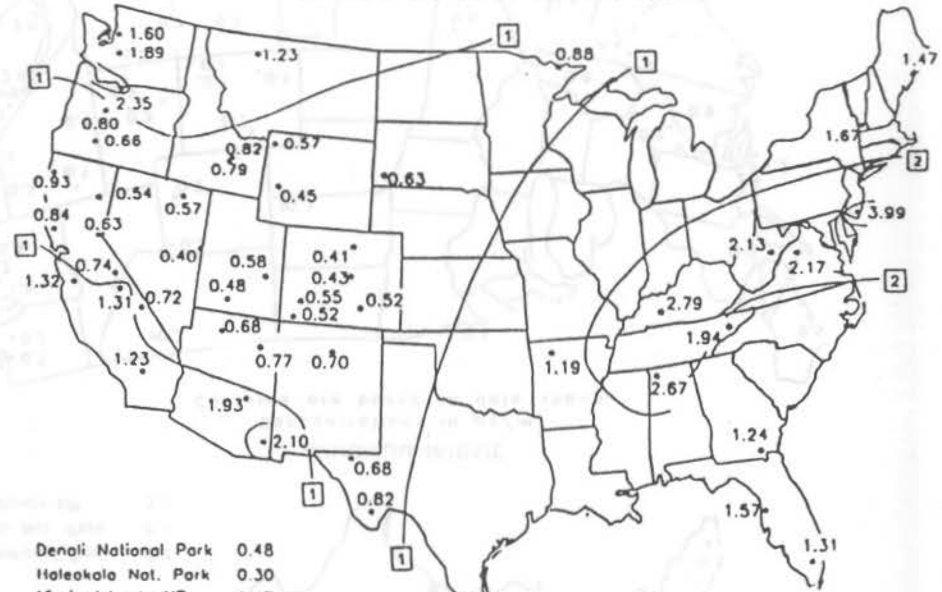
ZINC
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	1.33
Haleakala Nat. Park	0.77
Virgin Islands NP	0.76

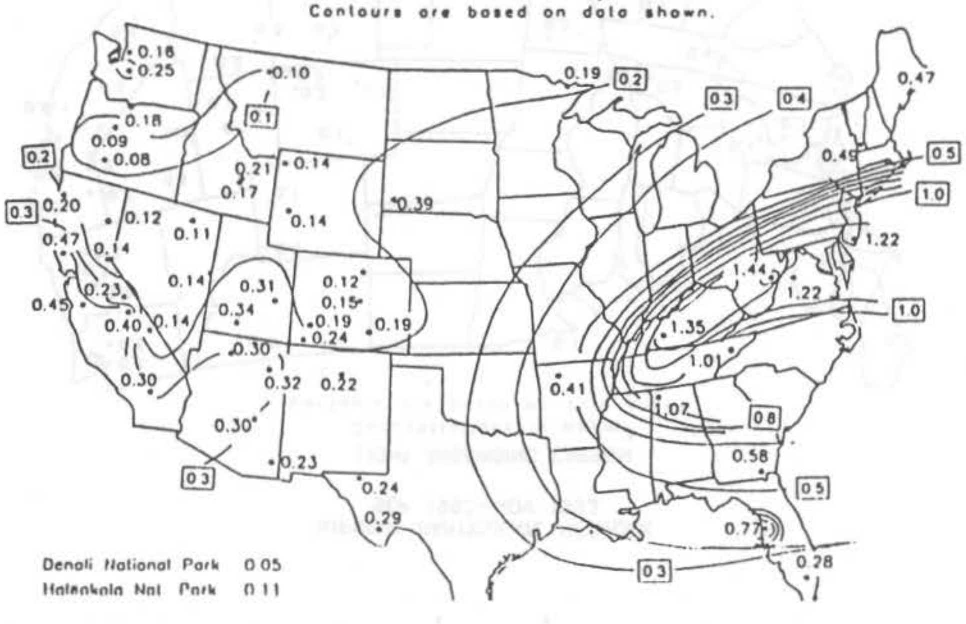
IMPROVE PARTICULATE NETWORK
SEP 1993–NOV 1993

LEAD
Concentrations in ng/m^3
Contours are based on data shown.



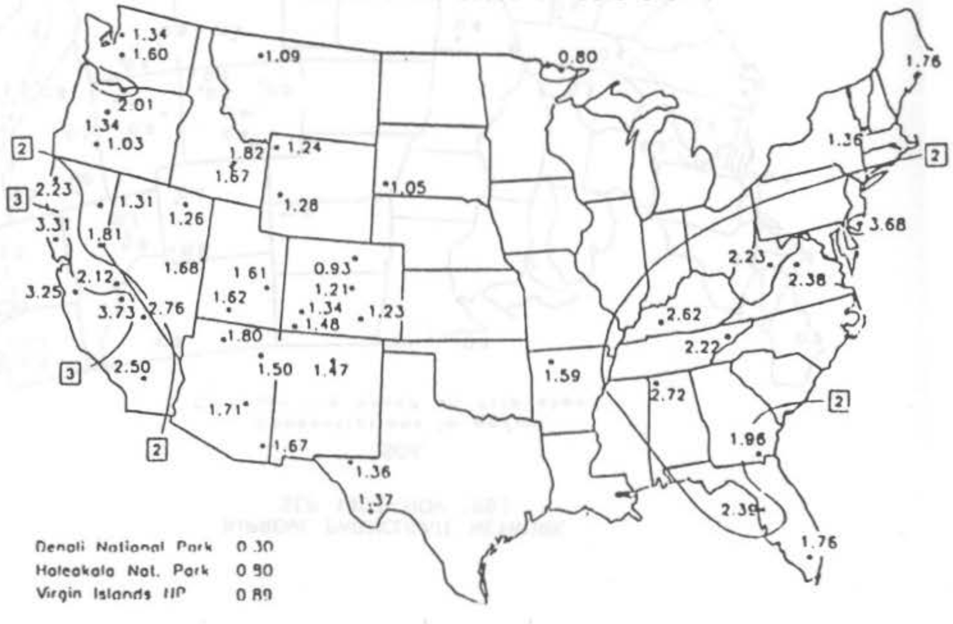
Denali National Park	0.48
Haleakala Nat. Park	0.30
Virgin Islands NP	0.47

SELENIUM
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.05
Haleakala Nat. Park	0.11

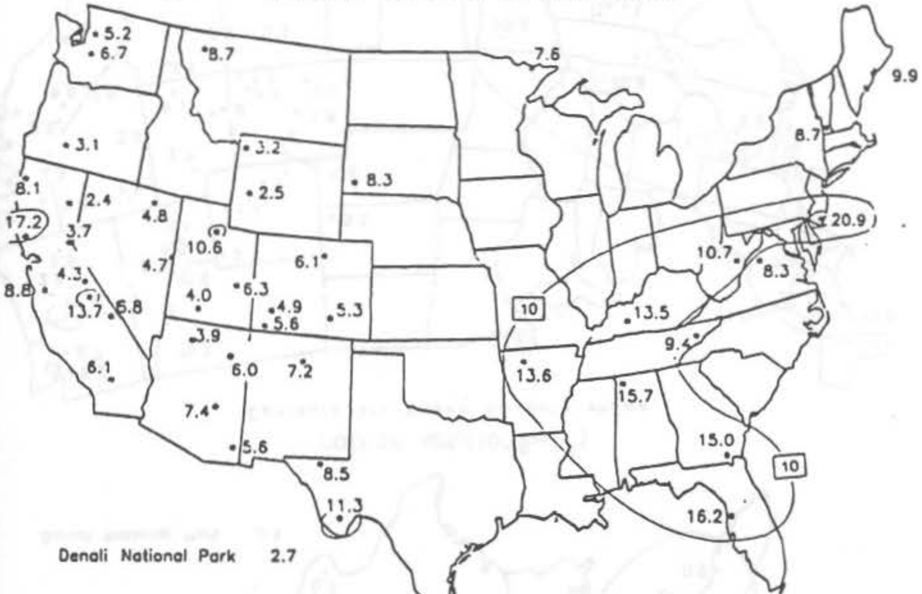
BROMINE
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.30
Haleakala Nat. Park	0.90
Virgin Islands NP	0.89

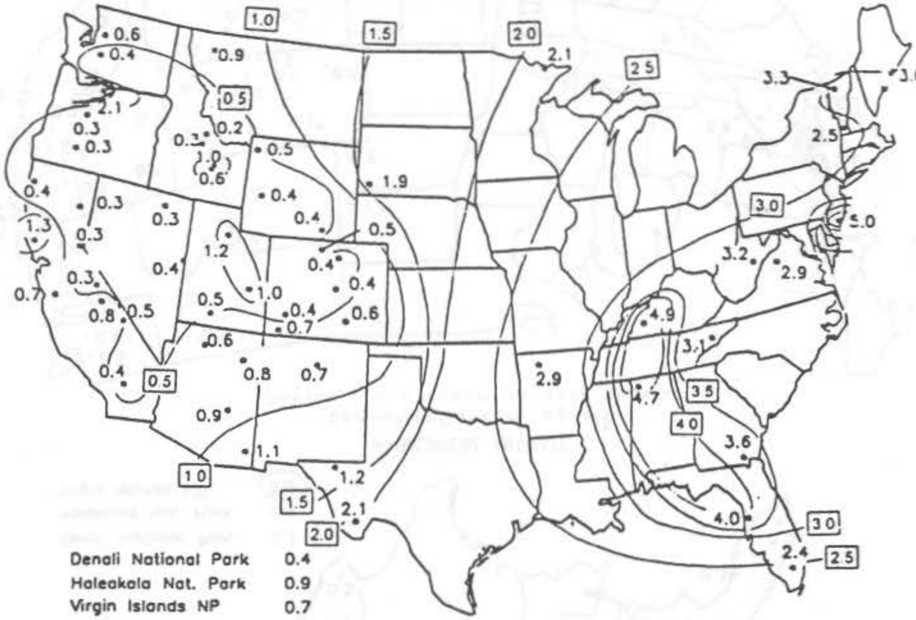
IMPROVE PARTICULATE NETWORK
DEC 1993–FEB 1994

TOTAL MASS
Concentrations in $\mu g/m^3$
Contours are based on data shown.

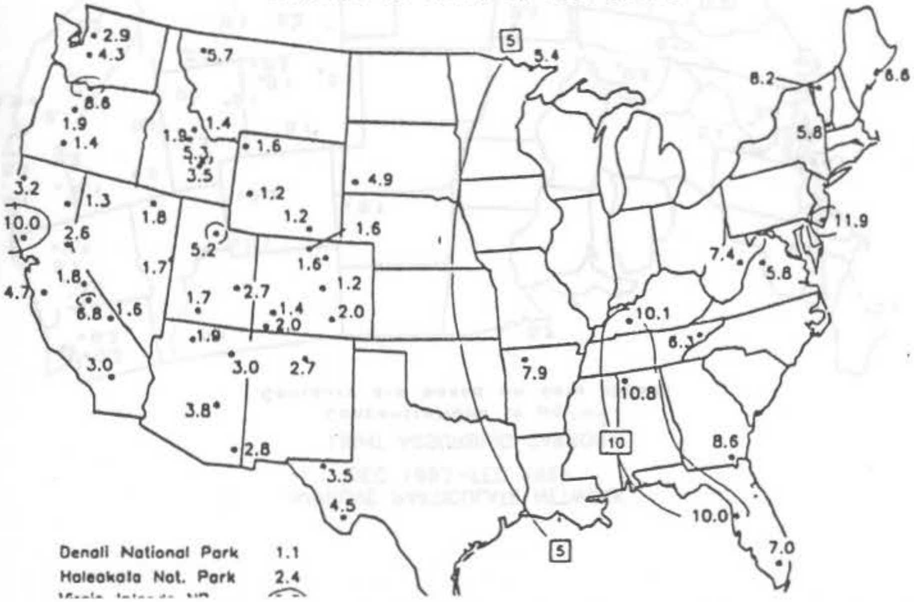


IMPROVE PARTICULATE NETWORK
DEC 1993–FEB 1994

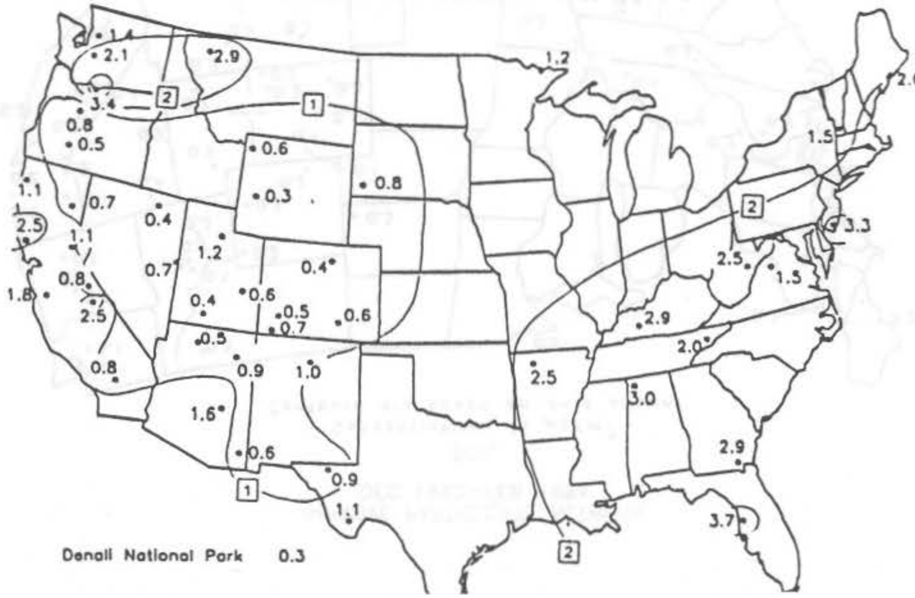
AMMONIUM SULFATE
Concentrations in $\mu g/m^3$
Contours are based on data shown.



FINE MASS
Concentrations in $\mu g/m^3$
Contours are based on data shown.



ORGANIC MASS FROM CARBON
Concentrations in $\mu g/m^3$
Contours are based on data shown.

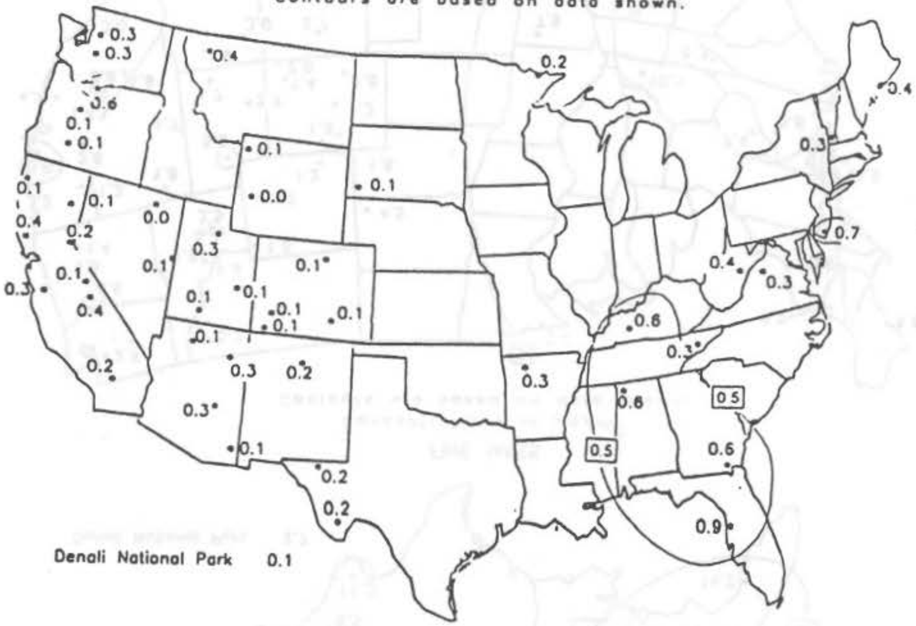


IMPROVE PARTICULATE NETWORK
DEC 1993–FEB 1994

LIGHT ABSORBING CARBON

Concentrations in $\mu g/m^3$

Contours are based on data shown.

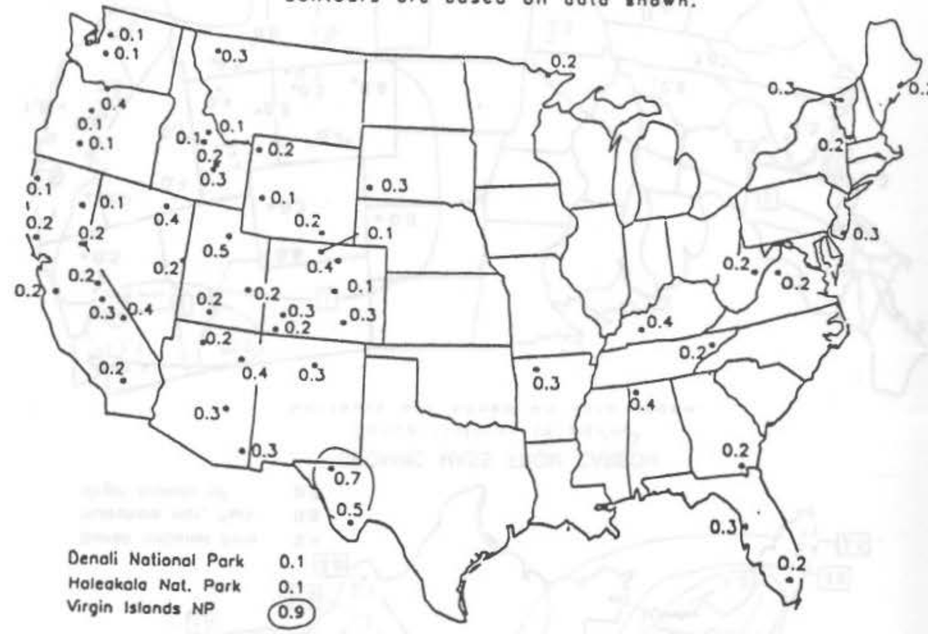


IMPROVE PARTICULATE NETWORK
DEC 1993–FEB 1994

SOIL

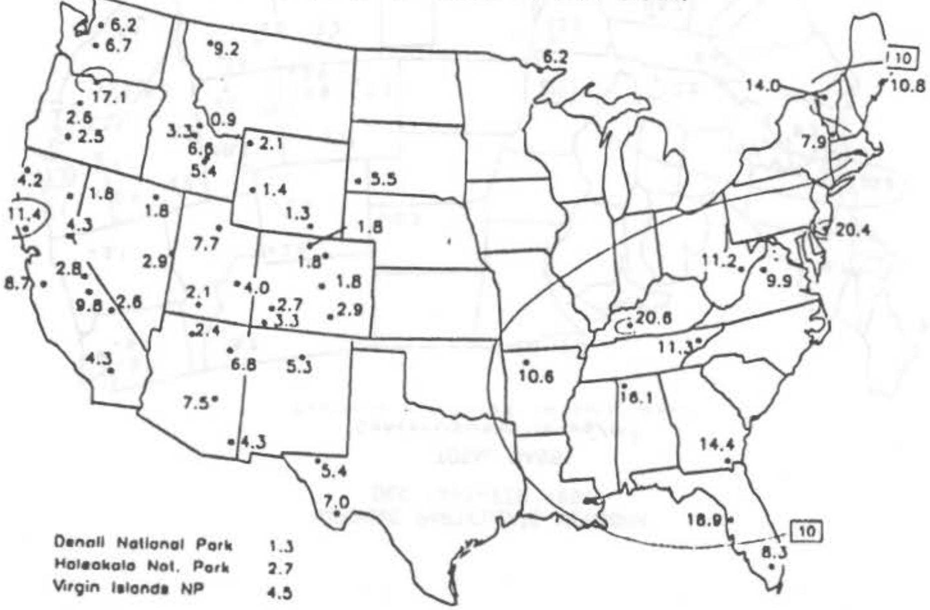
Concentrations in $\mu g/m^3$

Contours are based on data shown.



COEF.OF ABS.($10^{-6}m^{-1}$)

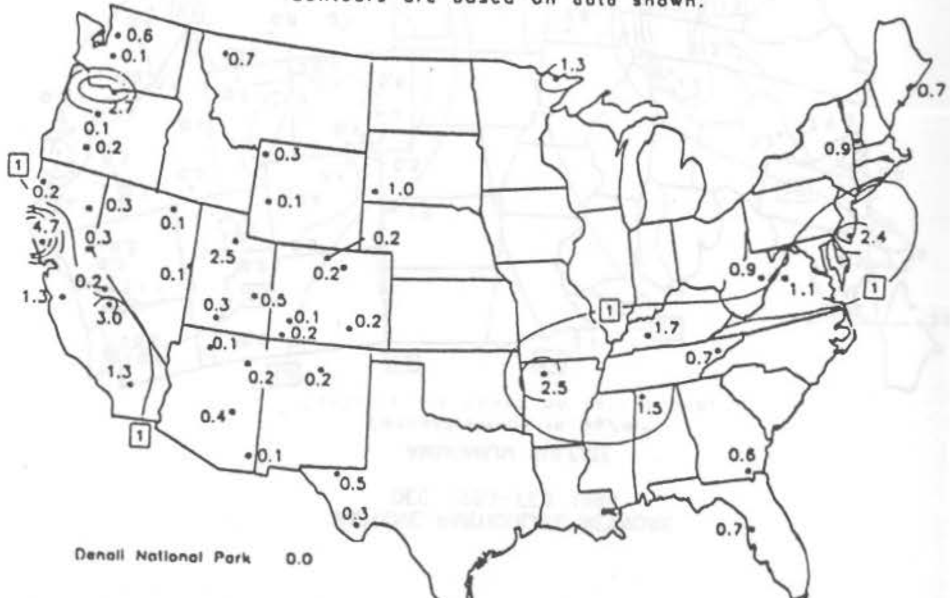
Contours are based on data shown.



AMMONIUM NITRATE

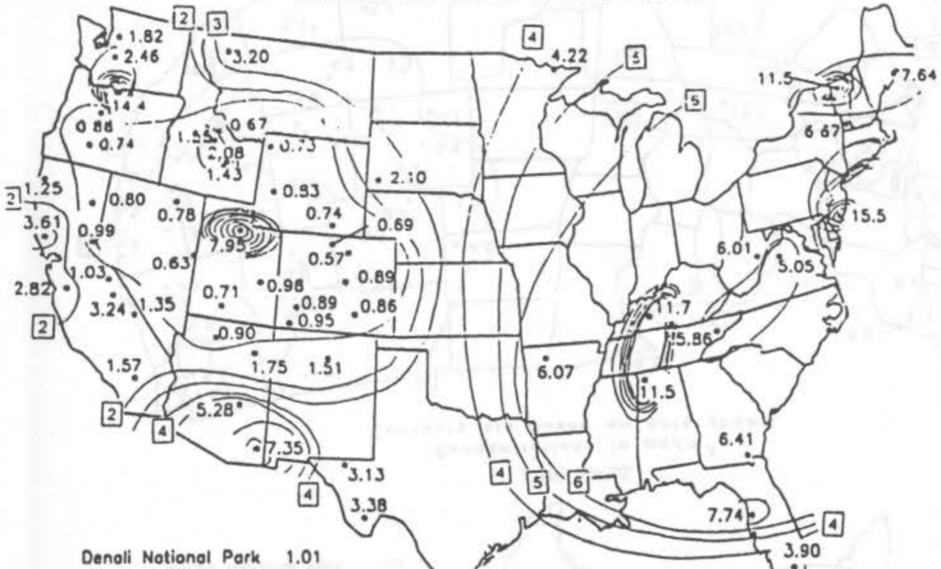
Concentrations in $\mu g/m^3$

Contours are based on data shown.



IMPROVE PARTICULATE NETWORK
DEC 1993–FEB 1994

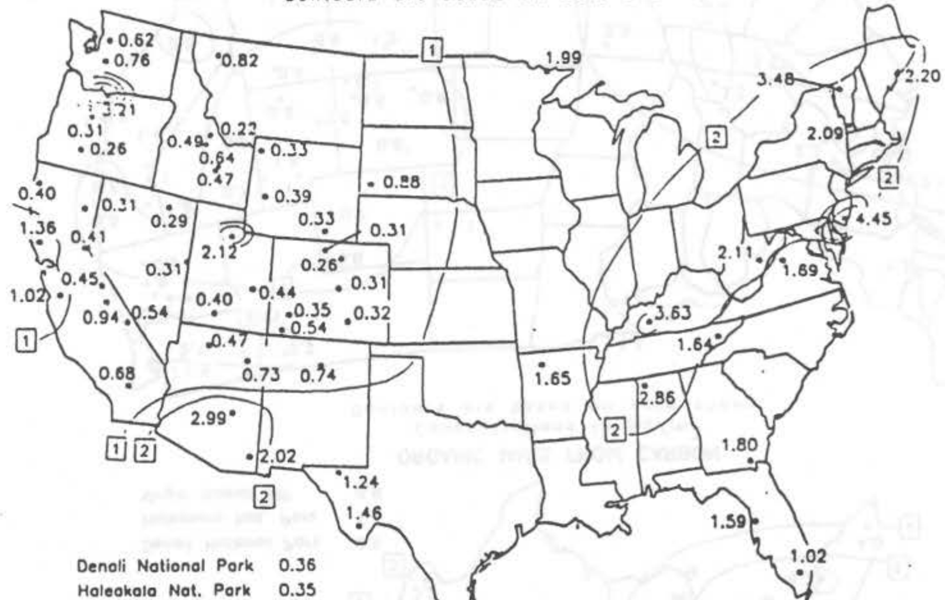
ZINC
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	1.01
Haleakala Nat. Park	0.65
Virgin Islands NP	1.14

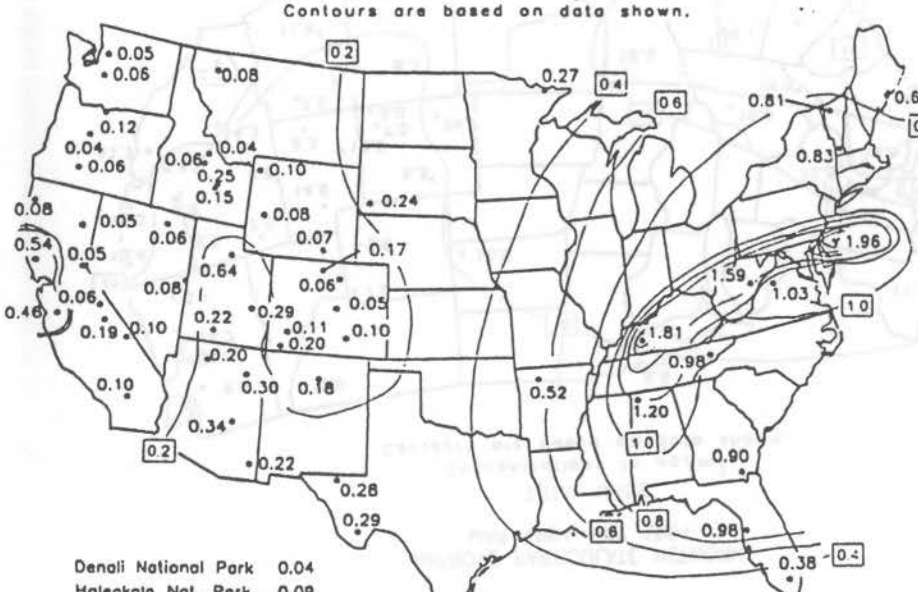
IMPROVE PARTICULATE NETWORK
DEC 1993–FEB 1994

LEAD
Concentrations in ng/m^3
Contours are based on data shown.



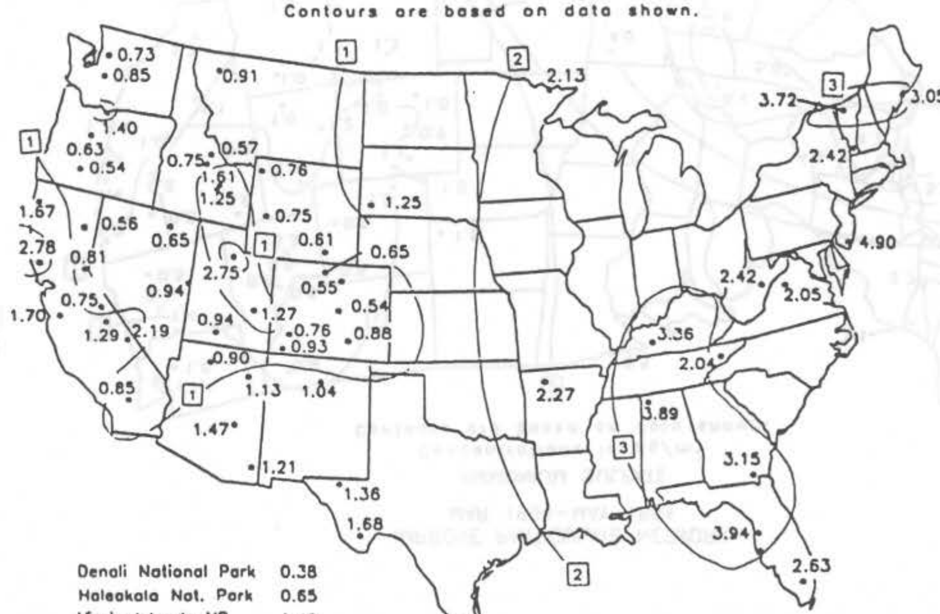
Denali National Park	0.36
Haleakala Nat. Park	0.35
Virgin Islands NP	0.39

SELENIUM
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.04
Haleakala Nat. Park	0.09
Virgin Islands NP	0.21

BROMINE
Concentrations in ng/m^3
Contours are based on data shown.

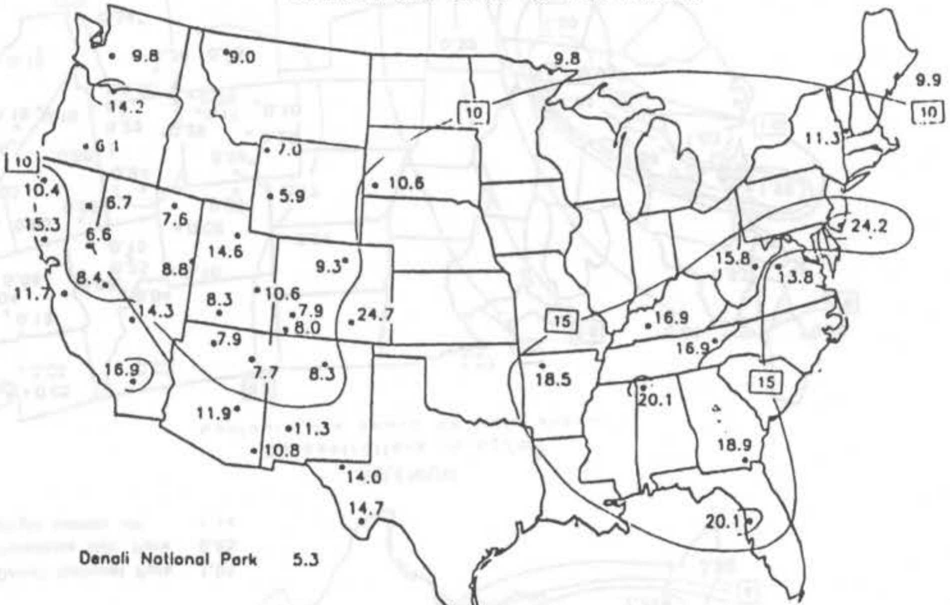


Denali National Park	0.38
Haleakala Nat. Park	0.65
Virgin Islands NP	1.40

IMPROVE PARTICULATE NETWORK
MAR 1994–MAY 1994

TOTAL MASS

Concentrations in $\mu g/m^3$
Contours are based on data shown.

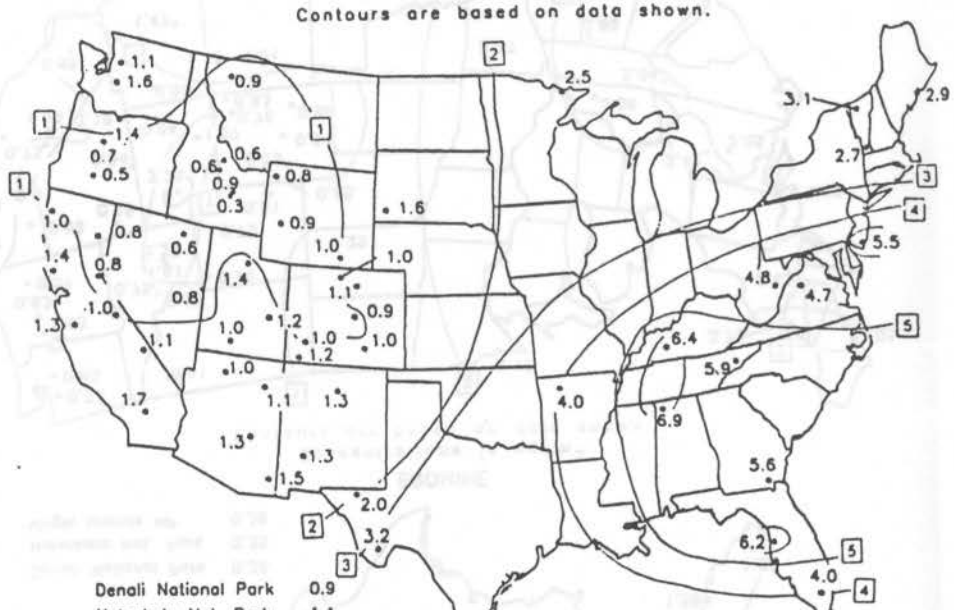


Denali National Park 5.3

IMPROVE PARTICULATE NETWORK
MAR 1994–MAY 1994

AMMONIUM SULFATE

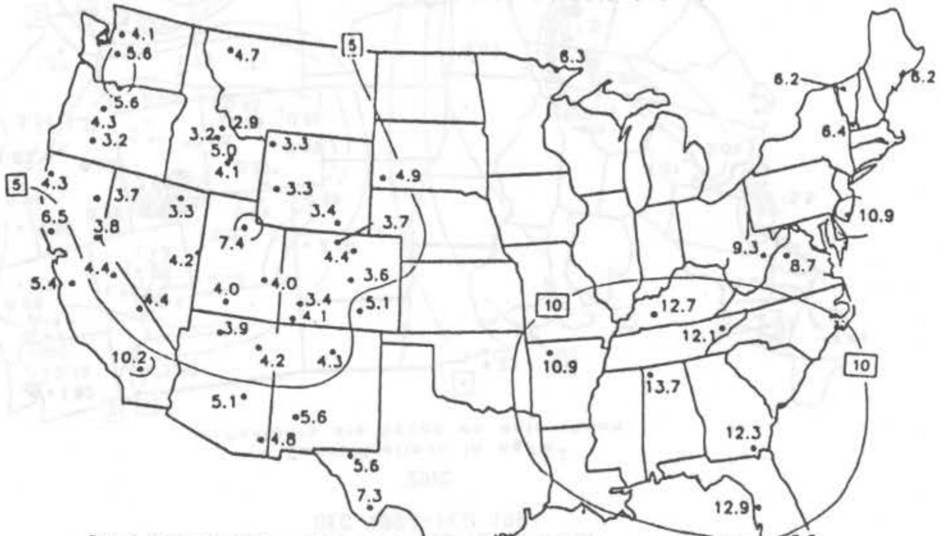
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 0.9
Haleakala Nat. Park 1.1
Virgin Islands NP 0.9

FINE MASS

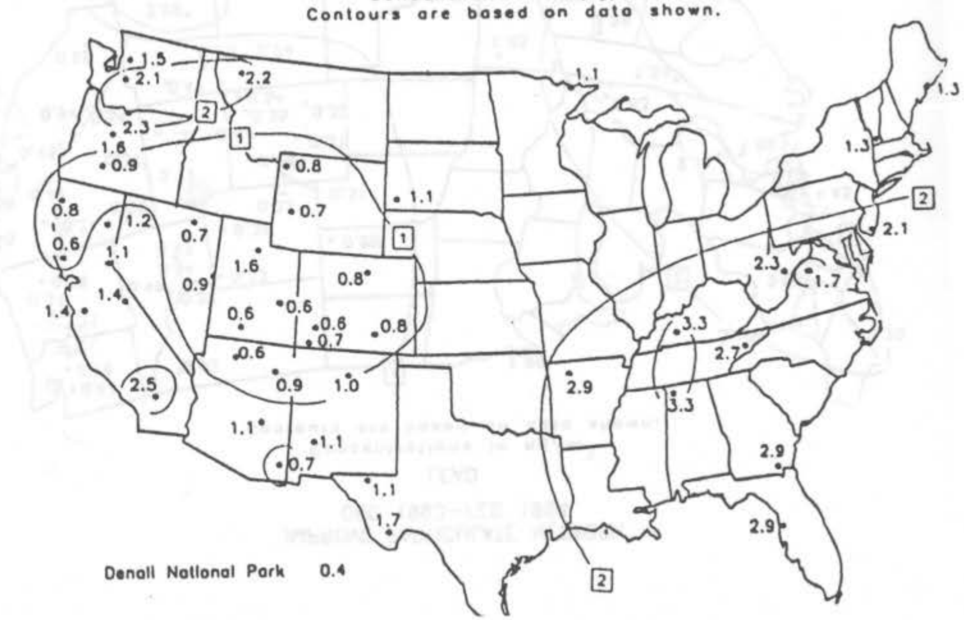
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park 2.4
Haleakala Nat. Park 3.4
Virgin Islands NP 9.0

ORGANIC MASS FROM CARBON

Concentrations in $\mu g/m^3$
Contours are based on data shown.

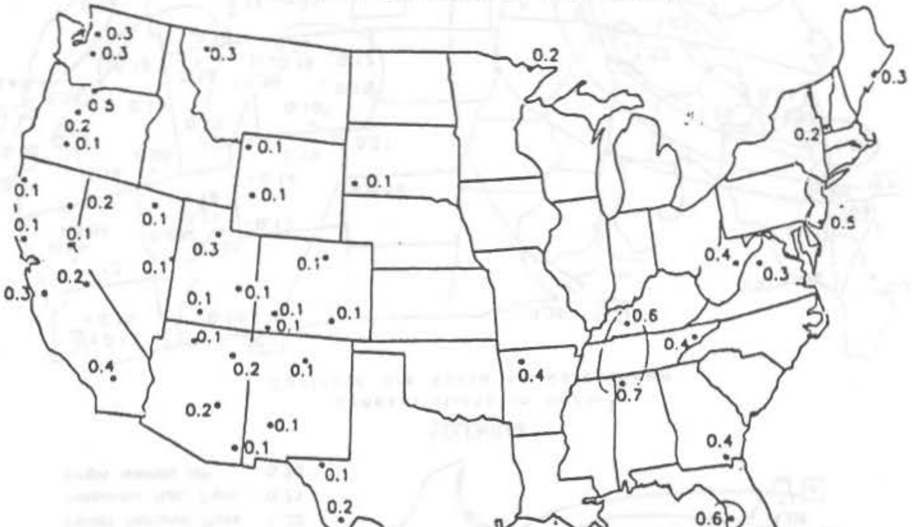


Denali National Park 0.4

IMPROVE PARTICULATE NETWORK
MAR 1994–MAY 1994

LIGHT ABSORBING CARBON

Concentrations in $\mu g/m^3$
Contours are based on data shown.

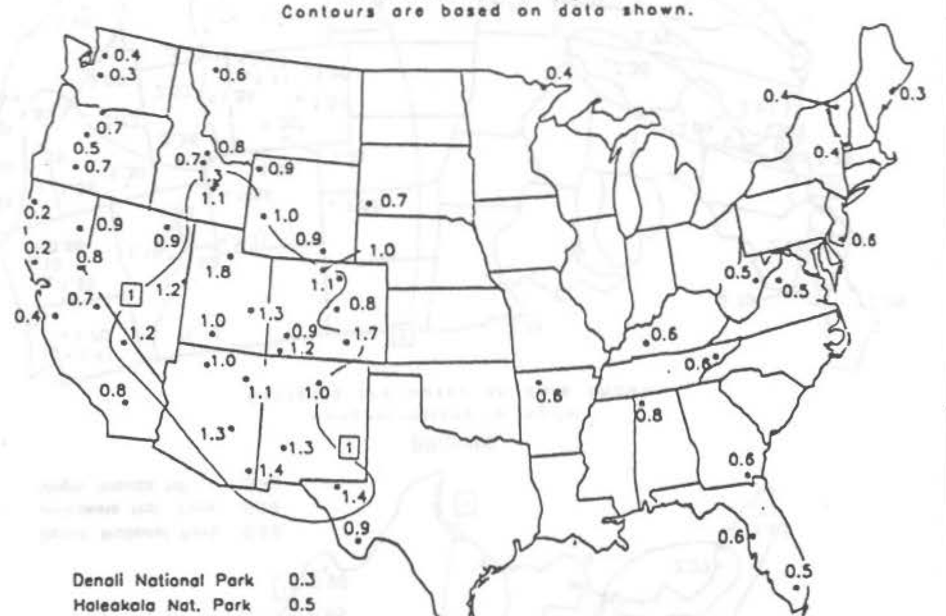


Denali National Park 0.1

IMPROVE PARTICULATE NETWORK
MAR 1994–MAY 1994

SOIL

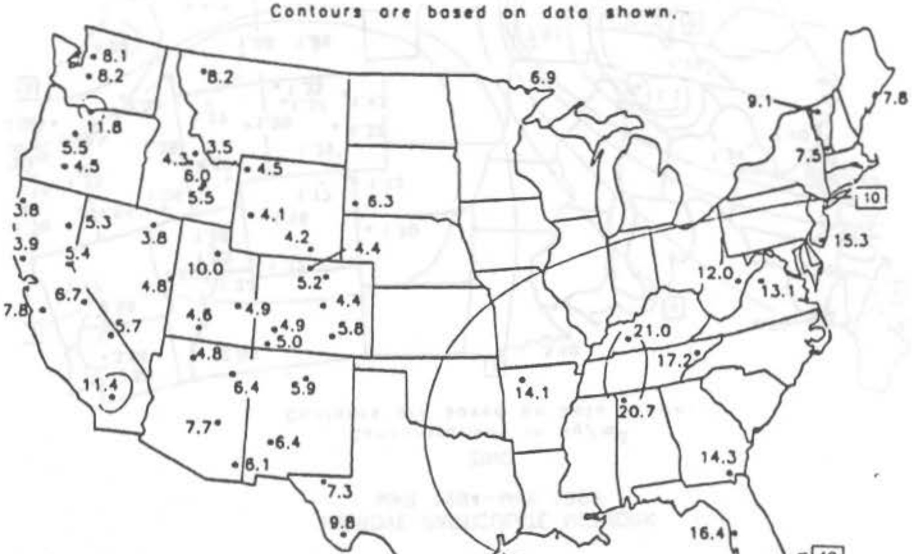
Concentrations in $\mu g/m^3$
Contours are based on data shown.



Denali National Park	0.3
Haleakala Nat. Park	0.5
Virgin Islands NP	2.0

COEF.OF ABS.($10^{-6}m^{-1}$)

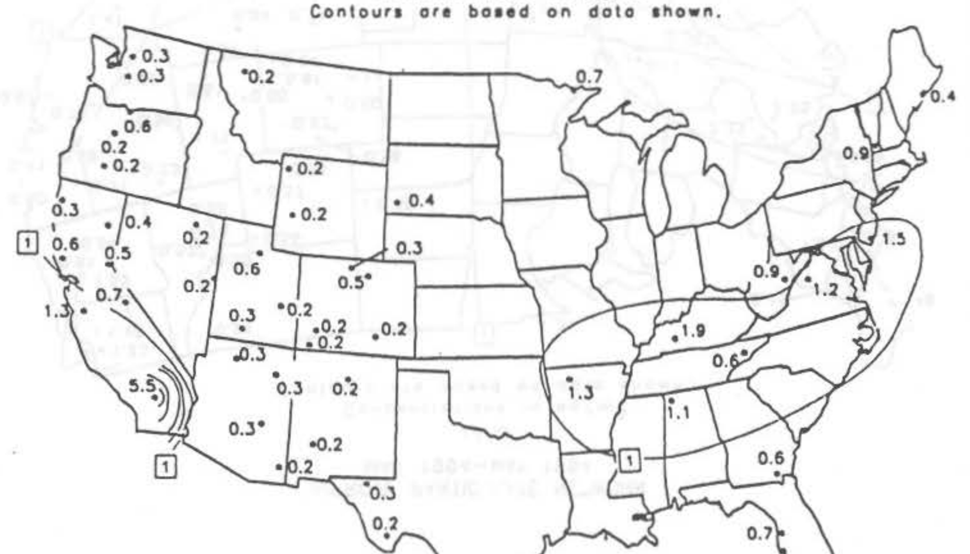
Contours are based on data shown.



Denali National Park	2.9
Haleakala Nat. Park	4.0
Virgin Islands NP	5.1

AMMONIUM NITRATE

Concentrations in $\mu g/m^3$
Contours are based on data shown.

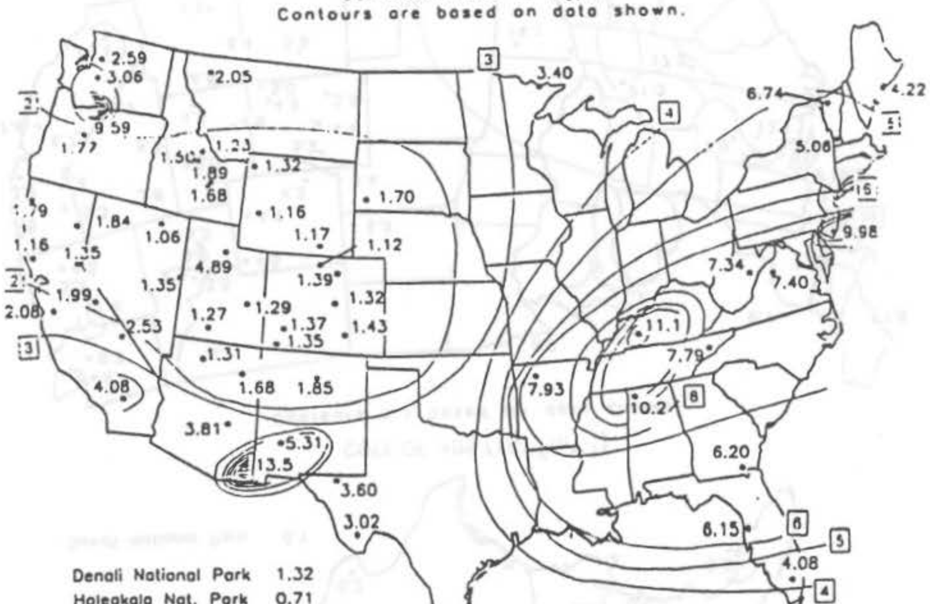


Denali National Park 0.1

IMPROVE PARTICULATE NETWORK
MAR 1994–MAY 1994

ZINC

Concentrations in ng/m^3
Contours are based on data shown.

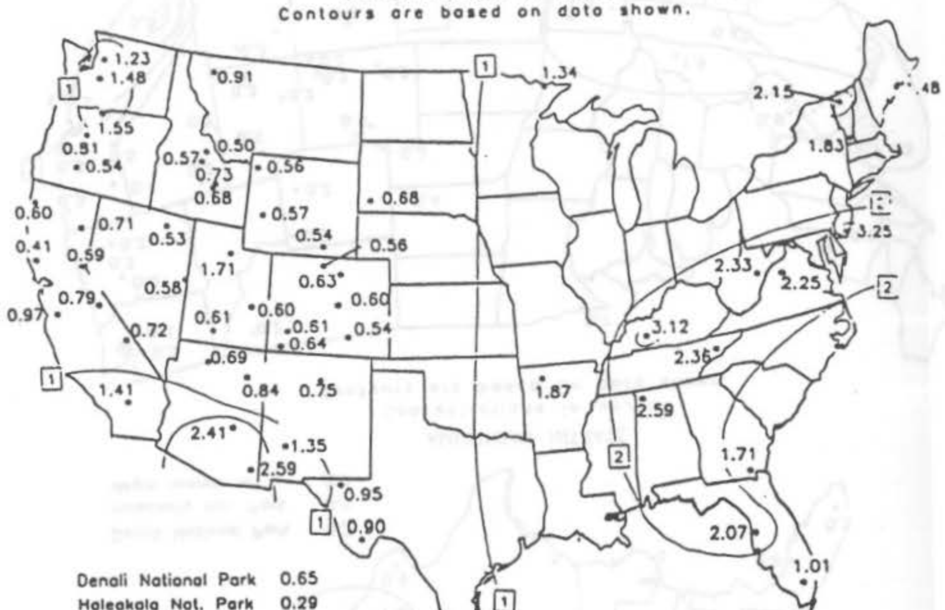


Denali National Park	1.32
Haleakala Nat. Park	0.71
Virgin Islands NP	0.78

IMPROVE PARTICULATE NETWORK
MAR 1994–MAY 1994

LEAD

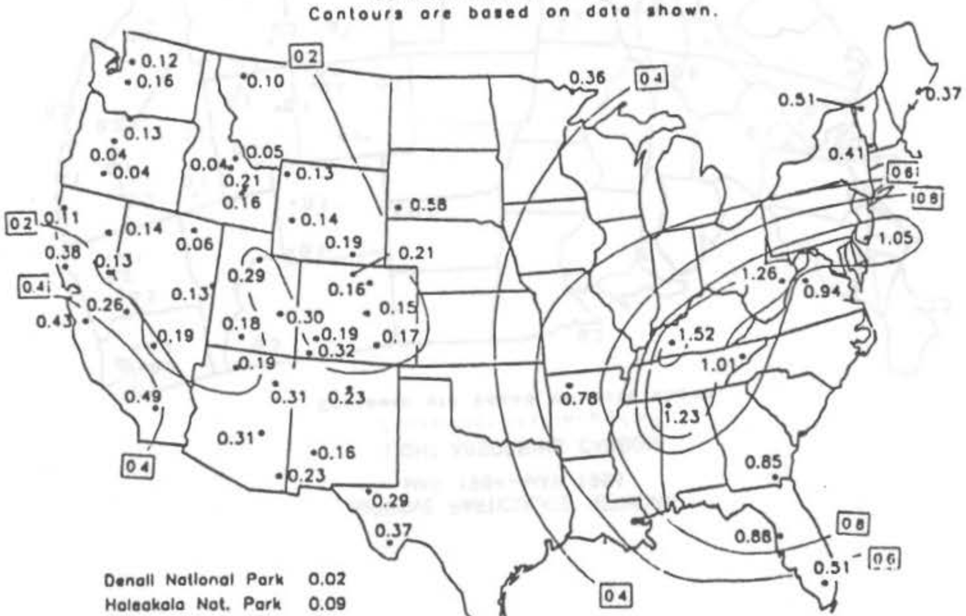
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.65
Haleakala Nat. Park	0.29
Virgin Islands NP	0.40

SELENIUM

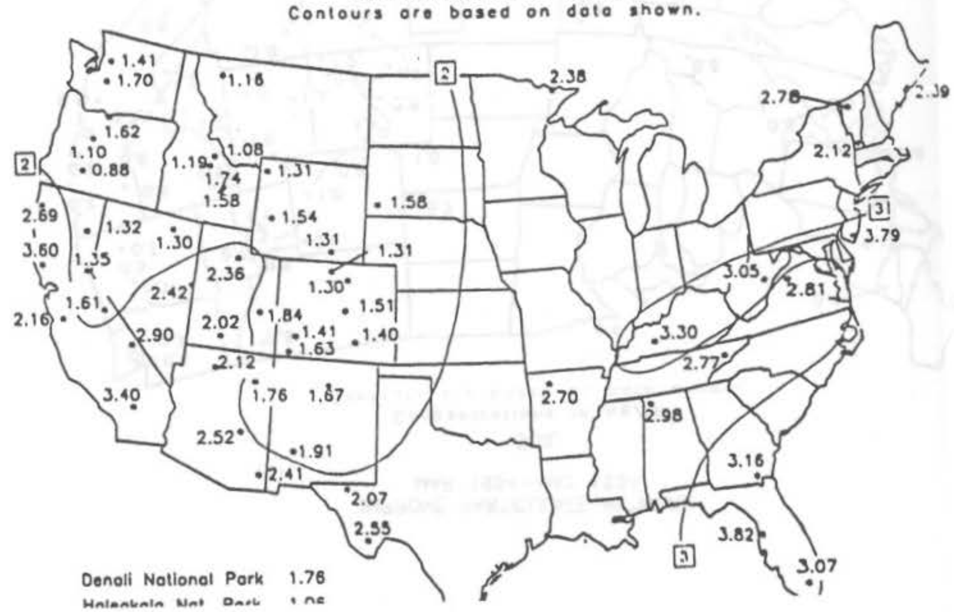
Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	0.02
Haleakala Nat. Park	0.09
Virgin Islands NP	

BROMINE

Concentrations in ng/m^3
Contours are based on data shown.



Denali National Park	1.76
Haleakala Nat. Park	

APPENDIX C

VEGETATION SPECIES LISTS

APPENDIX C-1. PLANTS IN CHASSAHOWITZKA NATIONAL WILDLIFE REFUGE
(updated 1982-1983)

Botanical Name	Common Name
Algae and Lichens	
Acetabularia crenulata	Venus Wine Glass
Anadyomene stellata	-
Batophora oerstedi	Chenille algae
Caulerpa paspaloides	-
C. prolifera	-
Chara hornemannii	Musk grass
Chondria sp.	-
Cladonia subtenuis	Deer moss
Digenia simplex	-
Halimeda gracilis	-
Laurencia sp.	-
Penicillus sp.	-
Polysiphonia ferulacea	-
Sargassum sp.	Sargassum
Udotea conglutinata	-
U. flabellum	-
Usnea strigosa	Old-man's Beard
Ferns and Fern Allies	
Acrostichum danaeifolium	Giant Leather Fern
Blechnum serrulatum	Swamp Fern
Osmunda regalis	Royal Fern
Phlebodium aureum	Golden Polypody
Polypodium polypodioides	Resurrection Fern
Pteridium aquilinum	Bracken Fern
Pteris vittata	Chinese Brake Fern
Thelypteris normalis	Wood Fern
Vittaria lineata	Shoestring Fern
Herbs and Vines	
Acacia farnesiana	Sweet Acacia
Aeschynomene viscidula	-
Agalinis fasciculata	-
A. maritima	-
A. purpurea	a False Foxglove
Amaranthus australis	Giant Amaranth

Ambrosia artemisiifolia	Ragweed
Ampelopsis arborea	Pepper Vine
Andropogon virginicus	Broomsedge
Anisostichus capreolata	Cross Vine
Aristida spiciformis	Bottlebrush Three-awn
A. stricta	Wire Grass
Asclepias tuberosa	Butterfly Weed
Aster carolinianus	Climbing Aster
A. subulatus	-
A.tortifolius	White-topped Aster
Astragalus obcordatus	a Milk-vetch
Aureolaria pectinata	-
Bacopa monnieri	Water-hyssop
Berchemia scandens	Rattan Vine
Berlandiera subacaulis	a Green-eyes
Borrichia frutescens	Sea Oxeye
Buchnera floridana	Blueheart
Campsis radicans	Trumpet Vine
Carex leptalea	Sedge
Carphephorus corymbosus	-
Cassia fasciculata	Partridge Pea
Cenchrus incertus	Coast Sandspur
Centrosema virginianum	Butterfly-pea
Ceratophyllum demersum	Coontail
Chamaesyce hyssopifolia	Hyssop Spurge
Chenopodium ambrosioides	Mexican Tea
Chrysopsis mariana	Golden Aster
Cirsium horridulum	Horrible Thistle
Cissus trifoliata	Marine Vine
Cladium jamaicense	Sawgrass
Clematis reticulata	Leather Flower
Clitoria mariana	Butterfly-pea
Cnidoscolus stimulosus	Tread Softly
Commelina erecta	Dayflower
Conyza canadensis var. - pusilla	Dwarf Horseweed
Coreopsis leavenworthii	-
Crinum americanum	Swamp Lily
Crotalaria mucronata	Smooth Crotalaria
C. purshii	Rattle-box, Rabbit-bells
C. rotundifolia	Rattle-box, Rabbit-bells
Croton argyranthemus	Croton
Crotonopsis linearis	Rushfoil
Cymodocea filiformis	Manatee Grass
Cynodon dactylon	Bermuda Grass
Cyperus polystachyos	Texas Sedge
C. retrorsus	Cylindric Sedge

C. sesquiflorus	-
Dalea carnea	-
Decumaria barbara	Wild Hydrangea
Desurainia pinnata	Tansy Mustard
Desmodium canum	Tick Clover
D. ciliare	-
D. floridanum	a Beggar-weed
D. triflorum	Sagotia Beggar-weed
Dichondra carolinensis	-
Dichromena colorata	White-top Sedge
Diodia sp.	-
Distichlis spicata	Salt Grass
Drosera leucantha	Sundew
Dyschoriste oblongifolia	-
Eichhornia crassipes	Water Hyacinth
Eleocharis albida	-
E. cellulosa	Gulf Spikerush
E. parvula	Dwarf Spikerush
Elephantopus tomentosus	Elephant's Foot
Elodea canadensis	American Elodea
Elytraria caroliniensis	-
Epidendrum conopseum	Green Fly Orchid
Equisetum hyemale	Horsetail
Erechtites hieracifolia	Fireweed
Erigeron canadensis	Horseweed
E. quercifolius	Southern Fleabane
Eriogonum tomentosum	Wild Buckwheat
Eryngium aromaticum	Fragrant Eryngium
E. baldwinii	-
Erythrina herbacea	Cherokee Bean
Eupatorium capillifolium	Dogfennel
E.serotinum	-
Euphorbia sp.	Spurge
Eustoma exaltatum	Catchfly-gentian
Fimbristylis castanea	-
F. puberula	Sand Sedge
Flaveria linearis	a Yellowtop
Froelichia floridana	Cottonweed
Fuirena scirpoidea	-
Galactia volubilis	Milk Pea
Galium tinctorum	Bedstraw
Gaura angustifolia	Southern Gaura
Gelsemium sempervirens	Yellow Jessamine
Gleditsia aquatica	Water Locust
Gnaphalium pensylvanicum	Cudweed

G. purpureum	Purple Cudweed
Gratiola hispida	-
Halodule wrightii	Shoalgrass
Halophila engelmannii	-
Haplopappus divaricatus	Scratch Daisy
Hedyotis corymbosa	-
H. procumbens	Fairy Footprints
Helenium amarum	Bitterweed
Helianthemum corymbosum	-
Hibiscus moscheutos	Rose Mallow
Hieracium magacephalon	-
Hydrilla verticillata	Hydrilla
Hydrocotyle umbellata	Marsh Pennywort
Hymenocallis latifolia	Spider Lily
Hypericum gentianoides	Pineweed
Indigofera hirsuta	Hairy Indigo
Ipomoea sagittata	Morning Glory
I. trichocarpa	Sharp-pod Morning Glory
Iris virginica	Blue Iris
Juncus roemerianus	Black Needlerush
J. scirpoides	-
Kosteletzkya virginica	Saltmarsh Mallow
Krameria lanceolata	Sandspur
Krigia virginica	Dwarf Dandelion
Lachnanthes caroliniana	Redroot
Lactuca graminifolia	-
Lepidium virginicum	Pepper Weed
Leptochloa fascicularis	-
Lespedeza hirta	Hairy Bush-clover
Liatris pauciflora	a Blazing Star
Limonium sp.	Sea Lavender
Linaria floridana	Florida Toad-flax
Linum floridanum	-
Lippia nodiflora	Match-heads
Lobelia paludosa	-
Lonicera japonica	Honeysuckle
L. sempervirens	Coral Honeysuckle
Ludwigia maritima	-
Lyonia palustris	-
Lythrum lineare	Loosestrife
Mecardonia acuminata(????)	-
Medicago lupulina	Black Medic (???)
Melanthera nivea	-
Mikania scandens	Climbing Hemp Vine
Mitchella repens	Partridge Berry
Mitreola petiolata	Miterwort

Myriophyllum spicatum	Eurasian Watermilfoil
Najas guadalupensis	Southern Naiad
Neptunia pubenscens	-
Oenothera laciniata	Cutleaf Evening-primrose
Oxalis stricta	Yellow Wood Sorrel
Oxypolis filiformis	Water Dropwort
Palafoxia integrifolia	-
Panicum commutatum	Variable Panicum
P. hemitomon	Maidencane
P. tenue	White-edge Panicum
P. virgatum	Switchgrass
Parthenocissus floridanum	Florida Paspalum
P. notatum	Bahia Grass
Phlox nivalis	Trailing Phlox
Physalis sp.	Ground Cherries
Phytolacca americana	Pokeweed
Piriqueta caroliniana	-
Pistia stratiotes	Water Lettuce
Pityopsis graminifolia	Silk-grass
Pluchea odorata	a Marsh Fleabane
P. rosea	-
Polygala lutea	Candyweed
P. nana	Bachelor's Button
Polygonella gracilis	Wireweed
Polygonum hydropiperoides	Smartweed
Polymnia uvedalia	Bear's Foot
Polypremum procumbens	Rust Weed
Pontederia cordata	Pickerel Weed
Portulaca amilis	-
Potamogeton pusillus	Slender Pondweed
Psoralea lupinellus	Scurf-pea
Pterocaulon pycnostachyum	Black Root
Pyrrhopappus carolinianus	False-dandelion
Raphanus raphanistrum	Wild Radish
Rhexia mariana	Pale Meadow Beauty
Rhus radicans (Toxicodendron radicans)	Poison Ivy
Rhynchospora fascicularis	Clustered Beakrush
R. plumosa	a Beakrush
Richardia brasiliensis	Brazilian Pusley
Rudbeckia hirta	Blackeyed Susan
Ruellia caroliniensis	Wild Petunia
Rumex hastatulus	Heartwing Sorrel
Ruppia maritima	Widgeon Grass
Sabatia brevifolia	-
Sabatia stellaris	-
Sacciolepis striata	American Cupscale

Saggittaria lancifolia	Arrowroot
Salicornia bigelovii	Annual Glasswort
S. perennis	Glasswort
Samolus parviflorus	Water-pimpernel
Saururus cernuus	Lizard Tail
Schrankia microphylla	Sensitive Brier
Scirpus californicus	Southern Bulrush
S. olneyi	Three-square Bulrush
S. robustus	Saltmarsh Bulrush
S. validus	Soft-stem Bulrush
Scutellaria arenicola	Skullcap
S. integrifolia	Rough Skullcap
Senecio glabellus	Butterweed
Setaria geniculata	Foxtail
Silphium asteriscus	a Rosin-weed
Smilax auriculata	Laurel-leaved Greenbrier
S. bona-nox	Catbrier
S. glauca	Glaucous Greenbrier
S. lanceolata	Lanceleaf Greenbrier
S. laurifolia	Laurel Greenbrier
S. pumila	Hairy Greenbrier
S. walteri	Red-berry Greenbrier
Solanum americanum	Nightshade
S. carolinense	Nightshade
S. nigrum	Nightshade
Solidago sempervirens	Seaside Goldenrod
S. tortifolia	a Goldenrod
Sonchus oleraceus	Sow Thistle
Sorghastrum secundum	Lopsided Indiangrass
Sorghum helepense	Johnson Grass
Spartina alterniflora	Smooth Cordgrass
S. patens	Cordgrass
Spermolepis divaricata	-
Spiranthes sp.	-
Stylisma patens subsp. angustifolia	-
Suaeda linearis	Sea Blite
Syngonanthus flavidulus	Bantam-button
Tephrosia chrysophylla	a Hoary-pea
Thalassia testudinum	Turtle Grass
Thalia geniculata	-
Tillandsia usneoides	Spanish Moss
Trilisa odoratissima	Deer's Tongue
Triodanis perfoliata	Venus's Looking-glass
Triticum aestivum	Wheat
Typha domingensis	Cattail
T. latifolia	Cattail

Utricularia subulata	a Bladderwort
Villisneria americana	Tapegrass
Verbesina virginica	Frost-weed
Veronia angustifolia	Narrow-leafed Ironweed
Vitis aestivalis	Bird Grape
V. munsoniana	Muscadine Grape
V. rotundifolia	-
Wahlenbergia marginata	-
Xyris caroliniana	Yellow-eyed-grass
X. elliottii	Yellow-eyed-grass
X. flabeliformis	Yellow-eyed-grass
Zannichellia palustris	Horned Pondweed

Shrubs and Trees

Acer rubrum	Red Maple
Aesculus pavia	Red Buckeye
Alnus serrulata	Alder
Amorpha herbacea	Lead Plant
Aralia spinosa	Devil's Walking Stick
Aronia arbutifolia	Red Chokeberry
Asimina longiflora	Slender leaf Pawpaw
A. parviflora	Small-fruited Pawpaw
A. speciosa	Hairy Pawpaw
Avicennia nitida (germinans)	Black Mangrove
Baccharis angustifolia	False Willow
B. halimifolia	Saltbush
Befaria racemosa	Tarflower
Borrichia frutescens	Sea Ox-eye
Callicarpa americana	American Beauty Berry
Carpinus caroliniana	Blue Beech
Carya glabra	Pignut Hickory
Castanea alnifolia	Chinkapin
Ceanothus americanus	New Jersey Tea
Celtis sp.	Hackberry
Cephalanthus occidentalis	Buttonbush
Ceratiola ericoides	Rosemary
Cercis canadensis	Redbud
Chionanthus virginicus	Fringe Tree
Chrysobalanus oblongifolius	Gopher Apple
Cornus foemina	Swamp Dogwood
Crataegus marshallii	Parsley Haw
C. uniflora	One-flowered Haw
Cyrilla racemiflora	White Titi
Decondon verticullatus	Water Willow

Diospyros virginiana	Persimmon
Euonymus americanus	Hearts-a-busting
Fraxinus caroliniana	Carolina Ash
Gaylussacia dumosa	Dwarf Huckleberry
G. frondosa	Dangleberry
Gordonia lasianthus	Loblolly Bay
Hamamelis virginiana	Witch-hazel
Hypericum hypericoides	St. Andrew's Cross
H. stans	St. Peter's Wort
H. tetrapetalum	St. John's Wort
Ilex ambigua	-
I. cassine	Dahoon Holly
I. coriacea	Large Galberry
I. glabra	Galberry
I. vomitoria	Yaupon Holly
Itea virginica	Virginia Willow
Iva frutescens	Marsh Elder
Juniperus silicicola	Southern Red Cedar
Kalmia hirsuta	-
Languncularia racemosa	White Mangrove
Lantana camara	Lantana
Leucothoe racemosa	Fetter-bush
Liquidambar styraciflua	Sweetgum
Lycium carolinianum	Christmas Berry
Lyonia ferruginea	Staggerbush
L. fruticosa	Staggerbush
L. lingustrina	Male-berry
L. lucida	Fetter-bush
Magnolia grandiflora	Southern Magnolia
M. virginiana	Sweetberry
Morus rubra	Red Mulberry
Myrica cerifera	Wax Myrtle
M. pusilla	Dwarf Wax Myrtle
Nyssa biflora	Blackgum
Opuntia drummondii	Prickly Pear Cactus
Osmanthus americanus	Wild Olive
Ostrya virginiana	Hophornbeam
Persea borbonia	Redbay
Piloblephis rigida	Pennyroyal
Pinus elliottii	Slash Pine
P. palustris	Longleaf Pine
P. taeda	Loblolly Pine
Prunus serotina	Black Cherry
Psychotria nervosa	Wild Coffee
Quercus chapmanii	Chapman Oak
Q. geminata	Sand-live Oak

Q. incana	Bluejack Oak
Q. laevis	Turkey Oak
Q. laurifolia	Laurel Oak
Q. minima	Dwarf Live Oak
Q. michauxii	Swamp Chestnut Oak
Q. myrtifolia	Myrtle Oak
Q. pumila	Running Oak
Q. shumardii	Shumard Oak
Q. virginiana	Live Oak
Rhamnus caroliniana	Buckthorn
Rhaphidophyllum hystrix	Needle Palm
Rhizophora mangle	Red Mangrove
Rhododendron surrelatum	Swamp Azalea
Rhus copallina	Winged Sumac
Rosa palustris	Swamp Rose
Rubus cuneifolius	Blackberry
R. trivialis	Dewberry
Sabal minor	Blue Palmetto
S. palmetto	Cabbage Palm
Salix caroliniana	Coastal Plain Willow
Sambucus simpsonii	-
Schinus terebinthifolius	Brazilian Pepper
Sebastiania fruticosa	-
Serenoa repens	Saw Palmetto
Styrax grandifolia	Bigleaf Snowbell
Symplocus tinctoria	Sweet Leaf
Taxodium ascendens	Pond Cypress
T. distichum	Bald Cypress
Tilia floridana	Florida Basswood
Ulmus alata	Winged Elm
U. americana	American Elm
Vaccinium arboreum	Tree Sparkleberry
V. caesium	Deerberry
V. myrsinites	Evergreen Blueberry
Viburnum nudum	Possum-haw Viburnum
V. obovatum	Walter Viburnum
V. rufidulum	Rusty Black-haw
V. scabrellum	-
Ximenia americana	Tallow Wood
Yucca aloifolia	Spanish Bayonet
Y. filamentosa	Bear Grass
Zamia integrifolia	Coontie
Zanthoxylum americanum	Toothache Tree

List compiled by Stuart Marcus (1982-83).

Identifications by:

- Dr. David W. Hall
- Dr. E.S. Ford
- Walter O. Stieglitz
- Edward Collinsworth
- Stuart Marcus
- Dennis Widner
- John Beckner
- Barry Cook
- Various other refuge personnel and visiting botanists

Most botanical nomenclature based on Radford (1974) and Gray (8th Edition).

APPENDIX C-2. LICHENS IN CHASSAHOWITZKA NATIONAL WILDLIFE REFUGE (collected and identified 1994)

Anthracothecium leucostomum (Ach.) Malme
Arthonia mesoleuca Nyl.
Arthonia sp.
Arthothelium interveniens (Nyl.) Zahlbr.
Brigantiaea leucoxantha (Sprengel) R. Sant.& Hafellner
Buellia punctata (Hoffm.) Massal.
Buellia sp.
Calicium cf. leucochlorum Tuch.
Canoparmelia caroliniana (Nyl.) Elix. & Hale
Canoparmelia cryptochlorophaea (Hale) Elix & Hale
Chiodecton sanguineum (Swartz) Vain.
Chiodecton montagnaei Tuck.
Cladonia sp.
Crocynia pxxinoides Nyl.
Dirinaria aegialita (Ach.) Moore
Dirinaria picta (Swartz) Clements & Shear
Dirinaria sp.
Glyphis cicatricosa Ach.
Graphis afzelii Ach.
Gyrostomum scyphuliferum (Ach.) E. Fries
Haematomma puniceum (Sm.ex Ach.) Massal.
Heteroderma albicans (Pers.) Swinscow & Krog.
Heterodermia caesarettiana (Massal.) Trev.
Heterodermia galatactophylla (Tuck.) Culb.
Heterodermia sp.
Lecanora sp.
Leptogium austroamericanum (Malme) Dodge
Leptogium azureum (Swartz.) Mont.
Leptogium cyanescens (Rabenh.) Koerber
Leptogium marginellum (Swartz.) S.Gray
Leptogium milligranum Sierk
Letrouitia vulpina (Tuck.) Hafellner & Bellem.
Lobaria tenuis Vain.
Melanotheca anomala (Ach.) Malme
Myriotrema reclusum (Krempelh.) Hale
Ocellularia americana Hale
Parmotrema crinitum (Ach.) Hale
Parmotrema cristiferum (Tayl.) Hale
Parmotrema dilatatum (Vain.) Hale
Parmotrema eudosulophureum (Hillman) Hale
Parmotrema michauxianum (Zahlbr.) Hale
Parmotrema perforatum (Jacq.) Massal.

Parmotrema praesorediosum (Nyl.) Hale
Parmotrema rampoddeuse (Nyl.) Hale
Parmotrema reticulatum (Tayl.) Choisy
Parmotrema tinctorum (Nyl.) Hale
Parmotrema ultralucens (Krog.) Hale
Pertusaria sp.
Physcia atrostriata (Moberg)
Pyrenula cruenta (Mont.) Vain.
Pyrenula marginata (Hook.) in Kurth
Pyrrhospora varians (Ach.) R.C. Harris
Pyxine caesioprinosa (Nyl.) Imsh.
Pyxine cocoes (Swartz.) Nul
Pyxine eschweileri (Tuck.) Vain.
Ramalina americana Hale
Ramalina sp.
Rimelia reticulata (Tayl.) Hale & Fletcher
Rimelia subisidiosa (Muell. Arg.) Hale(Nyl.) R.C. & Fletcher
Sarcographa tricosa (Ach.) Mull. Arg.
Trypethelium sp.
Trypethelium aenum (Eschw.) Zahlbr.
Trypethelium mastordeum (Ach.) Ach.
Trypethelium nitidiusculum Harris
Trypethelium ochroleucum (Eschw.) Nyl.
Trypethelium tropicum (Ach.) Muell. Arg.
Usnea mutabilis Stirton
Usnea sp.
Usnea strigosa

Identification by Dr. Dana Griffin, 1994.

APPENDIX D

WILDLIFE SPECIES LISTS

APPENDIX D-1. MAMMALS IN CHASSAHOWITZKA NATIONAL WILDLIFE REFUGE

1 - Confirmed existence
2 - Probably exist, but unconfirmed
3 - Remote chance of existence, also unconfirmed
4 - Accidental occurrence

	Common Name	Genus/Species
1	Opossum	Didelphis marsupialis
1	Florida Black Bear	Ursus americanus floridanus
1	Raccoon	Procyon lotor
1	Longtail Weasel	Mustela frenata
1	Florida Mink	Mustela vison lutensis
1	River Otter	Lutra canadensis
1	Striped Skunk	Mephitis mephitis
1	Gray Fox	Urocyon cinereoargenteus
1	Bobcat	Lynx rufus
1	Fox Squirrel	Sciurus niger
1	Eastern Gray Squirrel	Sciurus carolinensis
1	Southern Flying Squirrel	Glaucomys volans
1	Southeastern Pocket Gopher	Geomys pinetis
1	Eastern Harvest Mouse	Reithrodontomys humulis
1	Cotton Mouse	Peromyscus gossypinus
1	Eastern Woodrat	Neotoma floridana
1	Rice Rat	Oryzomys palustris
1	Hispid Cotton Rat	Sigmodon hispidus
1	House Mouse	Mus musculus
1	Eastern Cottontail	Sylvilagus floridanus
1	Marsh Rabbit	Sylvilagus palustris
1	Wild Boar	Sus scrofa
1	Whitetail Deer	Odocoileus virginianus
1	Armadillo	Dasypus novemcinctus
1	Manatee	Trichechus manatus
1	Mississippi Myotis	Myotis austroriparius
1	Atlantic Bottlenose Dolphin	Tursiops truncatus
1	Seminole	Lasiurus seminolus
2	Shorttail Shrew	Blarina brevicauda
2	Least Shrew	Cryptotis parva
2	Homosassa Shrew	Sorex longirostris eionis
2	Eastern Mole	Scalopus aquaticus
2	Eastern Pipistrel	Pipistrellus subflavus
2	Eastern Yellow Bat	Lasiurus intermedius
2	Evening Bat	Nycticeius humeralis
2	Spotted Skunk	Spilogale putorius

2	Florida Mouse	Peromyscus floridanus
2	Pine Vole	Pitymys pinetorum
3	Southeastern Shrew	Sorex longirostris longirostris
3	Red Bat	Lasiurus borealis
3	Hoary Bat	Lasiurus cinereus
3	Big Brown Bat	Eptesicus fuscus
3	Southeastern Big-eared Bat	Plecotus rafinesquii
3	Mexican Freetail Bat	Tadarida brasiliensis
3	Golden Mouse	Peromyscus nuttalli
3	Florida Panther	Felis concolor coryi
3	Coyote	Canis latrans
4	Red Fox	Vulpes fulva

APPENDIX D-2. AMPHIBIANS AND REPTILES IN CHASSAHOWITZKA NATIONAL WILDLIFE REFUGE

1 - Confirmed existence
2 - Probably exist, but unconfirmed
3 - Remote chance of existence, also unconfirmed

Salamanders

Common Name	Genus/Species
2 Two-toed Amphiuma	Amphiuma means
2 Slimy Salamander	Plethodon glutinosus glutinosus
2 Dwarf Salamander	Eurycea quadridigitata
2 Eastern Lesser Siren	Siren intermedia intermedia
2 Greater Siren	Siren lacertina
3 One-toed Amphiuma	Amphiuma pholeter
3 Striped Newt	Notophthalmus perstriatus
3 Mole Salamander	Ambystoma talpoideum
3 Eastern Tiger Salamander	Ambystoma tigrinum tigrinum
3 Rusty Mud Salamander	Pseudotriton montanus floridanus
3 Southern Dusky Salamander	Desmognathus auriculatus
3 Peninsula Newt	Notophthalmus viridescens piaropicola
3 Gulf Hammock Dwarf Siren	Pseudobranchus striatus lustricolus

Frogs

1 Oak Toad	Bufo quercicus
1 Southern Toad	Bufo terrestris
1 Green Treefrog	Hyla cinerea
1 Squirrel Treefrog	Hyla squirella
1 Bullfrog	Rana catesbeiana
1 Southern Leopard Frog	Rana utricularia
1 Florida Cricket Frog	Acris gryllus dorsalis
1 Little Grass Frog	Limnaoedus ocularis
1 Eastern Narrow-mouthed Toad	Gastrophryne carolinensis
1 Barking Treefrog	Hyla gratiosa
1 Florida Gopher Frog	Rana areolata aesopus
2 Eastern Spadefoot	Scaphiopus holbrooki holbrooki
2 Ornate Chorus Frog	Pseudacris ornata
2 Greenhouse Frog	Eleutherodactylus planirostris
2 Pig Frog	Rana grylio
3 Southern Chorus Frog	Pseudacris nigrita nigrita
3 Florida Chorus Frog	Pseudacris nigrita verrucosa
3 Southern Spring Peeper	Hyla crucifer bartramiana

3	Pine Woods Treefrog	Hyla femoralis
3	Bronze Frog	Rana clamitans clamitans
3	River Frog	Rana heckscheri

Turtles

1	Gulf Coast Box Turtle	Terrapene carolina major
1	Ornate Diamondback Terrapin	Malaclemys terrapin macrospilota
1	Gopher Tortoise	Gospherus polyphemus
1	Atlantic Green Turtle	Chelonia mydas mydas
1	Atlantic Loggerhead	Caretta caretta caretta
1	Atlantic Ridley	Lepidochelys kempi
1	Florida Box Turtle	Terrapene carolina bauri
1	Alligator Snapping Turtle	Macroclemys temmincki
1	Common Snapping Turtle	Chelydra serpentina
1	Striped Mud Turtle	Kinosternon bauri palmarum
1	Suwannee Cooter	Chrysemys concinna suwanniensis
1	Peninsula Cooter	Chrysemys floridana peninsularis
1	Eastern Chicken Turtle	Dierochelys reticularia reticularia
2	Stinkpot	Sternotherus odoratus
2	Atlantic Hawksbill	Eretmochelys imbricata imbricata
2	Florida Softshell	Trionyx ferox
3	Florida Mud Turtle	Kinosternon subrubrum steindachneri
3	Loggerhead Musk Turtle	Sternotherus minor minor
3	Florida Red-bellied Turtle	Chrysemys nelsoni

Crocodilians

1	American Alligator	Alligator mississippiensis

Lizards

1	Green Anole	Anolis carolinensis carolinensis
1	Six-lined Racerunner	Cnemidophorus sexlineatus sexlineatus
1	Ground Skink	Leiolopisma laterale
1	Southeastern Five-lined Skink	Eumeces inexpectatus
1	Broad-headed Skink	Eumeces laticeps
2	Southern Fence Lizard	Sceloporus undulatus undulatus
2	Eastern Glass Lizard	Ophisaurus ventralis
2	Eastern Slender Glass Lizard	Ophisaurus attenuatus longicaudus
2	Island Glass Lizard	Ophisaurus compressus
2	Peninsula Mole Skink	Eumeces egregius onocrepis
3	Cuban Brown Anole	Anolis sagrei sagrei

3	Five-Lined Skink	Eumeces fasciatus

Snakes

1	Southern Ring-neck Snake	Diadophis punctatus punctatus
1	Southern Black Racer	Coluber constrictor priapus
1	Eastern Indigo Snake	Drymarchon corais couperi
1	Corn Snake	Elaphe guttata guttata
1	Florida Crowned Snake	Tantilla relicta neilli
1	Blue-striped Ribbon Snake	Thamnophis sauritus nitae
1	Blue-striped Garter Snake	Thamnophis sirtalis similis
1	Eastern Coral Snake	Micrurus fulvius fulvius
1	Florida Cottonmouth	Agkistrodon piscivorus conanti
1	Eastern Diamondback Rattlesnake	Crotalus adamanteus
1	Dusky Pigmy Rattlesnake	Sistrurus miliarius barbouri
1	Florida Kingsnake	Lampropeltis getulus floridana

APPENDIX D-3. BIRDS IN CHASSAHOWITZKA NATIONAL WILDLIFE REFUGE (updated 1983)

Common Loon
Pied-billed Grebe
Horned Grebe
American White Pelican
Brown Pelican
Double-Crested Cormorant
Anhinga
Magnificent Frigatebird
American Bittern
Least Bittern
Great Blue Heron
Great Egret
Snowy Egret
Little Blue Heron
Tricolored (Louisiana) Heron
Cattle Egret
Green-backed (Green) Heron
Black-crowned Night-Heron
Yellow-crowned Night-Heron
White Ibis
Wood Stork
Tundra (Whistling) Swan
Greater White-fronted Goose
Snow Goose
Wood Duck
Green-winged Teal
American Black Duck
Mottled Duck
Mallard
Northern Pintail
Blue-winged Teal
Northern Shoveler
Gadwall
American Wigeon
Canvasback
Redhead
Ring-necked Duck
Greater Scaup
Common Goldeneye
Bufflehead
Hooded Merganser
Common Merganser
Red-breasted Merganser
Ruddy Duck
Black Vulture
Turkey Vulture
Osprey
American Swallow-tailed Kite
Bald Eagle
Northern Harrier (Marsh Hawk)
Sharp-shinned Hawk
Cooper's Hawk
Red-shouldered Hawk
Broad-winged Hawk
Short-tailed Hawk
Red-tailed Hawk
American Kestrel
Merlin
Peregrine Falcon
Wild Turkey
Northern Bobwhite
Yellow Rail
Black Rail
Clapper Rail
King Rail
Virginia Rail
Sora
Purple Gallinule
Common (Gallinule) Moorhen
American Coot
Limpkin
Sandhill Crane
Black-bellied Plover
Piping Plover
Killdeer
Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Willet
Spotted Sandpiper
Whimbrel
Marbled Godwit
Ruddy Turnstone
Red Knot
Sanderling
Semipalmated Sandpiper

Western Sandpiper
Least Sandpiper
Pectoral Sandpiper
Dunlin
Stilt Sandpiper
Short-billed Dowitcher
Long-billed Dowitcher
Common Snipe
American Woodcock
Laughing Gull
Bonaparte's Gull
Ring-billed Gull
Herring Gull
Caspian Tern
Royal Tern
Sandwich Tern
Common Tern
Forster's Tern
Least Tern
Black Tern
Black Skimmer
Mourning Dove
Common Ground-Dove
Budgerigar
Black-billed Cuckoo
Yellow-billed Cuckoo
Common Barn-Owl
Eastern Screech-Owl
Great Horned Owl
Barred Owl
Short-eared Owl
Common Nighthawk
Chuck-will's widow
Whip-poor-will
Chimney Swift
Ruby-throated Hummingbird
Belted Kingfisher
Red-headed Woodpecker
Red-bellied Woodpecker
Yellow-bellied Sapsucker
Downy Woodpecker
Hairy Woodpecker
Northern Flicker
Pileated Woodpecker
Eastern Wood-Pewee
Acadian Flycatcher

Eastern Phoebe
Great Crested Flycatcher
Eastern Kingbird
Gray Kingbird
Purple Martin
Tree Swallow
Northern Rough-winged Swallow
Barn Swallow
Blue Jay
American Crow
Fish Crow
Carolina Chickadee
Tufted Titmouse
White-breasted Nuthatch
Brown-headed Nuthatch
Brown Creeper
Carolina Wren
House Wren
Winter Wren
Sedge (Short-billed Marsh) Wren
Marsh (Long-billed Marsh) Wren
Golden-crowned Kinglet
Ruby-crowned Kinglet
Blue-gray Gnatcatcher
Eastern Bluebird
Veery
Gray-cheeked Thrush
Swainson's Thrush
Hermit Thrush
Wood Thrush
American Robin
Gray Catbird
Northern Mockingbird
Brown Thrasher
Water Pipit
Cedar Waxwing
Loggerhead Shrike
European Starling
White-eyed Vireo
Solitary Vireo
Yellow-throated Vireo
Red-eyed Vireo
Orange-crowned Warbler
Northern Parula
Yellow Warbler
Magnolia Warbler

Cape May Warbler
Black-throated Blue Warbler
Yellow-rumped Warbler
Black-throated Green Warbler
Yellow-throated Warbler
Pine Warbler
Prairie Warbler
Palm Warbler
Blackpoll Warbler
Black-and-white Warbler
American Redstart
Prothonotary Warbler
Worm-eating Warbler
Ovenbird
Northern Waterthrush
Louisiana Waterthrush
Connecticut Warbler
Common Yellowthroat
Hooded Warbler
Yellow-breasted Chat
Summer Tanager
Scarlet Tanager
Northern Cardinal
Rose-breasted Grosbeak
Blue Grosbeak
Indigo Bunting
Painted Bunting
Rufous-sided Towhee
Bachman's Sparrow
Chipping Sparrow
Field Sparrow
Vesper Sparrow
Savannah Sparrow
Grasshopper Sparrow
Henslow's Sparrow
Le Conte's Sparrow
Sharp-tailed Sparrow
Seaside Sparrow
Song Sparrow
Swamp Sparrow
White-throated Sparrow
Dark-eyed (Northern) Junco
Bobolink
Red-winged Blackbird
Eastern Meadowlark
Rusty Blackbird
Boat-tailed Grackle
Common Grackle
Brown-headed Cowbird
Northern Oriole
American Goldfinch
House Sparrow