Air Quality and Air Quality Effects in National Parks: AQRV and AQ Research Findings			
Park	**Title**	**Project Summary/Findings**	**Citation**
N and S Deposition and Effects			
Acadia National Park (ACAD)	Acidity of twelve northern New England (USA) lakes in recent centuries	Sediment cores from 12 acidic lakes (none on Mount Desert Island) in northern New England were studied to assess acidity and alkalinity. Ponds on Mount Desert Island and elsewhere were used for calibration in this study.	Davis, R. B., D. S. Anderson, S. A. Norton and M. C. Whiting. 1994. Acidity of twelve northern New England (USA) lakes in recent centuries. Journal of Paleolimnology. 12:103-154.
Acadia National Park (ACAD)	Detection and quantification of changes in membrane-associated calcium in red spruce saplings exposed to acid fog	Researchers investigated the effect of fog on cell membrane-associated calcium (mCa) of leaf mesophyll cells. In both years, mean mCa concentrations were significantly less in needles exposed to acid fog than in needles exposed to distilled-water fog or in untreated needles. Investigators found acid deposition induced calcium leaching from the membranes of photosynthetic mesophyll cells. Exposure to distilled-water fog also led to reductions in mCa in young needles, suggesting that water films on needle surfaces can induce losses by diffusion between the needle interior and surface. Field data obtained from red spruce trees at two sites in Maine showed that low mCa concentrations in needles were associated with exposure to acid fog.	Jiang, M. & Jagels, R. (1999) Detection and quantification of changes in membrane-associated calcium in red spruce saplings exposed to acid fog. Tree Physiology, 19, 909-916.
Acadia National Park (ACAD)	Effects of nitrogen enrichment, wildfire, and harvesting on forest-soil carbon and nitrogen	Soils at three paired watershed in Maine were investigated as case studies of experimentally elevated N deposition, wildfire, and whole-tree harvesting. Fifty years after wildfire at Acadia National Park, the burned watershed with hardwood regeneration had significantly lower forest-floor C and N concentrations than the reference watershed dominated by a softwoods. Forest-floor C and N pools were lower in the burned watershed compared with the reference. All perturbations studied were associated with lower forest-floor C pools.	Parker, J. L., Fernandez, I. J., Rustad, L. E. & Norton, S. A. (2002) Soil organic matter fractions in experimental forested watersheds. Water Air and Soil Pollution, 138, 101-121.
Acadia National Park (ACAD)	Elemental mass balances, and episodic and ten-year changes in the chemistry of surface water, Acadia National Park, Maine : final report	Water quality data collected in 1988-90 at Acadia National Park were compared to data from the same sites collected in 1982-84, to look for changes in ANC and SO4 and the factors that have contributed to this, including natural acids from soil solutions, and H2SO4 and HNO3 from acid precipitation. Researchers recommend that long term monitoring of water and chemistry be initiated at one or two permanent stream stations at Acadia. Using available National Atmospheric Deposition Program (NADP) records and other site-specific deposition data, such monitoring would provide data on elemental cycling of nutrients and water in forested ecosystems. These data are essential in determining long term response to changes in the atmospheric chemical environment, changes in the regional climate, and interactions between the two.	Heath, R. H., J. S. Kahl, S. A. Norton and W. F. Brutsaert. 1994. Elemental mass balances, and episodic and ten-year changes in the chemistry of surface water, Acadia National Park, Maine : final report. United States. National Park Service. North Atlantic Region, Boston. Technical Report NPS/NAROSS/NRTR-93/16.
Acadia National Park (ACAD)	Empirical modeling of atmospheric deposition in mountainous landscapes	The researchers developed an empirical modeling approach to predict total deposition as a function of landscape features at Acadia and Great Smoky Mountains National Parks (USA). A GIS-relevant statistical nitrogen (N) and sulfur (S) deposition model (LandMod) was used to create park-wide maps of total deposition, scaled to wet and dry deposition data from the closest national network monitoring stations.	Weathers, K.C., Simkin, S.M., Lovett, G.M., & Lindberg, S.E. (2006) Empirical modeling of atmospheric deposition in mountainous landscapes. Ecological Applications, 16, 1590-1607.
Acadia National Park (ACAD)	Forest canopy uptake of atmospheric nitrogen deposition at eastern US conifer sites: Carbon storage implications?	Dry deposition, wet deposition and throughfall (TF) measurements, at a spruce fir forest in central Maine were used to estimate the effect of atmospherically deposited nitrogen (N) uptake on forest carbon storage. Using nitric acid and particulate N as well as TF ammonium and nitrate data, the growing season (May-October) net canopy uptake of atmospheric N deposition was found to be 1-5 kg N ha(-1). The ratio of growing season net canopy N uptake to that of recycled root N uptake (10-30 kg N ha(-1) during the growing season) suggests a substantial modification of the N cycle at this Maine spruce fir forest over the past decade. The growing season 1-5 kg ha(-1) canopy N uptake may induce an enhanced annual carbon (C) storage of 250-1350 kg C ha(-1) yr(-1).	Sievering, H., Fernandez, I., Lee, J., Hom, J. & Rustad, L. (2000) Forest canopy uptake of atmospheric nitrogen deposition at eastern US conifer sites: Carbon storage implications? Global Biogeochemical Cycles, 14, 1153-1159.
Acadia National Park (ACAD)	Forest vegetation monitoring and foliar chemistry of red spruce and red maple at Acadia National Park in Maine	The USDA Forest Service Forest Health Monitoring (FHM) program indicators, including forest mensuration, crown condition classification, and damage and mortality indicators were used in the Cadillac Brook and Hadlock Brook watershed forests at Acadia National Park (ANP). Overall, the forests at these ANP watersheds were healthy with a low percentage (<= 22%) of trees showing symptoms of damage. Foliar nitrogen (N) concentrations were significantly higher in *P. rubens* trees growing in Hadlock Brook watershed. Foliar aluminum (Al) concentrations were significantly higher in *A. rubrum* growing in Hadlock Brook watershed. Foliar calcium (Ca) and manganese (Mn) concentrations, on the other hand, were significantly lower in Hadlock Brook watershed for both species. Foliar potassium (K) was significantly higher for *P. rubens* growing in Hadlock Brook. The higher foliar N concentrations as well as higher foliar concentrations of Ca and Al might indicate early stages of N saturation and acidification in Hadlock Brook watershed.	Wiersma, G. B., Elvir, J. A. & Eckhoff, J. D. (2007) Forest vegetation monitoring and foliar chemistry of red spruce and red maple at Acadia National Park in Maine. Environmental Monitoring and Assessment, 126, 27-37.
Acadia National Park (ACAD)	MECHANISMS OF EPISODIC ACIDIFICATION IN LOW-ORDER STREAMS IN MAINE, USA	The article discusses five factors contributing to episodic depressions of pH and acid neutralizing capacity in low order streams in Maine: increases in relative or absolute SO4, increases in absolute NO3, increases in organic acidity, salt effect generated acidity from soil solution, and dilution. The chemistry of individual precipitation events is irrelevant to the generation of acidic episodes, except those caused by high loading of neutral salts in coastal regions. Increases in discharge, but not necessarily in dilution of solutes, in combination with the chronically high SO4 from atmospheric deposition, provide the antecedent chemical conditions for episodic acidification. Differences in antecedent moisture conditions determine the processes that control output of either ANC or acidifying agents to aquatic systems.	Kahl, J. S., Norton, S. A., Haines, T. A., Rochette, E. A., Heath, R. H. & Nodvin, S. C. (1992) MECHANISMS OF EPISODIC ACIDIFICATION IN LOW-ORDER STREAMS IN MAINE, USA. Environmental Pollution, 78, 37-44.
Acadia National Park (ACAD)	RECENT TRENDS IN THE ACID-BASE STATUS OF SURFACE WATERS IN MAINE, USA	1982-1989 lake chemistry data is analyzed for changes in Acid Neutralizing Capacity (ANC) and sum of base cations. Acadia National Park lakes showed a slight increase in ANC, and a decrease in the sum of base cations. Presents NADP precipitation data for 1982-1989: pH, conductance, and eight other factors	Kahl, J. S., Haines, T. A., Norton, S. A. & Davis, R. B. (1993) RECENT TRENDS IN THE ACID-BASE STATUS OF SURFACE WATERS IN MAINE, USA. Water Air and Soil Pollution, 67, 281-300.

Acadia National Park (ACAD)	SCALING UP TO THE LANDSCAPE: EMPIRICAL MODELING OF ATMOSPHERIC DEPOSITION IN MOUNTAINOUS LANDSCAPES: A final report to the National Park Service – PMIS #75187 Acadia and Great Smoky Mountain National Parks	The project was designed to fill a critical gap in our ability to model atmospheric deposition to heterogeneous terrains. The authors developed an empirical modeling, LANDMod to update deposition maps to reflect changes in reference (monitoring station) deposition and/or to reflect changes in vegetation. Work published as Weathers et al. 2006.	Weathers, K. C., S. M. Simkins, P. M. Lovett and S. E. Lindberg. 2007. SCALING UP TO THE LANDSCAPE: EMPIRICAL MODELING OF ATMOSPHERIC DEPOSITION IN MOUNTAINOUS LANDSCAPES: A final report to the National Park Service – PMIS #75187 ACAD and GRSM
Acadia National Park (ACAD)	The contribution of Acadia PRIMENet research to science and resource management in the national park service	Acadia National Park was one of the 14 sites included in the Park Research and Intensive Monitoring of Ecosystems network (PRIMENet). For eight years the EPA monitored ultraviolet (UV) radiation at this site, with the National Park Service (NPS) sponsoring a total climate and air monitoring station. Under the auspices of PRIMENet, research projects were initiated that investigated the effects of UV on amphibians, determined watershed mass balances, and developed a model of deposition along an elevational gradient. The monitoring data and research results have been used by park management to protect vegetation and water resources from ozone and deposition. These data are now being used to develop a "vital signs" monitoring program under the NPS' Inventory and Monitoring Program. These data sets have been used in regional, national and international programs to protect human health and resources from air pollution. Public outreach has been accomplished through web site resources and via the Schoodic Education and Research Center.	Tonnessen, K. & Manski, D. (2007) The contribution of Acadia PRIMENet research to science and resource management in the national park service. Environmental Monitoring and Assessment, 126, 3-8.
Mercury and Airborne Toxics Deposition and Effects			
Acadia National Park (ACAD)	A comparison of mercury in the throughfall of spruce and beech canopies	The study consisted mainly of fieldwork measurements of mercury concentrations in spruce and beech throughfall and open field precipitation collected at Acadia National Park from late October to early November, 1995.	1992. The Deposition and fate of trace metals in our environment. Philadelphia, PA, US Forest Service, North Central Forest Experiment Station, St. Paul, MN October 8, 1991.
Acadia National Park (ACAD)	Comparison of Hg and Pb fluxes to hummocks and hollows of ombrotrophic big heath bog and to nearby Sargent Mt. Pond, Maine, USA	Two hummock cores, two hollow cores from ombrotrophic Big Heath, and a single core from Sargent Mountain Pond, Mt. Desert Island, Acadia National Park Maine, USA were collected in 1983 and dated using Pb-210 and analyzed for a suite of major and trace metals. The hummock cores correspond closely in terms of dating profiles, and concentrations of Hg and Pb. Background atmospheric deposition rates of Hg and Pb to coastal Maine appear to have been about 2.5 to 3 ng/cm(2)/yr and <0.2 mu g/cm(2)/yr, respectively. Atmospheric deposition of Hg acid Pb increased to as much as 20 ng/cm(2)/yr and 2 mu g/cm(2)/yr, respectively, by the 1970s and has decreased since then. More than half of the Hg and Pb are deposited in dry and occult deposition.	Norton, S. A., Evans, G. C. & Kahl, J. S. (1997) Comparison of Hg and Pb fluxes to hummocks and hollows of ombrotrophic big heath bog and to nearby Sargent Mt. Pond, Maine, USA. Water Air and Soil Pollution, 100, 271-286.
Acadia National Park (ACAD)	Controls on mercury and methylmercury deposition for two watersheds in Acadia National Park, Maine	Throughfall and bulk precipitation samples were collected for two watersheds at Acadia National Park, Maine, from May to November 2000, to determine which landscape factors affected mercury (Hg) deposition. Sites that face southwest received the highest Hg deposition, which may be due to the interception of cross-continental movement of contaminated air masses. Sites covered with softwood vegetation also received higher Hg deposition than other vegetation types because of the higher scavenging efficiency of the canopy structure. Hg deposition, as bulk precipitation and throughfall was lower in Cadillac Brook watershed (burned) than in Hadlock Brook watershed (unburned) because of vegetation type and watershed aspect. The total Hg deposition via throughfall and bulk precipitation was 9.4 mu g/m(2)/year in Cadillac Brook watershed and 10.2 mu g/m(2)/year in Hadlock Brook watershed. The total MeHg deposition via throughfall and bulk precipitation was 0.05 mu g/m(2)/year in Cadillac Brook watershed and 0.10 mu g/m(2)/year in Hadlock Brook watershed.	Johnson, K. B., Haines, T. A., Kahl, J. S., Norton, S. A., Amirbahman, A. & Sheehan, K. D. (2007) Controls on mercury and methylmercury deposition for two watersheds in Acadia National Park, Maine. Environmental Monitoring and Assessment, 126, 55-67.
Acadia National Park (ACAD)	Landscape controls on mercury in streamwater at Acadia National Park, USA	Fall and spring streamwater samples were analyzed for total mercury (Hg) and major ions from 47 locations on Mount Desert Island in Maine. Samples were collected in zones that were burned in a major wildfire in 1947 and in zones that were not burned. We hypothesized that Hg concentrations in streamwater would be higher from unburned sites than burned watersheds, because fire would volatilize stored Hg. Significant statistical associations were noted between Hg and the amount of wetlands in the drainage systems and with streamwater dissolved organic carbon (DOC). An unexpected result was that wetlands mobilized more Hg by generating more DOC in total, but upland DOC was more efficient at transporting Hg because it transports more Hg per unit DOC. Mercury concentrations were higher in samples collected at lower elevations. In this research, sample site elevation and the presence of upstream wetlands and their associated DOC affected Hg concentrations more strongly than burn history.	Peckenham, J. M., Kahl, J. S., Nelson, S. J., Johnson, K. B. & Haines, T. A. (2007) Landscape controls on mercury in streamwater at Acadia National Park, USA. Environmental Monitoring and Assessment, 126, 97-104.
Acadia National Park (ACAD)	Litterfall mercury in two forested watersheds at Acadia National Park, Maine, USA	Litterfall was collected at 39 sampling sites in two small research watersheds, in 2003 and 2004, and analyzed for total Hg. The mean litter Hg concentration in softwoods was significantly greater than in mixed and scrub, and significantly lower than in hardwoods. In contrast, the mean weighted litter Hg flux was not significantly different among vegetation classes, and according to the researchers due to the large autumnal hardwood litter Hg flux being balanced by the higher softwood litter Hg concentrations, along with the higher chronic litterfall flux throughout the winter and spring in softwoods. The estimated annual deposition of Hg via litterfall in Hadlock Brook watershed (10.1 mu g m(-2)) and Cadillac Brook watershed (10.0 mu g m(-2)) was greater than precipitation Hg deposition and similar to or greater than the magnitude of Hg deposition via throughfall. The results demonstrate that litterfall Hg flux to forested landscapes can be at least as important as precipitation Hg inputs.	Sheehan, K. D., Fernandez, I. J., Kahl, J. S. & Amirbahman, A. (2006) Litterfall mercury in two forested watersheds at Acadia National Park, Maine, USA. Water Air and Soil Pollution, 170, 249-265.

Acadia National Park (ACAD)	Mass balances of mercury and nitrogen in burned and unburned forested watersheds at Acadia National Park, Maine, USA	Precipitation and streamwater samples were collected from November 1999 to November 2000 in two watersheds at Acadia National Park, Maine, and analyzed for mercury (Hg) and dissolved inorganic nitrogen (DIN, nitrate plus ammonium). We hypothesized that Hg deposition would be higher at Hadlock Brook (the reference watershed, 10.2 mu g/m(2)/year) than Cadillac (9.4 mu g/m(2)/year) because of the greater scavenging efficiency of the softwood vegetation in Hadlock. We also hypothesized the Hg and DIN export from Cadillac Brook would be lower than Hadlock Brook because of elemental volatilization during the fire, along with subsequently lower rates of atmospheric deposition in a watershed with abundant bare soil and bedrock, and regenerating vegetation. Consistent with these hypotheses, Hg export was lower from Cadillac Brook watershed (0.4 mu g/m(2)/year) than from Hadlock Brook watershed (1.3 mu g/m(2)/year). DIN export from Cadillac Brook (11.5 eq/ha/year) was lower than Hadlock Brook (92.5 eq/ha/year).	Nelson, S. J., Johnson, K. B., Kahl, J. S., Haines, T. A. & Fernandez, I. J. (2007) Mass balances of mercury and nitrogen in burned and unburned forested watersheds at Acadia National Park, Maine, USA. Environmental Monitoring and Assessment, 126, 69-80.
Acadia National Park (ACAD)	Mercury bioaccumulation in green frog (Rana clamitans) and bullfrog (Rana catesbeiana) tadpoles from Acadia National Park, Maine, USA	The researchers report total Hg and methyl Hg (MeHg) concentrations for water, sediment, and green frog (*Rana clamitans*) and bullfrog (*Rana catesbeiana*) tadpoles from Acadia National Park. Total Hg concentrations in green frog and bullfrog tadpoles were 25.1 +/- 1.5 and 19.1 +/- 0.8 ng/g wet weight, respectively. Mean total Hg was highest for green frog tadpoles sampled from the Schooner Head site where Ranavirus was detected during the summer of 2003 sampling period. Dissolved organic carbon was a significant predictor of both total Hg and MeHg in water, and total Hg in water also was strongly correlated with MeHg in water. The data indicate that wetland food webs are susceptible to high levels of total Hg bioaccumulation and that methylation dynamics appear to be influenced by local abiotic and biotic factors. The findings may be important to National Park Service resource managers, especially considering the class I airshed status of ANP and the strong potential for negative effects to aquatic ecosystem structure and function from Hg pollution.	Bank, M. S., Crocker, J., Connery, B. & Amirbahman, A. (2007) Mercury bioaccumulation in green frog (Rana clamitans) and bullfrog (Rana catesbeiana) tadpoles from Acadia National Park, Maine, USA. Environmental Toxicology and Chemistry, 26, 118-125.
Acadia National Park (ACAD)	Mercury bioaccumulation in northern two-lined salamanders from streams in the northeastern United States	Investigators report concentrations of methyl Hg (MeHg) and total Hg in larval northern two-lined salamanders (*Eurycea bislineata bislineata*) collected from streams in Acadia National Park (ANP), Maine, Bear Brook Watershed, Maine, and Shenandoah National Park (SNP), Virginia. MeHg comprised 73-97% of total Hg in the larval salamander composite samples from ANP. At BBWM, significantly higher total Hg levels in larvae were detected in the (NH4)(2)SO4 treatment watershed. At ANP total Hg concentrations in salamander larvae were significantly higher from streams in unburned watersheds in contrast with samples collected from streams located in burned watersheds. Additionally, total Hg levels were significantly higher in salamander larvae collected at ANP in contrast with SNP. The researchers suggest that watershed-scale attributes including, re history, whole-catchment (NH4)(2)SO4 additions, wetland extent, and forest cover type influence mercury bioaccumulation in salamanders inhabiting lotic environments.	Bank, M. S., Loftin, C. S. & Jung, R. E. (2005) Mercury bioaccumulation in northern two-lined salamanders from streams in the northeastern United States. Ecotoxicology, 14, 181-191.
Acadia National Park (ACAD)	Mercury and growth of tree swallows at Acadia National Park, and at Orono, Maine, USA	In 1997 and 1998 we weighed nestling tree swallows (Tachycineta bicolor) and measured selected body components at two colonies: Acadia National Park on Mt. Desert Island, and at Orono, ME. We used differences in mean growth variables among individual nestlings to evaluate differences between colonies, years, and amount of total mercury (THg) in carcasses and methyl mercury (MeHg) in feathers. In 1998, linear growth rate of weight was higher at Acadia than at Orono, but not different in 1997. We detected no mean differences in asymptotic mean weight of nestlings between colonies or years. In 1997, mean linear growth rates of the wing (chord), tail, tarsus, and mandible were higher at Acadia than at Orono. The amount of MeHg in feathers was associated with a lower linear growth rate of weight during early age (2-10 days), but asymptotic mean weight during days 11-16 was not different. Fledgling tree swallows that survive to migrate, however, will leave Maine with substantial concentrations of Hg in their tissues.	Longcore, J. R., Dineli, R. & Haines, T. A. (2007) Mercury and growth of tree swallows at Acadia National Park, and at Orono, Maine, USA. Environmental Monitoring and Assessment, 126, 117-127.
Acadia National Park (ACAD)	Mercury Contamination of Biota from Acadia National Park, Maine: A Review	Abstract: We reviewed literature reporting both total and methylmercury from biota from Acadia National Park, Maine, USA. Our review of existing data indicates that 1) mercury contamination is widespread throughout the Park_s various aquatic ecosystems; 2) mercury pollution likely represents a moderate to high risk to biota inhabiting the Park; and 3) biota at all trophic levels possess elevated concentrations of both total and methylmercury. Watershed fire history and the resulting post-fire forest succession patterns are an important landscape attribute governing mercury cycling at Acadia National Park. Therefore, park service personnel should consider these factors when planning and implementing Hg biomonitoring efforts. Additional baseline funding from the National Park Service for Hg research and biomonitoring will likely be required in order to further evaluate the spatial and temporal patterns of mercury contamination in the park_s biota.	Bank, M. S., Burgess, J. R., Evers, D. C. & Loftin, C. S. (2007) Mercury contamination of biota from Acadia National Park, Maine: A review. Environmental Monitoring and Assessment, 126, 105-115.
Acadia National Park (ACAD)	Mercury in tree swallow food, eggs, bodies, and feathers at Acadia National Park, Maine, and an EPA Superfund site, Ayer, Massachusetts	We monitored nest boxes during 1997-1999 at Acadia National Park, MEand two other sites in Maine to determine mercury (Hg) uptake in tree swallow (*Tachycineta bicolor*) eggs, tissues, and food boluses. On average among locations, total mercury (THg) biomagnified 2 to 4-fold from food to eggs and 9 to 18-fold from food to feathers. These are minimum values because the proportion of transferable methyl mercury (MeHg) of the THg in insects varies (i.e., 35%-95% of THg) in food boluses. THg was highest in food boluses at Aunt Betty Pond at Acadia, whereas THg in eggs was highest at the Superfund site. A few eggs from nests at each of these locations exceeded the threshold (i.e., 800-1,000 ng/g, wet wt.) of embryotoxicity established for Hg. Hatching success was 88.9% to 100% among locations, but five eggs failed to hatch from 4 of the 11 clutches in which an egg exceeded this threshold. MeHg in feathers was highest in tree swallows at Aunt Betty Pond and the concentration of THg in bodies was related to the concentration in feathers.	Longcore, J. R., Haines, T. A. & Halteman, W. A. (2007) Mercury in tree swallow food, eggs, bodies, and feathers at Acadia National Park, Maine, and an EPA Superfund site, Ayer, Massachusetts. Environmental Monitoring and Assessment, 126, 129-143.

Acadia National Park (ACAD)	Paleoecological assessment of watershed history in PRIMENet watersheds at Acadia National Park, USA	Paleoecological reconstructions of forest stand histories for two upland watersheds at Acadia National Park in Maine were completed to support related watershed chemistry studies. The project hypothesis was that forest type and fire history influence long-term cycling and storage of atmospheric mercury and nitrogen within watersheds. The unburned watershed has been dominated by spruce (*Picea rubens*) and fir (*Abies balsamea*) for 500 years or more and has not recently burned or been substantially cleared. The burned watershed is dominated by a heterogeneous forest of patchy hardwood, mixed wood, and softwood stands. A large portion of this watershed burned severely in 1947 and probably more than once in the 1800s, and has supported heterogeneous successional forests for 200 years or longer. The results support the underlying premise that the experimental design of this watershed research can be used to infer landscape controls on biogeochemical processes.	Schauffler, M., Nelson, S. J., Kahl, J. S., Jacobson, G. L., Haines, T. A., Patterson, W. A. & Johnson, K. B. (2007) Paleoecological assessment of watershed history in PRIMENet watersheds at Acadia National Park, USA. Environmental Monitoring and Assessme
Acadia National Park (ACAD)	Population decline of northern dusky salamanders at Acadia National Park, Maine, USA	Researchers investigated the current and historic distribution of northern dusky salamanders (*Desmognathus fuscus fuscus*) in Acadia National Park, Maine during 1938-2003. Historical data indicate that northern dusky salamanders were once widespread and common in ANP. The investigators conducted intensive surveys for stream salamanders during 2000/2003 and observed only two adult northern dusky salamanders on one stream. No eggs or larvae were observed. he scientists identify multiple potential stressors including stocking of predatory fishes, fungal pathogens, substrate embeddedness, and atmospheric pollution of surface waters at ANP as the possiblecause of the observed population decline. The data suggest that ANP streams may no longer be suitable for northern dusky salamanders. This investigation is the first to document the decline of a stream dwelling amphibian species in a national park with widespread mercury contamination of its surface waters.	Bank, M. S., Crocker, J. B., Davis, S., Brotherton, D. K., Cook, R., Behler, J. & Connery, B. (2006) Population decline of northern dusky salamanders at Acadia National Park, Maine, USA. Biological Conservation, 130, 230-238.
Acadia National Park (ACAD)	The contribution of Acadia PRIMENet research to science and resource management in the national park service	Acadia National Park was one of the 14 sites included in the Park Research and Intensive Monitoring of Ecosystems network (PRIMENet). For eight years the EPA monitored ultraviolet (UV) radiation at this site, with the National Park Service (NPS) sponsoring a total climate and air monitoring station. Under the auspices of PRIMENet, research projects were initiated that investigated the effects of UV on amphibians, determined watershed mass balances, and developed a model of deposition along an elevational gradient. The monitoring data and research results have been used by park management to protect vegetation and water resources from ozone and deposition. These data are now being used to develop a "vital signs" monitoring program under the NPS' Inventory and Monitoring Program. These data sets have been used in regional, national and international programs to protect human health and resources from air pollution. Public outreach has been accomplished through web site resources and via the Schoodic Education and Research Center.	Tonnessen, K. & Manski, D. (2007) The contribution of Acadia PRIMENet research to science and resource management in the national park service. Environmental Monitoring and Assessment, 126, 3-8.
Acadia National Park (ACAD)	The effect of fire on mercury cycling in the soils of forested watersheds: Acadia National Park, Maine, USA	This study compares mercury (Hg) and methylmercury (MeHg) distribution in the soils of two forested stream watersheds at Acadia National Park, Cadillac Brook watershed and Hadlock Brook watershed. Total Hg content was significantly highe in Hadlock soils compared to Cadillac soils. Soil pH was significantly higher in all soil horizons at Cadillac compared to Hadlock soils; especially significant in the O horizon. The results of Hg adsorption experiments indicate that the dissolved Hg concentration is controlled by the dissolved organic carbon (DOC) concentration. According to the reseachers, landscape factors such as soil pH, vegetation type, or land use history may be the determining factors for susceptibility to high Hg in biota.	Sheehan, K. D., Fernandez, I. J., Kahl, J. S. & Amirbahman, A. (2006) Litterfall mercury in two forested watersheds at Acadia National Park, Maine, USA. Water Air and Soil Pollution, 170, 249-265.
Ozone Pollution and Effects			
Acadia National Park (ACAD)	DETECTION OF CHANGES IN STEADY-STATE CHLOROPHYLL FLUORESCENCE IN PINUS-STROBUS FOLLOWING SHORT-TERM OZONE EXPOSURE	Investigators conducted experiments in 1992 and 1993 as part of a study of the effects of short-term ozone exposure to native plants at Acadia National Park, Maine. There were detection of changes in steady-state chlorophyll fluorescence in white pine following short-term ozone exposure. The R/FR ratio means at 24 hrs post-fumigation were significant at P = .05 for the 120 mm(3) m(-3) ozone exposure and at P = .20 for the 220 mm(3) m(-3) ozone exposure. The researchers suggest a potential recovery of photosynthetic processes from the effects of ozone exposure. Red/far-red fluorescence ratios indicates that stress-induced fluorescence changes may be detectable in direct sunlight.	Theisen, A. F., Rock, B. N. & Eckert, R. T. (1994) DETECTION OF CHANGES IN STEADY-STATE CHLOROPHYLL FLUORESCENCE IN PINUS-STROBUS FOLLOWING SHORT-TERM OZONE EXPOSURE. Journal of Plant Physiology, 144, 410-419.
Acadia National Park (ACAD)	Pathological anatomy of needles of Pinus strobus exposed to carbon-filtered air or to three times ambient ozone concentrations, or infected by *Canavirgella banfieldii*	A necrosis of succulent, elongating, current-year needles of Pinus strobus in the northeastern United States, frequently attributed to "ozone damage," is not due to ozone. The pathological anatomy of affected needles differs from that described for ozone injury and is virtually identical to that described as "semimature-tissue needle blight." The syndrome on affected trees throughout the northeastern United States is consistently associated with the presence of the needlecast fungus, *Canavirgella banfieldii* . Researchers compared the damage done to needles by ozone with the damage to needles affected by the syndrome "semimature-tissue needle blight" which is associated the presence of the fungus *Canavirgella banfieldii* , using needle samples from Acadia National Park and sites in Vermont, Pennsylvania, New Hampshire and other parts of Maine.	Wenner, N. G. & Merrill, W. (1998) Pathological anatomy of needles of Pinus strobus exposed to carbon-filtered air or to three times ambient ozone concentrations, or infected by *Canavirgella banfieldii* . *Canadian Journal of Botany-Revue Canadienne De Botanique* , 76, 1331-1339.
Acadia National Park (ACAD)	Reductions in tree-ring widths of white pine following ozone exposure at Acadia National Park, Maine, USA	Polluted air masses create elevated ozone episodes throughout the growing season, causing visible foliar damage to some native plant species in Acadia National Park, Maine. This study used dendroclimatic techniques to investigate the possibility that elevated ozone levels adversely affected white pine (*Pinus strobus L.*) radial growth rates. Tree-ring cores were extracted from white pine trees in eight separate stands within the park. Tree-ring indices were then regressed with ozone variables to model the effects of elevated ozone levels on tree growth under field conditions. Models from seven of the eight stands documented negative associations between tree-ring indices and ozone levels that were stronger than any associations between tree-ring indices and climate. The modeled growth-ozone associations exhibited stand-level variations, suggesting that site characteristics affect tree responses to ozone pollution.	Bartholomay, G. A., Eckert, R. T. & Smith, K. T. (1997) Reductions in tree-ring widths of white pine following ozone exposure at Acadia National Park, Maine, USA. Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere, 27, 361-368.

Acadia National Park (ACAD)	Surface level measurements of ozone and precursors at coastal and offshore locations in the Gulf of Maine	The northeastern United States has episodic high ozone several times each year at locations remote from urban and industrial centers. Extended measurements of ozone and the ozone precursors, volatile organic compounds (VOC) and nitrogen oxides, were made at Acadia National Park, Cape Elizabeth, and other coastal Maine locations during the North Atlantic Regional Experiment (NARE) intensive. In addition, ozone was measured from a commercial ferry, the Scotia Prince, in the Gulf of Maine where ozone concentrations up to 129 ppb were observed. Two high-ozone episodes were observed during late August 1993 when ozone was greater than 90 ppb along much of the Maine coast. NOy concentrations at Acadia averaged 2.0 ppb (+/-1.97), maximum 12.0 ppb. During the high-ozone episodes, NOy had linear relationships to ozone with slopes 4-16. The timing of maximum values and extent of the high-ozone air mass suggests that urban plumes transported over the Gulf of Maine are brought inland by sea breezes to the coastal regions but not to the interior areas of Maine.	Ray, J. D., Heavner, R. L., Flores, M. & Michaelsen, C. W. (1996) Surface level measurements of ozone and precursors at coastal and offshore locations in the Gulf of Maine. Journal of Geophysical Research-Atmospheres, 101, 29005-29011.
Biogeochemistry of Pollutants in Ecosystems			
Acadia National Park (ACAD)	Nutrient export from watersheds on Mt. Desert Island, Maine, as a function of land use and fire history	A study of 13 small watersheds on Mt. Desert Island, Maine, was conducted from January 1999 to September 2000 to determine nutrient export delivery to coastal waters around the island, and to determine whether a series of wildfires in 1947 have affected nutrient export in burned watersheds. Nutrient export (nitrate-nitrogen, total nitrogen, total phosphorus) was determined for each watershed during the study period, and was normalized by watershed area. The yield of nitrate-nitrogen (N) ranged from 10 to 140 kg/km(2)/year. Total N yield ranged from 42 to 250 kg/km(2)/year. Total phosphorus (P) yield ranged from 1.4 to 7.9 kg/km(2)/year. Watersheds entirely within Acadia National Park exported significantly less total N and total P than watersheds that were partly or entirely outside the park boundary. Nitrate-N export was not significantly different in these two groups of watersheds, perhaps because atmospheric deposition is a dominant source of nitrate in the study area.	Nielsen, M. G. & Kahl, J. S. (2007) Nutrient export from watersheds on Mt. Desert Island, Maine, as a function of land use and fire history. Environmental Monitoring and Assessment, 126, 81-96.
Acadia National Park (ACAD)	Watershed Nitrogen and Mercury Geochemical Fluxes Integrate Landscape Factors in Long-term Research Watersheds at Acadia National Park, Maine, USA	The research was initiated as part of EPA/NPS PRIMENet (Park Research and Intensive Monitoring of Ecosystems Network), a system of UV-monitoring stations and long-term watershed research sites located in US national parks. The initial goals at Acadia NP were to address research questions about mercury, acid rain, and nitrogen saturation developed from prior research at unburned 47-ha Hadlock Brook watershed is 70% spruce-fir mature conifer forest, and, burned 32-ha Cadillac Brook watershed. We are testing hypotheses about controls on surface water chemistry, and bioavailability of contaminants in the contrasting watersheds. Differences in atmospheric deposition are controlled primarily by forest stand composition and age. The stream water chemistry factors result in higher nitrogen and mercury flux from the unburned watershed, reflecting differences in atmospheric deposition, contrasting ecosystem pools of nitrogen and mercury, and inferred differences in internal cycling and bioavailabilty.	Kahl, J. S., Nelson, S. J., Fernandez, I., Haines, T., Norton, S., Wiersma, G. B., Jacobson, G., Amirbahman, A., Johnson, K., Schauffler, M., Rustad, L., Tonnessen, K., Lent, R., Bank, M., Elvir, J., Eckhoff, J., Caron, H., Ruck, P., Parker, J., Campbell, J., Manski, D., Breen, R., Sheehan, K. & Grygo, A. (2007) Watershed nitrogen and mercury geochemical fluxes integrate landscape factors in long-term research watersheds at Acadia National Park, Maine, USA. Environmental Monitoring and Assessment, 126, 9-25.
Climate Change Effects			
Acadia National Park (ACAD)	Soil organic matter fractions in experimental forested watersheds	Recent concerns about climate change and atmospheric greenhouse gas concentrations have demonstrated the importance of understanding ecosystem C source/sink relationships. Researchers conducted soil organic matter fractionation in three paired, forested watershed sites where one of each watershed pair represented a different ecosystem perturbation. The perturbations were 8 years of experimental N amendments at the Bear Brook Watershed in Maine (BBWM), Acadia National Park (ANP), and Weymouth Point Watershed (WPW). Whole soils, and density and particle-size fractions were analyzed for total C and N. At ANP, soil organic matter fractions generally had lower C/N associated with the wildfire. The results indicated that there were no consistent shifts in fraction distributions in response to perturbation that were consistent across all paired watershed study sites.	Parker, J. L., Fernandez, I. J., Rustad, L. E. & Norton, S. A. (2002) Soil organic matter fractions in experimental forested watersheds. Water Air and Soil Pollution, 138, 101-121.
Other Atmospheric Deposition Effects			
Acadia National Park (ACAD)	EPISODIC STREAM ACIDIFICATION CAUSED BY ATMOSPHERIC DEPOSITION OF SEA SALTS AT ACADIA NATIONAL-PARK, MAINE, UNITED-STATES	Major episodic acidifications were observed on several occasions in first-order brooks at Acadia National Park, Mount Desert Island, Maine. Surface water acidifications is due primarily to an ion exchange "salt effect" of Na+ for H+ in soil solution, and secondarily to dilution, neither of which is a consequence of acidic deposition. The requisite conditions for a major episodic salt effect acidification include acidic soils, and either an especially salt-laden wet precipitation event, or a period of accumulation of marine salts from dry deposition, followed by wet inputs.	Heath, R. H., Kahl, J. S., Norton, S. A. & Fernandez, I. J. (1992) EPISODIC STREAM ACIDIFICATION CAUSED BY ATMOSPHERIC DEPOSITION OF SEA SALTS AT ACADIA NATIONAL-PARK, MAINE, UNITED-STATES. Water Resources Research, 28, 1081-1088.