Water Quality Monitoring Fact Sheet

Great Smoky Mountains National Park

General Program Observations

- Parkwide program began in 1993 as a cooperative effort between NPS, University of Tennessee, and Trout Unlimited (TU)
  - Basic design was to co-locate water quality, fish and aquatic insect sites in select watersheds
- 32 sites sampled bi-monthly in 7 watersheds (Cosby Creek, Little River, Abrams Creek, Oconaluftee River, WP Little Pigeon, Cataloochee Creek)
- TU volunteers hiked >5,000 miles over last 15 years
- Collected at least 11,048 water samples from 1993 -2007

Park-wide Trends

Acid Neutralizing Capacity (ANC)

- 95% of GRSM streams have acid neutralizing capacities (ANC) <25µS/cm (i.e. sensitive or extremely sensitive to acidification) (Robinson *et al.* 2005)
  - sandstone geology coupled with thin soil profiles provide little buffering capacity
- ANC, pH, Na+, K+, and other cations decrease as elevations increase (Robinson *et al.* 2005)
- No general trend observed for ANC (Robinson *et al.* 2007)

pH

- 77% of the sites sampled have a median pH<6.5 (Robinson *et al.* 2005)
- Base flow pH decreasing at 0.016 units/yr (Robinson *et al.* 2007)
  - Al, Mn, and Zn main leachates with a pH of ~4.5 (Huckabee et al. 1975)
- pH declining at 0.2 units/yr at elevations 1,000-3,500' but no change above 3,500'
- If current trends continue, median pH of Little River at Elkmont (elev. 2,146') will be 6.0 in 34 years, many others <25 years (Robinson *et al.* 2007)
- During storm events, pH may drop as much as 2 full units and much higher Al^{-}

Nitrate & Sulfate

- Nitrate (NO_3) and sulfate (SO_4) are the major pollution sources (Robinson *et al.* 2005)
  - levels increase as elevation increases
  - primary source of nitrate = auto exhaust; sulfate = coal-fire plants
- Sulfate declining at a rate of -0.83 to -1.3 µeq/l/yr at elevations less than 3,500ft consistent with decreasing atmospheric sulfate deposition; similar to rates seen at Hubbard Brook (Gbondo-Tugbawa and Driscoll 2002) from low to high elevation (-1.2 to -2.5 µeq/l/yr) (Robinson *et al.* 2007)
- Nitrate concentrations and total N deposition (kg/ha) show no change, although ammonia and nitrate in precipitation has been declining (Robinson *et al.* 2007)
- Elevated nitrogen and cations leaching in soils following hemlock decline and mortality (Yorks et al. 1999)
- Soil pH lowest and exchangeable Al and Fe to be highest under hemlock (Fenzi *et al.* 1998)
- Replacement of hemlocks by hardwoods is likely to result in increases in pH and N turnover rates, reductions in forest floor carbon and nitrogen, and reductions in exchangeable cations (Yorks et al. 2004)

Impacts to Aquatic Organisms

- Anakeesta fill killed 8km (5 miles) of fish from upper Beech Flats Prong; only 2 miles have recovered to date (Huckabee *et al.* 1975)
- Gill hyperplasia is a sign of Zn/Al poisoning observed in fish – primary stressor observed in Beech Flats fishes (Huckabee *et al.* 1975)
- Nitrate toxicity of embryos >2mg/l (Johnson 2002)
- Softer waters significantly increase mortality of embryos (Johnson 2002)
- Reduced growth due to nitrate exposure (Johnson 2002)
- Larvae and later life stages more resistant to NO_3 than early life stages (*i.e.* eggs); groundwater nitrate levels a concern (*e.g.* WI 2.8-37.8 mg/l) (Johnson 2002)
- Brook trout less sensitive to 96hr LC_{50} acute concentration of 1,250-1,400 mg/l (Johnson 2002)
- Streams with pH<6.0 at low summer flow had lowest density (Nislow and Lowe 2003)
- Density of brook trout negatively correlated to time since logging (Nislow and Lowe 2003)
- Since the 1980's, 6 brook trout populations have been lost due to what appears to be increased stream acidity
    - ◇ Acid rain kills different fauna in many different ways:
        1. Indirectly by stressing these ecosystems to the point where they are vulnerable to insects and diseases
        2. Leaches ions out of the soil that are toxic to various species
        3. Inhibits metabolic, cellular processes, or reproductive functions

What's the future look like . . . if the current trends continue:

	Current	Years to pH of:			Current Conditions			
Elevation (ft)	pH	*6.5*	*6.0*	*5.5*	ANC	Cond.	Nitrate	Sulfate
1,000-1,500	6.66	*26*	*46*	*67*	145.8	23.2	10.5	44.2
1,500-2,000	6.57	*13*	*26*	*39*	200.9	26.9	11.5	35.6
2,000-2,500	6.34	*14*	*32*	*50*	59.6	13.7	12.8	32.8
2,500-3,000	6.30	*11*	*26*	*42*	51.6	14.8	18.8	36.8
3,000-3,500	6.12	*4*	*15*	*26*	30.9	14.3	23.9	42.9
3,500-4,000	6.18				41.5	20.4	35.2	71.2
4,000-4,500	5.85				22.3	20.1	34.7	74.8
4,500-5,000	5.74				31.6	20.8	34.6	72.8
5,000-5,500	5.66				18.1	17.3	49.9	37.7
>5,500	5.11				2.1	22.8	64.3	38.0