Indicators of Ecological Effects of Air Quality Project

Ecological Change Subcommittee
August 14-15, 2007 – Washington, DC

MEETING SUMMARY

Participants: *Jill Baron (US Geological Surve/Natural Resource Ecology Laboratory), Tamara Blett (National Park Service), Kent Burkey (USDA-ARS), Emily Elliott (University of Pittsburgh), Dave Evers (BioDiversity Research Institute), Mark Fenn (USFS Pacific Southwest Research Station), Patricia Glibert (University of Maryland Center for Environmental Science), Sagar Krupa (University of Minnesota), Robert Mason (University of Connecticut), Mark Southerland (Versar, Inc. ESM), Jill Webster (U. S. Fish and Wildlife Service)*

Subcommittee charge: The Ecological Change subcommittee was charged with recommending metrics of ecosystem condition most appropriate for examining the influence of air quality on ecosystems. Participants were asked to review and categorize a comprehensive list of potential ecological endpoints of air pollution (see page 3 as follows:

1. Ecological effects of air pollution for which indicator metrics are well-established.
2. Ecological effects with a substantial research base that merit further investigation within the context of this project.
3. Ecological effects requiring substantial additional research to enable quantitative evaluation.

Subcommittee recommendations: By the end of its discussions, the subcommittee had identified nine major categories of endpoint effects – topics in **bold** were recommended for further investigation through this project:

1. Ozone-induced plant injury: *focused on forests, croplands and grass/shrublands*
   - Metrics of **foliar damage** – address **links to physiological changes** and/or species composition
2. Nitrogen enrichment: *focused on systems with AD-N as primary N source*
   - Ratio-based metrics of nitrogen enrichment in soil organic matter (specifically **C:N**) and possibly plants (e.g., **foliar N:P**)
   - Change in **nitrate in freshwater** and **ratio-based metrics of aquatic nitrogen enrichment** (e.g., N:P; DIN:total P; DON:DIN) and – address temporal and geographic sampling issues
3. Acidification
   - **Acid Neutralizing Capacity** in streams, lakes and ponds
   - Metrics of **base cation status in forest soils** (e.g., BC:Al; base saturation) and possibly **soil pH**
4. Deposition of mercury
   - Methylation capacity as measured by change in the **abundance of methyl mercury** (MeHg) relative to total mercury in streams, lakes, ponds, wetlands, estuaries and coastal bays – address interactive effects of temperature and sulfur addition
   - Biomagnification in fish as measured by **MeHg in young-of-the year** and in terrestrial biota as measured by MeHg in tissues
   - Biomagnification in higher trophic levels as measured by **total Hg in tissues of piscivores** and in invertivores – address temporal sampling issues and thresholds for changes in behavior, physiology and species abundance as synergistic effects with acid-induced calcium depletion

5. Changes in primary productivity: *focused on systems with AD-N as primary N source*
   - Metrics of **change in *Chlorophyll a*** (e.g., abundance, timing) – address temporal and geographic sampling issues
   - Metrics of change in terrestrial systems (e.g., mycorrhize; root:shoot; nitrophilic:nitrophobic species)
6. Community structure: *focused on systems with AD-N as primary N source*
   - Metrics of **change in diatoms** (e.g., species composition, chemical thresholds) and possibly fish
   - Metrics of **change in lichens** (e.g., abundance of specific species, tissue chemistry) and **change in grass species** (e.g., dominance relative to forbs) – address geographic sampling issues and thresholds for effects
   - Change in N-sensitive plants in forest understory
7. Altered chemical cycles
   - Metrics of change in N uptake by microbes/plants
   - Metrics of alteration in biological communities (e.g., fungi:bacteria, heterotrophic:autotrophic nitrifiers)
   - Metrics of change in litter decomposition/accumulation (e.g., lignin; vertical distribution)
   - Metrics of **change in mineralization/nitrification rates** (e.g., relative net netrification; increased N volatilization; triggered nitrification in acidic systems)
8. Organism- and species-level changes
   - Metrics for **'sentinel' species** (e.g., high-elevation red spruce; checkerspot butterfly and N-sensitive serpentine grasses)
   - Metrics for shifting species dominance (e.g., regional shifts in red and sugar maple)
9. Altered disturbance regimes
   - Metrics of **altered fire vulnerability and fuel load** in forests and grass/shrublands (e.g., increase in annual grasses and fire severity in the Southwest; altered carbon cycle and fuel load in San Bernadino)
   - Metrics of **altered system types** (e.g., woody encroachment in grasslands; change in shrub:grass composition and system hydrology) and **invasive species** (e.g., Japanese stiltgrass in the Midatlantic) – address interactions with habitat
   - Altered **pest susceptibility** (e.g., N/ozone-induced bark beetle infestation; gypsy moths) – address relationship to C:N in plant tissue

<u>Next steps</u>: In the coming weeks, the bolded ecological endpoints listed above will be investigated through targeted literature review (note that all topics will be addressed in the final report's comprehensive literature review and description of future research needs). Those endpoints for which literature synthesis can produce a viable indicator metric will be presented as recommended indicators in the final report. Those endpoints for which customized modeling analyses are needed to formulate a suitable indicator metric will be carried forward to upcoming technical subcommittees.

<u>Additional topics</u>:
The subcommittee also offered several criteria for indicator selection, including: (1) knowledge base for the effect and measurability of the endpoint; (2) utility as an 'early warning' signal that is integrative of multiple stressors; (3) intensity of the air pollutant stress; (4) magnitude of public perception and conservation concern and accessibility for non-technical audiences; (5) responsiveness

to pollutant level/multiple pollutants. There was also discussion of how to incorporate visibility into the scope of this project, however no definitive recommendation was made.

The subcommittee recommended that one or more members of the Ecological Change subcommittee be invited to participate in subsequent workshops to enable continuity and insight into subcommittee recommendations.

			Affected ecosystems/land cover types										
	ADVERSE ECOLOGICAL EFFECTS OF AIR POLLUTION		Alpine tundra	Coniferous forests	Deciduous forests	Croplands	Grass/ shrublands	Streams	Lakes/ ponds	Wetlands	Estuaries/ shallow bays	Coastal waters	Urbanized areas
~~Ambient Gaseous~~ N, S, O_3	Diminished visibility							human benefit					
	Foliar injury												
	Physiological changes (growth, aging, susceptibility)												
	Change in species composition												
	Climate forcing (N_2O, O_3)							synergistic effects					
TOTAL DEPOSITION	~~Direct foliar injury~~ MOVED TO AMBIENT	BE											
	Increased plant susceptibility to pests/injury	BE											
	Changes in plant morphology	BE											
	Changes in primary productivity	BE						alpine					
	Behavior change/injury/~~extinction in individual species~~	BE											
	Change in viability of populations	BE											
	Change in phenology	BE											
	Altered chemical cycles (nitrification, decomposition)	BGC											
	Base cation depletion (soils, plants)	BGC											
	N/S leaching	BGC											
	N volatilization (soil surfaces, biogenic N_2O) RATE CHANGE	BGC											
	Mobilization of Al, other metals	BGC											
	P, N release from anaerobic sediments	BGC											
	Altered N/S/C composition (soil, litter, water, biota)	CC											
	Acidification (soil, water)	CC											
	Altered ~~habitat~~ nutrient quality/quantity	CC											
	Eutrophication	EC										Part blue/part pink?	
	Increase in invasive species	EC											
	Altered biological community structure	EC											
	Altered disturbance regimes (fire cycle)	EC											
	Change in biodiversity	EC											
	~~Methylation of Hg by S-reducing bacteria~~ MOVED TO Hg												
	N deposition affects methane emission from soils>> more GHG												
Deposition of Hg	Methylation												
	Bioaccumulation												
	Biological effects -- species												
	Altered biological community structure												
	Bio effects -- individuals												
	Altered biodiversity												