MEETING NOTES

Forest Service Air Resource Management Program,
Western Lakes Monitoring Workshop
March 2-4, 2010, Stevenson, WA

Topic: Program Drivers and Key Management Questions

Presenters: Janice Peterson

Key Presentation Points:

- Foundations of the Forest Service Air Resource Management Program
  - Statutes, Forest Service Policies
- Forest Service Air Program Vision/Mission
- Partners
- Why Lakes?
  - Air Quality Related Value (AQRV)
  - Known issues with deposition and lake chemistry in the eastern United States
- Key Management Questions
  - Evaluate efforts/transition to the future – what have we found and where does the program go from here?
- Read a letter from Anne Acheson, who could not make the meeting because of prior obligations.

Questions/Discussion

- None

Recommendations/Decisions

- None

Topic: Region 1 Program Summary

Presenters: Mark Story

Key Presentation Points:

- 13 Wilderness Areas, 7 Class I, 6 Class II
- Found elevated levels of ammonium in northwest Wyoming and southwest Montana
- Elevated mercury levels in north-central Montana, likely associated with mining activities
- Increased visibility levels at all IMPROVE sites
- Increasing levels of ammonium at all NADP sites
- Ran statistical analyses using SAS Institute stat software to find if trends were statistically significant
  - Did not find many significant trends. Of those that were significant, most showed decreases.
  - Decreases in chlorate
  - Increases in pH
- Looking into investigating climate change and its effects on lake chemistry

Questions/Discussion:

- It was noticed that there was a lot of variability in trends, and that some samples were taken in early July and some in September. Could this explain some of the variability?
    - Yes, the difference in sampling dates surely has some influence on the variability seen in the trends.
- The graph showing trends in chloride levels shows a dramatic drop in the first 3 years, and then levels off. Why do you think this is?
    - These trends are driven by few data points, particularly in the early years. The dramatic drop is likely a reflection of that, and not a true representation of what was really going on.
- There is not a committed hydrologist working in the air program in Region 6. How did Region 1 get a dedicated hydrologist?
    - Mark started on the San Juan National Forest and had an interest in air quality monitoring for awhile. This led him to pursue ways to integrate into the air program.
- There was a comment on trend variability and timing of sampling from Region 5. There were the same trends in Region 5, but the variability could not described by timing of sampling.
    - Regions 2 and 4 found the same variability in trends, and found that there's could be described by the differences in timing of sampling.
- Has anyone ever analyzed the level or type of deposition and lake chemistry? Is it obvious what's happening?
    - Yes, that has been done and there appears to be some level of correlation.
- Do the sample lakes in Region 1 contain fish? Are most wilderness lakes stocked?
    - 3 lakes contain fish, 3 lakes do not contain fish. Mark would estimate the 40% of Wilderness lakes are or have been stocked.

Recommendations/Decisions/Further Questions:

- There were significant concerns over the timing of sampling and how this affects how trends are interpreted.
- Secondly, there were concerns over the paucity of data points and how this affects how trends are interpreted.
    - How does this variability in the data affect what trends are expressed?
    - How confident can we be whether or not we are truly seeing a trend in deposition rates?

Topic: Region 2 Program Summary

Presenters: Andrea Holland-Sears

Key Presentation Points:

- Study Objectives
- Lakes were selected based on their sensitivity to deposition
    - Headwaters, low acid neutralizing capacity (ANC), areas with bedrock resistant to

weathering, minimal inputs of alluvium and glacial till

- The White River National Forest found increases in sulfate, although NADP and USGS found decreases. Why?
    - All monitored lakes on the WRNF are in the Colorado Mineral Belt.
    - Are we seeing effects of climate change? Are shorter periods of snow cover leading to increased weathering and, thus greater rates of metal releases into the runoff?

Questions/Discussion:

- Do trends represent same starting period?
    - All sampling efforts began within 5 years of each other, in the late 1980's or early 90's.
- Does it make sense for the all the regions to display there trends starting from the same time? Would it make it easier to compare data across Regions?
    - Should show all data one has. Plus, it is difficult to compare trends across regions anyhow since they are so different.
- Forest Service Regions are divided by artificial (political) boundaries. Should the program be set up by geological or other environmental lines?
    - It was suggested that this question be added to the "tarmac" list, as it was beyond the breadth of the current discussion.

Recommendations/Decisions/Further Questions:

- It is an enormous job to do trends analysis, particularly consistently across so many Regions. Attempts have been made in the protocols to develop a standard, simple trends analysis, but it takes formal statistical training to perform scientifically sound trends analysis. It cannot easily be described by a step-by-step protocol designed for the lay statistician. The program might be better off using a simple linear regression, like the ones that can be performed in Excel. What does the group think about this dilemma, and does anyone have any tips?
    - It seems that the program tends to do a lot of "binge analysis". That is, the monitoring is done annually, then stored somewhere without annual analysis. It is crucial to add data to data sets annually and do the analysis on an annual basis. Data sets can get large and pulling years of unincorporated data all together can take months. Once the historical data is all together it is fairly easy to keep up with it.
- What are the limitations keeping individual programs from doing this?
    - There is a lack of personnel and staff gets busy with other duties after the monitoring season. Generally, there is not one person dedicated to data input and analysis.
- Trends analysis and length of trend:
    - Can be useful to do several different trend analyses, from the entire dataset, last 10 years, etc. Maybe more interested in different time periods, i.e. when the Clean Air Act amendments were enacted, and their effects on lake chemistry.

Using the entire data set is important, but looking at different time periods can tell other stories.
    - All regions should do trends analysis separately, as they know their areas and what environmental factors might be affecting chemistry. But again the issue of lack of personnel to do this. But…
        - Would it be beneficial to put a group together nationally every certain amount of years to focus on mass data input and analysis?

Topic: Region 4 Program Summary

Presenters: Ted Porwoll

Key Presentation Points:

- Wind River Mountain Lakes Monitoring Program – Bridger-Teton National Forest
    - Straddles Region 4 and Region 2
- The Region 4 program was born out of a workshop at Colorado State University to discuss potential effects of energy development on the Bridger and Fitzpatrick Wildernesses
- Sampling Issues:
    - Most inlets and outlets don't lend themselves to discharge measurements with current measuring methods.
    - Precipitation collecting methods are great for collecting chemistry data, but are not good for measuring levels of precipitation. The program should be making more of an effort of looking into the level of deposition.
    - Difficult to measure actual amounts of precipitation in "shoulder seasons", i.e. ending up rain in snow collectors, snow in rain collectors.
    - Would like to come up with a better way to collect snow. The bigger collectors are getting wind scoured, and samples are about 40-50 pounds of snow. Only need small amount of snowmelt to analyze chemical data, and it might be more efficient to use smaller collectors.
- Have found upward trends in ammonium, nitrate, and general decrease in sulfate

Discussion/Questions:

- What is being used to power the pumps for the oil/natural gas wells that are in the immediate area?
    - Several large compressor stations pressurize gas for delivery down the pipeline. Some run on diesel fuel, some are large turbine engines which are powered by natural gas.
- Will there be more emissions associated with powering the wells in the future?
    - Later on, as pressures decrease, the wells will need more compression so that gas can be delivered through the high pressure pipelines, which will create additional emissions. Secondly as older wells drop in pressure and new wells are drilled there will be a need to balance out the pressures, which will require additional compression.

- What kind of organic pollution is affecting the lakes?
    - Likely nitrogen oxides, which results from emissions from the oil/natural gas fields. As production increases and infrastructure deteriorates, there will be more fugitive VOCs (volatile organic compounds). For now there is a lot of money that goes into mitigation of emissions, but as the wells start to dry up (20-30 year) there is a worry that mitigation efforts will decrease as funding dries up. It costs up to $200,000 to plug just one well. Most wells are on BLM, which permits new wells. This has resulted in somewhat of a disconnect between those responsible for permitting wells and those responsible for monitoring effects of industry on air quality.
- Has anyone looked at USGS snowpack monitoring and how do their data compare to that collected through Forest Service monitoring?
    - Yes, it has been looked at. While the USGS data gives a good regional perspective, it does not do a good job of estimating total deposition for the year.
- Have they tried a wind screen around bulk collection sites to minimize wind scour?
    - Yes, but wind is so extreme at areas that even that does not suffice in some cases.

Recommendations/Decisions/Further Questions:

- Ted offered lots of great suggestions for changes to the program. Is there a way, either regionally or nationally, to implement these changes?
- A weakness of the program is its inability to collect sufficient precipitation data. Mainly related to the paucity of collection stations and the difficulty to extrapolate what data is available to other areas.
- Concern was expressed that the program looks only at small, specific areas when measuring deposition, when teams should be looking at a watershed or larger scale. There are lots of other tools, i.e. satellite imaging
    - Also suggest using predictive modeling programs to look at deposition levels.

Topic: Region 5 Program Summary

Presenters: Trent Proctor

Key Presentation Points:

- Have not missed a year of annual data analysis.
- What has been observed?
    - Need more data to develop significant trends
    - Data revealed no evidence of acidification or eutrophication
- See Recommendations/Decisions/Further Questions for other key presentation points

Discussion/Questions:

- What is the feeling of the group on returning to shoreline sampling?
    - Shoreline sampling the easiest method to contaminate samples and it requires skill. If it is done correctly there is no reason why it cannot be used.
    - Showing that there is no difference between mid-lake and shoreline sampling

gives a good basis to moving back to shoreline. But there are a lot of factors that go into how the environment will affect the samples.
    - Some lakes are shallow enough to not show much stratification.
- What's the rationale for sampling from the lake mid-point vs. the outlet or lakeshore?
    - In some cases they are the same. Some lakes don't have outlets, which would prohibit outlet sampling anyway. Looks like a lot of lakes have rocky bottoms, which makes it easy to sample from the shore. Look for outlet first, but if no outlet look for the best shoreline place.
    - Suggestion that if questions over when outlet will be flowing, should just do shoreline sampling throughout the seasons to maintain consistency. A lot of care needs to be taken when sampling from the shoreline.
    - Have to know when sampling during high water periods. Variability in the data might be attributed to when samples are taken during the hydroperiod. Lot's of different regions sample during different hydroperiods. To the analyst this makes it very difficult to compare across regions.
- When using a sediment core and diatoms to determine historical lake chemistry what is the most recent period that surface sediment samples would represent?
    - Probably 3-5 years, but this depends on which diatom specialist you ask.

Recommendations/Decisions/Further Questions:

- Lessons learned (presented in presentation):
    - Annual monitoring is crucial
    - Refresher training important
    - No significant difference between mid-lake and shoreline sampling. Decided to return to shoreline sampling in 2010.
- Further questions (presented in presentation):
    - How important is zooplankton?
    - Value of diatom data?
- Suggest that if there are questions over when an outlet will be flowing, it would be better to only do shoreline sampling, even if the outlet is flowing on some sample days. This would maintain consistency.
- It is critical to an analyst that it is noted where in the hydroperiod a lake was when the sample was taken.
- Is there a bioindicator that could be used to determine where in the hydroperiod a lake was when a sample was taken? This would eliminate the need to get out to the lake's mid-point to measure temperature profiles.
- Would it be better to sample less lakes more times? More samples have the benefit of smoothing out trends.

Topic: R6 Program Summary

Presenters: Janice Peterson

Key Presentation Points:

- Mt. Baker-Snoqualmie has been the focus area of program because of low ANCs and pHs ranging from 5.5-6.0
- The program has been having difficulty getting reliable pH measurements, so monitoring has focused on ANC
- Found ANC is lower in the spring. This is likely due to dilution caused by snowmelt.
- Layer of bryophytes is growing on the bottom of Summit Lake. Suspect that this is providing some sort of buffering capacity.
- Of the two study lakes that were evaluated, both lakes are phosphorous limited, not nitrogen, as was suspected. This was determined by observations that increase in phosphorous led to eutrophication.

Discussion/Questions:

- Was there any sense from diatom work that lakes were once nitrogen limited, but in the past became nitrogen saturated and are now in a phosphorous limited phase?
    - The paleolimnology has shown very little change over time in nutrient concentrations. Nitrogen is still very low, but adding more does not do much to the biotic life.

Recommendations/Decisions/Further Questions:

- None

Topic: Group Discussion: Regional Programs – Strengths and Weaknesses

Presenters: All

Strengths:

- Teams are asking questions
    - Results in continued evolution of the program
- There is a common goal
    - Collaboration in analysis
    - Consensus of using ANC to decide which lakes to monitor
- Lab consistency
    - Use of the same labs
    - Centralized lab
- Large quantity of sample data in some regions
    - Long sample period
- QA/QC in Regions
    - Defined protocols
    - Attention to quality in data
    - Common methodologies between regions
- Core visible measurements
- Level of statistical analysis
    - Critical loads
- Dedicated individuals

- Good knowledge of basic supporting parameters
- Use of data to make management decisions
    - Use of critical loads

Weaknesses

- Lack of training
- How trends and analysis correlate with policy
- Quality control of data
    - Limited statistical sampling
- It would be helpful if program measured more parameters/indicators
- Lack of consistent funding
- Lack of coordination with other programs within agency
    - Reporting
- Lack of ability to access labs analysis protocols
- Lot's of data missing from NRIS
- Sampling design is directed towards yesterdays issues, not the future
    - Limited bio response sampling
    - Limited analysis of nutrient loading
- Need to do a better job of linking NADP data with lake measurements
- Coordination with climate change policies
- Process for changing protocols is weak

Topic: Leveraging Funds/Forest Service Groundwater Program

Presenters: Joe Gurrieri

Key Presentation Points:

- Asked group how many are:
    - Air Program full-time funded: 3
    - Air Program Part-time: 6
    - Watershed:
    - Other NFS: 3
    - Other Non-FS: 3
    - Note – not all meeting participants were back in the room after the break, when Joe surveyed the group.
    - Conclusion: This program is run by a lot of "volunteers", people not officially charged with running or working with the Forest Service Air Program
- Problems with "volunteer" help
    - Hard to keep the same people involved through time
    - Program often stops when people leave, unless an effort is made to train/entice a successor
- Working with partners as a marketing tool
    - Have to be able to get out, volunteer, go to meetings

    - Partnerships across agencies and integrating what each agency is focusing on
- Groundwater Program
    - Initially started out as a new program, now a legitimate program. In the flowchart
    - Centralized, so anyone who needs assistance can call up one office and get assistance. It is free throughout the Forest Service (unless there is a need for a lot of help in a specific area)
- History/Creation of Groundwater Program
    - Why does the Forest Service need one. USGS has one, and it has been found to be very helpful
    - Where groundwater is at the surface in porous habitats (i.e. springs, seeps). Supports ecosystems across landscape. This is where the focus/niche is.
    - Steve Glasser created program. The groundwater program has put out the Forest Service guide to groundwater. Put out protocols to spring inventory. Learned how to work national protocols through the system. No reason the Air Program can't do it too.
    - Protocol becomes part of Forest Service policy, gets signed all the way up at the top. Officially signed off on, otherwise it's a "quasi-white paper".

Discussion/Questions:

- If someone wants to inventory groundwater resources across forest, where does the funding come from?
    - There is a protocol available for surveying for groundwater, but the groundwater group does not do any surveying themselves.
- What is the Business Requirements Analysis
    - The Business Requirements Analysis is performed when creating a new program or group in the Forest Service. Also, information resource people want to know that there is need for the data a group is interested in gathering. It helps you form what the questions are, and what are the needs.
- How can the groundwater program benefit the Air Program/Lake Program?
    - Groundwater affects lake chemistry and can create a lot of "noise" for the data analyst to sift through. Groundwater can potentially be the largest confounding factor when analyzing lake chemistry data.
- Does groundwater have a different influence than lake bed material? Groundwater is the main transport mechanism of the underlying sediment characteristics, and therefore should not vary much from the lakebed.
    - That is true in some cases. But, for example, measurements from a lake on the Umpqua National Forest were showing very low pH levels. Further examination showed that the lake was fed by groundwater that runs through a volcanic vent, and was supplying a high level of sulfur to the lake.
- Is it safe to assume that in glacial landscapes that the majority of lakes are highly influenced by groundwater?

- It all depends on the time period. During spring freshets, all the water in a lake runs through. After freshets, water sits in lake and does not change much. But, if groundwater is coming in, the water is constantly cycling. Important to know where one is during the continuum of seasons to understand what you are analyzing.
- It was noted that a lot of lakes have no inflow, but have outflow. This means that the lake must have groundwater influence to maintain lake level.

- Is there a period of residence that defines groundwater v. surface water? For example lots of water seeps through talus, and then pops back out. What's the difference between subsurface flow and groundwater?
  - Many of lakes are influenced by both surface flow and groundwater. Lakes can be very complex systems, trying to tease the atmospheric deposition influence on lake chemistry out of all the other influences represents a huge challenge.

Recommendations/Decisions/Further Questions:

- Need to collect more limnological/physical data on factors that could be influencing a particular lake's chemistry.

Topic: Willamette and Umpqua National Forest Hydrology Programs – Waldo Lake Science Plan Implementation and Diamond Lake Restoration Monitoring

Presenters: Al Johnson

Key Presentation Points:

- Waldo Lake:
  - ANC is very low, making the lake weakly buffered and highly susceptible to inputs that change lake acidity
  - Among the lowest phytoplankton primary production rates of any lake this size in the world. Also considered one of the clearest lakes in the world
  - A report completed in 1995 concluded that between 1969 and 1994 zooplankton became many times more abundant, and the species composition changed entirely. Phytoplankton primary production increased 20-fold and blue light was attenuated more rapidly in the later portion of the study period.
  - The Waldo Lake Science Plan was implemented in 2003 under an agreement between the Forest Service and the Center for Lakes and Reservoirs at Portland State University. Goals of the plan include: Compile historic data, determine current chemical and biological properties of the lake.
  - Water has extremely low levels of particulate matter and is known for its clarity
  - Lake has deep water bryophytes (liverworts), down to 128 meters. The benthic area of the lake also has a diverse assemblage of photosynthetic organisms including high densities of nitrogen-fixing cyanobacteria. These organisms are potentially a large source of organic and combined inorganic nitrogen in the lake.
  - An increase in phytoplankton primary production is a concern because this could contribute to an increase in the attenuation of blue light, reducing the available

light for deep water plants resulting in a shift of primary production from the benthic zone to the water column.
    - Recent analysis of data from earlier studies has led to uncertainty about whether the adverse trends described in the 1995 report exist or not.
    - Preliminary analysis of bulk precipitation samples indicates a seasonal variation in deposition rates of ammonium, sulfate, and nitrate.
    - Some years Waldo Lake freezes. Implications of climate change: unknown consequences if the lake never freezes over or if stratification begins earlier in the year and persists longer?
- Diamond Lake
    - Influence of non-native fish: Led to increases in cyanobacteria. Eventually all invasive fish were removed with rotenone
    - After rotenone treatment, pH dropped from as high as 10 to about 8. Also resulted in a dramatic increase in water clarity. Before treatment Diamond Lake was dominated by cyanobacteria, but after treatment the phytoplankton community shifted to diatoms

Discussion/Questions:

- Can you explain how dissolved inorganic carbon (DIC) acts as a limiting factor in the lower levels of Waldo Lake?
    - Before the Waldo Lake stratifies, lake water is mixing and DIC from the atmosphere is incorporated into the upper levels and mixed to lower depths. After the lake stratifies the hypolimniom is no longer interacting with the atmosphere however due to the extreme depth of light penetration, plants in the hypolimnion utilize DIC for photosynthesis.
- Having spent time at Diamond Lake, as a casual observer it appears that benthic algae levels have increased dramatically. Do the historical data show this?
    - There's not a whole lot of historical data on the benthic algae. It's hard to say what has changed over time. Recent sampling has shown that an increase in light penetration may result in an increase in primary production in the benthic zone.
- Do fish occur naturally in Waldo Lake, or has it been stocked?
    - Fish were stocked from the 1930's-1991. There is a population of naturally reproducing brook trout. In the benthic areas the trout do well on benthic invertebrates.
- Are there limited levels of oxygen in Waldo Lake?
    - Waldo Lake is very oligotrophic, and therefore respiration levels are very low, and oxygen levels are high.
- Of all the parameters measured in the monitoring of Diamond Lake, the only one in common with the Lakes Program is pH. Why are the things being measured so different from what the air program measures?
    - Those studying Waldo Lake believe that if one is looking for anthropogenic changes, it will show up in the biota before you will see a difference in the actual water chemistry.

- That is a very important point. If you look at chemistry it is not as sensitive as the biota.
- But the biota is dependent on the nutrients. Shouldn't the change in nutrients be seen first?
  - Nutrients get taken up very quickly by the biota, and even if they do not show up in measurements they may be present in the biotic environment, inside the bodies of the plants and animals.
- When the protocol was written were biometrics looked at? How come none of the metrics in Diamond Lake are included on the Air Program?
  - No, bioindicators were not considered when writing the protocols. The parameters that were considered were those that would be influenced by acidity changes.
  - Noted that since Diamond Lake is not very sensitive to some environmental changes it should not be used as an example of what/how to measure for things like climate change. Waldo Lake is better.

Recommendations/Decisions/Further Questions:

- Consider looking at biological metrics that could be measured to show changes in lake chemistry.

Topic: National Park Service Program Overview – Monitoring Surface Waters

Presenters: Tamara Blett

Key Presentation Points:

- Park Vital Signs:
  - Selected physical, chemical and biological elements to be used as indicators. Each Park came up with their own
  - Vital Signs Surface Water Monitoring: mainly measure pH, specific conductance, dissolved O_2, temperature and some flow discharge. Parks can also look at other parameters
  - Focus mainly on Category 1 sites(as defined by the Clean Water Act), but also look at Category 2 sites
- How the Air Resource Division of the NPS uses surface water monitoring and its strategy:
  - To take data and turn it into policy (emissions reductions)
  - Facilitate/Fund Science
  - Expand understanding of scope and scale
  - Make the case…communicate
  - Develop processes for action. Get the information to regulators
  - Facilitate emissions reduction
- The NPS has asked, is ANC the best/most sensitive indicator of water quality?
- Have looked at incorporating Total Maximum Daily Loads (TMDL) to provide a linkage between air and water quality
- Critical loads: potential for linking air and water quality

- Definition: Deposition loading below which ecosystems are not significantly affected by air pollution
- Managers define "significant harmful effects" and "specified sensitive elements", and what the critical load is for these

Discussion/Questions:

- How do Parks decide what levels to set their critical loads at?
  - The Park superintendent makes the decision. For example, we went to a Park superintendent and were able to get critical loads set very low. Diatoms are often the first indication that deposition is occurring in a lake. But since diatoms are not a very visible or publicly popular creature we used them as an indicator of ecosystem change. Sort of had to sell the idea to the superintendent.

Recommendations/Decisions/Further Questions:

- Since many Forest Service lands sit adjacent to National Park Service (NPS) lands it is recommended that forests explore NPS data, stored in EPA's STORET. This would provide a larger context when exploring possible reasons for lake chemistry change.

Topic: Environmental Protection Agency National Lakes Assessment Program

Presenters: Steve Paulsen

Key Presentation Points:

- National Aquatic Resource Surveys
  - Use the biota to decide if there is a problem with water quality because it is the biota that is what we are worried about in the end. Use the chemical data to determine what is causing a perceived problem
  - Program looking at all water resources
- National Lakes Assessment (NLA) – 2012
  - Goal of performing national and regional assessments. Over 1100 unique lakes sampled, with about 10% of lakes re-visited
  - About 50% of lakes would be classified as having good biological integrity, based on what is already known. Looked at trophic condition (chlorophyll concentration) and habitat integrity of lakeshores.
  - Looked at the stressors to biological integrity of lakes. Lakeshore habitat stress appears to be among the most important stressors to focus on from a policy perspective.
- Opportunities for the Forest Service
  - Using data from NLA
  - Enhance sample size for subpopulations of interest to the Forest Service. Either geographic subpopulations of choose subpopulations because of a specific risk.
- NLA provides a great opportunity for interagency collaboration through doing sampling on Forest Service land.

Discussion/Questions:

- How do we influence program or get involved?
    - One option is to get in touch with the Forest Service representative in Washington D.C., or even sit in on the planning team to influence which lakes get sampled.
- Are any lakes surveyed previously going to be sampled again?
    - Yes a good survey design samples a few, but not all of the previously sampled lakes. NLA will re-sample about half.
- Of all the indicators sampled for could the Forest Service or National Parks adopt some of them? Are certain ones more helpful when sampling a large population vs. an individual site?
    - Some indicators could be used. For single sites it's mostly important what you compare them too. Indicators have more or less meaning depending on particular type of system.
- EPA doesn't seem to like to go "too far off the road", off the beaten path. This seems to pose an issue with the lakes the Forest Service deals with.
    - It is mostly up to what the states decide to look at. Some states have logistical issues with how far individuals can travel to sample lakes. Have looked at contracting.
- If the Forest Service was going to be involved would we have to work with each individual state?
    - Not necessarily, involvement could just be involved in study design (i.e. getting more of the small lakes sampled).
- Why did states not want to sample the small lakes (< 4 hectares)?
    - The states that did not want to look at them it were the ones that generally don't look at lakes of that size in their usual monitoring. In the west, if a few key states/agencies stood up and advocated for the importance of the small lakes it may be possible to convince them to include them in this study.
- What effect would adding small lakes back into sample have?
    - If you under sample the small lakes, each lake that you do sample carries a heavier weight that will influence the overall trends of final estimates. Sampling a higher number of smaller lakes would reduce this effect.

Recommendations/Decisions/Further Questions:

- Get involved with the National Lakes Program in order to leverage funding opportunities.

Topic: Group Discussion: Opportunities to Leverage Programs

Presenters: All

Top leveraging opportunities:

- Critical loads.
- Working with EPA.
- Working with EPA in terms of the next National Lakes Survey. It's an opportunity to work with the agency and to get more data. Increase survey numbers.

- Leveraging NPS and FS in critical loads.
- Forest Service research in helping with analysis and stats.
- Universities. Good source of research opportunities and grad students.
- Noted USGSs successful PR program
- Collaboration between EPA STORAGE and FS NRIS.
- Working with multi-agency critical load group
- EPA 2012 lake study
- Regional Office and Washington Office cooperation
- Cooperate with EPA's multi indicator approach
- Collaboration with outside agencies. Coalesce around critical loads and what it would take to get them in place.
- Better data sharing between agencies
- Bringing info more to line officers, leadership teams. Probably good talking to staff.
- Other Fed agencies: USGS, EPA, NPS
- State regulatory agencies. Relay info as we watch secondary standards evolve.

End of Day 1

Topic: Limnology – Obtaining a Common Framework of Understanding the Big Picture

Presenters: Tim Sullivan

Key Presentation Points:

- Study Design
  - Important to have a solid linkage between what you're concerned about, what you're questions are and what you're going to sample
  - If possible, make the effort to make sampling statistically significant
  - Be careful about making changes in protocols involved in long-term studies. A change in protocol could compromise future data and prevent comparisons across years
- Nitrogen Effects
  - If nitrogen is the limiting nutrient and comes in through the air and is used biologically it can lead to nutrient enrichment and shifts in species
  - Climate can have effects on how much nitrate is leached out of the soil and available for runoff into lakes

Discussion/Questions:

- Are base cation measurements easier to get in the east than in the west?
  - Not more difficult. In the west, more likely able to use the lithology as the trigger because the soils aren't as developed.

Recommendations/Decisions/Further Questions:

- None

Topic: Western Regional Air Partnership (WRAP) Modeling Projections of Nitrogen and Sulfur

Deposition

Presenters: Tom Moore

Key Presentation Points:

- As the US reduces their emissions other countries/areas will increase theirs
- Off-shore shipping is projected to contribute a massive increase in both sulfur dioxide (SO2) and nitrogen oxides (NOx) emissions by 2018
- Ammonia emissions in space, time, and magnitude are poorly quantified, may be relatively correct at the regional level between source categories
- Models predict a large increase in ammonia across the West

Discussion/Questions:

- How were on and off road emissions for SO2 and NOx calculated?
  - Extrapolations based on estimations of future population size and fleet characteristics, while taking into consideration that EPA and states have rules and programs that will reduce the amount of SO2, NOx, and other emissions coming from tail pipes. Rising gas prices will also likely reduce use.
- What are off road mobile sources?
  - Things like bulldozers, tractors, etc. Not allowed on the roadway, but move around, and therefore are not fixed point sources.
- The increases in contribution by off-shore shipping are shocking, never heard of it. Why are they so massive?
  - These are massive container ships with huge engines, and we have seen steady increases in their use and it shows no sign that it may plateau any time soon. Compounding the problem, these ships are flagged in other countries so the US has no control over their emissions. Without these controls they burn "bunker fuel", which is 1% SO2 by volume. In contrast, SO2 concentration in US diesel is limited to 15 parts per million.
- The shipping contribution to volatile organic compounds decreases? Why?
  - Because the projection also includes what happens at the ports and the Western states have all put in venting systems that prevent a lot of emissions.
- Is there a member of the board that represents USFS?
  - Ann Acheson is the main contact.
- To what extent do you think the maps of projected deposition of NOx and SO2 are good references for future strategies to focus research/monitoring? What are the levels of uncertainty?
  - They are more maps of change, not actual levels or rates of deposition. There has been work on emissions. Unfortunately, with these models, the meteorology used is the same in 2018 as it was in 2002, which is highly unlikely, and they don't factor in climate change. The model has absolute values for each year. But they are a reasonably good starting point.
- Was the influence of China's emissions considered?
  - Yes, Harvard has a model for the whole world, and the transport of emissions from Asia was considered. It was found though that local emissions will have a

much larger influence in changes than what is happening in China.

Recommendations/Decisions/Further Questions:

- The WRAP models would be a good starting point when determining where to focus future research/monitoring, but must be used with caution.

Topic: Nutrient Enrichment

Presenters: Jim Sickman

Key Presentation Points:

- It is important to keep in mind that instrumental records of lake chemistry only go back to around 25-30 years. This makes it difficult to determine what the "normal" status of a lake is, given the paucity of historical data.
- Found that the ANC, N and S concentrations in Emerald Lake displayed a sinusoidal distribution through the couple decades of measurement. It was determined that this was most likely driven by hydrological cycles (i.e. a series of wet years then a series of dry years).
- Key to using diatoms to reconstruct past conditions is to calibrate your model by sampling lakes with a wide variety of conditions.
- Found an inverse relationship between N concentration and the indicator species. It is likely there are other factors affecting the abundance of diatoms in the Sierra Nevada, such as lithology and pH.

Discussion/Questions:

- How were nutrient/chemical concentrations measured?
    - Inferred from snow analysis.
- The Western Lakes program does not use biological indicators for lake sampling. Diatoms look like indicators. If you were tasked with having to monitor all the stressors of the program, what would you're program look like?
    - Would not use diatoms to track changes in lake chemistry because the fluctuations in populations are so strong (i.e. blooms in certain season). They are helpful in looking at sediments when determining historical lake chemical composition. Can't really think of a good biological indicator in this program, but maybe zooplankton. Would stick with chemistry.
    - Seems like there is a consensus that with lakes there is not really a good bio indicator, except maybe zooplankton.
    - May be good for comparing across chemical gradients over a landscape.
    - Phytoplankton can change so rapidly at quick timescales that it is almost impossible to get a baseline.
- Where is the phosphorous (P) in Sierra Nevada lakes coming from?
    - There is a grad student looking into the atmospheric deposition of P. Seems to be enough P coming from atmospheric deposition to influence the levels they are seeing in the lakes.
- When the Western Lakes program started monitoring projects in California they thought they would be measuring ANC. Later they determined that they should be looking at N

and S pollution. Should we be looking at P too? How do we really establish what N levels should be?
    - Would take the paleolimnology approach and look at sediment cores.
    - To determine what the historical range of N was collect data to get history of lakes and use to gather a more complete and extended timescale of historical condition of lakes. Other ideas: tree ring studies looking at changes in N.
- Has there been a relationship found between the National Park Services introduction of prescribed fire in the area and phosphorous levels in Emerald Lake?
    - Have always had a pet theory that there was some effect, but graduate students have not found much P when fires are burning. The amount of P released by a fire varies depending on fire intensity, and prescribed fires are generally of low intensity.
- How would you describe the trend in phosphorous release over the 20th century?
    - P levels are definitely increasing with increases in agriculture, as well as activities in Asia. P has long enough atmospheric life time to get transported to the Sierra from agricultural activities in the valleys as well as in Asia.
    - But work has shown that phosphorous from the west does not make it east of the Sierra crest.
- In lakes where there is anticipation it is moving towards N limitation have they looked to see if there is a shift in the algal community to more N fixing cyanobacteria?
    - They have not, as they have mainly been following population dynamics of diatoms.
    - It is possible to analyze sediment cores for this as well.
- The sinusoidal period for ANC and S changes is almost identical, while N has a totally different period. Any thoughts?
    - ANC and S respond similarly to dilution, while N responds in an opposite fashion. In a high snow year the inputs of N are high, while ANC and S are diluted.
    - Secondly, Nitrate concentrations are highly variable. You can see the range of the entire data set in one year alone.

Recommendations/Decisions/Further Questions:

- Would not use diatoms to track changes in lake chemistry because the fluctuations in populations are so strong (i.e. blooms in certain season). They are helpful in looking at sediments when determining historical lake chemical composition. Can't really think of a good biological indicator in this program, but maybe zooplankton. Would stick with chemistry.

Topic: Acidification in the Western U.S. – Is This Still an Issue?

Presenters: Bob Musselman

Key Presentation Points:

- Is deposition increasing?
    - Up to 1999 (the end of the data set) ammonium and nitrate have been increasing, while sulfate decreasing.
    - What about after 1999? There have been increases in oil and gas exploitation through the 2000s, so it is likely emissions have increased.
- Watershed sensitivity to acidification
    - Must look at critical loads
    - Watersheds more sensitive in the west than the east. Have not yet exceeded critical loads in the west, have some of this in the east.
- Is acidification still an issue?
    - Hard to say. Some emissions down, deposition up in some cases.

Discussion/Questions:

- Are you going to summarize trends analysis for R1, 2, 4?
    - We had nine years of data. Didn't really see anything that could be qualified as a long term trend by region, forest, or watershed. Now have data through 2009, going to re-analyze. Note, a study at Hubbard Brook found it took 17 years of data for a trend in change in nitrate to become statistically significant
- Comment directed towards the previous question: The National Park Service in Sequoia and Yosemite did a sensitivity analysis to determine how long one would have to monitor to see certain level of change.
    - Came to the conclusion that there would need to be annual monitoring for nitrate. For example, nitrates inter-annual variability exceeds the decadal variability. Other chemicals easier as there is less inter-annual variability.
    - Conclusion? We might not have enough data to be making conclusions regarding trends.
- Have there been any studies done looking the effects of episodic acidification on the local lake biota?
    - With high elevation lakes a lot of nutrients/chemicals get flushed out so quickly and so early biota doesn't have a chance to utilize it.
        - May be that downstream riparian habitats might show a response to episodic acidification, as this is where it likely gets incorporated into the environment.
    - Levels of episodic acidification in the west are not all that acidic, especially when compared to the eastern US. Have never seen a die off of species related to acidification. Haven't seen anything that would suggest a bio-indicator.
        - Caveat: lakes in west sensitive, so there is no suggestion that something like this will not occur in the future.
    - Comment on previous question: There has been some work looking at small ponds and salamanders. The study found that the snow was highly acidic due to power plants, and found some evidence of episodic acidification, but could not determine if there were any effects on the salamanders.
- You talked about sulfate and nitrogen deposition throughout the year, and that it peaks

very early in the season. But you suggest that if measuring sulfate and nitrogen then it should be done at the end of the year and not during the peak. Why?

- The point was that the peak is very difficult to catch, as it is very early in the season when mountain lakes are snow covered and very difficult to sample. If you miss that peak, which always occurs at first melt, then you don't know where you are along the trend line. Therefore, it is better to sample at a time when you are pretty confident that chemical levels are relatively the same. The best time for this is at the end of the season. This way you are always measuring when chemical levels are at their lowest, and can track changes this way. It is a way to reduce the noise from intra-annual variability.

Recommendations/Decisions/Further Questions:

- May not have enough long-term data to determine whether trends seen are due to actual changes in the levels of deposition, or whether they are representative of historical ranges.
- It is best to measure chemical levels at the end of the season when you know they will always be at their lowest. It is a way to reduce the noise from intra-annual variability.

Topic: Responses of Lake Chemistry to Changes in Atmospheric Deposition and Climate

Presenters: Alisa Mast

Key Presentation Points:

- Variety of trends in both increases and decreases of different chemicals. Hard to reach any solid conclusions.
- Lakes in mineral belt saw increases in sulfate (likely from weathering).
  - There have been weak trends in changes of precipitation.
  - Could be due to increasing air temperatures? With increases in air temperatures across the state there is a shorter period of snow cover and melting of glacial ice. This exposes more rock earlier in the year to the weather and permits higher rates of weathering. This is perhaps leading to higher releases of minerals in the rocks.
  - The rate of pyrite decomposition is dependent on oxygen availability. As declining water table leads to increased oxygen availability, is this leading to greater inputs of mineral sulfates?

Discussion/Questions:

- The monitoring showed pretty consistent increase in base cations in lakes across the region.
  - The magnitude of trends was not very big, but could be an effect of climate change. Didn't find any trends in chloride, which is considered an atmospheric indicator.
- Have you done any work on ammonia?
  - Not detectable in the lakes.
  - Would speculate that the ammonia is related to the nitrogen oxide emissions,

and not climate change, but the two do vary independently.

- Any data on nutrient particulate concentrations?
    - No, we but that would be useful to add.

Recommendations/Decisions/Further Questions:

- Important to remember when we are talking about climate, 20 years worth of data is not a very long time. When looking at patterns, we might be seeing 'trends within trends'.

Topic: Airborne Toxics in National Parks – Western Airborne Contaminants Assessment Project (WACAP)

Presenters: Tamara Blett

Key Presentation Points:

- Found a strong pattern related to a Park's proximity to agricultural activities and pesticide concentrations. It was determined that agricultural and industrial activities in a Park's immediate vicinity had far higher effects on toxic concentrations than the general level of activity around the world.
    - This is mostly related to concerns that Asian countries would be contributing high levels of toxics to the west coast, but found that this was usually not the biggest worry.
- Higher elevations collect higher concentrations of easily volatilized chemicals as they reach cold elevations that prevent further volatilization. High elevations become sinks.
- Intersex condition of fish found only in the Rockies. Can't say for sure the condition is related to contaminants, but there does appear to be a relationship between estrogenic compounds and intersex fish.

Discussion/Questions:

- Has there been long term monitoring to see how things change over time?
    - Funding has been an issue, but really do not have a need for the long term data. More interested in how the contaminants are affecting the environment and wildlife now, not in tracking changes through time.
- Have used "fat-bags" SPMDs that act like the fat in fish, absorbing chemicals. Have you considered using these?
    - Think they are a good idea, but really interested in what's actually happening in the fish. Secondly, the bags are only in the water for one season, while the fish have been accumulating chemicals for years and years.
- Is their a correlation between changes in atmospheric concentrations of toxics and what has been found in the wildlife? Are the mechanisms well understood how the chemicals get from the air to the fish?
    - There is data on concentrations in the air, snow, lichen, and fish. You can see it

accumulate by orders of magnitude in the different trophic levels.
    -

Recommendations/Decisions/Further Questions:

- Short of an outright ban on toxics, any control mechanisms will have to go beyond the proximity of sources to sensitive areas. Need to be cautious when talking about proximity as a measure of effect that a particular source will have on an area. If we could determine particular mechanisms about what carries things to certain areas (i.e. atmospheric transport, transport through streams, etc.) then we could develop more effective regulatory controls.
    - Point: We can't make a blanket statement that being closer to agriculture is worse. If one wants to determine sources of pollutants, suggest contacting other agencies (i.e. USDA or the states) to provide data on which pollutants are used where.

Topic: What's in the New Forest Service Protocols Documents?

Presenters: Tim Sullivan

Key Presentation Points:

- Field Sampling Protocol
    - Includes the 'why' of study design so individuals can understand why certain aspects are in the protocol and can choose to modify them if they see fit for their particular situation
- Laboratory Protocol
- QA/QC Protocol
    - Lots of disagreement how to approach aspects of detection and reporting limits
- Data Analysis Protocol
    - Heavy on the validation of data
    - Provides key aspects on data preparation
- Biological Indicators Protocol
    - Lake zooplankton and stream benthic macroinvertebrates
- Lake sampling video will be out before Spring 2010 training
- Data Analysis
    - Kind of like art in the creativeness of how you set up you analysis and what you can get out of it
    - Important to analyze preliminary samples/data for interference from other sources of chemical (i.e. geological) inputs

Discussion/Questions:

- Which software was used for data analysis? Is there software advice in the protocol?
    - Not sure, as a lot of analysis was done in the past. No there is no software advice.
    - Excel is the most often used because of its availability to FS staff. Lot's can be done in Excel.
- How did the video come out before the protocols had been developed? Are there

differences?
    - There is some disconnect between the video and the protocol. There are proposals to re-shoot and fix the inconsistencies in the video.
- Are there considerations of safety in the protocols?
    - Yes, the general safety items are in there. It is important to remember that each region has specific safety concerns, and will need to develop safety plans accordingly.
- When it comes to changing protocols, when you get a more sensitive instrument, what do you do with your old data? Do you adjust it?
    - Suggest doing side-by-side of the data and compare how closely they resemble each other. But do not recommend changing data in the database. When presenting an analysis of the data it is appropriate to adjust the data for that particular analysis. Just be up front and give your whys.
- Is there a metadata file in NRIS that asks for the instrument used in a measurement?
    - Yes, it will be in the new NRIS database, along with spots for the method code and detection limits.
- We spend a lot of our time trying to get discharge measurements. Is it possible to put in staff gauge?
    - Can't use staff gauges in Wilderness areas. It is possible to put in 'natural' gauges.
- Have used salt dilution tests as a way to get discharge measurements, and this seemed to have worked well. Helped especially with irregular streams. Was this method considered?
    - It was, but it is not included in the protocol. In general the thinking was that it is easy enough to use the methods in the protocol, and we did not want to recommend a method that introduced salt into Wilderness streams.
- Would you comment on the increasing interest in nutrient enrichment? Most of our monitoring only gets basic cations and anions, not getting total P and N. Should this be a highlight?
    - Think it's important for all of the areas, and it's not that expensive to incorporate into the studies. Definitely recommend it. Puts one in the position to evaluate whether lake is N-limited or not. But remember that because the lake doesn't appear N-limited at one point in time does not necessarily mean that the lake is N-limited, as nutrient levels vary relative to each other through the year. It is important to understand the dynamics between different nutrients. Also important to experimentally add nitrate to the water, either in the laboratory or in situ. It is not enough to simply measure nitrate and draw any conclusions. It is necessary to know about your N-inputs.
- Saw a paper on detecting algae loads through satellite data. Has anyone used satellite data to look at indicators?
    - Not aware of any, but likely someone has tried. A little concerned about the kinds of nutrient issues and algae we are concerned about and that the satellite

images may not be high enough resolution, but it is certainly a good idea to look at.

Recommendations/Decisions/Further Questions:

- Important to get discharge information.
- Each region has specific safety concerns, and will need to develop safety plans accordingly.
- Start measuring nutrient levels.
- Look at using satellite images to monitor algae loads.

Topic: The Role of Groundwater in Alpine Lake Chemistry

Presenters: Joe Gurrieri

Key Presentation Points:

- It is important to choose lakes for acidity/deposition studies that have little or no groundwater influence. Also want to minimize, to as much as an extent, other water sources EXCEPT rain/snow.
- There is a direct correlation between the amount of time groundwater stays in the rock and the amount of dissolved solutes it delivers to surface water
- When to sample: Degree day tracking
    - If hydroperiod is dependent on degree days, and you want to sample during the same hydroperiod, the hypothesis is that by counting to the same degree day each year you will be there in the same general hydroperiod

Discussion/Questions:

- Might it be beneficial to make a checklist for environmental conditions on field forms and the database?
    - They do include spots for environmental conditions.
- Has it been taken into account that environmental effects last a lot longer in perched lakes with no outlet, and that we could still be seeing effects from events that happened many years ago?
    - Yes we have acknowledged that these systems are incredibly complex, and that effects from fire, climate change, pollution, and natural variability make it difficult to develop significant trends. This complexity highlights the importance of having long term monitoring studies in order to tease out causal factors in trends.
- I can see lots of utility for degree day graphs. Where can you find them?
    - Lots of places have them online. Would suggest a simple online search for 'degree day graphs'.
- Are there ways of tracking how much of the inflow is from melting glacial ice v. seasons snow melt?
    - Yes, you would have to sample the glacier, looking for O18 ratios. Would either have to get an ice core, or it might be possible to simply gather water right from the toe of the glacier, where it is melting.

Recommendations/Decisions/Further Questions:

- Need a way to store environmental conditions in the database on the day measurements and samples were taken.
- It would be beneficial to go check around the lake shore with a conductivity probe or checking for perennial swampy areas to look for possible ground water sources. Using stable isotope analysis as a way to find sources of ground water is another option, as testing has gotten much cheaper.
- Suggest carrying little bottles to fill with lake water, archive them, and then when the opportunity arises (funding) send them off to a lab in bulk for analysis.

End of Day 2

Topic: Screening Methods: A History

Presenters: Janice Peterson

Key Presentation Points:

- Document: A Screening Procedure to Evaluate Air Pollution Effects… from the late 1980s
  - Were already using the term 'critical loads'
  - Green Line: If loads below this level no harm to the environment
  - Red Line: If loads above this level definitely will be harm to the environment
- Document: A Screening Procedure to Evaluate Air Pollution Effects…from 1991. Each Region developed their own
  - Steered away from discrete critical loads. Moved towards using Limits of Acceptable Change (LAC)
- Currently the program is trying to steer back towards critical loads

Discussion/Questions:

- None

Recommendations/Decisions/Further Questions:

- None

Topic: Critical Loads

Presenters: Tamara Blett

Key Presentation Points:

- Document: Screening Methodology for Calculating ANC Change to High Elevation Lakes
  - Seeking to develop a mechanism to measure how NEPA projects were going to affect sensitive lakes
  - Quick method to figure out if emissions from projects were going to cause more than a 10% change in ANC. Cumulative effects were considered, not each point source independently.
- Deposition Analysis Threshold (DAT)
  - Defines what amount of deposition (from a single-source) is insignificant
  - Needed to determine what the natural-background levels of N or S were? What levels are within the natural range of variability?
  - This is a way to see if we need to look more closely at the emission source in the

PSD/NEPA process.
    - Provides a method to sort projects based on their potential influence to the environment.
- Critical Loads (CL)
    - Based on science. Asks, what is the amount of pollutant below which significant harmful effects on identified sensitive elements in the environment?
- Target load
    - Based on values. What is the acceptable level of resource protection? What is the acceptable level of resource damage?
    - Target loads are usually lower than critical loads. But can be interim targets along the path to a specified critical load.
- Scientists v Regulators
    - Scientists develop the CL while regulators use CLs to determine how they could be used to protect environment. Land managers do both.
- What are CLs used for?
    - Assessing ecosystem health. Can be used to inform how lands should be managed, or for planning into how to manage in the future.
    - Assess efficacy of control statutes/programs
    - Develop plans to improve air quality. How do we get below a desired CL?
- Critical Loads Ad Hoc group (CLAD)
    - Nested within NADP
    - Meets bi-annually to work on problems and issues with CLs and their use. Also facilitates collaboration with nationwide work.
    - Facilitates information sharing and how programs are ran to make sure results are comparable to help with developing regional or nationwide CLs
- European approach to CLs
    - LRTAP-Convention: Intergovernmental bodies, expert groups and scientific centers
    - CLAD works together with this group to see what is the same/different and how to work together
    - Some US scientists work with them too
- Case example of critical loads from Rocky Mountain National Park (RMNP)
    - Critical load levels are different depending on which part of the ecosystem you are worried about. Some of them are more sensitive to changes than others.
    - The Park Supervisor decided he was willing to defend that a change in diatom species (which represented the lowest CL in the continuum) was what the park wanted stand for. Basis is that diatoms where an indicator of ecosystem health, and are the most sensitive to changes. Good indicators of environmental change.
    - A study found that the diatom species in RMNP lakes have seen more change in species composition since 1950 than in the previous 14,000 years, but…
        - Still needed to link the changes to chemical deposition. Hindcasting was

used to determine what the wet N deposition was between 1950 and 1960. But there are other things that can change species composition of diatom communities.
    - Did experiments on lakes to show that N can provide a mechanism for diatom species change.
    - Result: Developed a glide path for N emissions reductions in the area
- Dose-response
    - Testing to see what is the level of "dosage" of NO3 (or any other chemical) to force an effect on the change of a particular indicator, usually biological.
- Work needs to be done in the PNW to see what CLs are in the region.

Discussion/Questions:

- Which do you use for baseline deposition: IMPROVE or NADP?
    - Would want the deposition that you think is most representative of the lake in question, of the two.
- If you have multiple NADP sites which do you use? Do you pick the dirtiest data, or average it across the region?
    - Err on the side of being the most conservative; err on the side of the resource. That would mean picking the dirtiest data.
- Have an issue with the Screening method for predicting change in ANC used with cumulative deposition. It takes a lot for to change the ANC 10%. Why such a high number?
    - Set up that way, to allow for some development.
    - Lots of ways to fight future development in light of cumulative effects. It depends on where you are in the country. In the east where you already have lots of problems, each source is adding to an already huge problem, and it is relatively easy to argue that point. In the west we have a harder time, and need to get creative. One argument is that since the environment is still in a relatively good condition, in light of everything that has happened in the last century, let's not blow in now. When arguing policy it is more about how you present the data than how you calculate it.
- Have had several consultants use DAT, and have found that consultants will not submit a PSD that exceeds DAT. Any suggestions?
    - The Park Service has had problems with that as well. The models are so sensitive that consultants can, and do, tweak the inputs to models until they get the result that they want, as related to where deposition is occurring or the rate of deposition.
- Are CLs subject to change? When a new supervisor comes in do they have to authority to change them as they feel?
    - It depends on if you incorporate them into a more permanent management plan, such as a Forest Plan, or if they are just some sort of informal policy. This is an example at the crossroads of science and policy.
- In relation to the ecological continuum, it shows that at the same time N deposition is

affecting lakes with low ANC it is also affecting soils with low ANC. N deposition on the soils is increasing productivity, this is the first time hearing about worries about increasing productivity in the terrestrial environment.
    - Has gotten calls from the media about the same thing, and has had to explain to them that while fertilizers on farms are fine, it is not something we want in our parks.
- Does N go away in soils?
    - Probably pretty stable if its dry, not getting leached very much.
- A lot of wilderness lakes have been stocked with fish, which results in a trophic effect on the algae community. It is possible this could be affecting the diatom communities as well. Does this make it difficult to find lakes that are appropriate for paleolimnology analysis because of the influence of fish?
    - Jim looked at this when they did there analyses. Don't think people have looked at fish's affects on diatoms, done on zooplankton.
    - This was considered in the RMNP analyses. Stocking history was an important factor in the metadata.
    - This highlights the importance of how one set up their subsets of data analysis. Many ways to set this up prior to analysis. Signals you are looking for can be obscured by other confounding factors. Takes a level of creativity to tease out the signal you are looking for.
- Is there any value in getting new cores over analyzing cores that have been stored for 20+ years?
    - It would definitely be beneficial to get the 20 years of data missing from the older cores, so it is best to get new cores, if possible.

Recommendations/Decisions/Further Questions:

- On topic of soils: If working in acidity arena then soils might matter a lot. But when thinking about nutrients soils might not play as prominent a role.
- It appears that other resource areas are affected by atmospheric deposition. Are they being implemented into the air program?
- When arguing policy it is more about how you present the data than how you calculate it.
- Need to start to determine aquatic CLs for each ecoregion. What are the needs?
    - Sierra Nevada: need some site specific data on N v P; diatom response to NO3
    - PNW: need N v P limitation; determine episodic acid depositions link to biota
    - Wind River Range: diatom analysis for Black Joe Lake sediment cores; explore macroinvertebrate link to 'organic' impacts
    - All: need to determine the ground water influence to lakes; is sampling period (fall?) nationally consistent for hydroperiod (EPA CLs)?
- Every region's "continuum" or conceptual diagram may be different…ecosystems are different!
- Look at FS – Limits of Acceptable Change – might use as basis for critical loads development in western aquatic systems

- Just got English 'translation' of what would be acceptable CLs on website. When FLAG goes through will probably put DATs on there.

- From Glenn, R5, on CLs:
  - Their study was originally designed to determine CLs for acidification. This showed the importance of determining where and what you are looking for prior to implementations. Information forces them to look at SSWC (steady-state water chemistry) model. Important to determine where and what you are looking at.
  - Have the preliminary evaluations for some of the lakes. Most work has been done in lower elevations, while they want to be working in higher elevations, above the tree line.
  - Things still needed to determine critical loads:
    - Which are the important base cations to focus on?
    - Mineral weathering rates
    - Flow rates through the catchment
    - Links between the biota and different critical loads
  - Influence of groundwater is also a troublesome factor. Especially complicates the time of sampling.
- Tim Sullivan's response to understanding some of the variables that go into determining CLs:
  - Would follow Glenn's method. It is most beneficial to work with modeling efforts while at the same time refining the parameters that go into the models. Come at it from lots of different directions simultaneously.
  - Want to be strategic, spread out preliminary research to multiple areas, but only if money and resources are available to do a good job.

Topic: Group Discussion: Assessing the Air Program

Presenters: All

Goals:

- 3 Main Goals of the Lakes Program:
  - Detecting change in lakes
  - Assessing sensitivity of lakes
    - Can you use monitoring data to do this (i.e. CLs)
  - Identification of the change agent
    - Climate change can affect nutrient cycling independent of deposition
- Auxiliary Goals:
  - Identifying biological response functions
    - Stronger foundation in how/what changes in chemistry can effect changes in biology
    - What should we be looking at as a bio-indicator?

        - Are changes affecting T & E Species?
    - Expand baseline characterization with current data (data mining)
        - Have lots of data that could be analyzed in other ways than looking for trends
        - Identifying risk factors as data moves into categories of indications of change for the future. Are lakes approaching an intuitively determined threshold?
    - Develop a decision matrix/schema. A guide to answering a wide variety of questions, such as where to direct research or how a certain finding should influence policy.
        - Where does the science meet the management?
        - Field protocols are laid out in a fashion to guide the thinking process in study design towards how this will influence management. Maximize the utility of the data when done
        - Think of data as a "package". Treat the entire process from design, sampling, analysis, etc. as one package
    - Have managers make a preliminary "decision" about what they are worried about (Tamara's continuum from RMNP)
        - Make a recommendation to managers ahead of time to feel where their particular concern level falls along the continuum. This would help direct monitoring
        - Probably have enough data now to clarify/recommend things to managers about making decisions
    - Make a push to other programs to centralize data in one location in order to increase efficiencies.
        - Could develop a bigger picture of what is going on in the environment, not just surface waters or air quality
        - The whole concept of NRIS is to integrate data to answer questions that span multiple disciplines
    - A methodology of how to develop cause and effect conclusions from NRIS data
        - Can this data be strong enough, highly correlated enough to influence policy?

Discussion/Questions:

- Will the data warehouse down the road be able to assess where the FS stands as a whole as far as lake/ecosystem help?
    - If the data is comparable, likely yes. If someone had the foresight to look at the data in a broad enough scale to allow this.

Topic: Regional Programs: Thoughts on Moving Forward

Presenters: Mark Story (R1, R2, R4), Terry Svalberg (R4), Trent Proctor (R5), Rick Graw (R6)

Region 1, 2, 4 Reporting –

- Regional threats to Wilderness lakes:
  - Deal with issues unique to the Rocky Mountains
  - Specific to Region 1
    - Industrial sources
    - Episodic smoke
  - Specific to Regions 2 and 4
    - Climate change
    - Drought
    - Oil exploration
- Issues with the program in general:
  - Training of crews
  - Funding
  - Different sampling regimes in each region – difference in levels of size and intensity of sampling
  - Discharge is difficult to measure
- Questions and action items:
  - When is the appropriate time to sample for N and P?
  - How pristine are our lake systems?
  - Are there really degradation trends, or are we seeing natural variability?
  - Need to clarify trends and threats, mainly in relation to acidification, but also to nutrients and climate change. Believe nutrient concentrations and effects from climate change can be analyzed using current sampling techniques.
  - Associated with climate change, they believe they have some lakes might have a hydro-geological source. Would like to look at chloride:sulfate ratios from precipitation and lake water to determine this.
- Changes:
  - Reluctant to make any major changes due to the fear that this could disrupt and invalidate baseline data
  - Will consider changing the sampling date in Region 1
  - Would like to measure discharge at all sites
  - Would like to measure total N and P
- Further Comments:
  - Would like to switch to sampling in September because it is much easier to determine a consistent place to sample. But worried that switching the sampling date will mean that they will not be able to compare those data. Thinking about continuing to sample in July and adding a September sample data.
    - Bob Musselman suggested taking close look at July and September data and seeing if there is enough similarity to compare.

Region 2 Reporting-

- Future plans:
    - Helping Jill (a graduate student) continue her with thesis work in Region 4
    - Try to integrate program with other programs in the agency
    - Probably will continue with their current monitoring schemes, but will tweak it for efficiency
    - Will continue to monitor most sensitive lakes while taking a harder look at what the data is showing by re-analyzing
    - Could integrate synoptic lake sampling
    - Decipher data and reports from the bug lab and ecological study units. Determine how they may be used to improve their current monitoring
    - Perhaps gather current data on soils, and compare to soils data from the mid-1980's to see if there are any trends
    - Going to focus on looking at cause and effect relationships as they have not been able to correlate inferred impacts with changes
    - Look at how to use diatom cores from 2 lakes and using them to gather information on the historical diatom communities
    - In FY2011 will be performing a coordinated effort with other forests to look at critical loads in the Greater Yellowstone Area, and how to share data and integrate better
    - Taking a look at the initial study question and making sure that they are still on track with the original question, or if they need to formulate new questions to study new issues

Region 5 Reporting-

- Regional threats to Wilderness lakes:
    - Pesticides
    - Toxics
    - Smoke
    - Deposition
    - Episodic nutrient enrichment
    - Situated near the worst non-attainment area (Clean Air Act) in the US
- Questions:
    - What are the easy things to measure for tracking climate change?
- Changes:
    - Would like to investigate the groundwater conditions of their lakes and its influences on lake chemistry
        - Perform conductivity surveys
    - Taking another look at all the lakes in the program and determine whether all should remain in the program
        - Look into the possibility of using data to characterize the entire Sierra Nevada

- Sample lakes with records of high N concentrations multiple times through the season to determine if there is a trend, or just inter-annual variation
- Add easily attained items that are helpful in tracking climate change
- Integrate ecologists that match up with the air program
- Determine spring flow chemistry to gather data for episodic and base flow
- Develop critical loads
- Model weathering rates through the Sierra Nevada
- Would like to move to shore-line sampling, but still concerned about the amount of questions associated with it (i.e. losing temperature stratification and clarity data)
- Perform diatom analysis in more lakes, particularly from deeper lakes with deeper sediments
- Would be valuable to get GTR or documentation developed, improving coordination with State Resources Board, developing a marketing strategy (perhaps a powerpoint) to present to Regional and Forest Leadership Teams emphasizing the importance of the air program
- Adding P, N, NH4 kits
- Continue to develop the degree-day concept to determine where in the hydroperiod one is at sampling time
- Investigate tracking chemical deposition through isotope analysis
- Measure the discharges of more lakes
- Write a report of how they got where they are now. Present what they have found up to now, something like a resources status report

Region 6 Reporting-
Changes:

- Not seeing any signs of acidification. Does a synthesis report need to be written?
- Would like to take a statistically significant snapshot of lakes in the region to be able to make informed statements of the health of the lakes
- Look into leveraging with EPA and their National Lakes Assessment

Questions:

- What are some easy climate change indicators?
- Are there degree-day curves for every sno-tel? These may be very easy way to track climate change by looking at the migration of curve one way or the other.

Action Items at a National Level-

- Look at how water quality data has been used and how it has influenced management decisions, or how it has not worked
- Lab needs assessment. How can we change it?

Topic: Other Program/Agency Thoughts on Moving Forward

Presenters: Joe Gurrieri (Groundwater), Al Johnson (Hydrology), Tamara Blett (National Park Service)

Groundwater Program Reporting-

Comments:

- Would request that everyone collect discharge measurements at inlets and outlets. This is a critical piece of information that really does the data analyst a favor. Good flow measurements help determine what is going on with the chemistry and are the only way to measure where in the hydroperiod a lake was when samples were collected.
- Disappointed at the bad rap the 'orange-float method' has gotten. Thinks it is a really good idea. Written up in USGS protocol for data acquisition.
- Groundwater program is here to help, 4 folks available nationwide. Thanks for being receptive to groundwater, appreciates how the group has picked up on it.

Questions From the Group:

- Has there been a document produced that describes the signs of groundwater influence, so it can be added to basic site selection protocol?
    - There are plans on writing one up and including it in the protocol.
    - There was a request that within the next 6-8 weeks there be a document produced that describes what information needs to be collected to analyze whether there is groundwater influence on a lake.
        - It was answered that the request be given directly to Chris Carlson and it will be officially assigned to a team member.
- Lakes often have multiple inlets. Does it suffice to simply measure the outflow of a lake to see how much water is moving through it?
    - Yes, that would probably work.

Hydrology Reporting-

Changes and Action Items:

- We are already considering proposing a business plan to integrate aquatics with the air program, and will continue to investigate this. See lots of integration opportunities
- Have been organizing nationwide lakes data into a database and are now at a point where they need a database to put it in. Would like to take advantage of the migration to the NRIS database as an opportunity to integrate aquatics data with information from the air program, and get linked up to NRIS
- Will continue to pursue partnerships with universities and other agencies especially in investigations related to climate change
- The issue of toxic cyanobacteria plumes is likely to become a bigger issue in the future as it appears as if occurrences of these events is are increasing globally, but it is still unclear whether this is due simply to increase awareness. Would like to track the number of blooms to see if occurrences are in fact increasing

- Would like to include data they collect on cyanobacteria blooms with the lakes program database
- Would like to improve data management

Comments and Questions From the Group:

- If the hydrology program wants to load data into NRIS air that is fine. Just need to talk to the right people.
- Is NRIS air ready for biological data?
  - There is a spot for zooplankton data in ACCESS, but not for phytoplankton
  - Encouraged to look at NRIS and see if there are places for it
- Suggestion that it may be beneficial to get together with the database people and see what other fields could be integrated into NRIS. The hydrology program has collected lots of historical lake data, and would be very interested in getting it into NRIS

National Parks Reporting-

- There will be an information gap to fill considering that there was not a representative from Region 3 at the conference. From the models it looks like there will be a lot of N deposition in that region, and it will be important to fill them in on what was learned here and keeping them engaged in the program
- How can Park Service, Forest Service, and EPA coordinate better?
  - The agencies have many similar interests and there are lots of ways to work together, such as sharing in projects, joint funding between agencies, or leveraging resources by answering similar questions in the same areas

Topic: Group Discussion: Bringing it All Together – Consensus Points, Outstanding Issues, and Action Items

Presenters: All

Where does the Group Go From Here?

1. 1-Page Summary:
   R1-step 4 done for data through 2007
   R2-by July 2010
   R4-By July 2010
   R5-by May 2010
   R6-By June 2010

2. Western Waters Working Group:
   R2-Conference Call Fall 2010. Meet again Fall 2011. Informal, not FARM team.
   R4-Conference call fall 2010. Meet fall 2011. Informal communication group
   R5-Conference call fall 2010. Meet again fall 2011. This group, not FARM.
   R6-2010 conference call for info sharing, discuss issues

3. Establish Commonalities, Coordinate Monitoring, Western Trends Monitoring:
   R4-See informal group discussions from #2

R6-2012 only if new sources of funding. Need more evidence of benefit in PNW scientific/management justification

4. Regional Science Reports on Lakes Supported by Science and Statistics:
   R2-In process, completed 2011 or 2012
   R4-By FY2011
   R5-By March 2012
   R6-2014? Only if we can pull together funding for statistical/scientific support

Moving in to the future: Western Waters Working Group

- It was decided that there should be an informal inter-regional conference call at the end of the field season to touch base again.
- There should be a rotating Regional responsibility if there is to be an annual inter-regional conference call. Ted Porwoll is this year's volunteer!
    - The Region in charge gets to set the agenda. What do they want to hear? Set up the purpose and the objectives as a Region.
- Potential objectives for call:
    - Information sharing
    - Present goals for the season in a one-page summary prior to field season and sum up if or how these goals were reached or not reached. Status report?
    - Investigating balancing between pure monitoring and analyzing data
    - Setting up clear objectives
    - Coordinate lakes monitoring programs and compare results to characterize the West:
        - Report on the success of this years data collection
        - How was data used to make management decisions? Plans for the future with these decisions.
        - How many lakes have been used to detect change and what are the agents of change?
        - What is the status of these lakes and what about other lakes similar to them?
    - Talk about how the one page reports are coming along and how can they be set up to have a similar appearance

Topic: Information From Other Documents Collected During the Meeting

From the Tarmac:

- Develop protocols for making changes to monitoring programs
- Develop better methods for collection of precipitation at mountain lake sites
- Need for business requirements
- Regulatory drivers for N v P limited lakes
- Looking at mercury in fish tissue and contaminant analysis

- Need to establish procedures and protocol for doing trend analysis to provide consistent approach across regions – Tim Sullivan and Joe Gurrieri
- Is there a need for or is it worth investing in a zooplankton data analysis (2 comments on this)?
- What is EPA doing?

Final Questions/Action Items:

- Which lakes are nitrogen limited?
    - Will we do this West wide? How to set up the statistical analysis? W
- Where are the commonalities across the West's lakes? Especially in relation to climate change.
    - Are we dealing with the same issues across the West? What are the signals we can use from lakes that indicate climate change is taking affect?
    - Give all data to a contractor to synthesize data from across the West. What will we discover? Where are problems with acidification, nutrient enrichment, climate change, etc.
    - What's happening across the West?
- Should we invest more in sediment cores to gather historical data instead of focusing on collection 20+ years of data?
    - Statistically sound so that we can extrapolate to other lakes
- Value to doing annual report?
- Data:
    - How do we use our existing data to influence management decisions (ex. PSD); what will it take to strengthen our data?
    - Draw conclusions from data w/ confidence? Dose response? Methodology with connecting cause and effect?
    - What about other historical data sets that did not make it into the database?
    - Expand baseline data on lakes? Need more data mining. Frequency distributions of pH of lakes in a region or forest.
    - How are we going to get all the nutrient and chlorophyll measurements done?
- Program Management
    - Given all of the issues before us, what is the top priority to address?
        - How can we expand that priority work over large areas?
    - Quality Assurance: What are the workloads on the Regions-can they handle the extra work?
    - How to adjust/present data warehouse, etc. so that it works with management questions.
    - Copy Tamara Blett's graph showing the progression of deposition impacts on biota. Show to managers.
    - Ask managers to formulate questions now, so that data is not overly complicated or to get managers to buy into monitoring plans early.
    - Add risk factors (i.e. new coal fire plants may go online) to prioritize work geographically.

    - Create a decision matrix. Managers ask questions, what needs to be addressed, which questions need to be answered. Help to focus data collection.
- Dose-Response:
    - How to determine PSD go or no go? Develop glide scale like Tamara Blett's.
    - Use critical load/LAC framework to work with dose-response.
    - Can the monitoring program detect subtle changes?
    - Can the program assess the probability of change occurrence?
    - If a change is detected, can it be tied to a specific stressor?
- Regulatory Control Measures:
    - What are the impacts of growth of oil and gas development on our Wilderness values and can our monitoring program (current or revised) help lessen these impacts?
    - Is native biota in our most fragile waters seeing changes from human activity?
    - Are wilderness lakes impacted by anthropogenic pollutants, and if so, to what degree?
    - How do "on the books" control strategies affect exposure and emissions?
- Modeling:
    - Need to find time and money to revamp program to address needed changes:
        - More sample dates
        - Update MAGIC calibration
        - More field parameters
        - More lab parameters (i.e. ability to determine N:P ratio)
- Critical Loads:
    - What methods will be used to determine critical loads?
        - Need to develop a critical loads plan.
        - Create a glide path to get to critical loads.
        - Assign risk of exceeding critical loads.
    - What can we do with the data we have now, and where are the gaps?
    - How can we use existing data or frame future research to establish critical loads?
    - How do we specify what variables to measure when determining critical loads?
- Climate Change:
    - What are the impacts of climate change on lakes?
    - How will climate change affect our lakes?
- Nutrients (N:P):
    - What is the trans-pacific transport contribution of N and P to West coast ecosystems?
    - Need to determine which lakes are nitrogen limited and which are phosphorous limited.
    - Establish critical loads for nitrogen and phosphorous.
    - Better estimations of nitrogen and phosphorous deposition, especially at high elevations.
    - What is the best way to transition from acid deposition monitoring to both acid

and nutrient deposition monitoring?
    - How do we efficiently determine the N:P ratios of our lakes?
- Expanding Scope:
    - Can we do a better job of integrating and combing forces with other management areas and programs?
    - Do our research questions need to go beyond lake or water quality to total ecological health of our sensitive ecosystems?
    - Use data warehouses to expand disciplinary analysis and to fill knowledge gaps.
    - Wildlife biologist concerns – what are impacts of deposition to T&E species?