US FOREST SERVICE WIND RIVER MOUNTAIN LAKES MONITORING PROGRAM

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Air Quality and Acid Deposition Potential in the Bridger and Fitzpatrick Wildernesses Workshop March 1984

- In March 1984, a workshop was held on the Colorado State University campus to discuss the "Air Quality and Acid Deposition Potential in the Bridger and Fitzpatrick Wildernesses". This workshop involved scientists and air quality specialists from research, state, and federal governments. They reviewed the state of knowledge at that point in time, then made recommendations for future monitoring to protect the air quality and monitor acid deposition and it's effects in these sensitive Class I Wilderness areas.

- As a result of the 1984 workshop, several recommendations were made. Here is a summary of those recommendations and a short discussion of where we are in relation to fulfilling those recommendations.

SURFACE WATER

SURFACE WATER

- . “Approximately 100 additional lakes should be sampled for the basic water chemistry analysis as proposed in the original action plan.”

- The Forest Service has sampled approximately 150 lakes as part of our synoptic and long term lake sampling programs. In addition there are approximately 10 lakes sampled on the Wind River Reservation. Since 1996, we have identified 22 sensitive lakes with ANC’s less than 50 ueq/l in the Wind River Range.

SURFACE WATER

- . "At least one monitor lake in the 20-30 ueq/l. alkalinity range should be established".

- Since 1997 the Forest Service has been trying to phase in Upper Frozen Lake as a long term lake with an ANC less than 20 ueq/l.

SURFACE WATER

- "Permanent water flow measurement stations combined with chemical water analysis should be located near if not within wildernesses".

- At our 5 long term lake sites (Hobbs, Black Joe, Deep, Ross and Lower Saddlebag lakes), water flow and chemistry is measured at the inlet and outlet when we do our mid summer lake sampling.

SURFACE WATER

- . “The fish, macro invertebrate, and zooplankton survey should be continued throughout the period of the monitoring program.”
- As part of our Long term lake sampling we continue to sample for macro invertebrates and zooplankton on an annual basis.
- We are also willing and able to collect tissue samples, (fish). Just say the word.

SURFACE WATER

- Recent Macroinvertibrate samples from Deep and Black Joe Lakes were analyzed at the Buglab at Utah State University using the Hilsenhoff Biotic Index. This biotic index indicates that 80% of inlet and outlet samples from 2006 and 2007 show Fairly significant organic pollution, while the other 20% show Some organic pollution.

SURFACE WATER

- . "A diatom and heavy metals analysis of the monitor lakebed sediments should be conducted."

- Sediment cores were taken from Hobbs, Black Joe and Deep Lakes during August 1984 by a group of researchers from the University of Maine. In 2003, the USFS in cooperation with the USGS assisted in sediment core sampling of Hobbs lake. Part of the emphasis of the sampling was to focus on heavy metal analysis and to facilitate correlation with Ice Core samples from Fremont Glacier.

SURFACE WATER

- "One of the monitor lakes should be located east of the continental divide, probably in the Fitzpatrick Wilderness."

- We currently have 2 long term lakes on the east side of the Wind River Range. These are Ross Lake in the Fitzpatrick Wilderness and Lower Saddlebag Lake located in the Popo Agie Wilderness, both Wilderness areas are a part of the Shoshone NF.

DEPOSITION

- "Temporary rain gauges should be installed at the monitor lakes for water chemistry analysis."

In 1986, the Forest Service, through industry funding, established sites for the collection of precipitation (rain and snow) at our long term lake sites to determine precipitation amounts and also for chemical analysis of the precipitation to quantify deposition. Around 1996, the number of bulk deposition samplers was reduced from 5 to 2 to reduce costs of operation, and also because data gathered in the same general area was not significantly different between the samples. Currently there are 2 bulk deposition collectors still in use at Hobbs and Black Joe lakes

DEPOSITION

DEPOSITION

- "Dry acid Deposition collection sites should be established."
- When the four NADP sites around the Wind River Range were developed, they originally sampled for both wet and dry deposition. The bulk deposition samplers currently at Hobbs and Black Joe Lakes are wet and dry samplers, because the collection devices are open to the atmosphere. It is believed these collectors give representative measurements of wet and dry deposition associated with the sites.

DEPOSITION

- "Better information is needed on acid deposition rates, particularly the dry component, to assist the soil column study, and to predict effects on soil properties."

- Again, as part of the NADP program, dry deposition was collected for many years. Also, as part of the bulk deposition sampling program wet and dry deposition are collected, The only work we know of related to deposition and soil properties is a study from INEEL and WY Game and Fish looking at selenium increases in plants related to Big Horn Sheep mortality, and initial work for MAGIC modeling.

DEPOSITION

- "Snow collectors for chemical analysis of snowfall should be considered."
- As part of the bulk deposition program currently funded by industry, the Forest Service does collect snow for chemical analysis at Black Joe and Hobbs lakes.

DEPOSITION

- "Upper air information is needed at the northern end of the Green River Basin in the Pinedale area."

- To our knowledge the only upper air information gathered for Upper Green River Basin is related to the SWWYTAF study, various O3 studies, and NEPA related modeling.

Pinedale Field Office Wells as of 10/28/2009

Natural Gas	
Producing=	3,723
Capable of producing=	259
Total=	3,982
Oil	
Producing=	462
Capable of producing=	24
Total=	486
In some state of drilling or completion=	454

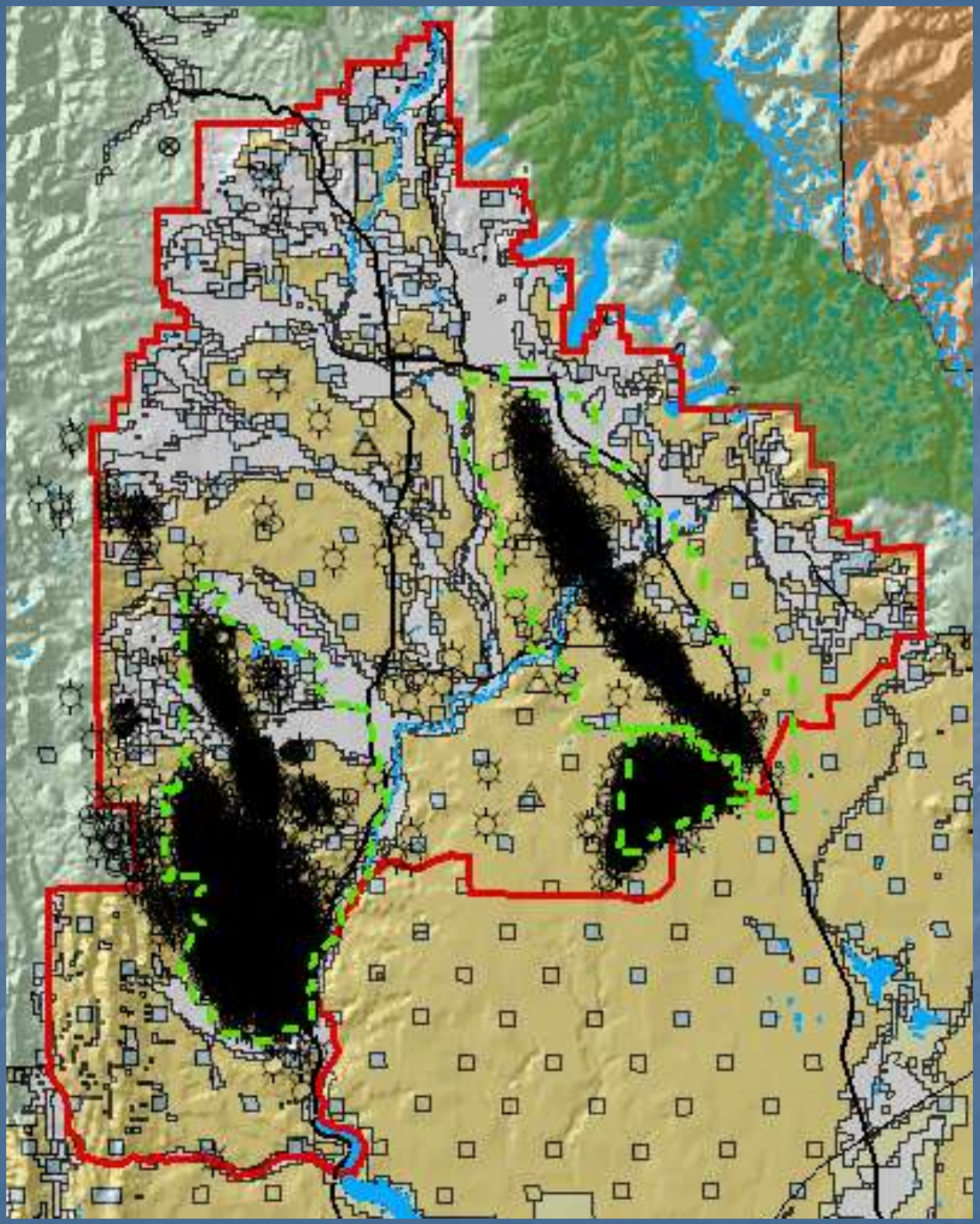
Totals are wells administered by BLM. May be more on State and Private Lands.

Source: Merry Gamper, Petroleum Engineer, BLM, Pinedale Field Office.

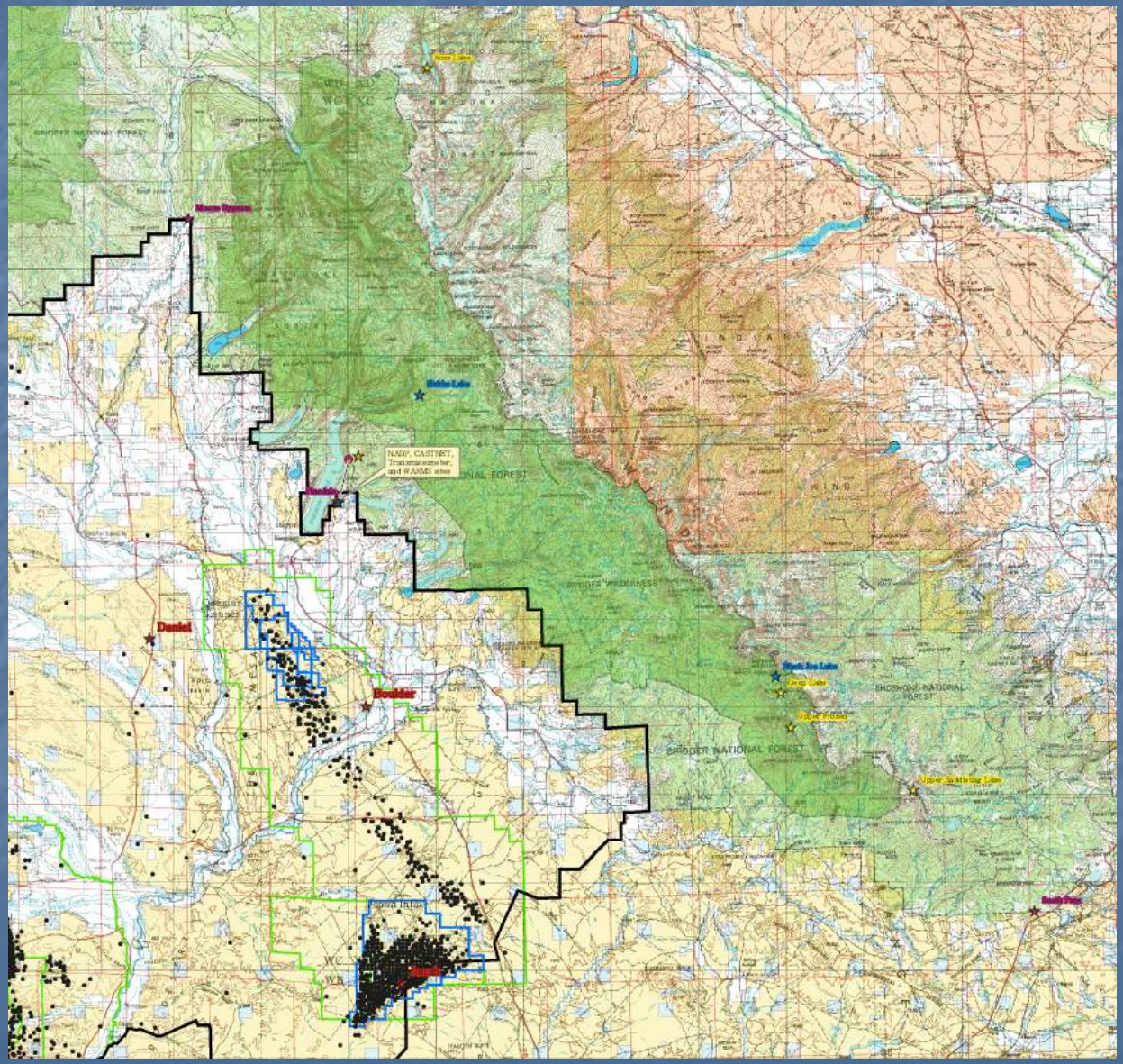
Other Proposed Southwest Wyoming Oil and Gas Projects

- Continental Divide / Creston – Blue Gap = 4,200 wells
- Normally Pressured Lance = 85 wells
- Hiawatha = 4,208 wells
- Moxa Arch = 3,261 wells
- PXP = 133 wells

- TOTAL WELLS = 11,887 wells



Local Emission sources and Monitoring Sites

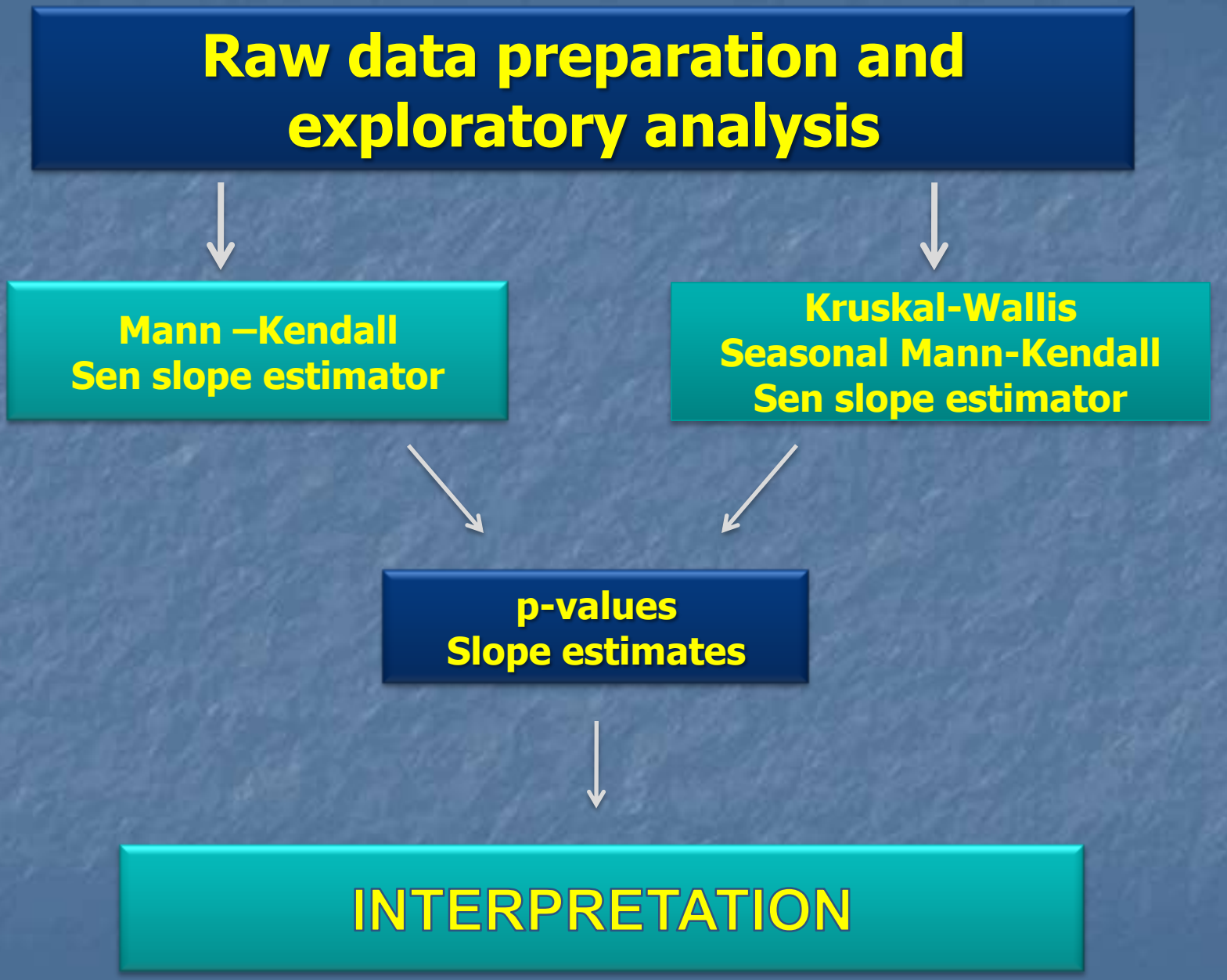


Statistics

- SAS Institute statistical software was used to run analyses following draft USFS Data Analysis Protocol (DAP) recommendations in coordination with Lori Porth, RMRS Statistician

- Non-parametric tests because we are working with non-normal distributions that have errors, gross outliers, or missing data in the data set.

- Our designated alpha level for trend detection was $\alpha = 0.1$, we also reported α levels of 0.05, 0.01, 0.001. A significant p-value does not speak to the magnitude of a trend.


Raw data preparation and exploratory analysis
Mann –Kendall
Sen slope estimator
Kruskal-Wallis
Seasonal Mann-Kendall
Sen slope estimator
p-values
Slope estimates
INTERPRETATION

Statistical Tests Used

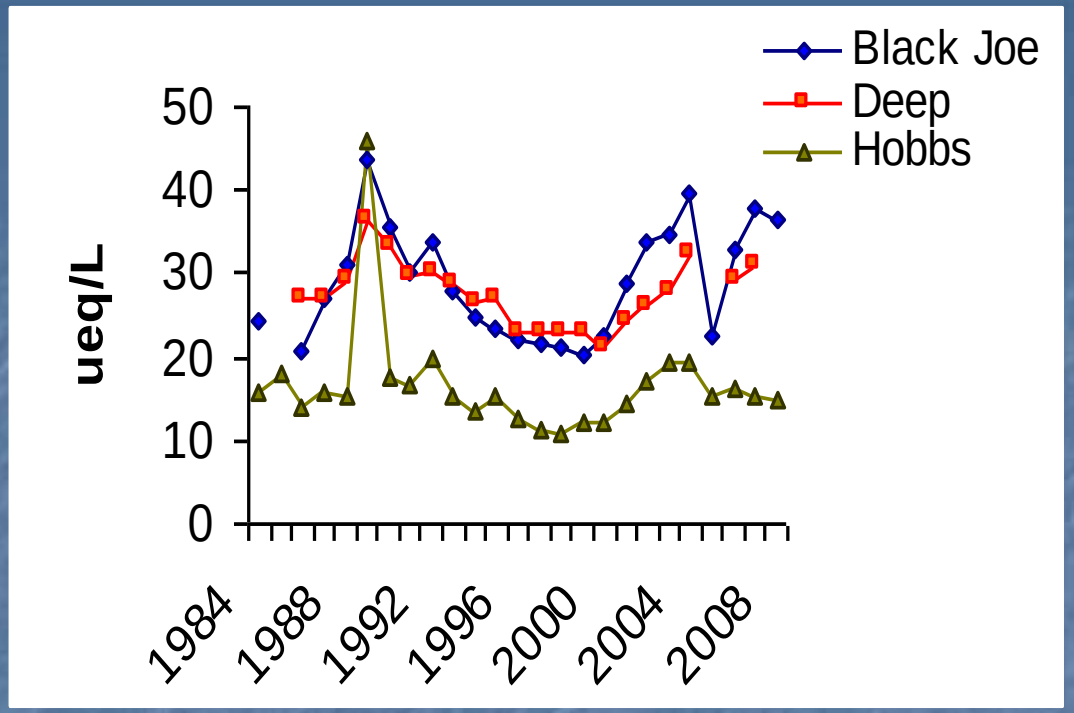
- Mann-Kendall – calculated each elemental variable over the years to see if there were statistically significant increasing or decreasing trends.
- Kruskal-Wallis -- to see if seasons in the data set were statistically different
- Seasonal Mann-Kendall-run to look for trends while taking seasonality into account
- Sens slope estimator- magnitude of slope.

Trends in Annual Lake Concentrations (µeq/L)

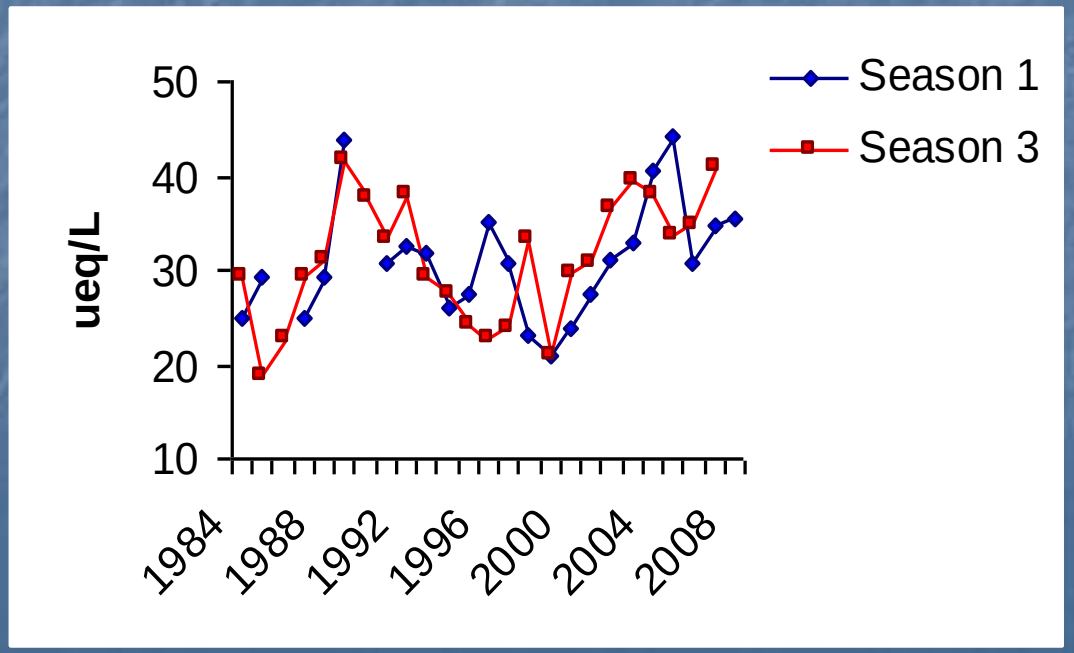
	Black Joe		Deep		Hobbs	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
NH_4^+	---	↑*	---	---	↑**	↑*
NO_3^-	↑***	↑**	↑**	---	↑*	---
SO_4^{2-}	↑*	---	---	---	---	---

* = p<0.1, **= p<0.05, ***=p<0.01, **** =p<0.001

Annual sulfate conc. From the hypolimnion



Seasonal sulfate concentrations From Black Joe Outlet



Trends in Seasonal Lake Conc. **(µeq/L)**

(at inlets unless stated otherwise)

	Black Joe			Deep			Hobbs		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
NH_4^+	---	---	---	---	---	---	↑**	↑*	---
NO_3^-	---	↑**	↑***	---	↑**	↑*	---	↑**	---
SO_4^{2-}	---	↑**	---	---	---	---	---	↓**	---
Outlet NO_3^-	---	↑**	---	---	---	---	---	---	---
Outlet SO_4^{2-}	↑*	---	↑*	---	---	---	---	---	---

* = p<0.1, **= p<0.05, ***=p<0.01, **** =p<0.001

Brief Summary

- General decrease in sulfate (but increase in some of the lakes)
- Increase in ammonium (agrees with the general increase occurring across the western US).
- Increase in nitrate this trend was also found in the CO Front Range.

Where do we go from here?

- Analyze the Bulk deposition sites for seasonality.
- Quantify the deposition for each of the data sets and compare total deposition for N and S between data sets.
- How much of an increase or decrease is there?
- Compare N and S deposition in R4 to R1 and R2.
- What are the repercussions for increase in N and S?
- Critical loads?

N deposition and Critical Loads

- Total N deposition at the Hobbs and BJ bulk sample sites average 2.35 and 2.66 $kg/ha^{-1}year^{-1}$ respectively and range from 1.23 to 4.3 $kg/ha^{-1}year^{-1}$
- Baron (2006) suggest CL for high alpine lakes in CO ~1.5 $kg/ha^{-1}year^{-1}$
- Fenn et al. (2008) suggest CL for lichens communities in mixed conifer forests of CA to be around 3.1 $kg/ha^{-1}year^{-1}$

CONCLUSION

- The USFS has moved toward the implementation of most of the recommendations of the workshop. Most of our work is directly in line with their findings. As we have learned more in the process, we have decreased sampling frequency to reduce costs while still gathering sufficient data to monitor changes over time.

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