DISTRIBUTION OF OZONE AND OZONE PRECURSORS IN THE LAKE TAHOE BASIN, USA

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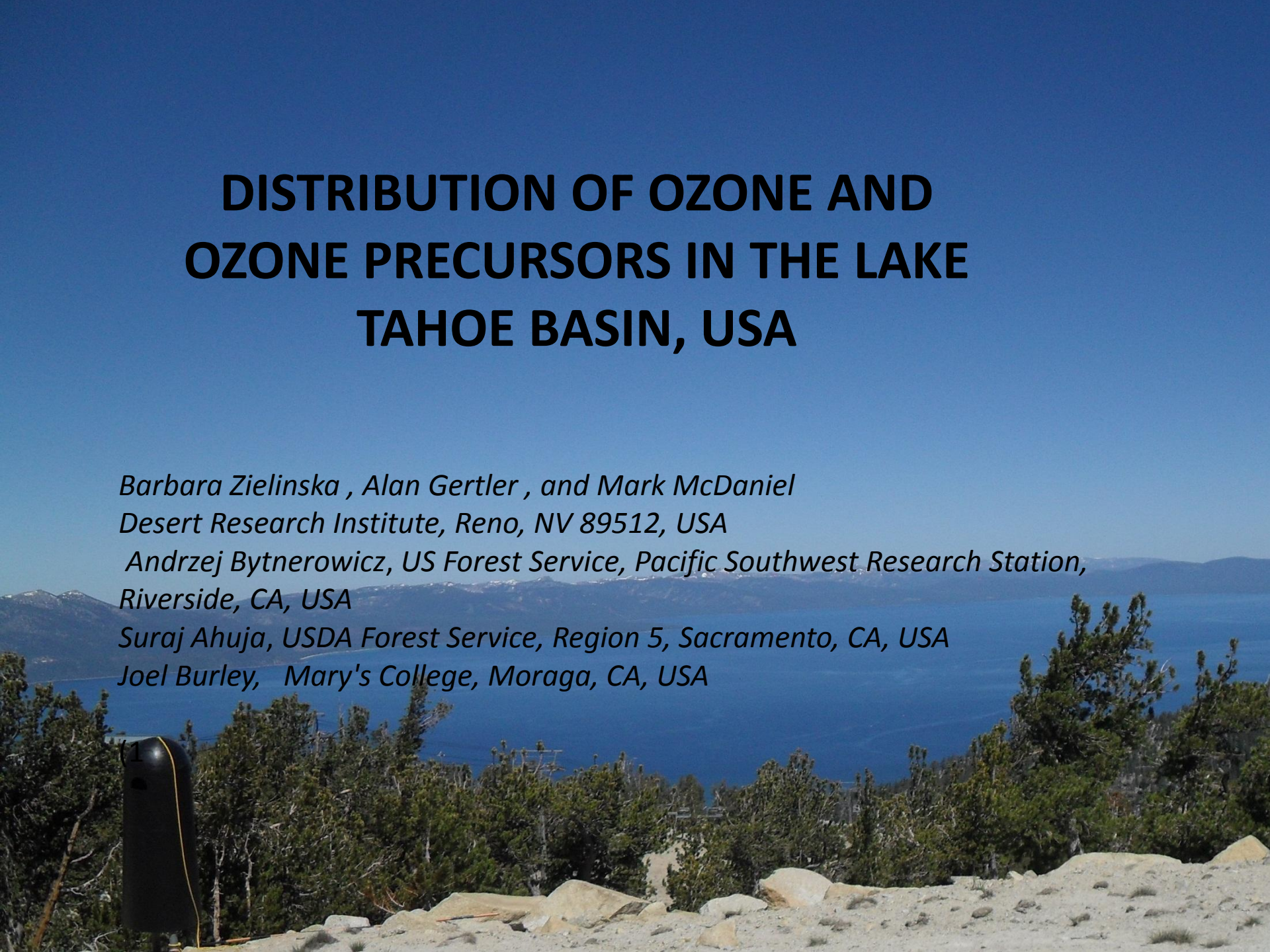


Introduction

- Lake Tahoe, situated at 6,225 ft in the Sierra Nevada mountain range, is the largest alpine lake in North America. Its depth is 1,645 ft making it the USA's second-deepest lake. It has 191.6 sq mi of surface area and 71 mi of shore line.
- Known for the clarity of its water and the panorama of surrounding mountains on all sides, Lake Tahoe is a major tourist attraction in the California – Nevada area. It is home to a number of ski resorts and summer outdoor recreation. The Nevada side also includes large casinos.
- However, the Lake Tahoe Basin is facing major problems in air quality and declining water clarity (due to urban stormwater runoff, atmospheric deposition, etc.) Ozone (O_3) levels in the Tahoe Basin are coming dangerously close to violating the Federal Air Quality Standards

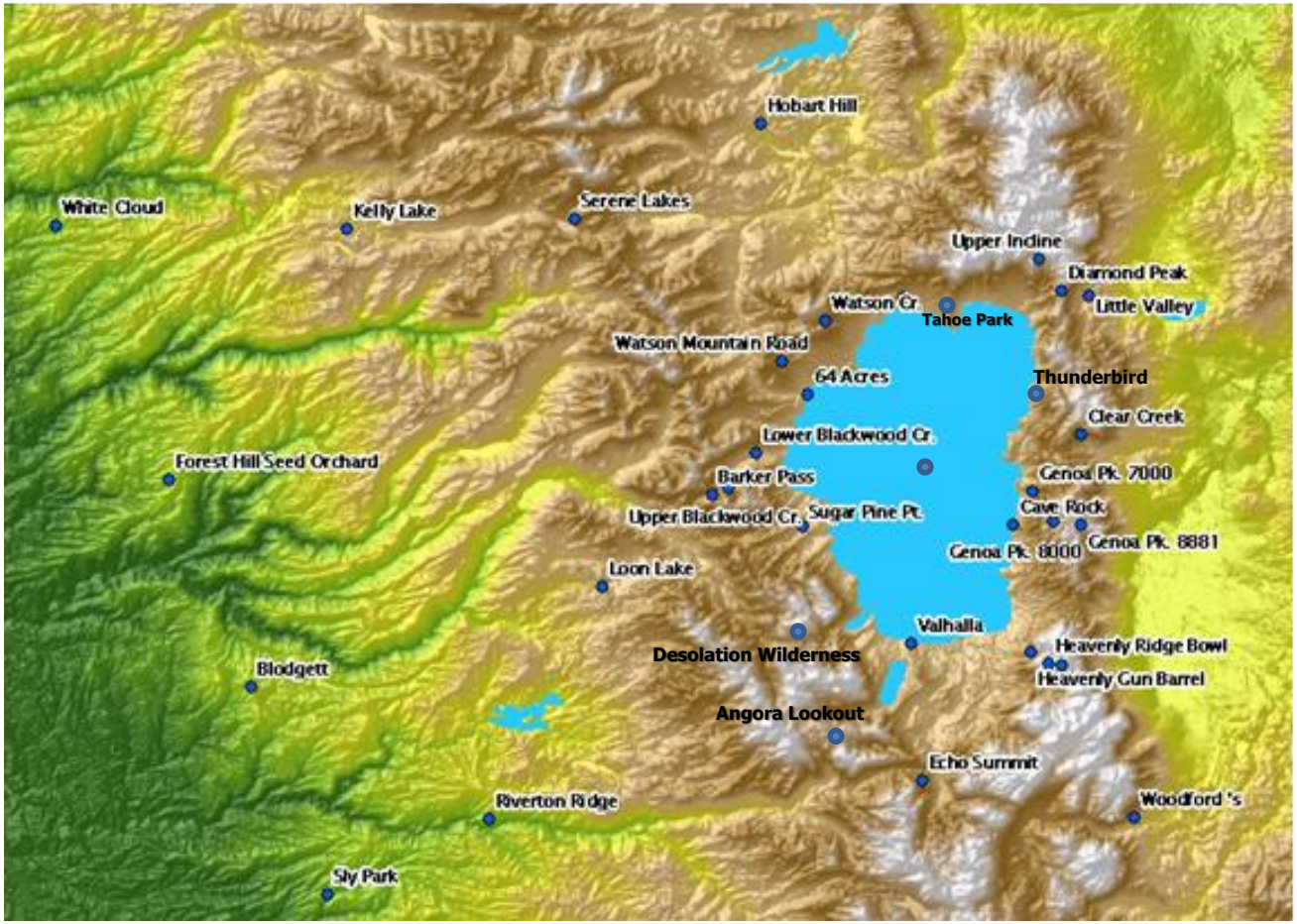
Major Objectives

- Primary objective of this study was developing a better understanding of the distribution of ozone, ozone precursors and their contribution to ground-level ozone formation in the Lake Tahoe Basin
- Importance of the long-range transport of polluted air masses from the California Central Valley vs. the local generation of the pollutants

Methodology

- Air quality monitoring network was established on 34 remote sites inside and outside of the Lake Tahoe Basin, using passive samplers for nitrogen oxides (NO_x), nitrogen dioxide (NO_2), ammonia (NH_3), ozone (O_3), nitric acid (HNO_3) and volatile organic compounds (VOCs)
- Passive samples were collected over 2-week periods from June 15 to September 29, 2010.
- On a subset of 10 monitoring sites (called “mega sites”), we measured real-time O_3 concentrations to evaluate diurnal changes of the pollutant concentrations and to calibrate the passive O_3 samplers.

Monitoring Sites



Site (type)	Elevation (feet)
White Cloud	4197
Forest Hill Seed Orch.	4109
Blodgett	4260

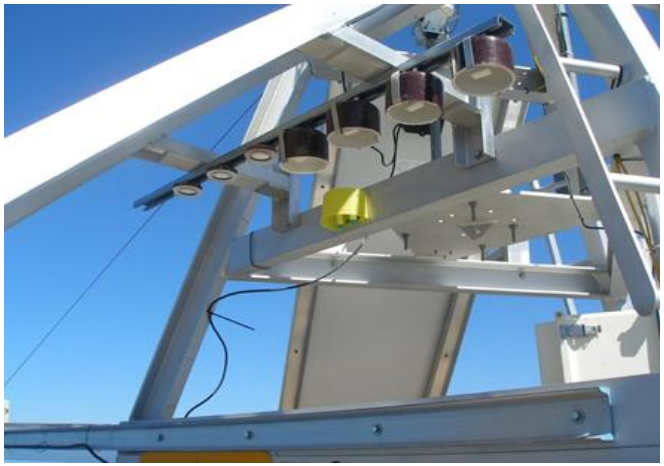
Site (type)	Elevation (feet)
Sly Park	3500
Riverton Ridge	4024
Kelly Lake	4197

Site (type)	Elevation (feet)
Serene Lakes	7370
Loon Lake	6323
Hobart Mills	5926
Watson Creek (M)	7524
Watson Mountain Road	7176
64 Acres	6235
Lower Blackwood Ck. (M)	6392
Upper Blackwood Ck.	7149
Barker Pass	7690
Sugar Pine Point (M)	6400
Angora Lookout (M)	7277
Desolation Wilderness	7992
Valhalla (M)	6252
Echo Summit	7310
Woodford's	7014
Heavenly Gun Barrel	7829
Heavenly Ridge Bowl	9128
Heavenly Sky Express	9984
Genoa Peak 7000 (M)	7071
Genoa Peak 8000 (M)	8035
Genoa Peak 9000 (M)	8881
Clear Creek	6886
Little Valley	6417
Diamond Peak	8434
Upper Incline (M)	8278
Thunderbird (M)	6171
Buoy on the Lake	6225
Tahoe Regional Park	6437

Monitoring Methods

- Passive samplers:
  - Ogawa passive samplers for NOx, NO_2, NH_3, O_3
  - nitric acid (HNO_3)
  - Radiello passive samplers for VOC
- Real-time O_3 concentrations with the active UV-absorption 2B Technologies instruments powered by 12 V batteries and solar panels

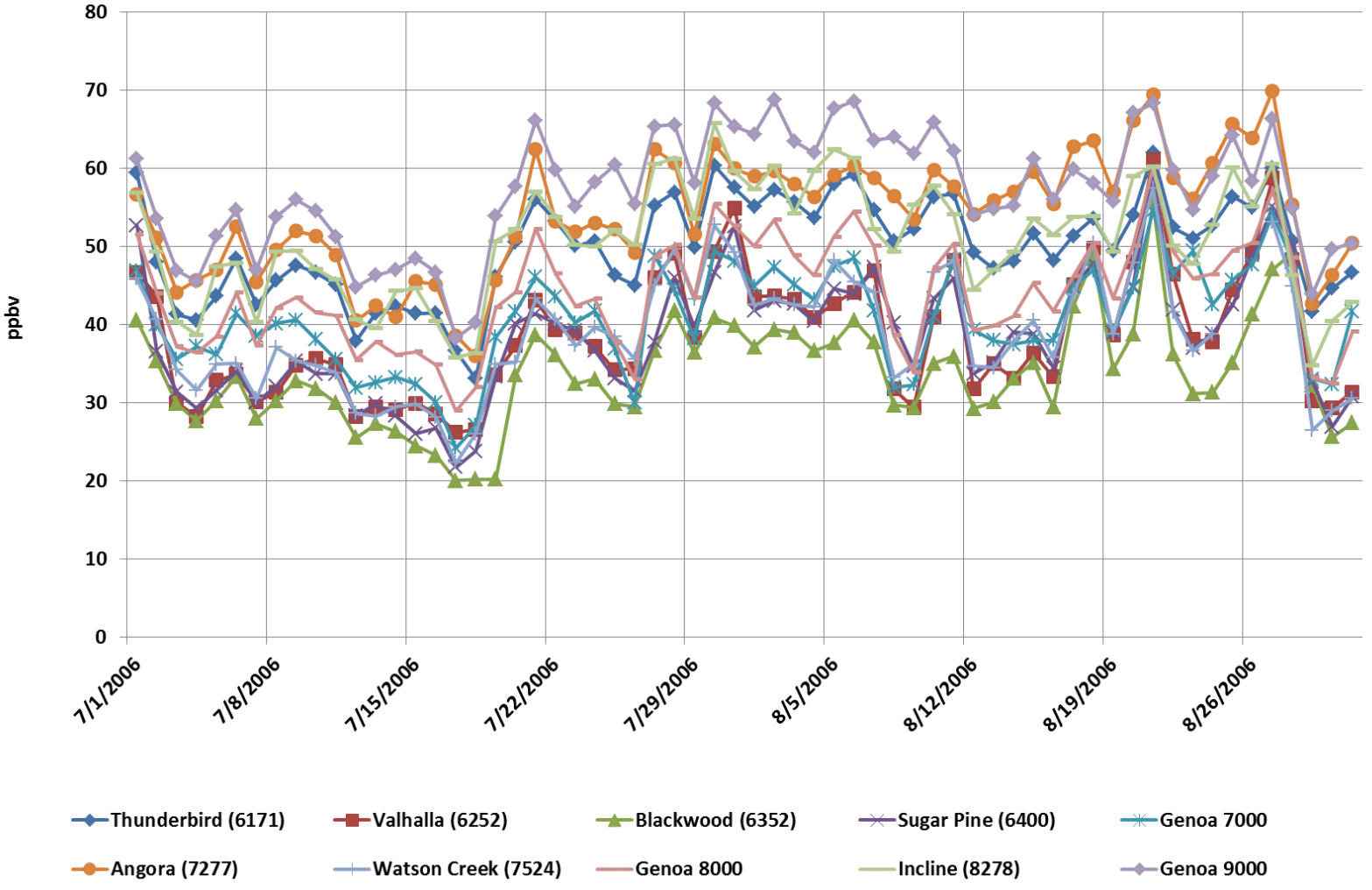
Monitoring Methods, cont.



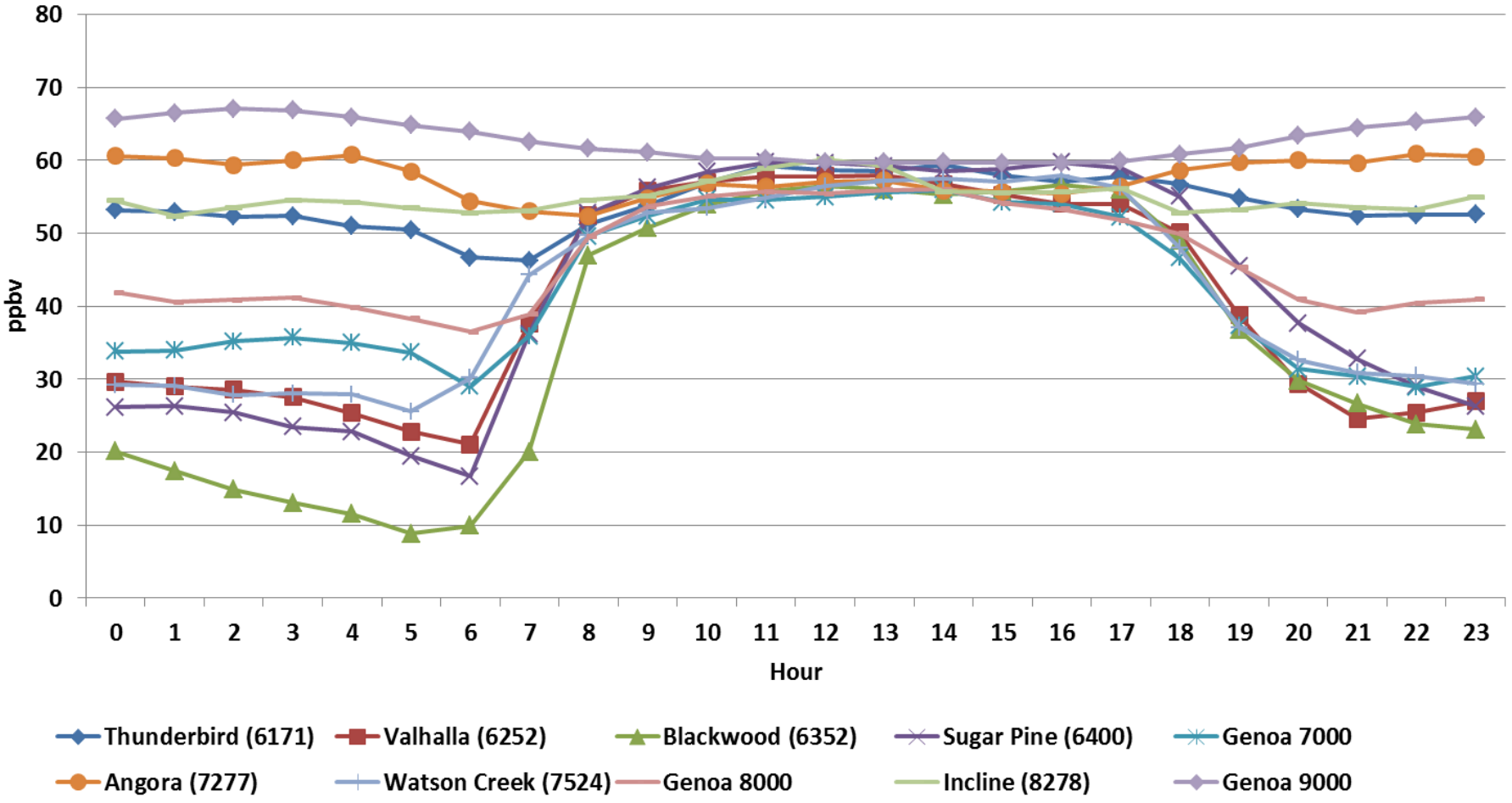
Analytical Methods

- Radiello VOC samples were analyzed by the thermal desorption gas chromatography/mass spectrometry (GC/MS) method. A Varian 3800 GC with Saturn 2000 MS detection equipped with a Gerstel TDSA-3 thermal desorption unit was used for these analyses.
- Radiello 141 packed with Carbopack X adsorbent was analyzed for isoprene and 1,3-butadiene and Radiello 145 packed with Carbograph 4, for α-pinene, benzene, n-hexane, cyclohexane, toluene, ethylbenzene, m/p-xylene, styrene, n-octane, n-nonane, n-decane, n-undecane).
- Ogawa passive samplers were analyzed according to manufacturer protocols (Ogawa & Co., USA, Inc., http://www.rpco.com/assets/lit/lit03/amb3300_00312_protocolno.pdf).

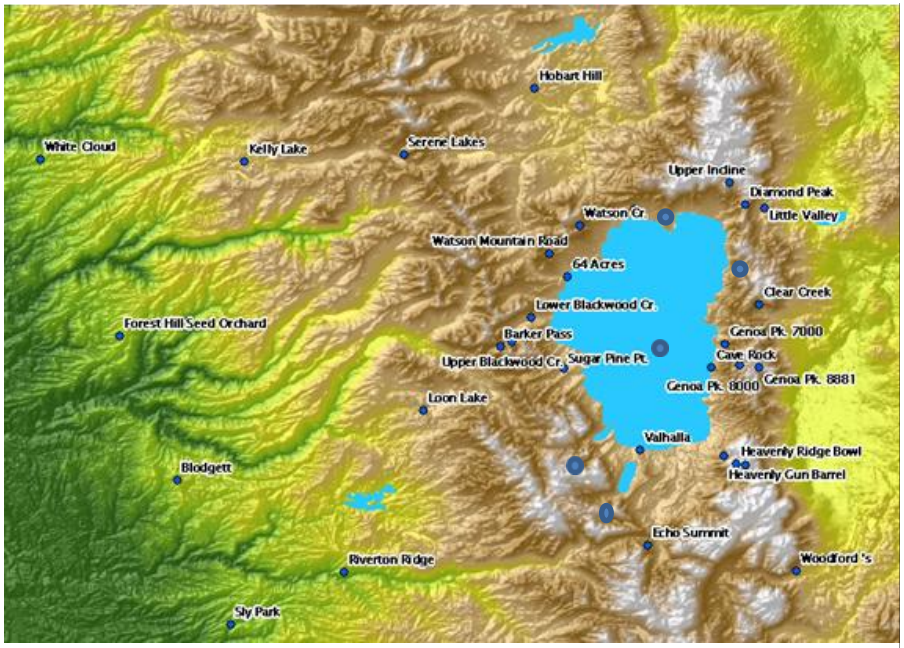
Results – Ozone Daily Data

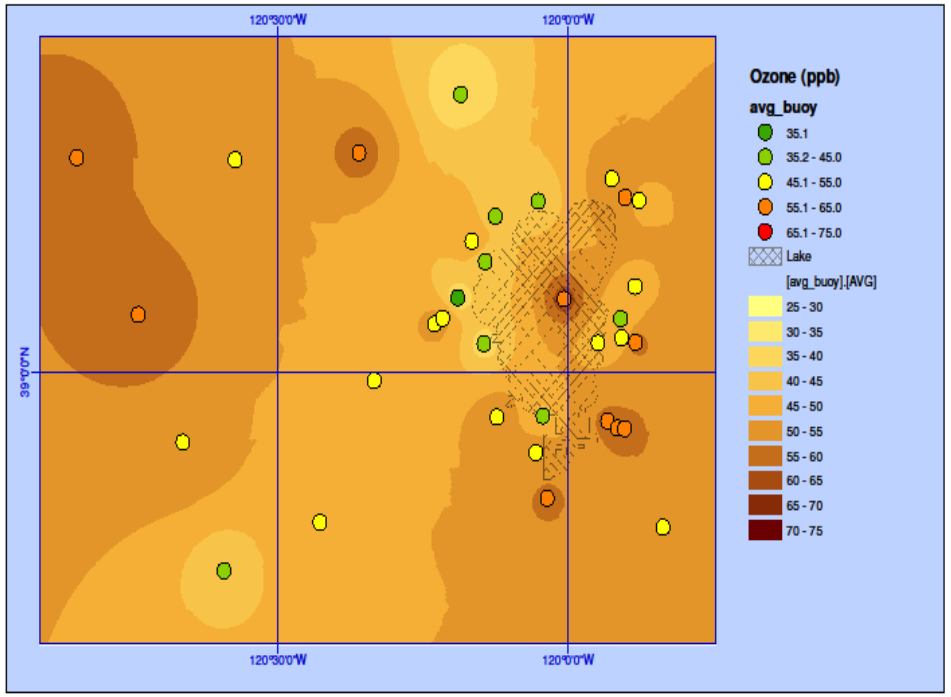


Ozone Diurnal Concentrations



Ozone Average Concentrations - Passive Data





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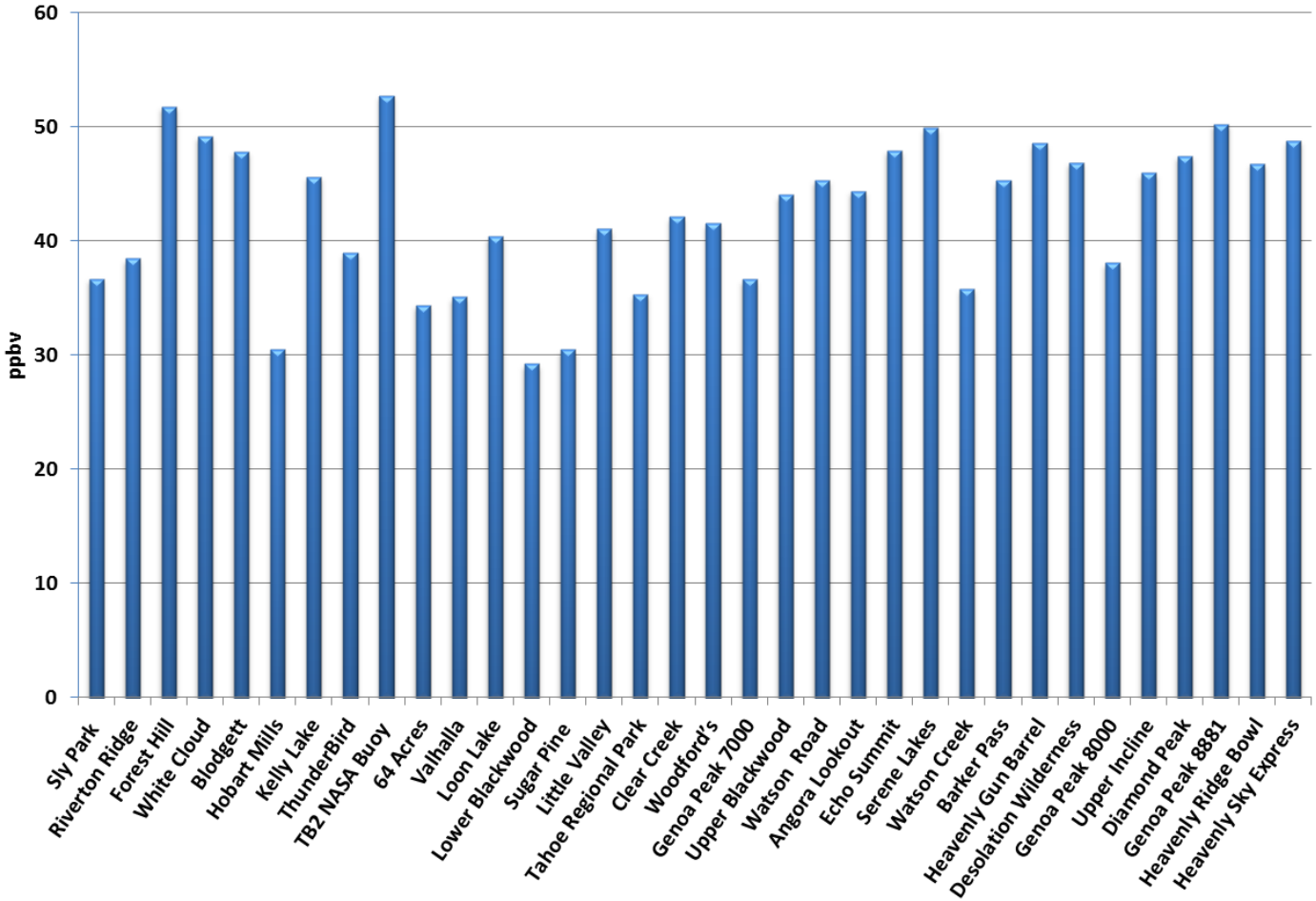
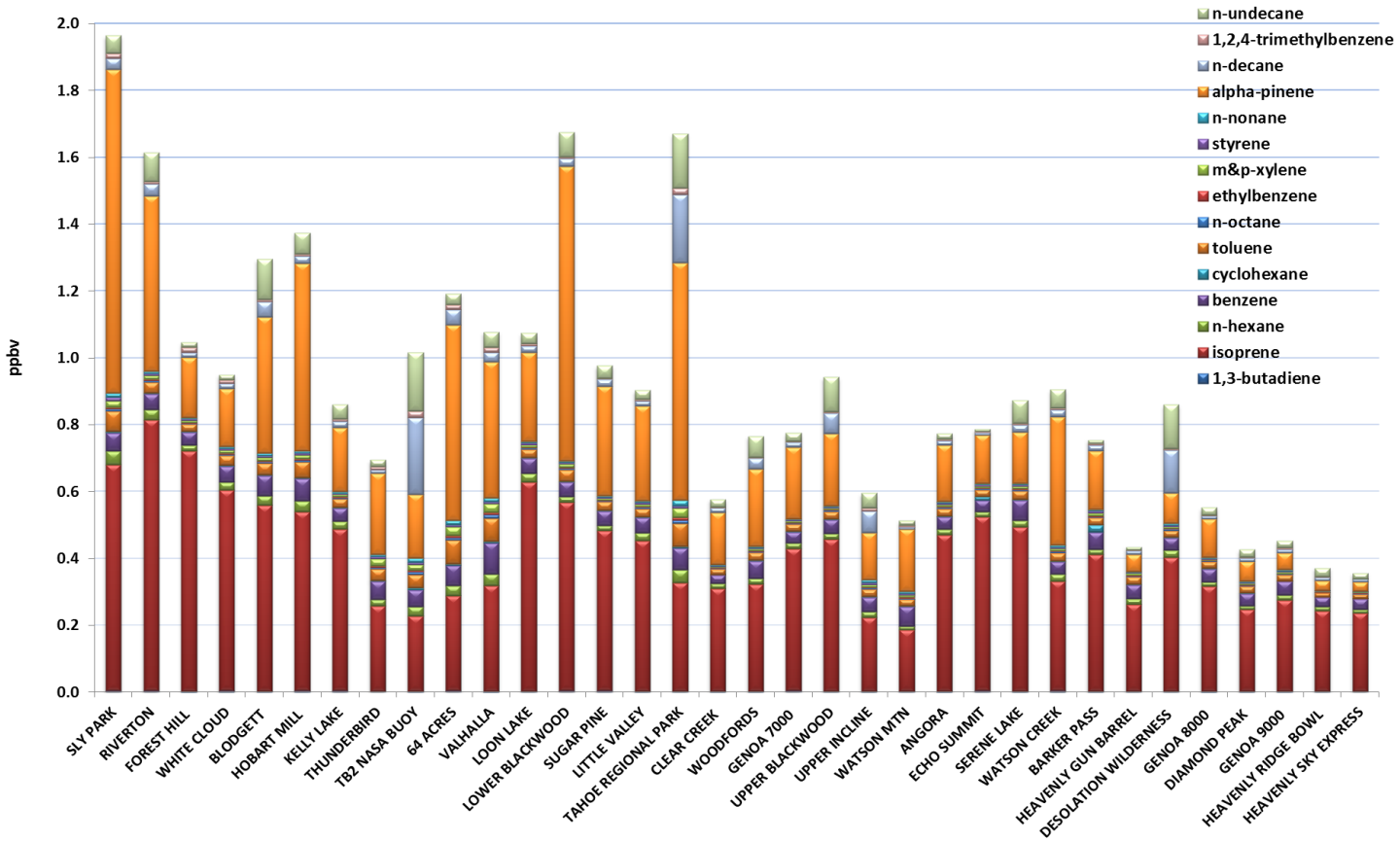
Ozone Passive Data: July 29 – August 25, 2010

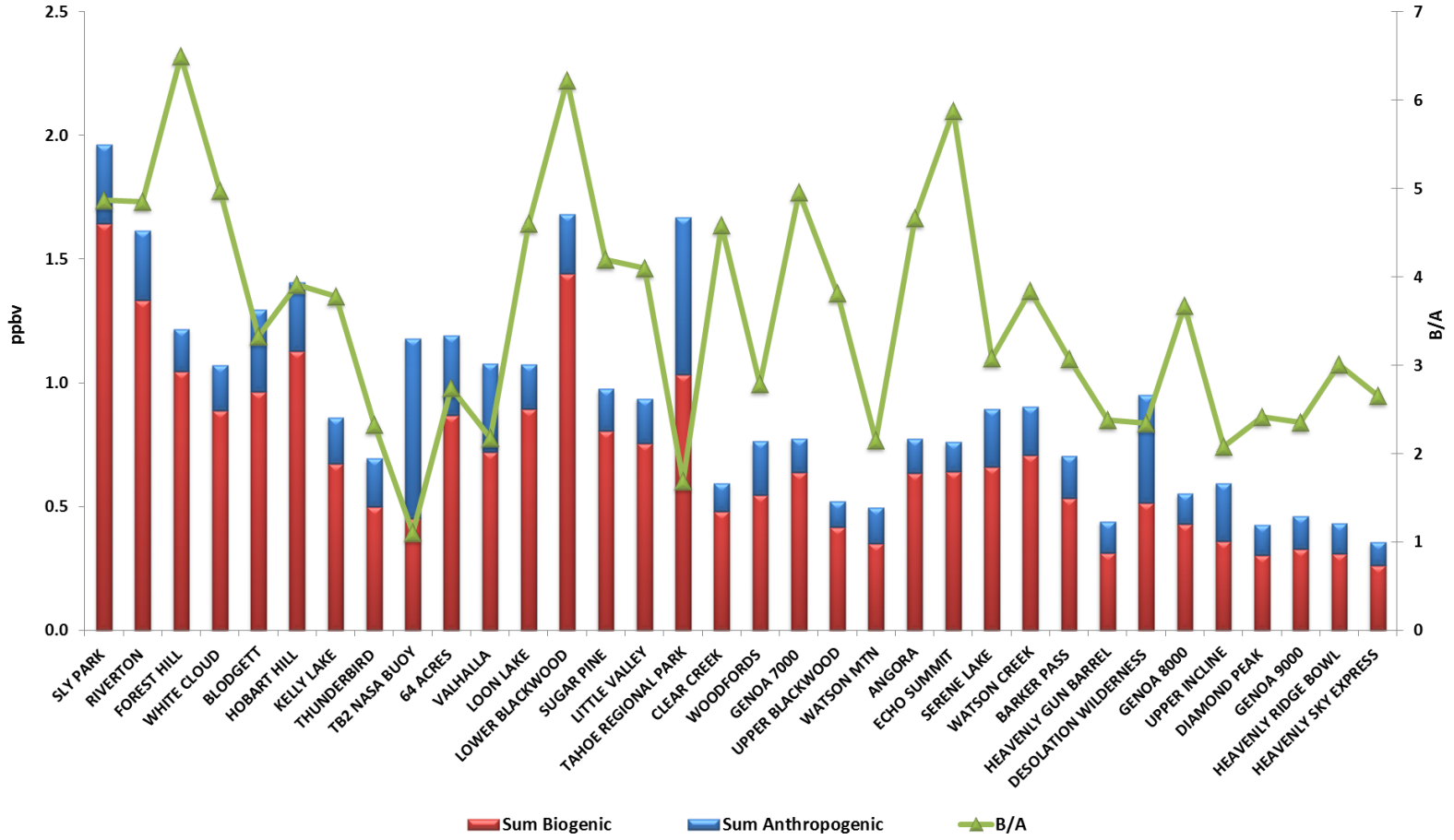


Volatile Organic Compounds (VOC) Averaged over whole Monitoring Period

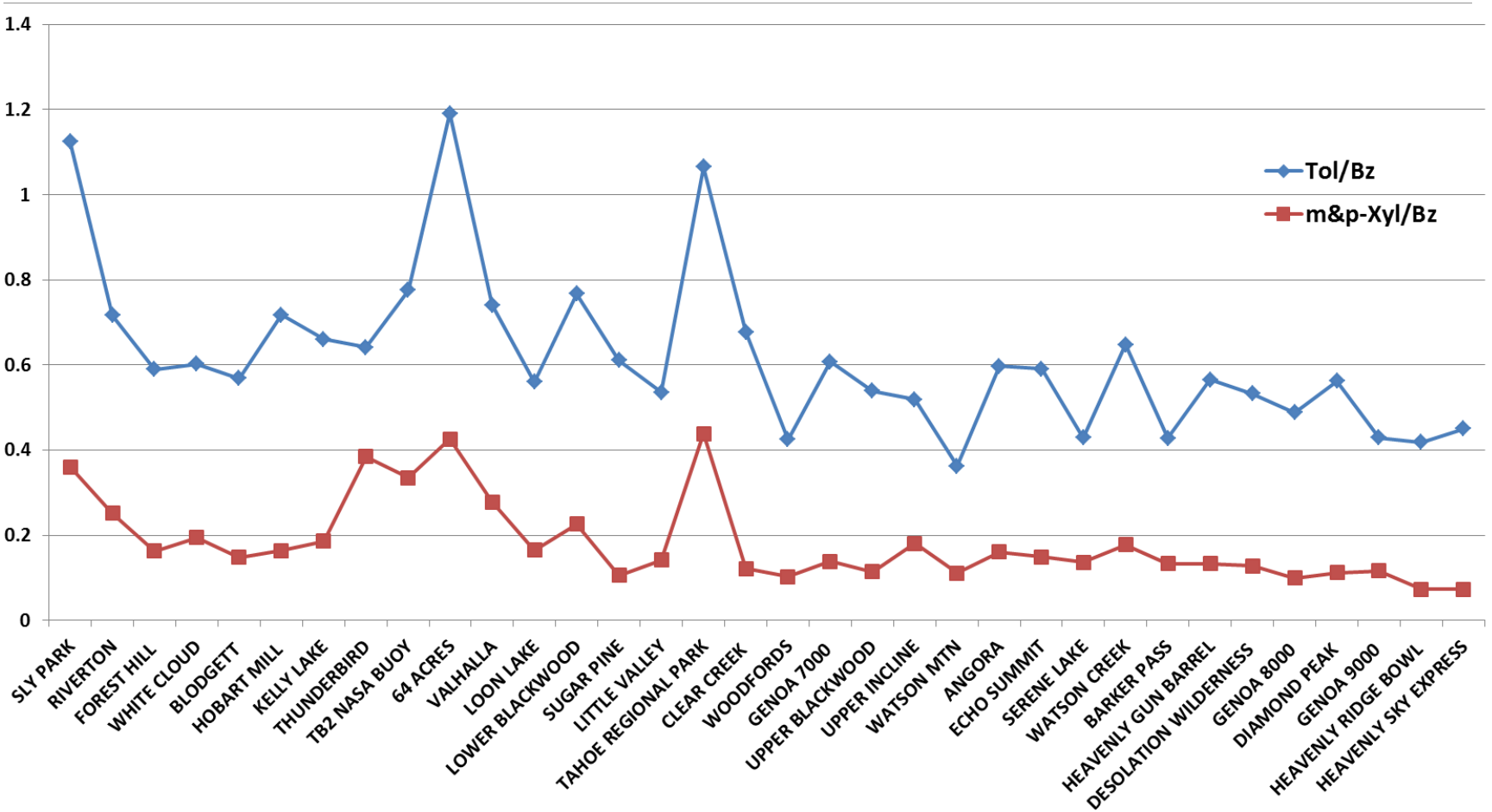


Sampling sites are arranged according to their elevations

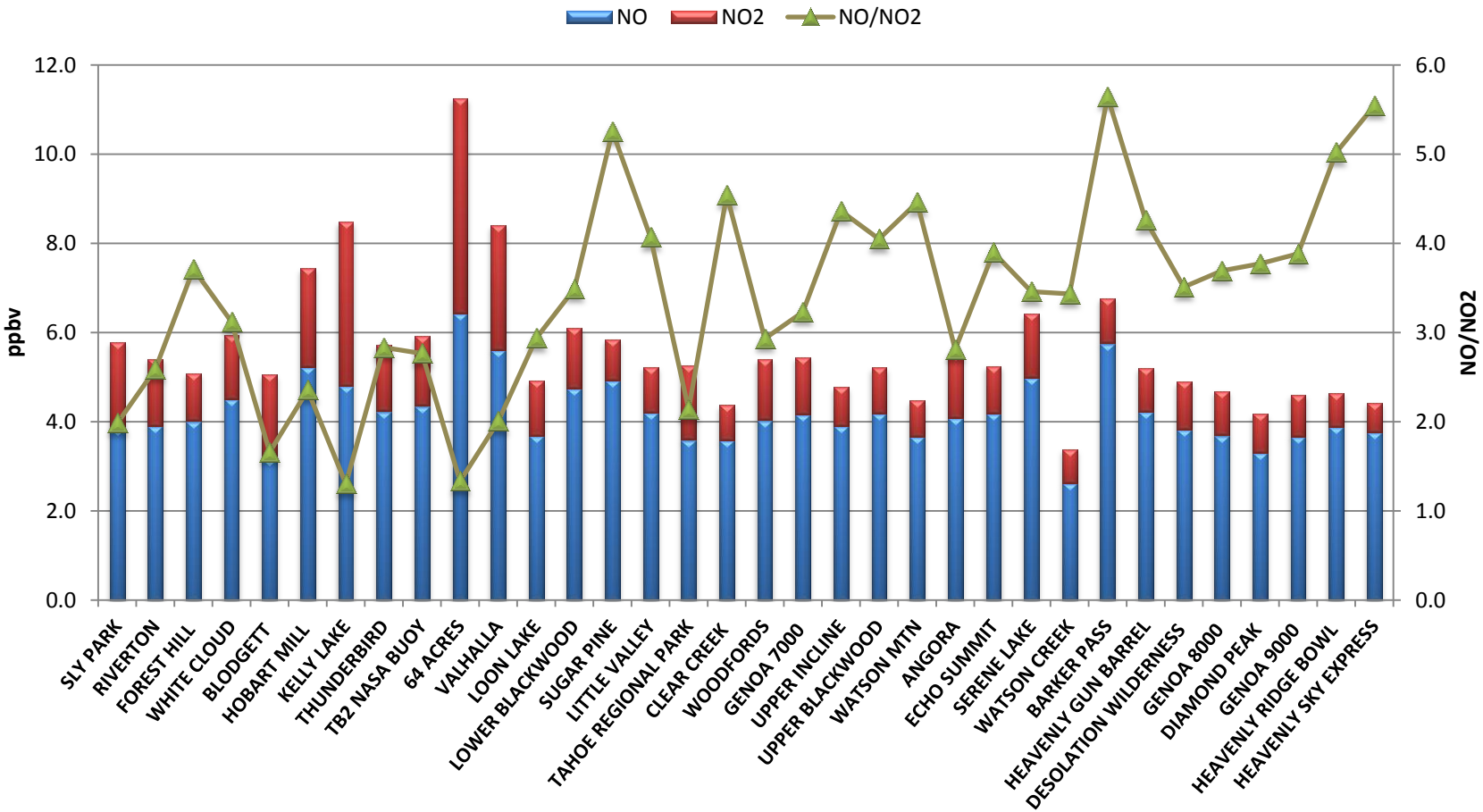
Biogenic and Anthropogenic Hydrocarbons



Toluene/Benzene and m&p-Xylene/Benzene Ratios (ppbv/ppbv)



Oxides of Nitrogen



Preliminary Conclusions

- High concentrations of O_3 were found on the western slope of the Sierra Nevada mountain range affected by emissions from the California Central Valley. For those sides, Toluene/Benzene (Tol/Bz) and m&p-Xylene/Benzene (m&pXyl/Bz) ratios were generally low, which indicates aged air masses.
- High O_3 concentrations were found in the middle of Lake Tahoe, accompanied by high Tol/Bz, m&pXyl/Bz, and NO/NO_2 ratios as well as high anthropogenic VOC concentrations, especially higher molecular weight hydrocarbons n-decane and n-undecane. This may indicate the influence of local spark ignition and diesel engine emissions (for example from large boats)
- Another high O_3 concentrations were measured on the eastern side of the Basin at high elevation sites, which showed low Tol/Bz and m&pXyl/Bz ratios. This may indicate long range transport of pollutants.

Acknowledgments

This study was supported by the grant from the U.S. Department of Agriculture Forest Service through the Tahoe Science Program funded by the Southern Nevada Public Lands Management Act (SNPLMA).