**Using Epiphytic Lichens to Elucidate the Sources and Spatial Distribution of Inorganic Air Pollution in the Athabasca Oil Sands Region**

Mathew S. Landis

landis.matthew@epa.gov

U.S. EPA Office of Research and Development, Research Triangle Park, NC USA

Joseph R. Graney

jgraney@binghamton.edu

Geological Sciences and Environmental Studies, Binghamton University, Binghamton, NY USA

Patrick Pancras

jpatrick1972@gmail.com

Pancras Consulting, Cary, NC USA

Sagar Krupa

Krupa001@umn.edu

Plant Pathology, University of Minnesota-Twin Cities, St. Paul, MN USA

Eric Edgerton

eedgerton@atmospheric-research.com

Atmospheric Research and Analysis Inc. Cary, NC, USA

Keith Puckett

keithpuckett20@gmail.com

Ecofin, Waldemar, ON, Canada

KevinPercy

kpercy@wbea.org

Wood Buffalo Environmental Association, Ft. McMurray, Alberta, Canada

The Wood Buffalo Environmental Association (WBEA) conducted studies to document the geographic patterns of atmospheric deposition of sulfur (S) and nitrogen (N) in the Athabasca Oil Sands Region (AOSR) using epiphytic lichens as bioindicators of atmospheric pollution. Epiphytic lichen samples (*Hypogymnia physodes*) were collected from 44 locations in 2002, 359 locations in 2008, and 21 locations in 2011 within the AOSR. A subset of samples from 2002 (15) and 2008 (121); and all the samples from 2011 were microwave extracted and analyzed for a comprehensive suite of trace elements using DRC-ICPMS. In addition, source profiles were developed for samples from a variety of available process stacks, heavy duty diesel fleet vehicles, bulk materials representing the various stages of oil sands processing operations, and forest fires. The lichen monitoring and source profile information were integrated into a receptor modeling framework to elucidate the relative importance of natural and anthropogenic sources to the observed atmospheric deposition of S and N in the AOSR. U.S. EPA implemented statistical receptor models utilized included Positive Matrix Factorization (PMF), Unmix, and Chemical Mass Balance (CMB). The sources uniquely identified that significantly contributed to concentrations of elements in the lichen tissue include: fugitive dust from haul roads, tailing sand, and oil sand mining; oil sand processing; combustion processes; and a general urban regional source.

The spatial patterns of CMB, PMF, and Unmix receptor model estimated source impacts on the *Hypogymnia physodes* tissue concentrations from the oil sand processing and fugitive dust sources had a significant association with the distance from the primary oil sands surface mining operations and related production facilities. The spatial extent of the fugitive dust impact was limited to an approximately 20 km radius around the major mining and oil production facilities, indicative of ground level coarse particulate fugitive emissions from these sources. The impact of the general urban source was found to be enhanced in the southern portion of the sampling domain in the vicinity of the Fort McMurray urban area. The receptor model results also indicated lower Mn concentrations in lichen tissues near oil sands production operations suggesting a biogeochemical response. Overall the largest impact on elemental concentrations of *Hypogymnia physodes* tissue in the AOSR was related to fugitive dust, suggesting that implementation of a fugitive dust abatement strategy could minimize the near-field impact of future mining related production activities.