A31C-0085

Seasonality of common carbon and nitrogen trace gas emissions from sagebrush-steppe fires

Aaron M. Sparks[1], Robert J. Yokelson[2], Alistair M. S. Smith[1], Amanda K. Argona[1], John D. Marshall[1], Wade T. Tinkham[1]

[1]University of Idaho | College of Natural Resources | Department of Forest, Rangeland, and Fire Sciences | Moscow, Idaho | USA

[2]University of Montana | Department of Chemistry | Missoula, Montana | USA

INTRODUCTION

Biomass burning is among the dominant sources of emissions to the atmosphere. Quantifying the sources of uncertainty in these emissions is critical to further understanding the role of fires in biogeochemical processes. Fire emissions such as carbon dioxide (CO_2) have significant global warming effects while other emissions like carbon monoxide (CO) and nitrogen oxides (NO_x) have been linked with tropospheric ozone (O_3) formation. The influence of biomass burning emissions on the atmosphere makes accurate emission estimates crucial for determining air quality, especially in heavily populated areas where prescribed fire is prevalent. Emissions have been observed to be significantly influenced by time of season, especially in grass-dominated ecosystems like those studied in southern Africa. The following study was designed to help minimize uncertainty associated with seasonal influences on emission factors of major carbonaceous (CO_2, CO) and nitrogenous (NO, NO_2) trace gas species in sagebrush-steppe ecosystems. The specific questions we sought to address were:

(1) How do seasonal influences (like moisture content and nutrient cycling) affect biomass burning emissions of common carbon (CO_2, CO) and nitrogen (NO, NO_2) trace gases from three sagebrush-steppe plant species?

(2) How do the calculated emission factors for each of the three plant species differ throughout the season?

METHODS

1. Three rangeland species were chosen based fuel bed contribution: big sagebrush (*Artemisia tridentata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and cheatgrass (*Bromus tectorum*).

2. Ten, 200 g samples of each species were collected, weighed, and transported back to the IFIRE lab in air-tight coolers every two weeks throughout the burn season (mid-May to late-October).

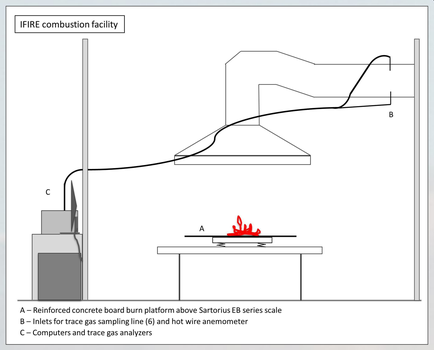
3. At IFIRE, half of the samples (5) from each species were dried in a drying oven for at least 24 hours at 90 degrees C.

4. All samples were burned directly on top of a Sartorius Practum 5101 scale (accurate to 0.1 g) and mass was recorded every 1 s. Stack flow and temperature was measured every 1 s with an Extech hot wire anemometer (temperature resolution: 0.1 degree C, velocity resolution: 0.1 m s^{-1}) at the location of the sampling ports. Trace gas concentrations were determined with the following analyzers:

CO = LASCAR CO data logger (500 ppb resolution)

CO_2 = LICOR CO_2/H_2O analyzer (resolution <1.5% of reading)

NO, NO_2 = Thermo Scientific model 42i-TL (50 ppt resolution)



The IFIRE facility consists of two adjoining rooms, each roughly 5 m x 5 m x 7 m high. In the burn room, a 0.5 m x 0.6 m exhaust stack with a 1 m x 1.5 m opening extends from 2 m above the burn table and curves out the side of the building. Smoke sampling ports were located on each side of the square stack and ~1 m from the exit of the stack on the side of the building. Smoke is drawn through 0.635 cm diameter Teflon tubing from the sampling ports to gas analyzers (distance of ~5 m) in the other room.

RESULTS

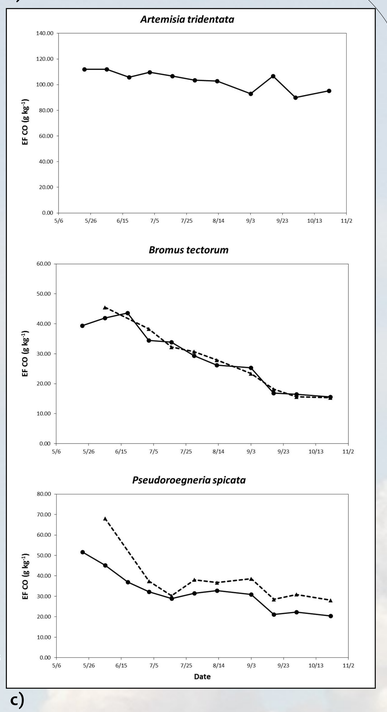
> CO EF_x were 2.5 - 3 times higher at the maximum EF_x date (early spring) compared to the minimum EF_x date (late fall)

> NO EF_x were 1.9 - 3.9 times higher at the maximum EF_x date (early spring) compared to the minimum EF_x date (late fall)

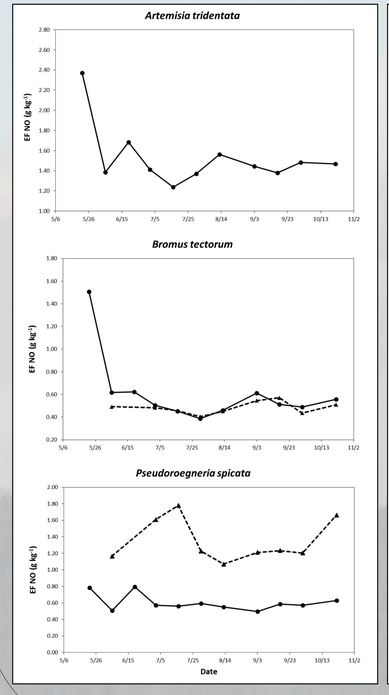
> NO_2 EF_x were 1.6 - 2.1 times higher at the maximum EF_x date (early spring) compared to the minimum EF_x date (late fall)

Figures (a - c): Emissions (expressed as EFx) for all three rangeland plant species for CO (a), NO (b), and NO_2 (c).
Solid line = samples burned after drying at 90ºC for >24 hours
Dotted line = samples burned at field moisture content

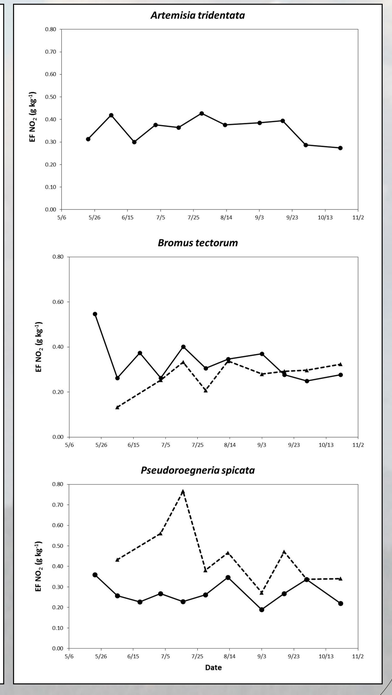
a)



b)



c)



CONCLUSIONS

> Emissions of major carbonaceous (CO_2, CO) and nitrogenous (NO, NO_2) trace gases from sagebrush-steppe fires are seasonally dependent

> Nutrient cycling influence on emissions currently being analyzed

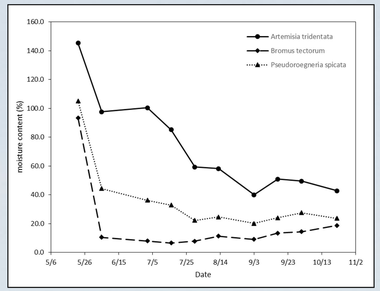


Figure above: Moisture content (dry weight basis) of the three plant species studied from mid-May to late-October.

FUTURE WORK

Research is clearly warranted to further study seasonal influences on emission factors of other trace gas species in not only sage-steppe environments, but others as well. Future work could possibly study seasonality of emissions in ecosystems such as temperate forests, grasslands, etc.

REFERENCES

Andreae MO, Merlet P (2003) Emission of trace gases and aerosols from biomass burning, *Global Biogeochemical Cycles* **15**, 4, 955-966, doi: 10.1029/2000GB001382.

Chen, L. W. A., H. Moosmuller, W. P. Arnott, J. C. Chow, J. G. Watson, R. A. Susott, R. E. Babbitt, C. E. Wold, E. N. Lincoln, and W. M. Hao (2007), Emissions from laboratory combustion of wildland fuels: emission factors and source profiles, *Environmental Science and Technology*, 41, 4317-4325.

Hoffa, E. A, D. E. Ward, W. M. Hao, R. A. Susott, and R. H. Wakimoto (1999), Seasonality of carbon emissions from biomass burning in a Zambian savanna, *Journal of Geophysical Research*, 104(11), 13841-13853.

Jacobson, M. Z. (2001b), Strong radiative heating due to the mixing state of black carbon in atmospheric aerosols, *Nature*, 409, 695-697.

Khalil, M. A. K., and R. A. Rasmussen (1988), Carbon monoxide in the Earth's atmosphere: indications of a global increase, *Nature*, 332, 242-245.

Korontzi, S., D.E. Ward, R.A. Susott, R.J. Yokelson, C.O. Justice, P.V. Hobbs, E.A.H. Smithwick, and W.M. Hao (2003), Seasonal variation and ecosystem dependence of emission factors for selected trace gases and PM2.5 for southern African savanna fires, *Journal of Geophysical Research*, 108, doi:10.1029/2003JD003730.

Lashof, D. A., and D. R. Ahuja (1990), Relative contributions of greenhouse gas emissions to global warming, *Nature*, 344, 529-531.

Wiedinmyer, C., B. Quayle, C. Geron, A. Belote, D. McKenzie, X. Zhang, S. O'Neill, and K. K. Wynne (2006), Estimating emissions from fires in North America for air quality modeling, *Atmospheric Environment*, 40, 3419-3432.

ACKNOWLEDGEMENTS

This work was supported by the Joint Fire Sciences Program under award number 07-2-1-60 and the National Aeronautics and Space Administration (NASA) under award NNX11AO24G . We also thank Stephen Baker at the Missoula Fire Lab for lending equipment and expertise.

University of Idaho
College of Natural Resources

The University of Montana