DETERMINING CO_2 FLUX COMPONENTS IN THE DENVER URBAN ECOSYSTEM

D. E. Anderson and T. Thienelt

U.S. Geological Survey, Water Resources Discipline, Federal Center, Denver, CO 80225; deander@usgs.gov

ABSTRACT
Within urban ecosystems are strong anthropogenic emissions of CO_2 as well as significant CO_2 sinks associated with vegetation. CO_2 profiles and net flux of CO_2 (NEE) over Denver was measured over a multi-year period and compared with certain component fluxes (soil surface net flux, and emissions from fossil fuel combustion). CO_2 concentration and NEE typically exhibits a diurnal trend, apparently due to emissions from transportation and sequestration by vegetation.

INTRODUCTION
Urban lands cover just 3% of the global land surface, yet by the end of the 20th century, more than half of the world's population were living in urban areas. Projections by the United Nations indicate that by 2025 nearly two-thirds of the population will be urban. Locally, the Colorado Front Range urban corridor which includes Denver, doubled in population during the 1990s, affecting local air quality and landuse. The impact of urban areas on climate are likely to become increasingly important. Although they contain strong emissions of carbon-gas fluxes, urban forests and other vegetation appear to be a significant sinks, thereby measurably reducing net flux from cities [*Grimmond et al.* 2002, *Anderson and Taggart* 2002.]. Milesi et al. [2005] note that lawns are the largest irrigated crop (by area) in the U.S., recently surpassing corn. Characterizing and quantifying urban sources and sinks for CO_2 is necessary if we are to understand the complete global carbon cycle. Urban ecosystems, a richly diverse composite of natural and anthropogenic elements, maybe expected to have increasing landuse and environmental impact (particularly on carbon and hydrological cycles) for the foreseeable future.

METHODS
Net ecosystem flux was measured continuously (2002-2005) with eddy covariance arrays (sonic anemometer and open-path H_2O/CO_2 gas analyzer) at 100 and 70m on a 120m tall tower in southern Denver. These arrays provided estimates of vertical flux and flux divergence. Following the method of Yi et al. [2000] the relative magnitude of advection could be determined. Data were screened for periods when NEE measured at the two levels agreed within 20%. Measurements of the CO_2 concentration profile on the tower provided estimates of CO_2 storage flux. Soil surface chambers (6 Liter) with a CO_2 gas analyzer (in a closed loop configuration with the chamber) were utilized to measure net CO_2 flux over grasses (managed and unmanaged). Net ecosystem flux of CO_2 was estimated by summing key flux components in the conservation of mass equation for CO_2. Data from public utilities and transportation agencies were utilized to estimate certain anthropogenic emissions.

RESULTS AND DISCUSSION
Under nearly constant synoptic (weather) conditions, there appeared to be a diurnal pattern in CO_2 concentration profiles. Nighttime CO_2 concentrations decreased with height but increased through the night at all heights. After peaking during the morning rush hour, concentrations decreased until early afternoon when they began to rise again. During weekend days, concentrations were lower in comparison to weekday measurements at similar times. The pattern was slightly different during the growing season. Concentrations exhibited a peak near sunrise, decreased somewhat over a couple hours, then rose again peaking during the morning rush hour. At times during late morning, concentrations fell below the background concentration and NEE was negative. Both observations appear to indicate an influence of CO_2 sequestration by vegetation. During cloudy periods, NEE and concentrations were higher than those measured under clear skies. Overall, average NEE was positive during daylight hours and slightly less

than the average flux estimate due to transportation emissions (~7 micromole m^{-2} s^{-1}). Lawn surfaces were an active sink for CO_2 over most daylight hours with a sink strength determined by the intensity of active management (soil aeration, fertilization, irrigation). At longer time scales, seasonal trends were distinguished by lower (positive) NEE and lower CO_2 concentrations during the growing season; these tendencies were more pronounced in wetter years.

CONCLUSIONS

NEE and concentration profiles of CO_2 and NEE at the soil surface over the Denver urban ecosystem were measured over multiple years. Diurnal and season patterns indicate the influence of strong anthropogenic sources as well as the urban vegetative sink. During the growing season, NEE was slightly less than that estimated from transportation emissions alone, suggesting that sequestration by urban vegetation substantially modifies the net emission of CO_2 from the urban ecosystem.

REFERENCES

Anderson, D.E. and J. Taggart. 2002. Urban ecosystem-atmosphere exchange of carbon dioxide. Amer.Meteorol. Soc. 4th Urban Conf.Ext. Abst., Norfolk, VA. May 18-23.

Grimmond, C.S.B, T.King, F. Cropley, D. Nowak, and C. Souch. 2002. Local scale fluxes of carbon dioxide in urban environments: methodological challenges and results from Chicago. *Env. Poll. 116*: S243-S254.

Milesi, C., C. Elvidge, J. Dietz, and B. Tuttle. 2005. Mapping and modeling the biogeochemical cycling of turf grasses in the *U.S. Biogeochem Cy*. (in press)

Yi, C., K. Davis, P. Bakwin, B. Berger, and L. Marr. 2000. Influence of advection on measurements of net ecosystem-atmosphere exchange of CO_2 from a very tall tower. *J. Geophys. Res. 105*(D8): 9991-9999.