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Field assessment of the effects of roadside vegetation on near-road black carbon and particulate matter

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HIGHLIGHTS

- Vegetation barriers altered near-road black carbon concentrations.
- Vegetation reduced downwind black carbon concentrations by approximately 12%.
- Downwind fine and coarse particle concentration were unaffected by vegetation.
- Black carbon gradients more gradual behind vegetation compared to a clearing.

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ABSTRACT

One proposed method for reducing exposure to mobile source air pollution is the construction or preservation of vegetation barriers between major roads and nearby populations. This study combined stationary and mobile monitoring approaches to determine the effects of an existing, mixed-species tree stand on near-road black carbon (BC) and particulate matter concentrations. Results indicated that wind direction and time of day significantly affected pollutant concentrations behind the tree stand. Continuous sampling revealed reductions in BC behind the barrier, relative to a clearing, during downwind (12.4% lower) and parallel (7.8% lower) wind conditions, with maximum reductions of 22% during the late afternoon when winds were from the road. Particle counts in the fine and coarse particle size range (0.5–10 μm aerodynamic diameter) did not show change. Mobile sampling revealed BC concentration attenuation, a result of the natural dilution and mixing that occur with transport from the road, was more gradual behind the vegetation barrier than in unobstructed areas. These findings suggest that a mature tree stand can modestly improve traffic-related air pollution in areas located adjacent to the road; however, the configuration of the tree stand can influence the likelihood and extent of pollutant reductions.

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1. Introduction

Public health concerns related to near-road air quality have become a pressing issue due to the increasing number of epidemiological studies suggesting that populations spending significant amounts of time near heavily trafficked roads are at a greater risk of adverse health effects (HEI, 2010). These effects may be attributed to increased exposure to particulate matter, gaseous criteria pollutants, and air toxics emitted by vehicular traffic. The significant impact of traffic emissions on urban populations all over the world has motivated research on methods to reduce exposure to these pollutants. While emission control techniques and programs to directly reduce emitted air pollutants are vital components of air quality management, other options, including the preservation and planting of vegetation and the construction of roadside structures such as noise barriers, may be near-term mitigation strategies useful for urban developers. These methods, if successful, can complement existing pollution control programs or provide measures to reduce impacts from sources that are difficult to mitigate.

Despite recent studies employing modeling, wind tunnel, and field measurements to evaluate the role of vegetation on pollutant concentrations in urban areas (Baldauf et al., 2008; Brode et al., 2008; Hagler et al., 2012; Nowak, 2005; Nowak et al., 2000; Stone and Norman, 2006), the extent to which vegetation barriers can reduce air pollution near roads under varying traffic and meteorological conditions remains uncertain.

Vegetation, particularly trees, can reduce a population's exposure to air pollution through the interception of airborne particles (Petroff et al., 2009) or through the uptake of gaseous air pollution via leaf stomata on the plant surface (Smith, 1990). Noise barriers combined with mature

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