# The potential of urban forests to mitigate atmospheric $CO_2$ concentrations

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## INTRODUCTION

Urban greening programmes form an important part of many urban climate change mitigation policies (e.g. Auckland). However, knowledge about the direct impact of urban vegetation and soils (collectively known as urban forests) on atmospheric $CO_2$ concentrations is still limited and comprehensive measurement programmes are scarce. We examined the methods currently used to quantify carbon (C) pools and $CO_2$ fluxes of urban forests and compiled currently available results.

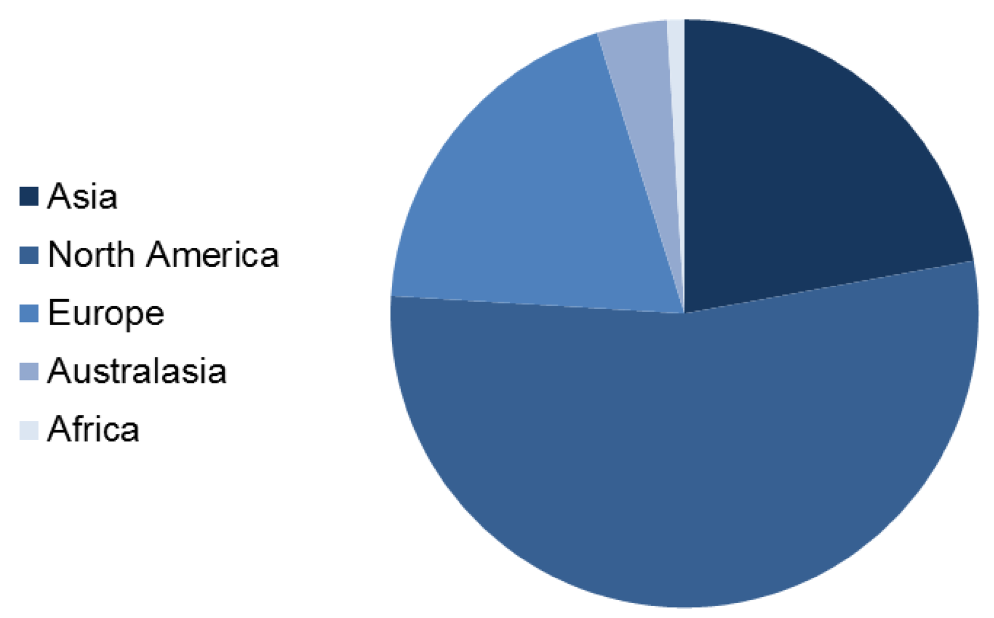


Fig.1. Number of studies that investigated C pools and $CO_2$ fluxes of urban forests in different continents.

## METHODS

**Biomass estimates** - Carbon storage and sequestration rates of trees are estimated as a function of tree biomass derived from allometric equations.

**Soil carbon storage** - Soil carbon storage is calculated as a function of soil depth, soil carbon concentration and bulk density.

**Soil $CO_2$ efflux** - Soil $CO_2$ efflux is directly measured with chamber systems.

**Photosynthesis and leaf respiration** - Photosynthetic $CO_2$ uptake by trees and leaf respiration is directly measured with cuvette based portable infrared gas exchange systems.

**Atmospheric $CO_2$ concentrations** - Atmospheric $CO_2$ concentrations are monitored using air samples or infrared gas analysers.

**Eddy covariance (EC) technique** - EC measurements are based on high frequency measurements of turbulent fluctuations of the vertical wind velocity and the mixing ratio of a trace gas.

**Stable isotope and radioisotope analysis** - Stable isotope and radioisotope analysis is based on the differences in the isotopic composition of trace gases resulting from different anthropogenic and biogenic activities and is used to partition $CO_2$ sources.

## RESULTS

Key results from the reviewed studies:

- Annual $CO_2$ fluxes are negatively correlated to vegetation cover within the measurement footprint ($r = -0.839$, $p<0.01$)
- Urban $CO_2$ fluxes and concentrations often reach a minimum at midday and during summer and are lower from wind directions with high vegetation cover (e.g. [1])
- Seasonal variation of $\delta^{13}C$ and $\delta^{18}O$ due to ecosystem respiration (e.g. [2])
- During summer, $CO_2$ uptake by urban forests is comparable to $CO_2$ emissions related to fossil fuel combustion (e.g. [3])
- 0.3 – 22.0% of annual $CO_2$ emissions are offset by urban vegetation ([4], [5])
- 1.3 – 65.3% of total measured $CO_2$ concentrations are related to below- and aboveground respiration ([2],[6])

## PRELIMINARY RESULTS FROM AUCKLAND

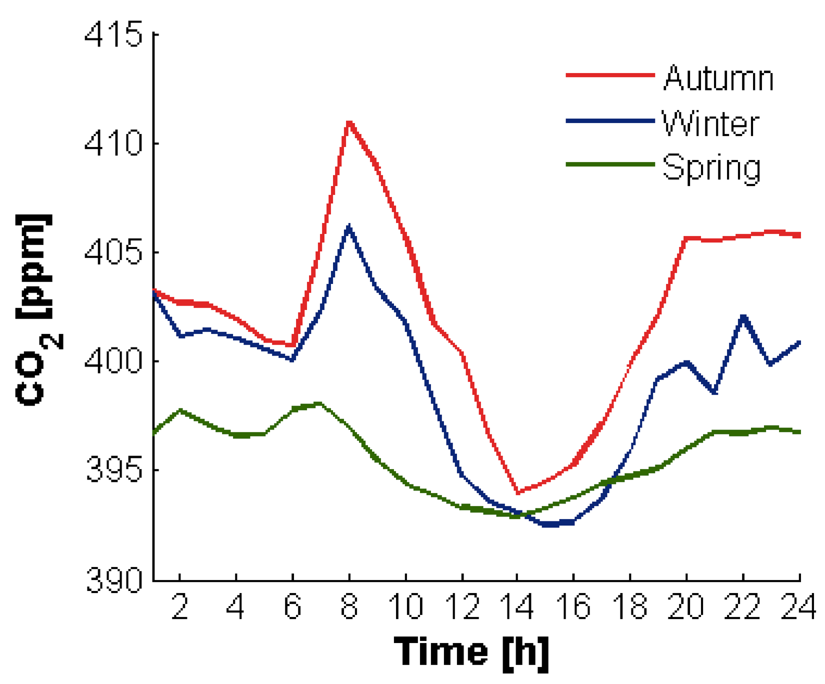


Fig. 2. Average seasonal diurnal profiles of atmospheric $CO_2$ concentrations in Auckland's CBD.

Atmospheric $CO_2$ concentrations monitored in Auckland's city centre in 2012 follow a distinct diurnal pattern, which is typically observed in urban areas. Spring $CO_2$ concentrations have a lower amplitude diurnal cycle, possibly due to higher photosynthetic $CO_2$ uptake during the growing season. However, to assess the contribution of different $CO_2$ sources, additional methods, such as stable isotope or radioisotope analysis, are required.

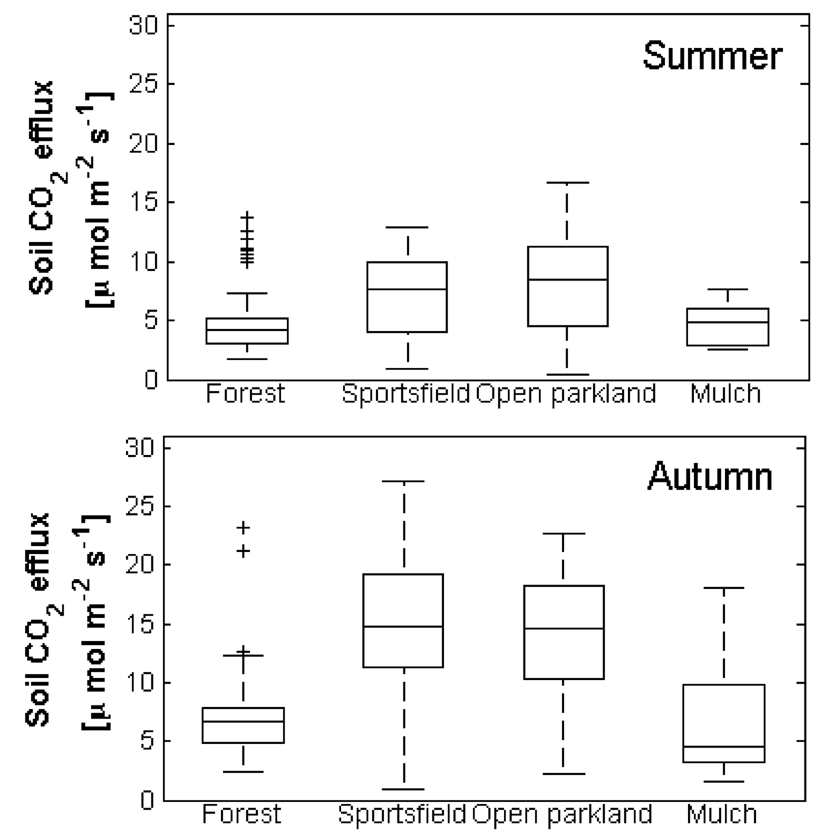


Fig.3. Soil $CO_2$ efflux measured in Auckland urban parks (Nov - Apr 2012/2013).

Soil $CO_2$ efflux measurements from urban parks in Auckland show large variability between parkland types during both seasons with significantly higher $CO_2$ fluxes in autumn ($p<0.01$), indicating the importance of field measurements at different spatial and temporal scales.

## CONCLUSIONS

A variability of methods have been applied to assess the potential of urban forests as a climate change mitigation measure. Results from the reviewed studies have shown that whilst vegetation did not offset $CO_2$ emissions on an annual basis, vegetative $CO_2$ uptake contributed to the significantly lower atmospheric $CO_2$ fluxes in summer. However, the currently available results are related to a large degree of uncertainty due to the limitations of the applied methods, the limited number of urban areas studied and the temporal/spatial resolution of the measurements. Also, large variability within and between cities make it difficult to generalise results.

## FUTURE RESEARCH

To effectively quantify and incorporate $CO_2$ fluxes from urban forests into annual $CO_2$ budgets, future research needs to integrate data from a combination of methodologies collected at a range of different scales, particularly from cities in the southern hemisphere.

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