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MEASURED AND MODELLED LEAF AREA OF URBAN WOODLANDS, PARKS AND TREES IN A HIGH LATITUDE CITY

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Valuation of ecosystem services provided by urban greenery

- Rapid urbanization transform the natural environment
- Urban ecosystem services
  - Climate regulation
  - Biodiversity
  - Air, water and soil management
  - Noise reduction
  - Recreation and well-being

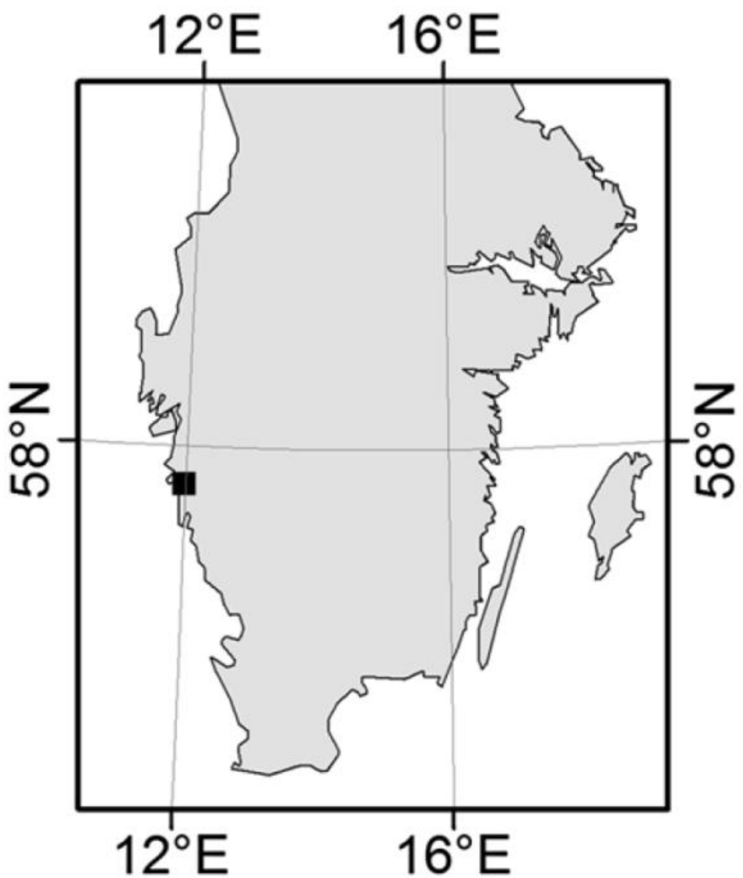
Leaf area

- The amount of foliage is a basic ecological characteristic
- Drives within and below canopy microclimate, determines and controls canopy water interception, radiation extinction, water and carbon gas exchange, etc.
- Measured as leaf area index (LAI), a dimensionless quantity defined as the total one-sided leaf area (m^2) per unit ground surface area (m^2).
- Measurement methods include destructive, allometric techniques and optical methods based on measurements of light transmission through the canopies.

Aim

- describe seven different types of urban green areas in terms of leaf area index (LAI) of trees
- compare two different methods to measure LAI of urban trees
- estimate urban LAI based on aerial discrete-return LiDAR

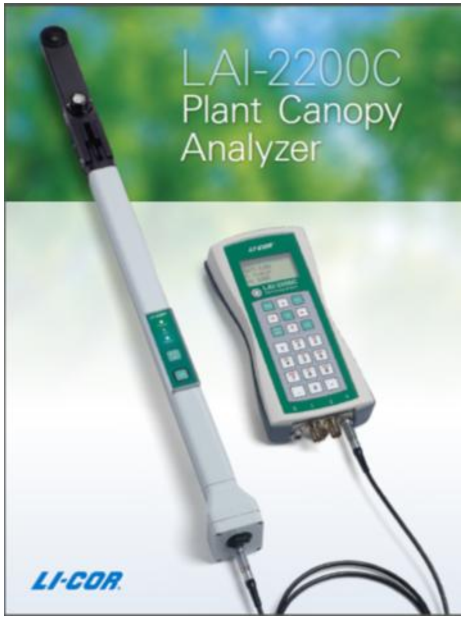
Study area - Gothenburg, Sweden

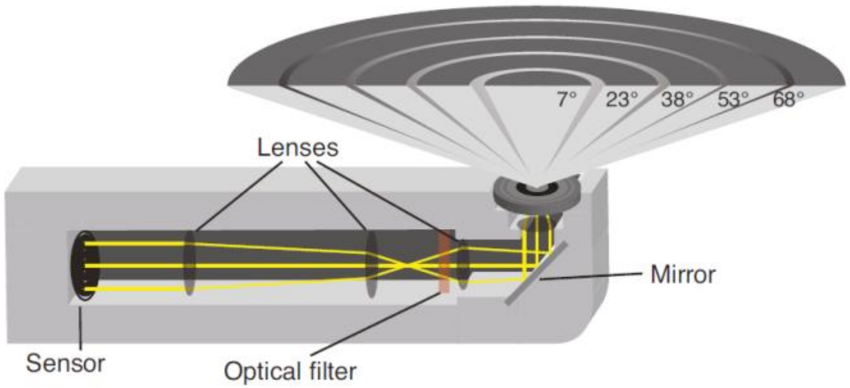


- 7 case study areas
  - Residential area with green yards
  - New park by river
  - Old central park
  - Suburban forest
  - Allotment gardens
  - Central woodland
  - Traffic area

Ground measurements

- Commercial plant canopy analyzer LAI-2200 (LI-COR Biosciences, Lincoln, USA)
  - Measures solar radiation below and above the canopy
  - FV2200 software





Ground measurements

- Commercial plant canopy analyzer LAI-2200 (LI-COR Biosciences, Lincoln, USA)
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  - FV2200 software
- Hemispherical photography
  - Nikon D5100 with Sigma 4.5 mm fish-eye lense
  - Hemisfer software (Schleppi, WSL)
  - Blue channel, underexposed images

Blue channel (blue light)

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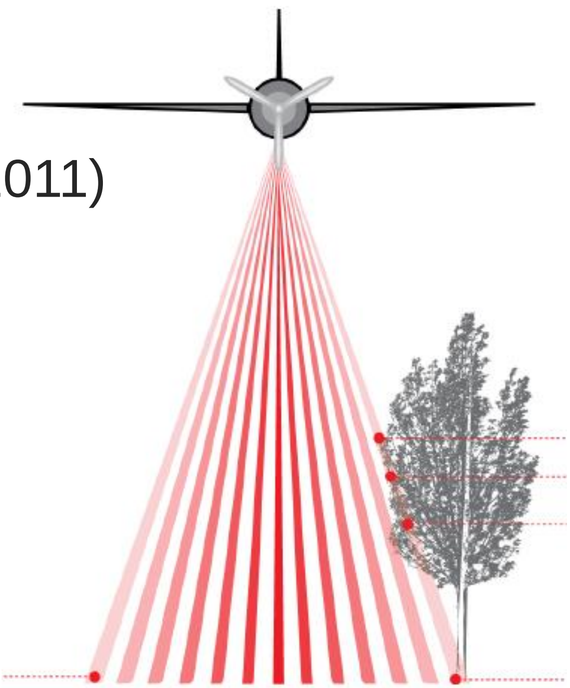
  - Blue channel, underexposed images
- Effective LAI (L_e) - include all canopy elements intercepting radiation (do not distinguish photosynthetically active leaves from other plant elements e.g. stems and branches).
- Overcast skies

Aerial light detection and ranging - LiDAR

- Descrete-return LiDAR of the Gothenburg municipality
- Max scan angle ±20° and mean pulse density 13.65 m^{-2}
- FUSION software
- Vegetation (>1 m) part of the point cloud filtered according to Lindberg and Grimmond (2011)
- $L_e = -\beta \, ln\left(\frac{R_{ground}}{R_{total}}\right)$
- where R_{ground} is ground returns, R_{total} is ground + canopy returns and β is a constant (2.097, Richardson et al. 2009).



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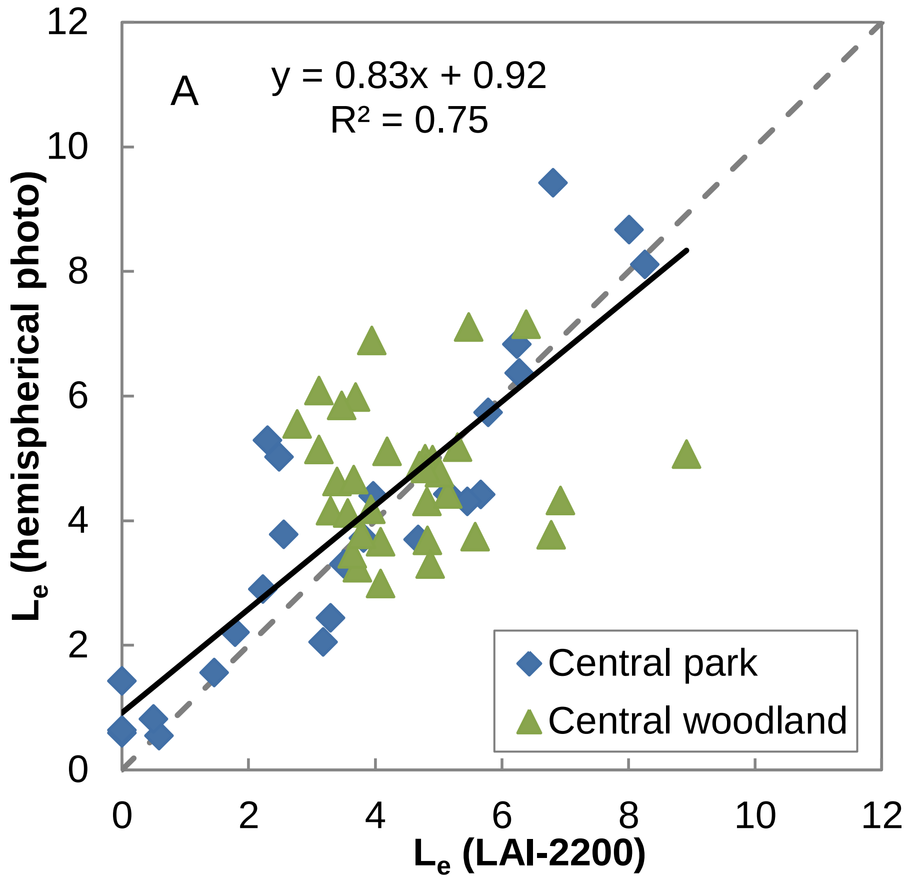
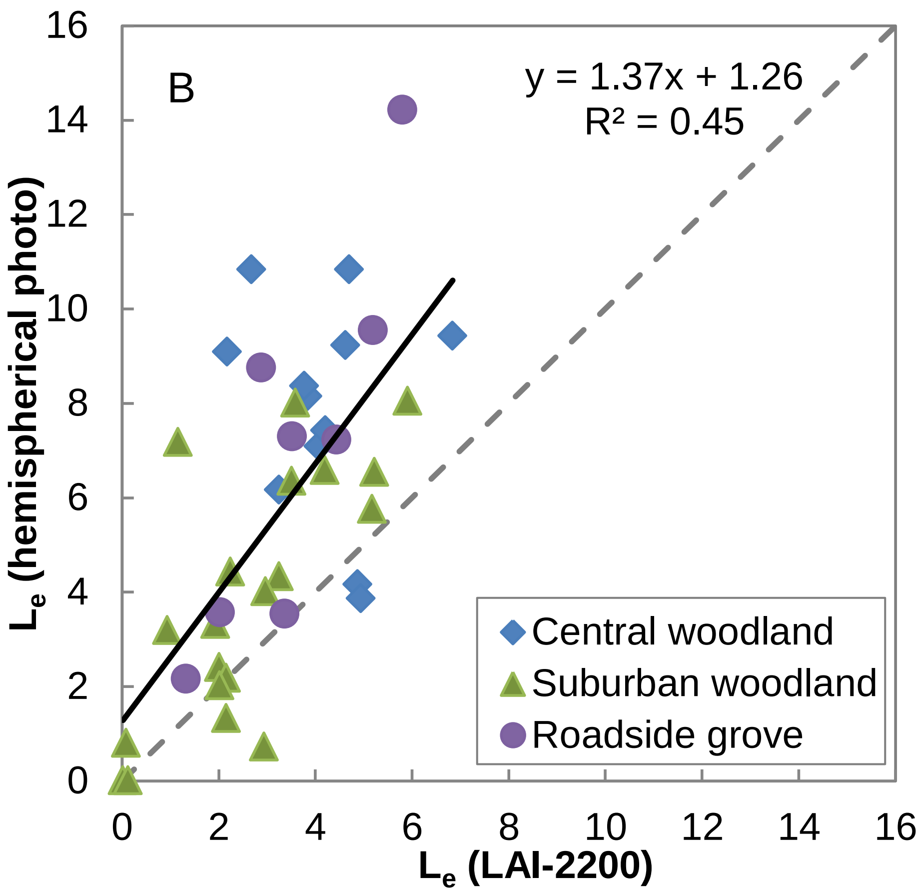
Comparison of measurement methods



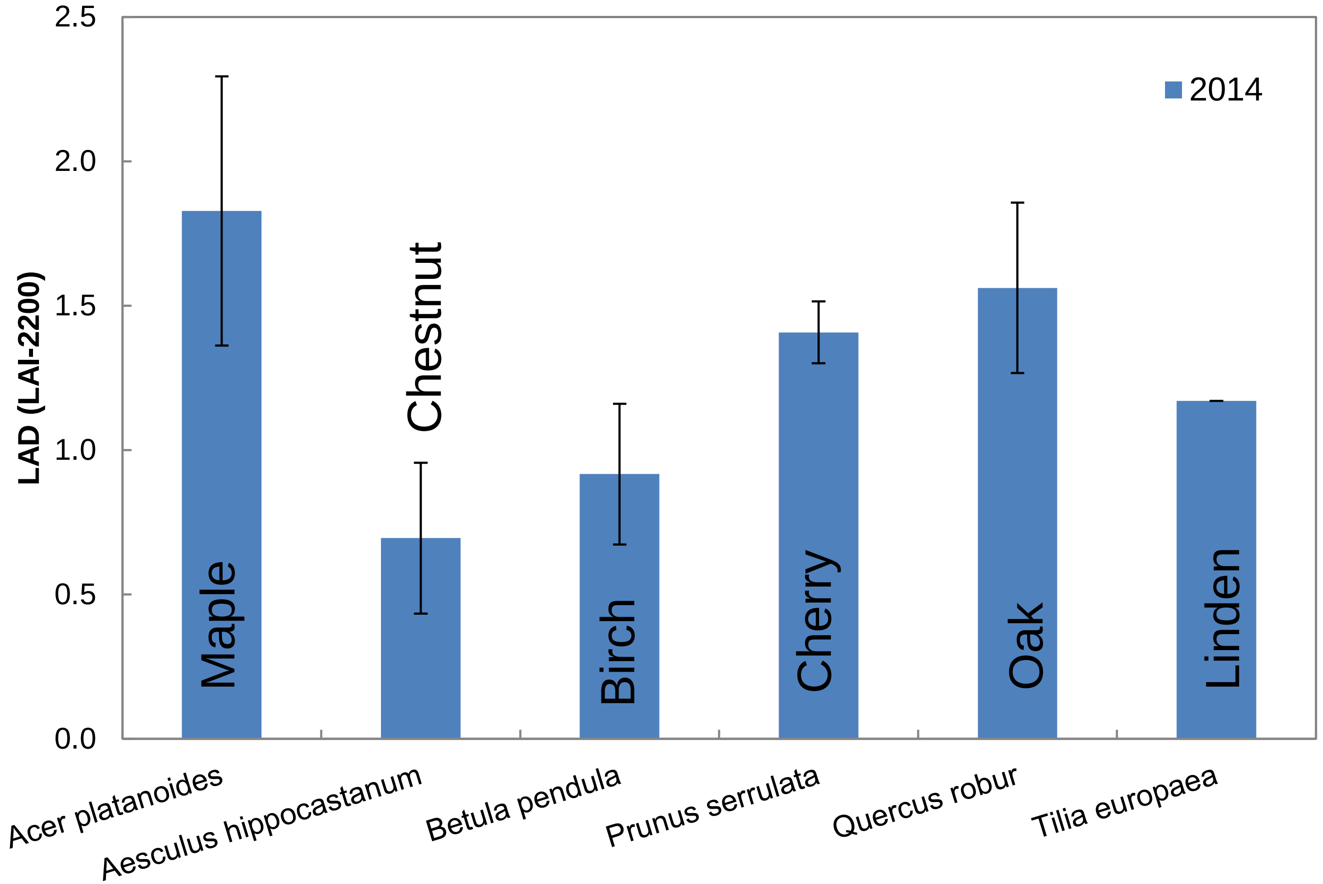
Uniformly overcast sky

Comparison of measurement methods

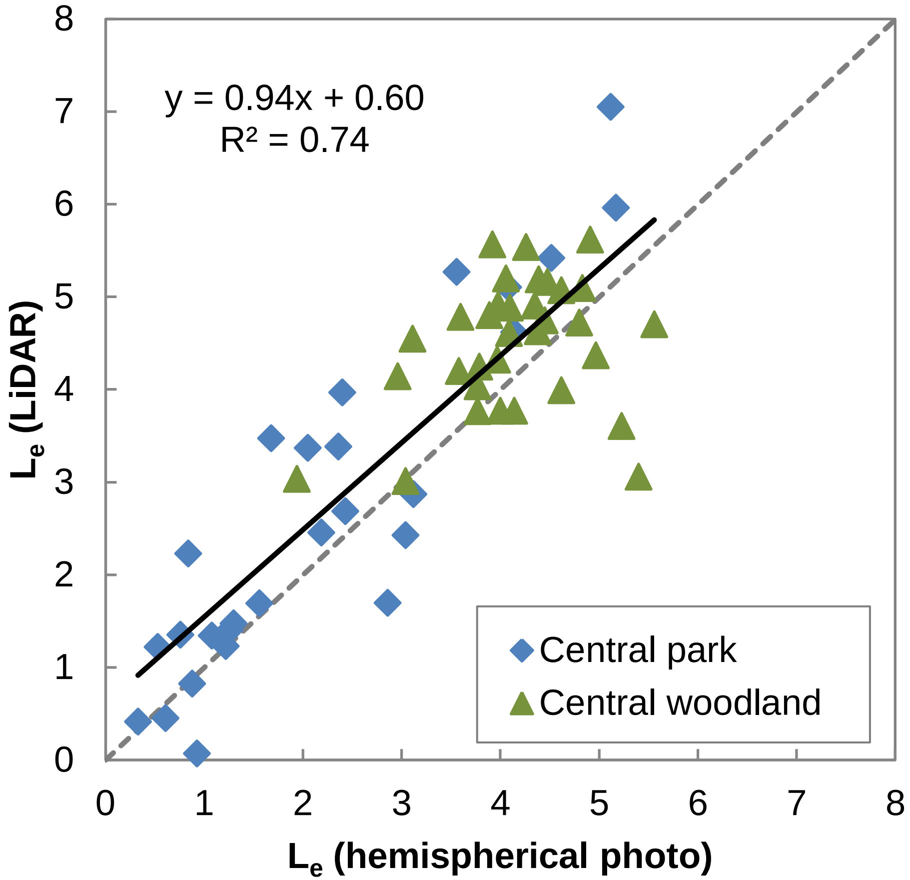


Sunny and blue sky

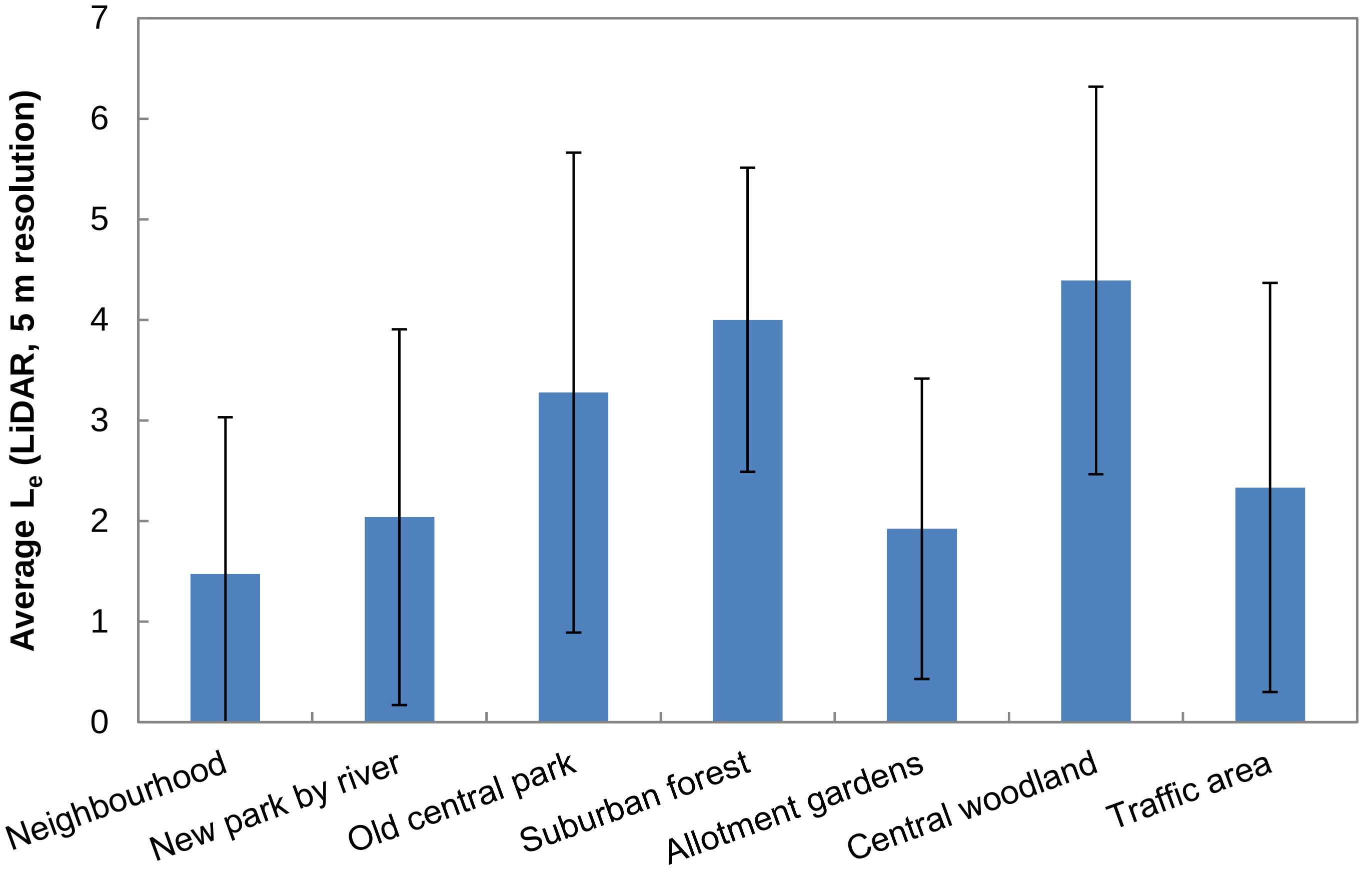
Single street trees (leaf area density based on LAI-2200)



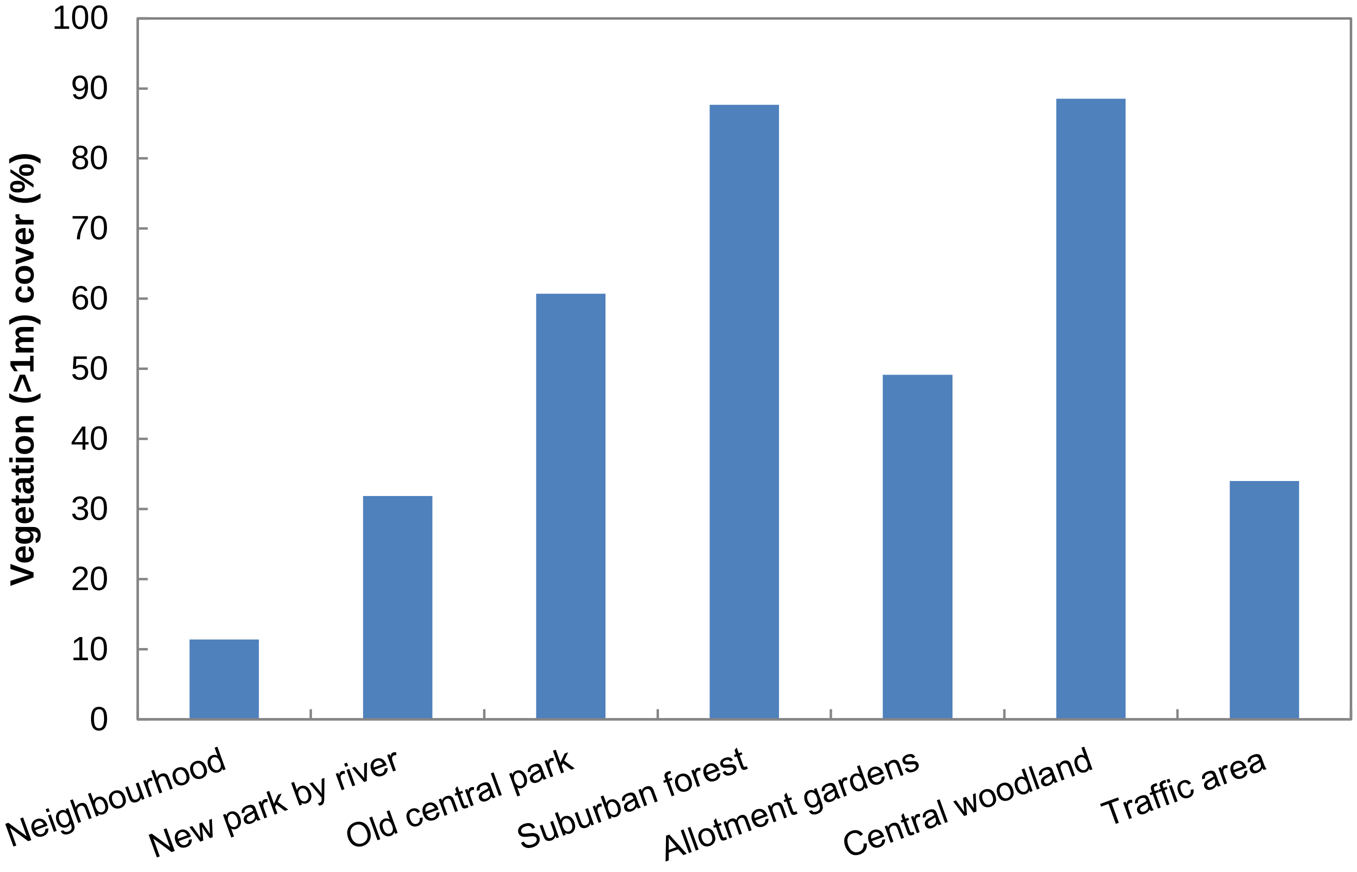
Modelled and measured L_e



L_e in urban greenery (based on LiDAR)



Vegetation (>1m) cover (based on LiDAR)



Summary

- It is challenging to measure leaf area in the urban environment, but hemispherical photography was found to be advantageous to LAI-2200.
- L_e can be successfully modelled based on LiDAR data in the urban environment.
- The large variation in leaf area between species and types of greenery in the urban environment emphasizes the importance of detailed estimates of L_e for urban applications.

Future research

- Estimation of LAI instead of L_e
  - NIR hemispharical photography allows distinguishing photosynthetically active leaves from other plant elements and buildings based on NDVI (difference between the reflectance of visible and infrared light)
- Improved estimation of T_{mrt} from hemispherical photographs at vegetated urban sites