PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVI cycle, 2020-23)

Project draft

1.Field of interest

AGR/03

2.Project title

Measurement of regulation ecosystem services by urban trees and shrubs

3.Tutor (membro del Collegio dei Docenti): Alessio Fini

- Eventually: co-tutor/s

4.Relevance of the topic and state of the art:

Achieving a sustainable management of all types of forests, including the urban forests and improving the capacity to adapt to climate change and enhancing human well-being are among the key goals to be achieved in the forthcoming years (United Nations Sustainable Development Goals n. 11, 13, and 15). Urban green areas are key elements to strengthen the resilience and the adaptive capacity against global change, as well as to strengthen communities and enhance safety and inclusivity in cities (Haines-Young and Potschin, 2018). Ecosystem services have been recently categorized into provisioning of resources, cultural benefits, and regulation of environmental phenomena (Haines-Young and Potschin, 2018). The latter category includes carbon assimilation and storage, air pollution removal, and microclimate amelioration, which are now widely recognized ecosystem services from urban vegetation able to improve the quality of life of citizens. Benefits by urban trees, however, are indirect and difficult to quantify, so they often remain "obscure", while costs for planting and management are always clear. Several attempts have been carried out using dendrometric and micro-meteorological models to quantify benefits of urban trees (Nowak and Crane, 2002; Nowak et al., 2018), but a better linkage of benefits to tree physiology is needed for accurate quantification. For example, carbon sequestration (i.e. the yearly increase in carbon stored as woody biomass) has been shown to both poorly correlate and underestimate the amount of carbon assimilated (i.e. converted in carbohydrates with photosynthesis) by urban vegetation (Weissert et al., 2017). Similarly, there is need of better understanding how species-specific leaf and canopy traits affect PM deposition, wash-off, and resuspension (Chen et al., 2017). Finally, accurate data are missing to quantify the amount of latent heat dissipated by transpiration by different genotypes. Such data could improve the quantification of the cooling effect of urban trees against the urban heat island, which is up to date mostly founded on the shading effect (Rahman et al., 2015). This research is aimed at integrating physiological and dendrometric data to derive empiric and process based models to quantify CO_2 assimilation, PM removal, and transpirational cooling by urban trees.

5.Layout of the project (draft)

5.1.Materials & Methods:

The research will be carried out in different European municipalities. Four cities, Bolzano (IT), Rimini (IT), Krakow (PL), and Lugano (CH) are currently involved in the project, but the research will also include other cities which will join the research. *In situ* measurement campaigns will be carried out in the different municipalities in different periods of the year to assess: 1) growth and biometric parameters; 2) Leaf Area Index; 3) CO_2 assimilation per unit leaf area; 4) transpiration per unit leaf area; 5) PM accumulation per unit leaf area.

Growth will be measured by recording DBH, plant height, the area of the dripline (Pretzsch et al, 2015). Also, LiDAR data will be used to accurately estimate plant biomass and total leaf area (Van der Zande et al., 2009).

Leaf area index will be measured using both a ceptometer and LiDAR scanning (Van der Zande et al., 2009).

Leaf gas exchange will be measured according to different methods: instantaneous measurements, daily measurements, response curves (Tattini et al., 2017).

PM accumulation will be determined on about 300 cm^2 leaf area per plant by gravimetric methods (Mori et al., 2018).

Measurements will be carried out on about 5300 leaves from about 700 urban trees and shrubs.

Data collected from in situ measurements need to be used to generate empiric and process-based models.

5.2. Schedule and major steps (3 years):

Year 1: literature search for existing models for the estimation of regulation ecosystem services, with particular focus on input requirement and model accuracy. Preliminaty experimental campaigns to measure ecosystem services in the different cities.

Year 2: Abroad stay to learn novel methodologies related to the project. Statistical analysis of preliminary data. Experimental campaigns to measure ecosystem services in the different cities.

Year 3: Data analysis and modelling. Experimental campaigns to fill research gaps and to get additional data. Thesis preparation.

6. Available funds

LIFE URBANGREEN – 379’775 euro

Consulenza relativa a Progetto Interreg VERDEVALE – 25'000 euro

7. Literature:

Chen, L., Liu, C., Zhang, L., Zou, R., Zhang, Z. 2017. Variation in tree species ability to capture and retain airborne fine Particulate Matter (PM2.5). Scientific Reports, 7: 3206.

Haines-Young, R., Potschin, M., 2018. Common International Classification of Ecosystem Services (CICES) V5.1. and guidance on the application of the revised structure. www.cices.eu.

Mori, J., Fini, A., Galimberti, M., Ginepro, M., Burchi, G., Massa, D., Ferrini, F., 2018. Air pollution deposition on a roadside vegetation barrier in a Mediterranean environment: Combined effect of evergreen shrub species and planting density. Science of the Total Environment, 643: 725-737.

Novak, D.J., Crane, D.E., 2002. Carbon storage and sequestration by urban trees in the USA. Environmental Pollution, 116: 381–389.

Nowak, D.J., Hirabayashi, S., Doyle M., McGovern M., Pasher J., 2018. Air pollution removal by urban forests in Canada and its effect on air quality and human health. Urban Forestry and Urban Greening, 29: 40-48.

Pretzsch, H., Biber, P., Uhl, E., Dahlhausen, J., Rotzer, T., Caldentey, J., Koike, T., van Con, T., Chavanne, A., Seifert, T., du Toit, B., Farnden, C., Pauleit, S., 2015. Crown size and growing requirement of common tree species in urban centers, parks, and forests. Urban Forestry and Urban Greening, 14: 466-479.

Rahman, M.A., Armson, D., Ennos, A.R., 2015. A comparison of the growth and cooling effectiveness of five commonly planted urban tree species. Urban Ecosystems, 18: 371-389.

Tattini, M., Sebastiani, F., Brunetti, C., Fini, A., Torre, S., Gori, A., Centritto, M., Ferrini, F., Landi, M., Guidi, L., 2017. Dissecting molecular and physiological response mechanisms to high solar radiation in cyanic and acyanic leaves: a case study on red and green basil. Journal of Experimental Botany, 68: 2425-2437.

Van der Zande, D., Mereu, S,, Nadezhdina, N., Cermak, J., Muys, B., Coppin, P., Manes, F., 2009. 3D upscaling of transpiration from leaf to tree using ground-based LiDAR: application on a Mediterranean holm oak (Quercus ilex L.) tree. Agricultural and Forest Meteorology 149: 1573-1583.

Weissert, L.F., Salmond, J.A., Schwendenmann L., 2017. Photosynthetic CO_2 uptake and carbon sequestration potential of deciduous and evergreen tree species in an urban environment. Urban Ecosystems, 20: 663–674