AIRFRESH

LIFE19 ENV/FR/00086

Air pollution removal by urban forests for a better human well-being

NATIONAL BIODIVERSITY FUTURE CENTER

The urban forest in climate resilient strategies

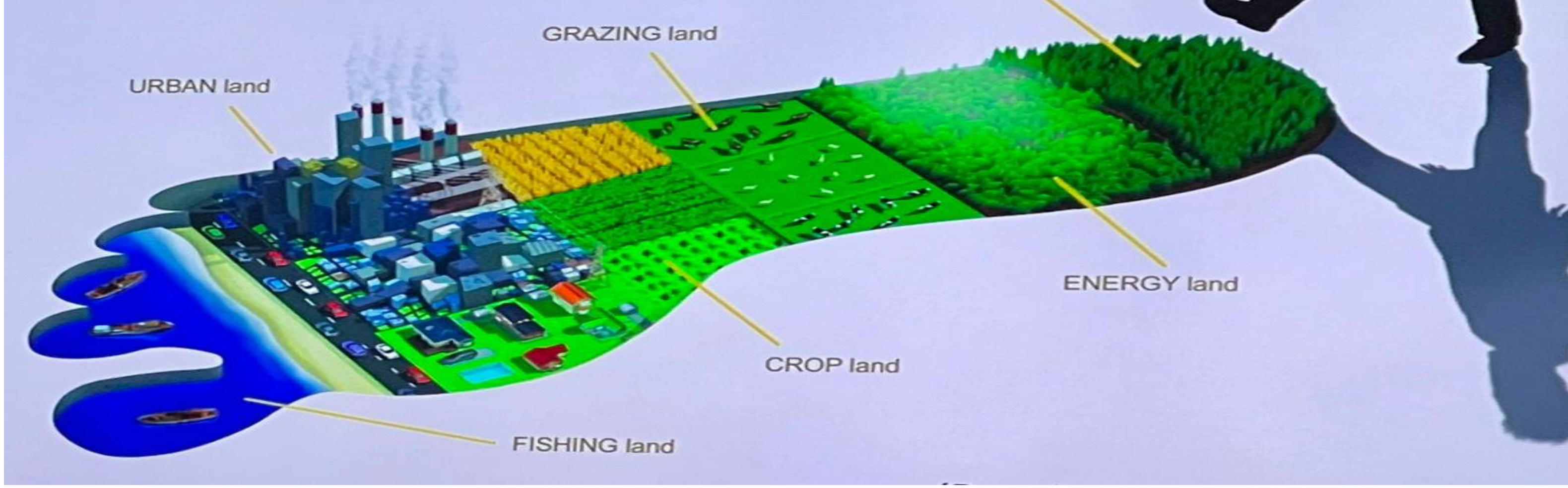
Jacopo Manzini, Yasutomo Hoshika, Pierre Sicard, Alessandra De Marco, Barbara Baesso Moura, and **Elena Paoletti**

elena.paoletti(at)cnr.it

ACRI ST

CNR IRET

ENEA
Italian national agency for new technologies, energy and sustainable economic development



Urban footprint

- Since the 21st century, the global urban population has grown at a much faster rate than the total population, with urban areas expected to accommodate **~68% of the global population by 2050** (He et al., 2021a) relative to the present 58%. In response to the growing population, urban areas continue to expand
- Although **urban areas cover only ~3%** of the global land area and includes only **0.1% of global trees**, they use **70% of energy**, emit **75% of traditional pollutants** and **75% of carbon non-offset emissions**, consume **80% of water** and **80% of food**, and produce **85% of waste**

Impacts of urban expansion on vegetation

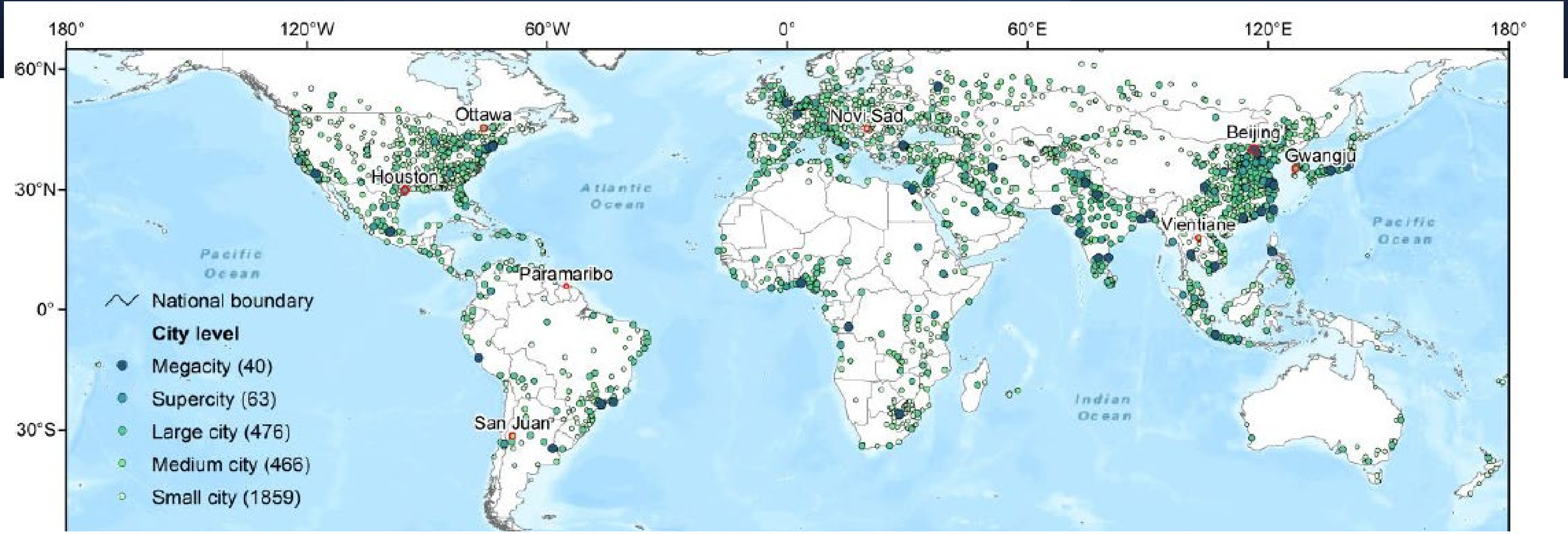
- Large-scale urban expansion encroaches on ecologically productive land, resulting in reduced vegetation cover, loss of agricultural land, and destruction of natural habitats (He et al., 2023).
- Urban expansion triggers localized climate change, disrupting ecosystem structure and function and reducing vegetation productivity (Wu et al., 2024).
- Elevated tropospheric CO_2 concentrations, as well as higher temperatures and increased atmospheric nitrogen deposition caused by the urban heat island effect (UHI) may enhance the growth and development of urban vegetation (Gao et al., 2023; Guo et al., 2024).
- Vegetation gradual response and adaptation to changes in the urban environment follows a time course, and the long-term persistence of this effect remains unclear.

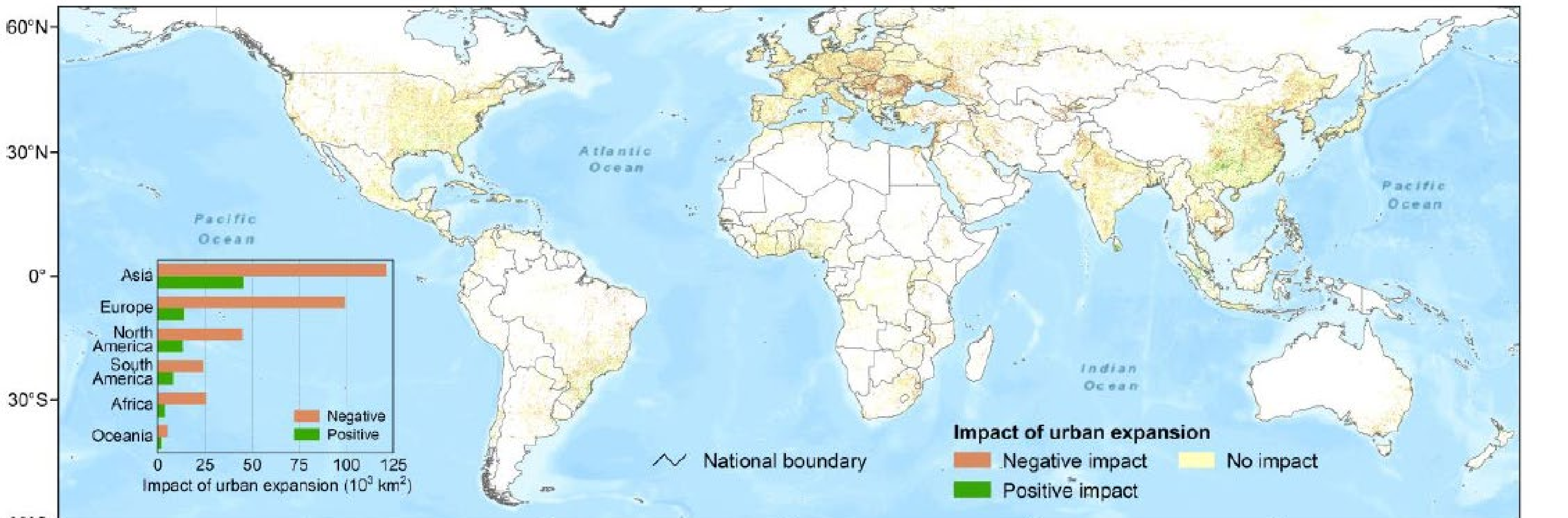
Impacts of urban expansion on vegetation

World inequalities

Location and city level of 2904 cities globally

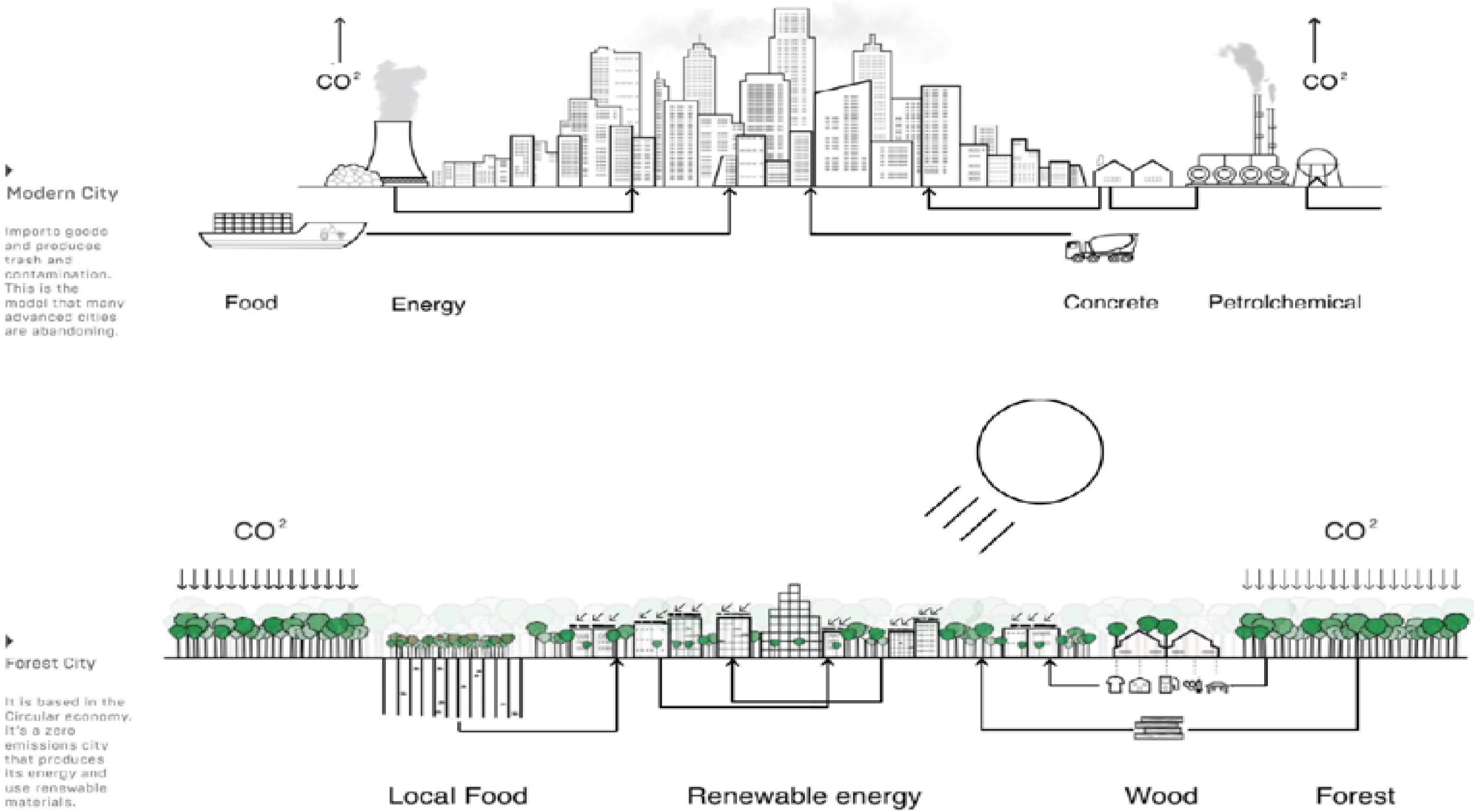
Spatial patterns of negative and positive impacts of urban expansion on Net Ecosystem Productivity



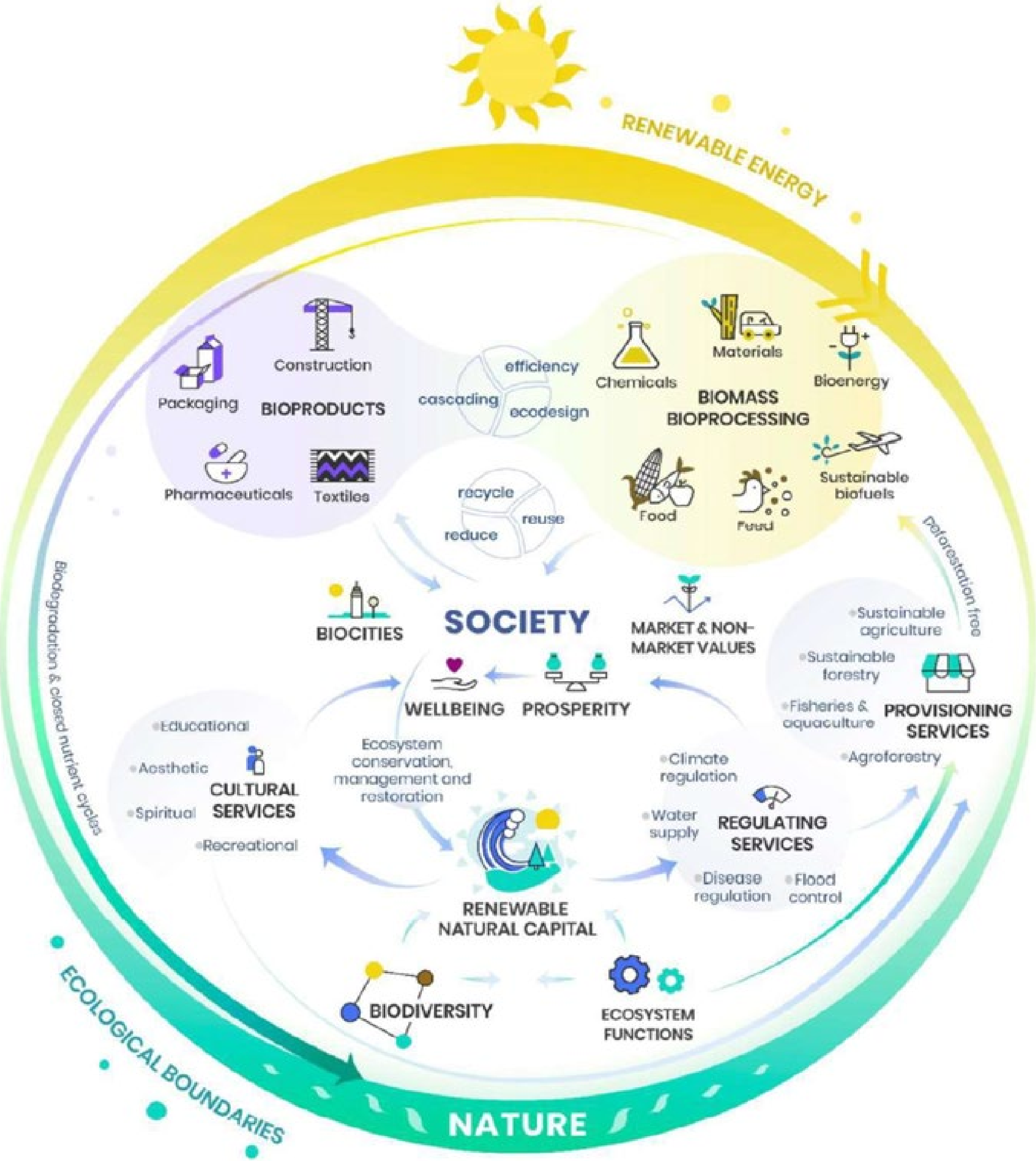


The city as a forest (Scarascia Mugnozza et al., 2023)

Urban forests are the backbone of green infrastructure, bridging rural and urban areas and ameliorating a city environmental footprint (FAO 2016). Urban forests comprise all woodlands, groups of trees, and individual trees located in urban and peri-urban areas



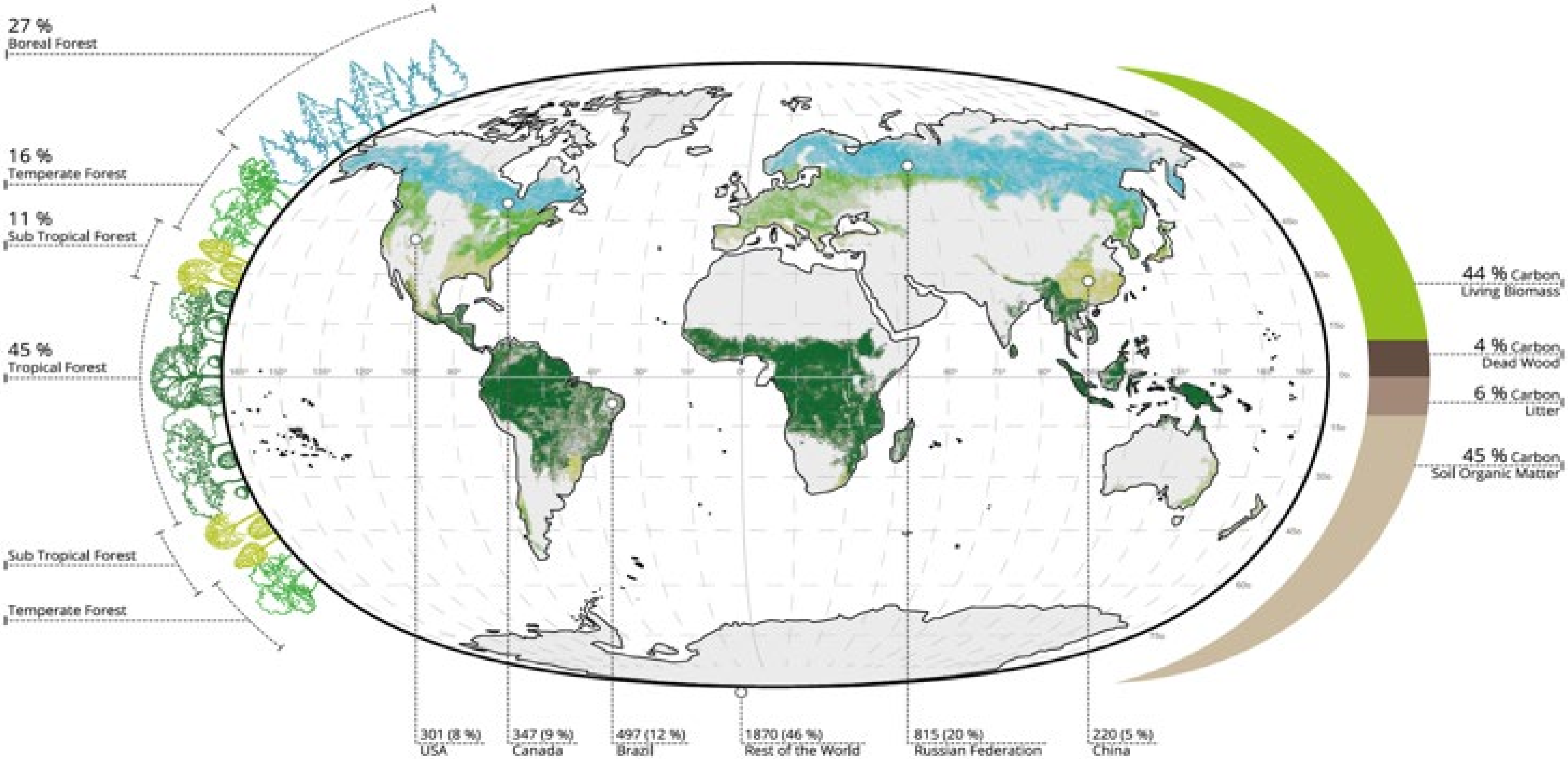
The circular bioeconomy



Global carbon sequestration in forests and soils ©IAAC

?

Global carbon in urban forests and soils ?



Carbon Balance of a new green area

Emissions

CO_2

+ Net CO_2 trees seq. – Carbon footprint – Soil respiration

Temperature

Species-specific feature

Photosynthesis

- Light
- Temperature
- Relative humidity
- CO_2

Dark Respiration ← Temperature

Test area - San Bartolo (Firenze Italy)

Planted trees:

70 *T. platyphyllos*
30 *C. sempervirens*
15 *A. rubrum*
15 *A. opalus*
40 *Ulmus* “Plinio”

Area extension = 0.55 ha

AIRFRESH

LIFE19 ENV/FR/00086

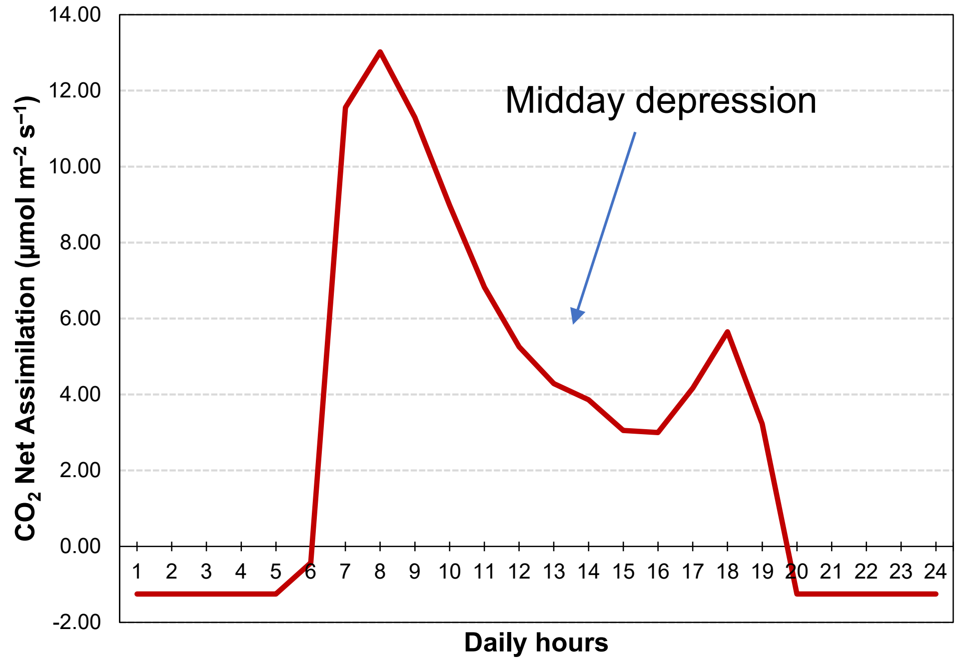
Net CO_2 tree sequestration

Species-specific ecophysiological measurements:

- Light-response curves and CO_2-response curves
- Instantaneous measurements of A_n along the day (Temperature, relative humidity)
- Dark respiration (Temperature)

By merging light-response curves, istantaneous measurements and hourly meteorological data (T, RH PPFD) it will be possible to assess the daily CO_2 assimilation for each species

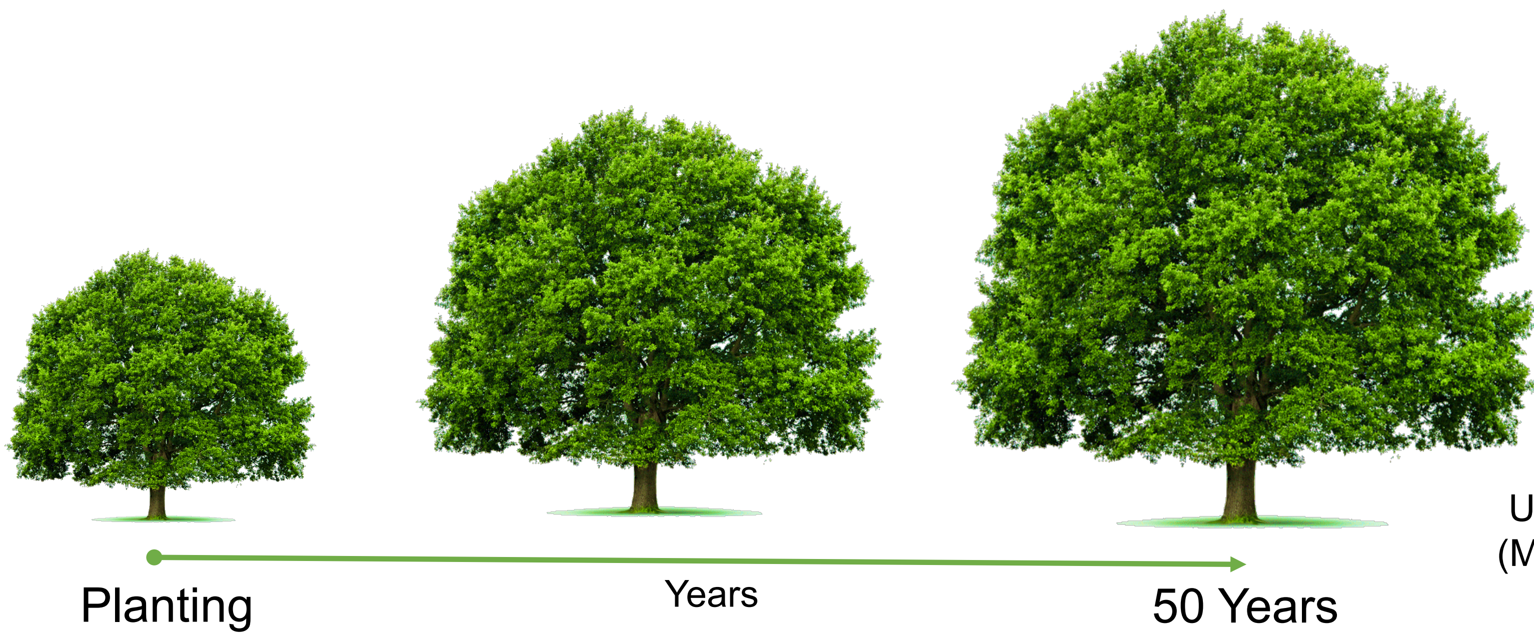
Example – daily CO_2 assimilation_summer



$$A_n = A_{max} \times f_{light} \times f_{temp} \times f_{VPD} \times f_{CO2} - \text{Resp.}$$

Scaling-up and Trees Growth

values of h, DBH, LAI and LMA were recorded



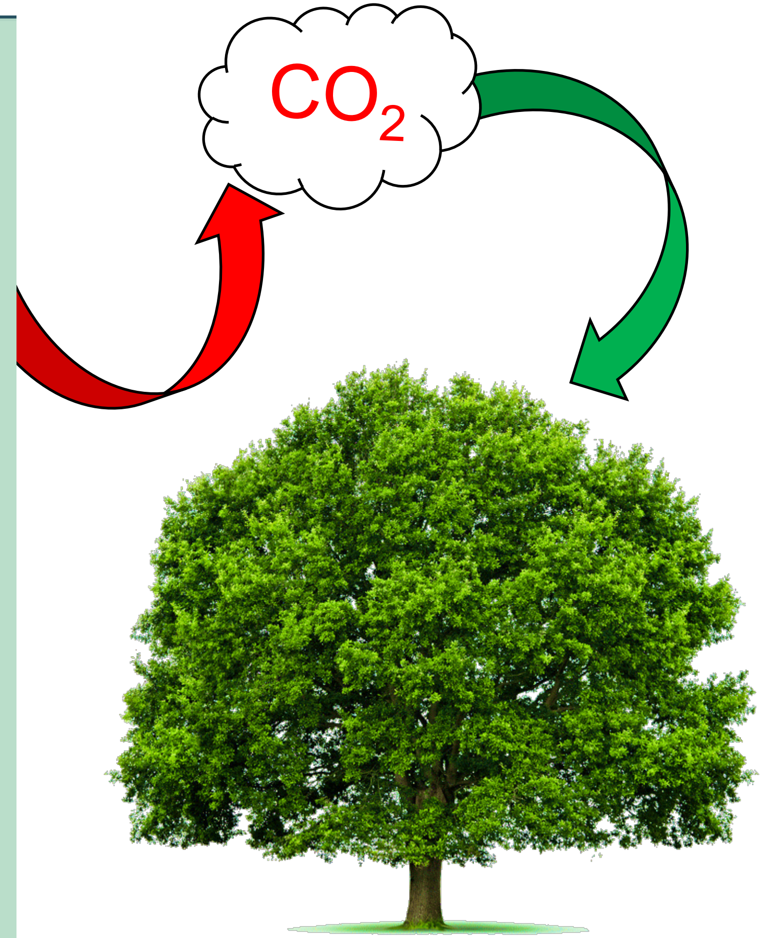
Species-specific Growth model considering DBH, age and Leaf area

Urban Trees Database (McPherson *et al.*, 2016)

CO_2 emissions - Life Cycle Analysis

…*From cradle to grave* approach…

Functional unit : **test area (0.55 ha)**
Time horizon : **50 years**

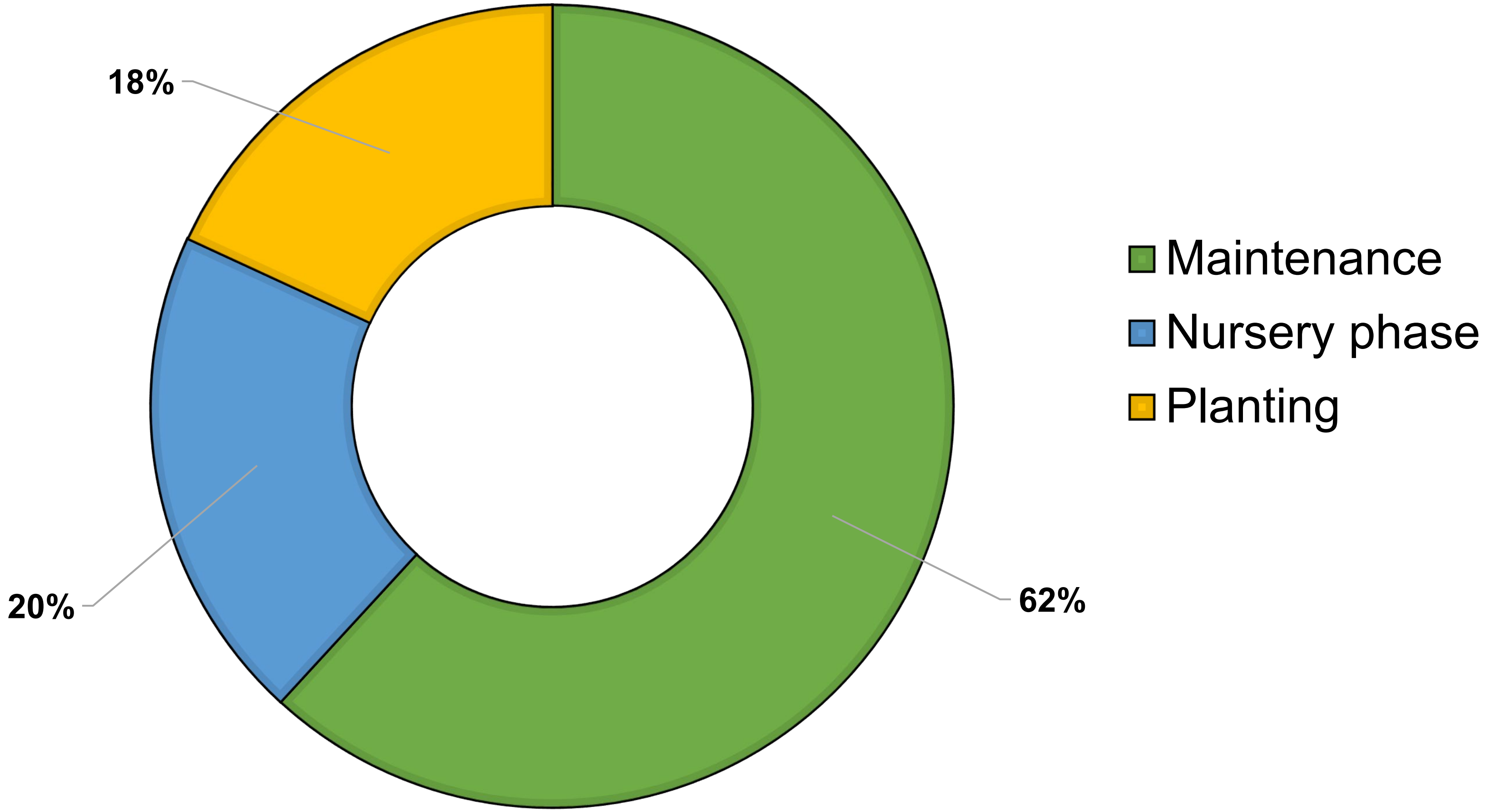


Model to assess CO_2 uptake from trees

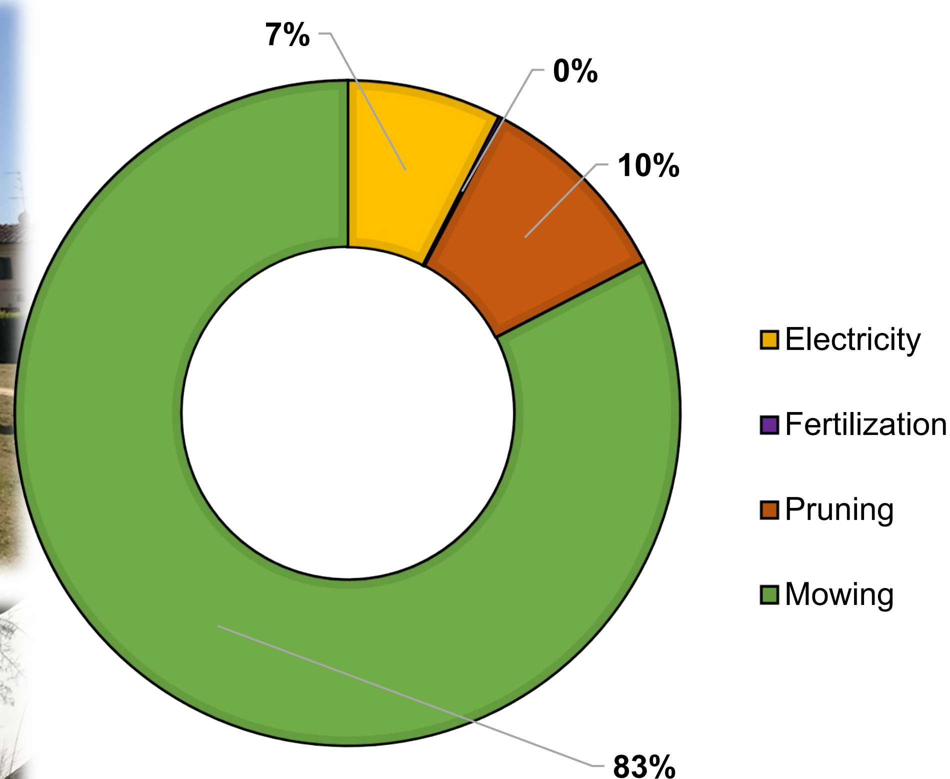
Carbon footprint – Results

Emissions in kg of CO_2 equivalents

Carbon footprint = **14.7 ton CO_2eq**

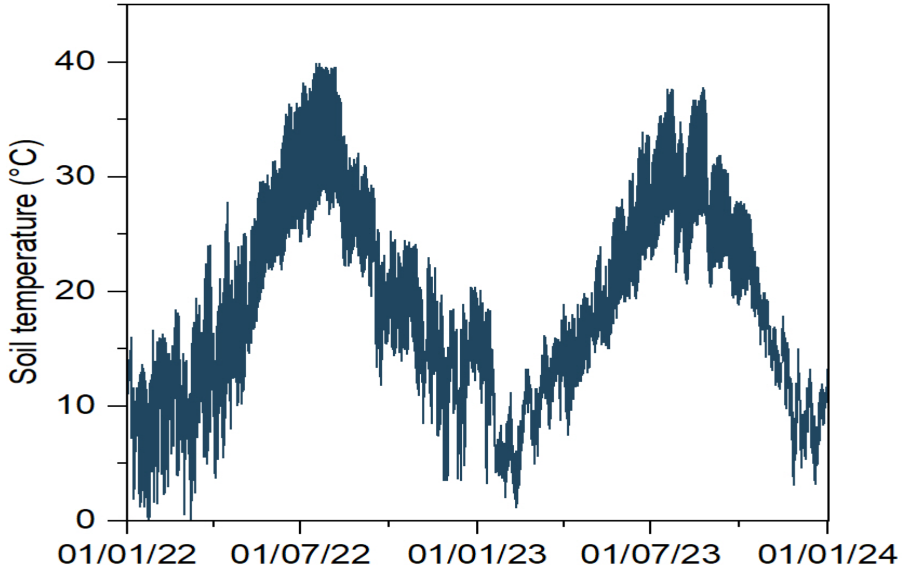


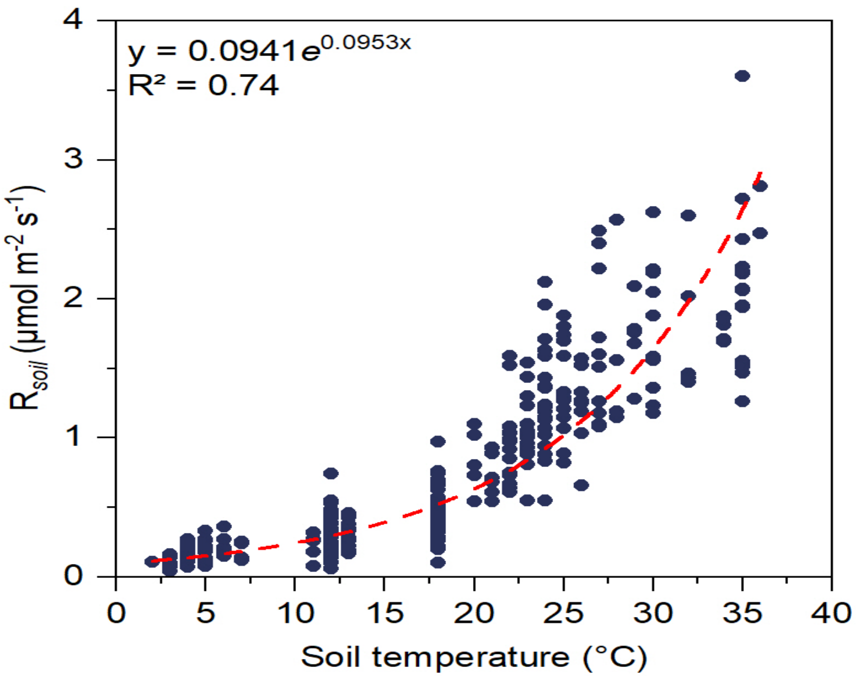
Results – Maintenance over time



- Fertilization N-P-K only first two year
- Irrigation first 3 year
- Pruning 3 times in 50 year
- 6 grass cutting/year for 50 year

CO_2 emissions - Soil Respiration

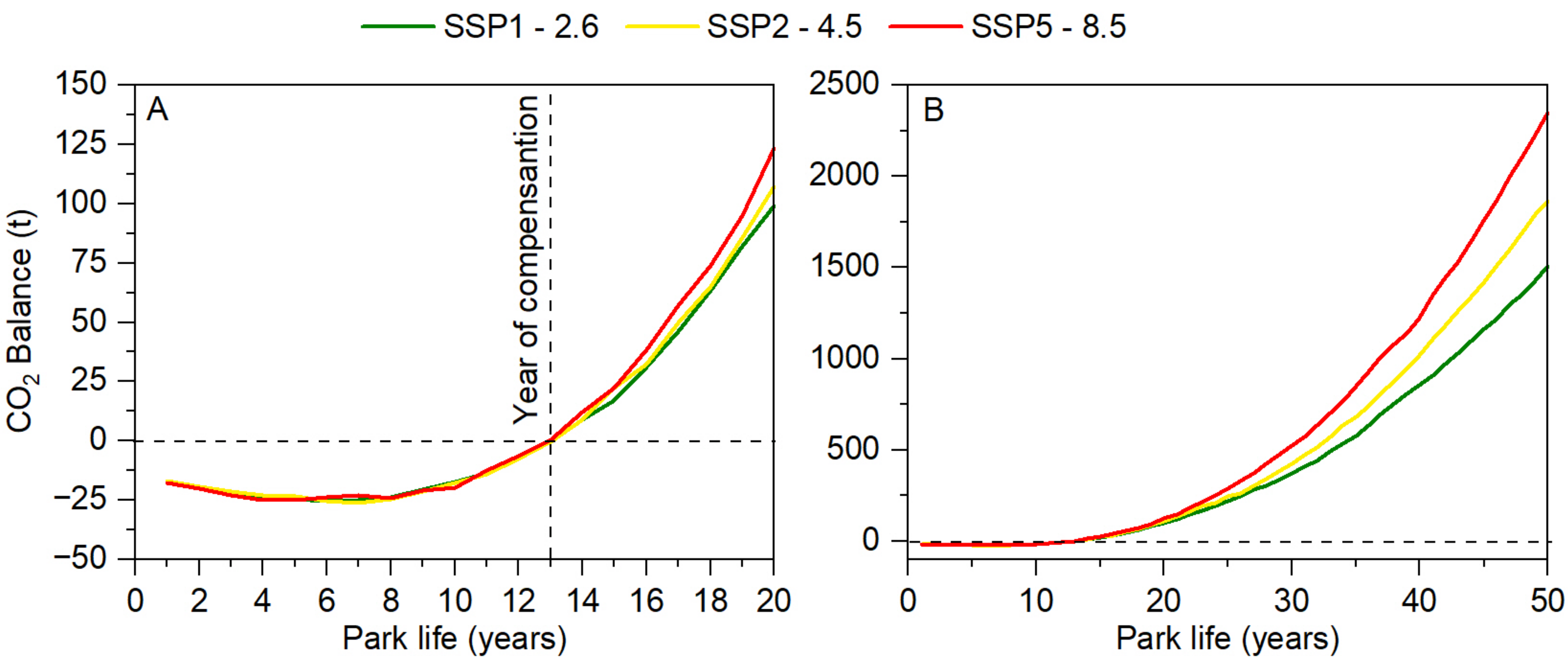




- EGM-4 equipped with SRC-1 (PP-Systems, Herts, UK)
- 3 sub-areas; 300 measurements
- Hourly soil temperature recorded by Decagon RT-1 sensors

CO_2 balance and Year of compensation

CO_2 balance = + Net CO_2 tree assimilation – Carbon footprint – Soil respiration



To run the model hourly meteorological data (T, RH, PAR) and soil temperature were recorded for 2022 and 2023 while 3 climatic scenario (SSP1-2.6, SSP2-4.5, SSP5-8.5) were considered for the next 50 years

Conclusions from a case study

- Life Cycle Analysis demonstrated to be a useful tool to underscore the most environmentally critical phases linked to our case study.
- Park maintenance over time resulted the highest source of CO_2 emissions (62%) with grass mowing the most impactful activity.
- Soil respiration resulted a key CO_2 emission factor in the Mediterranean area.
- **13 years** are needed for a new urban forest to become a real CO_2 sink in a Mediterranean city.
- Stakeholders and administrations can use these results to take actions to reduce Carbon footprint and to achieve aims of carbon neutrality.

General conclusions

- Urban forests provide a variety of benefits to citizens
- The impacts on global services e.g. carbon sequestration and climate control, are still to be fully evaluated