

A trees network to improve ecophysiology and biodiversity monitoring

Alessandro Messeri¹, Riccardo Giusti¹, Maurizio Iannuccilli¹, Francesco Mazzenga¹, Giorgio Matteucci¹, Marco Marchetti² and on behalf of the TTIN Collaborative Group

¹ Institute of Bioeconomy (IBE)
National Research Council (IBE-CNR)

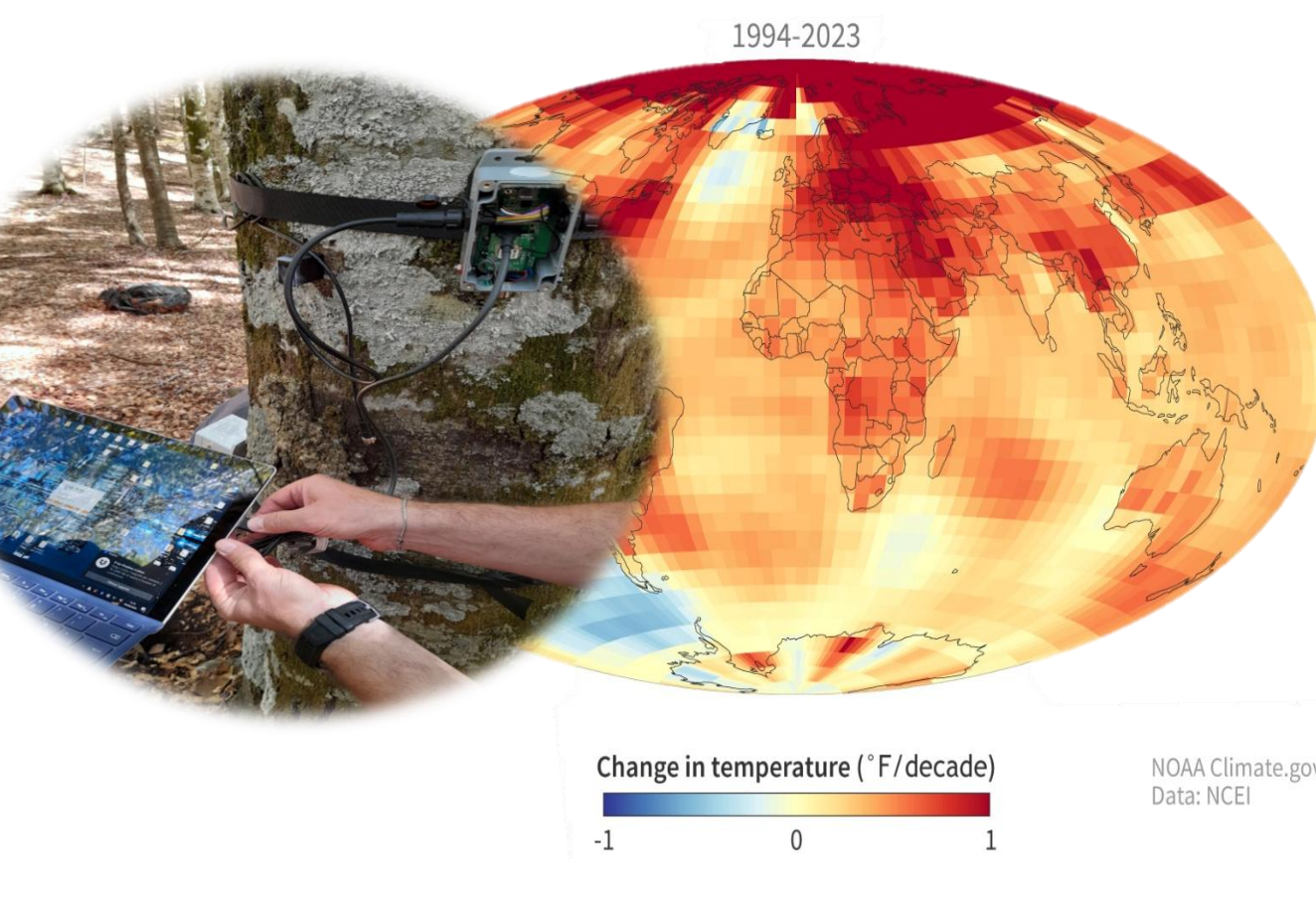
² Department of Architecture and Design (DiAP)
Sapienza University of Roma

State of the art

High biodiversity levels allow forest ecosystems more resilient to global changes (global warming, soil loss, invasive alien species, etc.) and maintain their role in ecosystem services. New advanced IoT devices (Figure 1), able to collect real-time, tree-based data (sap flow density, stem radial growth, air temperature and humidity, tree stem movements and water content, canopy transmitted radiation) are produced by Nature 4.0 group.



Figure 1. Tree Talker device to collect real-time tree data.

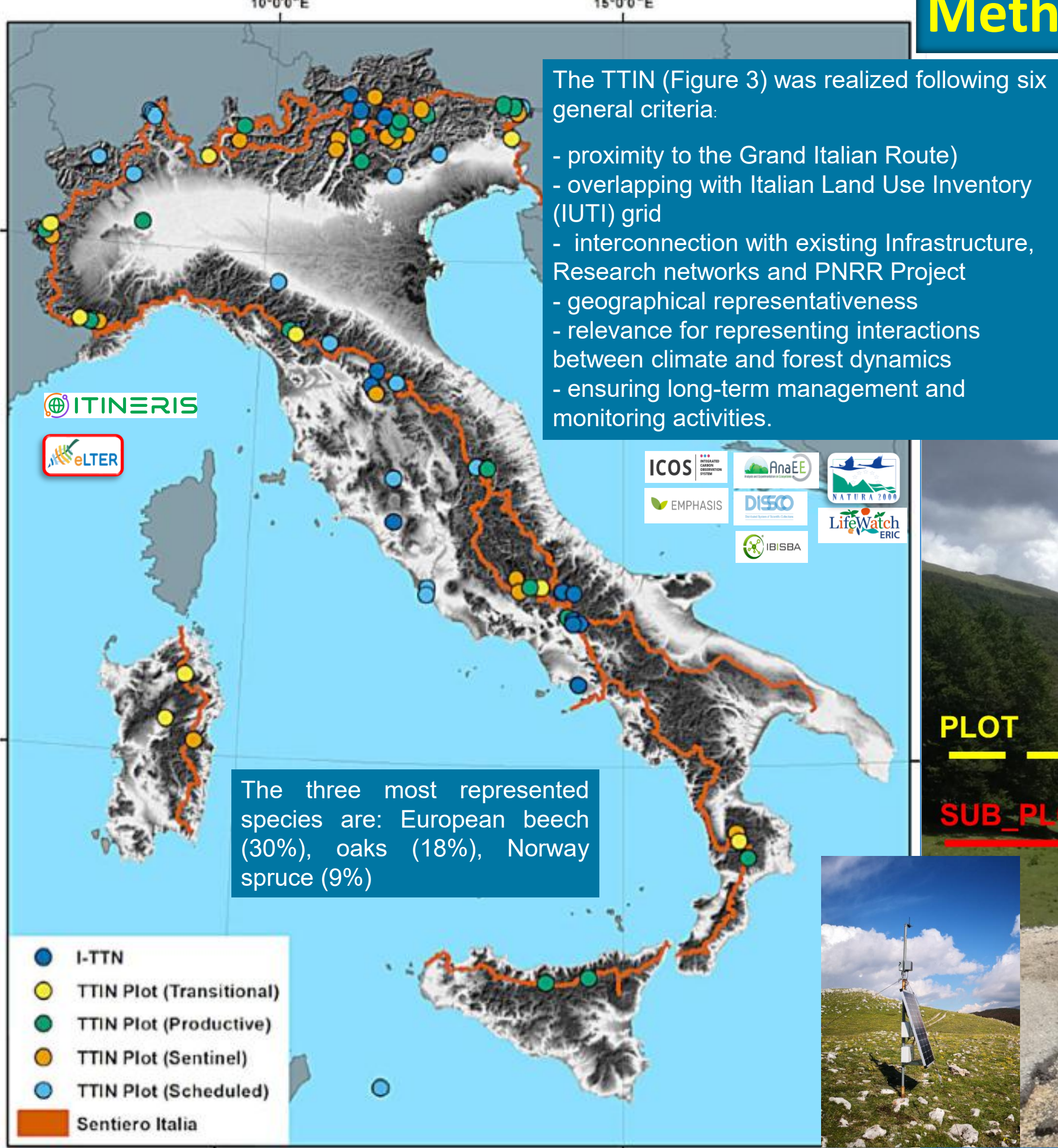


Objectives

Realize a long-term monitoring network of the Italian forest status and functionality (TTIN, <https://www.treetalkeritalia.it/>), focusing the attention on 3 forest stand categories (Figure 2).

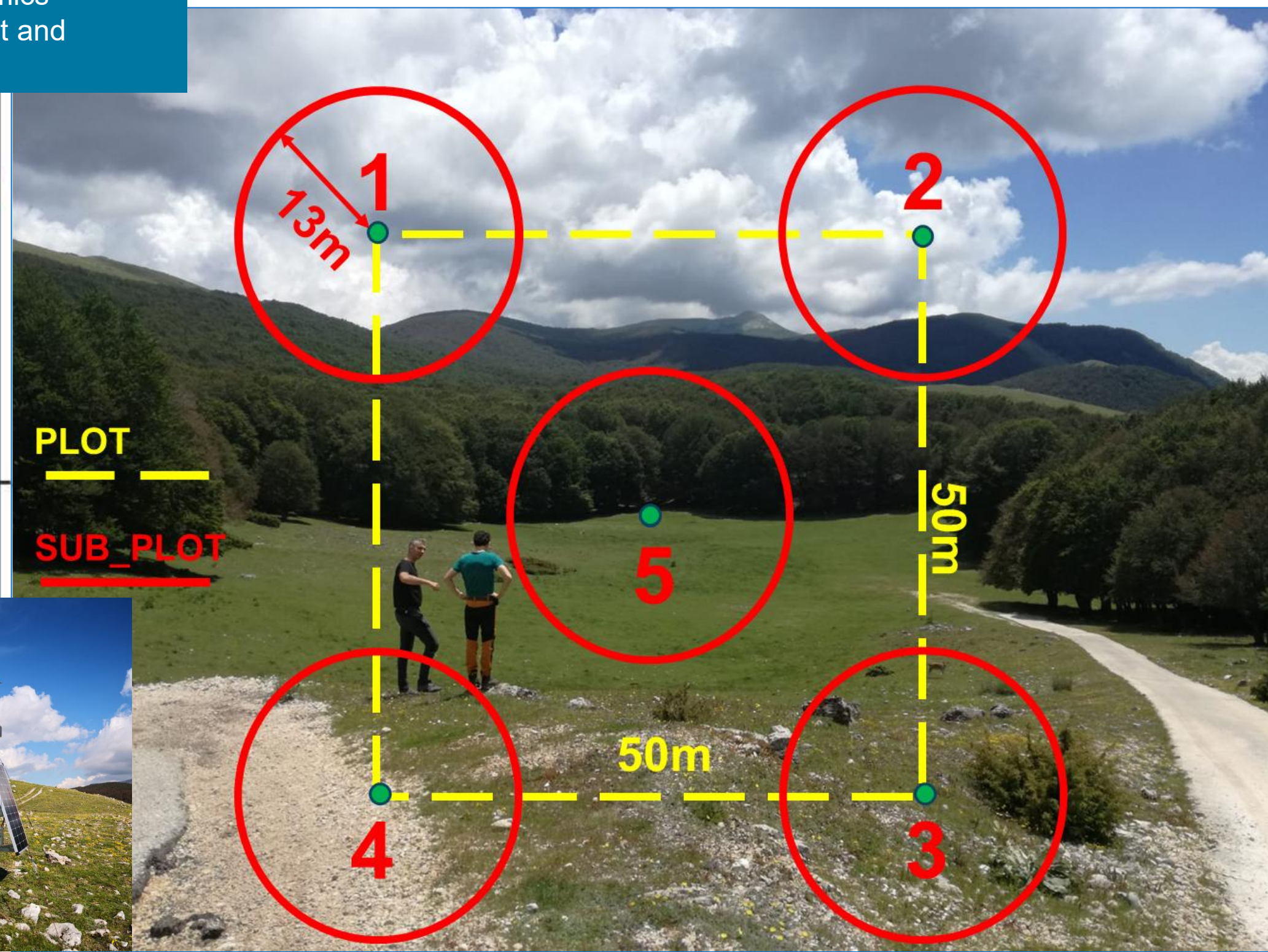
	Productive forest	Transitional forest	Sentinel forest	
Cluster of forest dynamics	Current successional stage	Human interactions	Susceptibility to climate change effects	Ecological dynamism
Productive forests	Early to intermediate	High	Low to mid	Low to mid
Transitional forests	Early (new-growth stands) or late (over-mature stands)	Low	Mid	Low (late stages) and high (early stages)
Sentinel forests	Early, intermediate, or late, depending on recent development	Low	High	High

Figure 2. Forest stand categories involved in the study (Vizzarri et al 2025).



Methods and approaches

In each TTIN site, a reference area (100 × 100 m) with homogeneous forest characteristics (e.g., forest type, management system) and continuous canopy cover was identified, and the center is georeferenced. Then, a squared plot (50m × 50m) was established and five subplots anchored to the centroid with one tree talker device (Figure 4).



Complementary surveys at the stand level:

In each TTIN site, a series of stand-level surveys was envisaged to complement the information collected by TTs at the individual tree level:

- key stand parameters (horizontal and vertical structure, canopy cover, etc.),
- forest stand's biodiversity proxies and indicators (microhabitat)
- soil

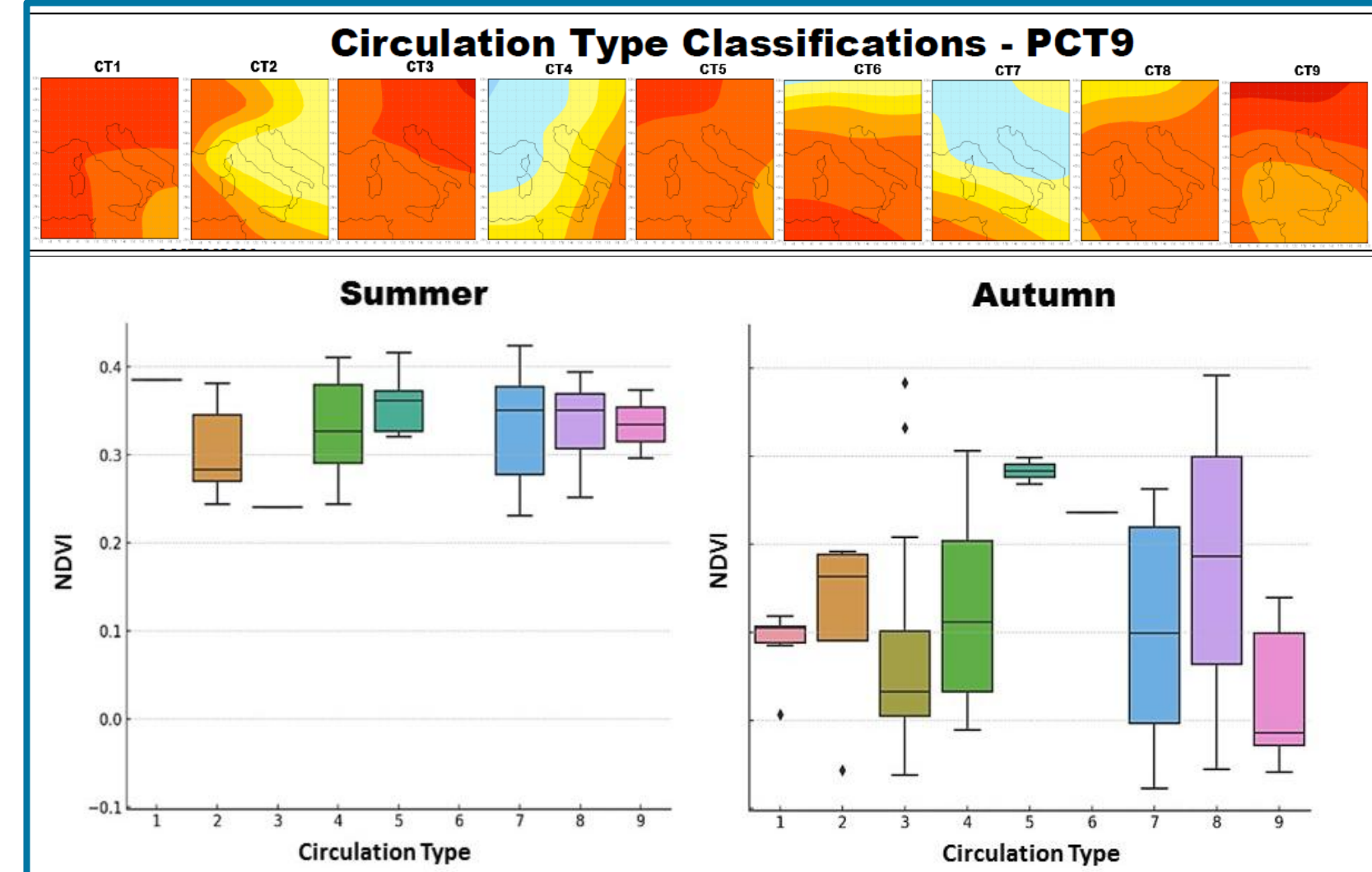
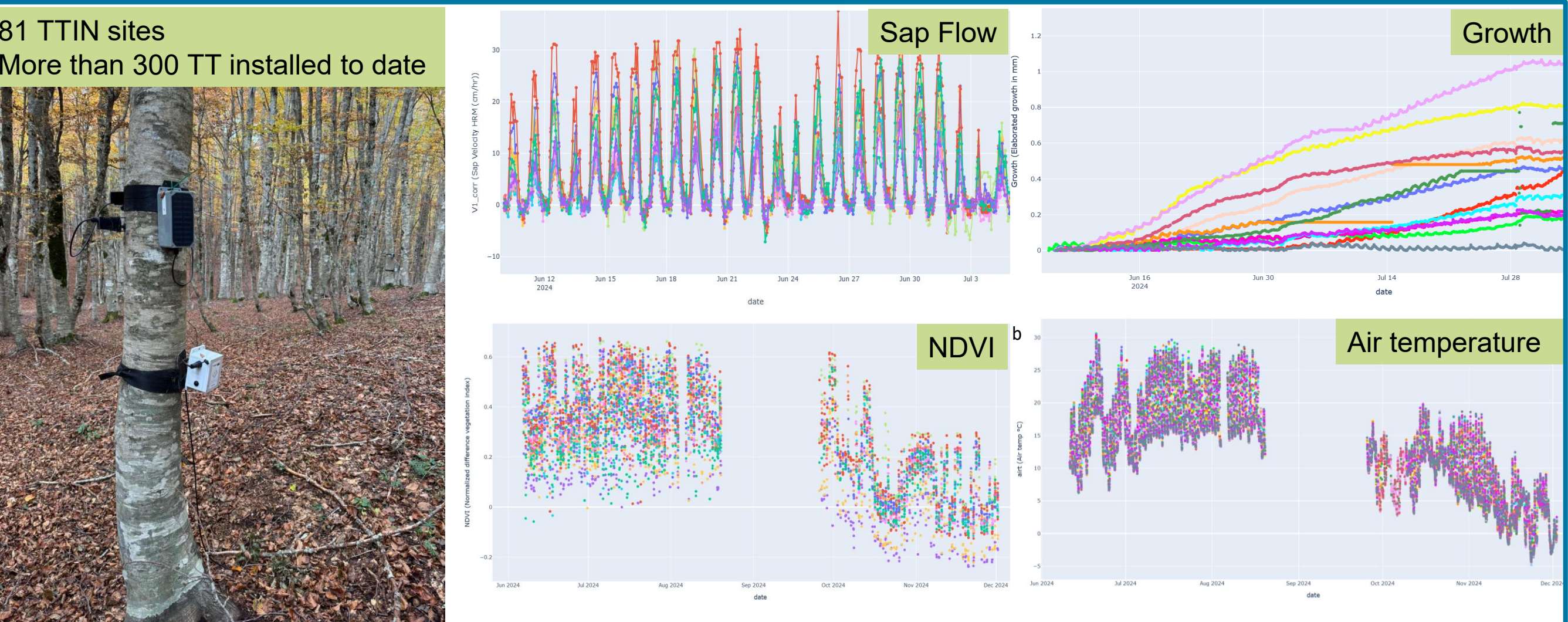


Complementary surveys at the ecosystem level:

To implement the study biodiversity conservation, ecosystem functions and processes, associated with climate change impacts, a wildlife biodiversity monitoring was carried out in some TTIN sites:

- Mammals detection with camera traps
- birds and chiropterans monitoring with audio recorders

Preliminary results



Data analysis was carried out in Collelongo (AQ) with NDVI data to explore the relationships between the beech forest phenology and the prevailing atmospheric conditions. Box plot shows NDVI data for each PCT in two seasons.

Acknowledgements

Activities were carried out in collaboration with TreeTalker Italia Network (TTIN) and with the support of the ITINERIS (Italian Integrated Environmental Research Infrastructures System) PNRR project (IR0000032).

References

Vizzarri M, Belelli L, Piermattei A, Santopioli G, Ottaviano M, Parisi F, Yates J, Asgharina S, Alberti G, Antonucci S, Ascoli D, Battipaglia G, Bizzarri A, Castagneri D, Castaldi S, Coccozza C, Dionigi M, Djacenko S, Donati C, Freppaz M, Garfi V, Gianelle D, Giusti R, Iannuccilli M, Kabala J, La Mantia T, Larsen S, Lasser B, Lombardi F, Magnani F, Massari C, Matteucci G, Mazzenga F, Meloni F, Messeri A, Montella M, Niccoli F, Pellizzari S, Pindo M, Renzi F, Sala G, Salbitano F, Sirca C, Spann D, Stefani E, Tomao A, Motta R, Tognetti R, Tomelleri E, Vacchiano G, Valentini R, Marchetti M 2025. Hearing nature's heartbeat: towards large-scale real-time forest monitoring network in Italy. *iForest - Biogeosciences and Forestry*, Volume 18 (4), 202-211pp. doi: <https://doi.org/10.3832/ifor4830-018>.