

Forest Map for Health (4Map4Health)

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Objectives

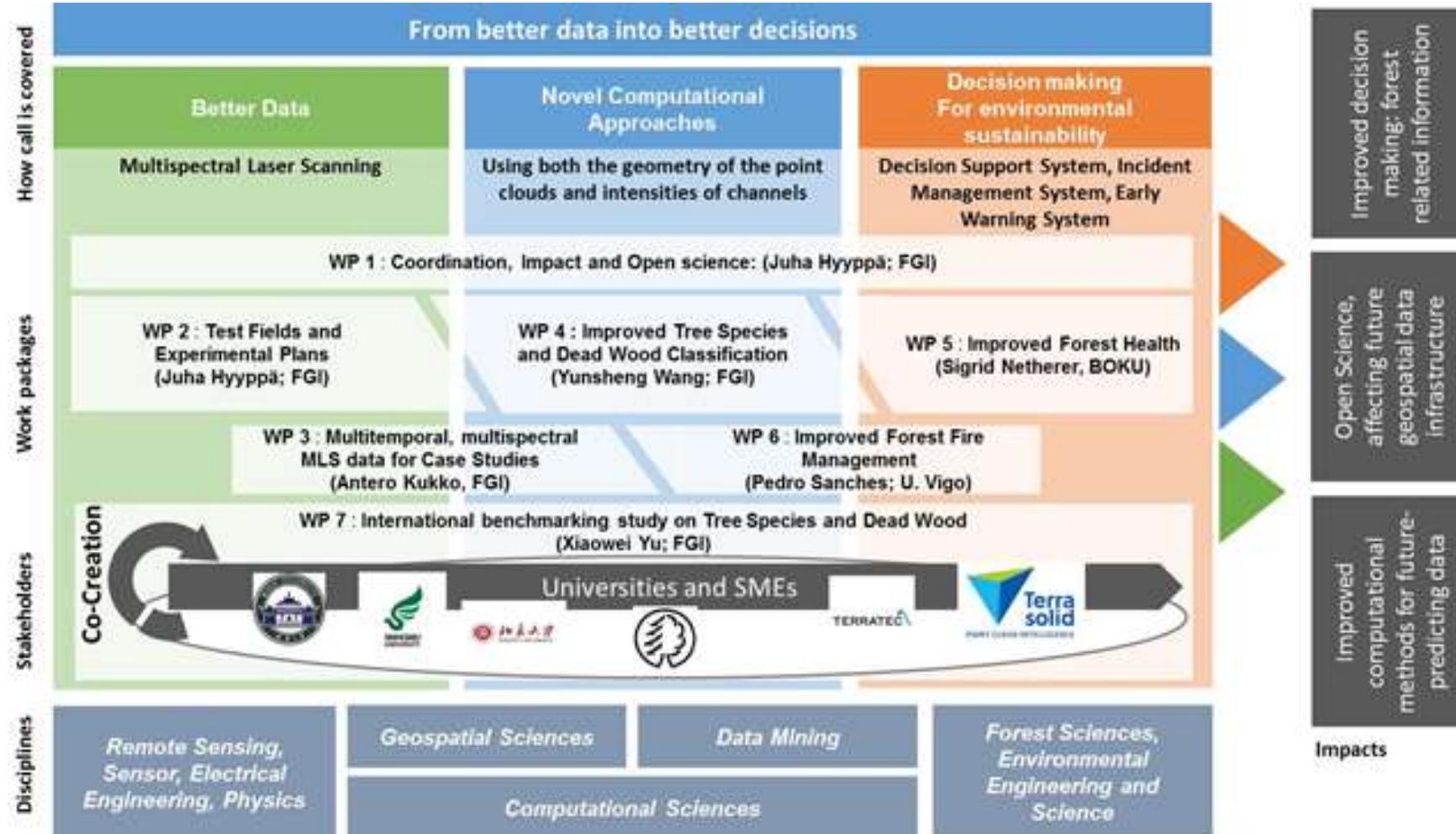
The major research question of the project is:

- How should the future high-resolution, multitemporal, multispectral laser scanning data be computationally processed to provide timely information for environmental sustainability and especially for mapping of the forest health, tree species classification, mapping of dead trees, and forest fire risk.
1. We **conduct pioneering measurements and case studies for next-generation forest data**, such as multitemporal, multispectral LS, using world-first multispectral mobile LiDAR.
 2. We apply **novel computational methods utilizing both spectral and geometric features** in point cloud analysis to improve estimation and prediction for tree species of living trees and amount of dead wood, forest health and forest risk management.
 3. We study the use of complementary data and computational methods (satellite- and UAV based change detection, terrestrial photogrammetric point clouds) to improve the predictions.
 4. We take the international collaboration into account and **accomplish a global benchmarking study of new computational methods, especially for tree species and dead wood**, inside the project.

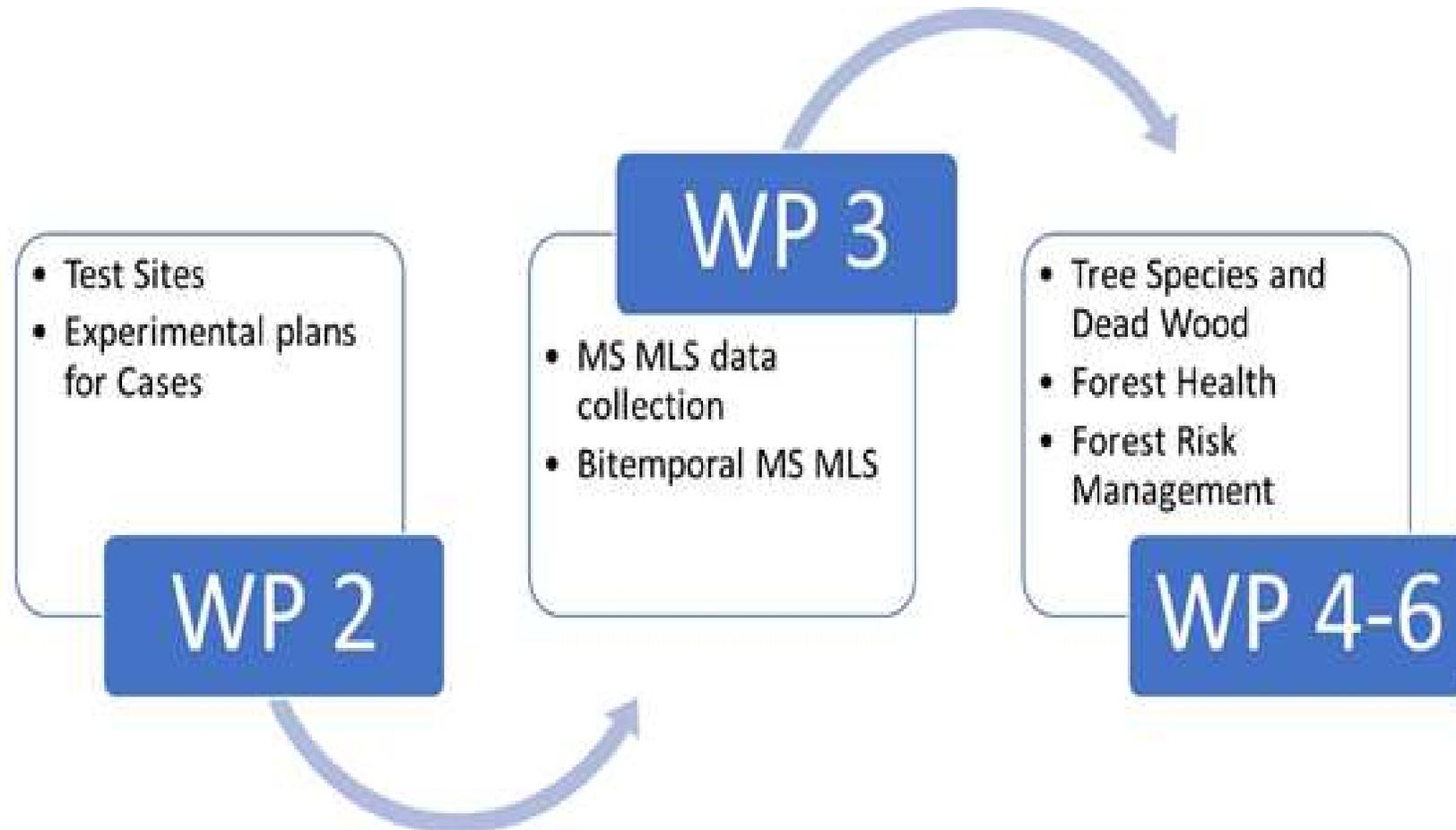
Approach

- Our long-term vision is to provide **active UAV-based multispectral laser scanning (LiDAR) data for large-areas with the required (temporal resolution (more qualified data))**, and we will develop better ICT methods for such data in order to be able to make more advanced estimates, and that way to permit timely and well informed decision making in the future.
- What is **common in mapping of forest health, tree species, dead wood and forest fire risk**, is that they are correlated to structure and moisture of canopies and understorey vegetation.
- LiDAR backscatter is strongly dependent on the set topography, object structure, moisture and roughness. Recently, a strong correlation was found between a normalized ratio of the two laboratory-level LiDAR measurements at different wavelengths and the measured Equivalent Water Thickness of samples of trees
- **Lidar metrics calculated could be an early signal of tree stress caused by drought, disease, or pest insects - metrics important for tree species, dead wood, forest health, and forest risk management.**

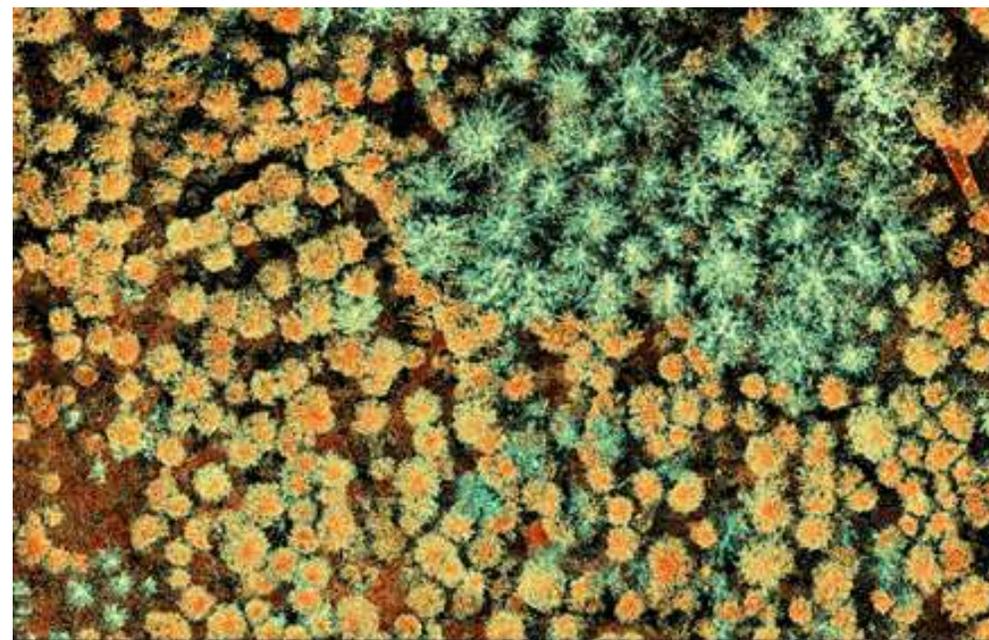
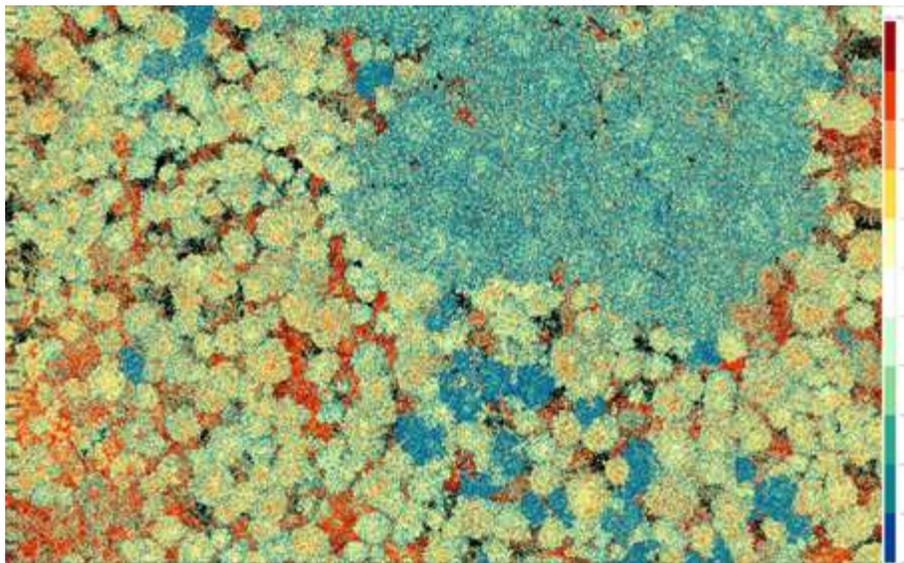
WP structure



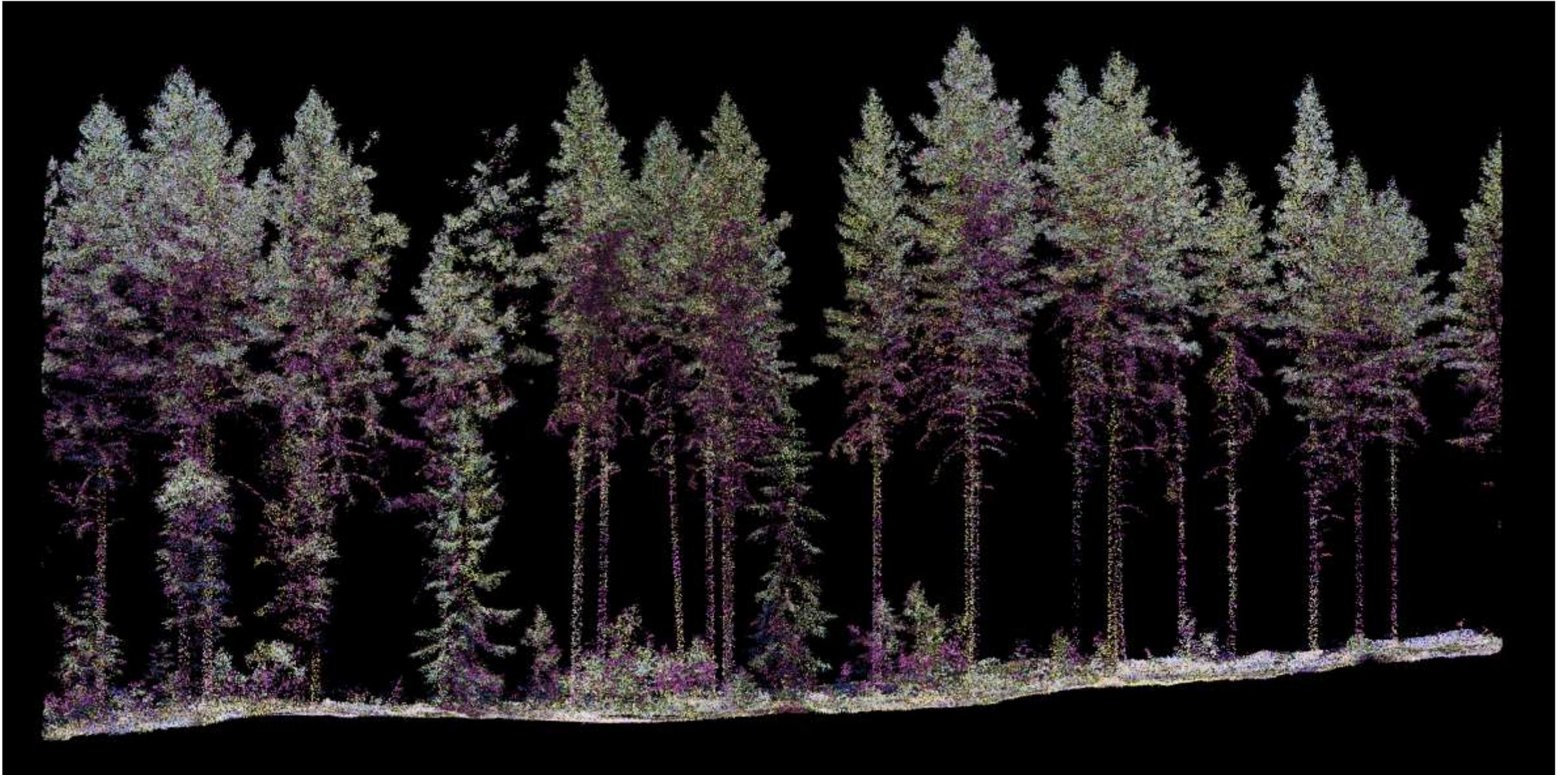
Workflow



Forest seen with reflectance at 1550 and 905 nm



Images from the new system (Finnish Test Site)



Consortium

Partner NB	Funder (if any)	Country	Institution / Department	Name of the Principal Investigator (PI)	Name of the co-Investigators	Name of the other personnel participating in the project
1 <i>Coord.</i>	AKA	FIN	FGI	Juha Hyypä	Prof. Antero Kukko, Prof. Markus Holopainen, Dr. Xiaowei Yu	Dr, Xinlian Liang, Dr. Yunsheng Wang, Dr. Matti Lehtomäki
2	FWF	AUT	TU WIEN	Markus Hollaus	Prof. Norbert Pfeifer	PhD Yi-Chen Chen
3	FWF	AUT	BOKU	Sigrid Netherer	Josef Pennerstorfer	PhD
4	AEI	ESP	U VIGO	Pedro Arias-Sanchez	Henrique Lorenzo Cimadevila, Belén Riveiro, Joaquín Martínez Sánchez	
5	TACR	Cz	U of Life Sciences Prague	Assoc. prof. Peter Surovy	Dr. Martin Mokros, Dr. Karel Kuželka, Dr. Roman Modlinger	PhD students Martin Slavík, Zlatica Melichová
6	FCT	POR	U Porto	José Alberto Gonçalves	Clara Lázaro	João Honrado

Joint activities during the first year

- Starting date: 1 April 2021
- Consortium meetings: 1. kick-off 26 May -21; 2. 15 June – 21; 3. 19 oct -21; 4. 8 March -22; 5. 18 March -22; 6. 19 April -22
- Mobilities: U Vigo – FGI (3 months)
- Joint campaigns: U Porto, U Vigo, FGI (Sept -21), Planned: Tu Wien, Boku, U Prague, FGI (June -22), U Porto, U Vigo, FGI (May -22)
- Publications:
 - Comesaña-Cebral, L.; et al. 2021. Individual Tree Segmentation Method Based on Mobile Backpack LiDAR Point Clouds. *Sensors*, 21, 6007. <https://doi.org/10.3390/s21186007>
 - Hyypä, E., et al. 2022. Direct and automatic measurements of stem curve and volume using a high-resolution airborne laser scanning system. Accepted for Science of Remote Sensing (open journal). (performance of the new system evaluated for stem geometry)

- Forests are the **world's lungs and life-support system**, hosting 80% of the Earth's biodiversity. But today on the average, 800 football fields of forest are lost every hour by **devastating forest fires** all around the world. In Europe in 2018, forest fires (30 ha or bigger in size) had an extent of more than 100 000 ha alone in five major countries suffering from it: Portugal, Spain, Italy, UK and Sweden.
- EU forests account for 2 trillion € in **annual turnover** and more than 22 million **jobs in bioeconomy**; 10% of the global's annual **carbon sinks**; and are home to a significant amount of the bloc's **terrestrial biodiversity** (European Commission, 2012).
- In 2019, wood quantities of more than 2 million cubic meters harvested in the Austrian forests related to **bark beetle infestation**. Situation in the Czech republic is even worse. Approximately 30 million cubic meters were affected by bark beetles in 2019, which is five times higher than 2017. The amount of damaged trees is higher than what the logistics allows to process. The **situation is in all terms disastrous** and economic loss is estimated to be 1.6 billion €.

Industry and end-users

Company	Characteristics	Interest
Stora Enso	one of the world's biggest companies (among the two largest in Europe) by sales and by earnings, among forest, paper and packaging industry companies with current turnover of 10 billion	Tree Species
Riegl	European leading manufacturer in laser scanners	All topics
Terrasolid	leading preprocessing laser scanning SW company	All, especially tree species
Asefor	Forest consultant	All
HITRAF SA	Forest machinery	New possibilities
Geotronics Praha	Trimble representative	New possibilities
COETFG	Advisor for forest organisations and forest experts	New possibilities
HS Timber Group GmbH	Sustainable woodworking company	Forest health
Öbf	Cares for, protects and manages the natural resources of the Republic of Austria	Forest health
Industrias Guerra SA	Forestry machine manufacturer	Forest fires
ENCE	Energy and Cellulosa	All applications
Terratec As/Oy	ALS data provider and forest inventory value adding, one of leading European mapping companies	Tree species
Lourizan Forestry Research Center	Sustainable forestry	Forest health and forest fires

International benchmarking study –Additional partners

- **Wuhan University, China (Ruizhi Chen, Jingbin Liu)**
- **Natural Resources Canada, PFC, Canada (Mike Wulder)**
- **SLU, Sweden (Johan Holmgren)**
- **NIBIO, Norway (Rasmus Astrup)**
- **Shinshu University, JPN (Masato Katoh)**
- **UNESP, Brazil (Antonio Tommaselli)**
- **TU München, Germany (Uwe Stilla)**
- **Terrasolid, Finland (Arttu Soininen)**
- **Terratec, Finland/Norway (Pekka Savolainen)**
- **Beijing University (Yi Lin)**
- **Uni Helsinki (Markus Holopainen)**
- **UEF (Mikko Vastaranta)**
- **Turku Uni (Petteri Alho)**
- **Aalto Uni (Matti Vaaja)**
- **Guandong TU (Qiong Ding)**