Training a new generation of researchers for effective forest management strategies under the effect of global warming: the ETN Skill-For.Action

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DISSEMINATION Skill-For.Action

Drought related losses in growth efficiency, the increase in intensity and frequency of threats (e.g. wildfires, wind-storms) (Figure 1) and the subsequent exponential increase in biological risks (e.g. bark beetle outbreaks) (Figure 2) are just a few of the most perceptible effects across forests in Europe and worldwide. The relevance of forests in terms of climate protection is not doubted. However, it is complex to determine how much and how the forest carbon sink and reservoir can be managed to mitigate atmospheric CO_2 build-up.

Moreover, modern forestry should also consider and minimise carbon release by monitoring, modelling and managing relationships between carbon sequestration from forest and carbon emission due to forest operations. Thus, an innovative, integrated forest management system is vital to make forests and forestry adaptive to immanent environmental changes and increasing risks is urgently needed.

Drought, together with the increasing susceptibility of European forests to other abiotic (e.g. wild fires in Croatia and Portugal 2017, extreme wind events in Poland in 2017, 'Friederike' storm in Germany and 'Vaia' storm in Italy in 2018) and biotic (e.g. bark beetle outbreaks such as in Central Europe in 2017, 2018, 2019, 2020, 2021 and in the Southern Alps 2020, 2021) risks, can compromise the resilience of forests and reduce the efficiency of removing anthropogenic carbon through growth (del Rio *et al.* 2016). Consequently, losses in productivity and lower carbon sequestration rates are expected.

One of the aims of forest management strategies should be to improve water use efficiency on trees and forest stand scales to enhance forest resilience. For example, differently sized trees (Pretzsch, Schütze and Biber, 2018) within a stand show an unequal response to water limitation, with smaller trees being less vulnerable. Conversely, there are still many uncertainties about how stand structure is modifying resource partitioning between trees of a stand and within a tree and how wood density, forest growth and the carbon storage may be affected.

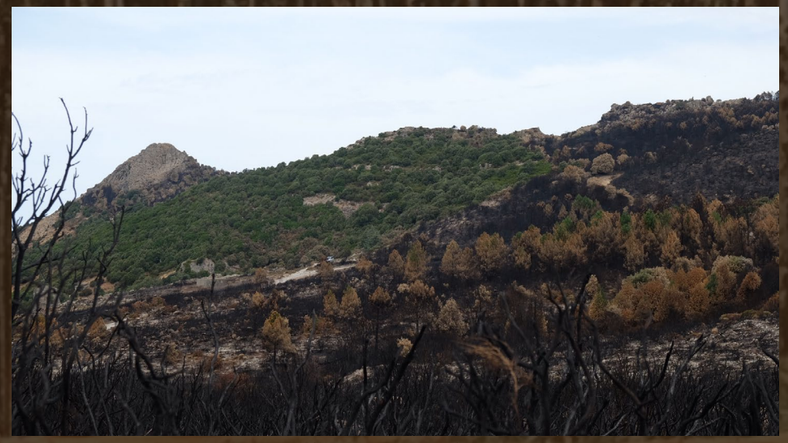

Figure 1: Wildfire in Mediterranean area (Monte Ferru, 2021).

Figure 2: Windthrows and bark-beetle damages in the southern-Alps (Livinallongo-Col di Lana, 2021).

The effective implementation for adjusted forest management strategies depends largely on forest operations, which can account for a substantial amount of carbon emissions (Cosola *et al.* 2016). The need to set intervention protocols that consider the adaptation of silvicultural practices through an eco-efficient use of harvesting systems is an existing challenge. The carbon emission rate is related to silvicultural treatments, harvesting systems and operational conditions. In particular, the shift to more complex stand structures of close to nature forest stands (Figure 3) requires higher sophistication of forest operations than those applied in mono-layered (Figure 4) or even-aged stands. Consequently, there are challenges in terms of harvesting criteria and harvesting methods.

The lack of comprehensive information on the appropriateness of forest ecosystems concerning their resilience and resistance against biotic and abiotic risks also produces further uncertainness for forest management in terms of financial returns, carbon dynamics and climate change mitigation. Therefore, there is a strong need to develop applied models to optimise carbon balance and financial performance.

Our strategy

We aim at responding to the lack of comprehensive information on effective implementation of forest management strategies under the effect of global warming.

Figure 3: Mountain forest (Altopiano dei Sette Comuni, 2021).

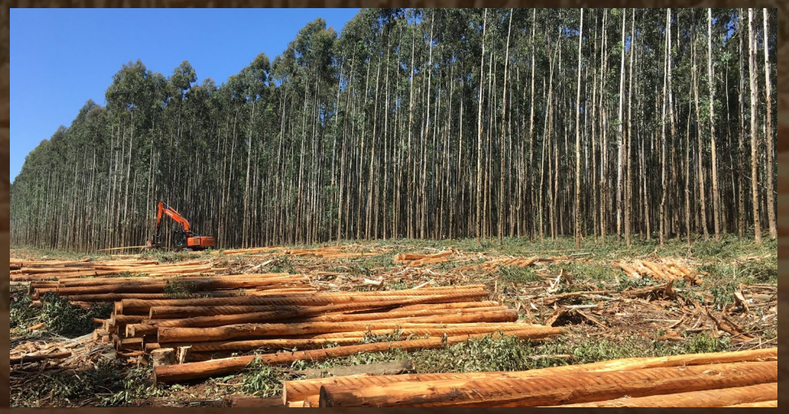

Figure 4: Forest plantation (Karloof, 2019).

The ETN Skil-For.Action is a a project founded under the Marie Skłodowska-Curie Innovative Training Networks (ITN) of EU commission with the aims to train PhD students and postdocs and improve their early-stage researchers' career opportunities in the public as well as in the private sector. The project consists of founding and training 12 early stage researchers (ESRs) thematically focussing on understanding the carbon fluxes in managed an unmanaged forest systems. The ESRs network will be motivated and trained to deepen the knowledge on adapting forest management regimes in different climates regarding carbon balance optimisation. The main assumption is that adaptive and integrated forest management can contribute considerably to a low carbon-emitting society.

Along a wide spectrum of climate zones and a gradient of forest management intensities, the general objectives and challenges of the ETN Skill-For.Action are to generate a clearer knowledge about:

i) the dynamics of carbon sequestration and enhancing forest resilience against biotic and abiotic stressors acknowledging site and stand characteristics

ii) the potential to reduce carbon emissions generated from forest operations

iii) provide forest managers with innovative approaches to optimise smart forest management by linking biological and technical production to cope with climate changes.

The pillars of ETN Skill-For.Action' ESRs

i. Follow an inter/multidisciplinary approach involving different disciplines related to forest management and forest engineering. This multilevel and multidisciplinary approach will overcome the restrictions concerning the transferability of locally and case study based results.

ii. Focus on forest areas encompassing a broad range of climatic zones and providing highly different growing conditions affected differently by climate change.

iii. Follow a multi-scale approach by analysing carbon sequestration and carbon emission across different levels (from wood cell to forest stand level and from single machine to operation chains).

iv. Involve academic and non-academic partners to cooperate in international and inter-sectoral research and innovative training activities.

v. Contribute to capacity building of young professionals high qualified to face future challenges.

Our research methodology and approach

We will focus on tree species most relevant to the European forest biomes, e.g. pine, spruce, fir, beech, and oak. Our empirical work uses existing long-term and temporary yield trials that are maintained and provided by the partners. Temporary trial series have been recently established across Europe and South Africa within several EU projects (EuMixFor, FP1206; CLIMO, CA 15226; CARE4C, GA 778322).

Five ESRs will deepen the understanding of the carbon sequestration dynamic by analysing the resource use efficiency at single-tree and stand level to maximise carbon sequestration. Forests adaptation capacity to environmental stresses is determined by selected species, species composition, vertical structure and resource availability. The overall objective is to quantify and understand carbon sequestration dynamics by analysing productivity in terms of tree and stand growth, according to forest management and environmental changes.

Four ESRs will focus on forest operation efficiency, at different scale, regarding minimising fuel consumption and CO_2 emissions. The overall objective is to optimise forest operation according to operational and environmental conditions by minimising CO_2 emissions.

Again, two ESRs will focus on precise inventories for forest management and harvesting optimisation, and another ESR will focus on forest management optimisation. The overall objective aims at overarching adaptive forest management optimisation, bridging the research framework of the other ESRs to achieve a more carbon-efficient forest management.

The key role of ESRs' training and secondments

The network-wide training activities, supported by the academic and non-academic partners, are structured to prepare a new generation of ESRs able to innovate forest management in the EU towards a carbon-smart forest management based on multidisciplinary expertise.

The non-academic participants of ETN Skill-For.Action are unique in terms of multi-disciplinarily and trans-sectoral representations. Their strong involvement is an efficient way to qualify ESRs in transforming research ideas into products and services.

Each ESR will also be involved in more than one secondment a period of research training with another academic or non-academic partner implemented to further enrich the training experience. Also, short missions will thus encourage cross-fertilisation of exploring ideas and improve the skills of ESRs.

All ESRs will be enrolled on a PhD programme to boost a more robust scientific knowledge.

Our ambitions

The ESRs will specifically address a 'contamination of ideas' between the domains of forest growth (regarding carbon sequestration) and forest operating efficiency (regarding minimising fuel consumption and carbon emission).

The ERSs' societal challenges will focus on: *(a)* understanding complex system dynamics of forests in relation to global change and human society; *(b)* developing decision support systems for multifunctional forest management; and *(c)* developing intelligent forest operation systems.

For the ERSs, the ETN Skill-For.Action represents a unique opportunity to cope with the societal challenge priorities in line with the recommendation of the forest-based sector by merging the basic sciences with applied sciences.

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PROJECT SUMMARY

Innovative, adaptive and integrative forest management plays a key role in driving forests to face environmental changes, maintain high forest carbon sequestration potential, and guarantee economic efficiency and more ecologically sound forest operations. The ETN Skill-For.Action integrates the fundamental research in forest ecology and applied science of forest engineering to comprehensibly understand carbon dynamics in forests.

PROJECT LEAD

Stefano Grigolato is an associate professor at Padova University. Main research activities are related to forest operations. He is involved in research projects at an international and national level. Executive board member of LERH PhD School of the University of Padova. IUFRO Division 3.01.01 deputy and member of Italian Association of Agriculture Engineering and of Italian Society of Silvicultural, Ecology and Forestry.

PROJECT PARTNERS

Università degli Studi di Padova, IT; Technische Universität München, DE; Berner Fachhochschule, CH; Stellenbosch University, ZA; Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria, ES; Libera Università di Bolzano, IT; Szkola Glowna Gospodarstwa Wiejskiego, PL; Universidad de Valladolid, ES; Rheinisch, Westfälische Technische Hochschule Aachen, DE; Ministerium für Klimaschutz Umwelt Landwirtschaft Natur und Verbraucherschutz des Landes Nordrhein, Westfalen, DE.

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