EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Brussels, 25 May 2021

COST 072/21

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action "Urban Tree Guard - Safeguarding European urban trees and forests through improved biosecurity" (UB3Guard) CA20132

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Urban Tree Guard - Safeguarding European urban trees and forests through improved biosecurity approved by the Committee of Senior Officials through written procedure on 25 May 2021.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA20132
URBAN TREE GUARD - SAFEGUARDING EUROPEAN URBAN TREES AND FORESTS THROUGH IMPROVED BIOSECURITY (UB3Guard)

The COST Members through the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action, referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any document amending or replacing them.

The main aim and objective of the Action is to co-create (involving researchers and stakeholders) and recommend science-based, socially-acceptable and harmonized prevention strategies and technological solutions for safeguarding the urban trees. The desired impact is reduced risk of tree pest entry and establishment in urban settings and further spread to native woodlands. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

OVERVIEW

Summary
Green infrastructure, including urban forests, has been proposed by European Commission as a strategy to support climate adaptation capacity and sustainable development in the urban areas where over 70% of the EU's population live. Alarmingly, the green infrastructure and especially its characteristic elements, trees, are increasingly threatened by alien pests (insects and pathogens) that are introduced via trade and transports. In a new environment, these pests may become invasive, causing devastating environmental and economic losses, and threatening also unique cultural values such as those linked to veteran trees. The current biosecurity system fails to capture alien pests that often also benefit from the altered climate. New tools and better integration of different knowledge pools are urgently needed to support better biosecurity in urban settings. The Action will bring together a pan-European and international network of scientists and stakeholders to meet this challenge. The network will 1) Collect, share and harmonize scientific and stakeholder knowledge, 2) Accelerate development of innovative technological tools and solutions for biosecurity purposes, 3) Inform policy and support implementation of the EU plant health regime while providing science-based recommendations for decision makers, especially at operational levels, 4) Foster an inclusive and open research environment, with explicit support to young professionals, and 5) Increase European competitiveness in the field of biosecurity, improving also the quality of everyday life for people, especially urban dwellers, in Europe and beyond. A co-created Wiki database, teaching tools for education in urban forest health, and a decision support tool will ensure the long-term impacts of the Action.

Areas of Expertise Relevant for the Action	**Keywords**
● Environmental engineering: Risk assessment, prevention and mitigation ● Agriculture, Forestry, and Fisheries: Forestry: fauna and flora ● Biological sciences: Conservation biology, ecology, genetics ● Biological sciences: Biodiversity, comparative biology ● Other engineering and technologies: Biohazards, biological containment, biosafety, biosecurity	● urban trees and forests ● green infrastructures ● biological invasions ● alien invasive species ● tree and forest health

Specific Objectives
To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination
● Compile scientific and stakeholder knowledge about the tree species and genotypes with high relevance as urban trees, the resistance and vulnerability traits of these species, and management practices that may increase/reduce their vulnerability to pests.
● Detail (describe and where possible quantify) the risks along the known pathways for introduction of pests into urban settings and beyond, using selected urban areas and the most frequently used tree species (in Europe and beyond) as case studies.
● Map and evaluate the documented and potential wider consequences of these risks for the society and environment (multiple ecosystem services).
● Compile and evaluate information on the tools and measures that are currently available and feasible to use in detection, early eradication and containment of tree pests in urban settings.
● Conduct a horizon scanning of emerging innovative concepts and technologies for rapid early detection (e.g., portable sequencing devices, analysis of volatile compounds and spectral traits) and effective

monitoring of pest situations and urban tree health (e.g, multilure traps, drones, remote sensing and satellite monitoring, artificial intelligence capacities).
● Develop a multicriteria decision support tool to identify tree species, suitable for planting in urban areas, that will tolerate and resist the expected problems with introduced pests.
● Describe regulatory, institutional challenges in the efficient implementation of EU policies related to prevention and containment of tree health problems across different scales of governance and countries; suggest measures for better implementation of these policies in urban tree care and urban forest management.
● Inform policy and practice in a rational and problemsolving manner by communicating and interacting with the relevant national and international decision-making forums, across the different scales of governance, in order to ensure efficient knowledge exchange and transfer of the Action's outputs to policies and practices.
● Identify knowledge gaps where new European research initiatives are needed to promote tree health and reduce the risk of the negative effects due to pests in urban settings.

Capacity Building
● Establish a multinational, multidisciplinary and multisectoral network of researchers, professionals and relevant organisations to create a platform for knowledge exchange regarding urban tree health and biosecurity issues related to it.
● Promote inclusive, innovative and translational research by increased opportunities for development of multinational (pan-European and global) collaborations, facilitating participation of ITC countries while supporting long-term commitments and actions in research on urban tree health.
● Foster the competence and career development of next generation of professionals and research leaders by creating an inclusive and open environment, promoting equality among genders, age-groups and nationalities, by assigning Early Career Researchers to leadership roles.
● Promote innovation, creativity and entrepreneurial mind-sets of researchers and stakeholders by organising a series of MAKEATHONs where participants with diverse backgrounds and experiences will come together and focus on creating and making something (e.g., a prototype or a practical application) over a limited period of time (usually two days).
● Ensure open and rapid knowledge exchange, and support awareness raising by co-creating an "Urban Forest Health" Wiki, a wiki-based hypertext publication that functions as an open repository for relevant information regarding tree health in urban settings.
● Support education in urban tree health by developing an online repository of "Teaching Tools in Urban Forest Health". This online resource will contain teaching and study material (presentations, texts, exercises, videos) for education at different levels, from primary and secondary school to under-graduate and graduate levels, including also professional training.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1 Soundness of the Challenge

1.1.1 DESCRIPTION OF THE STATE-OF-THE-ART

Over 70% of the EU population (about 335 Million people) live in cities, towns and suburban areas and the proportion is predicted to exceed 80% by 2050. The benefits to living in an urban area are obvious (e.g. jobs, education, facilities, social and cultural life) but there are also downsides. The life quality of residents in urban areas is often reduced by exposure to harmful levels of noise, air pollution and excess heat, and an increased risk of premature mortality has been associated to life in urban areas. In its recent communication "*Bring back nature to our lives*", the European Commission emphasizes the value of green urban spaces for the physical and mental wellbeing of people, and calls on European cities of at least 20,000 inhabitants to develop Urban Greening Plans by the end of 2021. FAO emphasises the role of urban green infrastructure also in ameliorating the environmental footprint of cities, and bridging rural and urban areas. Urban green spaces are also pivotal for achievement of the UN's Sustainable Development Goal "*Make cities and human settlements inclusive, safe, resilient and sustainable*", and its target to provide "universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities" by 2030. The importance of urban green spaces in improving community resilience has been clearly demonstrated during the COVID-19 pandemic.

Trees, such as plane (sycamore), oaks, lindens, locusts and maples, make up the backbone of the urban green infrastructure. In densely populated countries, almost 20% of forest area can be found in urban or adjacent (peri-urban) areas, which are visited by people more frequently than the rural (countryside) forests. In urban settings, trees deliver invaluable ecosystem benefits to people by filtering the pollutants from air, assisting with the management of stormwater and flooding, attenuating urban heat islands, and providing possibilities for recreation, thus supporting physical and mental well-being. Especially the old, veteral trees often have also significant cultural and scenic values for the community. Urban trees are thus a significant environmental element, influencing the everyday life of a vast majority of the European population. Urban trees also make a significant contribution to sequestration of atmospheric carbon dioxide, thereby mitigating the impacts of climate change. Their role in conserving and promoting biological diversity is estimated to grow in the future, because changes in land use priorities and pesticide applications make the rural landscapes less suitable for many species. Considering their immense socio-economic and ecological relevance, **investments in the maintenance and promotion of healthy and vital urban and peri-urban forests and trees should have a high priority**.

While the benefits of urban trees are obvious and dominate the discussion, recent research has also emphasized the potential problems and ecosystem disservices associated with urban trees. Problems include infrastructure conflicts, public health and safety issues (e.g. falling branches, allergenic pollens) and trade-offs related to costs of management and maintenance of the trees. Moreover, planting of urban trees may have environmentally detrimental consequences that extend to areas beyond the urban sphere. As junctions for international trade, traffic and frequent planting of imported nursery stock, including non-native tree species, **urban settings are centres for introduction of alien tree pests** (insects, nematodes, pathogenic fungi and bacteria). Once these organisms have entered, they can establish populations in soils, water and vegetation, eventually spreading from urban settings to the surrounding environment. In the worst case, they may become invasive, posing a threat to native tree populations, potentially initiating extinction cascades and changing the ecosystem processes in unpredictable and negative ways. Society incurs huge costs due to management of risks and disturbances related to the damage from these alien pests. Their ecological consequences, especially if spread to habitats within the Natura 2000 network, may be irreversible.

Several cases exemplify the magnitude of the economic and ecological impacts that introduced pests have already had on the tree populations in Europe. Since the early 20th century, two waves of Dutch

elm disease, caused by vascular pathogens in the genus *Ophiostoma,* vectored by bark beetles, continue to kill elm (*Ulmus* spp.) trees. The more recent destruction caused by another fungal pathogen, *Hymenoscyphus fraxineus,* in European ash (*Fraxinus excelsior*) populations is another sad example. Introduced, soil-borne *Phytophthora*-pathogens (fungus-like "water-molds") are also an increasing concern in cities and towns where infested soil is frequently moved due to construction and maintenance works. Damage by the leafminer *Cameraria orhidella* makes the leaves of the horse chestnut trees fall in the middle of the summer, and the boxwood topiaries are devastated by the defoliation of the tree moth *Cydalima perspectalis*. The oak lace bug, *Corythucha arcuata*, a species native to North America, is currently colonizing Europe through early settlements in urban oak forests. It is particularly worrying that several new tree pests are emerging or "on the horizon" for Europe, with high potential to cause significant and permanent damage to green infrastructure. These problems include, e.g., emerald ash borer (EAB; *Agrilus planipennis*), an insect pest that is spreading in European Russia and at the borders of Ukraine and Belarus. In the USA, EAB has killed hundreds of millions of ash trees in forests and urban environments, causing accumulating costs that exceed $10 billion USD in just removal and replacement, and driving six ash species to the brink of extinction. Similarly, on the horizon for Europe is Polyphagous Shot Hole Borer (PSHB; *Euwallacea* spp.) beetles that occur in combination with the fungal disease *Fusarium*-dieback, damaging hundreds of woody plant species. This insect has emerged as an important invasive pest, killing avocado and other urban trees in Israel and the United States of America in the early 2000s. In 2017, it was found in South Africa where it is damaging the country's historic, non-native and indigenous trees. Its spread to the wider environment has catastrophic impacts on horticultural tree plantings and commercial forests. Also because of the warming climate, pest species that previously were limited to southern regions are able to survive in European conditions, particularly in urban settings that are often warmer (the heat island effect). In summary, trees in urban and peri-urban settings are thus threatened by both the species already found in EU and those on the horizon (for examples, see Fig. 1).

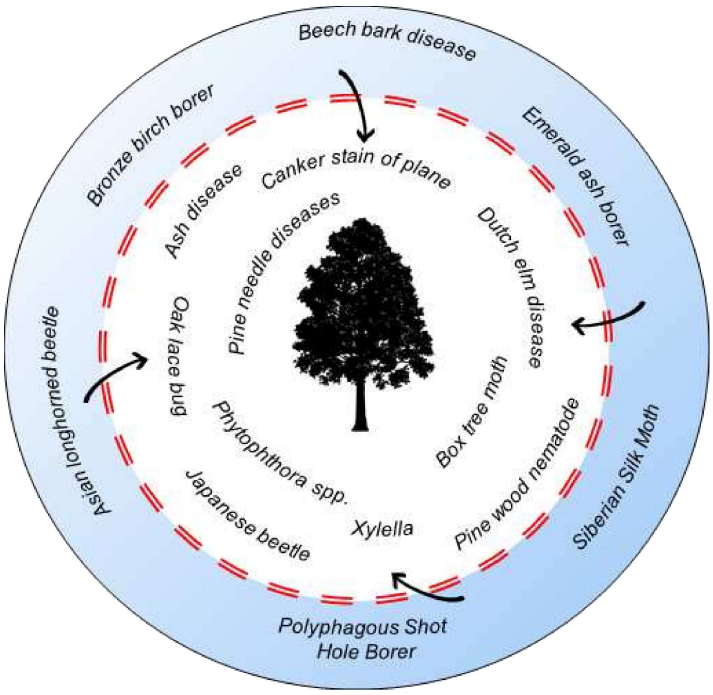

Figure 1. In urban settings, the European trees are threatened by insects and diseases (caused by fungi and bacteria) that are not yet found in EU (examples given in the outer ring) and those that are already present (inside the circle). The double dotted line represents the barriers for invading pests, which need to be strengthened using new tools and socially acceptable measures.

The pathways of introduction of new pests to and between European urban areas are many. Planting of non-native trees and annual ornamentals is common and often involves imported planting materials, such as seeds, seedlings, or even young but large trees that are transported with root balls containing soil. The planting materials and also soil can carry pests and random, visual inspections at border

controls or phytosanitary certificates are unlikely to capture them all. New pests may enter urban areas also with passengers or cargo at sea ports, railroads and airports, hitchhiking in plant-based commodities, or on vehicles and containers. Risk behaviours, e.g., tourists bringing plants and plant parts as souvenirs, are yet another pathway for introductions. Tree pests may have been introduced several years or even decades prior to detection, and the measures to reduce and stop the spread of the organisms may no longer be practically feasible when the tree health problems surface.

Biosecurity refers to measures that aim at preventing the introduction and/or spread of pests, and reducing their impacts in nature. Three phases are usually described for these measures: *prevention, mitigation (eradication, containment)* and *asset based protection (long-term management)* (Fig. 2). The effectiveness of measures decreases and the costs increase rapidly if the prevention fails and the spread (invasion) of the pest moves to phases where containment or management are required. Recent research has revealed clear weaknesses in the capacity of the current biosecurity system to protect the European urban spaces against alien invasive pests. A technologically secured transition to a better, knowledge-based biosecurity system for urban green spaces is therefore urgently needed. Especially the prevention and early detection stages needs to be strengthened so that establishment of new pests can be prevented, or stopped as quickly as possible.

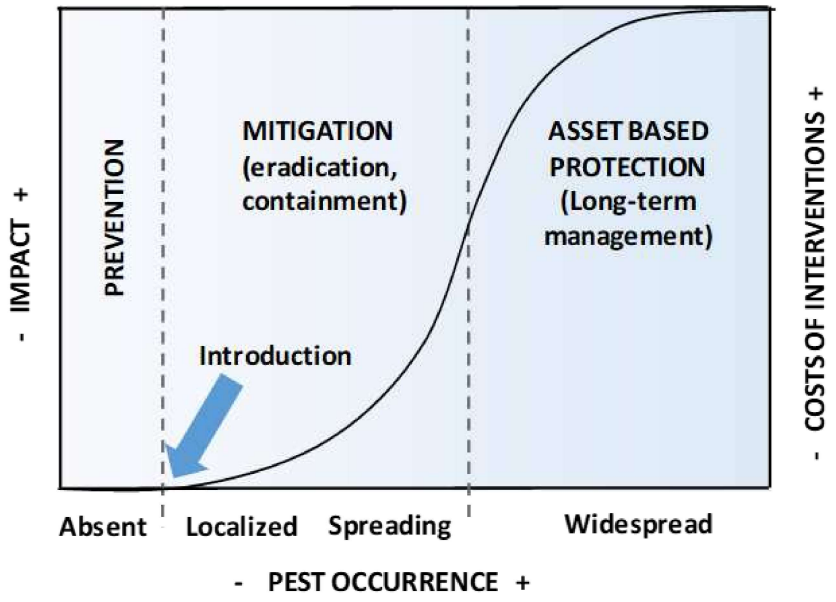

Fig 2. The three phases of biosecurity (*prevention, mitigation* and *asset based protection)* in relation to the pest invasion. Both the impacts of the pests and costs of interventions increase rapidly if the prevention of introduction fails. Therefore, early detection and rapid responses are essential foci when aiming to improve the biosecurity.

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The main aim of the Action is to co-create (involving researchers and stakeholders) and recommend science-based, socially-acceptable and harmonized prevention strategies and technological solutions for safeguarding the urban trees. The desired impact is reduced risk of tree pest entry and establishment in urban greenspaces and further spread to native woodlands. To meet this challenge, the Action will address the following questions:

1) What scientific and stakeholder knowledge is available, and where, and what further knowledge needs to be developed, in order to support better biosecurity in urban areas?
2) What are the most promising new tools and solutions available or under development (with high potential for breakthroughs), for rapid and efficient implementation of better biosecurity in urban settings?

3) What are the crucial regulatory and institutional challenges in efficient implementation of EU policies related to prevention of pest risks in urban settings, and how can they be overcome?

The Action is timely and relevant given the importance of urban green infrastructure for the sustainable life of a large part of the European population. As centres for sea, air and road freight cargo, and as hotspots for planting activities, urban areas are obvious frontiers for strengthening the biosecurity against the alien pests. The major pathway for introductions, i.e., trade in plants and plant-based products is an important component of the European and global economy, providing jobs and revenues to many people; in many cases local/national production cannot meet the demand for planting materials. Adaptation to climate change calls for testing the potential of non-native tree species as alternatives also in production forest settings. Therefore, more strict, large-scale restrictions in plant trade that could be an effective means to reduce the risk of introductions may not be a socio-economically defensible solution, nor practically feasible. Instead, the Action proposes to revamp the capacity of European countries to curb the problem using **improved prevention strategies and tools for early detection and rapid responses**. Preventive strategies should involve risk anticipation, surveillance, and awareness. Socially acceptable, nature-based solutions, including appropriate choice of native and non-native tree species and resistant genotypes should be used to reduce the vulnerability of urban settings to introduced pests. Cutting-edge technologies, including portable devices, bio-based methods (e.g. multilure traps) and Artifical Intelligence need to be applied to detect and monitor pests threatening the trees in urban settings.

The end user groups targeted by the Action include the global researcher community, educators (e.g., arboriculturist and horticulturist education, university programs with urban forestry and landscape planning orientation), professionals at operational level (e.g., arboriculturists, green area managers in cities and municipalities, nurseries, phytosanitary authorities), and decision makers dealing with urban green spaces and biosecurity. In addition, the outputs have relevance for communicators (including science journalists) and a large majority of European residents, especially urban dwellers.

1.2 Progress beyond the state-of-the-art

1.2.1 APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE-OF-THE-ART

In order to develop sustainable, cost-efficient and socially acceptable solutions to a multifaceted problem such as urban tree biosecurity, scientific knowledge and stakeholder knowledge need to be intertwined. The innovative approach of the Action is to elevate the pan-European capacity to protect urban trees by combining stakeholder's knowledge with theoretical and approaches from two large scientific domains:

1. **Urban and Peri-Urban Forestry (UPF)** which FAO describes as an "*integrated, interdisciplinary, participatory and strategic approach to planning and managing tree resources in urban and peri-urban areas for their economic, environmental and sociocultural benefits*." The practical elements of UPF include planting trees to new areas, supporting existing natural vegetation, and harmonizing urban sprawl into green spaces. UPF includes approaches of the single-tree management but also large-scale management of urban green infrastructure.
2. **Forest Entomology and Forest Pathology** involve studies of the insect and microbial (mainly fungal) pests of the forests and how damage can be prevented or controlled. The scope includes molecular aspects, chemical ecology, genetics and ecology of the pests, and the research often occurs in close interaction with silviculture and forest management, tree genetics and resistance biology (single-tree and landscape levels).

The Action will achieve its goals by establishing a multinational, multidisciplinary and multisectoral network of researchers (including pathologists, entomologists, plant physiologists, environmental and social scientists, landscape architects, urban foresters), professionals (phytosanitary authorities; urban planners, city park managers; arboriculturists; managers of nurseries and plant retail; technology companies), relevant organisations (relevant NGOs, global, European and national citizens associations and societies dealing with arboriculture, nurseries and plant trade), and decision and policy makers, especially at operational level (government authorities, cities, municipalities). The collaboration will stimulate exchange of information to capitalize the joint knowledge and experience pool, in order to develop socially acceptable and innovative solutions for urban tree and forest biosecurity.

The Action will progress beyond the current state-of-the-art by producing knowledge syntheses that pool information from different disciplines, sectors and countries. The multiactor collaboration will allow the development of unique research outputs that combine cutting-edge science with the tacit knowledge possessed by professionals. The network will promote innovative applications and new research on technological tools and nature-based solutions, e.g. through Short Term Scientific Missions (STSMs). The findings will be rapidly presented in meetings, workshops and Training Schools, and transferred to forums where policies are informed, discussed and implemented through a series of dedicated dissemination activities.

1.2.2 OBJECTIVES

1.2.2.1 Research Coordination Objectives

The Action has nine objectives that contribute to *Identification* of the problems and knowledge related to urban tree health matters (RCO1-3), *Innovations* (tools and measures) that are needed to explicitly reduce and mitigate the problems (RCO4-6) and *Implementation* of the knowledge and innovations to support to EU Plant Health regulations (RCO7-9). The Action will:

RCO1. Compile scientific and stakeholder knowledge about the tree species and genotypes with high relevance as urban trees, the resistance and vulnerability traits of these species, and management practices that may increase/reduce their vulnerability to pests.

RCO2. Detail (describe and where possible quantify) the risks along the known pathways for introduction of pests into urban settings and beyond, using selected urban areas and the most frequently used tree species (in Europe and beyond) as case studies.

RCO3. Map and evaluate the documented and potential wider consequences of these risks for the society and environment (multiple ecosystem services).

RCO4. Compile and evaluate information on the tools and measures that are currently available and feasible to use in detection, early eradication and containment of tree pests in urban settings.

RCO5. Conduct a horizon scanning of emerging innovative concepts and technologies for rapid early detection (e.g., portable sequencing devices, analysis of volatile compounds and spectral traits) and effective monitoring of pest situations and urban tree health (e.g, multilure traps, drones, remote sensing and satellite monitoring, artificial intelligence capacities).

RCO6. Develop a multicriteria decision support tool to identify tree species, suitable for planting in urban areas, that will tolerate and resist the expected problems with introduced pests.

RCO7. Describe regulatory, institutional challenges in the efficient implementation of EU policies related to prevention and containment of tree health problems across different scales of governance and countries; suggest measures for better implementation of these policies in urban tree care and urban forest management.

RCO8. Inform policy and practice in a rational and problemsolving manner by communicating and interacting with the relevant national and international decision-making forums, across the different scales of governance, in order to ensure efficient knowledge exchange and transfer of the Action's outputs to policies and practices.

RCO9. Identify knowledge gaps where new European research initiatives are needed to promote tree health and reduce the risk of the negative effects due to pests in urban settings.

1.2.2.2 Capacity-building Objectives

The Action defines six Capacity-Building Objectives (CBOs) that support the capacities of individuals, enterprises and organizations, as well as decision-making bodies, so as to obtain and improve knowledge, tools and skills for early detection and rapid responses against forest pests in urban environments.

CBO1. Establish a multinational, multidisciplinary and multisectoral network of **researchers** (including pathologists, entomologists, environmental and social scientists, landscape architects), **professionals** (arboriculturists, urban planners, urban foresters, city park managers; phytosanitary authorities; pkant producers and retail; technology companies) and relevant **organisations** (NGOs, societies and other groups) to create a platform for knowledge exchange regarding urban tree health and biosecurity issues related to it.

CBO2. Promote inclusive, innovative and translational research by increased opportunities for development of multinational (pan-European and global) collaborations, facilitating participation of ITC countries while supporting long-term commitments and actions in research on urban tree health.

CBO3. Foster the competence and career development of next generation of professionals and research leaders by creating an inclusive and open environment, promoting equality among genders, age-groups and nationalities, by assigning Early Career Researchers to leadership roles.

CBO4. Promote innovation, creativity and entrepreneurial mind-sets of researchers and stakeholders by organising a series of MAKEATHONs, result-oriented workshops where participants with diverse backgrounds and experiences will come together and focus on creating and making something (e.g., a prototype or a practical application) over a limited period of time (usually two days).

CBO5. Ensure open and rapid knowledge exchange, and support awareness raising by co-creating an "Urban Forest Health" Wiki, a wiki-based hypertext publication that functions as an open repository for relevant information regarding tree health in urban settings.

CBO6. Support education in urban tree health by developing an online repository of "Teaching Tools in Urban Forest Health". This online resource will contain teaching and study material (presentations, texts, exercises, videos) for education at different levels, from primary and secondary school to under-graduate and graduate levels, including also professional training.

2. NETWORKING EXCELLENCE

2.1. Added value of networking in S&T Excellence

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

The Action contributes to the goals of the European Green Deal and Biodiversity Strategy for 2030 by protecting the health of urban trees. It also adheres to FAO's global level work on UPF (e.g., "Tree Cities of the World" programme), contributing with a specialized perspective (biosecurity). The conferences organized by FAO will be an important opportunity to communicate the Action's results and interact with the global community and with FAO experts in the field who are invited as expert speakers to trainings and meetings. The Action will also seek synergy with the recently established International Union of Forest Research Organizations (IUFRO) Working Party 7.03.17 *Tree Health in Urban Forests* that will begin its activities in 2021. The group has a global scope and aims to address a broad spectrum of ecological and socio-economic issues related to urban tree health. The Action will contribute to the common goal with a Europe-centered scope, putting also more emphasis on technological developments.

The risk of invasive forest pests is currently studied e.g. in the H2020 financed project "*Holistic Management of Emerging Forest Pests and Diseases*" (HOMED). In addition, the scope of COST Action CA17122 "*Increasing understanding of alien species through citizen science*" (Alien CSI) is relevant to the Action. However, these existing efforts do not have a particular focus on urban trees, and these projects and their outputs will be important sources of inspiration and knowledge for the Action. The Action will also seek connections with the *Neobiota network*, the European group on biological invasions, to adopt frameworks and terminology developed and used to study and manage biological invasions, allowing a wider scientific audience and, in turn, generating opportunities for collaboration.

Exchange with researchers outside Europe, especially in North-America where urban forestry has a long tradition, will be essential for the network.

To avoid redundancies and provide high European added value, the Action will systematically build on knowledge of forest pests developed in earlier projects under FP6 and FP7 (ISEFOR, PRATIQUE, QDETECT, FORTHREATS) and H2020 (POnTE, XF-ACTORS EMPHASIS, DROPSA), COST Actions FP1401 “Global Warning”, FP1406 “Pinestrength”, FP1002 “PERMIT”, and national/regional projects (e.g., ProTree, PuRpOsE, BRIGIT, PHYTOTHREATS and Observatree in UK, and the Interreg Sudoe project PLURIFOR). In this way, the Action can focus on identifying crucial knowledge gaps, and developing novel scientific and practically oriented knowledge that will help to address urban tree health in a comprehensive manner. The COST framework has earlier supported networks that focused on different aspects of urban green infrastructure (e.g., COST Action E12 “Urban forests and trees”, and FP1204 “Green Infrastructure approach: linking environmental with social aspects in studying and managing urban forests”). However, none of the previous COST networks had the same emphasis on invasive forest pests in urban settings.

The participating researchers are encouraged to create added value by bringing into the network interactions with relevant, smaller research projects at the national level. Stakeholders are invited to share their knowledge and findings from practical and development work regarding biosecurity in urban settings, e.g. in MAKEATHON workshops. Compared to the ongoing actions, the Action differs with respect to capacity building goals and dissemination activities (Wiki, Teaching Tools) that make the results accessible to a broad range of stakeholders, with potential to become long-term assets for the European and global scientific and professional community and education programs.

2.2. Added value of networking in Impact.

2.2.1. SECURING THE CRITICAL MASS AND EXPERTISE

The Action recognizes broad international and cross-disciplinary scientific collaboration as the key to excellence and to development of sustainable solutions to urban forest health issues. The Action has 52 Proposers from 25 countries: 20 COST Member Countries (12 ITCs), two NNCs and three IPCs. The scientific experience of the Action Proposers covers all stages, from ECRs (20) to Experienced (Senior) Researchers and Professionals, with universities, research institutes, governments, green infrastructure management and private entreprises (SME and large company) as affiliations. The main scientific fields (urban forestry, forest entomology and pathology, and related fields) are well covered by the proposers. The proposers are well connected with relevant technological experts (e.g., Artificial Intelligence). The critical mass and expanded expertise is secured because the topic is relevant for a broad range of disciplines, including forest pathology, forest entomology, ecology, landscape architecture, urban forestry and planning, and arboriculture. Potentially interested actors can also be found from the fields social sciences (e.g. environmental psychology), health care and medical sciences (e.g., “green rehabilitation”, “forest bathing”), and nature pedagogics. The Action will actively work to engage relevant actors missing from the proposer group, especially policy makers, EU phytosanitary authorities and technology partnerships. The proposer’s networks and contacts within previous and ongoing national projects will be activated to maximise the network’s expertise.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

The importance of stakeholder, researcher (especially ESR) and practitioner interactions for future cooperation and collaboration cannot be overestimated and will be crucial for the Action, in particular for the development of ESRs knowledge and competency, and ability to operate in the future. The proposers are well connected to relevant stakeholders in their countries (e.g., local and national phytosanitary authorities, city park and green area managers, local arborist organizations, teachers in relevant educations and training programs). In the beginning of the Action, the stakeholders will be identified and entered in a stakeholder inventory. The inventory will be updated throughout the project to facilitate interactions and dissemination. Attention will be given to good geographic coverage, representative of the different European bioclimatic zones, and a broad representation by different professional groups. The foreseen actors with stake in the Action include phytosanitary authorities, e.g.

EPPO in EU; U.S. Department of Agriculture (USDA - developer of the i-Tree tools for urban forest analyses) in North-America and their Animal and Plant Health Inspection Service (APHIS) division. Professionals, such as park and natural resource management units of cities in participant and other countries, arborists, landscape planners, nurseries, plant retail and relevant technology entreprises and SME's are given collaborators. Moreover, networks, societies and organizations, e.g., International Society of Arboriculture (ISA), European Forum on Urban Forestry; World Urban Parks; ICLEI - Local Governments for Sustainability, and The European Arboricultural Council (EAC), are identified as potential stakeholder collaborators.

To support and facilitate building of pan European and global networks stakeholder partners are engaged in different roles in all activities of the Action. **The detailed plan for the stakeholders' involvement includes:**

- **Co-creation of knowledge (research coordination tasks)**. The stakeholders will contribute to development of research coordination outputs, e.g., reviews, online teaching materials and a Wiki online resource. Stakeholders will also have central roles in the horizon scanning activity and a series of MAKEATHON workshops that aim to boost the technological innovations. Moreover, stakeholder partners will participate in reviews and other dissemination outputs.
- **Training Schools.** Stakeholders participate as trainers and participants, thus supporting the science-society knowledge exchange. The first Training School, with a preliminary title "*Current problems in urban tree health*" is run by the stakeholders and aims at identifying crucial problems and knowledge gaps as experienced by the practicioners, and developing science-based solutions to them.
- **Short Term Scientific Missions (STSMs)**. Stakeholders will suggest and be involved in STSMs taken up by Early Career Researchers, providing opportunities to co-develop science-based solutions to problems. These contacts with stakeholders may also promote the employment of ESRs outside academia, and spinoff innovative research and development projects.
- **Hosting excursions and study visits**. In connection to physical meetings and Training Schools, the stakeholder partners will act as hosts for excursions and study visits. **Communication, dissemination, and exploitation**. The Action will benefit from the expertise and established communication channels of stakeholders, which assist dissemination and distribution of outputs, several of which will be targeted to stakeholder groups.

2.2.3. MUTUAL BENEFITS OF THE INVOLVEMENT OF SECONDARY PROPOSERS FROM NEAR NEIGHBOUR OR INTERNATIONAL PARTNER COUNTRIES OR INTERNATIONAL ORGANISATIONS

Pests know no borders. Moreover, use of non-native tree species from different regions, even continents, is common in urban greening. For instance, the North American green ash (*Fraxinus pennsylvannica*) – it's cold tolerant forms - has been largely introduced to eastern European cities and peri-urban areas. Collaboration and knowledge exchange across geographic regions can help to foresee and manage problems related to non-native trees and pests, motivating a COST network. The Secondary Proposers from Near Neighbour Countries (Russian Federation; Ukraine) and International Partner Countries (USA, Canada, South Africa) involved in the Action will contribute their specific experience in biosecurity and urban tree pests that are now emerging or are on the horizon for Europe.

Russia and Ukraine are the current frontier for the spread of Emerald Ash Borer (*Agrilus planipennis*; EAB) which is expected to spread unhindered throughout the rest of Europe. In eastern North America, EAB has killed hundreds of millions of ash trees in forests and urban evironments, accumulating costs exceeding $10 billion USD in just removal and replacement, and has driven six *Fraxinus* species to the brink of extinction. In Europe, common ash (*Fraxinus excelsior*) – an important keystone species in temperate broadleaved forests - is already threatened because of an earlier introduced fungus (*Hymenoscyphus fraxineus*) from East Asia causing a disease commonly known as ash dieback. An expanding EAB population in Europe could also create potential for host jumps to other tree species in the Oleaceae in which ash trees belong, especially the economically significant olive trees and other ornamental trees that occur in urban setttings (e.g. fringetree). The involvement of Russian and

Ukrainian partners is invaluable for the efforts of the Action to learn how to maintain the European Ash as an alternative species in urban green infrastructure and to develop biosecurity against EAB. Partners from these countries will benefit from the technological and scientific exchange and sharing of research infrastructures with COST Member countries.

The International Partner Countries Canada and USA are pioneers in urban forestry. Even today the countries are leading actors in science, education, private sector sponsorship and government policy related to urban forestry, and thus evident partners in an initiative dealing with urban trees and forests. For example, the peer-reviewed software called *i-Tree* was developed, supported and distributed by American actors, USDA Forest Service, Davey Tree Expert Company, National Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, and Casey Trees. This free software suite is widely used by city foresters, teachers, researchers and other end users in over 100 countries, and provides urban and rural forestry analysis and benefits assessment tools. The countries are also advanced in development and implementation of phytosanitary standards (e.g., North American Plant Protection Organization, NAPPO) and biosecurity against alien invasive forest pests. In Canada, a large "bioSAFE" project was recently launched, with the mission to improve the detection and surveillance of forest invasive species. The project develops the next generation of genomic biosurveillance tools that will allow rapid and accurate identification of insects and pathogens, determine their origin, provide an assessment of the risk they pose and provide the end users with a decision-support system to guide their management and mitigation actions. The project also has an end user interface and decision support module. Mutual benefits from exchange of scientfic knowledge, practical experiences and technological know-how between the Action and the North-American actors are thus obvious.

The COST Partner Member South Africa possesses world-leading expertise in some of the important pests threatening urban trees in Europe (*e.g. Ceratocystis platani* threatening plane trees, PSHB) along with specific scientific competence of evolutionary and intrinsic drivers affecting pest emergence. The urban green infrastructure of the country is impressive, with 20 000 ha of green open spaces and 3.2. million trees in public spaces. The country's solid expertise in management of these spaces will bring added value to the network. The South African participants will benefit from involvement in data sharing and innovative solutions addressed in the Working Groups. The activities will also lay the basis for future collaborations in global constellations.

3. IMPACT

3.1. Impact to Science, Society and Competitiveness, and potential for Innovation/Break-throughs

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

At the **scientific** level, the Action will promote a holistic theoretical analysis and development of hypotheses regarding biological invasions, biodiversity conservation and sustainable management and land use strategies in urban settings (WG1). The short-term benefits are due to new scientific syntheses support better biosecurity. The long-term (>10 years after project start) scientific benefits are expected to be manifold: by establishing a multidisciplinary knowledge-base in the topic, the network can develop ideas for new, collaborative research initiatives involving members of the network. The Action will also promote the scientific development of the next generation of experts in urban tree health, thus supporting future scientific excellence in the topic.

The **technological** impacts of the Action include recommendations for innovative strategies and co-creation of technical solutions for early detection and diagnosis of pests in urban settings. The activities will support development of breakthrough ideas already in the short term, i.e., up to 5-10 years from project start. The envisioned breakthroughs deal with, e.g., application of new technologies in early detection and monitoring in authentic environments and use of decision support tools in new ways. Especially the Makeathon and Horizon Scanning workshops will be important instruments, bringing

together scientists, urban tree care professionals and experts in a wide array of relevant technologies (trapping networks, molecular techniques, spectral imaging, UAVs, remote sensing and AI). These excercises will support technological impacts also in the long-term, by training experts (and especially Early Career Researchers) from different fields to work together in a creative mode.

The short-term **socio-economic** impacts of the networking include increased awareness of the importance of urban tree health and about risk behaviors among stakeholders and general public. In the longer term, the action will promote (among the decision makers) recognition of the importance of urban tree health as an important attribute of the One Health concept, and as a factor affecting the everyday life of citizens (WG3). The Action will also contribute to improved and more harmonized preparedness for implementing EU Plant Health policies in the member countries.

Traditionally, the world-leading research in Urban Forestry comes from North America where the theories and concepts of the research field have developed, not leastly due to the need to respond to the immense impacts of the Dutch Elm Disease in cities in eastern North America in the early 1920's-1940's. The multidisciplinary, multisectoral and multinational networking will strengthen the **European competiveness** in Urban Forestry and related research fields (e.g., biosecurity, biodiversity conservation, landscape ecology, urban planning) and relevant technological domains.

3.2. Measures to maximise Impact

3.2.1. KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

By uniting the currently rather disconnected scientific knowledge pools in urban forestry and forest pathology and entomology, the Action will contribute to the development of holistic knowledge about urban tree and forest biosecurity. Through joint efforts, the Action will seek fresh perspectives and novel insights that combine cutting-edge scientific knowledge wth solid practical relevance. The Action will promote and facilitate creation of new scientific syntheses, presented as literature reviews. Using systematic mapping of existing knowledge, the Action will identify critical knowledge gaps, stimulating new and innovative knowledge creation, and supporting long-term international collaborations and science-based decision making.

Workshops (technological and policy related), Training Schools and STSMs function as a fast track to transfer the knowledge generated in the Action. Targeted dissemination activities, the Wiki and Teaching Tools will ensure a long-term knowledge development and exchange in the topic. Active dissemination through different communication channels (scientific and popular science publishing; conference contributions; social media) will continue during the lifetime of the Action.

The professional skills of Early Career Investigators develop during STSMs and in Training Schools. The possibilities to gain hands-on experience in leadership tasks (as WG leaders or co-leaders) and opportunities to participate in COST Academy will allow the ESRs develop leadership skills and expand their contact networks. The ESRs will author the review articles and have a possibility to obtain grants for attending relevant international conferences as active participants (poster and/or oral presentations), which allows them to build up their CVs and expand their international networks.

3.2.2 PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

Action outputs will be communicated and disseminated to, and exploited by the **main target groups**: global researcher community, professionals (e.g., arboriculturists, park and green area managers in cities and municipalities, nurseries, phytosanitary authorities), educators (e.g., in arboriculturist educations, university programs with urban forestry and landscape planning orientation), and decision makers dealing with urban green spaces and biosecurity, especially at local an regional levels. In addition, the outputs have relevance for NGOs, communicators (including science journalists) and general public, especially urban dwellers.

The communication, dissemination and exploitation activities aim to:

- Promote and facilitate knowledge sharing among relevant actors, including research community, professional groups and policy makers.
- Raise awareness about the urgency of protecting urban trees against pests through better biosecurity.
- Facilitate exploitation of the Action's outputs, in adoption of new tools, practices for better biosecurity.

The communication and dissemination activities will be coordinated by a dedicated WG. The WG leader will be also the Science Communication Manager. Dissemination will be an ongoing duty for all WGs. The dissemination takes multiple forms:

Web resources

Action website - An open website in English will be launched in the beginning of the action, to act as a one-stop source for all information from the Action, including general information, publications, news (e.g., STSM calls) and events (conferences and meetings), reseacher profiles (e.g., featuring the Early Career Researchers who have completed their STSM), and relevant links.

UrbanForestHealthWiki - For long-lasting knowledge sharing and development, a Wiki resource will be co-created by researchers and stakeholders. The main page will be in English and WG members will have tasks to populate the Wiki with information (pages in different languages are encouraged). The Wiki will gather knowledge about the topic from multiple perspectives, enabling the knowledge to be openly available, capturing also information that is evolving and under construction (e.g., terminology). The Wiki will provide UPF specific information which is currently not comprehensively covered by existing online resources.

Teaching Tools in Urban Forest Health - An online repository of teaching materials in Urban Tree Health will be developed as a part of the dissemination activities, to support educators. The input from professionals (e.g. arboriculturists) will ensure high practical relevance. The contents are targeted at different levels, and take various formats, from simple stories and videos to lecture notes, slides and recorded lectures.

Decision support tool - This tool will be based on multicriteria analysis of tree species traits/characteristics, to support biosecurity in urban settings. The criteria include resistance especially to new and emerging pests, drought, soil compaction, pollution; services (e.g. performance in mitigation of air pollution, heat islands, amenity value, provision of microhabitat for biodiversity) as well as disservices such as risks for branch falling and allergenic pollen. The tool will be developed with consideration of the existing tools (e.g., i-Tree in which the proposer group has expertise) to ensure added value.

Publications

Peer-reviewed articles - The network will produce a series of jointly authored, peer-reviewed scientific reviews that will be published in Open Access mode, if possible as a Special Issue.

Popular science articles - Popular science publications in different languages are produced to allow transfer of information to a non-scientific audience across the language barriers.

Guidelines and manuals - Guidance for best practices in urban tree biosecurity (information sheets, infographs or booklets translated to different languages).

Policy briefs - Short documents presenting key findings, recommendations or policy advice and promoting outputs to practitioners and regulators.

Activities

Meetings **-** Working Group meetings will be organized at least twice during each year. As soon as the pandemic will allow travelling and larger gatherings, these meetings will take place in different cities, strategically chosen to allow thematic excursions and study visits involving stakeholder partners. As alternative or complementary activities, online meetings are arranged.

Workshops - With input from stakeholders (identification of needs), the Action will organize a series of MAKEATHON workshops connected to annual meetings or other events (e.g., in collaboration with conferences that stakeholder organizations arrange). These events aim to gather a group of participants with different backgrounds to work on a topic, co-creating a solution, product or prototype. MAKEATHONs will last 1-2 days. In addition, two workshops are organized that will focus on policy issues.

Training Schools - Training Schools will focus on learning about the interface between practice and research (the first Trainining School will be run by the stakeholders) and latest scientific advances (e.g. specific detection technologies). Leading scientific experts and stakeholders are invited as trainers. Training Schools will be open to participants from outside the network, and representatives from COST Inclusiveness Target Countries and Early Career Researchers will be prioritised to host and attend Training Schools.

Short-Term Scientific Missions - Scientific visits of (especially) Early Career Researchers and researchers from COST Inclusiveness Target Countries will be supported during the Action period. The stakeholders will be engaged in the planning and organization of the missions that will support knowledge exchange, sharing of resources (e.g., specialized laboratories) and networking. Biannual calls will be made to recruit STSM participants.

Conference contributions - The Action will support participation of Early Career Researchers in international conferences and meetings, where they have a possibility to present their research findings and the Action. Young researchers from COST Inclusive Target Countries will be the prioritized group. All members are encouraged to disseminate network findings in national conferences and meethings.

4. IMPLEMENTATION

4.1. Coherence and effectiveness of the Work Plan

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

The management of the Action will be carried out by the Management Committee, in charge of the coordination and implementation of the Action's activities. It will be supported by a Core Group composed by a Chair, Vice Chair, Grant Holder Scientific representative, WG leaders and vice leaders (WG4 leader will take the role of Science Communication Manager) and STSM and Training School coordinators.

The scientific work will be carried out in four Working Groups (WGs), each adhering to specific Research Coordination or Capacity Building Objectives. The Capacity building Objectives CBO1 to CBO3 are cross-cutting to all WGs.

WG1 IDENTIFICATION - The Working Group will identify relevant stakeholder groups and map their needs. WG1 will also collect and analyse data regarding tree species and genotypes with high relevance as urban trees in different regions, their resistance and vulnerability traits in relation to new and expected threats, and management practices that may increase/reduce their vulnerability to pests (RCO1). It will focus on case studies (RCO2) and risk and consequence analyses (RCO2, RCO3).

WG1 - T1 Stakeholder inventory and identification of stakeholder's needs.

WG1 - T2 Setting the criteria and search strategies for data collection and analyses, deciding the case study areas covering cities, towns, urban sprawl and peri-urban areas across geographic and anthropogenic gradients.

WG1 - T3 Compiling the data regarding tree species and their vulnerabilities and strengths in urban settings, in relation to new and emerging pests.

WG1 - T4 Detailing the introduction pathways, spreading scenarios and plausible consequences for ecosystem benefits for selected cases of alien tree pests in case study areas.

WG1 - T5 Supporting decision makers at different levels by analysis of risks and consequences of different prevention and detection solutions in urban settings, and by developing a decision support tool.

WG2 - INNOVATIONS The Working Group will map the available tools and measures for urban biosecurity, with emphasis on prevention, early detection and rapid responses to tree pests introduction and spread (RCO4, RCO5; RCO6, CBO4).

WG2 - T1 Defining criteria and formats for data compilation.

WG2 - T2 Compiling the information according to the criteria defined in WG2-1.

WG2 -T3 Developing a standard practice for future biosecurity and conducting a Horizon Scanning workshop to map the emerging technologies and applications for the future (short, medium and long term).

WG2 - T4 Producing a report that describes the available and emerging technologies and tools in different countries and identifying the needs, classifying them according to urgency.

WG2 - T5 Supporting co-development of new, innovative and end-user friendly tools and measures for improved biosecurity in urban green spaces.

WG3 - INTEGRATION This WG deals with informing policy about research on threats and biosecurity in urban forestry, identifying obstacles to the implementation of relevant EU policies, suggesting measures to improve policy implementation, and ensuring the coherence between the suggested best practices and regulatory framework (RCO7, RCO8, RCO9).

WG3 - T1 Describing the regulatory and institutional structures and processes (EU and global levels) with relevance for implementation of biosecurity in urban green spaces.

WG3 - T2 Identifying social, cultural and behavioural obstacles and potentials related to biosecurity in urban areas.

WG3 - T3 Informing policy by preparing relevant and accessible information and delivering it effectively (e.g. at right phases of the political cycles), suggesting improved processes and practices for policy implementation and translational research on urban tree health and biosecurity.

WG3 - T4 Developing practical, science-based, policy-compatible, and socially accepted guidelines for the best practices in urban biosecurity.

WG4 - INFORMATION - The WG will organize, promote and support the capacity-building activities through transparent and rapid communication and dissemination activities and knowledge exchange (CBO4, CBO5, CBO6).

WG4 - T1 Website.

WG4 - T2 Design and launch the “Urban Forest Health” Wiki.

WG4 - T3 Organize the contents in Wiki from WG1 and WG2, produce missing parts.

WG4 - T4 Design and launch the “Teaching Tools in Urban Forest Health” platform.

WG4 - T5 Produce the contents to Teaching Tools.

The following tasks are general (GTs) involving all WGs (CBO1, CBO2, CBO3):

GT1. Kick-Off and Final Meetings. In accordance to COST Vademecum, the Kick-Off Meeting votes and elects the Chair, Vice Chair, WG leaders, coordinators for Training Schools and STSMs. The meeting will focus on clarifying the COST principles and practices, the general background and goals of the Action, its deliverables and timetables to all participants, and describe the WG structure and specific objectives. The Final Meeting is a closure and highlights the key messages from the Action.

GT2. MC, WG and CG meetings. Annual MC meetings will review Action progress, status of deliverables and plan for next steps. The venues will be selected in ITCs. WG meetings take place twice a year, one of them back-to-back with MC meeting and the other either virtually or as a separate physical meeting. These meetings will focus on WG tasks, milestones and objectives. The CG will meet at the same time and additional virtual meetings are arranged as needed for rapid decision making and administration.

GT3. Training Schools will be organized with major inputs from stakeholders, in order to promote rapid knowledge exchange and networking. The format will encompass lectures, demonstrations, excursions, group work and discussions. The training schools aim for a 50:50 Researcher:Stakeholder ratio, for gender balance, ESR participation and geographic distribution among participants. They are organized in connection with other activities when possible, to reduce costs. Participants from ITCs and ECIs will have priority as hosts and participants of Training Schools. The Training School Coordinator elected in the Kick-Off meeting will be in charge of organizing the training school.

GT4. Short Term Scientific Missions (STSMs) will be directed especially towards ECIs from ITC countries, and will aim to promote knowledge exchange, capacity development, sharing of infrastructures and networking among the participants. The short visits allow efficient use of pooled infrastructures and competences. The STSM calls are published twice a year, evaluated on the basis of coherence with the Action's scientific and capacity building objectives, and the applicant profiles. The STSM Coordinator elected in the Kick-Off meeting will be in charge of organizing the STSM calls, evaluations and reviews.

GT5. Dissemination. All WGs and individuals involved in the Action will be engaged in disseminating and communicating Action objectives, its activities and progress to their own networks and professional forums. The members will support dissemination with information from the Action website, social media, Wiki and Teaching Tools.

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

Deliverables, type of deliverable (output), relevant objectives (RC or CB), Working Groups/General Tasks and timeframe. Y=year, Q=quarter. Cont. = continuous.

ID	Management deliverables	Output	Relevant Objective(s)	WGs/GTs	Time (Y, Q)
M1	Kick-off meeting	Agenda, minutes, other documents	CBO1	WG1-4 GT1, GT5	Y1, Q1
M2	MC meetings	Agenda, minutes, other documents	All	WG1-4 GT1, GT5	Y1-4 (1/Y)
M3	WG and CG meetings	Agenda, minutes, other documents	All	WG1-4 GT2, GT5	Y1-4 (2/Y)
M4	STSM call and visits	Calls (2/Y) and Reports	All	GT4	Cont.
M5	Training Schools	Training agendas and materials	RCO1-4, RCO6-8 CBO1-4	GT3	Cont.
M6	Final meeting	Agenda, minutes, other documents	All	GT1 GT5	Y4, Q4

ID	Coordination deliverables	Output	Relevant Objective(s)	WGs/GTs	Time (Y, Q)
D1	Description of stakeholder needs	Report/ Review paper	All	WG1	Y1-4, Q1
D2	Report on species traits and vulnenability /strengths	Review paper	RCO1	WG1	Y2, Q3
D3	Report on risks and pathways using case studies	Review paper	RCO2 RCO3	WG1	Y3, Q1
D4	Database for Multicriteria DST	Database.	RCO1-6	WG1	Y3, Q2
D5	Multicriteria decision support tool	Online resource and report.	RCO6	WG1	Y4, Q2
D6	Mapping of asset base and needs for new tools and measures	Database	RCO4	WG2	Y3, Q1
D7	"Horizon scanning" workshops	Workshop, minutes, report/review paper	RCO5 CBO4 RCO9	WG2	Y2, Q1 Y3, Q4
D8	Report on available and emerging technologies	Review paper	RCO5 CBO4 RCO9	WG2	Y4, Q3
D9	Three MAKEATHON workshops	Protocols, guidelines, roadmaps	CBO4	WG2	Y1, Q4 Y2, Q4 Y4, Q2
D10	Review of regulatory and institutional structures and processes	Review paper, policy brief	RCO7-8	WG3	Y2, Q1
D11	Two Policy Workshops	Workshop minutes, policy briefs to decision makers at different levels.	RCO7-9	WG3	Y1, Q4 Y4, Q2
D12	Review of research needs	Report, policy brief to research financers.	RCO7-8	WG3	Y3, Q4
D13	Guidelines and manuals for best practices	Guidelines, manuals	RCO1-8	WG3, GT5	Y2, Q1 Y2, Q3 Y3, Q2 Y4, Q3
D14	Wiki-based online resource	Online resource	CBO5	WG4	Cont.
D15	Online collection of teaching materials	Online resource	CBO6	WG4	Cont.
D16	Dissemination outputs	Social media outputs, infographs, popular and scientific articles	All	All	Cont.

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

Following risks and contingency plans are identified:

Envisioned risk	Likelihood	Contingency plan
Failure to adequately engage stakeholders	High	Mapping of stakeholders and their needs is done in the beginning of the project and revised annually. MC members have responsibility to inform and engage stakeholders in their countries, through personal contacts and open invitations. Active spreading of information to stakeholders e.g. via social media campaigns further mitigates the risk.
Budget underspend	High	The balance between budget and activities is monitored every quarter and proactive measures are taken to mitigate risk for not spending the budget.
Delays in deliverables	High	Monitoring of progress and use of management software to organize tasks and deadlines. Reminders are sent by WG leaders (1,5 months, 3 weeks and 1 week before deadlines).
Prolonged pandemic complicates and delays activities, or leads to passivity	Medium	Virtual meetings and other activities are organised if travelling is not possible. All the research coordination objectives and most of the capacity building objectives are designed to be possible to achieve through virtual interactions if in person contacts are restricted. The MC and task leaders will take responsibility for sending reminders and keeping the work groups active.
The Wiki and Teaching Tools are not adequately populated with input from members	Medium	Adequate time is allocated for the process. Task leaders organize continuous collection of input from members and encourage also contacts outside the network to contribute (e.g. members of the stakeholder organizations, other universities). Educators in universities and professional education (e.g. arboriculturist) programmes are contacted and encouraged to support.
Failure to engage technological experts needed in WG2	Medium	WG leader and members have well-established contacts with professionals, e.g. companies, these contacts are activate at an early stage of the project to allow stakeholders time to join. In addition, identification of stakeholders (WG1) will result in new contacts to be initiated with experts in different technological fields.
Inadequate uptake (dissemination failure).	Medium	Use of multiple dissemination formats and communication channels. Engagement of stakeholders to support the activities. Use of different languages.
Failure to attract participants to Training Schools	Low	Stakeholders and leading scientists are engaged to training schools to ensure high relevance and attractive contents. Information is spread by the Training School Coordinator to networks (personal invitations, social media).
Failure to promote Early Career Researchers	Low	Early Career Researchers are encouraged to volunteer to leadership positions and if selected, a more experience mentor is assigned to each Early Career Researcher as a support and advisor.

4.1.4. GANTT DIAGRAM

Gantt chart of the Action activities during the four year project time. Deliverables (Table 4.1.2) are marked for years and quarters. Some deliverables have a continuity nature, with input expected during a longer time period which is marked with arrows. WG=working group, T=task.

Activities	Year 1				Year 2				Year 3				Year 4			
General Activities																
Meetings	M1 M2		M3		M2 M3		M3		M2 M3		M3		M2 M3		M3	M6
STSMs		M4 →														
Tr.Schools				M5			M5			M5		M5		M5		
Research Coordination and Capacity Building Activities																
WG1-T1		D1			D1				D1				D1			
WG1-T2							D2									
WG1-T3									D3							
WG1-T4										D4						
WG1-T5														D5		
WG2-T1																
WG2-T2									D6							
WG2-T3					D7							D7				
WG2-T4															D8	
WG2-T5				D9				D9						D9		
WG3-T1					D10											
WG3-T2				D11										D11		
WG3-T3												D12				
WG3-T4					D13		D13			D13					D13	
WG4-T1	D14 →															
WG4-T2																
WG4-T3			D15 →													
WG4-T4																
WG4-T5			D16 →													