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COST 4128/12

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action FA1203: Sustainable management of Ambrosia artemisiifolia in Europe (SMARTER)

Delegations will find attached the Memorandum of Understanding for COST Action as approved by the COST Committee of Senior Officials (CSO) at its 185th meeting on 6 June 2012.

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MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action FA1203
SUSTAINABLE MANAGEMENT OF AMBROSIA ARTEMISIIFOLIA IN EUROPE (SMARTER)

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4154/11 "Rules and Procedures for Implementing COST Actions", or in any new document amending or replacing it, the contents of which the Parties are fully aware of.

2. The aim of the Action is to initiate and coordinate long-term management options to reduce ragweed in Europe by establishing an inter-disciplinary consortium that serves as a template for implementing integrated control measures against invasive alien species across Europe.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 120 million in 2012 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter V of the document referred to in Point 1 above.

A. ABSTRACT AND KEYWORDS

Common ragweed (*Ambrosia artemisiifolia*) is one of the most prominent invasive alien species (IAS) in Europe. Its pollen grains are noxious aeroallergens, it is an important agricultural weed and also occupies large non-crop areas with a range that is likely to accelerate under climate change. As a result, long-term and widely applicable options are required for its sustainable management, as well as the coordination of institutions involved in *Ambrosia* research and management throughout Europe. SMARTER will establish an interdisciplinary network including experts currently involved in the control of ragweed, Non-COST key-experts, health care professionals, aerobiologists, economists, and atmospheric and agricultural modellers. SMARTER will provide a forum for discussing long-term management and monitoring options and the development of new innovative management solutions, such as a synergy between biological, physical and chemical control measures and vegetation management, and assess their cost-effectiveness in mitigating the effects of IAS. SMARTER will act as a catalyst for long-term research, provide an information platform and develop best practice manuals for the integrated management of ragweed. It will also help to tackle other IAS, benefit all sectors affected by IAS, promote outstanding R&D, innovation in industry and provide support for policy-makers in the European Research Area (ERA).
Keywords: Invasive alien species, Common Ragweed, biological control, integrated weed management, economic and environmental management assessment

B. BACKGROUND

B.1 General background

Invasive alien species (IAS) are organisms whose introduction outside their natural ranges pose a threat to the environment and biodiversity and/or impose costs on agriculture, forestry, fisheries or other human enterprises as well as on human health (Pyšek & Richardson 2010). In contrast to North America, Australia or New Zealand, serious concerns about the negative economic and ecological effects of IAS in Europe arose only a decade ago, despite an estimated monetary impact of at least €12 billion annually (Kettunen *et al.* 2009; Vila *et al.* 2010). For this reason, regulation and management of IAS in Europe is less advanced than elsewhere. Recently, the European Commission has committed itself to adopt a EU Strategy on IAS by 2011 (Shine *et al.* 2010).

Based on the experience made in countries with a long invasion history, e.g. Australia and New Zealand, tackling IAS requires a concerted Action that brings together all sectors and stakeholders (potentially) affected. IAS can affect a large number of sectors, including agriculture (e.g. reduction in crop yield due to new crop pests or weeds) and other fields of economy (costs related to infrastructure maintenance, loss of land value, reduction in tourism), environment (e.g. threats to native species, communities or ecosystems, increased risks of erosion and flooding, risk of further spread through inappropriate landscaping), or human health (e.g. intoxications, vectors of human diseases and allergic diseases such as seasonal allergic rhinitis and asthma that are often distressing and sometimes debilitating diseases that affect quality of life and have high socio-economic costs). Collaborative transnational networking within the European Research Area (ERA) is a highly suitable tool for approaching the challenges imposed by IAS. In order to develop the methodology for setting up such concerted Actions and to ultimately successfully manage IAS in Europe, it seems ideal to focus on a model IAS that is very well known to the public, that impacts a majority of the sectors potentially affected by IAS, and that is of no benefit in the introduced range. Common ragweed, *Ambrosia artemisiifolia* L. (Asteraceae), has uniquely raised the awareness of invasive alien plants in Europe. A main problem with this plant is its particularly large production of highly allergenic pollen generating huge medical costs and reduced quality of life among the allergic population (Fumanal et al, 2007; cf. B.2). Ragweed also has increasingly become a major weed in European agriculture, especially in spring-sown crops such as sunflower, maize, sugar beet and soya beans (Kémives *et al.*, 2006). Furthermore, the majority of infested land in Europe is non-crop land and both its spread and impact are likely to increase with changing climate (Vogl et al. 2008; Csontos et al. 2010; Kasprzyk et al. 2010, Wayne et al. 2002), posing a significant risk to society even in countries presently not yet affected. This alarming situation has prompted some European authorities to react quickly. For example, already in 1999 the Lombardy region of northern Italy and in 2006 Hungary and Switzerland established a legal basis for mandatory control of *Ambrosia*. Still, although chemical and mechanical control methods have been developed and partially implemented, other key control strategies such as biological control or habitat management, while successfully implemented in other continents, are lacking in Europe.

Numerous research institutions in over 30 COST-countries are currently performing research on *Ambrosia*, but control actions undertaken by extension services and other stakeholders of every affected European country are more or less uncoordinated. IAS spread (by seed and human introductions) and associated impacts do not stop at national borders and do not respect boundaries between public and private goods, clearly indicating the need for a European network and a concerted trans-European Action plan to combat IAS. A concerted international Action is therefore urgently needed to bring together scientists and stakeholders to elaborate new sustainable control measures and to provide a long-term platform to network, strengthen and disseminate research towards a cost-effective and successful Europe-wide management against this 'flagship' IAS. **COST offers an excellent framework to lead such an interdisciplinary Europe-wide concerted effort and to form partnerships with international programmes and institutions.** Such a comprehensive approach is likely to result in significant capacity-building, and establish new and permanent collaborations resulting in huge economic benefits. Emphasis will be put on integrating all possible management options against *Ambrosia*, including those developed in other parts of the world (e.g. Australia, China), and on developing technical files and best practice manuals for region- and habitat-specific and economically feasible management solutions for this IAS across all Europe, and by combining both short-term and long-term management interventions.

B.2 Current state of knowledge

In Europe, control, eradication and management investments against IAS are decided at decentralised (often local) level without higher coordination. In a recent report for the European Commission, Shine et al. (2010) stressed that trans-national coordination is important and recommended. Moreover, since Europe is a large continent with different climates and landscapes and since a specific IAS may be a greater problem in one region than in another, a biogeographic approach is fundamental to proportionate Action (Shine et al. 2010). Therefore, they propose that Action plans could be prepared at the European level for selected key species that threaten values of European relevance, similar to what has been done in Australia and elsewhere.

According to Shine et al. (2010), candidate IAS for such European-wide Action plans could include: (a) IAS with biodiversity impacts that affect multiple member states; (b) migratory IAS for which population management needs to be considered at the European level; (c) IAS that affect more than one sector. Common ragweed meets all of these criteria. However, a bio-geographical approach that on a European-wide level addresses this problem has not yet been developed. Such a methodology must be based on a habitat-specific approach in order to be generally applicable to any IAS.

Common ragweed is an annual native to Mexico, the United States and Canada. It was introduced to parts of Asia, Central and South America as well as Australia, New Zealand and Mauritius. In Europe, common ragweed has become invasive in more than 30 countries (DAISIE 2009). Southern-central and south-eastern European regions are most affected; here common ragweed can be found in a wide range of nutrient-rich, disturbed habitats (Chauvel *et al.* 2006, Essl *et al.* 2009, Sikoparija *et al.* 2009). Furthermore, it is reported from several hundred places in Scandinavia and the UK, mainly being introduced with contaminated birdseed and fodder pellets. Climate change is expected to facilitate the establishment of ragweed as a self-propagating weed in these regions in the near future (Hyvönen *et al.* 2010).

Common ragweed possesses highly allergenic pollen that causes sensitisation of an estimated 15% (e.g. Germany, Netherlands, Denmark) to 60% (Hungary) of the allergic population, with annual medical costs of these allergies amounting to, for example, €110 million in Hungary and €88 million in Austria (Gerber *et al.* 2011, and references therein). As a further consequence, tourism can be affected if visitors avoid areas with high *Ambrosia* occurrence (e.g. the Dalmatian coast). Ragweed also has increasingly become a major weed in European agriculture, especially in spring-sown crops such as sunflower, maize, sugar beet and soya beans. Yield losses alone were estimated at €130 million/year for Hungary (Kémives *et al.*, 2006). Because of the taxonomic relatedness of sunflower and ragweed, herbicides are of limited use in this crop and thus occurrence in crop systems facilitates the spread of *Ambrosia* throughout Europe by contaminating birdseed, other feeding mixtures (such as for game animals) and crop seed. Recently, the European Union has adopted the Swiss limitations on *Ambrosia* in food (especially birdseed) in a directive, which is believed to decrease the speed of invasion throughout Europe by limiting one of the invasion pathways (cf. B.4).

Herbicides and mechanical control (uprooting, cutting and ploughing) are best suited as local and short-term measures to eradicate initial and small populations and to reduce yield losses in crops. Such methods have recently been investigated and compiled by a consortium of national experts in the framework of an ERA-NET EUPHRESCO (European Phytosanitary Research Cooperation) *Ambrosia* project (Buttenschøn *et al.* 2009). Combinations of herbicides with cutting, together with crop cultivation methods, are presently further elaborated in the EC DG Environment project 'HALT AMBROSIA' (cf. C.4). However, these control methods remain limited to well-managed habitat types with the main focus to protect crop yield. Also, herbicide treatments are normally not aimed at eradicating the weed so that ragweed may still flower and produce pollen and seeds. For some crops, no herbicides are available, and tolerance to specific herbicides creates further gaps. In organic farming as well as on fields in water protection areas herbicide use is forbidden. Moreover, the majority of land infested by common ragweed in Europe is non-crop land such as riverbeds, roadsides and field borders, on which eradication of ragweed using herbicides is too expensive. Additionally, the need to protect the accompanying vegetation, especially in sensitive ecosystems, does not allow large-scale application of herbicides. In summary, herbicide treatments in crops may be sufficient to prevent yield losses but cannot prevent ragweed populations from producing pollen, setting seeds and to further increase. **Sustainable control strategies to mitigate *Ambrosia's* further spread into areas not yet invaded and to reduce its abundance in badly infested areas in Europe therefore needs to be based on a wider combination of methods.**

One long-term management tool not yet implemented in Europe is **biological control (BC)**, i.e. the use of natural enemies either by introducing host-specific arthropods or fungal pathogens from the area of origin of the plant (classical BC), or by periodic releases of an abundance of antagonists (inundative or bioherbicide method). Modern classical BC projects that are based on in-depth investigations on the host-range and impact of potential BC agents prior to their release have a high safety track record (e.g. Pemberton 2000) and belong to the standard measures to combat invasive species in Australia, New Zealand, South Africa, USA, Canada or China, i.e. in regions most heavily affected by biological invasions. In Europe, classical BC of weeds is still in its infancy; in 2010, a psyllid originating from Japan was released in the UK against Japanese knotweed, *Fallopia japonica* (Shaw *et al*. 2011), representing the first and only European case of a BC agent release against an invasive plant based on a rigorous pest risk assessment.

Five years of host-range testing demonstrated that this psyllid will not harm native plant species; rather, it is expected to benefit native biodiversity through the reduction of the vigour and the environmental impact of the invasive knotweed itself. The classical BC project against Japanese knotweed has successfully tested the permit system in the UK and has thereby paved the way for developing legal and regulatory frameworks for the release of exotic BC agents across Europe. SMARTER aims towards a similar outcome by implementing BC against *Ambrosia* in Europe.

Ragweed is an excellent target for BC since classical BC has already been successful in other parts of the world. In Australia, three insect species were released against ragweed in the 1980s; to date, the plant is considered under good control (Palmer *et al.* 2010), and from an economic point of view, BC of *A. artemisiifolia* is regarded as an outstanding success in Australia, resulting in a benefit to cost ratio of 103.7 (Page & Lacey 2006). One of the BC agents released in Australia was also released in China in the 1990s. Together with a second biological control agent released in the early 2000s, good control of *A. artemisiifolia* populations was achieved in some regions (Zhou *et al.* 2009). Recently, a mass-rearing programme was established with the two agents in China with the aim to use them for inundative application in severely invaded habitats (Zhou *et al.* 2009). At the very beginning of BC activities against ragweed in Europe, a leaf beetle was released against ragweed in Eastern Europe; yet, this beetle proved to be ineffective, both in Europe as well as in all other parts of the world to which it had been released (Gerber *et al.* 2011).

The feasibility of the inundative approach was studied in both Canada and the USA. For example, a *Phoma* sp. recorded on *A. artemisiifolia* in North America was considered as a potential mycoherbicide candidate. A combination of this *Phoma* sp. and the leaf beetle *Ophraella communa* LaSage (Coleoptera: Chrysomelidae) had a synergistic effect and resulted in high plant mortality. Unfortunately, the culture of *Phoma* sp. lost its virulence and attempts to revive or re-isolate the species from natural sites failed (Teshler *et al.* 2002). Nevertheless, an inundative BC approach could be suitable for either eradication purposes, in case of localized infestations, or for applications in places where other control strategies/tools cannot be applied (e.g. in repeatedly disturbed crop fields where classical BC agents cannot build up high densities).

Building on the extensive studies on antagonists of ragweed in its native range and on the BC activities conducted worldwide, Gerber *et al.* (2011) recently proposed six insects and one fungus that appear to be most promising BC agents either for a classical and/or inundative approach in Europe and therefore will build the core of our BC approach: *Tarachidia candefacta* (Lep., Noctuidae; defoliater), *Ophraella slobodkini* and *Zygogramma disrupta* (Col., Chrysomelidae; defoliators), *Smicronyx perpusillus* (Col., Curculionidae; seed feeder), *Trigonorhinus tomentosus* (Col., Anthribidae; pollen feeder), *Euaresta bella* (Dip., Tephritidae, seed feeder), and *Puccinia xanthii* (Basidiomycota, Pucciniales). However, even for "off-the shelf" agents such as *T. candefacta* and *E. bella*, both of which have already been assessed and released as BC agents elsewhere (Russia, China), bio-safety studies including environmental impact assessments and especially host-specificity tests need to be extended by including high cash crops and closely related European plants (e.g. sunflower varieties, endemic plants), and the effectiveness of the BC candidates evaluated under European climatic conditions. Europe, as compared to China and Australia, also has a more fine-grained mosaic of agricultural, ruderal, semi-natural and naturalhabitats, which requires a higher level of integration of BC, and other weed management methods (see below). The import and release of microorganisms for the BC of invasive species in Europe are regulated by the EU Council Directive 91/414/EEC. In contrast, there is currently no harmonized regulation of the import and release of invertebrate BC agents across all European countries. As a consequence, some European countries have regulatory systems, others do not, and among countries with regulation, there is no consistency in the information requirements that petitioners must produce when seeking a permit to release non-native species (Bale 2011). COST SMARTER **will be innovative by coordinating and promoting the use of the technical files for implementation of BC across Europe that have been developed in the EC project 'REBECA'** (eg. standardized application form for the import, rearing and release of arthropod BC agents) and that are currently under consideration for adoption by the European and Mediterranean Plant Protection Organization (EPPO), **and assist and encourage European harmonization of regulations for IAS and BC organisms.**

A second management tool that may offer long-term control of *Ambrosia* is weed management by competition. In the last decades, the linear transport infrastructure, such as the network of major streets and railways, facilitated the spread of common ragweed. For instance, in Austria invasion of *A. artemisiifolia* is strongly related to railway and roadside habitats. Mowing of roadsides enhances the spread, as significant numbers of seeds stick to the mowing machines. Such infestations have then been shown to act as entry ports to colonize adjacent crop field and semi-natural grassland (Kazinczi *et al.* 2008, Vitalos & Karrer 2009). Whereas weed management by competition is well established in crop fields (Zimdahl 2004), there is less experience in managing invasive weeds by such means in other areas. Sowing highly competitive species has recently been shown to reduce germination of ragweed and even to eliminate it before seed set (Milakovic & Karrer 2009). **A European-scale effort to develop different vegetation management strategies in non-agricultural areas such as roadsides and fallow land will be most efficient in mitigating further spread of ragweed.**

One of the key challenges in weed management is to optimally integrate the various management tools available, taking into consideration the climatic regions, habitat types and stage of invasion in Europe. The development of optimally integrated management approaches against a specific weed requires a platform for discussion among agronomists, biologists, weed scientists, entomologists, pathologists and population modellers that facilitates the designing of ecologically and agronomically sound experiments. Both classical and inundative BC have been successfully used to complement other weed management methods either to meet context-specific requirements (herbicides to remove new infestations; BC to give long-term control of large, established infestations) or to exploit synergistic interactions between sub-lethal effects of herbicides and the effectiveness of BC organisms. For instance, herbicides are known to increase incidence of infection and growth of antagonists, but infection can also facilitate the uptake of herbicides (reviewed by Müller-Schärer & Collins 2012). This approach is especially interesting for sunflower, where herbicide use is limited due to the taxonomic relatedness between sunflower and ragweed. Both new herbicides and bioherbicides have been developed very recently, and there is a great interest to jointly explore potential synergistic effects for *Ambrosia* control in crop fields (cf. the objectives of the EU 'HALT AMBROSIA' project). **Integration of the new management measures biological control and of vegetation management with existing short-term control measures may lead to a sustainable management strategy of *A. artemisiifolia* covering all invaded or susceptible habitats and biogeographic regions in Europe.**

In regions where ragweed has not reached invasive status '**early detection and eradication**' turned out to be efficient in controlling this species (i.e., Switzerland: Popow 2011). Such success can be achieved by enhancing the public awareness of ragweed as problematic plant.

Atmospheric concentrations of ragweed pollen can also be spread across national boundaries and so a European approach to monitoring airborne concentrations of this aeroallergen is required. The European Aeroallergen Network (EAN) pollen database (https://ean.polleninfo.eu/Ean/) holds information from more than 600 pollen-monitoring stations from all over Europe. The majority of data were recorded during the previous two decades, but some datasets reach back as far as 1974. During the period 2000-2009, 368 of the EAN stations have reported various quantities of ragweed pollen (Skjøth *et al*. 2012). These data are available to scientists and other end users via a secure website and access is restricted to registered users with a valid password. EAN data have been used to identify large local permanent populations of ragweed (Sikoparija *et al*. 2009), expanding populations (Thibaudon *et al*. 2010) or long distance transport in the atmosphere from the large local populations (Stach *et al*. 2007, Smith *et al*. 2008). The data are owned by the participants and are only available under specific agreements. Pollen data can be used by the public for avoiding exposure to aeroallergens and planning their medication (made available by national networks as well as in the form of graphics on (www.polleninfo.org.), but these data are also an important source of information for monitoring the abundance and distribution of IAS and the efficacy of possible control measures (Figure 1a, b). Use of atmospheric models to describe ragweed dispersion is a supplement to operational monitoring programmes (e.g Sofiev *et al*. 2006), but the large uncertainties in the source term (Skjøth *et al*. 2010) currently limits the use of these advanced models to process studies and as additional source of information in forecasting. An alternative method for monitoring is therefore an integrated strategy that is used in air quality monitoring (Hertel *et al*. 2007; Brandt *et al*. 2012) within the concept "Integrated Air Quality Monitoring" This is the combined used of measurements and several models for improved understanding and monitoring of chemical and biological air pollutants. For ragweed, both national networks, the European based EAN network and active involvement of a number of modelling groups from different scientific disciplines is vital for such a strategy. **Here, SMARTER can make a difference by uniting all major contributors in order to define a common vision for future research, monitoring and mitigation strategies on ragweed.**

The effect of ragweed pollen on the allergic population is also an important measure of the effectiveness of any control measures. For this reason, COST SMARTER will have links with various health care professionals and patient organisations. In addition, the Patients Hayfever Diary (PHD) (https://www.pollendiary.com/Phd/) is a free web-based service for people suffering from pollen allergy that is integrated with EAN and allows participants to compare their symptoms with pollen levels. PHD was launched in cooperation with the Austrian Pollen Information Service, the Stiftung Deutscher Polleninformationsdienst, Réseau National de Surveillance Aérobiologique France and the Allergy-Centre-Charité Berlin. PHD currently exists in 9 languages. To date, more than 18,000 participants have used this tool. PHD users can link their ocular, nasal and respiratory symptoms with the pollen levels at the places where they have been located and thus identify the aeroallergens they are likely to have been exposed to. **COST SMARTER will bring together results of EAN and PHD to show where the ragweed pollen is a problem and what impact regional scale control measures can have.**

According to international treaties (International Plant Protection Convention and the Convention on Biodiversity), phytosanitary measures against introduction and spread of invasive plant pests and invasive species must be justified by a science-based pest risk analysis (PRA). Part of the PRA consists of an evaluation of risk management options (ISPM 11) and measures taken have to be cost effective, cause minimum impact, be equivalent and be non-discriminating between countries; also, additional measures cannot be imposed, if current measures are effective (FAO 2004). The assessment of the cost effectiveness of options for managing invasive alien species is part of all PRA's that have been performed according the guidelines set by ISPM 11. PRA's on Ambrosia have been produced for Poland (see Karnkowski 2001) and Lithuania. **The assessment of the cost effectiveness of options for managing IAS has not been done at the European scale so far.**

Innovation is given both by addressing a new problem and a new approach by uniting an interdisciplinary group of experienced researchers, i.e. by developing long-term and sustainable management options against an IAS that are new to Europe, capitalizing on the experience gained in countries with a long history of biological invasion. Furthermore, apart from the earlier but more restricted *Heracleum* project (FP5: GIANT ALIEN 2002-2005), this will be the first European-wide comprehensive Action to develop best practice manuals for region- and habitat-specific management recommendations against an IAS (cf. section H).

This can only be achieved, and this is a further innovation, by bringing together scientists (with nationally as well as internationally funded research projects) already involved with the control of ragweed with Non-COST key-experts, aerobiologists, atmospheric modelers, ecosystem- and agricultural modelers, economist and stakeholder groups to provide a forum for discussing innovative, multi-forked, long-term options for managing and monitoring IAS and to pioneer the integration of multidisciplinary research activities across Europe to fight ragweed, a most prominent IAS.

B.3 Reasons for the Action

Europe has an increasing problem with invasive alien species (IAS), which are causing a huge impact on a diverse set of sectors, including agriculture and other fields of economy, environment, economy and human health. Therefore, the development of new management solutions and the assessment of their cost-effectiveness in reducing or mitigating the negative effects of IAS require serious efforts for trans-sectoral and European-wide coordination and research. This Action will set up an interdisciplinary top-level coordinated network to act as a pre-cursor for establishing novel management approaches for Europe including biological control, focusing on the economically most important plant invader in Europe, Common ragweed. By this, SMARTER will contribute substantially to the coordination and defragmentation or research across Europe and to the strengthening of Europe's scientific networking capacity. The Action is aimed both at scientific/technological advance and at European economic/societal needs. The development of SMARTER, long-term and cost-effective management options for *Ambrosia,* is far beyond the scope of individuals or small groups of researchers that usually participate in research consortia or national research programmes. Thus, the objectives of the COST Action are to: (a) make available a forum for discussing innovative long-term options for managing and monitoring ragweed; (b) train, educate and motivate skilled young scientists to work on invasive species management to meet increased demands of the society for experts on this issue; (c) to identify knowledge gaps hindering the sustainable integrated management of *Ambrosia* and promote new research to fill these gaps, (d) to promote site- and country-specific recommendations for *Ambrosia* management and promote their implementation, and (e) develop a common vision for interdisciplinary collaboration in research and monitoring of IAS, especially ragweed.

Expected results are to: (a) advance sustainable measures to control exotic plant invaders by better understanding the mechanisms underlying their invasiveness; (b) set up a framework and an interdisciplinary network of experts and stakeholders that will monitor management success of ragweed from the local to the European level, (c) compile an integrated *Ambrosia* management manual for Europe, considering the different levels of invasion in different countries and habitats; (d) develop a European-wide plan for the cost-effective control of IAS and educate scientists from diverse disciplines who will act long after the Action is finished; (e) reduce human exposure to the highly allergenic pollen, hence reducing the health and economic impact of this plant in Europe and benefiting society in general.

The specific means are: a) thematic workshops and dedicated sessions at high-profile international conferences, training courses, stakeholder meetings at the national and European level; b) personal contacts between European researchers from different disciplines to foster disciplinary and interdisciplinary Working Groups to achieve the declared objectives; c) a public website for internal management and for dissemination of activities and outcomes and; d) scientific publications, including reviews and perspectives in prestigious international journals.

B.4 Complementarity with other research programmes

Several ongoing European research programmes deal with selected aspects of the invasion, impact and control of *Ambrosia* or of invasive plants in general, or related issues, such as introduction pathways and risk assessments of IAS, or monitoring and impact of allergenic pollen.

The Action is complementary to and extends the two programmes launched by EC DG Environment in 2010, i.e. **'HALT AMBROSIA'** (project leader: Julius Kühn-Institute, Germany; 2011-2014) and **'Assessing and controlling the spread and the effects of common ragweed in Europe'** (project leader: NERC Centre for Ecology and Hydrology, UK; 2011-2012). The objective of the first study is to test and evaluate available eradication and containment measures for common ragweed, while the latter aims to assess the costs of common ragweed and to develop protective measures to control the introduction and spread of ragweed in Europe. The lead applicants of both programmes are involved in this COST Action, which avoids duplication of efforts and promotes studying the various options for integrating all available management options to achieve synergistic control effects.

Valuable information on the spread and economic impact of *Ambrosia* is also available and summarized in two national Pest Risk Analyses (PRAs) on *Ambrosia* (by Poland and Latvia), the opinions of EFSA on those PRAs (plant health perspective) and in the recently adopted EC Regulation 574/2011 that restricts the maximum level of *Ambrosia* seeds in animal feed assessed the threats posed by a further dispersal of Ambrosia seeds (EFSA 2010).

Further related projects are the FP7 project 'PRATIQUE' (KBBE-2007-1-2-03) which assembles datasets required to construct effective PRAs and develops more efficient risk analysis techniques for pests and pathogens of phytosanitary concern, as well as the FP7 projects ATOPICA (http://www.moverim.eu/images/pdf/atopicapressrelease.pdf) and ECLAIRE (http://www.eclaire-fp7.eu/research_components), where ECLAIRE also collects important data sets for an integrated approach to describe agricultural management, air pollution and climate change and how this affects ecosystem composition. ATOPICA aims amongst others at modelling the effects of climate variability, the spread of ragweed and land use changes on the spatial and temporal distribution of airborne allergens, in particular ragweed pollen. This EU-project also pays much attention to dissemination processes, i.e. interactions with policy makers and stakeholders.

Previous programmes relevant to the Action are the FP6 Specific Support Action *'REBECA'* (*Regulation of Biological Control Agents*) which developed recommendations on how to accelerate the regulation process for BC agents in Europe, and the FP6 Project *'DAISIE' (Delivering Alien Invasive Species Inventories for Europe),* the FP6 Project '*SEAMLESS*' (*System for Environmental and Agricultural Modelling – Linking European Science and Society*) and the COST Action 'EUPOL' on the *'assessment of production release, distribution and health impact of allergenic pollen in Europe*',

Most helpful procedures have been developed through these programmes and collaboration established to build upon in the new COST Action (cf. Figure 2). COST SMARTER will integrate information from these loosely connected programmes with the findings from new work initiated and coordinated by this Action in order to develop region- and habitat-specific recommendations for *Ambrosia* management across Europe, and to monitor management impact and success.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The aim of the Action is to initiate and coordinate long-term management options to reduce ragweed in Europe by establishing an inter-disciplinary consortium that serves as a template for implementing integrated control measures against invasive alien species (IAS) across Europe.

The Action will provide a forum for multi-disciplinary discussion to initiate and coordinate SMARTER long-term management such as biological control, vegetation management and the integration with different control techniques. Methods for verifying the efficacy of these measures will be developed in close collaboration with health care professionals who work with ragweed allergy and aerobiologists, who monitor and record airborne concentrations of ragweed pollen (i.e. via the European Aeroallergen Network (EAN) database). For this, SMARTER will create a dynamic multidisciplinary network of researchers and stakeholders, mainly by coordination and defragmentation of the large number of already ongoing research on ragweed across Europe, to prepare an economic and sustainable management solution for this most harmful exotic plant invader. COST SMARTER will. Therefore, towards the end of the Action the experience gained will be reviewed and incorporated in a document outlining a generic strategy for developing concerted Actions against IAS in Europe. At the moment, more than 100 researchers from both the public and private sector, and from 30 COST countries and 9 Non-COST countries have already expressed their interest in this Action. These top-leaders are networked scientists in complementary skills such as biology, agronomy, biological control, epidemiology, aerobiology, ecological and atmospheric modeling, economy and medicine. The envisaged multi-disciplinary approach will bring together, for the first time, experts from these different fields to tackle a most prominent environmental, agronomic and human health problem at its roots, and to monitor the efficacy of the planned management interventions across Europe. A COST Action with its inter-governmental networking character seems to be the best approach to coordinate, streamline, integrate and harmonize interactions among researchers from different disciplines to form a wide international community on scientific issues related to IAS management, with an expected huge impact on the European society and economy. One final outcome of the COST Action will therefore be a common vision for interdisciplinary collaboration in research and monitoring of IAS, especially ragweed.

C.2 Objectives

There are three main target areas for the management of *Ambrosia*: (1) crop fields and areas with emerging or small populations; (2) highly infested non-crop areas (e.g. semi-natural grassland), and; (3) habitats enabling fast spread, such as roadsides, waterways, highways and railway tracks.

The predominant means to manage *Ambrosia* include: (1) prevention tools (laws and regulations) and measures for early detection (information flow between local authorities and general public) and rapid response (combined chemical, mechanical and inundative BC); (2) measures for long-term sustainable control, most prominently through classical BC; (3) vegetation management in combination with the other two types of measures (1 and 2).

The specific objectives of the COST Action include, but are not limited to:

(a) conduct trans-national and trans-sectoral cooperation in integrated management of ragweed, a flagship IAS in Europe. **Outcome**: Provide a platform for the elaboration of context-specific control solutions and their impact evaluation at the local scale;

(b) promote and coordinate biological control and vegetation management schemes against ragweed and combine these new control measures with existing chemical and physical control methods to elaborate context-specific and synergistic control solutions. **Outcome:** A unified management strategy for ragweed adapted for the whole of Europe,

(c) assess large-scale effects of proposed integrated management measures using coupled ecosystem and atmospheric models (capitalizing on the achievements of the ongoing *Ambrosia* EC DG Environment projects and of the pollen monitoring networks 'EUPOL' and 'EAN') as well as connections with the two large integrated projects ATOPICA, PASODOBLE and ECLAIRE that deal with chemical and biological air quality, climate change and ecosystems including possible feed-back mechanisms. **Outcome:** Suitable evaluation techniques for monitoring the spread of ragweed and a sustainable system for evaluation the success of implemented strategies;

(d) assess the economic, environmental and social impact of the proposed interventions against common ragweed for the various stakeholders (private and public sector) and various spatial scales (local to Europe), taking into account its predicted future spread due to climate and land-use change. **Outcome:** Support for policy-makers in the European Research Area (ERA);

(e) capacity-building through Summer Schools and STSMs, especially for early stage researchers (ERS), in the field of understanding, managing and monitoring plant invasions. **Outcome:** Increased knowledge and expertise for ERS from different fields that will be carried beyond the end of this Action.

(f) promote and assist the implementation of regulations for the import and release of BC organisms, and of management schemes against IAS of European-wide concern. **Outcome:** The novel nature of this Action is such that deliverables are difficult to envisage, but could include a list of institutions and agencies aided by the Action and results of any successful management campaigns carried out within the time-frame of the Action**.**

C.3 How networking within the Action will yield the objectives?

The networking is one of the most important keys to success of the objectives defined in this Action and detailed above. The interest in this COST Action was overwhelming: more than 100 researchers from 79 institutions and 30 COST countries so far expressed their interest to join this Action. This reflects (i) the severity of the problem caused by *Ambrosia* in Europe, (ii) the large number of institutions already actively involved in *Ambrosia* research, and (iii) the great interest in and timely issue of this Action, i.e. the need for a joint networking approach and for developing sustainable management measures that can be applied throughout Europe. Thus, the backbone of the Action is created by these experts covering all key aspects in the field of ragweed biology, management and monitoring, and the objectives will be achieved by establishing a truly collaborative forum for scientists that currently work in nationally- and internationally-funded projects on various aspects of ragweed in Europe.

The networking, strengthened by the organization of Working Groups and workshops, research exchanges, summer schools, mobility, conferences and joint publications will initiate new scientific collaborations and identify research priorities that will lead to funding applications at the national and international level, with the specific objective to provide doctoral or post-doctoral research opportunities. Furthermore, scientists not only from North America, the area of origin of common ragweed, will be included, but also from other regions of the world where this plant has become a problem, such as Australia and China, in order to learn from their experience and to share achievements.

There will be a strong emphasis on knowledge and technology transfer by including stakeholders right from the beginning of the Action. A final high-profile international meeting will disseminate the Action outcomes to policy-makers, conservation managers and stakeholders. Summer Schools will be established to ensure capacity-building for invasion ecology and management – presently under-studied in Europe.

C.4 Potential impact of the Action

The Action will bring benefits for:

The scientific community by providing a framework where new sustainable control measures such as BC and vegetation management can be developed and initiated (with co-financing) in combination with physical and chemical control methods, and to establish a link with monitoring programmes for testing tools to evaluate the ecological, economic and social impact of expected successful integrated ragweed management from the local to the European scale. It will further lead to a better integration of researches across different areas of IAS management and monitoring, and strengthening connections to end users, leading to mutual enrichment and cross-validation, which in turn will help identifying important areas for future research and planning of new activities.

The private sector, especially SME's and spin-offs by providing opportunities for forming collaborative projects to develop efficient, safe and reliable bioherbicides that can be used alone or in synergy with synthetic herbicides and physical control, as well as the agrochemical industry to further develop joint applications of chemical herbicides with both classical and inundative (bioherbicide) biocontrol organisms;

National authorities and practitioners by providing (i) best practice manuals for control of *Ambrosia* infestations in various habitats, and (ii) a platform for sharing information and experience, and for the dissemination of research results on ragweed control;

National and European policymakers by providing guidance in (i) developing and implementing a regulatory framework for BC in Europe and (ii) designing European-wide management schemes against individual IAS;

The general public by coordinating control measures and developing a structured plan for reducing (i) exposure to the highly allergenic pollen, (ii) yield losses of some major crops, (iii) the spread of ragweed in non-crop habitats, thus protecting tourism and biodiversity, and (iv) major financial losses due to expensive anti-allergy and anti-asthmatic treatments and lost working time caused by debilitating allergic reactions.

C.5 Target groups/end users

The Action is aimed at:

- Scientists and students researching/teaching in the area of plant invasions, their management and monitoring (plant ecologists, entomologists, plant pathologists, agronomists, weed scientists, biocontrol experts, in collaboration with health care professionals, aerobiologists, atmospheric modelers and economists).
- ESR's will be involved in an international, multi-disciplinary research framework that will stimulate their creativity and professional growth. The Action will thus provide practical support to build on their successful career with gender balance.
- SME's, spin-offs and agrochemical industry involved in weed control and vegetation management;

- Practitioners: farmers, road services, railway services, water management services, advisory service, municipalities, plant protection services, nature conservation organizations, etc. and through them to the general public.
- National and European authorities and policy makers (ministries of health, environment and agriculture, traffic; quarantine offices, etc).

Representatives of all five groups were involved in the preparation of this Action.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The development and implementation of a biological control (BC) programme against *Ambrosia* constitutes an innovative phytosanitary approach for Europe. By this, Europe will gain expertise in the practical application of this management strategy that is already very successfully applied elsewhere (cf. B.2) and which has the potential as a model for the management of other IAS. Also, research on vegetation management to reduce the establishment and spread of plant invaders is yet in its infancy in Europe, but this measure, together with the identification of the vectors involved and measures to mitigate their impact, is expected to be most efficient and economical, especially to prevent linear dissemination along aquatic and terrestrial pathways. Modelling the spread of aeroallergens is most efficiently carried out using traditional air quality models such as the SILAM (Sofiev et al. 2006), DEHM (Brandt et al. 2012), or COSMO-Art (Zink et al. 2011) systems. Their main limitation is the quality of those input data that are related to the source term. Additionally, for climate change predictions this requires a mechanistic approach for estimating the source term and how this varies under climate change. One methodology is the use of dynamic vegetation models as proposed by the ATOPICA project. However dynamic vegetation models require careful calibration in all major European biomes, which again requires collaboration with both monitoring networks and nationally based research activities. Given the limitations of these modeling techniques, tools such as the EAN database and PHD will be central to any monitoring strategies as they are the foundation on which the models are based. Finally, the results from the integrated management experiments and from mechanistic model(s) will be used to assess the cost effectiveness of the proposed management interventions, taking all sectors affected by ragweed invasion into consideration.

COST SMARTER will (1) promote and coordinate nationally funded research activities of these two sustainable control measures, and (2) coordinate their integration with (a) eradication methods (chemical or mechanical control), and (b) studies on further spread and impact of ragweed, which will be specifically elaborated in parallel EC DG Environment programmes. The concerted research effort will therefore complement and integrate all elements of an integrated weed management against *Ambrosia* to provide habitat- and region-specific control solutions for the sustainable management of *Ambrosia* across Europe. Furthermore, it will also elaborate and test methods for evaluating management impact both at the local and regional scale (Figure 2).

From the beginning of the Action, a strong effort will be put on the establishment of a top-level interdisciplinary collaboration between scientists and the various stakeholder groups. A trans-national community will drive the development of new sustainable management measures for ragweed and develop a strategy of how to monitor their efficiency by means of coordinated and networked activities. Such work requires a flexible and dynamic consortium, such as COST concerted Action, which can easily incorporate new participants with specific contributions and network capabilities. This work will be carried out by COST Action partnership in co-financed manner by current nationally-funded and newly-submitted national/European/international research projects. Significant progress in this area may lead both to widen of the application sectors to other IAS and to feed other fields such weed science, integrated weed management, biological control, ecological modelling, environmental economics and biodiversity conservation.. This open scheme of the Action is at high added value for advancements in science and cooperation in technology.

D.2 Scientific work plan methods and means

Work plan

The Action is structured into 6 Tasks.

Task 1 Biological control (BC) will initiate a Europe-wide BC programme against *Ambrosia*. Capitalizing on the extensive information available on natural antagonists associated with *Ambrosia* species in its native range in America and on repeated world-wide attempts to control *Ambrosia* using BC, the Action will promote and coordinate classical and inundative BC activities among European labs and experts from the Non-COST countries USA, Canada, Australia and China in order to concentrate efforts on the most promising BC candidates that have recently been prioritized (see B.2). With regard to new BC candidates, comprehensive pre-release studies will be conducted applying the technical files for implementation of BC in Europe that have been developed in the EC project 'REBECA' (see B.2). For BC candidates that have already been considered and/or released as classical BC agents elsewhere, existing bio-safety and impact studies need to be extended by taking into consideration the European climatic characteristics and landscape conditions (see B.2)

This work will be carried out co-financed by current and newly submitted national research projects and collaborative international projects. The key outputs of these research activities will be petitions for field release of safe and efficient BC agents, based on Pest Risk Assessment (PRA; see also B.2 regarding the permitting process in the UK) using the scheme of the European and Mediterranean Plant Protection Organization (EPPO) that has recently been revised in the framework of the EC project 'PRATIQUE'.

Procedure: Discuss and coordinate Actions in order to: a) define the habitat-specific management goals; b) concentrate the studies on the most promising species based on the recent review by Gerber et al. (2011); c) establish joint procedures to allow their importation in the European labs; d) define taxonomic, genetic, biological and physiological properties of the agents; e) initiate nationally funded studies and collaborative international projects on the host-specificity (direct non-target effects) and potential interference with the native food web (indirect non-target effects) of promising biological control candidates both under quarantine conditions in Europe as well as under field conditions in countries where the BC candidates are native or have already been released; f) identify the best procedures to obtain an effective application; g) establish joint protocols for assessing impact prior to the release of the BC agents (that can then be compared with the outcomes of Task 4 'Management evaluation'; h) establish techniques for cheap and fast mass production and application of inundative BC candidates; and i) design post-release monitoring studies to assess impact and non-target effects of the BC agents. The Action will allow European institutions to strengthen their contacts with leading BC research institutes from Non-COST countries (USA, Canada, Australia and China) through STSMs and joint meetings.

Deliverables

- Elaboration of a coordinated European approach towards BC of *Ambrosia* in order to ensure that the test plant list covers closely related native species from the whole of Europe, to focus on host-range and impact assessment of the most promising classical biological control candidates, and on potential indirect effects on native ecosystems (food chain);
- Promote and coordinate experimental examination of selected pathogens isolated from the target weed in Europe for their potential as inundative BC agents against *Ambrosia*;
- Elaboration of Pest Risk Assessments for promising BC candidates for BC of *Ambrosia* at the European level**.**

This task will be developed by WG 1: Biological Control. Experts on BC at the European level will participate in this WG, together with experts on BC from the Non-COST countries (USA, Canada, Australia and China)**.**

Task 2 Vegetation management will concentrate on measures to reduce the establishment and fast spread of *Ambrosia* along dissemination pathways that also act as entry ports for invading adjacent cropland and semi-natural habitats. Adequate measures will focus on establishing and managing a competitive vegetation cover both by sowing specific seed mixtures for re-vegetation to increase biotic resistance, and on developing specific management regimes to prevent the production of fertile seeds. Based on the results of the ERA-NET EUPHRESCO project (Holst 2009) and interacting with the 'HALT Ambrosia' project, greenhouse and field experiments using different seed mixtures and cutting regimes to reduce the establishment, growth and seed set of ragweed presently underway in several countries will be co-ordinated and their extension to field trials promoted through the COST-Action.

Procedure: WG meetings, workshops and STSMs to institutions that already run relevant experiments will help to optimize site-specific habitat management measures and to coordinate and set up new experiments in target regions that have not yet developed vegetation management schemes. Main emphasis will be given to the selection of regionally and habitat-type adapted seed mixtures and locally adapted timing of the cutting regimes.

Deliverables

- Synthesis of previous and ongoing experiments aiming at *Ambrosia* control by vegetation management, including recommendations for setting up new experiments;
- Manual (including common reporting) for testing the efficiency of vegetation control measures (printed and online);
- Reports and publications on best practice in vegetation management control.

Task 2 will be developed by WG 2: Vegetation management

Task 3 Integration of management options is dedicated to integrating the long-term control measures developed in WG 1 and 2 with available short-term management measures (topic of the EU project 'HALT AMBROSIA'), and to providing a platform for the elaboration of context-specific control solutions. It will coordinate and promote experimental research on the optimal *combination* of management schemes, including chemical, mechanical, bio-preventive and BC of *Ambrosia*, depending on climatic regions, habitat type and stage of invasion. This task will also promote research on the mechanistic modelling of ragweed population dynamics, with particular emphasis on the soil seed bank in order to predict the *local* impact of integrated ragweed management. Exchange of detailed knowledge about temporal and spatial dynamics of *Ambrosia* soil seed bank will provide a serious assessment of this efficacy measure to work on the local scale (cf. also Task 4).

Procedure: In an early stakeholder meeting with practitioners involved in ragweed management, the various types of *Ambrosia* infestation (including density, habitat type, climatic and administrative conditions) will be listed and ranked according to their control requirements. This information will then be used to design and promote ecologically and agronomically sound experiments in order to test the effect of different combinations of management measures on the population dynamics of *Ambrosia*. Available life cycle data can be further ascertained and extended to, and recorded in specific habitats such as non-agricultural land, which includes field margins, ex-arable land, and roadside verges using a general protocol to construct habitat-specific *Ambrosia* population models. These models will allow to predict the impact of specific management measures by analysing the effects of a) competition between species (through vegetation management), b) herbivory or pathogen infection on ragweed populations (through BC), targeting the sensitive transitions in the *Ambrosia* life cycles (timing for efficient control measures). Coupled plant-herbivore models are available (Buckley *et al*. 2005) that allow predicting the impact of BC agents on their target weed populations. They can be adapted using, at this stage, preliminary impact data under controlled conditions elaborated in Task 1, as well as from ongoing *Ambrosia* BC projects in China and Australia. Results of the parallel EU *Ambrosia* programmes on the efficacy of short-term control methods and the distribution and impact of ragweed will also be considered. COST SMARTER will also provide detailed recommendations on what method should be applied in which environment to estimate ragweed soil seed bank. This will help to formulate a standard protocol for determining the size of the soil seed bank as a measure of the success and sustainability of ragweed control activities.

Deliverables:

- Recommendations for experimental assessment of integrated *Ambrosia* management measures, depending on region, habitat (including cropping systems) and stage of invasion;
- Develop *Ambrosia* population models for different habitats to evaluate and model impact of management measures at the local scale;
- Protocol for the quick but reliable determination of ragweed in the soil seed bank;
- Scientific publications on the combined use of biological, chemical and bio-preventive weed control measures, and stakeholder report on options for combinations of region and habitat-specific management measures.

Task 3 will be developed by WG 3: Integration of management options. This WG will primarily deal with an experimental approach to test the impact of context-specific combinations of *Ambrosia* management options at the local (population) scale.

Task 4 Management evaluation. To scale up predictions on the impact of proposed integrated *Ambrosia* management from local experiments (Task 3) to scenarios where integrated *Ambrosia* management is implemented at a regional scale, mechanistic models will be developed through links with existing networks and programmes (cf. Figure 2) and with especially long time series of relevant data, such as aerial pollen counts. The efficacy measure 'Ambrosia soil seed bank' represents an important aspect of mechanistic models at the local scale whereas pollen load in the air integrates the efficacy measures both at the local and the regional scale. Combining the results from the mechanistic model and from the small-scale experiments (see Task 3), this task will then evaluate impact of the proposed management interventions on various sectors affected by ragweed invasion, i.e. agriculture and other sectors of the economy (e.g. tourism), environment, and health care, at various spatial scales (farm-scale to Europe), taking into account the predicted future changes in climate and land-use. Partial budgeting and partial equilibrium modeling are among the most frequently used methods for determining the (economic) impacts of management interventions. At farm level for agriculture, or individual firm level for other sectors of the economy, partial budgeting is usually employed, as it can systematically determine additional costs, reduced revenues, revenues forgone and reduced costs due to the implementation of management interventions (Soliman et al. 2010).

The impacts at farm or individual level can be scaled up to higher levels of aggregation, e.g. for all farms in a region or country. However, at higher levels of aggregation, other impacts have to be accounted for, such as impacts on markets (price effects due to reduced or increased supply). Impacts on markets can be captured using partial equilibrium models. The cost effectiveness compares the overall economic impacts with the effectiveness in terms of reduced prevalence of Ambrosia spp. of different management interventions. Hence, by bringing together experts from different fields (ecologists, agronomists, economists, aerobiologists, modelers, medical doctors), task 4 will take a truly integrative, trans-sectoral approach to develop habitat- and region-specific recommendations for the sustainable management of *Ambrosia* across Europe, and for monitoring its efficiency and cost effectiveness.

Procedure: To model the effect of proposed *Ambrosia* management measures on a regional scale, generalized coupled ecosystem and atmospheric models will be developed, with feedback mechanisms in the reproductive cycle of *Ambrosia* (pollen and seeds) and climate. The task will therefore establish links to the FP6 European Aeroallergen Network (EAN), COST ES0603 network (EUPOL) and capitalize on the results of the two recently launched EC-DG Environment-funded projects on *Ambrosia* (see B.4), required for reciprocal transfer of knowledge and information (such as impact of eradication initiatives for health assessments in EUPOL, other COST networks, GA2LEN or the permanent EAN network). As management measures have direct and indirect effects and as the impacts are measured at local, regional and national level, emphasis will be put on comparing the outcome of different methodological approaches, all done by intensively cooperating with the leaders of the respective task in the ATOPICA project. For the assessment of the economic impacts at farm, regional and European scales, this project will use the pan-European database that was constructed by the consortium in the FP6 project SEAMLESS.

Deliverables

- Construction of an integrated method that combines recorded data and coupled models for ragweed population development and reproduction (pollen and seeds) that will be used for evaluation of integrated management of *Ambrosia*;

- Application and testing of ecological, economic and social impact assessment methods when developing habitat and region-specific recommendations for the management of *Ambrosia*;
- Publications (both in disciplinary and interdisciplinary journals) and stakeholder reports (for practical implementations of integrated management solutions).

Task 4 will be addressed in WG 4: Management evaluation. This WG will include members of WGs 1-3 with expertise in *Ambrosia* (small-scale) population modelling, key members of the networks and programmes dealing with *Ambrosia* (large-scale) pollen monitoring and modelling, and of the ongoing *Ambrosia* EC DG Environment programmes, experts in ecological, economic and social impact assessment as well as human health experts, who will help in understanding when to expect long term effects of ragweed control Actions to human health (e.g. changes in allergy intensity, sensitisation rate etc.). The coordinators of the two DG Environment programmes as well as members of all other networks and programmes mentioned above already expressed their interest in participating in our Action. Representatives of national and European policy institutions will also participate in this WG, which will greatly increase the likelihood of producing recommendations that are amenable for implementation.

Task 5 Training, and knowledge and technology transfer (KTT): The COST Action will strongly focus on capacity-building in the field of understanding and managing plant invaders, a discipline of applied ecology still novel for Europe. Research in this area can only be of true value if ultimately the public and the society in general reap the benefits of the findings. The Action will provide a platform for experts in different fields to give presentations and promote new ideas. Against this background the Action will include a specific task that will focus on training and KTT to ensure that the Action is focusing on topics relevant to the stakeholders and that the outcomes of the Action are most effectively transferred to the stakeholders (cf. C.4 and C.5). This Action will greatly contribute to a European-wide strategy in managing and handling IAS and provide an effective toolkit for practical applications.

Procedure: Summer Schools and STSMs will provide scientists and early stage researchers (ESRs) with relevant interdisciplinary skills for scientific development and application of both experimental work and modelling. Effective KTT will be achieved by including the various stakeholders from the beginning of the Action and by continued intensive interactions throughout the duration of this Action and beyond.

Deliverables:

- Website for project information management (with restricted access), communications and awareness-raising will be established for stakeholders and the general public and run throughout and beyond the life of the Action;
- Various best practice manuals (cf. tasks 1-4) will be produced;
- International stakeholder meeting in years 1 and 4, and inclusion of representatives of the various target groups and end-users (cf. C.5) in appropriate WGs.

This task constitutes a horizontal activity involving all WGs and will be achieved through STSM, Summer Schools and specific stakeholder meetings.

Task 6 Policy support will assist, support and encourage national and EU institutions in the implementation of regulations concerning a) the import and release of BC agents and b) European-wide IAS management. The Action will test and promote recommendations developed by the EU project 'REBECA' (see above) as well as experience gained in an ongoing classical BC control project against Japanese knotweed in the UK. The *Ambrosia* project will thus become a model of how to improve and harmonize procedures to introduce macrobial (insects in our case) and microbial (pathogens) BC agents into Europe.

The Action not only aims to develop European-wide recommendations to manage the model IAS *Ambrosia* and to implement them, but it will also serve as a template for developing and conducting region- and habitat-specific management plans against other IAS in Europe. The experience gained in this Action will be summarized in a document outlining a generic strategy to develop management plans against a wide range of IAS across biogeographic regions and political boundaries. Thus, this document will provide a tool to implement European-wide Action plans against IAS, one of the goals outlined in the 'Assessment to support continued development of the EU Strategy to combat invasive alien species' (Shine *et al*. 2010).

Procedure: this will be achieved through an inception workshop in Year 1 and continued knowledge transfer throughout the Action. People invited to the workshop will include European and National decision-makers, experts from the 'REBECA' project, organizations actively involved in BC worldwide and from countries where effective BC of *Ambrosia* has been achieved (e.g. International Organization for Biological Control (IOBC), CAB International, the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Chinese Academy of Agricultural Sciences (CAAS)), as well as stakeholders (e.g. EPPO, environmental organizations, agricultural sector, plant nurseries etc.) that may be concerned about conflicts of interest when introducing BC agents. Moreover, detailed contacts with the Commission (DG ENV working on the forthcoming IAS strategy) have been established and cooperation during the Action is secured.

Deliverables:

- Review of previous and current activities to develop guidelines for the introduction of biological control agents in Europe;
- Compilation of a list of European stakeholders involved in, or potentially affected by, the introduction of BC agents into Europe;
- Organization of an inception workshop to inform and consult European stakeholders regarding the BC project against *Ambrosia*, and to outline a knowledge transfer plan throughout the Action;
- Organization of a workshop to appeal to policy makers and stakeholders to take their (partial) responsibility for efforts in the context of concerted control actions against this most prominent IAS.
- Towards the end of the Action, the experience gained will be reviewed and incorporated in a document that will include regulatory, institutional, scientific and technical aspects that should be considered when designing concerted actions against IAS of European-wide concern.

This task will be achieved through specific stakeholder meetings, both at the national and international level, and regular communication with stakeholders, including national and European policy institutions.

The scientists involved in the various tasks of this Action have external funding for research in their areas, which also supports graduate studies. Joint WG meetings and annual workshops bringing together all participants will guarantee full **integration** of the work plans. Invitations to experts from research programmes relevant for this Action will give the opportunity to cross-link the various types of expertise resulting in a large synergistic effect. The frame of the work plan will be sufficiently flexible to permit the inclusion of disciplinary perspectives and activities needed. Partners will aggregate in WGs according to their main competences; there will be **open access to new partners** entering during the course of the Action.

E. ORGANISATION

E.1 Coordination and organisation

This COST Action will respect all organizational features described in the "Rules and Procedures for Implementing COST Actions" (doc. **COST 4159/10**).
In line with the COST mission, i.e., to strengthen Europe in scientific and technological research by international cooperation and networking between European Researchers in the ERA and Non-COST countries top-level Scientists, COST SMARTER will have 4 coordination aspects to achieve its objectives: Management, Networking, Training and Dissemination.

Management

The COST Action will be coordinated by a **Management Committee (MC)**, representing the participating countries (**national representatives, NR**), which will meet once per year. During the first MC meeting, i.e. the Kick-off Meeting, a Chairperson, Vice Chairperson, WG leaders, the Training Coordinator (TC) and the Website Coordinator (WC) will be elected. They form the **Steering Group (SG)**, which will assess the deliverables (workshop reports, mid-term reports, and the annual reports), monitor the budget, evaluate the financial situation, evaluate Short Term Scientific Missions and report to the MC. The SG will meet 2-3 times per year (including an annual meeting with the MC) and will solve most of the issues by email and phone/video conference.

The MC is responsible for planning and controlling the activities within the available budget, will monitor and evaluate the achievement of objectives and all ongoing activities based on Quality Management Systems, and will create and maintain contacts with appropriate ongoing COST Actions for synergies. Participants will specify their own aims and contribution to the Action through the Expression of Commitment scheme recommended by the Domain Committee (DC).

Networking

A common framework will facilitate and enhance information exchange between COST Action partners in the ERA and Non-COST countries. Thus, it will lead to closer collaboration between COST member states and Non-COST countries. At the same time by preserving individuality and diversity of expertise, methods and models, SMARTER will foster growth of individual researchers and national research capabilities that provide expertise to local/national/ European authorities by addressing specific issues related to IAS management. Furthermore, it will provide a platform for better understanding and increase awareness of problems caused by IAS and provide well-tailored management for different regions of Europe. The research institutions, that have expressed their interest in SMARTER are complementary in IAS management and monitoring, essential for achievements in a multidisciplinary integrated approach. The research is carried out in the participating countries by national and already established regional funding, while COST will provide necessary coordination. Once more, organization of Action concerns only the coordination of participants coming from European research institutes, universities and industry, including outstanding R&D organizations from Non-COST area. To enhance international networking and capacity building activities, other than thematic Working Groups, various means will be implemented such as state-of-the-art communication methods that are well suited for various aspects of science and communication. This includes youtube, LinkedIn, DropBox, Facebook, GoogleEarth, Smartphone apps etc. as a number of the participants have experience with the use of such tools in communication and research.

Special Interest Groups (SIGs): SIGs will be created by the MC on specific issues, which are more interdisciplinary and involve well-defined expertise from different WGs. Every SIG will elect a Chairperson, who will refer directly to the MC Chair. A SIG could be nominated to follow hot issues on new R&D environmental research involving IAS management, Calls from FP and Non-FP, Joint Programming Initiatives, European Platforms, Public Private Partnerships, etc.

Short Term Scientific Missions (STSM): A high priority will be given to STSM in order to establish personal contacts between researchers and other communities in the field of IAS management and monitoring. High priority will be attributed to Early-Stage Researchers (ESR) and female-applicants for gender-balance. The goal is to support the development, validation and monitoring of specific IAS management measures to enhance the collaboration between science and industry, COST-partnership and Non-COST country partners for networking and capacity building. Budget will be allocated to STSM for exchange of students, early-researchers and senior scientists between the participating research groups (cf. also below on Training).

One to two **Workshops** will be organized per year as a stakeholder meeting (in year 1 and 4; Task 5) or on a general or transversal topic (such as to prepare Task 6). A final stakeholder workshop will be held to present, discuss and disseminate our findings (Task 5). These workshops will be held in areas with high ragweed infestation to allow field excursions highlighting specific local issues.

A **website** will form a major link among participants between the meetings. A scientific discussion forum will be included in the site. Most of the areas will be made publicly available to ensure wide dissemination of the Action results, while access to other parts will be restricted to participants only. The website will be updated regularly by a **website coordinator (WC)**, with the help of graduate students involved in the Action.

Training

Scientific training and technology transfer will be essential elements of the Action (cf. Task 5). **Short-Term Scientific Missions (STSMs)** will be organized to enhance mobility of **Early-Stage Researchers (ESRs)**, to foster collaboration between institutions and laboratories of the participating countries and to enable technology transfer. Students and scientists will visit participating institutions with specific expertise to learn procedures and techniques used in BC, vegetation management, modelling techniques and monitoring ragweed populations subjected to different treatments or natural expansion. The **Training Coordinator (TC)** will facilitate this process and also be in charge of organizing Summer Schools for both students and scientists involved in the Action. Such events will strengthen the connection among the participants and especially among ERSs. Topics will be identified in the course of the Action and two **Summer Schools** will be offered, in the second and the third year.

Dissemination

Besides the deliverables of Task 5, Workshops and the website outlined above, the following means will be implemented to promote dissemination:

Editorial Board (EB): During the elaboration of the State-of-Art Report, Final Report and Special Reviews, an Editorial Board, nominated by MC, will coordinate the work and collect the necessary information from the WGs members. This group will also be responsible for setting up the Action fact sheet, the Action Leaflet and the Action Poster at the beginning of the Action. The EB will also contribute to the website by preparing, collecting and editing information about partner groups, research activities, conference/workshops/symposia, list of potential host groups for short visits and training, forthcoming activities, mutual publications, common participations and provide a complete list of SMARTER MC members and a short CV of each member.

Local Organising Committee (LOC): This COST Action is concerted at European level, including Non-COST area, and provides the necessary coordination for national research on IAS. The coordination of national research will be implemented by conferences, workshops, symposia, training courses, field campaigns, experiments, model developments and STSMs, Cross-cutting activities will be organized in collaboration with other complementary programmes and organisations. Such meetings of COST Action will be organized in various COST countries at participating institutions by installed LOC. Its Chair will report to MC on the organised event in a short summary.

Milestones	**Month**
Nomination of the National Delegates to form the MC	M1
Plenary Kick-off Meeting, nomination of Chair, Vice-Chair, WG leaders, as well as of leaders for Tasks 5 and 6, TC, WC, EB	M3
Set-up of the internal and public website	M4
First meeting of the Working Groups	M4-M6
Scientific Programme to the SG	M6
1st Stakeholder Workshop completed, MC meeting,	M12
Approval of first-year report Separate or combined meetings of WGs and STSM	M 14 M13-24
1st Summer School	M18-24
2nd and 3rd Annual Workshop and MC Meeting, Approval of second-year report	M24 M 26
Scientific meeting within or between WGs and STSM	M25-M36
2nd Summer School	M30-M36
4th and 5th Annual Workshop and MC Meeting Approval of third-year report	M36 M38
Scientific meeting within or between WGs and STSM	M37-M46
Final Stakeholder Conference and Final Plenary Meeting, MC Meeting, Approval of the final results and reports of the Action	M42-M48

E.2 Working Groups

The scientific program will be carried out in close cooperation among all WGs and strong overlap between the members of these groups is expected in all fields of interest. Strong interactions amongst these WGs will build-up a multidisciplinary Action that will be responsive, adaptive, flexible and open to new scientific and technological demands. Each WG will house a number of ESR from the member states.. The scientific programme that accounts for six tasks (objectives and deliverables as described in D2), will be developed by four Working Groups (WGs) and further specific activities (cf. E1 & F):

WG 1 **Biological Control** will develop task 1;
WG 2 **Vegetation management** will develop task 2;
WG 3 **Integration of management options** will develop tasks 3;
WG 4 **Management evaluation** will develop task 4.

Leading European experts elected by the MC will set up the Working Groups (WG). The WG leaders will be responsible for organizing the WG scientific meetings to meet their objectives and assess their progress. One aim is to set up joint research activities (WGs 1-3). Moreover, the WGs will strive to achieve trans-WG cooperation, exchange of novel insights and assist to secure fulfillment of Tasks 5 and 6. The results of the activities of the WGs will be reported to the Steering Group and MC.

E.3 Liaison and interaction with other research programmes

The multidisciplinary nature of this subject means that this COST Action will have a broad impact and make a significant contribution to the European Research Area. The Action will be an open platform for discussion and will actively reach out to other relevant research programmes (cf. B4) and organisations in order to foster collaboration. In particular, the Action will bring together those already working in biological control and vegetation management with aerobiologists, who monitor and record temporal and spatial variations in airborne ragweed pollen, with healthcare professionals who are interested in the effects of ragweed allergens on the allergic population, and with economists who have a strong background in economic analysis of impacts affecting multiple sectors.

Such collaboration will be the basis of management evaluation described in Task 4. One particularly useful tool for evaluating both the historical expansion of ragweed as well as the efficacy of control measures are the European Aeroallergen Network (EAN) database (https://ean.polleninfo.eu/Ean/) as analysis of the information from EAN can provide information about atmospheric ragweed pollen and as such is an indication of the abundance of ragweed plants in a particular area. Another useful tool is the patient's pollen diary (https://www.pollendiary.com/Phd/) that can be used to examine an individual's symptoms to specific aeroallergens. Analysis of these data can be used to monitor how new changes in ragweed distribution (e.g. due to invasion or eradication of ragweed) changes the load of allergenic pollens and affects sensitive patients. SMARTER will also involve the European Academy of Allergology and Clinical Immunology (EAACI, with Interest Groups on Aerobiology and Air Pollution and Allergy Diagnosis), and GA2LEN. The latter is a EU-funded consortium of European research centres specialised in allergic diseases that recently published data on trends of ragweed sensitization rates in Europe. Information about the implementation of control measures would be disseminated and representatives of these organisations would provide feedback about the effects of these measures on the allergic population. The Action will also encompass meteorologists, economists and modellers examining the spread of ragweed under changing climates and/or producing forecasts for atmospheric concentrations of ragweed pollen grains, such as PASODOBLE (Promote Air Quality Services integrating Observations – Development Of Basic Localised Information for Europe) in the context of the European GMES Programme (Global Monitoring for Environment and Security), ECLAIRE (Effects of Climate Change on Air Pollution and Response Strategies for European Ecosystems) and ATOPICA (Atopic diseases in changing climate, land use and air quality). These collaborations are facilitated by the fact that the Action includes experts in the fields of agronomy, aerobiology, meteorology, economy and allergology.

A number of these specialists were involved in the extremely successful COST Action ES0603 EUPOL that recently ended (October 2011) and in the FP6 Project '*SEAMLESS*' on environmental and agricultural modelling. Furthermore, the Action will bring together, coordinate and defragment the many presently ongoing national research projects across Europe, such as the French observatory of ragweed (www.ambroisie.info), the interdisciplinary ragweed working group in Switzerland (http://www.ambrosia.ch), Germany (http://pflanzengesundheit.jki.bund.de/index.php?menuid`&downloadid_40&reporeid'1) and Austria (http://www.dafne.at/dafne_plus_homepage/index.php; http://ragweed.boku.ac.at/index.php), and the many regional ragweed working groups in Hungary, Italy, Serbia, Bosnia & Herzegovina and Ukraine. SMARTER will also liaise with organisations such as the French Foundation for Ragweed Study (AFEDA; http://assoc.wanadoo.fr/afeda) and working groups of the European Weed Research Society (EWRS; http://www.ewrs.org/IW/default.asp) and of the International Ragweed Society (IRS; http://www.internationalragweedsociety.org). Additional experts from these programmes and research organisations, as well as lead scientists from Non-COST countries active in IAS management will be invited to participate in the Action's annual Workshops, and ESRs to join the Action's Summer Schools. Finally, the Action's web site will be inter-linked to the web pages of these research programmes and organisations. All these measures will ensure continuous exchange of information between the Action and other relevant research programmes to avoid duplication and to promote and ensure synergies.

E.4 Gender balance and involvement of early-stage researchers

Already about one third of the researchers that expressed their interest in SMARTER so far are female; nevertheless, the scientific sector object of this Action is male-dominated, especially in Western Europe, which is then also reflected in the participation profile and responsibility positions. Therefore, contacting female to become participants and to nominate them as WG leader and/or MC Vice-Chair and/or WG Vice-Chairs will be of highest priority in order to achieve also at least a 33% balance of female experts in the leadership of the Action. For this, the Action will **develop a gender Action plan** to promote gender equality in all forms within the network. Each of the participating institutions will be requested to comply with an appropriate gender balance in recruiting its personnel for the participation in the Action.

The Action will also place a high priority on the involvement of ESRs in all activities in order to ensure that the project successfully contributes to capacity building within European Science. According to our preliminary survey nearly all participating teams involve many young researchers who will be further supported by the Action. To involve ESRs, the Action will **develop an ESR Action plan** and invite an ESR representative to the MC. This role will be undertaken for one year, such that four young researchers will pursue valuable managerial experience by the Action. By using this instrument an ESR group inside the Action will be created that is a very effective instrument to support new talents and actively involve ESRs into the definition process of the Action strategy, work-plans and activities. Furthermore, due to the strong interdisciplinary aspect of the Action, as many STSMs as possible - especially devoted to younger researchers - will be organised to support in an intensive way the exchanges of knowledge between the different participants and communities and to create their own international profile. Part of the ESR Action plan will include focus on ESR with children and how exchange of such young researchers can be carried most efficiently as this has often been observed to be a limiting factor especially for young female scientists.

F. TIMETABLE

The duration of the Action is four years. A Kick-off Meeting will be organized within a few weeks after its approval.. The specific coordination activities of this COST Action will be decided at the first MC meeting, in the first month of the Action, when preparations for the first conference, Workshops and WG meetings will be made. STSM plans and event announcements will be advertised immediately following the Kick-off Meeting. The Action will finish with an international summit conference where the results achieved in the 6 Tasks will be presented. Each year there will be at least one meeting of the MC, at least two meetings of the SG and at least one meeting of each WG, with meetings of the MC, SG and WGs coinciding with an annual workshop. Years 2, 3 and 4 will see 1-2 workshops per year, exchanges of personnel using the STSMs instrument and implementation of the Summer School for students in year 2 and 3. The Action website will be generated during the first semester and will be updated 4 times per year. Reports will be generated at the end of every year (see also Milestones under E.1).

G. ECONOMIC DIMENSION

The following 30 COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: AT, BA, BE, BG, CH, CZ, DE, DK, EE, EL, ES, FI, FR, HR, HU, IL, IT, LT, LU, MK, NL, NO, PL, RO, RS, SE, SI, SK, TR, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 120 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

The findings and results of the COST Action will be disseminated to the various target groups including other researchers in the field; other research frameworks; research and agricultural institutes and universities; practitioners such as farmers, road services, railway services, water management services, advisory services, municipalities, phytosanitary institutions/quarantine officers, plant protection services and nature conservation organizations involved in handling and fighting IAS; national authorities and policy makers in the ministries of health, environment and agriculture and traffic; European level policy makers in the DG for Agriculture & Rural Development, DG for Research, DG for Environment and DG for Health and Consumers of the European Commission; European and International organizations dealing with IAS, and not least the general public.

H.2 What?

The Action will prepare a dissemination and sustainable operation plan that will be updated throughout its duration to transfer results to different target audience and communities. During the Action the following dissemination activities are planned:

- Press releases and publications for the general public;

- An Action Leaflet and Poster will be designed at the beginning of the Action;
- Public access website and password protected website for working documents;
- Publications: articles in peer-reviewed scientific and technical journals, state-of-the-art reports and proceedings, guidelines and best practice manuals, interim and final reports;
- Events: workshops and conferences of the Action (key international experts in the field will be invited as speakers, when appropriate); organization of, and contributions to, other national and international conferences and symposia (to promote the European know-how and expertise in the area);

STSMs , Summer Schools and other teaching activities.

H.3 How?

Press releases and publications for the general public

The activity of the COST Action will be drawn to the attention of the scientific community, governments, policy makers and the citizens of Europe by production of a press release at the commencement of the Action at the Kick-off Meeting and at the Final Conference. These will be released in all the countries taking part in the Action. For this, contacts with media via press offices and communication services of each participating institution will be established. The SG will be in charge for these activities and will also identify appropriate findings for press releases throughout the duration of the Action.

Public access website and password protected website for working documents

A public access website will be established in order to provide a portal to the mass of information generated by the Action for access by the international scientific community, but also for stakeholders, students and the public audience. This website will be established and maintained by one designated partner in this Action to be agreed at the MC1meeting.

The website will contain general information about COST and this COST Action and its WGs (e.g. workshops, meetings); publications; contact details of Action members; details of courses including on-line content and other teaching material; calls for STSM; reports of workshops and meetings; links to other COST Actions and framework programmes; job and fellowship availability. The website will contain a password protected section for communication of information among the members of the Action. Practical control methods and best practice manuals will be made available to stakeholders as electronic documents freely downloadable from the website.

Publications

- The scientific results of the project will be published in refereed scientific journals, joint publications are encouraged.
- State-of-the-art reports and proceedings will also be encouraged in order to disseminate results to a broader, less specialized public to provide information to end-users such as practitioners working in the agricultural, traffic (railway, highway) and nature conservation space.
- Guidelines and a best practice manual will be produced specifically for the various stakeholders and end-users (cf. C.5).
- Interim and final reports will be produced as part of the requirements of the COST Action and to communicate our findings among the participants of the Action.

Events

Workshops and conferences of the Action: The Action will run open sessions at the Workshop Meetings and the Final Conference to inform interested scientists, regulatory bodies and policy makers about the results of the project and about new strategies and management measures developed throughout the project. These sessions will provide theoretical as well as practical opportunities and will be organized in different geographic regions to allow participants from across Europe to gain access to the leading European expertise on managing and monitoring *Ambrosia*. Efforts will be made to have the proceedings of the conferences published in special issues of appropriate international peer-reviewed journals. Members of the Action are either on editorial boards of such journals or have contact with the editorial boards.

Conferences of associated learned societies: Participants of the COST Action will present the concepts and achieved results at international and national conferences on plant/biological invasion and biological control (e.g. Neobiota, Int. Congress on Biological Invasions, Int. Symposium on Biological Control of Weeds, Int. Conference on the Ecology and Management of Alien Plant Invasions, European Weed Research Society Symposium, Int. Workshop Invasive Plants in the Mediterranean Type Regions of the World) or organize specific session at European or international conferences (nearly every international congress in botany, vegetation science, ecology, entomology or phytopathology has a specific session on invasive species and their management) in order to disseminate the knowledge and data resulting from the COST Action activities. This will increase the knowledge base in COST countries and will further lead to increased international visibility and collaboration.

Short-Term Scientific Missions and teaching activities

Short-Term Scientific Missions will allow the dissemination of accumulated knowledge on invasive plants (especially *Ambrosia*) and their management to early-stage as well as senior scientists who require such knowledge for the first time. Thus, the STSM will facilitate technology and knowledge transfer within the Action and increase the opportunities for synergies between experts and early-stage researchers.

SMARTER will generate substantial knowledge and material, which can be used for teaching activities in Universities at undergraduate and post-graduate level, and this will be made available through the website. Participating ESRs and scientists of the Action as well as associated researchers and students will have the opportunity to attend the Summer Schools to become fully acquainted with the state-of-the-art theories, approaches and technologies to understand and manage plant invaders.

It is important to note that the dissemination plan will be updated during the course of the Action taking into account the progress of the Action as well as the results of its evaluation. The research published in the field during the final years of this COST Action and application of guidelines produced in this research will allow evaluation and determination of how successful this Action will have been in realizing dissemination of the results in the field.