Brussels, 12 May 2023

COST 012/23

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action “European Network In CHEmical Ecology: translating the language of life into sustainability” (E-NICHE) CA22102

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action European Network In CHEmical Ecology: translating the language of life into sustainability approved by the Committee of Senior Officials through written procedure on 12 May 2023.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA22102
EUROPEAN NETWORK IN CHEMICAL ECOLOGY: TRANSLATING THE LANGUAGE OF LIFE INTO SUSTAINABILITY (E-NICHE)

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

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

The main aim and objective of the Action is to unify European players in chemical ecology, promoting visibility and sharing knowledge, tools, and platforms. It addresses major societal issues for environmental and sustainable development goals, by describing chemodiversity, evolutionary forces, and global changes that will impact biodiversity and ecological interactions. This will be achieved through the specific objectives detailed in the Technical Annex.

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

OVERVIEW

Summary
E-NICHE will help unify the different branches of chemical ecology (CE) by bringing together researchers who study natural compounds that can act as semiochemicals (i.e., communication signals). At present, collaborations among these researchers are limited because CE is an extremely fragmented field. E-NICHE will foster partnerships between (a) scientists studying aquatic and terrestrial ecosystems; (b) natural products chemists, biochemists, and ecologists; (c) vertebrate biologists and entomologists; (d) plant and animal biologists; (e) zoologists and molecular biologists; and (f) neurobiologists and microbiologists. Their interactions will generate original ideas and perspectives while simultaneously meeting societal needs, a challenge that involves the creation of new chemical formulations, novel molecules, and innovative applications for natural compounds. This work will be nourished by a deeper understanding of the living world through the lens of chemical mediation, the main system of biological communication. It will also aim to prevent the loss of the chemical biodiversity found in nature, under threat because of global changes. Consequently, E-NICHE's overarching objective is to establish a strong, extended European CE network that catalyses international, interdisciplinary, and cross-sectoral exchanges with a view to building knowledge and intergenerational sustainable development solutions. Via the new network created by E-NICHE, researchers will broaden their breadth of knowledge, define new research directions, and transform their discoveries into pioneering solutions.

Areas of Expertise Relevant for the Action	Keywords
● Biological sciences: Ecology ● Biological sciences: Metabolomics ● Biological sciences: Biodiversity, comparative biology ● Chemical sciences: Organic chemistry ● Environmental biotechnology: Environmental biotechnology, e.g. bioremediation, biodegradation	● Chemical ecology ● Natural products ● Chemical communication and mediation ● Innovative science and applications ● Cross-disciplinary interactions

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

Research Coordination
● Develop standardised terminology to describe the different chemical interactions and mediation modes observed in the living world with a view to defragmenting the CE community.
● RCO 2 – Develop a conceptual framework for understanding the evolution and mechanistic underpinnings of chemical mediation that will be shared by chemical ecologists in different disciplines.
● RCO 3 – Share existing knowledge and defragment CE to promote understanding of the origins and ecological roles of chemical diversity, molecular modes of action, and compound biosynthesis pathways.
● RCO 4 – Share CE resources among E-NICHE participants while also granting access to stakeholders and the general scientific community.
● RCO 5 – Assess global dissemination of the knowledge gleaned using CE and highlight its potential to generate sustainable solutions for a changing world, with a focus on EU issues.

Capacity Building
● CBO 1: Promote interactions among CE disciplines to foster collaboration among EU researchers.
● CBO 2: Build collaborations among CE researchers, SMEs, and larger companies.

● CBO 3: Establish a pan-European network in CE.
● CBO 4: Inspire the next generation of chemical ecologists to explore new lines of investigation and novel research ideas.
● CBO 5: Unite chemical ecologists of different disciplines, ages, genders, and countries of origin.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. SOUNDNESS OF THE CHALLENGE

1.1.1. DESCRIPTION OF THE STATE OF THE ART

Chemical ecology (CE) is an interdisciplinary research field that seeks to understand and describe the chemically mediated mechanisms that underlie intra- and interspecific interactions and communication among living organisms. The "language of chemistry" is the Earth's oldest and most widespread form of communication. Regardless of size or habitat, all organisms use chemical signals (i.e., semiochemicals or infochemicals) to transmit diverse information to other organisms. CE research aims to study the natural substances that serve as transmitters; elucidate the systems being targeted; and characterise the developmental, behavioural, and ecological consequences of chemical signals. Ecologists, biochemists, microbiologists, and biologists in many fields recognise the importance of exploring the chemistry of natural substances. In turn, chemists often seek to expand their understanding of biology to better grasp how natural substances are synthesised, function in situ, and mediate communication. Chemical ecologists, in contrast, specifically study the origins, roles, complexity, and fates of chemical signals in natural systems.

CE is a keystone discipline at the crossroads between biology and chemistry. It also spans many other scientific fields and areas of knowledge. Across Europe, scientists are conducting fundamental and/or applied research in CE. For example, basic CE research looks at biodiversity, ecosystem functioning, and community functioning within simple to complex plant and animal communities. Additionally, there are many fields in which applied CE research is useful, notably in agronomy but also in the blue economy (i.e., the sustainable use of marine resources), biodiversity research, conservation, pharmacology, bioremediation, antifouling research, and fragrance/cosmetics creation. For decades, natural substances have been used for commercial purposes. For example, in agricultural systems, natural products, CE-based methods, and CE-based strategies can help drastically reduce the need for pesticides. However, it remains uncommon for European researchers to collaborate on CE projects because interdisciplinary familiarity with the work of others is lacking, often because model organisms or study systems may differ considerably.

Partnerships exist among researchers in CE-related disciplines at the global scale, largely thanks to the International Society for Chemical Ecology (ISCE). Thirty years ago, ISCE stated that substances produced by the living world have immense value and that efforts should be made to preserve bio- and chemodiversity as well as to develop the use of such substances to promote well-being worldwide. This statement remains relevant and all the more urgent in the present day. Given that climate change and environmental degradation are leading to profound ecosystem modifications and biodiversity losses, global and regional approaches must be employed to assess, limit, and, hopefully, counteract these changes.

Cooperative CE research mainly occurs at the continental scale. The CE societies of the Americas (*Asociación Latino Americana de Ecologia Química* [ALAEQ]) and Asia (Asia-Pacific Association of Chemical Ecologists [APACE]) have established extensive collaborations to examine plant-insect interactions at intra- and intercontinental scales, even though both societies typically focus on regional problems and local solutions. In contrast, in Europe, no such collaborations exist. CE research remains highly fragmented, even if European scientists across different countries possess the knowledge, expertise, and potential for generating innovations in CE. Due to the aforementioned global challenges, it is essential to construct a European CE network capable of assessing and addressing multilevel changes, where the continent's various CE research groups contribute their specific skills. It is also crucial to be able to apply research discoveries at appropriate spatial scales with fewer logistical constraints (i.e., compared to global organisations) in a manner that is tailored for European needs.

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The main aim of the E-NICHE Action is to **defragment CE research in the EU**. This work will have the additional benefits of hastening the discovery of new compounds with agricultural or medical applications, among others, and of helping limit species losses, thus preserving chemodiversity. To this end, the Action will confront a major challenge in the field: the need to create a broad network of chemical ecologists within Europe and beyond. This network will include both private-sector stakeholders (e.g., small and medium-sized enterprises [SMEs], R&D companies) and public-sector researchers (e.g., ecologists, green

chemists, ethnologists, pharmacologists). At present, these individuals work in separate laboratories; they are exploring distinct research questions using dedicated study systems and terminology. More specifically, the Action seeks to bring together CE researchers who differ in country of origin, gender, and age and whose different forms of expertise will build the foundation for future CE research at European and global scales. The immediate product will **be a European research community in CE,** and our efforts will foster collaborations within this broad interdisciplinary research field. The Action's main aim can be broken down into four specific challenges.

As a cross-disciplinary science, CE is well positioned to help **address major societal issues in the EU and achieve environmental and Sustainable Development Goals** (SDGs) **worldwide.** In particular, CE can promote the protection of biodiversity, and thus chemodiversity, an objective of the EU Green Deal. The field also has specific contributions to make to the EU's Zero Pollution Action Plan and several of the UN's SDGs. For instance, before biological compounds can be employed to bolster environmental sustainability and healthy eating, the compounds' chemical structures and natural functions must be described. Semiochemical-based biocontrol research should help foster to a greener economy and more affordably attain sustainability (e.g., using sex pheromones, biopesticides, biostimulants, antifouling compounds). The study of chemical communication in terrestrial and aquatic plant-herbivore systems, allows the identification of beneficial metabolites, effective pest/natural enemy management methods and efficient integrated pest management (IPM) strategies. (e.g., "attract and reward" or "push and pull" approaches). To meet the challenge of antibiotic resistance and to develop innovative solutions in natural medicine, efforts will have to be made to discover new families of natural antibiotics and to study how odours can be exploited to detect and/or mitigate diseases. CE research will thus play a pivotal role in the development of state-of-the-art technologies by identifying semiochemicals with a wide range of applications.

Establishing a European CE community will engender specific projects to **describe chemodiversity** and to clarify the links between molecule production and ecological function within ecosystems by **characterising the molecules' biosynthetic pathways**. These are major issues of concern in CE in the EU. Collaborations are also essential for addressing certain key questions, such as how chemical mediation is influenced by microorganisms—the "micropartners" in mutualisms and symbioses. These topics are currently understudied because scientists generally work at a single specific scale. It is certainly feasible to use a systems biology approach, which CE has begun to do via metabolomics and metagenomics tools. However, more support for this multiscale, integrative work is needed. Another current gap in the field is how molecule chirality affects communication. Indeed, chirality could be strongly related to biological function. Unfortunately, this question is rarely addressed because of technical limitations. These two examples underscore the need for chemists and biologists to more closely interact. Given that, communication often involves complex chemical mixtures, it is important to incorporate knowledge about compound functionality into biological models to better understand biodiversity and shifts in natural equilibria.

E-NICHE will tackle a fundamental challenge: characterising natural sources of chemical diversity, understanding the evolutionary forces driving chemical diversity, and deciphering chemical complexity within ecosystems. The difficulty of exploring this issue is amplified by the currently fragmented state of CE research and the lack of a shared conceptual/theoretical framework. Europe is already in the vanguard of research in evolutionary ecology. Thus, unifying the CE community will contribute to new insights. It will also help build a broadly shared conceptual framework, which will, in turn, improve understanding of how stimuli and stimulus processing have evolved. For instance, specialised metabolites have been shaped by selective forces to improve species survival and reproduction. Therefore, such metabolites make an integral contribution to various evolutionary processes, including speciation, adaptation, convergence, co-evolution, and domestication. At the same time, global changes are dramatically modifying these processes, effects that can be seen in insect/pollinator sensory systems and plant emissions, for example.

It is now possible **to combine molecular and chemical approaches**, thanks to analytical techniques recently developed by chemists and biologists. Indeed, high-sensitivity nuclear magnetic resonance, mass spectrometry, and omics tools can be deployed to study chemically mediated interactions across many individuals, communities, and ecosystems. A key challenge will be to **generalise and share knowledge about data processing tools** (e.g., databases, statistics, open-source platforms) and to allow E-NICHE participants to **access Europe's diverse analytical platforms and experimental sites**. To facilitate CE analyses of metabolomes and metagenomes, it is essential to improve CE researchers' right to use high-performance analytical instruments. To this end, all EU countries should collaborate to address this need for technological innovation. In summary, E-NICHE has the major aim of unifying key players in CE in Europe and promoting the field's visibility via the broader dissemination of CE knowledge.

1.2. PROGRESS BEYOND THE STATE-OF-THE-ART

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

By definition, Chemical ecology (CE) is a multidisciplinary area of study located at the interface between ecology and chemistry. At the same time, it is also so much more than a simple overlap between fields. Indeed, it can function as mechanism for driving scientific synergies. At present, however, CE has not reached its greater potential because CE research is highly compartmentalised: individual researchers, research teams, and SMEs explore specific models within specific ecosystems using their distinct set of techniques. Such leads to a constrained vision of the chemobiodiversity and functionality that exist at multiple scales within landscapes. **The E-NICHE COST Action thus aims to develop a European CE research community that can take a more holistic approach, positioning the EU in the global vanguard of interdisciplinary CE research while simultaneously addressing continent-specific problems.** E-NICHE participants are currently working with a variety of study systems found within diverse ecosystems, including those occurring in Antarctica, to those in the tropical forests of South America, but also specifically in Europe. The range of the expertise represented within the E-NICHE network will be a powerful tool for **defragmenting CE research** as collaborators will begin to share terminology and toolkits. E-NICHE's approach holds great innovation potential as the Action will **coordinate knowledge transfer** between public-sector scientists working on aquatic and terrestrial systems and R&D companies that are interested in CE applications.

Current major changes in ecological and chemical interactions will certainly impact ecosystem dynamics. Therefore, a better understanding of these changes, both in the short and long term (e.g., evolutionary time), is needed to assess and mitigate the effects of anthropogenic forces on key ecosystems. Rooted in "omics" as well as in other sciences (e.g., math, microbiology, computing sciences), modern research approaches allow us to constantly improve our understanding of ecosystem structure, ecosystem function, and the construction of biosynthetic pathways. They can also be used to explore how rapid habitat changes (e.g., due to invasive species, climate change, or pollution) affect organisms and their relationships with their chemical environments. For instance, peatlands are fragile yet essential freshwater environments—they create healthy environmental conditions, store carbon, serve as biodiversity hotspots, and ensure the persistence of freshwater species. It is therefore necessary to better understand their chemical mediation processes to better preserve these habitats. E-NICHE's framework will facilitate knowledge transfer to decision-makers, with whom certain Action participants already have established relationships. In this way, authorities can be warned about issues of major concern with sufficient lead time.

The Action will also produce scientific knowledge that can serve as the foundation for **concrete applied solutions in the fields of human and animal health, aquaculture, agriculture, and biodiversity conservation**. CE has already led to the reduced usage of commercial chemicals, via the incorporation of its findings into REACH legislation. There are other opportunities for exploiting CE discoveries. For example, EU countries are seeking to limit the use of pesticides in agriculture and antifouling compounds in the blue economy; they could be replaced with semiochemicals and natural antifoulants, respectively (Directive 2009/128). E-NICHE's work should result in measurable improvements to worker health as well as economic benefits for employees and employers alike. It is also important for CE to expand its focus, such as by characterising poorly known freshwater or ultramarine systems or examining ultra- peripheral regions. Additionally, CE should tackle a broader range of subjects, including ethnobotany and biomimicry, which will improve its responses to societal needs and build a greater foundation of knowledge.

The above topics were among those identified as being of the greatest importance. They served as the basis for defining E-NICHE's objectives and working groups (WGs). Other related topics and approaches will be explored in depth at E-NICHE meetings and training schools (TSs). These topics will help foster collaborations among all E-NICHE participants, regardless of experience, expertise, or country of origin. Renowned ecologists and chemists from outside the EU will be invited to WG meetings and TSs to foster discussion and foment new ideas that will help **shape the next generation of chemical ecologists**.

1.2.2. OBJECTIVES

1.2.2.1. Research Coordination Objectives

The E-NICHE COST Action has the following Research Coordination Objectives (RCOs):

RCO 1 – Develop standardised terminology to describe the different chemical interactions and mediation modes observed in the living world with a view to defragmenting the CE community. It

is essential to arrive at **standardised definitions** for the terms used in CE so that chemical ecologists in different disciplines have a shared lexicon. For example, the words semiochemical, infochemical, specialised metabolite, secondary metabolite, chemical cue, and signal all have similar meanings but may be used in slightly different ways, depending on the research area. Such can lead to misunderstandings. Achieving this objective will cement the foundation for future collaborative projects and publications. It will also lead researchers to **build and adopt an interdisciplinary lexicon**, where the field's terminology is clearly defined. This lexicon will be made freely available on the E-NICHE website. Breaking down the walls that separate chemical ecologists should shed new light on the living world, where natural molecules function as the words of a universal language. (D1.1)

RCO 2 – Develop a conceptual framework for understanding the evolution and mechanistic underpinnings of chemical mediation that will be shared by chemical ecologists in different disciplines (e.g., ecology, chemistry, biology, humanities, mathematics). The Action will identify the factors driving speciation, adaptation, and convergent evolution in relation to chemical communication. In the current context of global changes, it is important to compare and contrast processes across diverse taxa, ecosystems, and environments. Chemical communication will be studied among organisms at a broad scale, regardless of system type (e.g., active or passive, positive or negative, neutral or priming). (D1.1-4; D2.1-3)

RCO 3 – Share existing knowledge and defragment CE to promote understanding of the origins and ecological roles of chemical diversity, molecular modes of action, and compound biosynthesis pathways. In addition to being a strength, CE's multidisciplinarity is also a weakness: chemical ecologists do not always exchange information in an effective manner. E-NICHE will tackle this issue by strengthening cross-disciplinary and international relationships among CE researchers. Through collaborative efforts, this new CE network will document the chemodiversity present in diverse ecosystems. The resulting (bio)chemical libraries can then be screened by private companies, allowing them to develop a range of potential applications. Furthermore, research on the structure and metabolic pathways of natural substances will lead to the discovery of new products/processes via biomimetics, using such tools as bioinspiration, synthetic biology, or chemomimicry. (D1.1-4; D2.1-3; D3.1)

RCO 4 – Share CE resources among E-NICHE participants while also granting access to stakeholders and the general scientific. A list of all databases, modelling systems, mathematical and statistical analyses currently used by the E-NICHE network laboratories, but also beyond, will be made. The same will be done for the platforms that carry out metagenomics, chromatography, spectroscopy, spectrometry, electrophysiology, olfactometry, proteomics, metabolomics, and spectrum imaging; this list will also include observatories, macrocosms, and microcosms. Both lists will be published on the E-NICHE website to (a) promote sharing of knowledge and tools; (b) raise public awareness of the EU's strong commitment to CE research; and (c) make practical information about these resources available to young researchers and any other interested parties. Researchers can embark on short-term scientific missions (STSMs) to carry out work in the network's labs and technical platforms. Sharing information, technologies, and study systems in this way will promote mobility and collaboration within and beyond the E-NICHE community. (D3.1-5)

RCO 5 – Assess global dissemination of the knowledge gleaned using CE and highlight its potential to generate sustainable solutions for a changing world, with a focus on EU issues. It is a challenge to implement innovative and sustainable applied solutions in wide-ranging domains such as biological pest control, antifouling, aquaculture, agriculture, and human health. Yet, such efforts are crucial to limiting anthropogenic impacts. This requires an understanding of the factors involved in the introduction and effects of invasive species and environmental contaminants; the adaptability of species to ecosystems, climate change and environmental sustainability. Consequently, it will be essential to define a suite of indicators and measurement tools suited to evaluating the effects of human activity on biodiversity and chemobiodiversity. The broader goal is to inform public policy and disseminate E- NICHE's results to the scientific community, stakeholders, and the general public with a view to preserving these sources of richness. European decision-makers should thus be strongly encouraged to consider the impact of global change on chemical mediation and chemobiodiversity. (D4.1-7)

1.2.2.2. Capacity-building Objectives

The E-NICHE COST Action will pursue several Capacity-Building Objectives (CBOs):
CBO 1: Promote interactions among CE disciplines to foster collaboration among EU researchers. In general, the disciplines that contribute to CE are compartmentalised. Researchers are thus frequently

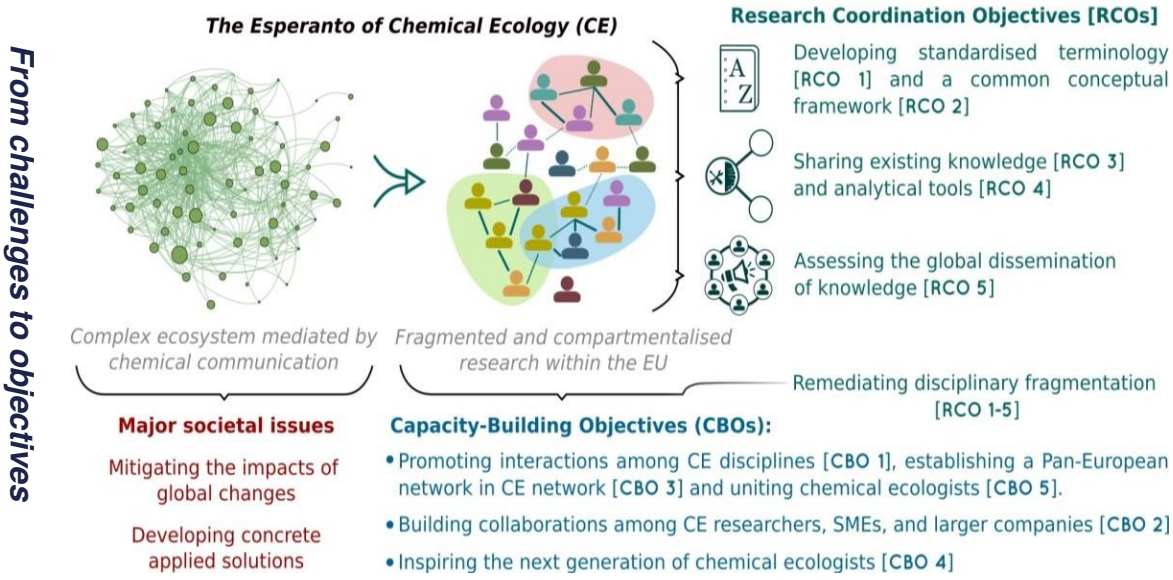
unaware of each other's work and the connections among their fundamental or applied discoveries. An interdisciplinary approach, such as the one used in CE, is well suited to creating bridges between otherwise isolated scientific disciplines. (RCO 1 - WG4)

CBO 2: Build collaborations among CE researchers, SMEs, and larger companies. CE could greatly benefit from interactions between scientists working on fundamental versus applied research. Also of value are collaborations between the public and private sectors, which have been rare in the EU to date. Indeed, to develop innovative and sustainable solutions, CE must construct relationships across EU sectors, a task in which STSMs could be particularly helpful. (RCOs 2,3,4 - WG4)

CBO 3: Establish a pan-European network in CE. By establishing a CE network, this will generate a critical mass of complementary expertise, which will fuel scientific and technological progress in CE at the international scale. (RCOs 1,4,5 - WG4)

CBO 4: Inspire the next generation of chemical ecologists to explore new lines of investigation and novel research ideas. Developing a shared research agenda centred on new and emerging questions in CE will encourage young researchers to head in novel directions and will replenish the field's pool of talent, with Europe in the vanguard. (RCOs 1–5 - WG4)

CBO 5: Unite chemical ecologists of different disciplines, ages, genders, and countries of origin. E-NICHE will bring together participants with broad-ranging backgrounds because diversity is an important strength. Indeed, the network's participants will help shape future collaborations in CE. E- NICHE will thus unite the best CE researchers and stakeholders in the EU while also accounting for differences in resource availability, as countries differ in R&D capacity. (RCOs 1,4,5 - WG4)



2. NETWORKING EXCELLENCE

2.1. ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

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

In the late 1980s, immediately after the creation of the *International Society of Chemical Ecology* (ISCE), European researchers were largely underrepresented in the field because few considered themselves to be chemical ecologists. However, these same scientists are rapidly becoming major players in CE as European research teams grow and conduct high-level interdisciplinary research. The EU is also home to renowned institutes specialising in chemistry and ecology. **Unlike Asia or the Americas, Europe has no scientific society for CE**. There are, however, some centres of excellence that underscore the potential for strong European synergies in CE and that are models for the pan-European network that E-NICHE aims to establish. It is clear from the scientific literature and national and international conferences that CE is at a crossroads: while CE research has generally followed a rather conventional course, E-NICHE firmly

expresses the belief that **the time is ripe for major conceptual advances**. The field must aspire to become a "new area of research" and a potent scientific force in Europe.

There are currently many COST Actions and international research projects that are partially linked to the present Action. Primarily focused on agronomy (e.g., crop protection) or targeted species conservation, they lack the holistic, interdisciplinary approach that is needed to achieve what E-NICHE is proposing: an ambitious degree of research coordination and capacity building (see 1.2.2). Indeed, **none are as overarching as E-NICHE,** a network unprecedented in its scale and objectives.

By unifying scientists from CE's extremely diverse disciplines, E-NICHE will generate synergies that drive creativity and innovation. From the olfaction/perception of semiochemicals to the synthesis of biomimetic chemicals, from theoretical ecology to applied ecology, there are **many unexplored research directions** whose successful pursuit will require the broad range of expertise represented by E-NICHE participants. For instance, natural product chemists working on marine systems have characterised the complex compounds found in sponges or corals but do not understand the compounds' semiochemical functions. Other researchers have described the relatively simple semiochemicals found in plant-insect systems. However, they lack the more advanced functional understanding that is necessary if such compounds are to be used in agricultural systems, which would be a great-applied leap forward. Clearly, E-NICHE participants only stand to benefit from working together. If a stakeholder (e.g., R&D company or decision-maker) wants to identify pheromone-based techniques for improving livestock welfare or trapping insect pests, helpful solutions could be rapidly identified by appealing to a diverse network of expert scientists. This work will be facilitated via specific meetings and workshops organised by E-NICHE. The **creation of a pan-European CE community** will expand knowledge in the field. It will also encourage the next generation of chemical ecologists to challenge the discipline's current conventions, giving rise to novel collaborative projects.

To ensure that E-NICHE activities gain traction and visibility beyond Europe, the E-NICHE network will be opened up to participants from **Near-Neighbour Countries (NNCs)**, who have their own expertise and research topics; **a COST Cooperating Member country**, home to some very productive and innovative scientists; and **International Partner Countries (IPCs)**.

Drawing upon the long experience of leading senior scientists and the creative energy of emerging junior scientists, E-NICHE will foster new collaborations, generate innovations, yield publications in high- impact journals, and help identify new research directions in ecology and chemistry.

2.2. ADDED VALUE OF NETWORKING IN IMPACT

2.2.1. SECURING THE CRITICAL MASS, EXPERTISE AND GEOGRAPHICAL BALANCE WITHIN THE COST MEMBERS AND BEYOND

Critical mass: The E-NICHE COST Action has 112 participants from 29 COST full-member countries (of which more than 50% are COST Inclusiveness Target Countries [ITCs] and 1 CCM), 1 NNC, and 2 IPCs. Thus, E-NICHE has the critical mass needed to tackle the above-mentioned challenges and objectives. Around 50% of the participants are women. The network will also include researchers of diverse ages: 15 Young Researchers and Innovators (YRIs) alongside many mid- career scientists (> 1/3 are younger than 45 years old). Supporting young researchers is essential to reinvigorate the field and encourage cutting-edge interdisciplinary research in lifelong learning in Europe.

Expertise: E-NICHE participants work in a wide range of complementary disciplines. Some are interested in developing environmentally friendly techniques for controlling pests, while others are focused on innovative biological processes, chemical processes, or ecosystem services. Most are knowledgeable about natural infochemicals and their potential applications; they are also extremely familiar with chemobiodiversity and multitrophic relationships in aquatic and terrestrial ecosystems. The expertise of E-NICHE participants covers all compartments of the biosphere and several coastlines. All types of European climates and organisms are represented: from invertebrates to vertebrates, insects to cows, sponges to fishes, herbaceous plants to trees, and mushrooms to microorganisms. E-NICHE will include Europe's most active CE research teams. Interestingly, some participants specialise in the study of social or multitrophic systems (e.g., insect societies, microbial communities, or complex multitrophic systems such as coral reefs or fig fruits). In these systems, chemical communication is essential, of great evolutionary relevance, and representative of CE's multiscale complexity. The diversity of expertise represented within E-NICHE

underscores the vast nature of CE.

Geographical distribution: E-NICHE has participants from all the regions of Europe (29 COST full-member countries out of 33 countries in total; 53.3% are ITCs). The network's participants include individuals working in Higher Education & Associated Organisations (79.5%), Government/Intergovernmental Organisations except for Higher Education (15.2%), and in the private sector (5.4%). Also involved are one NNC and two IPCs, as a result of mutually beneficial relationships.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

One of E-NICHE's objectives is to employ CE as a tool for preserving biodiversity and the environment, notably by accumulating knowledge about chemobiodiversity and the various uses of infochemicals. By bringing together theoreticians and scientists working in applied CE, the network will help significantly advance our understanding of ecosystems and improve our ability to safeguard our environmental and biodiversity heritage.

E-NICHE's main stakeholders are decision-makers and industry leaders who want to develop innovative, sustainable health and wellness products for consumers that are based on biosourced molecules. These individuals are interested in **pharmacology and pharmacognosy** (e.g., new medicines, aromatherapy); **agronomy** (e.g., livestock and poultry); **agriculture** (e.g., biological parasite and pest control for crop and tree species, enhanced pollination); **aquaculture**; **cosmetics, perfumes, and antifoulants** (e.g., discovery and development of natural compounds from various organisms); plant-based **soil remediation**; and **CE consulting services**. E-NICHE participants have pre-existing ties with six private-sector stakeholders (SMEs) that are working on CE applications in the above fields. More precisely, they are exploring marine biotechnology, integrated pest management strategies, seaweed-based and fungus-based products, livestock breeding, and flavour and fragrance production. These stakeholders are more broadly focused on clarifying the nature and function of chemical interactions between living organisms and the environment as well as the impacts of those interactions on the species involved. This work will identify natural compounds that could be exploited to develop novel commercial compounds. Such efforts will also result in cross-sectoral and interdisciplinary networking and the creation of new collaborations, notably with chemical ecologists in the public sector.

E-NICHE will thus promote the development and sustainable use of environmentally friendly products based on natural compounds. Several E-NICHE activities are already planning —such as meetings, Training Schools (TSs), and STSMs (see the WG actions below)—that will boost stakeholder engagement in the Action. These events will also forge links between the participants (researchers, engineers, decision-makers, biotechnology companies, green consultants, and manufacturers) via various networking tools, and stakeholders will thus be encouraged to join E-NICHE. The Action will regularly invite stakeholders with an interest in natural products to take part in network activities (WG2 Workshop, STSMs, WG2 & 4 meetings).

3. IMPACT

3.1. IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAK-THROUGHS

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

Scientific impacts (all RCOs and CBOs). By achieving the objectives set out in section 1.2.2, this will help to create a pan-European network in chemical ecology (CE) by:

1) Establishing standardised terminology in CE: While E-NICHE participants currently use similar terminology, they are coming to the network with different CE perspectives and different definitions of certain words. E-NICHE will help a range of scientists, from field biologists to lab researchers, to adopt a shared CE lexicon and conceptual framework.

2) Creating an inventory of existing knowledge about chemical communication systems, chemical signals, and CE methods: The compilation of this information is essential to be able to compare in a general way the evolutionary dynamics of the chemical communication systems of life and the effects of global changes on these dynamics. It is also vital if we wish to maximise the research impacts of E-NICHE participants and foster the development of future collaborative European research projects in CE. Sharing knowledge within and outside of the network will promote methodological standardisation in CE, a necessary step for rendering results comparable among and across research groups. This work will make it

possible to identify larger-scale patterns, global trends, and major gaps. E-NICHE participants will build the inventory during dedicated workshops.

3) **Improving our understanding of the living world:** To understand the evolutionary underpinnings of chemical information systems, it is crucial to determine whether the compounds involved are deployed in intra- or interspecific contexts, serve as inadvertent cues used by other organisms, or specifically evolved a communication function. A deeper understanding of chemodiversity can pave the way for novel study approaches, scientific discoveries, and innovative applications. CE research must better reflect science's increasing interest in gene evolution, regulatory network emergence, epigenetics, genomics, and evolutionary developmental biology (evo-devo). To this end, the field should conduct research on the evolution of biosynthetic pathways and expand its understanding of ecochemotypes. Evolutionary CE clearly has the potential to become a model system in its own right. E-NICHE will initiate and guide future research in this domain via scientific publications and targeted Training Schools. The objective is to position CE in the vanguard of research on how global changes are affecting biodiversity.

4) **Generating a searchable open-source database:** Public-sector researchers and private-sector companies will greatly benefit from a database that lists useful platforms, tools, and experimental sites as well as CE laboratories and researchers open to collaboration. The database will include a range of CE-related information, such as discipline (chemistry, ecology, physiology, neurobiology), clade of study (microbe, fungus, plant, vertebrate, invertebrate), scale of study (molecular, cellular, organismal), experimental approach (chemical, sampling, analytical, field, lab), and research goal (applied, fundamental). The database will be continually enriched and expanded as new information from participants is added. This task will be taken on by a dedicated team during and after the Action.

Technological impacts (RCO 4, RCO 5, CBO 2, CBO 4). E-NICHE will foster the development of innovative technological solutions to be used as part of sustainable development efforts. To encourage strong impacts, E-NICHE will contribute in the following ways:

1) **Agriculture and aquaculture:** The Action will develop (a) improved sensors that use semiochemicals to detect cattle fertility status; (b) compounds for treating and preventing pests in agricultural systems, vineyards, and livestock farms; (c) semiochemicals to prevent aquaculture pests and fouling organisms and to enhance the establishment and growth of target species; and (d) tools for understanding how global changes will drive chemical communication shifts in both terrestrial and marine organisms. Although advances are occurring at different speeds in different areas, novel tools are always needed.

2) **Environmental remediation:** A recently developed approach, ecocatalysis is a set of phytotechnologies that help eliminate toxic metals in zones in need of bioremediation following intensive mining or metallurgical activities. The Action will support advances in this area.

3) **Human health:** The Action will help develop semiochemical-based technologies for detecting diseases, preventing diseases, and improving mental health. Such tools are currently in their infancy and require focused research to progress. For example, newly emerging research is looking at odour- based methods for the early detection of illnesses, such as cancer, Alzheimer's disease, or pandemic viral infections. This task may later be automated via sensor development.

4) **Microbiology and synthetic biology:** A currently booming sector is the biotechnological production of target compounds by microbes (e.g., quorum-sensing or biofilm-forming bacteria) or by new model organisms (e.g., mosses, fungi, or bacteria). The Action will boost such research by clarifying the underlying biosynthetic pathways and discovering new enzymes.

Socioeconomic impacts (RCO 3, RCO 4, RCO 5, all CBOs) E-NICHE will facilitate information sharing among scientists performing basic versus applied research to fuel advances. Objectives will include (1) identifying commercially viable bioproducts; (2) improving the sustainability of crop protection and the health of agricultural systems through increased bioproduct use; and (3) replacing toxic chemical pesticides with low-risk bioproducts to reduce acute pesticide poisonings in European countries. In addition, fundamental and applied research opportunities will result from studies on the emergent properties of natural compounds and their biosynthetic pathways or from work discovering new infochemical families. Such could result, for example, in the production of novel fragrances and cosmetics. In the longer term, **new companies and/or existing companies exploiting this research will be able to expand into new markets**. For instance, SMEs or even entire industries will gain access to **more natural and cost-effective ways to cultivate plants or breed animals,** which will improve the profitability of agricultural and aquaculture systems. Consequently, by developing CE-based solutions for European problems, E-NICHE will automatically have major socioeconomic benefits in the medium to long term.

3.2. MEASURES TO MAXIMISE IMPACT

3.2.1. KNOWLEDGECREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

Contribution to knowledge creation: Via the actions of the 4 Working Groups (WGs), E-NICHE participants will prepare pan-European and international grant proposals; submit high-quality publications to top-ranked scientific journals, special issues, and topical reviews; and organise international conferences and workshops. Synergies will arise from the diverse specialities represented among E-NICHE participants, including within the SMEs. The network's enriching exchanges will lead to new avenues in CE research.

Contribution to knowledge transfer: E-NICHE's different networking tools (meetings, STSMs, and TSs) will foster exchanges among early career and senior researchers from different countries of origin, thus promoting knowledge transfer and future collaborations. Young Researchers and Innovators (YRIs), from different countries will be encouraged to help organise E-NICHE activities. As a result, they will acquire organisational skills and contribute new perspectives. More experienced researchers will act as mentors. The creation of the resource inventory and database will contribute strongly to knowledge transfer among all the network's participants.

Contribution to career development: E-NICHE will gather tools and unite partners in such a way as to successfully build bridges among researchers and guide early-career participants towards cutting-edge study topics, which will reinvigorate the field of CE. An important aim of the Action is thus to encourage young researchers (including PhD students) to play an instrumental role in CE's future. E- NICHE's YRIs will be strongly encouraged to (a) participate in the Action's activities, notably the Training Schools and STSMs (see Section 4) and (b) become proactive in the WGs. The YRIs from ITCs will be invited to apply for ITC conference grants. Furthermore, E-NICHE will foster public-private collaborations via projects with industrial applications, thereby creating non-academic job opportunities for YRIs. By connecting with renowned and experienced specialists in the academia and private sectors, YRIs will give a boost to their careers and introduce fresh ideas into CE. Attention will be paid to gender equity during all E-NICHE activities. The network's later-career researchers will particularly promote the careers of YRIs who are women.

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

E-NICHE participants fully understand that research communication activities are crucial to maximise the Action's impact. This work will be the focus of E-NICHE WG4, which will carry out one-way (dissemination) and two-way (outreach) activities targeting the general public. WG4 will also communicate the Action's results to the scientific community, stakeholders, and other potential end users. Very early on in the Action, a communications plan will be established (see the description of WGs), and its implementation will be overseen by a **science communications manager**, who will be chosen from among the network's participants. This plan will focus on the following elements:

E-NICHE website: A user-friendly website will be created and regularly updated by a dedicated webmaster. It will provide information on E-NICHE (e.g., objectives, WGs, members, activities, news) and will link to E-NICHE resources (database, MOOCs), including technical platforms, experimental sites, CE methodologies, online training programmes, and job opportunities. Its main target audience is the researchers and stakeholders (e.g., companies, decision-makers, managers) who might be interested in joining the Action or building on E-NICHE's results. However, the general public will be a communication target as well. The website will contain a link to a password-protected area where network participants can share information and documents. From the outset of the action, steps will be taken to ensure that information sharing, including the availability and sustainability of databases, continues after the end of the funding period.

Dissemination towards the scientific community:

E-newsletters: An e-newsletter will be put together twice a year to share the Action's results (= 8 newsletters over the funding period), and participants will be strongly encouraged to make contributions. The newsletters will be posted on the website and sent out to any interested labs or private companies who have joined our mailing list. Summaries of newsletter content and upcoming E-NICHE activities will also be shared via various social media outlets, including Facebook, Twitter, and YouTube. **Publications**: E-NICHE participants will publish the results of the Action, notably those arising from the STSMs. These publications will **target a broad CE audience** and focus on the most important scientific results obtained. Our work will be submitted to quality peer-reviewed journals and specialised journals (e.g., technical issues) preferentially those that are in open access and quality journals. The Action's results will also be **disseminated to decision-makers** via **policy briefs/guidelines** on topics such as the influence of climate change or invasive species on chemobiodiversity, more environmentally friendly processes, and systems that produce healthy

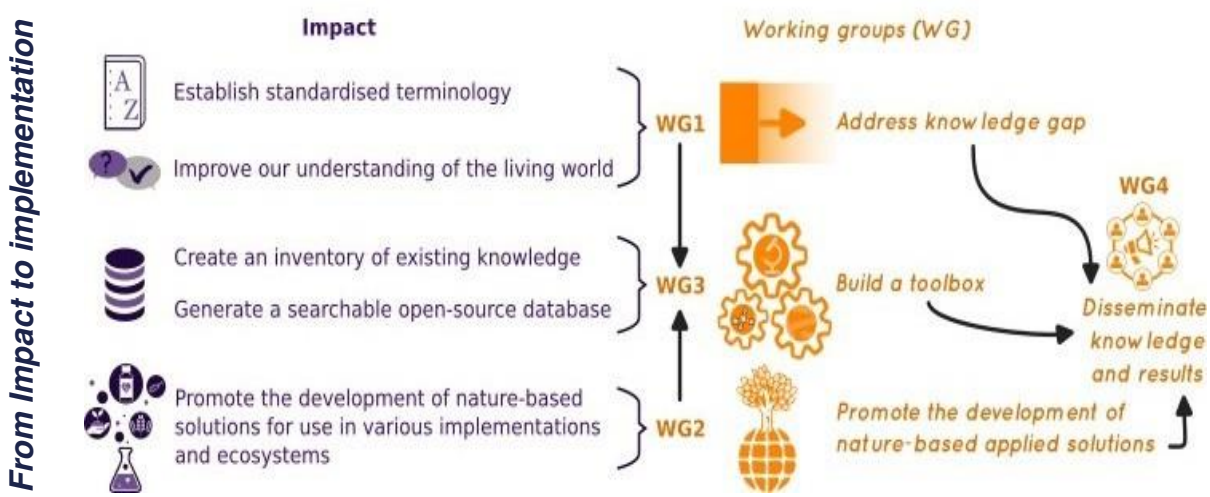
food and respect worker well-being.

MOOC: E-NICHE participants will share their basic knowledge to create a MOOC (Massive Open Online Course) dedicated to CE. This MOOC will be intended for a general audience and will discuss CE's foundations and challenges. Videos will be created to explain what lifelong learning is, learning activities and additional resources will be provided to go further.

Dissemination towards the private sector: The Action's results will be shared with individual companies and entire industries, ranging from those most closely related to CE to those that may seem, at first glance, to be rather unrelated. To this end, we will use the **website, e-newsletters, and social media.** We will also organise dedicated **workshops** on research and techniques related to high-value- added biosourced molecules; SMEs and various stakeholders will be specifically invited to participate.

Dialogues with the general public: E-NICHE participants will be strongly encouraged to use **broadcast media** (e.g., TV, radio) and **social media** to communicate about the Action and its results. To help participants prepare for such outreach activities, a special session will be organised during the Action's first year. Network members will learn about each other's activities and projects so that they are able to describe CE's diverse disciplines to all types of audiences. This process will ensure that participants can provide a holistic view of CE when communicating with the public. Outreach taking the form of **open-house events** at the participants' institutions will help shine the spotlight on E-NICHE and its results. Furthermore, producing **articles and press releases for the general public** in the respective languages of the participants and publication in local newspapers will introduce CE to a broader audience.

Exploitation plan: One of E-NICHE's main aims is to maintain, and expand, the network during the post-funding period, which will further strengthen the European CE community (and potentially result in a European society for CE). Various tools will be used to ensure this continuity.



4. IMPLEMENTATION

4.1. COHERENCE AND EFFECTIVENESS OF THE WORK PLAN

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

E-NICHE activities will be supervised by an **Action's Management Committee** (MC), whose members will be chosen before the beginning of the Action and whose work will be supported by the Core Group (CG), composed of network participants in leadership positions. To achieve the Action's objectives (RCOs and CBOs, see 1.2.2), E-NICHE participants have defined a work plan, which is presented below. The plan will be implemented by **four WGs**, each with a primary leader and several secondary leaders, who are all members of the CG. More specifically, the WGs will carry out all tasks related to COST-funded activities, ensure that milestones (M) are reached (part 4.1.1), and guarantee the timely production of deliverables (extended table in section 4.1.2). These tasks are specifically related to the different E-NICHE challenges and will maximise the Action's short and long-term impacts. The WGs' foci are as follows: WG1—addressing gaps and constraints in CE, WG2—promoting ecosystem management and preservation, WG3—building a

toolbox that includes shared E-NICHE resources, and WG4—disseminating and communicating the Action's results. All the WGs have a balanced gender ratio; contain a mix of early-, mid-, and late-career researchers from various European countries (including the IPCs); and have representatives from SMEs. All WG members were carefully chosen to obtain balance among chemists, biologists, and ecologists working on terrestrial and aquatic systems.

WORKING GROUP 1 (WG1): Addressing knowledge gaps and constraints in chemical ecology is a cross-thematic task in nature, bringing together participants through various coordinated activities. First, WG1 will inventory existing knowledge on chemical communication and the CE methodologies used by E-NICHE participants. In its first meeting (M1.1), CE terms will be collaboratively defined to obtain a standardised lexicon and thus facilitate information transfer among researchers (RCOs 1–3; CBOs 1,5). Next, a series of workshops (M1.2) will be held to identify gaps in knowledge and technical constraints in CE (RCOs 2,3; CBOs 1,5) and to draw up a roadmap for filling these gaps (RCOs 2,3). To this end, concrete strategies will be developed during several WG meetings (M1.3) and two Training Schools (M1.4) attended by the next generation of chemical ecologists (CBOs 1,2,4,5). WG1 will focus on three main topics: (1) elucidating biosynthetic pathways and the underlying genes, with a view to designing strategies for identifying the gene networks behind the biosynthesis of specialised metabolites; (2) deciphering chemical communication in multipartite and multitrophic interactions, with a view to designing robust experimental research examining these interactions also in aquatic systems; and (3) comparing laboratory and field experiments, with a view to developing approaches for studying complex chemical interactions in natural ecosystems rather than under controlled laboratory conditions. Several STSMs will be organised around these three topics. The results of this work will be published in reputable international journals, and the results will be communicated via social media.

Tasks	Activities
- Inventory CE knowledge and methodology (topics 1–3) - Identify knowledge gaps and technical constraints (topics 1–3) - Prepare strategic roadmap (topics 1–3) - Network, develop scientific collaborations, and broaden experiences of YRIs	- Initial WG meeting - WG meeting, workshops, Training School (TS) - WG meeting, TS - Short-Term Scientific Missions (STSMs)

Working Group 2 (WG2): By **applying insights from chemical ecology to promote ecosystem management and preservation** (RCO2, RCO3, CBO2, CBO3), WG2 will focus on identifying CE tools and methods for preserving biodiversity. It will also propose innovative CE technologies that directly impact food security and human health and that have applications in agriculture, forestry, breeding systems, aquaculture, antifouling, and medicine. Furthermore, WG2 will compare research approaches and applications across terrestrial and aquatic systems. Two workshops (M2.1) will be held to (1) explore the CE methods used to control pests and parasites and explore emerging ideas on sustainable pest control in animal husbandry and breeding, agriculture, forestry, and aquaculture and (2) examine communication systems in invasive species, including how they may interfere with the sensory systems of native species. WG2 will also examine how anthropogenic environmental changes and physical pollution affect the chemical information landscape experienced by plants/animals, including impacts on their ecological interactions. To this end, a Training School (TS)(M2.2) and STSMs (M2.4) will delve into the global effects of environmental factors (e.g., contaminants) on plant and animal metabolism, natural substances, and natural chemosensory activities. Results will be compared for natural aquatic and terrestrial systems versus managed ecosystems under different models of climate change. Finally, a workshop (M2.3) will focus on biotechnological innovations in sustainable pest control, animal husbandry, public health (i.e., disease vectors), biofouling, marine ecosystems, and medicine. The workshop will also identify key areas in which technologies based on olfactory cues could be used for aquatic pest management. The participation of end users will be encouraged.

Tasks	Activities
- Explore how CE principles, tools, and methods can inform ecosystem management and preservation across different systems - Investigate pollution's impact on chemosensory activities across different systems - Examine effects of environmental factors on plant and animal metabolism - Identify innovative CE-based solutions in collaboration with R&D companies and SMEs	- Symposium on CE methods and uses - STSMs - TS on how environmental changes impact CE-mediated interactions - Workshops

Working group 3 (WG3): **Building a toolbox of shared resources** will promote interactions, collaboration, and knowledge-building among CE disciplines via the development of toolkits and the implementation of best practices. WG3 will gather information about all the know-how, tools, methods, experimental sites, platforms, and laboratories currently available in the domain of CE. This work will be accomplished with the help of the other WGs. An open-source searchable database will then be constructed using the above findings. The main objective will be to help researchers and industry stakeholders identify and establish collaborations with CE platforms, tool providers, laboratories, and research institutions. With E-NICHE funding, the database will be built by software developers with help from network participants. Users will be able to find any information they need using appropriate keywords. The database will be continuously updated with new information obtained by network participants. It will be hosted on the E-NICHE website and transferred to other reliable web hosts identified during the Action. WG3 will also organise a meeting (M.3.1) to (1) structure the database's contents; (2) take stock of existing CE methods, tools, and experimental sites; and (3) lay the foundation for future research and best practices in CE. Two subsequent meetings will take place during the funding period: one halfway through to assess the progress being made on the database and the development of best practices (M.3.3) and one towards the end to review what WG3 has achieved (M.3.6). In addition, a workshop (M.3.4) will be held to explore CE concepts and knowledge in greater depth and to highlight existing gaps. WG3 will promote networking, partnership building among participants, the dissemination of cutting-edge CE knowledge, and the development of grant proposals. A series of STSMs (M.3.2) will foster collaboration in general and identify any bottlenecks. A Training School (TS)(M.3.5) will be organised for the next generation of chemical ecologists at which CE experts give presentations about gaps in knowledge and promote best practices.

Tasks	Activities
- Classify and review available CE expertise, tools, methods, experimental sites, platforms, and laboratories - Create a database of CE researchers and laboratories - Develop a methodology to promote best practices in CE research	- Initial, intermediary, and final WG meeting - One 4-day workshop - TS (8-10 days) - Series of STSMs

Working Group 4 (WG4): **Communicating about E-NICHE and disseminating its results** will take cross-thematic efforts. WG4 brings together marine and terrestrial chemical ecologists from across Europe, including junior, mid-career and senior scientists in a balanced gender ratio. This multidisciplinary WG will organise, promote, and support capacity building objectives (CBOs 1–5) through rapid and transparent communication, dissemination activities, and knowledge transfer among scientists, end users, decision-makers, and the general public (RCO 5). First, WG4 will define the identity of the E-NICHE network. It will be in charge of setting up the E-NICHE website and updating it periodically. Consequently, at E-NICHE's first meeting (M4.1), a Science Communications Manager will be chosen. This person will be responsible for boosting visibility of the network and its activities, including via the development and maintenance of the website. Second, WG4 will ensure that the resources generated by all the WGs are mobilised to promote novel scientific perspectives. Data and resources will be made available in accordance with specific stakeholder needs (bottom-up approach). WG4 will monitor and evaluate the Action's impacts on science and society. The communications plan will be updated as necessary during intermediary WG4 meetings (M4.2) (see section 3.2.2). Third, WG4 will pave the way for a long-lasting pan-European CE network. This WG is tasked with actively recruiting new members and organising scientific meetings for the entire network.

During the final WG4 meeting, the goal will be to lay the foundation for a European Society of Chemical Ecology (ESCE), an entity that could ensure the continued pursuit of E-NICHE's objectives (M4.3).

Tasks	Activities
- Publicly announce E-NICHE - Increase visibility of E-NICHE scientific activities and outputs - Disseminate scientific knowledge to target end users through reports, workshops, professional fora, and a MOOC - Monitor E-NICHE impacts - Review research needs - Promote network durability—creation of ESCE	- E-NICHE logo and templates for main documents and presentations - E-NICHE website - Media content (e.g., reports, blog posts) and newsletters - Quarterly e-newsletter - Social and broadcast media output - MOOC on CE - Open-house events - Monitoring website visitors, social media followers and interactions, MOOC attendance, and impact of (scientific) publications - Workshop minutes, reports, policy briefs to decision-makers and funding agencies - E-NICHE meetings to assemble a list of potential society members - Preliminary organisation of future ESCE (committee)

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

Deliverables for each WG, type of deliverable (output), relevant objectives (RC or CB), and timeframe. Y = year, Q = quarter.

ID	**Coordination deliverables**	**Output**	**Relevant Objective(s)**	**Time (Y, Q)**
D1.1	Inventory of existing knowledge in CE	List of standardised CE terminology	RCO 1–3	Y1, Q1–4
D1.2	Gaps and limitations in CE	Overview of constraints	RCO 2–3	Y2, Q1–4
D1.3	Solutions for addressing CE constraints	Roadmap for addressing the gaps in knowledge and methods	RCO 2,3	Y3, Q1–4
D1.4	Publications on challenges and solutions in CE	Review/opinion papers in high-quality journals	RCO 1–5	Y4, Q1–4
D2.1	Mechanisms underlying chemically mediated species interactions in diverse systems	Report	RCO 2, RCO 3	Y2, Q4
D2.2	Existing and novel CE-based methods, tools, and applications for ecosystem management and preservation	Report	RCO 2, RCO 3	Y3, Q4
D2.3	Chemical communication and ecosystem functioning in a changing world	Review paper	RCO 2, RCO 3	Y4, Q4
D3.1	Report on CE expertise, tools, methods, experimental sites, platforms, and laboratories	Report and protocols	RCO 1	Y1, Q1 Y1, Q4
D3.2	Searchable database of European CE researchers and laboratories	Database	RCO 4	Y1, Q4
D3.3	Assessment of database use, recommended improvements and updates	Database	RCO 4	Cont.

D3.4	Guidelines for CE best practices and experimental research	Handbook	RCO 1, RCO 3	Y2, Q4 Y3, Q2 Y3, Q4 Y4, Q3
D3.5	Review of research needs, knowledge gaps, and future perspectives	Reports, special issue, book chapter, and review paper	RCO 3, RCO 4	Y3, Q4 Y4, Q3
D4.1	E-NICHE identity	Logo, document and presentation templates	All CBOs, RCO 5	Cont.
D4.2	Online resources	E-NICHE website	All CBOs, RCO 5	Y1, Q2
D4.3	Communication efforts	E-newsletters, social media output, research dissemination, MOOC	All CBOs, RCO 5	Cont.
D4.4	Policy workshops	Workshop minutes, policy letters to decision-makers	RCO 5	Y1, Q4 Y4, Q2
D4.5	Review of research needs	Report, policy brief to funding agencies	RCO 5	Y1, Q4 Y3, Q4
D4.6	Establishing foundation for ESCE	Annual meeting, recruitment of ESCE members	All CBOs, RCO 5	Y1, Q3 Y2, Q3 Y3, Q3
D4.7	Impacts on science and society	Final report—E-NICHE impacts	RCO 5	Y4, Q3

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

Identified risk (R)	Contingency plan (CP)
R1: Actual producer(s) of chemical signal(s) may be challenging to determine, as much remains unknown in many systems (WG1)	**CP1**: At the very least, the literature review will point to current gaps in knowledge, which can help guide grant proposals, future research, and scientific collaborations
R2: Comparing chemical communication in aquatic vs. terrestrial ecosystems may be difficult due to the different chemical types used in air vs. water (WG1)	**CP2**: We will focus on common principles and methodologies for the two systems
R3: Identifying the biotic and abiotic factors that differ between controlled lab settings and natural ecosystems will be challenging (WG1)	**CP3:** By comparing successes and failures for CE-based biocontrol measures developed in the lab and applied in the field, we should be able to identify the key biotic and abiotic factors at play
R4: Fully reviewing the literature as required may be daunting (WG2)	**CP4:** WG2 will get feedback from all E-NICHE participants on the literature review
R5: Public-private relationships may not develop (WG2)	**CP5**: Experts in both sectors are committed to ensuring efficient knowledge transfer and information flow; the workshop will bring sector representatives together
R6: New methods, technologies, and research directions may not be adequately encouraged (WG2)	**CP6**: These topics will be the subject of regular MC and WG meetings, and various STSMs will focus on exploring novel research directions
R7: Successful communication is limited because the Action's results fail to interest potential end users and the general public (WG4)	**CP7:** The levels of interest displayed by potential end users and the general public will be regularly monitored; communication efforts will be adapted as needed
R8: Pooling knowledge from chemists and biologists working on different biotopes and biological models may prove difficult (WG3)	**CP8**: Database creation will promote knowledge and cohesion in the CE community
R9: Continuing COVID-19 pandemic	**CP9**: E-NICHE activities will be held remotely as much as possible

4.1.4. GANTT DIAGRAM

	YEAR 1				YEAR 2				YEAR 3				YEAR 4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Action management & coordination																
Action MC meetings (MCM)	Kick-off			MCM				MCM				MCM				Final FAE
Final Action event (FAE)																
WG1 - Addressing gaps and constraints in CE																
Working Group Leaders meetings	WGL 1		WGL 2		WGL 3		WGL 4		WGL 5		WGL 6		WGL 7		WGL 8	
Working Group meetings		Meeting 1				Meeting 2				Meeting 3				Meeting 4		
Workshops					WS				WS							
Training school								TS				TS				
Short Term Scientific Missions					STSM		STSM		STSM		STSM					
Deliverables	D1.1				D1.2				D1.3				D1.4			
Milestones		M1.1			M1.2	M1.3		M1.4	M1.2	M1.3		M1.4		M1.3		
WG2 - Promoting ecosystem management and preservation																
Working Group Leaders meetings	WGL 1		WGL 2		WGL 3		WGL 4		WGL 5		WGL 6		WGL 7		WGL 8	
Working Group meetings		Meeting 1				Meeting 2				Meeting 3				Meeting 4		
Workshops				WS				WS			WS					
Training school										TS						
Short Term Scientific Missions			STSM			STSM					STSM				STSM	
Intersectoral workshop																
Deliverables								D2.1				D2.2				D2.3
Milestones								M2.1		M2.2	M2.3 -M2.4				M2.4	
WG3 - Building a toolbox that includes E-NICHE resources to share																
Working Group Leaders meetings	WGL 1		WGL 2		WGL 3		WGL 4		WGL 5		WGL 6		WGL 7		WGL 8	
Working Group meetings		Meeting 1				Meeting 2				Meeting 3				Meeting 4		
Workshops						WS										
Short Term Scientific Missions			STSM		STSM				STSM					STSM		
Training school										TS						
Deliverables	D3.1			D3.1, D3.2				D3.4		D3.4		D3.4, D3.5			D3.4, D3.5	
Deliverables (continue)	D3.3				D3.3				D3.3				D3.3			
Milestones		M3.1				M3.2		M3.3	M3.4	M3.2	M3.5		M3.2		M3.6	
WG4: Communicating and disseminating the Action's results																
Working Group Leaders meetings	WGL 1		WGL 2		WGL 3		WGL 4		WGL 5		WGL 6		WGL 7		WGL 8	
Working Group meetings		Meeting 1				Meeting 2				Meeting 3				Meeting 4		
Communication & dissemination (continue)																
WG meeting on paper, report and guideline writing				WS				WS				WS				WS
Deliverables		D4.2	D4.6	D4.4, D4.5			D4.6				D4.6	D4.5		D4.4	D4.7	
Deliverables (continue)	D4.1 & D4.3															
Milestones		M4.1				M4.2				M4.2				M4.3		

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