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Summary report and strategy recommendations for EU citizen science gateway for biodiversity data

M46

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Executive Summary

Introduction

The report reviews biodiversity related citizen science initiatives in Europe, specifically the data mobilization aspect and gives an overview of citizen-science related activities in the project EU BON, the European Biodiversity Observation Network. In addition, recommendations for a pan-European citizen science gateway and data mobilization efforts will be given, with the aim of filling in existing biodiversity data gaps.

Progress towards objectives

The current report is the final product of EU BON's work on mapping citizen science involvement in biodiversity research, its challenges, opportunities and actual contribution to research outcomes. EU BON partners have reviewed and analyzed citizen science data, networks, researchers' motivation, and best practice cases. A survey was conducted in 2014 to explore citizen science involvement in biological research; the results are presented and analyzed in the report.

Achievements and current status

EU BON partners have analyzed the current situation of citizen science in biodiversity research and proposed action plan and gateway elements to mobilize biodiversity data coming from the public sector. Some of the gateway elements are developed and presented by EU BON in the framework of the European Biodiversity Portal http://beta.eubon.ebd.csic.es/home

Future developments

The recommendations for an EU citizen science gateway for biodiversity data are linked with policy toward supporting citizen science in general. As already pointed out by other EU citizen science review projects as Socientize, the future of citizen science depends on how it is prioritized in research financing programmes and how the open data policies are fulfilled.
For the sustainability of the EU citizen science gateway it has to be affiliated with active research infrastructure and/or Pan-European citizen science organizations.

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1. Introduction

This report reviews biodiversity related citizen science activities in Europe, specifically the biodiversity data mobilization aspect and gives an overview of citizen-science related tasks of the project EU BON, the European Biodiversity Observation Network. In addition, recommendations for a pan-European citizen science gateway and data mobilization efforts will be given, with the aim of filling in existing biodiversity data gaps.

Citizen science (CS) is a term which has been used to describe volunteer participation in research or activities which have scientific meaning. The exact meaning and context of the term can vary and sometimes it is used as general notion to describe interactions between science and society. “Public participation in scientific research” (PPSR), “crowdsourcing”, “participatory monitoring” and “citizen observatories” are examples of the terms which are used sometimes as synonyms and some other times covering specific aspects of the broader term “citizen science”. A definition which suits the scope of EU BON project regarding citizen science is offered by Roy et al. (2012): "Volunteer collection of biodiversity and environmental data which contributes to expanding our knowledge of the natural environment, including biological monitoring and the collection or interpretation of environmental observations”. We will use in turn this definition and particularly focus on biodiversity observation data.

1.1 Biodiversity and citizen science

Biodiversity is a widely used term, both in science and policy making. The meaning of the term is often context dependent. One of the policy-related definitions is provided by the Convention on Biological Diversity (CBD): " 'Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". For science communication purposes there are more accessible concepts for the general public when talking about biodiversity. Meinard and Quetier (2013) suggest that considering biodiversity as "learning experience" would make it more interdisciplinary and accessible. Citizens can relate to biodiversity in various ways, directly or indirectly, but for the concept of citizen science in biodiversity monitoring volunteering is an important aspect (Roy et al. 2012). In research which employs citizen science methods the largest body of articles is in biology and conservation, followed by geographical research, social sciences and health (Kullenberg and Kasperowski 2016). Within the framework of the EuMon project (EU-wide monitoring methods and systems of surveillance for species and habitats of Community interest, http://eumon.ckff.si/) four types of participatory networks were identified for biodiversity monitoring which rely on volunteering: participating in environmental tourism; virtual network organisations; national NGOs and local associations (Bell et al. 2007). Some of those networks have been active for more than 100 years, but virtual network organisations and information sharing using the internet are relatively new concepts and practices which have quickly advanced. With the rise of online nature observation portals the number of opportunistic observations that are publicly available has also been increasing.

1.2 Europe and citizen science

Europe has an active and vibrant community of citizen scientists and their organizations. CS encompasses a wide range of scientific studies, including astronomy, biology and the environmental sciences. However, research related to biodiversity monitoring is one of the most active. The EC-funded project EuMon studied EU-wide biodiversity monitoring methods and systems in 2004-2008. EuMon compiled a database (DaEuMon) of European biodiversity monitoring schemes (at the moment it counts 656 schemes) to draw a first image of biodiversity monitoring in Europe. Among other aspects the project also focused on volunteer participation (Schmeller et al. 2009, 2012). They found that of 327 participatory monitoring networks in Europe, 80% relied on volunteer help (EuMon 2016). There are several important organizations guiding and connecting CS schemes in Europe including OPAL (Open Air Laboratories, https://www.opalexplorenature.org/) from London's Imperial

College, which is a well known initiative in UK. Another important network is the ECSA (European Citizen Science Association, http://ecsa.citizen-science.net/) which was launched in 2013 as an informal network of researchers and communicators and as of 2016 is a NGO under German law. ECSA has more than 150 individual and organizational members from 28 countries (European Citizen Science Association 2016). ECSA is also collaborating with other major citizen science organizations - CSA (Citizen Science Association, http://citizenscience.org/) in USA and ACSA (Australian Citizen Science Association, http://csna.gaiaresources.com.au/wordpress/). Although there are efforts to guide and manage citizen science initiatives, an enormous number of organizations involved in this field in Europe are still fragmented by country, region, language, taxonomic interest and methodology. European Seventh Framework Programme project Socientize (http://www.socientize.eu/?q=eu) identified the challenges and solutions for citizen science in Europe and published a white paper on the subject (Socientize consortium 2014).
Furthermore, the research landscape is highly heterogenous with regard to the acceptance and engagement of citizen science involvement in research (Snäll et al. 2011, Theobald et al. 2015, Gollan et al. 2012, Kamp et al. 2016,Tulloch et al. 2013). There are also efforts of evaluating citizen science motivations, costs and benefits (Blaney et al. 2016, Hobbs and White 2012, Schmeller et al. 2009) which are useful for both policymakers and researchers. A report carried out on behalf of the UKEOF (UK Environmental Observation Framework) outlines the motivations, benefits and barriers in citizen science and suggests that there is “a need to understand how motivations differ in/between developed and developing nations” and summarises what encourages and discourages participation (Geoghegan et al. 2016).

1.3 EU BON, biodiversity and citizen science

The EU-funded project EU BON (European Biodiversity Observation Network, cf. Hoffmann et al. 2014) addresses the existing barriers to improve the biodiversity data landscape by integrating, harmonizing and standardizing biodiversity information from on-ground to remote sensing data. The global framework is set by GEO, the Group on Earth Observations and its biodiversity section, the Biodiversity Observation Network of GEO (GEO BON). Europe’s support for this initiative is currently EU BON an EU-funded project which builds on existing biodiversity information systems and infrastructures (e.g. the Global Biodiversity Information Facility, LifeWatch, LTER) thereby aims to provide improved access to integrated data from various fields.
One of the central tasks is the development of a new open access platform (called the European Biodiversity Portal) for sharing biodiversity data and tools, as well as results from current analyses. There are a number of contributions of Biodiversity Observation Networks (BONs) towards mobilizing biodiversity information for use by policy development and decision-makers (Wetzel et al. 2015). Data leveraged from various sources are standardised and integrated by BONs (e.g. application of standards, creation of data and knowledge products, modelling), whilst ensuring alignment with policy needs hence making biodiversity data discoverable, accessible and processable.

For EU BON citizen science is a vital element with regards to biodiversity information sources that provide data for research and policy-making. CS data are used by many research institutes, public organisations and local data portals (see **Appendix 1**). CS data offer volumes of field data, which would otherwise not be possible to collect with the limited resources of research institutes and agencies. Thus one of the main targets for EU BON is to make CS data available through various efforts, for example through networking and by using new technologies for data mobilisation (EU BON consortium 2016). As the data quality is one of the main concerns about data collected by volunteers, EU BON has also evaluated existing solutions to improve the quality of biodiversity data, mainly by developing best practice examples or tools for citizen science projects in cooperation with other citizen science initiatives. Cooperation will help to avoid duplication, collectively work on data standards and distribute knowledge of tools and best practices. Overall, one of the main goals of a common EU Citizen Science Gateway is to integrate CS data for European biodiversity research. EU BON also seeks to develop a strategy for achieving this goal and encourages educational aspects of citizen science through networking and the development of tools.

1.4 EU citizen science gateway for biodiversity data

With the growing interest of citizens to contribute and participate in scientific research a huge variety and number of CS initiatives emerged. In parallel, the mobilization of citizens to participate in scientific research creates a growing need for systematized, standardized creation of workflows for citizen science data in order to generate scientific knowledge.
A range of CS projects are already active or just recently started their activities and many of them want to learn from existing knowledge, experiences and best practices already gained in former projects (see an EU BON analysis of the current biodiversity data and project landscape in **Appendix 1**).

EU BON has identified the need for the action plan for pan-European citizen science gateway. The EU citizen science gateway for biodiversity data is in essence a CS network for biodiversity information. It offers information for CS project leaders, project members and citizen science stakeholders (environmental agencies, municipalities, educational institutions, NGOs etc) in Europe. The EU BON proposed CS gateway includes a wealth of information on CS project designs, standards in use, directories of projects and SC data providers (**Appendix 2**) as well as guidelines with an option for project leaders to improve their own projects, data and workflows.

The EU BON citizen science gateway builds on many existing initiatives and one of the tasks of the work in EU BON was to provide additional support for the networks and projects in order to overcome existing limitations and problems. One of the main data providers for biodiversity data is the Global Biodiversity Information Facility (GBIF) that also offers a quite significant amount of CS data. To make publishing in GBIF easier, EU BON offers centralized entry points for data holders - as an instance of Integrated Publishing Toolkit and PlutoF biodiversity data platform.
There are other portals that offer CS data but they have some limitations for European stakeholders: for the USA there is a portal called Scistarter (https://scistarter.com/ , LLC 2016) but only few European projects can be found in this database. For example a search on CS projects from France, Germany or Spain returns no results (search performed in September 2016). The portal has an interface (API) for providing machine-readable data and thus has strong appeal for stakeholders with easily accessible project metadata. Another portal for CS projects in the USA is CitSci.org (Colorado State University 2016), which provides a platform for managing projects, collecting and visualizing data and communicating with collaborators. The platform has an international focus, but there are only six projects from Europe listed (as of 2016) and most of them not active. Also the European Environmental Agency posted a list of biodiversity observation schemes that use CS methods on their website (European Environmental Agency 2013), however, many initiatives are not listed. The EU BON Citizen Science gateway will close this knowledge gap and provides updated information on the CS project landscape in Europe.

In this deliverable we focus on different aspects of the work in EU BON that are related to citizen science:
(a) Experiences in linking networks and main actors of Citizen Science on a European scale (Chapter 2),
(b) Work on data governance and data requirements: data standards, quality and intellectual property rights (Chapter 3),
(c) EU BON citizen science gateway as a model for improving the European CS data landscape (Chapter 4),
(d) Conclusions and recommendations for the European Commission.

2. Experiences in linking networks and main actors of Citizen Science on European scale

2.1 Challenges for European citizen science networks

An important task of the Citizen Science gateway is, in addition to provide tools and the technical infrastructure, to establish cooperation between the main actors of CS on European scale. There are many projects, initiatives and networks that focus on citizen science or that involve citizen scientists, for example in data collection and monitoring of species. Best practices, experiences and tools should be shared, discussed and further developed and common approaches are needed in order to avoid duplicating efforts. Other challenges, specifically for citizen science data exist and common solutions need to be established that could be only found by a close cooperation of networks, projects and individual researchers and citizen scientists.

Citizen science is highly relevant to European biodiversity networks, not only for exchanging knowledge and actively engaging citizens in biodiversity related issues but also for obtaining valuable data that can be used for science and policy (e.g. reporting). For example, monitoring programmes rely heavily on the participation of citizen scientists. The EuMon project documented 395 monitoring schemes for a set of taxonomic groups (plants, birds, amphibians and others). These monitoring schemes alone involved more than 46,000 persons who contributed over 148,000 person-days/year to biodiversity monitoring activities (Schmeller et al. 2009). Another study showed that in 388 projects around 1.3 million volunteers participated with an estimated in kind-contribution of US$2.5 billion (Theobald et al. 2015). However, a lot of data from citizen science cannot be used yet. In an EU BON workshop it was shown that lots of data generated by citizen science projects cannot be used due to data usage restrictions. For example, of 560 million records of species occurrence data, only 100 million are available via GBIF (see **Fig. 1** for the publicly shared CS data, **Appendix 2** for a more detailed overview). This finding is also supported by a recent study showing that only 12% of the citizen science projects provide evidence that data are used in scientific research (Theobald et al. 2015). Even when those data are shared they tend to be licenced with more restrictive terms (Groom et al. 2016).

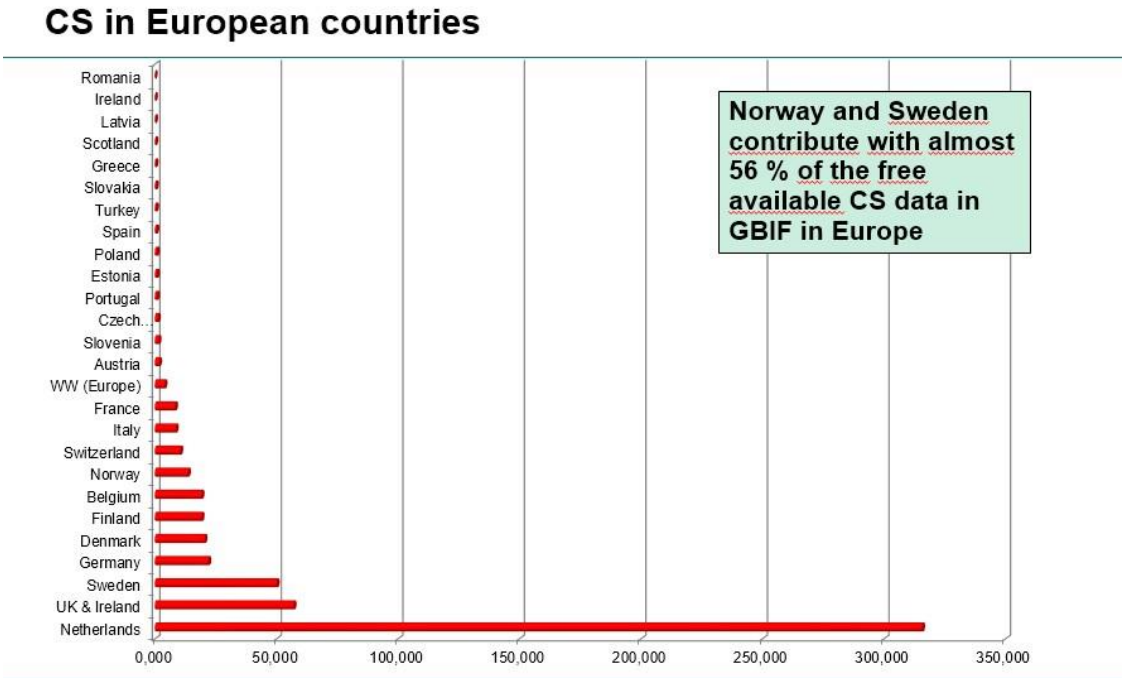


Figure 1. Publicly shared CS data in Europe. (produced by Nils Valland, 2016).

These cases illustrate that considerably more data could be made available with the help of projects such as EU BON. To achieve this, good communication and exchange of ideas within CS networks and with other initiatives and projects are needed. The individual researchers need appropriate tools for data mobilization; they need databases where the data can be hosted and curated and where quality control can take place. Finally they need help in making the data openly available, for example to GBIF or to open repositories such as Dryad or others to ensure that data will become discoverable in the GEOSS data portal (www.geoportal.org). A central aspect of the networking is to spread the word on data standards and enhancing open access, so knowledge about existing approaches for open data were disseminated. For example information on the GEOSS data sharing principles that demand that data, metadata and products are shared openly, made available with a minimum time delay and that data is free of charge or no more than the cost of reproduction.
Data mobilization is also important as many data gaps exist on a European scale with regards to biodiversity information. An EU BON analysis of data mediated by the Global Biodiversity Information Facility (GBIF), one of the most important European and global mediators for biodiversity data, shows that data are still biased, for example, there are spatial gaps in Eastern European countries (Wetzel et al. 2015). These gaps, along with taxonomic and temporal gaps, need to be filled in and citizen science projects could tremendously help to this end. A first step could be the mining of existing CS projects for their observation data. A good starting point is the EuMon database of biodiversity monitoring schemes which provides rich metadata for projects. One of the discussed topics was to generate an overview of existing citizen monitoring initiatives. This task was later followed in the course of designing the citizen science part of the biodiversity portal, e.g. by listing major citizen science data providers in Europe. Another open task is also to find strategies to leverage additional data, e.g. to fill the existing large gaps in genetic datasets (Geijzendorffer et al. 2015). So, data mobilization remains an important topic, also to fulfill national, regional and international reporting obligations, for example for monitoring progress on the Aichi biodiversity targets of the Convention on Biological Diversity (CBD 2014).
Data quality is another important topic that needs to be focused on when dealing with citizen science projects. Generally it was shown that CS initiatives can provide an important data source for research, for example eBird data has been used in at least 90 peer-reviewed scientific articles on climate change, ecology and other types of research (Bonney et al. 2014). However, data quality filtering mechanisms are needed as particularly unstructured citizen science data is often not suitable for analysing species state and trends or is generating mismatching trends (Kamp et al. 2016). Solutions for this are available and wait to be adopted by portals and the CS community, e.g. by promoting data curation platforms and mechanisms ensuring a high data quality (e.g. by expert validation as conducted e.g. on the Norwegian Species Observation System (NBIC 2016)).

2.2 Linking CS related data, projects, stakeholders and networks in EU BON

Many initiatives, projects and networks in Europe are already collecting, integrating and engaging citizen science based biodiversity data and activities. One group of stakeholders are end-users of the generated data (e.g. researchers, governments and political administration), another one are volunteers and citizen scientists and both groups have their own interests, intentions and aims they follow (cf. Pocock et al. 2015).

A major task for the EU BON Citizen Science Gateway is to improve CS data workflows from data collection to facilitate and enable data analysis and dissemination of the results. Products and tools that were developed and implemented by the EU BON project are available on the EU BON biodiversity portal and can serve this purpose. Exposing these tools and technological infrastructure will improve the frameworks of biodiversity related CS data workflows in Europe. In parallel, and not less important, is to verify aligning with requirements of the various stakeholders to harmonize with the activities of the other major players in citizen science.

As mentioned before, the European Citizen Science Association (ECSA) is an important player in CS networking, a non-profit organization to foster citizen science activities on a European scale. Over 150 individual and organizational members from 28 countries participate in the report with the main aim to link citizens and science (ECSA 2016). In ECSA there are several thematic working groups focusing on different aspects, for example a ‘ Sharing Best Practice and Building Capacity’ Committee, a ‘Citizen Science and Responsible Research and Innovation’ Committee or a ‘ Projects, Data, Tools,

and Technology' Committee. The latter focuses primarily on issues that are connected to the data collected by citizen science initiatives and hence central aspects of the work are on data interoperability, reliability and intellectual property rights (ECSA 2016).This working group shares many topics that are also relevant for the EU BON CS Gateway and a particularly tight collaboration and exchange was foreseen and carried out with this working group.

GBIF currently provides access to over 623 million occurrence records globally (as of September 2016) hence became a major player and leading facilitator in providing open access to data on global scale. GBIF promotes open standards and free tools for biodiversity data management and exchange (see more for example on the GBIF Integrated Publishing Toolkit (IPT) in this deliverable). Among sources of GBIF-mediated citizen science data are networks and tools such as eBird (more than 150 million observations worldwide), iNaturalist and others (e.g. anymals+plants, Diveboard, Scandinavian networks). Many European countries provide considerable amounts of citizen science-based data in GBIF (see **Fig. 2**). One of the tasks in the data workflow is also to make data that was mobilized by EU BON available in GBIF, hence a close collaboration is the key. One of the achievements of the project is the development of a spatial dataset browser and a species trends visualization tools that are part of the work of the European biodiversity portal. These tools help to visualize CS-derived observation records and also increase the discoverability of data.

GBIF citizen science records by top European publisher countries

Country	Count	Rank
SE	41630932	1
GB	21905500	2
NO	16564959	3
FI	15847030	4
DK	6628842	5
DE	5390347	6
IE	2316795	7
BE	1625973	8
NL	1386167	9
EE	921998	10
FR	578567	11
ES	561098	12
PT	257531	13
CH	151680	14
AT	16469	15

Figure 2. Citizen Science Data on GBIF ranked by countries (GBIF 2016)

Many European projects are contributing biodiversity data by involving volunteers that help in data collection and processing. Also there are sometimes similar efforts to integrate data and develop tools. A close link to ongoing projects in the field of CS is needed to avoid duplication of efforts and to find synergies among the projects. There have been specific EU-funded projects with similar intentions on building networks and harmonizing data. For example citizen science observatories - community-based environmental monitoring and information systems, in order to stimulate novel Earth observation technologies, exploiting capabilities of portable devices and collective intelligence and to enable participation of citizens in local stewardship. A closer exchange was conducted with three of the five citizen science observatory projects; moreover a more formalized cooperation was

initiated with the project Socientize by signing a Memorandum of Understanding with the EU BON consortium. The EU project Socientize had an open and collaborative approach by coordinating and linking participatory projects and actively engaging scientists and citizens that contribute with their knowledge and resources. Another EU project with a closer linkage was Citclops (http://www.citclops.eu/), a project on water monitoring and participatory science. In this project, citizens participated in the collection of environmental data, i.e. water color, transparency and fluorescence, by using smartphones and low-cost sensors in coastal and oceanic areas. Aim was to improve governmental environmental observation systems in order to improve current (political) decision making. Another EU project was COBWEB, the Citizen OBservatory WEB, (http://cobwebproject.net/about) for crowd sourced environmental data that was collected by citizen scientists with mobile devices in UNESCO biosphere reserves. These projects were all programmes funded under the 7th research framework and discussion took place on technological and data workflow issues.

Generally, it is interesting to put a specific light on the biodiversity data generated in citizen science projects. As an EU study shows, more than half of the projects last for more than 4 years, which indicates that these projects could potentially produce data and time-series for detecting changes over time, i.e. for producing long-term time-series (Schade and Tsinaraki 2016). Also open access is still an issue, as 26% of the respondents answered that the data from their projects are not available for re-use, however, also sustainable storage and access to data is an issue as 42% of the project respondents replied that access will only be guaranteed within the project's lifetime and in most cases the Citizen Science data is stored on a remote server that is hosted by a project member (Schade and Tsinaraki 2016).

An important way to facilitate exchanges between main actors and interest groups in EU BON were the Stakeholder Roundtables, a series of four meetings that aimed to enable discussions among relevant stakeholders (**Fig. 3**).

For the citizen science related tasks (Vohland et al. 2016), such meetings and roundtables are needed for:

- generally for connecting EU CS initiatives and networks and to allow feedback on the different approaches and exchange of ideas and strategies,
- finding solutions for existing problems (filling data gaps, workflows from data collection to analysis and dissemination, development of tools for data collection and curation),
- derive success factors of citizen science projects (lessons learnt, guidelines and methods to obtain adequate and high quality data),
- share best-practice examples from existing projects in different levels (from the project level to policy recommendations),
- facilitating new (technological) developments of portals, tools and databases by joining forces.

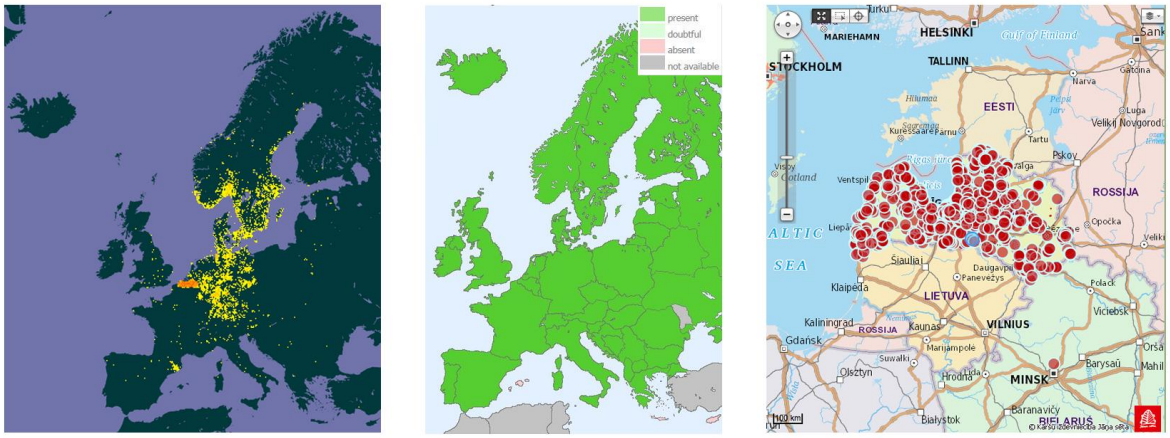
Figure 3. Break-out group discussion at the 2nd EU BON Stakeholder Roundtable (Credit: Florian Wetzel)

During the roundtables, citizen science subjects were discussed in many working groups, world café sessions and are part of products of EU BON, e.g. in the European Biodiversity Portal. One of the roundtables particularly addressed this topic, i.e. the 2nd EU BON Stakeholder Roundtable that took place in Berlin in November 2014 with the title *"How can a European biodiversity network support citizen science?"*. At the roundtable, various stakeholders from the field of citizen science were invited to discuss possibilities of interactions and the role of EU BON for supporting citizen science on a European scale. Addressed stakeholders were different citizen science projects, researchers and biodiversity networks.The aim of the roundtable on Citizen Science was to explore how and with which means EU BON can support citizen science activities and to connect the projects of EU BON consortium partners with other European initiatives. The project may act as data portal to find the right data base for the data, EU BON may provide tools to visualize and interpret data, EU BON may provide tool to assess the quality of data and link it to broader information pools such remote sensing data or modeling information. However, also the citizen science community was asked what it expects from EU BON.

The discussions and linkages at the roundtable were an important kick-off for the further work with other networks, such as ECSA and connections to other projects. In the course of the project, some important recommendations were drafted and experiences shared that helped to improve the citizen gateway approach. Overall, a tight exchange with stakeholders, e.g. citizen science projects, networks and initiatives is needed in order to include feedback mechanisms to adapt the original plans that were foreseen when writing project proposals. However, particularly in the rapidly evolving field of citizen science, European projects and web-based technology, such as smartphone applications it is important to conduct such feedback loops for adaptive management and reducing the duplications of efforts with regards to theoretic frameworks, infrastructure and technology.

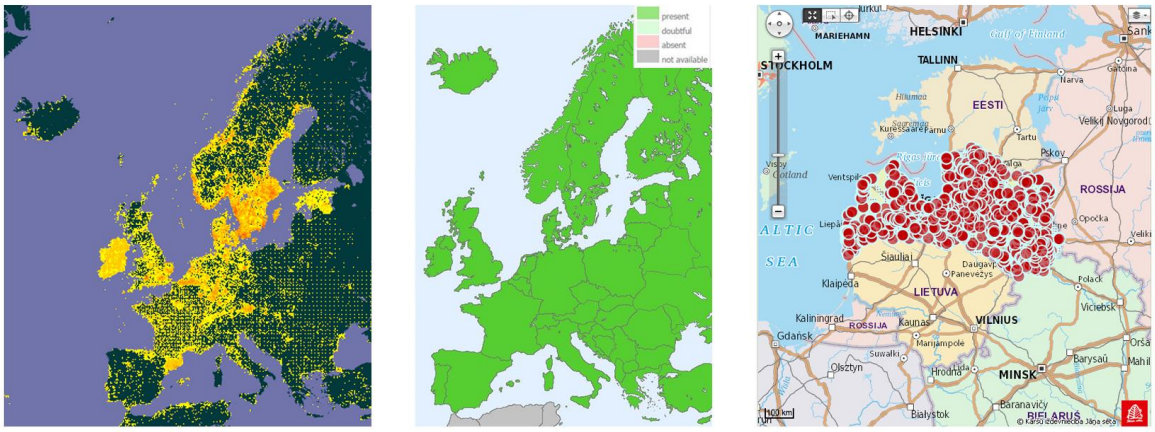
2.3 Citizen Science networking recommendations for Eastern and Central Europe

Biodiversity data from some regions of Central and Eastern Europe are still only partly shared to global infosystems and is often fragmented, as identified by the EU BON project (Deliverable D1.1, biodiversity data gap analysis, Wetzel et al. 2014). This is evident when looking for data on common European species. Global biodiversity data portals such as GBIF reveal data gaps which for some taxon groups are very noticeable when compared to the species distribution maps compiled by experts of Fauna Europaea. At the same time there exist national CS portals which show rich data that is not integrated with global systems (**Fig. 4, 5**). The reasons for data sharing restraints still need to be examined. In addition to technical or infrastructure hindrances for data sharing there can also be problems with volunteer motivation. Volunteering for biodiversity monitoring in Eastern and Central Europe has in some cases been influenced by socio-political background of these countries (Bell et al. 2011).



A. B. C.

Figure 4. Peacock Butterfly *Aglais io* (Linnaeus, 1758) occurrences visualized in GBIF portal (A), distribution map in Fauna Europaea (B) and occurrences in Latvian national observation portal dabastati.lv (C).



A. B. C.

Figure 5. European Starling *Sturnus vulgaris* (Linnaeus, 1758) occurrences visualized in GBIF portal (A), distribution map in Fauna Europaea (B) and occurrences in Latvian national observation portal dabastati.lv (C).

To draw focus on the potential of CS for biodiversity data mobilization, EU BON project organized a workshop specifically aimed at Eastern and Central European countries. During the Citizen Science workshop in Tartu (Estonia) that took place from 27-28 June in 2016, the participants analyzed how people and institutions that work on citizen science could more effectively collaborate, how they could share their data efficiently and what useful best practices exist. Participants identified solutions for better networking. For effective collaboration there is a need for improving the knowledge base. In order to achieve this goal, it was proposed to develop a special training program that could be organized by recognized expert organizations or institutions (like the European Citizen Science Association). For local counseling a solution could be to appoint a “community manager” or middleman (facilitator) who can advise both researchers and project managers how to communicate with volunteers (participants) in the best way, and to advise which methodology and standards should be used for data handling. Training of such community managers could be supported by European central institutions and ECSA could also be involved. Although bottom-up initiatives should be encouraged and are crucial for a long-term sustainability of citizen science, the countries with only little history of community-based research initiatives would benefit from top-down approach for building up the knowledge base and assistance network for citizen science. The existing networks of knowledge like schools would be a possible solution for citizen science community hubs. Data sharing is an important part of keeping citizen science approaches sustainable to ensure a long-term availability of data and in order to close temporal gaps of data. In order to reuse and harmonize data, it will be crucial that CS projects apply standards to enable data integration and interoperability. However, the ultimate challenge for any initiative is securing the funding. Clear funding mechanisms for citizen science can help to start new projects with strong predisposition for success so there is an urgent need for enhanced funding mechanisms from national governments and the EU. The most important players in the CS network that were, identified at the workshop are policy makers, key scientists, NGOs and opinion leaders - all these need to be involved for establishing successful CS initiatives in Eastern and Central European countries.

3. Data governance and requirements: data standards, quality and intellectual property rights

3.1 Data governance

Data governance in biodiversity research starts with the data collection and ends with the data use and data analysis. But also the visualization of data is an important part, and projects developed visualization tools which allow an easy data presentation for different stakeholders. Data collection starts with designing data forms, developing observation portals or mobile applications. Working with

citizen scientists also includes the communication of data collection methods to participants. Storing data by research institutions or government agencies need substantial resources for technical equipment, software and IT specialists and also for the provision of data to data mediators, for example to GBIF, trained people are needed. This also demands resources for maintenance and development of IT systems. A common data governance system from CS observation to GBIF data repository and stakeholders is depicted in **Figure 6.**

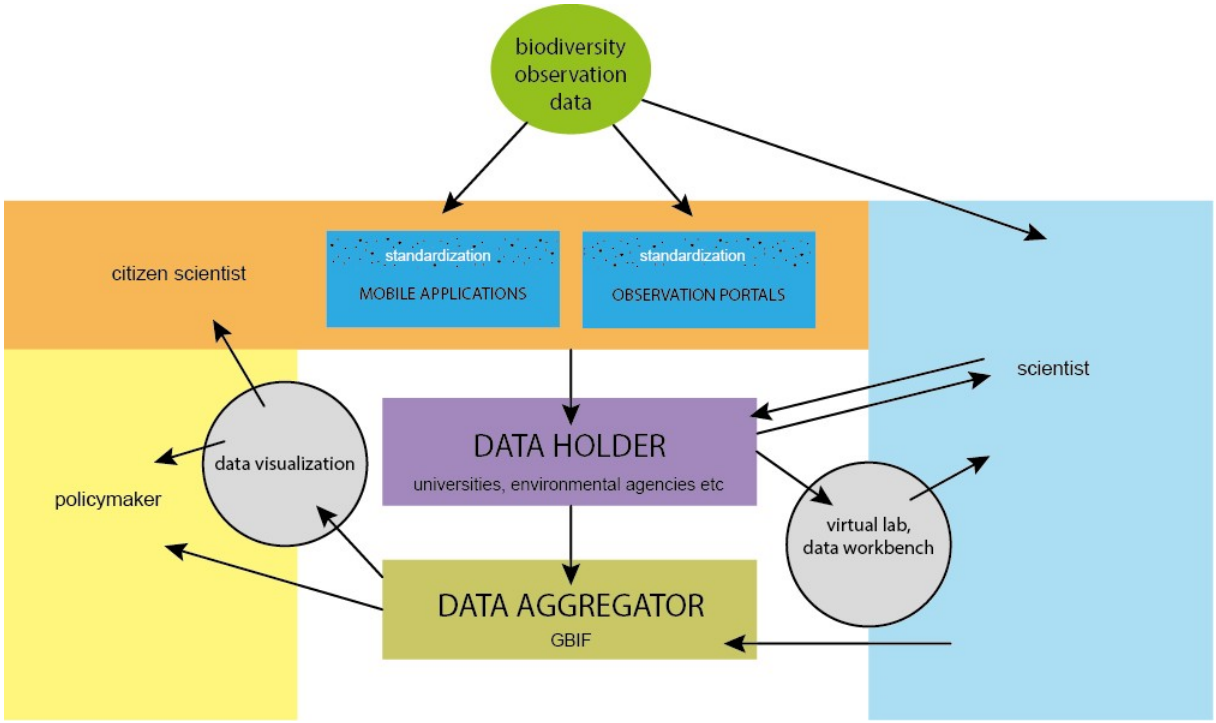


Figure 6. CS data governance with GBIF infrastructure

3.2 Data standards

An important aspect of data standards relates to the question of how citizens collect data and how reliable and repeatable they are. Sporadic reports of one species or another may be valuable, but any form of comprehensiveness and repeatability increases the quality of the data collected. Systematic monitoring schemes put particular effort into harvesting repeated observations, with known (or set) sampling effort, of all species at a given site. Data are much more scientifically valuable if they come from the same sites, multiple times within the year and over multiple years. Furthermore, such data can be improved with reports that include all species, preferably with an indication of abundance, because this open the route for key ecological analyses including population trends, changes in community structure and other metrics related to of populations, species and communities that form key EBVs (Essential Biodiversity Variables). Such data are illustrated in the examples of systematic monitoring of birds and butterflies.

Biodiversity data are highly heterogeneous due to the high diversity of observed taxonomic groups, the observation methods used and the different data types. Ensuring data interoperability was also one of the central aims of the EU BON citizen science gateway. There is an urget need for data standardization, and the standardization and data aggregation has to be done in such a way that it is both human and machine readable.

In the biodiversity research community the need for a common ground in terminology has created a well-known and broadly accepted standard called Darwin Core (DwC) with a set of terms with clearly defined semantics (Wieczorek et al. 2012). The DwC standard was developed and formalised by the Biodiversity Information Standards group (TDWG) and ratified in 2009. At first it mainly addressed the needs of natural history collections but later the scope was extended to documenting species occurrences in general. In March 2015, TDWG ratified changes to DwC standard that enabled it to

express sampling-event datasets. These data derive from environmental, ecological and natural resource investigations that follow standardized protocols for measuring and observing biodiversity (http://links.gbif.org/ipt-sample-data-primer). The DwC standard not only facilitates the interpretation of data in a unified way but also to publish it.

The Global Biodiversity Information Facility (GBIF) Integrated Publishing Toolkit (IPT) (http://www.gbif.org/ipt) is a free open source software tool that can be used to publish and share biodiversity data (Robertson et al. 2014). In September 2015 GBIF released a new version of the IPT (v2.3) allowing publication of sampling event datasets (http://www.gbif.org/ipt/releases). The IPT publishes datasets in Darwin Core Archive (DwC-A) format, which is a compressed set of files based on the Darwin Core terms, and the GBIF metadata profile built using the Ecological Metadata Language (EML). Many citizen science biodiversity projects and initiatives also manage data in compliance with DwC. The well known international citizen science initiative eBird publishes their datasets regularly to GBIF using the IPT. iNaturalist also publishes their dataset to GBIF in DwC-A format, however, they use their own software to do this. Certainly for small CS projects it could be technically more challenging to manage standardized data publishing on their own. Using existing tools such as the IPT, biodiversity monitoring applications or building applications that rely on well-established biodiversity databases via an application programming interface (API) can ease the pressure on data interoperability management. EU BON promoted also with regards to its CS activities the use of DwC and the provision of data to GBIF and training events were held to teach participants in the use of the GBIF IPT tool and in uploading standardized data.

There are also other biodiversity data standards which are relevant for citizen science, for example Access to Biological Collections Data (ABCD).

Standardized metadata are another important aspect to achieve interoperability and to enhance the usefulness of data. The Ecological Metadata Language (EML) is a widely used metadata standard for biodiversity data. Metadata describes the underlying basic features of a dataset for its identification and helps to increase data discovery, e.g. by providing information on when data was collected, where it was collected and by whom etc.

In addition to biodiversity data standards the citizen science itself is also subject to standardization regarding its metadata. Although numerous surveys have been conducted on testing and employing the mechanisms on citizen science projects to ensure scientific quality, a recognized framework of standards for projects hasn't been formalized yet. There are quite many inherent differences among the citizen science projects with regards to their structure, timespan, volunteer motivation and qualification etc. Due to the diversity of the projects, a standardized evaluation of the projects and data is quite challenging. Hence, the standard metadata for CS must include a broad range of field terms to ensure full coverage. Worth mentioning is a new initiative (PPSR_CORE where PPSR stands for “public participation in scientific research”) by the Citizen Science Association (CSA), an international working group which organized to form a core set of metadata fields as a first step towards obtaining standardized (meta)data on CS projects. Currently, the list of proposed metadata fields is focused on CS project definitions, statuses, participants, training etc. This is a first start for a proper CS project description. However, additional standards are needed, for example on CS data quality and validation methods.

3.3 Data quality and validation in Citizen Science

Public participation in scientific research and the use of volunteers helps to collect an extensive amount of data across large areas and over a long time span. However, data quality remains a primary concern for the research community as the data come from a large and often unknown population of volunteers with different levels of expertise (Conrad and Hilchey 2010).

A plethora of different methods, models and mechanisms exist that aim to enhance the reliability and thereby quality of community-generated data in citizen science. Most projects that have high quality standards employ multiple mechanisms to ensure data quality and appropriate levels of validation. An approach of the data mobilisation in EU BON is also to improve data quality in CS data, so basic error

sources of the biodiversity data were analysed and improvements and recommendations in order to enhance data quality were collected:

There are several error sources that negatively affect CS data quality, such error sources are for example:

- Errors in the identification of species, i.e. a misidentification of many species by the data collectors,
- Inaccurate measurements in the field (e.g. geolocation of observations, environmental conditions),
- Inadequate sampling design.

In addition to the pure methodological errors, often there are biases in data collection, especially for sporadic data, with a well-known tendency of observers to report on rare rather than common species, and especially to report unique observations - i.e., when species are observed out of their distribution area or period of occurrence. These create “conceptual errors” that require consideration by data users.

There are also different means to improve data quality that could be categorized by measures that take place before, during and after data submission.

The non-exhaustive list of measures to increase data quality includes:

- standardize sighting and monitoring protocols, designed by professionals: this is one of the key means to ensure highest data quality, and one which requires highest attention - as with good (and known) standards one can use even the simplest data,
- training workshops during the recruitment of volunteers,
- providing introductions and educational materials in order to improve the skills of the participants,
- regular monitoring of the performance to ensure that training and sampling design remain adequate,
- employing online data entry forms with automated error checking capabilities,
- screening and validation of potentially erroneous observations,
- developing smart filters to identify potentially erroneous observations,
- employing a confirmation process by expert reviewers,
- deploying query based algorithms on historical data to flag species that are reported out of its usual distribution range,
- using mobile applications that allow automated entries such as of geolocated specimens associated with a species sighting.

Citizen-science projects must apply standards for all phases of the data workflow. Standards must become widely accepted as a valuable research tool also for volunteer-generated data where a large number of people participate that have a varying level of expertise. Within the context of biodiversity-related projects, standardization is needed for the taxonomic identification, for monitoring and sampling protocols, for confirmation protocols as well as data fields and formats (e.g. date, time, units) and geolocation. For a validated, confirmed dataset which is targeted for data publication, the next step of standardization would be to qualify it for publishing with a standard biodiversity publishing tool, such as the GBIF IPT. This process involves the mapping of data-fields to comply with standards such as Darwin Core (DwC) or EML. The result is the provision of interoperable data, see also the GBIF manual and guide (http://www.gbif.org/resource/80509).

3.4 Data access and intellectual property rights

Factual data, such as collected by citizen science projects, is not subject to intellectual property rights (IPR) regulation as such, since it is not a ‘creation of the intellect’. Reuse would however still require an examination of the data to ensure it does not contain copyrightable work, and a database as a whole may be assigned *sui generis* rights. A license (or waiver, in the case of no imposed restrictions)

serves to signal any potential end user the terms under which the data may be reused indefinitely. This enables especially the use of large, compound “big data” datasets but requires the permission from the citizen scientist as the data provider. It is therefore advisable to implement a licensing policy, taking into account the purpose of the data that is to be collected.

GBIF summarizes its mission as that of making biodiversity information “freely and universally available for science, society and a sustainable future” (http://www.gbif.org/what-is-gbif#vision), an objective that was hampered by the use of non-standardized (free text) requirements that were imposed on data usage. In order to enhance the reuse potential of GBIF mediated data and to give both data providers and users more clarity on usage rights, all owners of occurrence datasets published through the GBIF network were required to assign to all datasets one of the following three standardized licenses or waivers:

- CC0 1.0, under which data are made available for any use without restriction or particular requirements on the part of users
- CC BY 4.0, under which data are made available for any use provided that attribution is appropriately given for the sources of data used
- CC BY-NC 4.0, under which data are made available for any use provided that attribution is appropriately given and provided the use is not for commercial purposes.

As of August 2016, datasets that were not assigned one of these licenses were no longer distributed through GBIF. This caused a decline in GBIF mediated data of 48.7 million records (7.5 per cent of the total number of records), because several data publishers did not select one of these licenses for their data before the deadline expired (GBIF 2016).

The GBIF case illustrates the trade-off between larger amounts of data due to a liberal licensing policy towards the data provider in which usage restrictions can be applied freely, and a policy limiting the restrictions a data provider can place on the data in order to accommodate reuse of especially larger datasets. At the same time it illustrates the difficulty of altering licensing policies at a later stage, as this requires data providers to reconsider the limits they wish to impose on usage by others and communicate their choice. It is advisable to specify the objective of the citizen science project and implement a licensing policy in line with this objective from the onset of the project. Within the scope of the EU BON project the emphasis lies on making reuse of biodiversity data both easy and legal, resulting in the recommendation of the CC0 waiver and the CC BY license (Penev et al. 2016).

4. The EU BON citizen science gateway - A model for improving the European CS data a project landscape in Europe

The EU BON citizen science gateway also led to the development of several products in order to obtain an enhanced knowledge on CS biodiversity data, as well as to provide useful tools and key infrastructures for citizen science projects and researchers. Firstly, the EU BON citizen science gateway provides, via the EU BON European Biodiversity Portal, an overview of existing citizen science data providers (Chapter 4.1), in the course of the project some mobile phone applications were developed to collect and upload CS data and in order to make standardized biodiversity data accessible (Chapter 4.2, for example “I saw a butterfly” and PlutoF mobile phone applications), and a directory of citizen science tools that give an overview of valuable and useful tools for CS projects (see Chapter 4.3).

4.1 CS data providers and the role of the EU BON CS gateway

Biodiversity data that was collected with the help of citizen scientists come from many different initiatives and projects. To give an overview of potential CS data sources, EU BON developed an overview of CS-based datasets that not only lists valuable CS data, but also gives additional information on the data providers itself. The list of data providers include leading CS-based biodiversity observation data providers and gives information, e.g. on the origin of the data (e.g. management, collections), type of taxa included, number of records, number of rapporteurs.

The source list of the data providers is managed via the PlutoF platform (https://plutof.ut.ee/#/reference/view/4533 registration needed first) and the list is accessible via the EU BON portal citizen science gateway. The last-updated time of each item in the list is displayed as well as a link to provider's site and email. To ensure the further sustainability of this list, the information on the CS providers is kept in the PlutoF database. There is an option for a multiple user access and data management via the PlutoF workbench, so the workload can be divided and additional collaborators can be invited. PlutoF is used as a workbench and a repository for the data. It is part of the science infrastructure for Estonian research institutions and is being developed and maintained by the University of Tartu Natural History Museum. PlutoF also provides a data endpoint for the EU BON portal to publicly display the list of CS data providers. Maintaining the list is an ongoing task in the EU BON project, needs a dedicated data manager to update current information on providers and data availability. Data integration with PlutoF and EU BON portal will also require technical assistance to periodically check for possible issues and to resolve them.

4.2 Mobile apps empower citizen science

A key task of EU BON was the development of mobile phone applications (“apps”) for the citizen science data collection, for example “I saw a butterfly” for sporadic data collection, or two apps for systematic monitoring. One app was developed to deliver data for “Butterfly Monitoring Schemes” or amphibians, another app was created to collect data stored and curated in the PlutoF database.

There are several reasons that stress the need for the development of mobile phone applications. A survey among the Butterfly Monitoring Scheme (BMS) members reveals that a main barrier in reporting is the time-consuming insertion of data by typing. This compromises in many cases the accuracy of the reported data, both in terms of spatial accuracy and additional information such as altitude, temperature or humidity. Mobile devices equipped with high-end applications can resolve many of these barriers based on the design concept of obtaining a maximum amount of data with minimum typing while allowing volunteers to focus on observing rather than typing. The concept involves getting automatic and implied data, thus relying less on user skills. Here are some examples of these practices, currently in use for bird and butterfly monitoring:

- GPS is constantly activated and provides information on the spatial location (coordinates) as well as on altitude, spatial accuracy, exact date and time for every reported specimen,
- Activation of camera enables adding documented records, improves validation capacity and may further contribute to learning about host plants and habitat,
- Weather data can be extracted both directly by the application and indirectly by linking to weather models or nearby meteorological stations,
- Speed of advancement on terrain can provide a measure of sampling-effort (e.g. for transect monitoring),
- Using a standard species list as a reference, resolves typing errors and taxon mismatch,
- Enabling profiled-based species list, e.g. by country, region, season or ranking of species according to “most observed”, eases the typing and enables on-the-ground validation (e.g., feedback to observer if reporting a species out of its season or distribution range),
- A simple guide (pictures, basic info) can aid identification (may also enhance the interest of volunteers in the application, and useful for learning and self-validation),

- For species not easily identified by sight, the guide may include audio files (and consequently the app should allow for audio recording of the subject) or images of the spoor or other relevant information.

There are some recommended design consideration for mobile applications, that were also implemented in the EU BON CS applications (for a list of the recommended design considerations, see **Box 1**).

Box 1: Design consideration for mobile applications that were also implemented in the EU BON CS applications

Basically there would be two different schemes for the app, one for sporadic recording and the other for systematic monitoring.
Following is a (non-exhaustive) summary of proposed topics and requirements to be considered for the design and handling of data-flow between apps and the EU BON Citizen Science Portal:

Minimum support of platforms:
- Android, iOS

User management/assistant:
- Observer receives User-ID upon registration plus limited access-writes to edit his/her own data.
- Provide users with common-names (Nomenclatural) to select from in addition to scientific names
- Multilanguage support

Quality Management (App side):
- Basic data validations (e.g. numeric values)
- predefined set of required fields according with a selected protocol,
- minimum typing (e.g. select from list of specimens).
- use standard taxonomy lists (e.g PlutoF taxonomy backbone)
- profile based lists e.g. by country, season etc.
- allow taking pictures for documentation

Communications (App to Server/Database):
- Http-based/post (preferred) , data export per sight (no batch mode)
- Employ server's API for data validation, writing to database, import and save pictures
- network links, to be serviced by the Citizen Science Portal (e.g. to GBIF)
- enable offline recording (Autosave data locally on device memory if communication fails)

Database (server side):
- database platform - MySQL, PostgreSQL , MS-SQL, etc
- taxonomy standards of species lists - ITIS, IOC etc
- configuration/scheme to support publishing to GBIF (DwC metadata field names)
- honor licenses (data and multimedia ownership, sharing etc)

Server application (optional):
- User interface – enable observers to edit their own data
- Sighting approvals - by expert, with feedback to observer
- Quality Management - alert sightings which are out of distribution range, season etc.

We note that is important to allow volunteers in systematic monitoring to report also "no butterflies observed", in order to ensure that a visit to a site is recorded.

4.3 Directory of citizen science tools

Over the past years there have been many projects and initiatives which have produced very useful internet-based tools and guidelines for citizen science. EU BON gathered a selected list of them in the form of a directory. The tools presented in the directory are searchable by tags which cover topics such as biodiversity data management, project management, publication, taxon identification etc. The 'Directory of CS Tools' is administered via EU BON portal CMS (content management system). Although this directory is part of the EU BON portal and does not need special care of data integration in the future, maintaining the directory still needs special attention, such as verifying URL links or updates e.g availability, change of tool usage policies or adding new tools. If the future gateway is managed by a CS network institution as ECSA or major science infrastructure as LifeWatch, this work can be integrated with other information services.

4.4 A guide for citizen science project management

As an EU BON survey on volunteer involvement shows, there is a huge potential for citizen science participation in many research projects. However, there are still many barriers that prevent project managers and scientists from involving citizen scientists and many projects need guidance in recruiting and training volunteers and generally in setting-up projects that enable a sound citizen participation. To make the CS project managing easier, EU BON provides a step-by-step guide on the proper design and management of citizen science projects that focus on biodiversity monitoring. With the help of this guide, users such as citizen science project leaders are pointed to a suitable PlutoF module. The guidelines will be further developed and improved until the end of EU BON project. Working with the guidelines is part of information management via the EU BON portal CMS. It is advisable to merge this job with other information services on CS gateway.

4.5 PlutoF citizen science module

This module (see chapter 6.3) which operates as a workbench provides users with tools and services to create, manage and share their biodiversity observation projects. However, its database is also used as the source for some content that is available on the EU BON portal. Furthermore, PlutoF is also linked with citizen science mobile telephone applications, such as the butterfly sighting app by GlueCAD and animal sound recording app by the University of Tartu).
PlutoF is a part of science infrastructure for Estonian research institutions and is being developed and maintained by the University of Tartu Natural History Museum. PlutoF workbench is open for all users worldwide. PlutoF also encourages its users to keep data open. Development to enable integration of biodiversity systematic monitoring data from mobile app (e.g. the new BMSapp from GlueCAD) is possible with PlutoF API.

5. Conclusions and recommendations for European Commission

5.1 Introduction

Citizen Science is a powerful ally to biodiversity research and conservation. Although it has its limitations and weaknesses, which are constantly being analyzed, previous findings suggest that it has the potential to deliver valuable data for science (Schmeller et al. 2009). The experience from well-monitored taxonomic groups such as birds and butterflies has further demonstrated that the expansion of citizen science initiatives, and particularly of systematic observatories, produces valuable data for science and policy making, touching some of the key challenges in tracing the impacts of global change. The citizen science gateway for biodiversity demonstrates a networking concept where CS project leaders and stakeholders would find and share best practices, helpful guides, and links to resources, to providers of data and to projects-hostings which can facilitate mobilizing biodiversity data. The EU BON survey showed that CS inputs are increasingly receiving acclaim from the scientific community while measures to enhance data quality get more attention.

5.2 Policy

In 2014 the EU project Socientize published a white paper with policy recommendations for CS in general and more particularly in Europe. The work behind the white paper is thorough and results are also relevant for biodiversity research. Its main action points for European policy: integrating CS into existing funding schemes and designing new programmes specifically for CS. From the proposed support measures the data policy will greatly affect the CS gateway. Quality, interoperability and data IPR issues are aspects to consider when reviewing the policy. Open data is a recommended first choice of any CS biodiversity data. EU BON will support the proposed actions and measures of the white paper of Socientize. EU BON findings on regional biodiversity data gaps indicate the importance of supporting central and eastern European countries in their efforts to integrate citizen science in biodiversity research, monitoring and management so that data gaps in these countries could be filled in.

In addition to that, EU BON proposes the formation of a European-wide institution for CS data mobilization. EU BON has identified more than 80 current CS systems in Europe (see **Appendix 2**) which contain more than 500 million of unshared species records. When the EU BON project is completed, permanent institutions are recommended to further work on data rescue, data mobilization and facilitate implementation of efficient tools for citizen science contribution. A European-wide institution would be expedient and need to cooperate with GBIF to ensure an efficient data dissemination.

- This institution, together with GBIF, should have the task to approach and negotiate with current reluctant European system owners aiming to share data with open licenses (CC BY 4.0)
- The target data owners should be institutions and organizations with systems containing large amounts of data, starting with data owners with public funding.
- The geographical target areas should be countries or European regions with gaps in data availability.
- The targets should cover both scientific institutions collaborating with naturalist NGOs and community based organizations with a potential for data sharing.
- For identifying the targets it would be helpful to maintain the EU BON database of current European CS systems and their metadata.

Also, a financing mechanism should be provided for facilitating the CS system development and implementation in countries and regions with few, small or non-existing efficient systems for species sighting and data sharing - with particular emphasis on an urgent need to establish systematic

monitoring schemes where these are not yet implemented. These implementations should be supported by governmental institutions (for sustainable funding and system operation), scientific institutions (for quality control and validation) and naturalist NGOs (for community relevance and voluntary contribution).

5.3 Community and networking

Citizen science initiatives are a mix of bottom-up and top-down approaches without an official agreed-upon structure to represent every stakeholder in Europe. However, a relatively new NGO is gaining momentum - European Citizen Science Association (ECSA). It has links to nearly every major CS organisation or initiative and also a very strong cooperation with US and Australian counterparts.
EU BON sees ECSA as a key organization in networking role in Europe and also for future development of CS gateway for biodiversity data. There is also the Citizen Science Alliance which hosts a collection of CS projects in its “Zooniverse”.

5.4 Data Sharing

EU BON advocates supporting citizen science projects that follow acknowledged biodiversity data standards, open data principles and publishes the data through recognized data portals such as GBIF.

5.5 Citizen science Metadata and Standards for biodiversity observations

While the huge data flow of community-based observations is streaming in, active measures to develop and provide standards are the key for future developments and effective usage of these CS-generated data. Standardization will pave the way to process large amounts of CS data in order to use it for scientific research and analysis. Components of such standardization should include the promotion of repeated observations in fixed sites (within and among years), communicating with citizens the value of reporting full species’ lists, and the use of known observation methods through systematic and coordinated schemes. A frame of CS-standards for biodiversity research should include: Metadata fields for a list of topics to cover for projects definitions, volunteer skills, education and training frame, protocols, data validation methods, annotation and confirmation protocols.

5.6 Empowering communities to influence decision making

CS communities which actively take part and volunteer in systematic monitoring programs (e.g. on birds or butterflies) have a high awareness of their environment and are particularly interested in conservation-related questions. This has empowered them to try to influence local and regional decision makers and there are many examples where such activities have prevented or changed potentially environmentally damaging policies or projects.
However, the link between CS data and policies remains often loose due to the lack of systematic prioritization of monitoring efforts (Henle et al. 2013). A combination of top-down and bottom-up processes will likely be the best means to ensure that the two meet each other.
EU BON should consider how to encourage or even support CS initiatives, and should support the expansion of citizen engagement from “just” performing observations, to becoming partners in a broader range of activities along the process of scientific research - including study (co-)design, experimentation and joint learning - whereby the broader sense of Citizen Science can be achieved.

5.7 Funding

A major obstacle for almost all CS initiatives is the funding issue, partly due to the assumption that is often taken by policy-makers and other data users that “voluntary data are free”. In reality this is far from the truth: the activation, recruitment, training and coordination of CS activities; followed by data validation, extraction and analyses; all require expenses both for coordination and IT support, without which such initiatives fail to exists. In many cases, prudent collaboration with like-minded organizations, communities or governmental projects can provide a starting point, but recognition by leading institutes to the costs of operating CS activities, may serve an important step in capacity building.
An EU based consultant group of advisors who are familiar with the funding application processes related to the topic could help these initiatives to come alive.

6. Best practice cases

6.1 Best practice case - Species Observation System in Norway

General description
The Species Observation System (NBIC 2016) was started in 2008 by the Norwegian Biodiversity Information Centre (NBIC). It is an online species observation reporting system providing more than 60% of all available occurrence data in Norway. There are more than 15 million records, 400,000 with pictures in the system as of 2016, covering 19 800 species and coming from 9400 contributors. 87% of the observations are of birds.

Integrating citizen scientists
In order to effectively reach citizen scientists there are 6 nation-wide naturalist NGOs involved. Contracts of collaboration guarantee mutual interest to data provision and validation. The benefit for governmental institutions is access to big data, while the naturalists and their organisations get public awareness and sustainable data maintenance.

Communication
NBIC communicates with reporters via online user support on the webpage. Contracted NGOs communicate with their members through their own communication channels, as well as with the general public via publications, web pages etc.

Data
System management, data maintenance and system development is run by NBIC. Data is shared to national data portals and GBIF using Darwin Core (DwC) standard, but the native data format is even richer than DwC. The full resolution of sensitive data about species is hidden from general public and can be accessed only by validators or specialists with extended data access.

Quality control
Taxonomy, coordinates and all parameters are automatically validated upon reporting, reporters get a warning when species are out of geographical range or period. Anonymous reporting is not possible. Reporters are encouraged to provide reliable data. Identifications are discussed on a public forum, so that crowdsourced voluntary quality annotation is part of the procedures. Rare and endangered species are finally formally validated by one of more than 150 validators.

Funding and dissemination
Development is funded by the Norwegian (40 %) and Swedish Environmental Agencies (60 %). All data are disseminated to national portals and GBIF.

Proven success factors for starting and maintaining citizen science projects/systems:
1. Raise awareness of the potential of CS for biodiversity management within authorities/institutions, NGOs and scientific institutions

2. Connect naturalist NGOs to a persistent data management/data mobilizing/data sharing institution
3. Define the role and contribution of the interacting partners – create an organizational structure
4. Define and create a common agreement among the partners on the data licensing (CC BY 4.0) and data sharing protocols (Darwin Core Archive, EML for metadata)
5. Involve NGOs in the development and configuration of a CS reporting system
6. Estimate and develop a long time budget, funding agreement, and procedures for economic management
7. Define and administrate contracts with partners on the ambitions and level of user support and validation procedures
8. Define and develop communication procedures, routines, and responsibilities
9. Administer yearly reporting and payment procedures among the partners
10. Involve partners in further development and improvement of the CS reporting system, including cooperation with international partners

6.2 Best practice case - Israeli Butterfly Monitoring Scheme (BMS-IL)

General description
The Israeli Butterfly Systematic Monitoring Scheme (BMS-IL) was established in April 2009 and is run by the Israeli Lepidopterists Society. It builds on the long tradition and experience gained through over 30 years of systematic butterfly monitoring by thousands of volunteers across Europe, USA and other regions. Coordinated by Dr. Racheli Schwartz-Tzachor, Dr. Guy Pe'er and Dubi Benyamini, BMS-IL includes three elements: a) systematic observations along fixed transects ("Pollard walks"), b) collation of opportunistic sightings and c) targeted observations on rare species.

Integrating citizen scientists
The main objective of the scheme is communicated to volunteers: to provide reliable data for assessing the status and trends in the abundance and phenology of Israel's butterflies, for both conservation and research purposes.

GlueCAD provides services to the Israeli Lepidopterists Society in designing, facilitating and organizing BMS-IL and the Israel Butterflies Observations portal starting in 2012, while the UFZ offers scientific guidances. GlueCAD is also working with EU BON partner PPBio in Brazil on a mobile application for monitoring Western Amazonian frogs using both photos and audio files for identification.

Communication
The Israeli Lepidopterists Society shares information about BMS-IL and provides experts' review on data validations, identifications and confirmations.

Data
GlueCAD provides data sharing tools and citizen-science based apps to facilitate data entry by volunteers. GlueCAD also performs system management, data maintenance and development of the Israel Butterflies Observations Portal, which enables volunteers to upload their data and facilitates data discovery: http://www.gluecad-bio.com/hompage.asp?lng=eng

Data is also published and shared in standardised DwC sampling-event format using the GBIF IPT: http://cloud.gbif.org/eubon/resource?r=butterflies-monitoring-scheme-il#methods. This standardised format faithfully stores the original data and allows it to be easily indexed into GBIF.org and integrated with other data sources.

Quality control
Systematic butterfly monitoring is carried out in a strictly controlled manner according to the sampling protocol: the observation protocol requires volunteers to take a slow walk along a fixed transect, and report all butterflies observed within a "box" of 5x5x5 m' (van Swaay et al. 2015). Unrecognized

individuals are reported as well, so that total abundance is known and the volunteers' recognition capacity can be evaluated. Every record uploaded by volunteers is flagged "for Approval" and the record status only changes to "Approved" after it has been reviewed by an expert. Furthermore, species out of season or distribution area are flagged for additional verification.

The Israeli Lepidopterists' Society waived all rights to the data and dedicated them to the Public Domain. The standardised data are publicly accessible via the EU BON IPT and have been indexed into GBIF.org facilitating integration with other data sources.

Proven success factors for starting and maintaining citizen science projects/systems:

1. The data is shared openly with the philosophy that transparency and sharing are routes for rapid knowledge generation, cooperation, and capacity building.
2. Involve experts for example in biodiversity data management to ensure the data is stored, standardised and shareable in the proper formats.
3. Ensure an expert is on site to help engage and guide first-time volunteers.

As an example for many other systematic monitoring schemes, the BMS-IL data has been linked with GBIF and intense discussion and development processes took place to ensure that GBIF can incorporate the meta-data which characterizes this scheme and others. Among others, it was important to identify how GBIF store and communicate information on…

a) the attribution of observations to fixed sites and sections of a transect (a hierarchical structure which also occurs in other scheme types) - allowing data-users to know that data from a given site repeat over time
b) the information that the abundance of all species in a given observation are being reported - allowing users to determine a "zero" for all other species not observed in a given date.
c) the provision of information on observation method and sampling effort and area, allows data users to calculate butterfly density or to convert between units - thereby offering interoperability e.g. between different monitoring methods or taxa (e.g. plants are usually reported based on density). The use of sub-sections also enables one to calculate the species' accumulation curve, in favour of estimating total species' richness and the Species Area Relationship.
d) the option to report on zero butterflies - seemingly a simple procedure from the butterfly perspective to ensure that all visits to a site are known even if no individuals are seen, but from a GBIF perspective required the creation of a "generic species zero". With this small modification, a door is opened toward improved analyses e.g. of species' phenology with "true zero" observations also in time

Through the work with BMS-IL, in cooperation with GlueCAD and the UFZ, GBIF could improve the means to accommodate systematic monitoring data, enhance tractability, identification and filtering of best data for analyses according to their suitability to address specific ecological questions.

6.3 Best practice case - PlutoF citizen science module

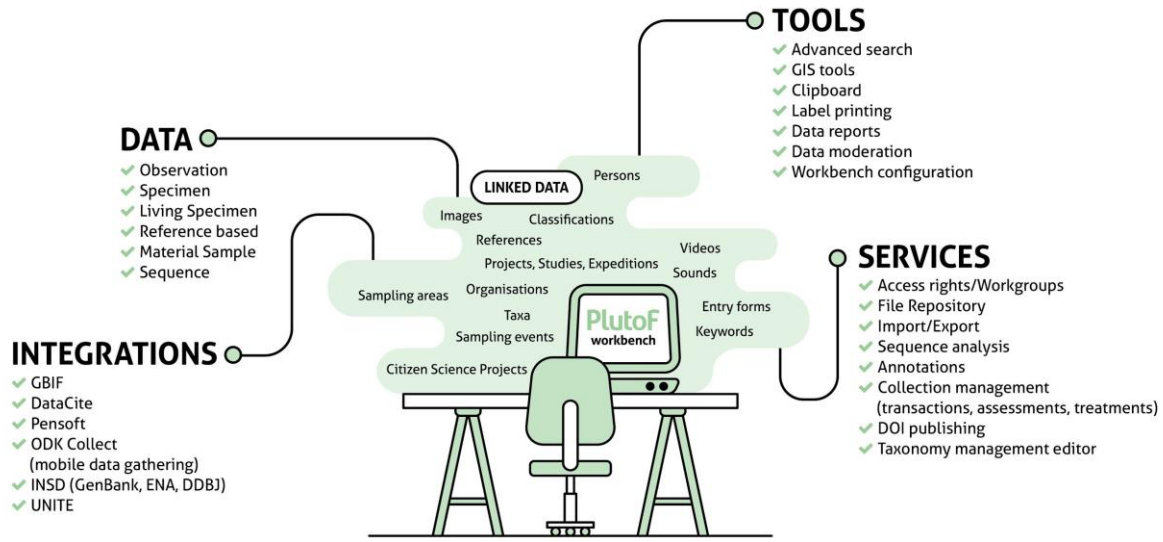


Figure 7: Components of the PlutoF workbench and dabase

General description
PlutoF is a web-based workbench (**Fig. 7**) and database solution for biodiversity research (http://plutof.ut.ee). It is developed and maintained by University of Tartu Natural History Museum (UTNHM). PlutoF database follows international biodiversity standards as Darwin Core. There are many institutional users who manage their biological data but private users can also freely access all the services and store their observation and sample data. PlutoF provides data collecting and sharing services for Estonian Ornithological Society, one of the major CS organizations in Estonia, PlutoF occurrence data are published on national biodiversity portal http://elurikkus.ut.ee. The PlutoF citizen science module for managing biodiversity projects was launched in 2015 and aösp qualified occurrence datasets could be exported to the GBIF database. The CS module is only one module out of many tools incorporated in the PlutoF system that can be also be used for collection management, DNA sequence analysis and other purposes.

Integrating citizen scientists
PlutoF is a tool which can be used by all persons who want to collect, manage and share species occurrence data. Citizen science organizations encourage their members to use PlutoF for reporting amd the collected observation data can later be published on portals which are built on database by using a specific API. It is also possible to use mobile applications to upload occurrence data in PlutoF and users can directly ask the PlutoF helpdesk for assistance.

Communication
Citizen science organizations who run PlutoF-based data projects manage the communication with their contributors themselves, but the PlutoF team offers courses and email support for the workbench users. There are video tutorials and user guides available that show the effective use of the PlutoF workbench. For project managers the PlutoF-based internal communication channel assists to discuss accepted or rejected occurrences, and supports the feedback to and from citizen scientists.

Data
Occurrence data follow Darwin Core standards. Datasets from various projects that comply with quality requirements will be published to GBIF via a locally installed IPT. For countries without a local GBIF node and IPT it could help to publish their data through the PlutoF system. Users can access their data after the submission and can add additional information about sampling area, interactions with other taxa (parasite, host), multimedia files, keywords and can manage identifications etc. For the legacy data the users have an option of importing csv format tables.

Quality control
Projects that use PlutoF tools for citizen science data collection can use an observation moderation service. In that case appointed users will check the data coherence and likelihood of the taxon to be observed at that time or place. In case of doubt the moderators can ask additional information from observers to verify the occurrences. For specific project datasets the project managers or managing institutions have to take the responsibility for data quality.After they have proved their capability of assuring the quality, data will be published to GBIF.

Funding and dissemination
PlutoF is funded by Estonian research networks and the University of Tartu. Some module developments are project-based.

6.4 Best practice case - Citizens' Network for the Observation of Marine Biodiversity


Credit: Thanos Dailianis, HCMR

General description
COMBER (Citizens' Network for the Observation of Marine BiodivERsity; http://www.comber.hcmr.gr/?q=news) was a pilot citizen science project initiated under the EU project ViBRANT. It was designed and implemented as a pilot project for divers and snorkelers who are interested in participating in marine biodiversity citizen science projects, in the framework of the ViBRANT e-Infrastructure Project. It demonstrates the necessity of engaging the broader community in marine biodiversity monitoring and research projects, networks and initiatives. It analyses the stakeholders, the industry and the relevant markets involved in diving activities and their potential to sustain these activities.

Integrating citizen scientists
Scientists from the HCMR (Hellenic Centre for Marine Research, Heraklion) were working with local diving and sailing clubs and offered short theoretical seminars for divers and snorkelers that are interested in participating in the project. During these seminars, divers get an overview of the local fish fauna and how to identify the different species. Afterwards, specially trained guides accompany the participants on their dive or snorkeling trip to help observing and recording fish.

Communication
Under the supervision of scientists and assistance of instructors, a simple protocol elaborated was implemented. This included professional lectures on coastal biodiversity and instruction on data

recording and up-loading, questionnaires and safety provisions. In addition, a blog has been developed to assist the communication between all members of the pilot project.

Data
After the dive, participants enter their observation into the COMBER database. The data will be used in the future to assess the marine biodiversity along the local coasts. Sensitive data about species is hidden from general public and can be accessed only by specialists. Data are open and available for further use and harvest by the large aggregators. After short seminars, divers are able to recognize and record the fish fauna of the Mediterranean by using the BIOWATCH underwater fishcard. They are be familiar with the recording software and can therefore independently contribute with observations during future dives. Data are also thoroughly checked by the scientists at regular intervals.

Funding and dissemination
COMBER operated under the ViBRANT project funded by the EU under the e-Infrastructures instrument (7th RTD Framework Programme). It is continued as a self-sustained project.

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Appendix 1: EU BON survey on citizen science data use among researchers in biological sciences

General Overview

In order to obtain an overview over the citizen science data landscape in Europe, particularly the relevance and importance for collecting and analysing biodiversity data, an online survey was developed in order to obtain crucial information for the further work on the EU BON European Citizen Science Gateway. The survey aimed to reveal trends of volunteer involvement among researchers in natural sciences, to explore the readiness and motivation of researchers using or not using volunteer help and to roughly evaluate the importance of citizen science and participation of citizens for the outcomes of research. The online survey "Assessing Citizen Science involvement in biological research" was conducted in February-March 2014 under the guidance of task 1.5 of EU BON work package 1.
The full report on the survey included 20 questions and is available online: http://dx.doi.org/10.15156/BIO/100001. The second part of the questionnaire contained additional questions for those participants that have already engaged volunteers in their work.

The survey was targeted to individual researchers rather than to organizations. Researchers were contacted by representatives of EU BON partners. Most responses came from academia (77%), non-governmental organisations (11%) or governments (9%) or related networks, only few from the business sector (1%, see **Table 1**). Ecology was the prevalent field of research of participants (**Table 2**). Overall, 151 researchers from 16 European countries responded to the survey, notable input came particularly from Norway, Sweden, Belgium, Estonia, United Kingdom, Bulgaria and Greece.

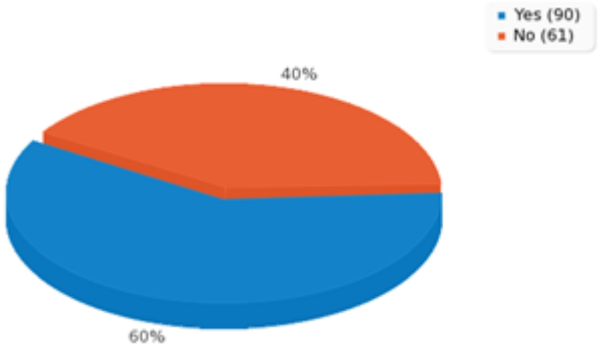
Table 1

Type of institution	**%**
Academic (institute, university)	77 %
Non-governmental organization	11 %
Government agency	9 %
Business company	1 %
Other	2 %

Table 2

Field of research	**%**
Ecology	51 %
Environmental protection	16 %
Biosystematics	11 %
Molecular biology, microbiology, genetics	4%
Agriculture	1%
Other	17%

a) *In your research, have you used any help or data input from volunteers?*



b) *Would you use volunteer help/data input in the future? (All respondents)*

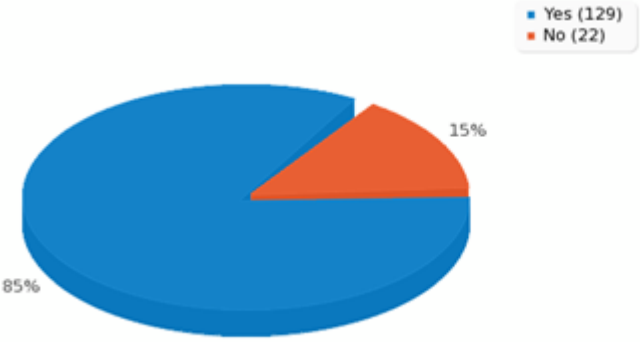


Figure 1 a, b: Overall involvement of citizen science in research

Our survey shows that almost two thirds of the respondents already include citizen scientists in their research, i.e. that they use the help of volunteers for conducting research. As can be seen from the graphs above (**Figure 1 a,b**), in most cases the willingness to use volunteers in the future is greater than actual engagement of volunteers in research at the moment. Furthermore, as the data shows, this gap is most obvious in the field of molecular biology and ecology and only to a lesser extend in the field of agriculture (**Table 3**). Participation of volunteers are already used to a large extent in the field environment protection and conservation, 76% already involve citizen scientists (Table 3). An analysis of European biodiversity monitoring schemes based on EuMon participatory monitoring networks study it was shown that almost 80% of the monitoring organizations were using help of volunteers in their work.

We were also interested in the reasons why researchers include volunteers in their research projects. The main reason why researchers use help of volunteers is the need to increase amount and variety of data (48% of respondents), so they are mainly used for data collection. The educational aspect is important for a much lesser number, 17% of researchers that educational aspects are also a reason for citizen science participation. Interestingly, one respondent commented, that sometimes the volunteer data is the only data source for research. However, there were also reasons for not engaging volunteers and the given answers were more diverse - for example that there are enough resources to do the research with only professionals (13%), engaging volunteers take too big efforts (12%), there are no capable volunteers (10%). Many respondents mentioned that their research topic is too specific or that the work is too demanding to engage citizen scientists; some researchers were concerned about the data quality of the collected data; some respondents were interested in using volunteers, but apparently did not have the opportunity or institutional support to engage them.

Table 3: Overall engagement of volunteers compared to willingness to engage volunteers in future, broken down by field of research of respondents:

Field	N	Actual engagement of volunteers	Willingness to engage volunteers in future
Agriculture	2	50%	50 %
Biosystematics	16	56%	63 %
Ecology	76	59%	90 %
Environment protection	25	76%	92 %
Molecular biology	6	17%	83 %
Other	25	56%	84 %

There was also a quite significant variation in the number of volunteers that were engaged in the citizen science projects - and the number of engaged volunteers ranged from one to 40 000. However, the majority of researchers engaged between 1-100 volunteers (67%) and 40% of the researchers reported that 1-10 volunteers helped them. In comparison, In EuMon study with monitoring programs 27 % organizations engaged 1-100 volunteers, 25% organizations engaged 100-10 000 volunteers.

How volunteers are involved

Most of the volunteers contribute to the research by collecting biodiversity data, either by (species) occurrence recording (36%) or assistive fieldwork (31%). Volunteers were also involved via crowdsourcing activities, like digitization. Some respondents also reported more complex involvement of citizen scientists such as for the project design or for doing laboratory analysis. Around 62% of researches who engaged volunteers also provided training for them and 61% had specific communication protocols to engage volunteers (in contrast to just passively receiving data or assistance).

Accessibility of citizen science data

Researchers were asked about the accessibility of the provided data. As our analysis shows, for a large part of the data only restricted access is provided (23%). Only for around one fifth of the data a free and open access is provided (19%, **Table 4**).

Table 4

Raw data can be downloaded under an open license or waiver	19%
Raw data can be downloaded under a restrictive license (e.g. non-commercial, research only)	8%
Raw data can be downloaded, but without a license (re-use must be requested)	5%
Raw data cannot be downloaded but the data can be browsed online	7%
Access to the data is restricted	23%
Other	8%

Citizen scientists can also be motivated to publish research findings themselves. Open access publications would help to disseminate the results to broader community without costs to the readers but without research funding are often behind paywall for citizen scientists (Ng, W., 2016).

Use of public data recording portals and applications

52% of researchers who engaged volunteers also use public portals for their data (e.g. for the data upload, data curation). There are numerous initiatives of websites and portals operating at the national and private level for citizen science-based biodiversity observation data and some offer not only repositories or tools for data curation but also mobile applications for data collection. No major favourite portal emerged from responses, but a few initiatives were mentioned more than once: eBird, iNaturalist, Anymals+Plants, Observado and GBIF (all global), elurikkus.ut.ee (Estonia), artportalen.se (Sweden), artsobservasjonen.no (Norway) and iRecord (UK). Of all counted names of portals there were apparently 23 national, while others were international.

Satisfaction with citizen science data

Another important question was how satisfied the participants are with the data collected in citizen science projects. Most respondents rated the data as “satisfactory” which means it matched their needs with respect to data quality and quantity. 15% of the respondents even rated that they are highly satisfied with the collected input, only 7% were not satisfied with citizen science data.

Conclusions

Citizen science data is important for generating knowledge on biodiversity in Europe. Hence, researchers use volunteer help in the data collection for biological sciences to a considerable amount and citizen science provides an important source for the generation of citizen science data. In some cases citizen science data was the only source of data available for researchers. The survey indicates that researchers would like to involve even more volunteers in their work, but recruiting process to allocate capable observers takes too long and consumes too much time and resources. Providing assistance and guidelines to researchers could help with the recruitment and managing of volunteers, but further development of monitoring approaches is needed that include plans and ways for a participation of volunteers. In addition to that, not only the human resources are often scarce, but also lacking funds often limit the capability for proper stakeholder participation.

Researchers in the field of environment protection were most inclined for citizen science involvement. However, there is a great potential for involving volunteers and for setting up citizen science initiatives that support data collection and analysis. As our study shows, ecologists showed most interest in prospective use of volunteers in their work in future. This is one of the target groups for leveraging integrate citizen science data. Including ecologically relevant metadata in citizen science observations could help ecologists more effectively utilize the data in order to obtain key information of the collected data.

Another important field of future action is the open access to citizen science data, as still only around one fifth of the data provides a true open access to the data. Open access is much encouraged in European science policies and attention should be paid to the fact that still a high percentage of citizen science data is only accessible under various restrictions.

Appendix 2: Citizen Science species occurrence data availability in Europe

Nils Valland

Species occurrence data sources metadata

A list of data providers who collect, store and share SC taxon occurrence data is available on the following pages and here:
https://drive.google.com/open?id=0B5jHxzgIMbK_bERaU1lSQnBzUFk

The list gives information on the names of institutions, contact emails, species groups, number of records, sharing availability, number of contributors etc.

Appendix 2: CS Species Occurence Data Availability in Europe									
Name	**Owner/provider**	**Country/region**	**Species groups**	**Rapporteurs**	**Records (mill)**	**Sharing in GBIF**	**GBIF**	**URL**	**email**
Artportalen	ArtDatabanken (Swedish Species information Centre)	Sweden	all	20.000	50,253	44,456	yes	htpps://artportalen.se	support@artportalen.se
Artsobservasjoner	Artsdatabanken (Norwegian Biodiversity Information Centre)	Norway	all	12.000	13,710	13,710	yes	https://artsobservasjoner.no	support@artsobservasjon
DOF-basen	Danish Ornithological Society	Denmark	birds	1.298	16,760	2,958	yes	http://www.dofbasen.dk/	dof@dof.dk
Naturtjek	Danmarks Naturfredningsforening	Denmark	plants, fungi, animals	12.000	0,094		no	http://www.biodiversitet.nu/	dn@dn.dk
ConDicact	Danske dyr	Denmark	animals		0,016	0,016	yes	http://danske-dyr.dk/	jeb@condidact.dk
Biowide	Natural History Museum of Denmark with partners	Denmark	all		0,039		no	http://www.biowide.dk/	snm@snm.ku.dk
Naturbasen	Fugleognatur.dk - and Natural History Museum Aarhus	Denmark	all	34.540	1,719		no	http://www.fugleognatur.dk/	support@fugleognatur.dk
Atlas Survey of the Butterflies of Denmark	Danish Biodiversity Information Facility	Denmark	butterflies		0,199	0,199	yes	http://www.naturogide.dk	naturogide@gmail.dk
Bugbase, Lepidopterological Society	Lepidopterological Society, Denmark	Denmark	butterflies		0,655	0,655	yes	http://www.lepidoptera.dk/	psn@lepidoptera.dk
Svampeatlas	The Natural History Museum of Denmark and partners	Denmark	fungi	434	0,568	0,520	yes	http://www.svampeatlas.dk/	jheilmann-clausen@snm.k
The Bird Ringing Center	Natural History Museum of Denmark	Denmark	birds		0,481	0,479	yes	http://www.rc.ku.dk	ringing@snm.ku.dk
Tiira	Birdlife Finland	Finland	birds		13,350	13,007	yes	http://www.tiira.fi/index.php	toimisto@birdlife.fi
Finnish Winter Bird Census	Finnish Museum of Natural History	Finland	birds		1,201	0,877	yes	https://kotka.luomus.fi/view?u	info@laji.fi
Fieldjournal.org observation database	Finnish Museum of Natural History	Finland	birds		2,083	0,229	yes	http://hatikka.fi/	info@laji.fi
Finnish Entomological Database	Finnish Museum of Natural History	Finland	insects and spiders		2,684	0,172	yes	http://hyonteiset.luomus.fi/	info@laji.fi
Estonian Nature Observations Database	Estonian Environment Information Centre (EEIC)	Estonia	all		0,180	0,180	yes	http://loodus.keskkonnainfo.ee	info@ic.envir.ee
PlutoF platform observations	University of Tartu	Estonia	all		0,742	0,742	yes	https://plutof.ut.ee/	info@plutof.ut.ee
Dabas Dati	Latvian Fund for Nature	Latvia	all		0,200		no	http://www.dabasdati.lv/en/	ldf@ldf.lv

Name	Owner/provider	Country/region	Species groups	Rapporteurs	Records (mill)	Sharing in GBIF	GBIF	URL	email
AwiBaza	Polish Society for Protection of Birds (OTOP)	Poland	birds	4.095	0,913		no	http://www.otop.org.pl/	awibaza@otop.org.pl
Anymals.org (Localcosmos.org)	Consortium (GBIF, Museum für Naturkunde, FAU, AWI)	Germany and worldwide	all	5.000	0,015	0,015	yes	https://www.anymals.org/	tom@anymals.org
ArtenFinder	POLLICHIA – Verein für Naturforschung und Landespflege e.V.	Germany	all	2.200	0,265	0,265	yes	http://www.artenfinder.rlp.de/	schotthoefer@konat.de
Dachverband Deutscher Avifaunisten	Federation of German Avifaunists	Germany and Luxemburg	birds	16.539	17,656		no	http://www.ornitho.de/	info@dda-web.de
Naturgucker	naturgucker.de / enjoynature.net	Germany and worldwide	all		4,140	4,140	yes	http://n.enjoynature.net/	info@naturgucker.de
Vogelwarte	Swiss ornithological institute	Switzerland	birds	12624	10,285		no	http://www.ornitho.ch/	support@ornitho.ch
NISM National Inventory of Swiss Bryophytes	Institut für Systematische Botanik, Universität Zürich	Switzerland	bryophytes		0,267	0,125	yes	http://www.nism.uzh.ch/i	nism@systbot.uzh.ch
Aves-Symfony	Ornithological NGOs	Slovakia	birds + other species groups		0,472		no	http://aves.vtaky.sk/index/	vtaky@vtaky.sk
Birds.CS	Czech Society for Ornithology	Czech Republic	birds		0,176		no	http://birds.cz/avif/	admin@birds.cz
SOM	Czech Butterfly Conservation Society	Czech Republic	butterflies		1,166		no	http://www.lepidoptera.cz/	alois.pavlicko@seznam.cz
Ornitho.at	BirdLife Austria	Austria	birds	2.829	1,873		no	http://www.ornitho.at/	office@birdlife.at
HERPETOFAUNA ÖSTERREICHS	Austrian Herpetological Society	Austria	herptiles		0,017		no	http://www.herpetofauna.at/	office@herpetozoa.at
BioPortal	Centre for Cartography of Fauna and Flora	Slovenia	all		1,604		no	http://www.bioportal.si/index.p	bioportal@ckff.si
Ornitorama	Societatea Ornitologica Romana	Romania	birds	289	0,023		no	http://www.sor.ro/	office@sor.ro
OrnithoTopos	Hellenic Ornithological Society	Greece	birds	1.030	0,345		no	http://www.worldbirds.org/v3/	thess@ornithologiki.gr
Comber	Hellenic Centre for Marine Research (HCMR)	Greece	marine species	141	0,005		no	http://www.comber.hcmr.gr/	arvanitidis@her.hcmr.gr

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Faune-Aquitaine.org	LPO Aquitaine	France	birds + other species groups	5.425	3,414		no	http://www.faune-aquitaine.or	aquitaine@lpo.org
LPO	LPO - Birdlife France	France	birds		0,043		no	http://www.ornitho.fr/	lpo@lpo.fr
Meridionalis	Naturalist organiszation Languedoc - Roussilon, Union MERIDIONALIS	France	birds		1,864		no	http://www.faune-lr.org/	meridionalis.fm@gmail.co
G.E.O.C.A	Groupe d'Études Ornithologiques des Côtes-d'Armor	France	birds		0,930		no	http://www.faune-bretagne.org	contact-geoca@orange.fr
Charente nature	Conseil d'Administration de Charente Nature	France	animalia		0,164		no	http://www.faune-charente.org	charentenature@charente
Migration Mission	www.migraction.net (Ornithological NGOs consortium)	France	birds	829	1,425		no	http://www.migraction.net/	gunter.desmet@lpo.fr
Tela Botanica	Tela Botanica -The French Botany network	France	plants	6.140	0,550	0,550	yes	http://www.tela-botanica.org/	accueil@tela-botanica.org
Diveboard	Diveboard	France - Worldwide	marine species		0,029	0,029	yes	http://www.diveboard.com/	alex@diveboard.com
www.ornitho.it	Centro Italiano Studi Ornitologici and 30 partners	Italy	birds 99% + other species groups	7.309	8,688		no	http://www.ornitho.it/	segretario@ciso-coi.it
LifeMIPP	The LIFE+ Nature project "Monitoring of insects with public participation" (MIPP)	Italy	insects		0,001		no	http://lifemipp.eu/mipp/	fmason@tin.it
Cuaderno de Aves	SEO / BirdLife (Spanish Ornithological Society)	Spain	birds + other species groups	3.182	0,678		no	http://birdlaa5.memset.net/wo	seo@seo.org
Portugal Aves	The Society for the Study of Birds (SPEA)	Portugal	birds	1.558	0,306		no	http://birdlaa5.memset.net/wo	spea@spea.pt
Biodiversity4all	Biodiversity4all (Consortium)	Portugal	all	1.775	0,361		no	http://www.biodiversity4all.org	biodiversity4All@gmail.co
Flora.on	Sociedade Portuguesa de Botânica	Portugal	plants		0,268	0,141	yes	http://www.flora-on.pt/	geral@spbotanica.pt

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Observado	Observado - other European countris	the Netherlands and Europe	all		7,705		no	http://observado.org/	info@observation.org
Waarnemingen.nl	Stichting natuurinformatie Waarneming	the Netherlands	all	68.097	39,112			http://waarneming.nl/	info@observation.org
Sovon	Sovon Dutch Centre for field ornithology	The Netherlands and Europe	birds	50.000	250,000	0,095	yes	https://www.sovon.nl/en	info@sovon.nl
Floron	Floristisch Onderzoek Nederland	the Netherlands	plants		9,521			http://www.floron.nl/	info@floron.nl
De Vlinderstichting	Dutch Butterfly Conservation	the Netherlands	insects		2,094			http://www.vlinderstichting.nl/	info@vlinderstichting.nl
Zoogdier Vereniging	Dutch Mammal Society	The Netherlands and Europe	mammals		0,009	0,009	yes	http://www.zoogdiervereniging	info@zoogdiervereniging.n
Nederlandse Mycologische Vereniging	Dutch Mycological Society, NMV	the Netherlands	fungi		2,095			http://www.mycologen.nl/	waarnemingen@paddesto
Rovon	Reptile, Amphibian & Fish Conservation the Netherlands	the Netherlands	reptiles, amphibians, fish		0,835			http://www.ravon.nl/	kantoor@ravon.nl
Telmee	National Database Flora and Fauna (NDFF) Consortium	the Netherlands	all		4,448		no	http://www.telmee.nl/	info@telmee.nl
Waarnemingen.be Observado	Natuurpunt Waarnemingen.be	Belgium	all	23.926	19,014		no	http://waarnemingen.be/statist	info@waarnemingen.be.
Arabel	Arachnologia Belgica	Belgium	spiders		0,291	0,291	yes	http://www.arabel.ugent.be/	frederik.hendrickx@natura
Scottish Ornithological Club	Scottish Ornithological Club	Scotland	birds		0,264		no	http://www.the-soc.org.uk/	mail@the-soc.org.uk
Saving Scotlands red Squirrel	Scottish Wildlife Trust	Scotland	mammals		0,060	0,051	no	http://www.scottishsquirrels.or	mshirkhorshidi@scottishw
National Mammal Atlas Project	The Mammal Society	UK	mammals		0,043		no	http://www.mammal.org.uk/nr	info@themammalsociety.c

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Bryophyte data for Great Britain	British Bryological Society	UK	bryophytes		2,419	2,419	no	http://www.britishbryologicals	oliver.pescott@ceh.ac.uk
EcoRecord	Biological Record Centre for Birmingham and the Black Country	UK	all		0,453	0,453	no	http://www.ecorecord.org.uk/	enquiries@ecorecord.org.
Butterfly Conservation	Butterfly Conservation	UK	butterflies	20.084	1,898		no	http://butterfly-conservation.or	news@butterfly-conserva
Opal explore nature	Centre for Environmental Policy at Imperial College London	UK	all		0,007	0,007	yes	http://www.opalexplorenature.	unknown
BirdTrack	British Trust for Ornithology	UK and Ireland + Europe	birds and other taxa	28.808	38,812		no	http://app.bto.org/birdtrack/	birdtrack@bto.org
Fungal Records Database	British Mycological Society	UK and Ireland	fungi		1,984		no	http://www.fieldmycology.net/	admin@britmycolsoc.info
Vascular Plants Database	Botanical Society of Britain & Ireland	UK and Ireland	plants		8,935	8,935	yes	http://www.bsbi.org.uk/	alex.lockton@bsbi.org
Seaweed and freshwater algae	British Phycological Society	UK and Ireland	seaweed		0,112	0,112	yes	http://www.bpsalgalrecords.co	secretary@brphycsoc.org
iRecord	Biological Record Centre	UK and Ireland	animalia		2,140	0,072	yes	http://www.brc.ac.uk/	brc@ceh.ac.uk
iSpot share nature	The Open University	UK and Ireland+ others european	all	42.000	0,390		no	http://www.ispotnature.org/	ispot@open.ac.uk
iBat Programme	The Bat Conservation Trust	UK and worldwide	bats				no	http://www.ibats.org.uk/	ibatsprogram@gmail.com
National Biodiversity Data Centre	National Biodiversity Data Centre	Ireland	all		0,137	0,137	yes	http://www.biodiversityireland	unknown
IWDG	The Irish Whale and Dolphin Group (IWDG)	Ireland	whales		0,002		no	http://www.iwdg.ie/	sightings@iwdg.ie
eKusBank/eBird	Doğa http://www.dogadernegi.org/	Turkey	birds	2.160	0,529		no	worldbirds.org/v3/turkey	doga@dogadernegi.org

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Bat Detective	University College London, Zoological Society of London, The Bat Conservation Trust, BatLife Europe, University of Auckland, and the Citizen Science Alliance	Europe	bats		0,008		no	http://www.batdetective.org/	unknown
Xeno-Canto	Xeno-canto Foundation	Worldwide	birds (sounds)	935	0,055		no	http://www.xeno-canto.org/	contact@xeno-canto.org
Project Noah	Project Noah (Network community)	Worldwide	all		0,079	0,079	yes	http://www.projectnoah.org/	info@projectnoah.org
iNaturalist	iNaturalist.org	Worldwide	all		0,004	0,004	yes	http://www.inaturalist.org/	unknown
eBird	Cornell Lab of Ornithology	Worldwide	birds		3,950	3,950	yes	http://ebird.org/	jag73@cornell.edu
Total in Europe					560,281				
5577 nu						100,078			