Citizen science and Crowd science in biodiversity research

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The artist in his museum (1822), self-portrait of Charles Wilson Peale.

The Exhumation of the Mastodon (1806) by Charles Wilson Peale.

Charles Wilson Peale (1741 – 1827), American painter, soldier and naturalist, remembered for his paintings of leading figures of the American Revolution, as well as for establishing one of the first museums.

1. Introduction

In the year 1801, in the USA the message came through a skeleton of a mastodon had been discovered near Newburgh NY. The news inspired Charles Wilson Peale, director of the Philadelphia Museum to raise funds for an expedition in order to bring the skeleton to his museum for public display. The site from where the skeleton had to be removed appeared to be a pit filled with water, so a paddle wheel was installed for drainage to create a safe and dry environment for excavation. Once it became clear there were not enough funds to hire sufficient staff, a publicity campaign was started, generating a constant stream of visitors, of which many offered help to keep the paddles going. This way of organizing became a huge success: visitors were actually queuing to take their turn on the treadmill for a few minutes. The story, as described by Lynn Barber in her book on naturalism in the 19th century, ends with the skeleton becoming part of the permanent collection of the museum. Today, it is more of a symbol of cooperation between professionals and the general public in the realm of nature, conservation and biology (Barber, 1980). At least Charles Peale estimated the significance of his work as a museum director by recording his achievements in artwork.

Today, the Internet has inspired many entrepreneurial minds like Charles Peale to explore innovative ways of organizing. The drive of volunteers to do monotonous work in relation to science, that is, knowledge creation through data collection and collection management, seems to be still alive among the general public. New arrangements have been developed to use the worldwide web, mobilizing masses of people to perform large quantities of small, simple and standardized tasks at a scale only possible using computers, labelled in 2006 by Jeff Howe of *Wired Magazine* as *crowd sourcing* (Brabham, 2012). The idea of invisible crowds processing a bulk of odd jobs has spawned a trail of projects exploring the possibilities of crowd sourcing (Franzoni & Sauermann, 2014). Crowd sourcing has been depicted as beneficial to business sectors as different as cultural heritage (Oomen & Aroyo, 2011), geography (Goodchild, 2007), health (Brabham, Ribisl, Kirchner, & Bernhardt, 2014), marketing (Kozinets, Hemetsberger, & Schau, 2008) and software development (Leimeister, Huber, Bretschneider, & Krcmar, 2009).

The example of the conservation of a mastodon skeleton demonstrates crowd sourcing is not as new as many would think, still it is mostly depicted as having revolutionary impact on masses of volunteers, recruited from a non-descriptive cloud of computer-literate citizens (Young, 2010). It has also been described as a new organizational form, pushing the concept of outsourcing a step further (Oomen & Aroyo, 2011). Where outsourcing transfers a specific workload in a business-to-business transaction from one organization to the other, crowd sourcing has been described as business-to-crowd oriented, allowing a crowd of workers to do a fixed set of tasks.

While crowd sourcing is generally viewed as a new, internet-based way of task structuring, society is also affected by other cyber-phenomena, just as well having consequences for the way science is organized. Stemming from relatively primitive services like email, blogs and discussion fora;

Twitter, Facebook and Skype are sophisticated post-millennium services penetrating the organizational domain (Leadbeater, 2010). The trend to use social media to develop and maintain communities is also affecting scientific and science-related policy processes (Brabham, 2008; Daume, Albert, & von Gadow, 2013).

Crowd sourcing as a new phenomenon shares both similarities and differences with the tradition of biodiversity research. Nature is usually studied by both professionals as well as amateurs, skilled and unskilled naturalists, highly specialized experts as well as the general public. Biodiversity research has been performed through the ages by ever-changing alliances of diverse backgrounds, being professionals making an income out of it as well as volunteers with intrinsic interest (Allen, 1976). The biodiversity domain is thus firmly built on tradition; populated with both paid scientists and skillful citizen-scientists, all with great enthusiasm for nature and biodiversity (Silvertown, 2009). These similarities and differences need further exploration.

During the past 150 years, biodiversity research has been mainly concentrated in three institutional arrangements of systematic enquiry and data collection: volunteering associations, natural history museums and universities (Allen, 1976; Barber, 1980; Stearn, 1981). Amateur naturalists or volunteers, of which birdwatchers are most common and therefore almost iconic, have organized themselves in associations of which some have reached high degrees of expertise, even employing an specialized and educated scientific staff (Greenwood, 2007). Natural history museums have vast collections of specimens that could not be created, categorized and managed without the help of volunteers helping professional staff with curating and public relations tasks (Stearn, 1981). Within universities there is a tradition of faculties studying nature, enthusing large numbers of students to become involved in sometimes extensive research projects (Kohler, 2002). Figure 1 depicts these three streams of biodiversity science, all embodying specific and distinct relationships between professionals and volunteers in biodiversity research.

Three current projects, each of them demonstrating volunteer-involvement in one of the institutional realms are now briefly introduced here as examples. The *Great Backyard Bird Count* is meant 'to create a real-time snapshot of bird populations' by asking participants 'to count birds for as little as 15 minutes' and to 'report their sightings online at www.birdcount.org'[1]. *V Factor* is meant to assist professional scientists within the Natural History Museum in London: 'V Factor is your chance to work alongside Museum scientists and help work on our renowned specimen collections, taking you from visitor to proactive volunteer'[2]. The *Omega project* was intended for harmonizing taxonomies and to verify discovery sites extracted from literature to enable paleo-climate reconstruction, for which students have processed manually large amounts of location-data[3]. These projects seem to represent distinct fields in biodiversity science where volunteering and professional worlds come together and where no specialized education or skills are required to assist curators,

[1] http://birds.audubon.org/great-backyard-bird-count

[2] http://www.nhm.ac.uk/about-us/jobs-volunteering-internships/volunteering-interns-information/v-factor/index.html

[3] http://www.museum-joanneum.at/upload/Workshop_OMEGA.pdf

academics and skilled citizen scientists. Being unique projects in their respective realms, they all three aim at inviting laypersons to collect and analyze biodiversity data and information.

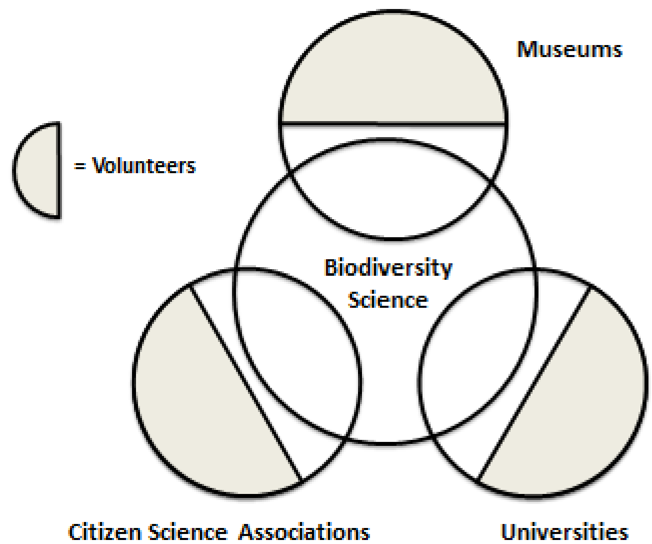


Figure 1. Volunteering aspects of the biodiversity science field

The afore mentioned projects reside in existing communities; all having a unique blend of professional and volunteer practices, where the omnipresent influence of the Internet works in different ways. However, it is their contribution to biodiversity research what they have in common. At first glance, the link between volunteered and professional science is just as superficial as crowd sourcing the way Jeff Howe has defined it, but looking further, however, within these three realms rich and fruitful worlds with different forms of volunteering might be expected. Internet-driven crowd sourcing and traditional citizen science seem to have influenced existing practices, in this research we want to grasp how this has happened. We are going to look into existing professional-volunteer relationships and in biodiversity research.

Instead of being strictly focused at undefined digital crowds, we want to find out how existing communities on biodiversity science acquire, adopt and transform both crowd sourcing and other community-centered digital approaches and incorporate them in their daily practices. Our aim is to assess how existing volunteering communities can be reached using strategies emerging from existing crowd sourcing processes and practices. Based on the examples presented above it is likely to expect volunteering processes going back at least a century that have proved to be lasting, but will however be affected by emerging crowd sourcing developments. These digitally enabled arrangements, specifically aimed at and used within the scientific community will be called crowd science (Young, 2010). This brings us to the following research questions:

1. What kind of volunteering arrangements have been developed and applied in biodiversity research?
2. How do digital crowd science developments affect existing volunteering arrangements in biodiversity research?
3. How can crowd science arrangements in biodiversity research be categorized?

As part of our participation in the Synthesis-3 project we are engaged in research on digitization of biodiversity data using crowd sourcing[i4]. We have developed a database of 80 projects of volunteering activities in biodiversity research. In this research project, we have collected information from documents, web pages, and occasionally by email or Skype interview.

The report will continue as follows. Chapter two provides a literature an overview of volunteering arrangements in the realms of volunteering associations, natural history museums and universities and a sketch of recent crowd sourcing activities in science. Chapter three describes the methodology we have applied. Chapter four presents the results of our exploratory investigation using qualitative data of 62 biodiversity volunteering cases. In chapter five we put our findings in perspective and provide some conclusions specifically aimed at practices in natural history museums.

2. From natural history to biology: how biodiversity research was constituted by volunteers and professionals.

It has been claimed crowd sourcing is going to change the way data processing is organized in fundamental way (Brabham, 2008; Doan, Ramakrishnan, & Halevy, 2011; Ross, Irani, Silberman, Zaldivar, & Tomlinson, 2010). In pre-internet times it was held impossible to mobilize an indiscriminate group of millions to get vast amounts of boring and tedious work done. The strategy of tempting a crowd of citizens doing the chores of data processing also found its way to the scientific realm (Brabham, 2008; Franzoni & Sauermann, 2014; Young, 2010).

Papers on crowd science sustain the dichotomy between fully informed professional researchers and ignorant laymen, denying the fact that amateur or volunteering scientists can reach professional levels of competence. Scientific disciplines like astronomy and ornithology have established successful collaborative practices between professional scientists and volunteer-, or citizen scientists (Dickinson, Zuckerberg, & Bonter, 2010). Most of all, they ignore how biological sciences originated from natural history and naturalism, in which volunteer involvement used to be the cornerstone of the paradigm (Allen, 1976; Barber, 1980). Looking further may shed light on how associations of volunteer-birdwatchers and other citizen scientists collect monitoring data using standardized and scientifically approved methods (Dickinson et al., 2010), how natural history

[4] www.synthesys.info (accessed march 2014)

museums have a long-standing tradition of helping volunteers (Star & Griesemer, 1989), and how university staff develop relationships to engage students and the general public in data collection processes (Geiger, Seedorf, Schulze, Nickerson, & Schader, 2011; Horne et al., 2011).

In this section we try to confront existing, long-standing relationships of professional scientists with volunteers with the Internet-induced crowd sourcing phenomenon. We do that by reviewing literatur to provide a glimpse of how professionally employed- and citizen-scientists have collaborated in institutional arrangements of naturalist-associations, natural history museums and biodiversity-focused faculties within universities. Our leading question here is: what kind of volunteering arrangements have been developed and applied in biodiversity research. In other words, we want to know how professional scientists and volunteers team up. We will proceed this section as follows. The next three sections are devoted to volunteering developments in volunteering associations, natural history museums and universities. Then we are going to depict recent developments of crowd sourcing and crowd science. In the concluding section we are going to make some general remarks and implications for our research.

2.1 Citizen scientists in the field: pushing naturalism towards ecology

People have always loved to go out in the fields to enjoy nature. They expressed their appreciation by talking and writing about it or by bringing home plants and dead animals as trophies (Allen, 1976). In the 19th century, people actively involved in nature were called naturalists, either being professionally involved making a living out of it, or gathered in groups of volunteers sharing an interest in living creatures (Greenwood, 2007). The interests of naturalists usually never stretched any further than their own neighborhood (Barber, 1980). Usually they were subdivided into field-naturalists, only interested in the practice of collecting specimen by treating them as hunting trophies; and closet-naturalists, focused at managing a collection, mostly consisting of a herbarium or stuffed, prepared animals. (Allen, 1976).

Natural history provided the paradigm to study nature in Western civilization. It was immersed with Christian values, as it had been common for ages to use biblical stories to learn about the creation of life (Barber, 1980). Because most associations for natural history could count both academic and volunteer among its members, there was considerable overlap between the two institutional realms, leading to academic publications focused at 'wondrous artifacts in nature', also reflecting values of 'natural theology' (Benson, 1988) :56). This attitude explains the initial halfhearted reception of Darwin's insights of natural selection, but also later on the eagerness to test them in a lab as they later were seen as the product of improper scientific methods.

In the last two decades of the 19th century Western society became gradually standardized and prone to become more science oriented (Knight, 1986). The naturalist, biblically oriented worldview of steady nature with kingdoms of species surrounding man became seriously challenged by practices of systematic investigation; naturalist theology embracing the concept of a divine static universe became untenable and was slowly but steady replaced by Darwinist, evidence-based ideas of dynamic, ever-evolving nature (Barber, 1980; Knight, 1986). Closet naturalists discovered the laboratory to shape their scientific methods and were increasingly inclined to call themselves biologists (Knight, 1986). Within the closed environment of the lab as the locus of scientific practice , focusing at the comparative study of body parts instead of whole animals; standards were set for biologists scientifically studying nature (Benson, 1988).

After 1900, field naturalists increasingly started to develop ideas on how to give their activities more scientific content. (Kohler, 2002). Field naturalists started to leave their gun at home and used cameras, binoculars, and counting methods instead, but had a hard time to become more scientifically oriented (Allen, 1976). Moreover, as society was globalizing, naturalists started to discover the world, for instance by studying migration in nature (Barber, 1980). Vegetation patterns of plants were systematically studied and lighthouse keepers in Great Britain organized themselves into a network, counting and registering selected bird species (Allen, 1976). Others discovered the scientific value of counting migratory birds on islands like Heligoland and the Orkneys (Greenwood, 2007). To produce scientifically sound and convincing results could not be done without technology like binoculars, photo cameras, thermometers and hygrometers, being lab instruments robust enough to be used in the field (Kohler, 2002).

In the 20th century, out of the world of field-naturalists a scientifically oriented new biological discipline started to emerge. In this new field of ecology, practitioners saw themselves as scientists operating in this distinct subfield of biology (Knight, 1986). At the brink of the 20th century, it were volunteer scientists dictating the scientific research agenda of ecology (Allen, 1976). This development, which was started by ornithologists, was increasingly affecting other disciplines, entomology and terrestrial zoology most prominently. This zest for science in naturalism brought better skills, more structured methods of data collection and separation between scientifically- and community- oriented activities (Van Nieukerken & Huijbregts, 2007; Wiggins & Crowston, 2011).

Today, naturalists-as-volunteer scientists have organized themselves into robust institutional arrangements. This can go quite far, as in the Netherlands the National Database on Flora and Fauna (NDFF) was established, 'the most complete database of nature in the Netherlands'[5]. Here the standardized results of data-collection projects of 10 so-called 'privately data-managing organizations' (known as *PGO's*) are collected and distributed amongst (mostly public) organizations in need for data on nature. These *PGO's* all work at a national scale and have professionally managed projects in place to manage data collected by volunteers. This form of highly institutionalized data-collection starts with nature-loving volunteers, willing to go out in the field in their spare time, doing their observations and willing to register and submitting them in a standardized, web-enabled way.

2.2 Natural history museums: collections as models of nature

The majority of natural history museums as we know them today have been established in the 19th century, with content mostly stemming from collections owned by wealthy citizens. Emerging from 'cabinets of rarities' owned by closet-naturalists, art collectors and the like,

[5] www.ndff.nl, accessed June 2014.

collections should be characterized as utterly miscellaneous: sculptures, paintings, furniture, botanical gardens, stuffed animals and other specimens (Alexander & Alexander, 2007; Allen, 1976). Once these collections were accessible to a wider circle of connoisseurs it became clear they were unstructured and poorly managed, neither of interest to scholars nor the general public. Specialization became the name of the game during the 19th century: in most Western countries developments were towards natural history collections being set apart in dedicated museums organized at a national scale to be subdivided into departments specializing along the lines of specimen classification: botany, entomology, ornithology, zoology, etc. (Stearn, 1981). Acknowledging that collections were in a rather desperate state, two basic notions stimulated towards improvement. It was acknowledged to have standardized collections according to scientific rules. It also became clear that it was impossible to have the whole collection permanently on display. Instead, the scientific collection became seen as a base for changing exhibitions, making natural history museums more relevant to the general public (Griesemer, 1990). Instead of only managing a static collection, gifts from private specimens collectors were used to fill gaps and sometimes active participation of citizen scientists was sought in order to add new species and to learn more about specific habitats (Star & Griesemer, 1989). Slowly but steady, natural history museums became seen as having a collection representing changes in nature which was suitable for the study of evolution (Griesemer, 1990).

From 1880 onwards, the idea of a natural history museum being beneficial to society became manifest. A specimen collection was seen as contributing to health, education and economy, and when they were studied by scientist's knowledge was produced. Studies by curators and other scientific staff used to be published in guides and catalogues in order to present sub-collections into a meaningful whole (Star & Griesemer, 1989; Stearn, 1981). Thus the insights of Darwin were tested, extended and specified through collecting and ordering specimens.

Collections could also play a role in demonstrating the unity and/or sovereignty of a specific state: the Berkeley's Museum of Vertebrate Zoology held a collection signifying the importance of the western part of the US and the state of California in particular (Griesemer, 1990), the Natural History museum in London held a collection attempting to cover the British Commonwealth, while the Royal Botanical Gardens at Kew had a collection aimed at ' economic botany' supporting colonial trade of staple products (Brockway, 1979; Stearn, 1981).

Today, natural history museums have developed themselves as multi-purpose organizations where brains, databases, funds and facilities are organized to be hotspots of biodiversity research. Still based on traditional skills and accommodating facilities, they try to adapt to the requirements of the digital age (Smith & Penev, 2011).

2.3 Universities and labs: from naturalist to biologist attitudes of science

The ideas of Darwin, being published in 1859 in his groundbreaking book 'On the origin of Species', generated a revolution, however it took some time before the actual message of evolution came through (Barber, 1980). It did not only challenge science as such by presenting a new paradigm, the presented evidence also casted doubts over the deeply rooted Christian belief in Western societies about nature as a gift from god (Allen, 1976). The love for nature in all its manifestations ran through the veins of religious Britain, with clergymen not only preaching the gospel, but also wanting to be true naturalists, out and about in the field, enjoying nature as god's creation, pushing natural history towards a religion-inspired version, known as theological naturalism (Barber, 1980).

Darwin's message of natural selection started a countermovement with a considerable number of naturalists fleeing towards a more theology-based version of naturalism, while others thought answers could be found in academia embracing the insights of evolution and natural selection. Because Darwin did his experiments during his expeditions, in open air and under primitive circumstances; it was generally believed these outcomes had to be replicated under controlled circumstances in order to harvest truly convincing evidence (Allen, 1976). Academic researchers started to study collections held by natural history museums, some universities even started a natural history museum themselves in order to explore evolution theories (Alexander & Alexander, 2007). Riding the waves of change, from 1880 onwards, in Britain and the US a new academic discipline emerged out of the lab-way of studying nature to become known as biology (Appel, 1988; Benson, 1988).

Biology was the first academic discipline studying biodiversity from a lab-centered perspective; following the common opinion among scientists in those days that scientifically sound research could only be done under controlled circumstances (Kohler, 2002). It enabled researchers to go beyond the perceived limits of studying whole specimens: comparative research of body parts as subject of investigation delivered new insights(Knight, 1986). The paradigm shift between natural history and biology caused by these developments can be best characterized considering respective sub-disciplines: where biology is thematically organized: anatomy, physiology and morphology, etc., natural history used to be hooked on species: concheology (shells), Ichthyology (fish), ornithology (birds), to name a few (Benson, 1988). Another sign of changing values were the formation of professional societies. Where associations of naturalists were focused at both volunteer and professional members at a general level, biologists associated themselves in specialized societies demanding relevant education and formal professional engagement to be admitted as members (Appel, 1988).

At the brink of the 20th century, the revolution of the lab-oriented biology was already past its peak and researchers were looking for new ways to learn about evolution in life. Natural history was still going strong, constituting the attitude of many going out in the field, however in need for a boost in methodological rigor (Knight, 1986). University based biologists sought methods to do field-studies in a more standardized way by creating lab-resembling environments like botanical gardens and zoological stations in rural parts of the country (Kohler, 2002). Marine laboratories in particular were trailblazers in clearing the obstacles between lab biology and natural history, in those days causing the latter to become known as 'new natural history'. The concept of lab research: using a single location under controlled circumstances for one type of research where unambiguous results were produced being universally applicable were of limited success, however opening up ways for further advancement (Knight, 1986).

Ecology became the new subfield of biology, covering practices that used to be done under the paradigm of natural history (Kohler, 2002). It became fashionable as a biologist to study nature in its natural habitat, being out and about, however using methods copied from the lab, using lab-equipment adapted to field circumstances. Taxonomy and ecology became the two sub-categories of biology of in-vivo research, being two inseparable and at the same time very distinct categories of biological practices (Gaston & Spicer, 2004).

Slowly but steady, ecology started to replace natural history. Moving within the same realm, ecology was recognized as being more standardized, methodological sound and therefore utterly scientific. It started to get hold of university research and education, also spreading out towards volunteering associations. Students were tempted to move out of classrooms and lecture-halls to participate in actual research. Sometimes they were recruited as volunteers to participate in specimen-gathering expeditions in order to maintain and to expand collections (Kohler, 2002).

2.4 Inviting the general public: crowd sourcing chores of science

The concept of crowd sourcing has many inputs, as it has been said to originate from a realm with applications like Open Innovation, User Innovation and Open Source software. It has been said it is connected to practices of product development, user satisfaction and bug-fixing in software application respectively (Schenk & Guittard, 2011). Ideas have been explored to move beyond the borders of traditional organizations, leading to a commonly used, management-driven definition of crowd sourcing: 'Crowd sourcing represents the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, and generally large group of people in the form of an open call'. (Schenk & Guittard, 2011) (p.94). It is treated as planned action: outsourcing work towards an unknown entity of people.

As a result, a bulk of research papers devoted to crowd sourcing is focused at topics related to the management of such projects (Brabham, 2008; Doan et al., 2011; Geiger et al., 2011; Leimeister et al., 2009; Parvanta, Roth, & Keller, 2013; Ross et al., 2010; Schenk & Guittard, 2011; Zhai et al., 2013). Brabham offers an exploratory study, making it distinct from open source software. He presents examples and definitions, making a plea for a research agenda focusing on the role of contributors and success- and fail factors of projects (Brabham, 2008). Crowd sourcing has been treated as a phenomenon to outsource a bulk of small repetitive tasks (Ross et al., 2010), to be used to attract funding (crowd funding), workers (crowd labor), voting data (crowd research) and ideas (creative crowd sourcing) (Parvanta et al., 2013). The nature of crowd sourced tasks are defined as either simple (‘the low-cost realization of tasks on a large scale'), complex ('to benefit from expertise and problem solving skills of individuals within the crowd') or creative (‘not to have a problem solved, but rather to benefit from the creative power of the crowd’) (Schenk & Guittard, 2011) p.99-100). Geiger et al., working towards a ‘Taxonomy of Crowd sourcing Processes’, discern the following elements in these processes: pre-selection of contributors, accessibility of contributions, aggregation of contributions and remuneration for contributions (Geiger et al., 2011). Doan et al. make an effort to review known web-based crowd sourcing systems, distinguishing four ‘Crowd sourcing challenges’: (1) recruiting and retaining of participants (e.g. paying/volunteering, establish reputation, provide ownership), (2) nature of contributions (impact, difficulty, repetitiveness), (3) how to combine contributions (defining an end-product) (4) how to evaluate contributions (detecting and blocking of malicious users and contributions) (Doan et al., 2011).

Motivation of contributors needs attention, as quite often it seems to be sheer interest keeping participants going only for a limited amount of time. Compensation for time and effort spent in an idea-searching crowd sourcing project can be direct in the form of money or career options, but also indirect as participation creates learning opportunities, self-marketing opportunities and forms of appreciation (Leimeister et al., 2009). The actual engagement in crowd sourcing activities can be rather tacit as the crowd sourcing activity might be piggybacked to other activities, making crowd sourcing as an implicit form of participation (Doan et al., 2011).

The phenomenon of crowd sourcing as described above has also been connected to science, in particular to scientific data collection. The worldwide web has unleashed new possibilities to engage crowds of people in scientific projects (Franzoni & Sauermann, 2014), as it was recognized that new IT methods and facilities together with the Internet will change the way data is collected, particularly (Young, 2010). It has been argued in astronomy (Kärnfelt, 2013; Littmann & Suomela, 2014) and ornithology (Dickinson et al., 2010) examples can be found that demonstrate involvement of crowds in data collection.

2.5 Institutions in biodiversity research embracing crowd sourcing and citizen science

Going out and feel at one with nature is a leisure activity for many. Nature is just as much a recognizable part of our environment as it is interwoven with society. This very notion might explain the natural history paradigm being still influential in the 20th century, while its foundations were already refuted during the 19th century. Involved volunteer naturalists, eager to apply science have been responsible for many successes of volunteering associations, natural history museums and biological faculties in universities. Doing research in order to acquire knowledge on nature automatically means the general public is never far away as almost every citizen has ideas about nature and how it should be studied

The intimate and longstanding relationship between biodiversity sciences and society might explain why biodiversity-mapping institutions are prepared to use crowd sourcing practices for the involvement of citizens in research. Tapping from a seemingly similar source, they are able to recognize the potential of volunteers participating in scientific data collection projects.

Two, at first sight unrelated phenomena in relation to participation of non-professionals in scientific biodiversity research stand out here. First, there is the ongoing involvement of citizen scientists in scientific endeavors, stemming from a tradition with less distinction between professionals and non-professional scientists than we see today. Second, there is the recent development of crowd sourcing tapping the possibilities of the Internet to mobilize masses, enabling scientists to reap the benefits of a non-descript crowd of workers to perform a bulk of simple tasks.

This dichotomy of distinct trends of non-scientists taking part in scientific research activities is not always as clear and detectable but nevertheless stands out as basic to a framework for analysis. This way of depicting reveals useful aspects for analysis, such as, institutional embeddedness, recruiting methods, motivation, remuneration, skills needed and funds available.

Natural history museums are still seen as centers of excellence in biodiversity. Vast and properly managed specimen collections seem to remain sources of knowledge, however their direct accessibility becomes less important as digitally disclosed collection data is increasingly used. These digital developments have impact on taxonomic and ecologic practices (Koerten & Van den Besselaar, 2013). New web-based digital data collections intensify international collaborations and create a potential for meta-collections (Van den Besselaar, Koerten, & King, 2013).

Shirk et al. (Shirk et al., 2012) describe a design model of citizen science called Public Participation in Scientific Research (PPSR), comprised of five models based on degree of participation. *A contractual citizen science project* (1) invites scientists to investigate data collected by the involved volunteer community. A *contributory project* (2) is designed by scientists and executed by volunteers. A *collaborative project* (3) is designed by scientists and fine-tuned by both groups. In *a co-created project (*4) scientists and experienced volunteers design while other volunteers execute. In *a collegial project* (5) there are no boundaries between the scientific and volunteer realms.

In order to use such a model it is essential to have a set of concepts available that would shed more light on the nature of volunteering in biodiversity research. In this research we are going to explore the concepts of citizen science and crowd science in attempt to specify their nature. The concepts of citizen science and crowd science will be the starting point of our research. In a grounded theory approach they will act as sensitizing concepts in a process of further articulating them.

3. Methodology

In order to learn more about how citizen-science and crowd-science practices have emerged in biodiversity, this research is exploratory in nature (Denzin & Lincoln, 1994). Since little is still known about theories of how laypeople are currently involved in biodiversity research we have applied qualitative methods of multiple case comparison. Inspired by Glaser and Strauss (Glaser & Strauss, 1967), an exploratory research procedure was followed, trying to develop and sharpen theories (Eisenhardt, 1989). The method comes down to case comparison, using sensitizing concepts leading to coherent theory (Strauss & Corbin, 1997).

Grounded theory is mostly seen as a method to construct theories from qualitative data as diverse as interview protocols, letters, diaries, field notes, and archival records. Unlike what is implicitly assumed it is not only a matter of induction, there is just as much deduction and verification involved when it comes to developing consistent theories (Strauss, 1987). Theories do not just ‘emerge’ out of the data collected, they have to be detected, specified and verified in order to become solid and therefore convincing. It is merely a process of following hunches, suggestive ideas and preliminary thoughts which can be labelled as data-driven research. Data analysis comprises both simultaneous and sequential processes of induction, deduction and verification, in which sensitizing concepts will ultimately be transformed into definitive concepts, being a conceptual vocabulary to be used to construct theory (Clarke, 1997). This process has been extensively described by Strauss and labelled as constant comparison (Strauss, 1987). It may take multiple cycles following different pathways until a certain saturation point is reached (Eisenhardt, 1989).

In the next section we will describe the research design and the final section of this chapter will give an account of the process of analysis.

3.1 Research design

Our line of enquiry was based upon the principles of grounded-theory multiple-case research as summarized above. Therefore we started out to study literature on volunteering in science to become familiar with the topic and to be able to recognize sensitizing concepts to initiate our research. This information was also helpful to develop a datasheet which was basic to our data collection process. The data to be collected was analyzed to start a process to develop definitive concepts, possibly leading towards theory.

Research activities have been conducted in 2014 in three phases; an exploratory phase (March-May), a data collection phase (June) and a data analysis phase (July-August), a procedure roughly based upon the 8-step model provided by Eisenhardt (Eisenhardt, 1989).

Exploratory phase

In the exploratory phase we have formulated research questions guiding this research and have explored literature on citizen science and crowd science. For that matter, both recent papers addressing themes as well as literature on historical accounts of biodiversity research have been studied. Chapter two reflects our journey exploring how professional science, volunteers, volunteer-experts and crowds of workers emerged. In the course of this phase we have also developed a procedure for case selection.

The notions of citizen science and crowd sourcing have been the sensitizing concepts that have been used to guide the sampling-method we have applied as well as the design of the data-collection procedure (Strauss, 1987). Both literature describing projects and experts on this topic were hinting towards a conceptual divide between citizen science and crowd sourcing, pointing at specific properties (Dickinson et al., 2010; Franzoni & Sauermann, 2014).

In an attempt to include as much cases as possible from European countries we invited all participants in this work package as well as some other Synthesys-researchers by email to come up with examples of biodiversity-oriented volunteer-driven research. Their feedback together with our own investigations helped to build a list of 80 biodiversity-related research projects in which volunteers were involved.

Based on our preliminary investigations in order to streamline the process of data collection, we then developed a topic list for data collection. This topic list was tested by selecting two Dutch examples from the list of biodiversity-science projects. These projects were investigated by the authors using the topic list with the purpose of testing and developing a datasheet, utilizing the results of the two examples for further refinement. The result of this procedure was a datasheet consisting of variables, metadata and empty fields to be filled; intended to collect data from the remaining cases, one sheet per case (appendix 1.). The two completed datasheets were used as examples to our fellow investigators to make them more familiar with our intentions (appendix 1.)

Two Dutch cases were deliberately chosen for multiple reasons. First, a citizen science and a crowd science case made the datasheet as fit as possible for the whole range of cases and also loosely coupled with our sensitizing concepts. Furthermore, they were selected because the authors were familiar with the Dutch situation. Finally, the completed datasheets were intended to be used as examples for other participants also showing the process of translating Dutch project information into data fit for our purposes in the English language. The process of datasheet-development was exclusively based on internet-data.

Data-collection phase

In phase two data of the other 78 cases was collected. We have followed a procedure of assigning non-Dutch cases on our list to our contributing European WP-3 participants, and invited them to collect data of the respective allocated cases, using the datasheet developed in phase one. We provided participants with a list of projects assigned to them, a letter with instructions (appendix 4), an empty datasheet and the two examples being the two completed datasheets from the earlier investigated Dutch projects.

The workload of each contributor was determined according to the person-months assigned to the respective institutions. We also had to deal with the fact not all case material was in English, which required the translation of some French, German and Swedish data into English. We are thankful for the contribution of a Synthesis-member not involved in Task 1.4 of work package 3 who was willing to collect data from two Swedish cases. All data on Dutch cases was collected by the VU research team.

Participants have checked websites to collect the required data, only in some cases they requested additional information through email or telephone conversation. Correspondence between the authors and the contributing participants regarding data collection was done via email. Empty datasheets, examples, workload distribution and instruction letter have been made in MS-Word and sent as email attachments. To collect and analyze the data it has been transferred into an MS-Access database.

In our case selection procedure we started with 80 cases as a result of the data collection procedure as described in the previous section of which 62 were fit for further analysis. Vital information was missing from 13 cases, 4 of them did not have any relationship with biodiversity and one case appeared not to be related with either crowd sourcing or citizen science.

Data-analysis phase

In phase three the returned data sheets were collected, analyzed and put in perspective. We started with collating the data we got back from our enquiry into our Access database. After a selection procedure, 62 of them were considered fit for further analysis. Vital information was missing from thirteen cases, four of them appeared to lack a relationship with biodiversity and one biodiversity-oriented case lacked aspects of volunteering .

It has been argued one of the pitfalls of comparative case research is the enormous amounts of within-case data that have to be digested (Eisenhardt, 1989). Piles of data per case need to be collected, analyzed and summarized in order to be able to present data to reveal between-case characteristics. We have tried to handle this laborious process by developing a datasheet, allowing us to structure the process of making within-case data fit for between-case analysis. Motivations for following that route were strictly practical: having only six months between initiation and the delivery of this report left us no other option.

Our first attempt to make cases fit for comparison was to score each project in a table using variables inspired by our sensitizing concepts. This table was meant to give a general overview allowing us to further explore our data in search of concept refinement. The method to explore and present data was based on insights derived from relevant literature where similar solutions were proposed (Eisenhardt, 1989; Ragin, 2000).

After going through several cycles of analysis we reached results that will be presented in the following chapter. This report being deliverable D3.4 of Synthesys 3 got its present form through editing and extending texts that were written in phase one.

3.2 Analysis

The concepts of citizen science and crowd sourcing have been considered as *sensitizing concepts,* as they have been frequently and intermittently used in literature on volunteering arrangements. This research is aimed at further specifying and analyzing these concepts by means of constant comparison (Strauss, 1987). In order to accomplish that we used comparative methods, based on Boolean analysis and ‘fuzzy-set’ analysis (Ragin, 2000).

In an iterative manner, we have specified aspects of the two sensitizing concepts and tested if and how they would appear in our research data. By doing that, we tried to be as exact as we possibly could to extract details from our dataset in order to come to more distinct conceptualizations.

Data was gathered qualitatively by giving answers to a set of open questions addressing the topics of organizational details (name, key-persons, number of staff, number of volunteers, etc.) aim of the arrangement, nature of the research field, qualifications, remuneration. The collected data was collected in a dataset holding all qualitative information per case.

As we were after organizing arrangements of volunteers in biodiversity research, we took the goal of the volunteering arrangement as the decisive concept to a general depiction. Other concepts such as Type, Scope, Nature, Skills needed, Field, Motivation and Time orientation. The next chapter is the result of this analysis in which we try to provide insight in this interesting world of biodiversity volunteering.

4. Research findings

This section is dedicated to results of our research, based on a dataset of 62 cases on volunteering in biodiversity research, showing considerable variety. Some cases have history going back over half a century, some are just a few years old, occasionally even ceasing to exist upon the moment of data collection. Some cases were started by one organization, others were the outcome of associating volunteers. Some were aiming at solving a clear and present problem, others were meant to be an ongoing monitoring system of a topic in biodiversity. The topics they have in common are biodiversity research and volunteer involvement.

First, we are giving a brief overview of how the sensitizing concepts of citizen science and crowd science were deconstructed in order to analyze data which has led to a new conceptualization of volunteering practices. The remaining sections give an overview of the analyses we have carried out using the sensitizing data of table 1.

4.1 Finding ways to deconstruct the dichotomy of Citizen Science and Crowd Science

At first glance, the nature of voluntary work seems to follow the dichotomy between citizen science and crowd science. Citizen science arrangements have the image of forming infrastructures at a national scale being exclusively involved in data collection, where crowd science is seen as crowd sourcing for science, meant to convert one type of data into the other. The BMP case is an example of citizen science in this respect, volunteers spot birds in a specific habitat and report the results. Galaxy Zoo is an example of crowd science, volunteers are asked to score images as smooth-, disk- or star-shaped, being in fact a process of (re)coding data.

Citizen science and crowd science as sensitizing concepts embody a dichotomy, almost acting as ideal types. Citizen science arrangements are seen as associations of volunteers forming an infrastructure on a national level, being focused at data collection, requiring considerable training and contributing to a permanent endeavor. Crowd science arrangements are ran by universities and museums in pre-fixed projects, internationally oriented, processing large quantities of data which only requires some instructions to get started within a limited period of time. Table 1 gives an overview of these notions.

	Citizen Science	**Crowd Science**
Type	Associated volunteers	Universities/museums
Goal	Infrastructure	Project
Scope	National	International
Nature	Data collecting	Data processing
Skills needed	Training	Instructions
Field	Mostly Ornithology	All Fields
Motivation	Community-based	
Time orientation	Permanent	Temporary

Table 1. The perceived Citizen Science – Crowd Science dichotomy

Table 2 provides an overview with a list of cases with corresponding data on variables that have been constructed in the research process of analyzing qualitative data into descriptive figures. We present this table with the intention to allow the reader to get to grips with our approach. Other variables we have developed will be mentioned in the course of this chapter. The next section will be devoted to a comparison of organizational arrangements, followed by an analysis of voluntary work. We conclude this chapter focusing at the position of natural history museums.

After validating the data and removal of the insufficient and unsuitable cases, the remaining dataset of 62 cases became subject of an exploratory process of converting qualitative data into descriptive variables. In table 2, cases have a name and have been given a number, also the country of residence is given. We have established whether the case is organized by a museum (M), a university (U), or a volunteering organization (V) (see Type-column)[6]. The scope of cases has been determined, being dichotomously scored as either N (Nationally) or I (internationally). Goal is a variable indicating the case is considered to be an infrastructure (I), project (P) or facilitator (F). The nature of voluntary work has been categorized as data collecting (C) or data processing (P). The time the case has existed has been labelled as Time Span. For most cases, training and instructions were required to qualify for participation. The column indicates an I where instructions were given, a T stands for a level of knowledge to be able to participate, en N indicates neither of them is required. Sometimes instructions are provided online which is indicated in the Online user support column, comprising documents, instruction videos, a FAQ-list, a chatroom, or even games. In case of mandatory training, sometimes participants are asked to go elsewhere, sometimes training is provided by the organizer, given in the column Additional training/workshops.

[6] A few research institutes have been counted as universities.

Number	Org Name	Country	Type	Goal	Time Span	Scope	Nature of work	Training required	User support given	Training given
1	Bird Cams	US	U	I	2	N	C	I	X	
2	Celebrate Urban Birds	US	U	I	7	N	C	I	X	
3	eBird	US	V/U	I	12	I	C	I	X	
4	FeederWatch	US	V/U	I	38	N	C	I	X	
5	Great Backyard Bird Count	US	U	I	16	N	C	I	X	
6	NestWatch	US	U	I	17	N	C	I	X	
7	Yardmap	US	U	I	5	N	C	I	X	
8	Yellowhammer	Czech Republic	V/U	I	3	N	C	I	X	
9	Water Quality Monitoring	US	U	I	3	N	C	T	X	X
10	CitSci	US	U	F	10	N	P	I		
11	Discover Life	US	U	F	15	I	P	I	X	
12	Herpetofauna	Austria	M/V	I	12	N	C	I	X	X
13	Naturbeobachtung	Austria	V	I	7	N	C	I		
14	Birdlife (Austria)	Austria	V	I	1	N	C	T	X	X
15	The Great Sunflower Project	US	U	I	5	N	C	I	X	X
16	Zooniverse	UK	U	F	7	I	P	N		
17	BioSpex	US	U	F	3	I	P	N		
18	Calbug	US	M	P	5	N	P	I	X	
19	CCC Coral Cay Conservation	UK	V	F	29	I	C	I	X	X
20	Citizen Science Central	UK	U	F	8	N	P	N		X
21	Earthwatch Institute	US	V	F	44	I	C	N		X
22	Les Herbonautes	France	M	P	2	N	P	I	X	
23	Notes from Nature	UK	U/M	P	2	I	P	I	X	
24	Operation Wallacea	UK	U	F	20	I	C	N		X
25	Telmee (Belgium)	Belgium	V	F	5	N	P	T		
26	Apiary	US	U	F	7	N	P	T		
27	BatDetective	UK	V/U	I	2	I	C	T		
28	Gänsezählungen	Germany	V	I	4	N	C	T		
29	Mueckenatlas	Germany	V	I	2	N	C	T	X	
30	MyOSD	Germany	V/U	F	1	I	C	T	X	X
31	Project Noah	US	V	I	4	I	C	I		
32	Public Laboratory	US	V	F	5	N	C	N		
33	rePhoto	US	U	F	1	I	C	I		
34	Sensebox	Germany	U	F	9	N	C	I		
35	Treezilla	UK	V/U	I	1	N	C	I	X	
36	Wasservogelzälung	Germany	V	I	50	N	C	T		
37	Anemoon	NL	V/U	I	25	N	C	T	X	
38	Evolution Megalab (NL)	NL	U/M	I	5	N	C	I	X	
39	Glashelder	NL	M	P	1	N	P	I	X	
40	Sovon	NL	V	I	30	N	C	T	X	
41	Schelpen Ontcijferen	NL	M	P	1	N	P	I	X	
42	Telmee (NL)	NL	V	F	8	N	C	T		
43	Vele Handen	NL	M	F	3	N	P	I		
44	Xneming.nl	NL	U	I	10	N	P	I	X	
45	Encyclopedia of Life	Denmark	U/M	I	7	I	P	I		
46	Smithsonian	US	M	P	1	N	P	I		
47	Artportalen	Sweden	U	I	10	N	C	T		
48	Racoon Dog Project	Sweden	V/U	P	5	N	C	I		
49	Field Trip GB	UK	U	F	1	N	P	I	X	
50	Garden BirdWatch GBW	UK	V	I	20	N	C	T		
51	NLS Georeferencer	UK	M	F	4	N	P	I	X	
52	Track a Tree	UK	U	I	1	N	C	T	X	
53	UKEOF	UK	U	F	1	N	C	N		
54	Air Survey OPAL	UK	V/U	I	5	N	C	I	X	
55	ALA Biodiversity Volunteer Portal	Australia	U/M	F	3	I	C	N	X	
56	Biodiversity Survey OPAL	UK	V/U	I	3	N	C	I	X	
57	Bugs Count	UK	U/M	I	3	N	C	I	X	
58	Climate Survey OPAL	UK	V/U	P	3	N	C	I	X	
59	Herbaria @ Home	UK	M/V	P	8	N	P	I	X	
60	Soil and Earthworm Survey OPAL	UK	V/U	I	5	N	C	I	X	
61	Tree Health Survey OPAL	UK	V/U	I	1	N	C	I	X	
62	Water Survey OPAL	UK	V/U/M	I	4	N	C	I	X	

Table 2. overview of variables

4.2 Three types of goals: Infrastructure, Project and Facilitator

In this section we start the exploration of data by looking further into how cases are organized using citizen science and crowd science as sensitizing concepts. Focusing at the goal of the cases in our dataset, the infrastructure and the project characteristics were present, however we also discovered a third type of goal. We decided to develop the *Goal* variable, for which a case has been determined as bringing about an ongoing infrastructure (I), a project (P) or being a Facilitator (F) to voluntary biodiversity research. An *infrastructure* is considered to be an ongoing endeavor such as a yearly animal count or the production of an atlas or reference book. A *project* is seen as having a fixed start- and endpoint, intended to complete a predefined workload, often, but not necessarily related to an infrastructure. A *facilitator* is an organizational arrangement where volunteering arrangements by other organizers are hosted, or coordinated for multiple organizations. The Goal-column in table 1 gives the results of this procedure.

An *infrastructure* is a collection of records that is accessible for research. It implies data needs to be collected in a rigid, standardized manner. These records may entail time series of decades, maybe even a century. Infrastructures appearing in our case material are almost exclusively focused at one particular biodiversity aspect, such as populations of bats in a particular habitat or a systematic collection of specimen slides or birdsong recordings.

A *project* is usually started to improve or change a specific infrastructural aspect in order to make it fit for future challenges and requirements. Today, quite often these aspects comprise digitization of infrastructures. Usually, digital images of analog sources (images, tags, etc) have been made to be classified and sorted by a crowd of people in a standardized way. Quite often these processes are tedious and monotonous, requiring repetitive, single tasks that can't be automated.

Some cases are acting as *facilitator,* being a platform to other cases. The relationship between the cases *Glashelder!* and *Vele Handen* may be explanatory. *Glashelder!* is a Dutch project set up and managed by Naturalis Biodiversity Center where the *Vele Handen* case acts as a facilitating website for the GLAM-sector[7]. Volunteers can register and process their tasks at the *Vele Handen* website and this is also the place where descriptive information can be found on the nature, aim and progress of the project. For reasons of completeness both cases appear in our dataset. Facilitator-cases have been included when rendering services to the biodiversity volunteering domain, regardless if they served to other business sectors. Quite another but revealing example are the *Telmee* arrangements in Belgium and the Netherlands. These cases act as data processors aggregating data from various data-collection infrastructures to make it available for policy purposes in public administration.

[7] GLAM is an acronym for Galleries, Libraries, Archives and Museums.

4.3 Museums do the projects, volunteering organizations do the infrastructures, universities do the infrastructures and facilitate

Table 3 gives a crosstab of type and goal, two variables of our dataset. Volunteering activities are to be found most when volunteering organizations are in some way involved (V, M/V, V/U and V/U/M; 20 out of 62) and Universities (U, V/U, U/M and V/U/M; 22 out of 62). Museums are a bit less represented (M, M/V, U/M and V/U/M; 15 out of 62). 12 out of 62 cases are collaborations, involving two (M/V, V/U and U/M; 11) or all three organization types (V/U/M; 1).

	M	M/V	V	V/U	U/M	U	V/U/M	Totals
Infrastructure	-	1	8	3	3	10	1	33
Project	5	1	1	1	1	-	-	9
Facilitator	2	-	5	1	1	11	-	20
Totals	7	2	13	5	5	21	1	62

Table 3. Cross table of Organization Type and Goal

A minority of about 20% of the cases (9 out of 62) has a temporary orientation because they have been identified as a project. It means volunteering in biodiversity is mainly oriented towards maintaining infrastructures (33), or offering facilities (20), both to be considered as permanent arrangements. Universities (17 out of 33) and volunteering organizations (13 out of 33) participate in the majority of infrastructures. Project cases are almost exclusively a museum affair (7 out of 9), with m half of them (5 out of 9) without collaborating with other organization types.

Museums collaborate with volunteering organizations (2) or with universities (3 out of 5) to be involved in infrastructures. The *OPAL Bugs Count* and *Evolution Megalab* are striking examples of volunteer involvement in data collection where a museum and one or more universities are working together to collect data. Facilitators are organized by multiple museums (2 out of 7) to organize crowd sourcing projects. These two cases comprise *Vele Handen* (the name is the Dutch phrase for Many Hands) and Georeferencer, a device developed for geo-tracking locations of collection items, offered as a service to volunteering projects in the GLAM sector. When volunteering organizations are involved in projects, they are mostly policy oriented. Museums organize their project oriented volunteering arrangements themselves, with the exception of British/Irish *Herbaria at Home*, which is organized in association with two volunteer-supporting organizations.

Table 4 informs about the relation of organization type with the field of biodiversity. Museums are not involved in climate-related volunteering. Museums specialize in their own volunteering projects, with the US *Smithsonian Museum* as the only exception. The only way museums are involved in general biodiversity topics is through joint cases with universities. The UK Natural History Museum is the only museum involved in climate, the *Opal Water Survey*. Ornithology is dominated by volunteering associations and universities, however the former like to associate themselves with museums. Cases aiming at biodiversity at large are in about half of the cases exclusively done by universities.

	M	M/V	V	V/U	U/M	U	V/U/M	Totals
Botany	1	1		3		2	-	7
Climate	-	-	1	2	-	2	1	6
Entomology	2	-	1	-	1		-	4
Ornithology	-	-	5	3	-	5	-	13
Marine zoology	1	-	1	1	1	-	-	4
Terestrial zoology	-	1	-	3	-	-	-	4
General	1	-	4	1	3	10	-	19
None	2	-	1	-	-	2	-	5
Totals	7	2	13	13	5	21	1	62

Table 4. Cross table of Organization Type with Biodiversity Field

4.4 The scope of volunteering: 75% of the cases have a nationally orientation

The majority of cases is organized at a national scale. Either the nature or the impact of them is of national importance, reflected in nationwide organizations, hosting multiple projects, jointly reflecting national interests or concerns.

Almost 25% of the cases in our dataset have an international in orientation, inviting the global population to participate in biodiversity volunteering. Issues to be dealt with are related to a higher, global goal: stimulating biodiversity or nature preservation, of which *Coral Cay Conservation* and *Earth-watch Institute* are examples. Table 5 compares organization types with their scope. International cases are mostly related in some way to universities (11 out of 14). Volunteering organizations also play a role, while museums are almost absent in the international setting. Only in three cases museums work together with universities: in the *Biodiversity Volunteer Project of the Atlas of Living Australia, Encyclopedia of Life* and *Notes from Nature*.

	M	M/V	V	V/U	U/M	U	V/U/M	Totals
National	8	2	10	10	1	16	1	48
International	-	-	3	3	3	5	-	14
Totals	8	2	13	13	4	21	1	62

Table 5. Cross table of Organization type and scope

Table 6 tells us infrastructures are mostly organized at the national level. Only four are internationally oriented when it comes to volunteer involvement, being *Bat Detective*, *eBird*, *Encyclopedia of life*, and *Project Noah*. About a quarter of the projects is internationally oriented, being *Coral Cay Conservation*, *Notes from Nature* and the *Earth-watch Institute*. A little less than 45% of the facilitator cases is an international case (7 out of 16), of which *Biodiversity Volunteer Project of the Atlas of Living Australia*, and Zooniverse are good examples.

	Infrastructure	Project	Facilitator	Totals
National	29	8	11	48
International	4	2	8	14
Totals	33	10	19	62

Table 6. Cross table of Goal and Scope

4.5 The nature of voluntary work: Collecting data for infrastructures, enabling and doing data processing in projects

Based on our case material, in this section we are going to give a characterization of voluntary work in biodiversity. We are going to look into the content of it and where it is actually done.

Task content of voluntary work

The analysis of our case material has identified two basic types of voluntary work. There is the work where the materials needed for the task are electronically provided by the work organizer, usually in a database. The task of the volunteer is to extract information from the provided data, and after recoding entering it into a web-based results-database. This work type can be summarized as restructuring data into a new format. The process of conversion into a new format makes the data fit for further analysis.

The other type of work is where the volunteer does observations that needs to be classified and entered into a computer system. Instead of organizers engaging in processing a fixed workload, volunteers go out and do observations. These observations are generally classified by the observer himself, he has to decide how the observation will be recorded.

	Data collection	Data processing	Totals
Infrastructure	31	2	33
Project	2	7	9
Facilitator	9	11	20
Totals	42	20	62

Table 7. Cross table of Nature of Task and Goal

Table 7 tells us about two third of the cases (42 out of 62) is aimed at volunteers making observations that have to be registered in a system. About 95% of the infrastructure cases (31 out of 33 cases) are meant to collect data. The two infrastructures classified as data processors, *Xneming.nl*[8] and *Encyclopedia of Life* receive data from other infrastructures in order to bring it into a meaningful whole through a standardized process of categorization.

7 out of 9 projects aim at data-processing, focusing at digitization, which generally means transcribing of information from digital images into dedicated databases. Project-oriented data collection is usually done to support biodiversity policies serving specific ends limited by time and effort, having a national scope like such organizations as the *British Opal Climate Survey* and the Swedish *Racoon Dog Project*.

Facilitators are to be found to support both data collection (7 out of 18) and processing (11 out of 18). Supporting data collection may entail offering tools such as sensors in the German

[8] *waarneming* is the Dutch phrase for observation.

Sensebox and photo-apps like *rePhoto*, but also volunteering-recruitment services like the *Atlas of Living Australia Biodiversity Volunteer Portal*.

4.6 Infrastructure volunteering often requires training, project volunteers only need instructions

Some tasks require a certain level of skills for which instructions are needed or sometimes even additional training or education. We present a variable in which three categories can be distinguished in relation to skill-qualifications participants should have. First, many cases require from volunteers to follow detailed instructions (labelled as I in tables 2), provided in the form of web pages, pdf-files, instructional videos or even a game to be played to improve skills before commencing. Second, for some cases qualifications are needed in the form of training (T), either to be provided by the volunteering organization or to be taken elsewhere. Third, for a few cases neither instructions nor training is necessary (labelled as N), the task to be done is considered simple or self-explanatory. We have scored all cases using the collected qualitative research material, results are presented in the following tables.

	None	Instructions	Training	Totals
Infrastructures	-	22	11	33
Projects	-	9	-	9
Facilitators	8	8	4	20
Totals	8	39	15	62

Table 8. Cross table of Skills Needed and Goal

From table 8 it becomes clear that training is almost exclusively related to infrastructures (11 out of 15 cases), with a few facilitators as well (4 out of 15). However, two third of the Infrastructure cases only requires to follow instructions, while none of them can do without anything. Projects, on the other hand, can do with instructions only, not a single case requires training. Facilitators sometimes provide training for cases they support, like *Ocean Sampling Day* is equipping science teams with training and support.

	None	Instructions	Training	Totals
Data Collection	5	25	13	43
Data Processing	3	14	2	19
Totals	8	39	15	62

Table 9. Cross table Skills Needed and Nature of Task

Training can also be related to the nature of the task, being data collection or data processing as presented in table 9. The two data processing cases requiring training, being *Telmee Belgium* and the *Apiary Project* are in fact collecting data from data-collection organizations and offering their services to other organizations. The training they provide is meant to let data processing organizations to get to grips with the process of data processing through digitalization.

When training is required in data-collection, volunteers going out in the field to get trained in observing, meaning recognizing and classifying species for appropriate registration.

Our data reveals there are nine cases where training and workshops are offered (see table 2 for details). In only three cases these educational endeavors are related to requirements for volunteers to participate. In the other six cases the provided training not being linked to the volunteering activity they host, but is related to acquiring general skills or to projects or infrastructures they facilitate.

4.7 Most infrastructures are ornithology-related, facilitators are usually generally oriented

In table 10 the Field of biodiversity is being compared with the goal of the case. Looking at the different fields in biodiversity, cases relate to ornithology or have a general orientation. There are no ornithological cases acting as projects or facilitators, they are to be treated as infrastructures and are counting projects. Moreover, about 35% (13 out of 35) of the infrastructure cases are ornithological in nature. As more or less expected, facilitators have a general or no orientation to biodiversity. As mentioned before, criteria for non-biodiversity dedicated cases is that they must serve to the biodiversity volunteering community.

	Botany	Climate	Entomology	Ornithology	Marine zoology	Terrestrial zoology	General	None	Totals
Infrastructure	5	3	2	13	1	3	6	-	33
Project	2	1	2	-	1	1	2	-	9
Facilitator	-	2	-	-	2	-	11	5	20
Totals	7	6	4	13	4	4	19	5	62

Table 10. Cross table of and Goal

Table 11 reveals information about the scope of cases in relation to the biodiversity field. Internationally oriented cases can be characterized as having a general orientation (8 out of 14). Among four marine zoology cases there are two international and two national cases to be found. The climate topic has a national focus in volunteering, only one climate case is labelled as international.

	Botany	Climate	Entomology	Ornithology	Marine zoology	Terestrial zoology	General	None	Totals
National	7	5	4	12	2	3	11	4	48
International	-	1	-	1	2	1	8	1	14
Totals	7	6	4	13	4	4	19	5	62

Table 11. Cross table of Field and Scope

Table 12 provides insights in the biodiversity field being related to the nature of the task. Here we see the Ornithological field and terrestrial zoology being exclusively devoted towards data collection. Terrestrial zoology entails cases like the Austrian *Herpetofauna*, the *Swedish Racoon dog Project*, the British *Opal Soil and Earthworm Survey* and *BatDetecive* cases. Climate cases involve three British OPAL cases on *Water*, *Air* and *Climate* in general.

	Botany	Climate	Entomology	Ornithology	Marine zoology	Terestrial zoology	General	None	Totals
Data Collection	5	6	2	13	3	4	8	2	43
Data Processing	2	-	2	-	1	-	11	3	19
Totals	7	6	4	13	4	4	19	5	62

Table 12. Cross table of the Field and Nature of task

4.8 Motivating volunteers: occasionally stimulating competition and recognition

According to our data, none of the volunteering organizations offers direct financial compensation. However, the US *Celebrate Urban Birds* case offers so-called mini-grants of about $ 500-750 for small projects on urban birding. Our data does not hold information on compensation of expenses. However, it does reveal at least something about how participants are being motivated.

We have developed a variable indicating whether volunteers are motivated by mutual competition, recognition, compensation in kind or a grant for organizing an event. Details of this variable can be found in table 12 in a cross table of motivation with Goal. Competition can be a motivator and has been defined as when participants are able to compare their contribution with peers. Recognition can take the form of progress information on the project being monitoring and displayed on the homepage of the case. Recognition can also take the form of participants and their production being mentioned or outstanding contributions of participants being highlighted or to awarded. Sometimes contributors are paid in kind after reaching a certain amount with tickets, books , cameras, etc.

	Competition	Comp/Recog	Recognition	In Kind	In Kind/Recog	CKR	Grant	None	Totals
Infrastructure	3	2	4	2	1	1	1	19	33
Project	-	1	3	-	-	1	-	4	9
Facilitator	-	-	2	1	1	1	-	15	20
Totals	3	3	9	3	2	3	1	38	62

Table 13. Cross table of Motivation and Goal

It becomes clear form table 14 that 60% of the cases (38 out of 62) do not use visible forms of motivation. Of the 24 cases that do take motivational actions, 15 cases give some form of recognition to the work being done, 9 stimulate competition and 8 reward work in kind. To recapitulate; many cases do not have any form of stimulating measure in place, and when they do, there is no clear preference for a particular type.

	Competition	Comp/Recog	Recognition	In Kind	In Kind/Recog	CKR	Grant	None	Totals
Data Collection	3	2	4	2	2	1	1	28	43
Data Processing	-	1	5	1	-	2		10	19
Totals	3	3	9	3	2	3	1	38	62

Table 14. Cross table of Motivation and Nature of Work

Almost half of the data processing cases (10 out of 19) do not take motivational measures against about 65% (27 out of 42) of the data collection cases. To apply some form of motivational policy seems to be a little more popular in data processing than in data collecting.

The *eBird* project awards prizes like cameras for processing large amounts of data and the Austrian *Birdlife* projects allows large contributors to use the collected data in a friendlier way than ordinary visitors. The *Earthwatch institute* claims the volunteering experience with their organization is of great value and is boosting the CV of participating volunteers. This experience may also be used to obtain points for some college- or university curricula.

4.9 Time matters: collection infrastructures are longer-lasting

In the light of this research it is quite tempting to declare cases as intended to be either permanent or temporary, however, the data that we have does not allow that. Quite often it is impossible to establish whether a case was meant to have an eternal or limited time span. Cases planned to be permanent in character may disappear through lack of funding or other means of support, other cases meant to be temporal might be repeatedly extended, thus acquiring a de facto permanent status. Cases that have been listed as a project are temporary by nature and have been treated as such elsewhere in this report, but if and how they will actually end is sometimes unclear.

To avoid discussions like these we have established the age of all of our cases they had at the time we did our research (2014). Table 15 gives results on that in a cross table with the goal of the case. One third of all cases (21 out of 62) fall in the category 3-5 years, while a quarter of them all (16 out of 62) has a history of less than two years. The oldest case is in our dataset is the German *Wasservogelzählung*[9] with a history of 50 years.

	< 2 years	3-5 years	6-10 years	11-25 years	> 25 Years	Totals
Infrastructure	7	12	5	6	3	33
Project	5	3	1	-	-	9
Facilitator	4	6	6	2	2	20
Totals	16	21	12	8	5	62

Table 15. Cross table of time span and goal

[9] The German expression for water bird count

About 80% (59 out of 62) of the cases do span decade or less. There are three infrastructures having a history over 25 years: *Wasservogelzählung* (50 years), *Feederwatch* (38 years) and *Sovon* (30 years) Two Facilitating organizations are over a quarter century old: the *Earthwatch Institute* (44 years) and *the Coral Cay Conservation* (29 years). The longest-running project, spanning 8 years, is *herbaria@home*, aimed to digitize handwritten labels on herbarium sheets.

	< 2 years	3-5 years	6-10 years	11-25 years	> 25 Years	Totals
Data Collection	10	16	5	7	5	43
Data Processing	6	5	7	1	-	19
Totals	16	21	12	8	5	62

Table 16. Cross table of Time Span and Nature of Work

Comparing the history of cases with the nature of work in table 16, we see data processing is almost absent in cases older than a decade. The oldest data-processing case is *Discover Life*, a 15 year old website where both volunteer and professional biologists can put their research data online for sharing and analyzing purposes.

	< 2 years	3-5 years	6-10 years	11-25 years	> 25 Years	Totals
M	4	3	-	-	-	7
M/V	-	-	1	1	-	2
V	2	4	2	1	4	13
V/U	4	6	-	2	1	13
U/M	1	3	1	-	-	5
U	5	4	8	3	1	21
V/U/M	-	1	-	-	-	1
Totals	16	21	12	8	5	62

Table 17. Cross table of Time Span and Organization Type

From table 17 we learn that Museums are hardly involved in cases being active for more than five years, and if they do, they collaborate with volunteering organizations (2) or a university (1). The British herbaria@home (8 years) and the Austrian *Herpetofauna* (12 years) are the exceptions linking Museums with volunteering organizations and the international *Encyclopedia of Life* (7 years), a collaboration of multiple museums and universities. Volunteering organizations provide three cases spanning more than a quarter century, of which two are birding infrastructures, one is climate-oriented and one Marine-oriented. The oldest volunteer/university-related case is project Feederwatch being 38 years old.

	< 2 years	3-5 years	6-10 years	11-25 years	> 25 Years	Totals
Botany	4	1	1	1	-	7
Climate	1	4	-	-	1	6
Entomology	2	2	-	-	-	4
Ornithology	2	3	1	4	3	13
Marine zoology	2	1	-	-	1	4
Terestrial zoology	1	2	-	1	-	4

General	2	5	10	2	-	19
None	2	3	-	-	-	5
Totals	16	21	12	8	5	62

Table 18. Cross table of Time Span and Field

Looking at the biodiversity field in relation to time in table 18 we see considerable differences between fields. Climate, Entomology, Marine Zoology and terrestrial zoology are topics being almost absent in cases of more than 5 years. orspan we see entomological and Climate oriented. General projects are the most common cases (about 15%, 10 out of 62 cases). After general cases, ornithology provides for the most long-lasting ones.

In this chapter we have presented an analysis of our qualitatively collected data comprising 62 cases. In 15 tables we made an attempt to present analogies, differences and categorizations, using the dichotomy of citizen science and crowd science as a starting point. Table 19 gives a summary of all the tables we developed to explore associations between variables.

topics	Type	Goal	Scope	Nature	Skills	Field	Motivation	Time span
Type		Table 3	Table 5			Table 4		Table 17
Goal			Table 6	Table 7	Table 8	Table 10	Table 13	Table 15
Scope						Table 11		
Nature					Table 9	Table 12	Table 14	Table 16
Skills								
Field								Table 18
Motivation								
Time span								

Table 19. overview of crosstables

Here is a brief summary of the results of the presentation and analysis of research findings:

- 20% of the volunteering cases are temporary projects, being a predefined workload with fixed start and end point.
- 25% of the volunteering cases have an international scope, of which 60% are facilitators and 55% having a general orientation. Only one out of 13 ornithological cases has an international scope. The majority of international cases have some form of university involvement.
- 30% of the cases involve more than one organization type. Museum volunteering is organized along the lines of their departmental division (botany, entomology, etc.). Universities address biodiversity at large in their volunteering arrangements.
- Two third of the cases concerns data collection, of which 95% concern data collection for infrastructures. 40% of all infrastructure cases are dealing with ornithology. 60% of the general biodiversity cases involve data processing. Ornithological, climate and terrestrial zoology data-processing cases could not be found.
- Not a single project requires training. For one third of volunteering in infrastructures some form of training is needed.

- Measures to motivate volunteers are taken in 40% of all cases, when looking only at data-collection this is in 50 % of the cases. 60% of the project cases have some form of motivation in place.
- Cases spanning more than a quarter decade are data-collecting Infrastructures (3) or Facilitators (2) and require training form its volunteering participants.

These results will be put in perspective in the next chapter.

5. Volunteer participation in research infrastructures

Biodiversity is a vital aspect of life on earth. In order to learn more about its history, presence and future, it needs to be studied in the light of ideas about evolution (Bowker, 2000; Busby, 2002). All cases in our dataset relate in some way to the topic of acquiring data about nature surrounding man. Monitoring biodiversity requires an infrastructure: data has to be collected in a standardized way, to be interpreted and to be presented in a meaningful whole . This has been done by natural history museums in specimen collections, by volunteering associations responsible for ongoing monitoring and counting arrangements and by universities in long-lasting research projects.

Such an all-encompassing infrastructure should be viewed as virtual, the cases appearing in our research are rather to be regarded as addressing one aspect of it. Many organizations are involved, operating at local, regional, national and global levels, increasingly collaborating and working on infrastructures to be treated in its own right, however also being a part of this virtual global biodiversity infrastructure (Bowker, 2000).

We are going to analyze our findings in the light of infrastructures for biodiversity research. By doing that we are able to put all contributions to the higher goal of monitoring biodiversity into a meaningful whole to make recommendations for volunteering policies to be maintained and developed, moving beyond the dichotomy between citizen science and crowd science.

An infrastructure can be considered as an arrangement meant to produce goods or services for the common good that only becomes visible upon breakdown (Star & Ruhleder, 1996). Information infrastructures require Funding, Technology, Skills, Careers en Datasets (Bowker, Baker, Millerand, & Ribes, 2010). It follows from this definition that infrastructure needs to be embedded in a community, this very aspect is what we are going to investigate here.

Embeddedness of infrastructures can be treated as a form of institutionalization (Scott, 1995). Natural history museums, volunteering associations and universities are the embodiment of institutionalization in biodiversity research as forms of organizational arrangements involving multiple stakeholders to bring about research infrastructures (Star & Griesemer, 1989).

The general public has ties with these institutions in many ways, one of them is that they can be involved as volunteers, meaning they are prepared to do an amount of work without being financially remunerated. Many people are aware of the importance of biodiversity research and are willing to do a small share of simple work for the up keeping of sets of biodiversity data. Others are intrinsically motivated to learn about nature, wanting to utilize their lust for knowledge for the benefit of biodiversity science. These two lines represent the respective connotations of crowd science and citizen science. Now it is time to look into the cases we have studied and to discern the organizational arrangements that have been identified in the light of volunteering in biodiversity .

5.1 Three modes of organizing: data-collecting infrastructures, data-processing projects and supporting Facilitators

The organizational arrangements that we have studied can be subdivided into three main types: data-collecting infrastructures, data-processing projects and supporting facilitators. This categorization will be explained below, elaborating on the relationship with biodiversity infrastructures.

5.1.1. The impact of volunteers in long-lasting data-collecting infrastructures

Long-lasting and enduring biodiversity infrastructures are founded and operated by volunteer-associations. However, sustainability requires also scientific relevance of some sort, being a scientific department or a form of cooperation with one or more universities. The oldest biodiversity infrastructures operate in the ornithological field, having a national scope and a strong scientific base, involving a volunteering association where skilled volunteers do the data collection. Volunteers are intrinsically motivated to apply their expertise of one biodiversity aspect by going out in the field, transferring their observations into a registering database. The expertise of volunteers demonstrated in their knowledge of nature gets recognition from the scientific community which uses observational data for their scientific output.

Dedication is what seems to be the distinctive element of volunteers active in these kind of infrastructures. They do not necessarily feel the urge to make a contribution to science themselves, they are committed to one specific aspect of biodiversity and want to know all about it. Either developing insights in migration patterns of birds or studying the occurrence of various types of butterflies in some particular habitat, it is their drive to know everything about it that keeps them motivated. For that matter, they improve their skills, read relevant literature and take courses if necessary. Generally these volunteers have a basic educational level of knowledge about living nature but also dedicated knowledge, based upon their experience and learning from peers. With in-depth knowledge and skills they master their biodiversity sub-field and are perfectly equipped to convert observations into reliable, standardized and structured records. The volunteering association gathers like-minded peers and recognizes individual efforts and makes sure they are valued, by fellow-volunteers as well as their scientific counterparts. Verification procedures are mainly skill-based and designed by committees of peers in close cooperation with scientists.

These cases resemble studies by Star and Griesemer, in which it was argued infrastructures require boundary objects to connect certain aspects of infrastructures to be lasting and successful (Griesemer, 1990; Star & Griesemer, 1989). Scientists need data they don’t have which volunteers are able to pride provide. Volunteers want to make their fieldwork meaningful by working in close cooperation with science, thus also learning new scientific insights. A registration database acts as a boundary object connecting the world of volunteers with the world of science (Star & Griesemer, 1989). Its definition is distinctive enough to be recognizable as an independent unit by both worlds, and at the same time fuzzy enough to be able to be a 'narrative anchor' to two different and yet mutually dependent worlds (Koerten, 2011).

5.1.2 Volatile involvement of Volunteers in data processing projects

Projects of data-processing have a clear definition of what has to be done, resulting in exact notions about start and end. To be a volunteer in these projects requires no special skills, only some instructions to complete standardized tasks with a repetitive character, belonging to a fixed set. The completion of the project is the motivational drive for volunteers to participate, being the processing of this huge amount of tasks to be done or a problem that gets solved by processing a large amount of data.

Quite often, quantitative aspects work as motivators to participants. It is taken for granted scientists should waste their talents and time doing such tedious work that could just as well be done by unskilled, yet enthusiastic people only requiring a few guidelines to get started. Thus, volunteers processing large amounts of work are recognized and rewarded. Tasks get structured through tight procedures, numbers reflect productivity. A reason for volunteers to participate is quite often a latent, non-descript interest in 'making a contribution to science' (Raddick et al., 2010), which might just as well be used as a justification for wasting time on dull jobs, however also reflecting the idea that they do the chores of science. Once they are in, they get challenged by numbers, acting as motivators. This is all electronically enabled in pre-designed structures. Instructions are also electronically provided and do not require face-to-face contact. Verification of results is provided by applying rigid procedures like comparing tasks being performed twice. Such procedures are designed within the academic realm and further fine-tuned and implemented by a specialized staff with no significant user-involvement.

The temporal project-based orientation is consistent with findings presented by Franzoni and Sauermann (Franzoni & Sauermann, 2014). They come with three examples (Foldit, Galaxy Zoo and Polymath) derived from a set of 40 crowd science projects. These examples match with our definition of volunteering projects having a tight structure with clear definitions of start and end (Foldit and Polymath as solving a predefined problem, Galaxy Zoo as processing 1.6 million photo images). A sharp delineation between the realm of science and the realm of data processing can be observed. Scientists are seen as designing the project in which data gets manipulated by participants. Participating volunteers are supposed to do the work, are perhaps allowed to come with feedback but are by no means co-creators of the project design. They also do not constitute a community and also may never become a community, which may strongly influence motivation and (long term) participation (Van den Besselaar & Koerten, 2014).

5.1.3 Facilitators in volunteering: supporting projects or infrastructures

There is a subset of cases in our dataset with no direct involvement of volunteers. They are meant to promote and enhance volunteering in biodiversity science and have been categorized as facilitators, enabling either infrastructures or projects. We see a range of different efforts to make volunteering in biodiversity prosper.

There are a few data-processing arrangements appearing in our research where data from data-collecting infrastructures are collected to be distributed to policy-making governmental organizations. Separate infrastructures aiming at specific aspects of biodiversity are brought into a meaningful whole to be relevant and beneficial to policy making.

Some facilitating arrangements host projects, acting as volunteering platforms to the public, offering a place where potential volunteers can find information on multiple projects, select a project of their interest, register themselves and get going. Organizing the presentation of tasks to the public and taking care of the back office of such projects is done by these kind of organizations.

On the international level there are a few organizations having a mission of encouraging others to start projects at a lower level aimed at nature conservation, producing information explicitly meant to influence policy making. This type of organization mostly has a single biodiversity issue to take care of which can be promoted through having grant application arrangements in place, offering training and education or help in establishing relationships with local authorities.

A few arrangements we found offer tools or equipment to enable projects to do tasks which are essential for volunteering. They may offer sensor-devices or software packages to enable volunteers either involved in infrastructures or projects to do their thing that could not be done otherwise. These organizations claim they have knowledge of the tasks to be performed and offer their services to volunteering organizations.

5.2 Natural history museums and volunteering

Traditionally, natural history museums usually have two tasks, based on the specimen collections they have (Allen, 1976; Barber, 1980; Stearn, 1981). One task of natural history museums is to open up and present their specimen collections to the public as a form of public education. The second task is to make the systematic collection of specimens available to scientists for research. While specimen collections and expertise are still to be found in natural history museums it has been argued this has all lost its relevance because there are no important research questions to be answered using these collections (Alexander & Alexander, 2007). Meanwhile there are debates where natural history collections are said to be relevant for biodiversity assessment, pushing towards the question how natural history collections could play a role in the light of current developments (Graham, Ferrier, Huettman, Moritz, & Peterson, 2004; Krishtalka & Humphrey, 2000; Lister, 2011; Ponder, Carter, Flemons, & Chapman, 2001; Shaffer, Fisher, & Davidson, 1998; Winker, 2004).

These publication all stress the importance of time and in biodiversity research. One publication defines the essence of specimen data as consisting of three elements: identity, space and time (Graham et al., 2004). In natural history museums, the elements of space and time define the unique qualities of natural history specimen collections; they usually go back at least a history covering a specific area, in some cases they even may go back over two centuries (Lister, 2011).

The public outreach function of natural history museums has a tradition going back centuries, however also using the possibilities of new technology (Barber, 1980; Barry, 2006). It seems like the function of public outreach and the function of science are treated separately, exemplified by publications of two representatives of one organization, each of them belonging to one of the respective spheres do not consider or even mention the existence of the other function in their arguments (Barry, 2006; Lister, 2011).

5.2.1 The internal orientation of natural history museums: going from analog to digital collection disclosure

Both public outreach and biodiversity research call for digitization of data. The necessity to make collections digitally accessible and searchable requires digitization of specimens through the creation of digital images to be disclosed by putting them into electronic databases. While future acquisitions also need to be digitized, now it is the time to make decisions about creating a digital natural history museum being beneficial to both the public and to scientists.

Given the outcomes of our research it makes sense to organize the digital revolution as data processing projects, to be organized using the format described in section 5.1: organized in discernible work packages, in a predictable form, using pre-structured verification methods, to be realized in a limited time period with clear start and end point, with transparent monitoring of of the project progression and to be carried out by registered crowd of workers. The nature of this operation is the manipulation of large amounts of data, stored and presented to crowd workers as digital images, of which the information will be entered in structured databases. Volunteers wanting to ‘do something for science’ should be the expected target group and tempted to participate in eliminating this workload.

5.2.2 The external orientation of natural history museums: the re-institutionalization of natural history collections

After collections are made digitally accessible, they still need to be relevant, to be connected to and part of discussions on biodiversity policy and biodiversity research. Within the process of policy agenda-setting, diminishing biodiversity as a global issue has to compete with other threats to humanity - like terrorism, economy and healthcare - which calls for collaborative action, engaging and reaching the public through venues for public science such as natural history museums and citizen science activities (Novacek, 2008).

To make this happen, scientific collections of natural history museums have to be visible and recognized as being essential to biodiversity research. Therefore, natural history museums have to be regarded as centers of competence in biodiversity, however with renewed ties with the public for which data-collecting infrastructures may be perfect vehicles. Establishing intense relationships between universities, data-collection infrastructures and natural history museums might give a boost to the recognition of biodiversity issues, thus forging a meta-infrastructure for research, creating the right circumstances for the re-institutionalization of natural history museums (Lister, 2011; Novacek, 2008; Scott, 1995).

Such collaboration between universities, data-collection infrastructures and natural history museums would bring in the strengths of citizen science as a means to make biodiversity research sustainable. One of the most striking result of our research is that the oldest data-collecting infrastructures are the ones having skilled volunteers doing the fieldwork, of which methods are designed in close cooperation with scientists, where a community of volunteers and professionals is focusing at a specific area or habitat. As this way of organizing biodiversity research has been developed and described in the 19^{th} century, it is striking that natural history museums seem to have lost the once so vivid relationship with involved volunteers (Griesemer, 1990; Shaffer et al., 1998).

Following the footsteps of universities in data-collecting infrastructures, natural history museums may engage and participate in could be treated as hybrid infrastructures. I might be considered an attempt to reclaim their position in biodiversity research, taking a role reminiscent to the one they used to play in the heyday of natural history. The natural history collection being kept by a dedicated department might turn out to be the perfect boundary object (Star & Griesemer, 1989) or 'narrative anchor' (Koerten, 2011) to reach out to the citizen science domain of data-collecting communities in an attempt to demonstrate the relevance of their collections.

Biodiversity is a global issue; still cooperation between departments of natural history museums and data-collecting infrastructures should be sought at the national level, where infrastructures focusing at specific areas could be integrated. There are many ways to accomplish that: either an existing infrastructure being a natural history collection or data-collecting infrastructure can integrate the other, a data-processing facilitator disclosing a hybrid dataset is also a possibility. Such an integrated infrastructure should ideally be made part of a global infrastructure.

5.3 Conclusion

We have done research focusing at citizen science and crowd science practices, asking the following research questions:

- What kind of volunteering arrangements have been developed and applied in biodiversity research?

- How do digital crowd science developments affect existing volunteering arrangements in biodiversity research?
- How can crowd science arrangements in biodiversity research be categorized?

In the preceding paragraphs we have presented a framework describing the three dominant types of volunteering arrangements:

- Data-collecting biodiversity infrastructures
- Data-processing biodiversity projects
- Facilitators supporting infrastructures or projects

Digital developments affect crowd science practices in data-processing projects, allowing them to be ran through the internet with more rigor, standardization and planning than before. Our findings suggest newly established data-collecting infrastructures require less skills than the older ones, suggesting the intellectual ownership belongs more to the scientists who have started them, which in turn would make them more vulnerable, being less recognized as a ‘ narrative anchor' connecting communities.

Based on our findings we suggest natural history museums should develop an internal and an external vision on volunteering. The internal focus is meant to transfer collections into digitally enabled electronic repositories. Related activities should be project based, short-term and temporary in nature, with fixed goals and procedures. The external focus is essential to making museum collections relevant again in the field of data-collecting infrastructures. Collections should be engaged in tight relationships with citizen science communities and universities . Natural history collections should be treated as data-infrastructures to biodiversity assessment with strong history-oriented orientation, making them perfectly fit for tracking changes in biodiversity richness. In order to make collections relevant and part of an inclusive research community, they should be virtually owned and maintained by such a community, requiring the involvement of skilled volunteers. For that matter, departments of natural history museums may engage strongly in collaborations and relationships with data-collecting infrastructures, being mainly citizen science associations.

Appendix 1. Datasheet used for data collection

Data on Crowd science and crowd sourcing websites

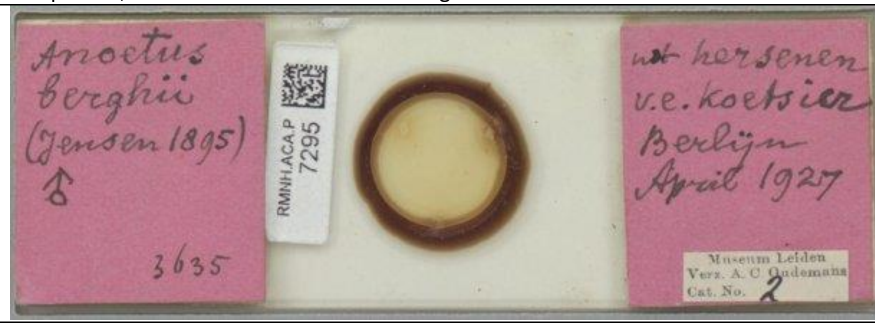
Variable	**Metadata**	**Data**
Name	As used in communications	
Project/infrastructure	A project has a fixed workload timescale and budget. An infrastructure is an ongoing endeavor aimed at maintaining a collection of records	
Project website	URL	
Email	Email address	
Logo	Please upload, cut/paste, or provide link	
Organization(s) involved	Principal organization, Founding organizations, agencies, etc.	
Organizer website	URL	
Nature of field	Describe the aim of the project (200 words max)	
Description	Introduction of basic ideas and objectives of the project.	
Example	Picture, drawing, description etc. of result and/or information source	
Number and nature of persons involved involved in management	Names of project/infrastructure leaders, iconic names associated, etc.	
Number of participants	Number of volunteers actually involved in the project	
Time span	How long does it exist, when	

	established, years/months	
Workload	(in sum or per participant, please indicate) Time, number of records, etc.	
Nature of crowdsourced tasks	collection, curation, analysis, processing	
Skills/qualifications needed	Requirements to participate	
Training facilities offered	Courses, workshops, etc.	
Visibility of results	reported on website, annual reports, etc.	
Member participation	Review commissions, member meetings, feedback facilities, social events	
Digitalization	website, app, ways of data processing	
Remuneration	Rewards for particpants (money, vouchers, benefits, recognition, etc.)	

Appendix 2. Data on Crowd science and crowd sourcing websites

Example Glashelder!

Variable	**Metadata**	**Data**
Name	As used in communications	Glashelder!
Project/database	A project has a fixed workload timescale and budget. An infrastructure is an ongoing endeavor aimed at maintaining a collection of records	Project
Project website	URL	http://www.naturalis.nl/nl/kennis/doe-mee/glashelder/ http://velehanden.nl/projecten/bekijk/details/project/nat_nbc
Email	Email address	glashelder@naturalis.nl
Logo	Please upload, cut/paste, or provide link	
Organization(s) involved	Principal organization, Founding organizations, agencies, etc.	Naturalis
Organizer website	URL	www.naturalis.nl
Nature of field	Describe the aim of the project (200 words max)	Deciphering of labels on museum's collection slides of acarid, springtails and other small organisms.
Description	Introduction of basic ideas and objectives of the project.	All collection slides have one or more (handwritten) labels holding information on its nature: 1. Scientific name in Latin. 2. Scientific name of the animal or plant on which the organism was discovered. 3. Sex. 4. Type-specimen yes/no. 5. Country (where collected) 6. Collection site (habitat) 7. Date collected

		8. Name of collector 9. Old collection numbers and other classifying information 10. Number of slides on this organism These slides have been photographed for digitization, the label information has to be deciphered, transcribed and added to the digitized record.
Example	Picture, drawing, description etc. of result and/or information source	
Number and nature of persons involved in management	Names of project/infrastructure leaders, iconic names associated, etc.	Maarten Heerlien, projectleader
Project costs	€ per annum, lumpsum, etc.	
Number of participants	Number of people actually involved per 1-1-2013	498
Time span	How long does it exist, when established, years/months	Started 26 march 2013, estimated to be completed summer 2015, completed early 2014.
Workload	(in sum or per participant, please indicate) Time, number of records, etc.	100.000 slides to be transcribed by two volunteers
Nature of crowdsourced tasks	collection, curation, analysis, processing	Every slide will be processed twice by different participants. An expert will check both results and decide upon admittance to the final database. Digital facilities were provided by www.velehanden.nl , a website facilitating multiple cultural heritage crowd sourcing projects.
Skills/qualifications needed	Requirements to participate	No prior skills/qualifications needed
Training facilities offered	Courses, workshops, etc.	Email address and digital forum for Q&A. Online manual with instructions.
Visibility of results	reported on website, annual reports, etc.	Indicator at www.velehanden.nl displaying the percentage of completion.
Member participation	Review commissions, member meetings, feedback facilities, social events, etc.	Crowd gathering at Naturalis on July 14 2013 (registration required) with free admittance to the museum, drinks and snacks, guided tour
Digitalization	website, app, ways of data processing	All work handled through website, registration as participant is required

Remuneration	Rewards for particpants (money, vouchers, benefits, recognition, etc.)	Contributor receives one point for every record processed. 1000 points: Meet & Greet in LiveScience (scientists at work) of Naturalis, guided tour on scientists premises, free admittance to the museum. 2500 points: A book: Nieuwe Insectengids (Dutch translation of Michael Chinery's Insects of Britain and Northern Europe 9e edition, 2012), or Leven met parasieten (live with parasites), book by scientist and parasite expert Frans Rochette. 5000 points: Guided tour of Naturalis Museum for a group of 8-15 (all ages).

Appendix 3. Data on Crowd science and crowd sourcing websites

Example BMP (Broedvogel Monitoring Project)

Variable	Metadata	Data
Name	As used in communications	Broedvogel Monitoring Project (BMP) (Summer Bird Monitoring Project)
Project/infrastructure	A project has a fixed workload timescale and budget. An infrastructure is an ongoing endeavor aimed at maintaining a collection of records	Infrastructure
Project website	URL	https://www.sovon.nl/nl/BMP
Email	Email address	info@sovon.nl
Logo	Please upload, cut/paste, or provide link of logo	
Organization(s) involved	Principal organization, Founding organizations, agencies, etc.	Sovon is an association of bird watchers, BMP is one of many (mostly ongoing) infrastructures they are running. Sovon has been recognized as a (PGO) (*Particuliere Gegevensbeherende Organistaties*, Private data managing organization), by the NDFF (*Nationale Databank Flora en Fauna*) A PGO provides data collected in survey networks like BMP to NDFF, which in turn acts as a data distributor to (licensed) scientific and policy oriented organizations.
Organizer website	URL	www.sovon.nl
Nature of field	Describe the aim of the project (200 words max)	Counting of territorial summer birds in fixed counting area (habitat) organized and executed by an ornithological, volunteering association.
Description	Introduction of basic ideas and objectives of the project.	Started in 1984 as the second project of Sovon ever, gradually diverging into multiple subprojects, aimed at all species or a subset of species, with a distinct approach, however having a common nature: the counting of territorial summer birds in predefined, fixed counting areas. The aim is to record population changes of nearly all species of Dutch summer birds. Subprojects are aiming at:

		BMP-A: all species BMP-Z: rare species BMP-B: special species BMP-W: Field birds BMP-R: Raptor
Example	Picture, drawing, description etc. of result and/or information source	
Number and nature of persons involved in management	Names of project/infrastructure leaders, iconic names associated, etc.	
Project/infrastructure costs	Indicative € per annum, lumpsum, etc. (if not available, from an overarching organization)	Annual turnover of the Sovon association: € 4,5 million (2012).
Number of participants	Number of people actually involved per 1-1-2013	Project workers recruited from a base of 8000 SOVON member/volunteers Managed by the SOVON organization (comprising 65 paid employees)
Time span	How long does it exist, when established, years/months	Ongoing since 1984
Workload	(in sum or per participant, please indicate) Time, number of records, etc.	8-12 full visits to the designated habitat per year per participant Area of 10-250 hectares (depending on complexity of the combination of area and species distribution). Online registration of observations
Nature of crowdsourced tasks	collection, curation, analysis, *processing*	A participant is carrying out a combination of fieldwork and deskwork

		Fieldwork -Visits in the March-June period, preferably at daybreak and 1-2 nightly visi - Record observations on a standardized paper field map. **Deskwork** -Registering observations in online mapping tool (transfer paper to digital) -Registering Territory/brooding pairs in the online autocluster program.
Skills/qualifications needed	Requirements to participate	Anybody having knowledge of bird singing voices and other brooding sounds can participate. Some species may require more experience, other more time. An overview of monitor projects scores all projects with 1 (min to three (max) stars on knowledge and time consumption. BMP scores on both indicators three stars (as do four other monitoring projects).
Training/other facilities offered	Courses, workshops, etc.	Bird counting manual, available online A BMP-course of breeding birds surveying which introduces also the BMP-methodology. 4 evening sessions (3 hrs.) and 6 field-training excursions (4hrs.). Course objectives: (1) Being able to perform self-reliant surveying of breeding birds (2) being able to register results online using the autocluste program. Assumed prior knowledge: being motivated to apply a standardize method. Basic knowledge of at least 50 common Dutch breeding birds is prerequisite.
Visibility of results	reported on website, annual reports, etc.	**Results** First impressions of population changes appear in the Sovon-quarterly newsletter, more extensive and sophisticated articles to be published in th annual Sovon-breeding bird report. Recent results to be published on the Sovon-website. As a PGO, Sovon uploads all data to the NDFF database for meta analyses of Dutch Flora and Fauna population changes.
Member participation	Review commissions, member meetings, feedback facilities, social events	Sovon has a board of representatives of 40 (17 vacant seats in 2014). A membership day on November 30, receiving 2500 participants in a conference center with a day program in 5 rooms and halls, comprising 30 lectures and presentations.
Digitalization	website, app, ways of data processing	Field recordings on paper, to be registered online at home.
Remuneration	Rewards for particpants (money, vouchers, benefits, recognition, etc.)	none

Appendix 4.

Work package WP3 Synthesys3

Task 1.4 Pilot study into optimal crowd sourcing processes for NH institutions

Instructions for data collection

As coordinators, we have identified about 75 projects/websites/infrastructures where amateurs/volunteers/laypeople have a distinct task. This list is by no means meant to be exhaustive, so additions by you as contributors to this project are warmly welcomed.

We have provided an empty datasheet, together with two completed datasheets (two Dutch crowd science/citizen science activities) to be treated as examples. Projects from our database have been assigned to you, below you will find a table with a list of projects that have been assigned to your name/institution.

Since most of the listed activities have an international and/or English flavor and we are aiming at getting a European data repository of crowd science/citizen science activities, *we would particularly encourage you to search for local, regional or national activities preferably comprising non-English cases* that can be added to our database. This can be done by completing additional datasheets.

Our aim is to describe the characteristics of crowd science/citizen science projects and analyze them in order to construct a topology of common approaches. We expect to get from you a completed datasheet for every crowd science/citizen science activity listed below, and hope for some additional ones meeting the characteristics stated above.

Most information can be derived from the activities' website, however, in some cases persons responsible have to interviewed through email or skype to collect essential data.

In short, we expect from you the following:

1. Study the empty datasheet and the two examples we have provided.
2. Collect the requested information for at least the activities listed in the table below, one sheet per item.
3. Try to collect some similar crowd science/citizen science activities in your country and fill in additional datasheets for these cases as well.
4. Return the completed datasheet **before June 28**.

The final report is due September 1st *2014, so please allow us enough time to complete it and hand in your datasheets as soon as possible, but not later than June 28.*

If you have any questions regarding this data collection project: please email h.koerten@vu.nl

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