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Natural History Collections Georeferencing Survey Report

Current georeferencing practices across institutions worldwide

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1 Background & Objectives

Georeferencing of Natural History Collections (NHC) is a critical step in the overall digitization process conducted at collection-holding institutions worldwide (Page et al. (2015)). It greatly affects the potential use of these collections in research, conservation and natural resources management. Additionally, the determination of the uncertainty implicitly embedded in the location description of specimens is crucial for a rigorous use of this information.

The complexity of georeferencing tasks lies in the difficulty of transcribing and interpreting handwritten text of many different collectors and times, some dating back centuries ago, into a pair of coordinates and an uncertainty (Murphey et al. (2004)). In spite of the current access to GPS technologies, most locations where specimens have been collected are described in textual form as sites relative to local landmarks. Georeferencing is thus a complicated task where the georeferencer may need to be able to unequivocally transcribe handwritten label tags at different degrees of verbal precision, in different languages, needing good and sometimes historical local cartography, and preferably being an expert of the local geography. Moreover, a good knowledge of coordinate reference systems and projections and map interpretation is necessary to finally convert the transcribed text into a pair of coordinates with the spatial uncertainty determined by the process. Much research and development of tools have been done in formalizing the georeferencing process in order to set standard guidelines to help make it robust and rigorous (e.g. Chapman and Wieczorek (2006); Bloom et al. (2018); Chapman and Wieczorek (2020)). Yet, despite the availability of available protocols and tools (Guralnick et al. (2006); Rios and Bart (2010); Wieczorek and Wieczorek (2019)) the state of georeferencing of specimens as reflected in GBIF or OBIS is still far from satisfactory and their potential use in ecological research and conservation is hindered.

In order to explore and discuss the reasons behind this situation a workshop on quality issues in georeferencing was organized in February 2020 in Warsaw, Poland (Marcer et al. (2020)). A survey was conducted prior to the workshop to assess current georeferencing practices across NHC-holding institutions worldwide. The aim of the survey was to gain first hand knowledge on the georeferencing work being done worldwide, specifically on the amount of effort put into it in relation to other digitization tasks, the resources and tools used, the handling of coordinate uncertainty, and the interaction with public data repositories. To give context to the answers, we also asked for information on the institutions and actual collections for which the responses referred to. This report presents the results of the 39 questions that were asked, individually and grouped by institutional geographical origin, type and by collections type.

The survey was sent to institutions around the world between December 9th, 2019 and April 6th, 2020.

2 Summary of key findings

The following are the major overall points that can be derived from the survey. Detailed results can be found below and a summary of the answers to each question can be found in the Appendix.

1. The overall size of the collections referred by the respondents amount to 1.4 billion specimens, a figure which can be considered as representative of the total global collection (estimated at 2.7 billion by Ariño (2010)) when talking about georeferencing practices.

2. The digitization of collections is still far from complete, although most collections have begun their digitization process and are at different degrees of completion. A notable 25% of them report being totally digitized, while 19% report still having no specimens digitized.

3. The vast majority of collections are still in the low percentages of georeferencing. About 12% of collections report having over 90% of their specimens georeferenced, 30% report having only up to 10% and the rest of collections somewhere in-between. These results point at georeferencing going at a slower pace than digitization, which may indicate some degree of separation of the georeferencing process from the whole of the digitization process. This may also point to a separation of tasks between staff members with different degrees of map-related competences. About 48% of respondents acknowledge that the time spent on georeferencing is less than 10% of time dedicated to digitization. Only 1% report spending above 90% of their time on georeferencing.

4. Locations in specimens' tags in the form of single or complex site descriptions predominate over the form of coordinates.

5. There is a general lack of commitment to follow standard protocols and guidelines as 44% of respondents declared using no protocol. Existing protocols are not widely adopted. A key publication, *Guide to Best Practices for Georeferencing* is reported to being used by 16%. The rest of respondents reported using other custom ad-hoc protocols. This deficiency in the standardisation of the georeferencing process is troublesome in that it makes difficult to compare results and in being able to reproduce how a pair of coordinates and uncertainty were assigned to any given specimen.

6. There is also a wide dispersion of tools used for georeferencing. Google tools such as Maps and Earth account for the biggest reported percentage (84%), followed by GeoLocate with a (29%). These percentages do not add up to 100 since respondents

use more than one tool. However, the use of a variety of tools is not considered to be problematic for georeferencing, as was the case in the previous point with protocols.

7. With respect to the management of georeferenced site names, a wide variety of software tools have been reported but still a 34% report not using any tool.

8. Coordinate uncertainty derived from interpreting the location description of specimens or directly given by GPS is not entered in 49% of cases. Only 35% of respondents consider it important to calculate uncertainty taking into account all its aggregate sources in the georeferencing process. Morevover, 68% do not apply error checking after the georeferencing process has been done.

9. 44% of the reported collections have not been uploaded to GBIF or other public repositories. About 22% of respondents do not make use of any public data repository in their usual work and the average relative importance from 1 (least) to 5 (most) for these repositories to have georeferenced data is 3.9.

10. There seems to be little awareness on the fact that many site names may be being georeferenced by more than one institution and, thus, little realization of how publicly shared global gazetteers could improve the efficiency of georeferencing efforts worldwide and reduce the overall time and effort put into this task.

3 Methodology

We invited a total of 4410 contacts from NHC-holding institutions across the world. Contacts were directly invited via personalized emails or through email and discussion lists. We used the following publicly accessible contact sources: the Consortium of European Taxonomic Facilities (CETAF), Index Herbariorum at the New York Botanical Garden, Botanic Gardens Conservation International, the Global Registry of Scientific Collections (GRSciColl), the Society for the Preservation of Natural History Collections (NHCOLL-L) and the Integrated Digitized Biocollections (iDigBio). The survey was anonymous but left it open for whomever wanted to acknowledge their personal and institutional identity and be sent a copy of this report. Some questions like the respondent's country were deliberately left optional in order to ensure the anonymous nature of the survey; institutions could be easily identified in some countries.

We used the SurveyMonkey (https://www.surveymonkey.com) online platform for conducting our survey. Once the survey was completed we downloaded all individual responses as a csv file and did all analyses using the R Computing Environment (R Core Team (2020)).

We started the survey on the 9th of december of 2019 and ended it on the 6th of april 2020. The number of respondents had three peaks; one at the start of the survey and one after each of the two reminder emails we sent. After each peak the number gradually leveled off till next reminder email. These three peaks were on the 9/12/2019, 7/1/2020 and 19/2/2020.

NHC are usually managed or curated by multiple personnel. While in a small institution an individual may serve all roles regarding its collection, from curator to director, in large institutions this is not the case. Large institutions hold multiple collections; each one the responsibility of and curated by a different staff member. Currently, there is not a single source for a complete and up-to-date list of NHC contacts, but multiple complementary sources (see above). Our approach was to make a list of all possible contacts from the sources at our disposal, whatever role they had in their institutions, and ask them to answer the questionnaire for the collection or collections they were responsible or most acquainted for. We also asked them to internally circulate the qustionnaire. Therefore, the individual responses need to be seen from the individual collection point of view; i.e. georeferencing issues need to be read accordingly.

We divided the questionnaire into 39 questions assembled into 8 different sections. The estimated time for completion was 15 minutes. In section 1, *Institution*, we asked for information regarding the institution to which the respondent was affiliated and its aim was to gather contextual information. The objective of section 2 *Specimen holdings*, was to gather data which allowed us to dimension the partial volume of the global overall NHC holdings we were getting information from. Section 3, *Collection characteristics*, gave us

direct first-hand information on the collections on which the rest of the answers were related to. Section 4, *Georeferencing effort* gave the possibility to gauge the effort that georeferencing represents within the digitization process. Section 5, *Collections, protocols, resources and tools*, provides a description of the different means with which georeferencing is done. Section 6, *Georeferencing uncertainty*, was aimed at weighing the importance of recording uncertainty information when georeferencing specimens. Section 7, was aimed at ascertaining the relation between NHC and public data repositories, specially GBIF. And, finally, Section 8, *Feedback* provide respondents the opportunity to be sent a copy of the final survey report and give feedback to the authors of the survey.

4 Results

Survey response statistics. We received a total of 784 responses which correspond to two different sets of invitations: a) 680 responses coming from 5857 email invitations via the SurveyMonkey tool, and b) 124 responses coming from invitations sent to email and discussion lists. There are data for responses and completion rate for the first set, which accounts for 86.7% of all responses. The response rate for this first set is 11.6% and its completion rate is 60.4% (411 out of 680 responses were complete). 295 invitations in the first set (5.0%) were bounced back while only 24 (0.4%) invitees opted out. The overall average time spent for completing the survey was 13m 31s.

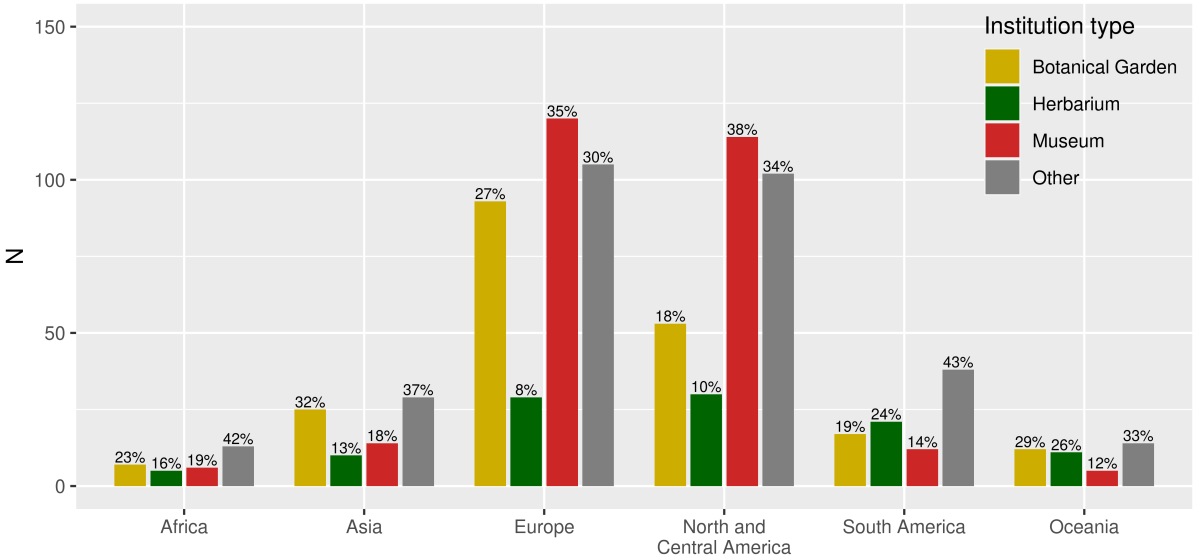
Question 39 was the most skipped question, only answered by 98 invitees of the overall 784 responses (12.5%). This was the final question, asking respondents in an open format for any additional input.

Geographical institutional profile. Europe with 304 (38.8%) responses and North and Central America with 270 (34.4%) are the continents with the highest number of responses; altogether accounting for 73.2% of responses. These two continents were followed by South America with 80 (10.2%), Asia with 69 (8.8%), Oceania with 37 (4.7%) and Africa with 24 (3.1%). Figure 1a shows percentages distributed by type of institution in each continent. Note that a respondent could answer to belonging to more than one type and, therefore, percentages do not add up to 100.

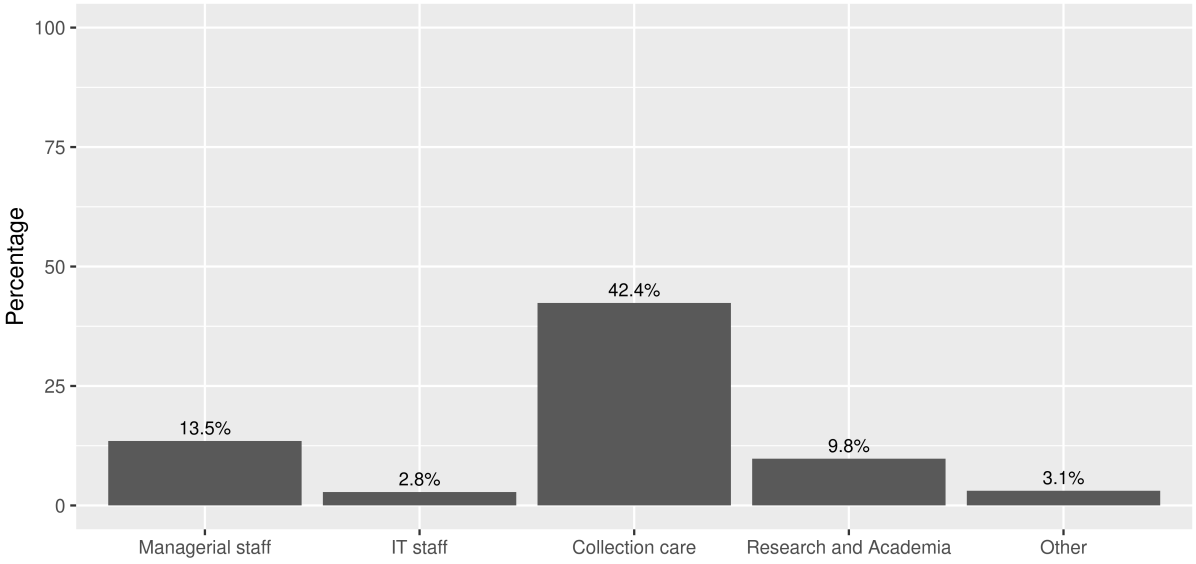
528 (67.3%) respondents stated their country of origin (see Q1 in the Appendix). The top five countries in number of respondents are: United States with 125 respondents, followed by Brazil with 24, Canada with 21, Italy with 21 and Germany with 20. See Q1 for the whole list of countries. Altogether, the survey represents institutions from – at least – 86 different countries.

Institution types were broadly represented, with 271 responses including Museum, 207 including Botanical Garden and 106 including Herbarium. (Figure 1a and Q2 in the Appendix). Whilst 268 represented University or Research institutions, respondents were able to select more than one institution type so these may also include museums, botanic gardens and herbaria. Other types of institutes were selected by 33 respondents.

Figure 1: Respondents' profile



(a) Number of respondents by continent and grouped by institution type. The 'Other' category includes different sorts of institutions such as protected areas, universities, NGOs, etc. (see Q2 in the Appendix). Figure based on 784 respondents.



(b) Distribution of respondents according to their role within their institutions. For a more detailed account see Q8 in the Appendix. Figure based on 615 respondents.

Professional respondents' profile The role of most respondents involved the active care of collections, followed by staff in managerial positions and research and academia (Figure 1b). For a more detailed account of respondents' roles see Q8 in the Appendix. Respondents were allowed to answer more than one role, which can be a usual case in small institutions. Therefore, roles other than *Collection care* should not be interpreted as not being directly involved in the collections.

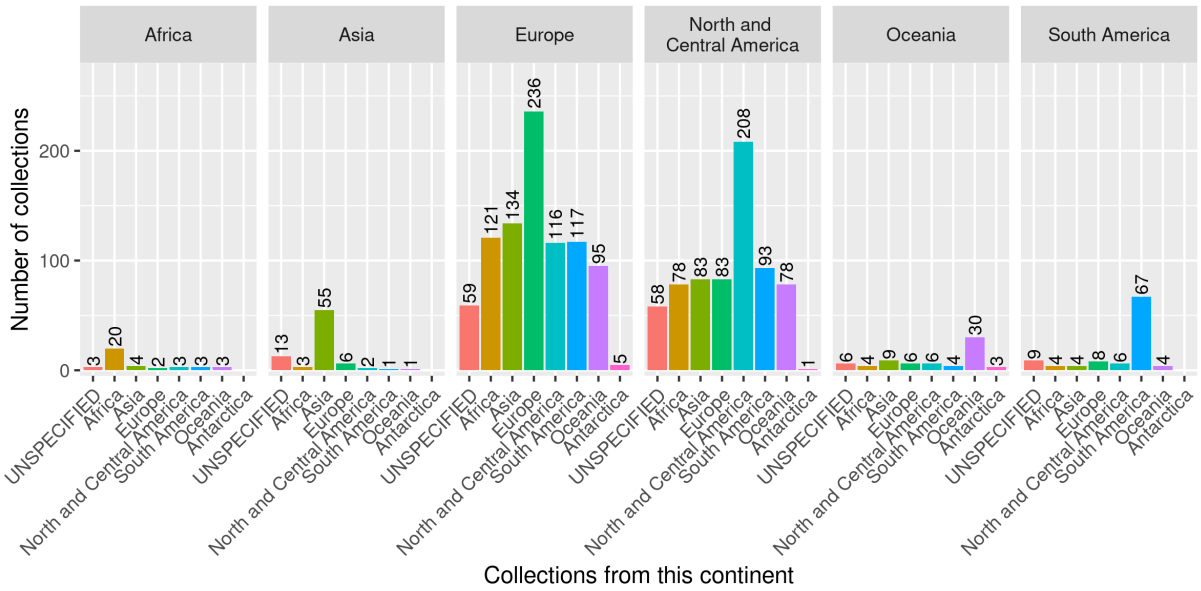
Institutional profile Figure 2 shows the collections' profile of the respondents' institutions. It should be noted that numbers for the actual set of collections worldwide are necessarily higher than those here reported since these results only refer to the institutions for which we had responses. In Figure 2a, we can see the origin of the specimens in the collections and the continent where they are held (X axis). It can also be noted that the highest number of collections in each continent correspond to specimens collected in the same continent. Morevover, institutions in two continents hold the vast majority of specimens collected anywhere in the world; *i.e.* 58.1% in Europe and 38.9% in North and Central America.

We have categorized respondents' free answers on geographical coverage (see Q6 in the Appendix) into 5 different spatial extents, from local to global (described in Figure 2b caption text). Collections of global scale are concentrated in Europe, with 55.4% of them, and North and Central America, with 35.5%.

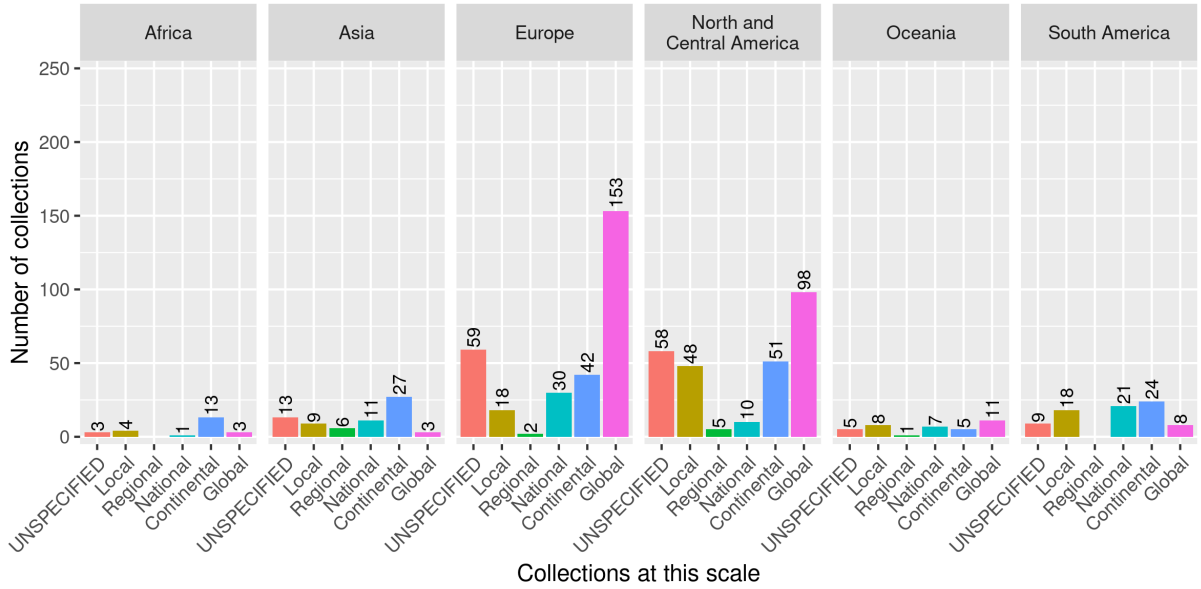
Figure 2c shows the number of collections encompassing each century since the 15^{th} century. Specimens from centuries 15 to 19 are highly concentrated in collections in institutions in Europe and North and Central America. Specimens from the institutions in the rest of the continents are mostly from the 20^{th} and 21^{st} centuries.

With respect to collection types (Figure 2d), plants are the most represented in all continents. Animals and fungi are the second or third most represented across continents, except for Europe where rocks and minerals collections have a high representation. The total number of specimens in institutions reported by this survey adds up to over 2.7 billion, which represents about 600 million more than the maximum estimate by Ariño (2010). Given that this survey does not include all institutions and collections worldwide, this number may be higher. A distribution of the whole set of collections from reported institutions can be seen in Q5 in the Appendix. Mid-size collections from 10^3 to 10^4 specimens predominate, followed by collections of sizes ranging from 10^5 to 10^6 and, in third place, collections from 10^3 to 10^4.

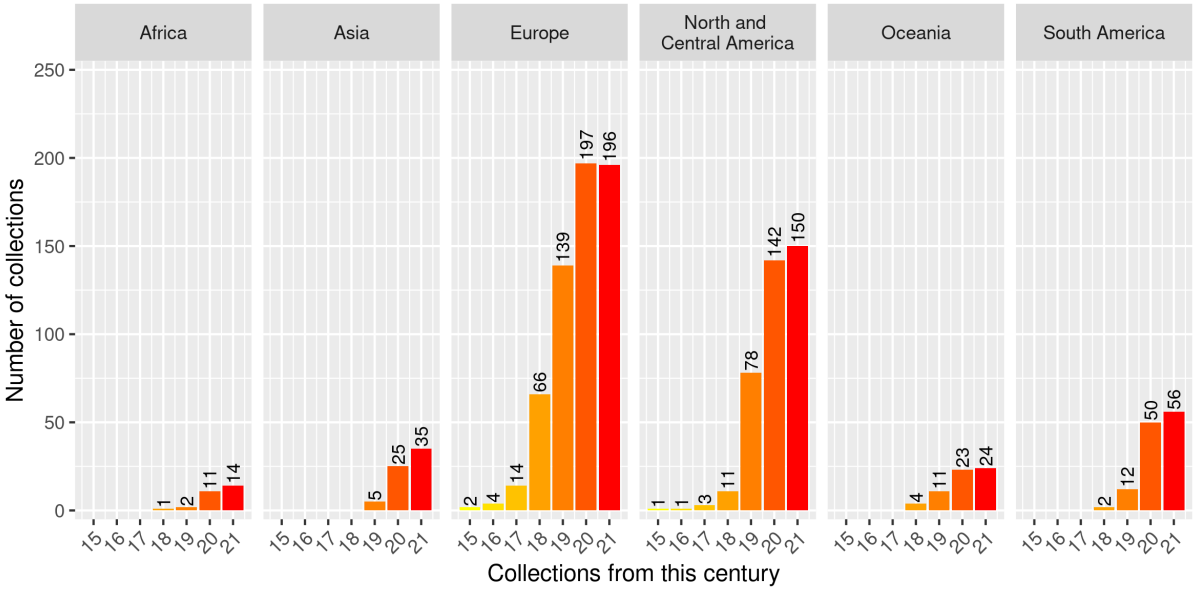
Figure 2: Institutions' profile



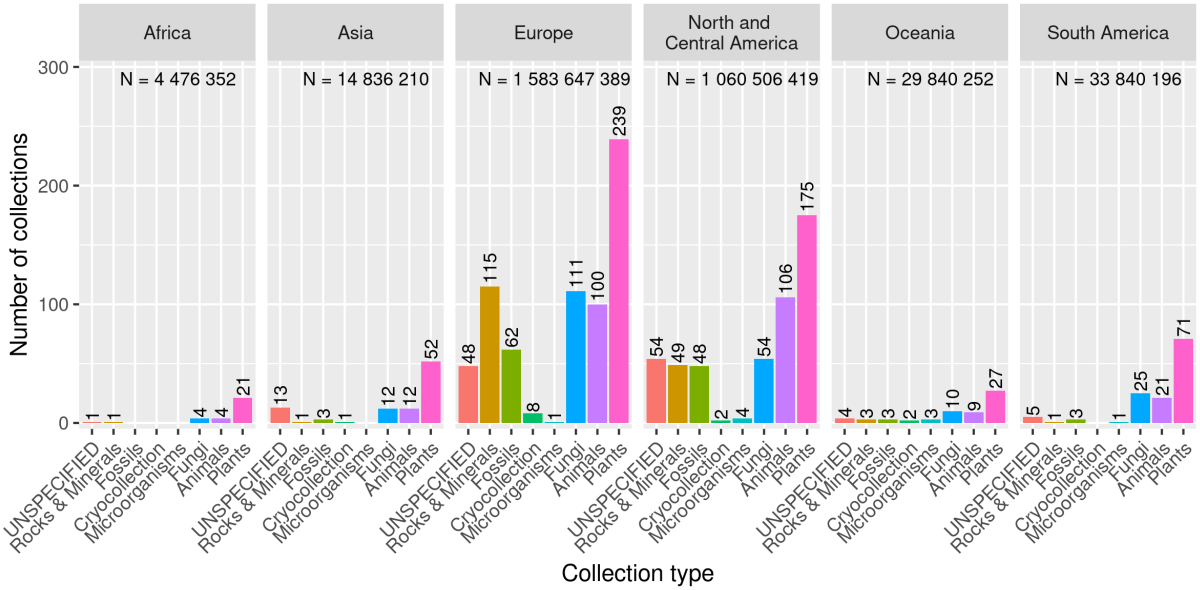
(a) Continental origin and destination of collections kept at institutions in different continents. Facets indicate in which continent the institutions keeping the collections are located while the X axis indicate where the specimens have been collected. Figure based on 636 respondents.



(b) Scale of collections hosted at institutions. Facets indicate the continent where the institution is located while the X axis indicates the areal extent of the collections. Areal extents labelled as follows: *Local* — extensions smaller than countries; *Regional* — extensions between local and national; *National* — extensions corresponding to countries; *Continental* — extensions bigger than countries up to continent; *Global* — extensions bigger than continents up to the whole world. Figure based on 637 respondents.



(c) Number of collections from different time periods kept at institutions in different continents. Facets indicate where collections are kept while the X axis indicates on which century the specimens were collected. Figure based on 467 respondents.



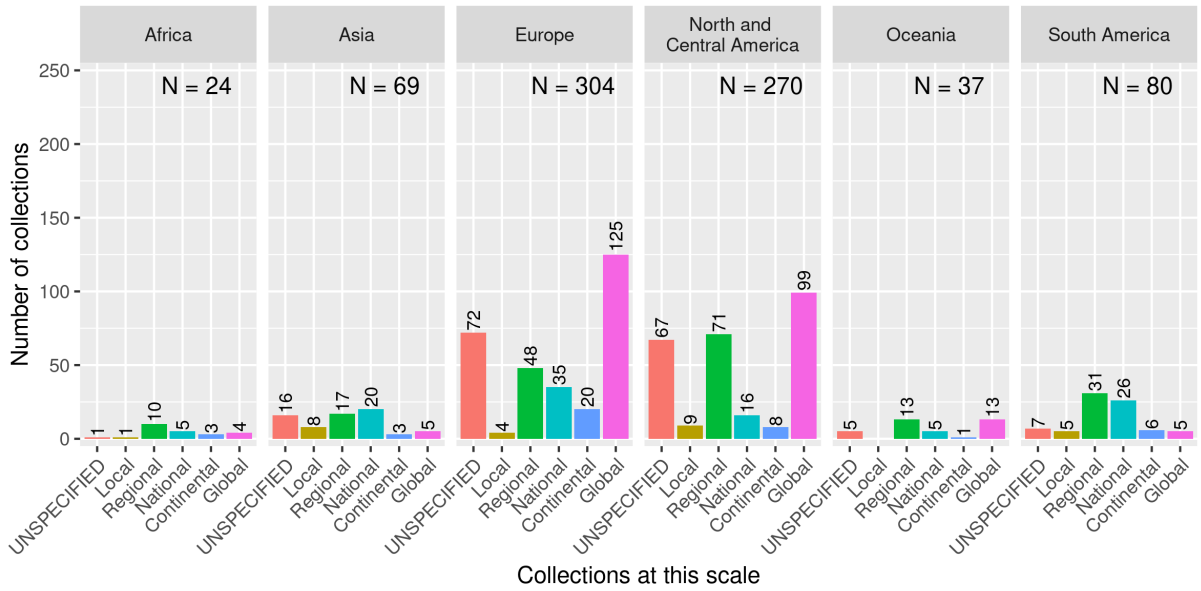
(d) Collection types kept in different continents. Overall continental size in number of specimens is given in each subplot. Bar labels indicate the number of collections per type. Total number of specimens reported in this survey equals 2 727 146 818. Figure based on 646 respondents.

Geographical profile of reported collections Figure 3a shows the number of collections reported from institutions in each continent. Whilst the geographical profile shown in Figure 2a referred to the overall collections held at each institution, this profile refers to the collections reported by respondents for this particular survey and, thus, on which all subsequent answers regarding georeferencing will be based. Most collections are reported from institutions in Europe and North and Central America, and within these, the

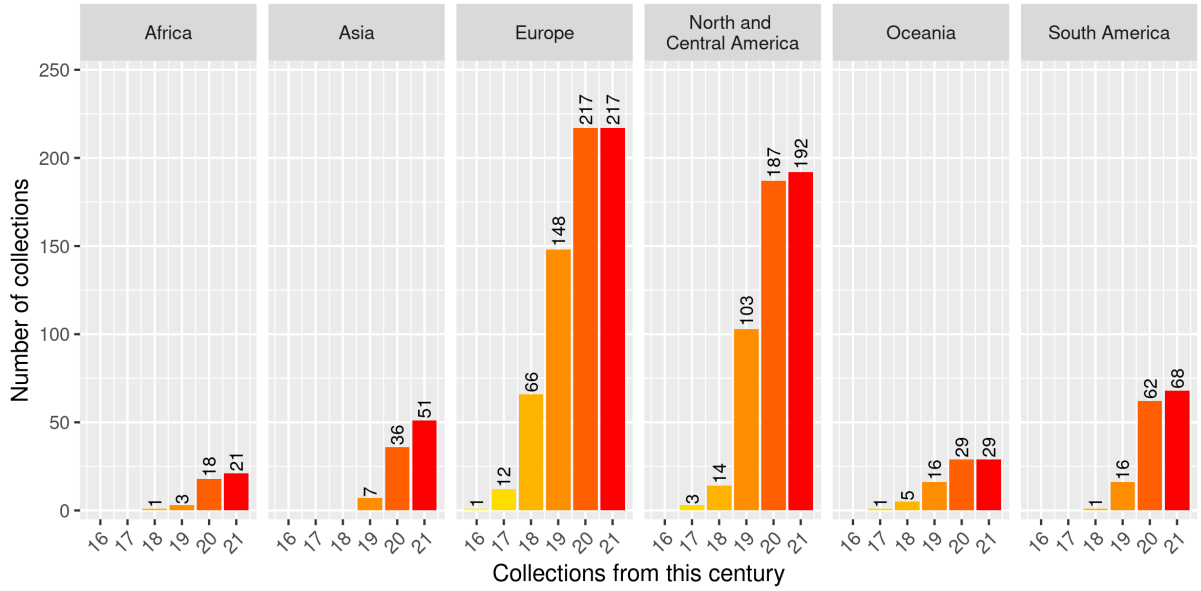
majority are of global scope. Across all continents, reported global collections dominate with 251 of them, followed by regional with 190, national with 107, continental with 41 and local with only 27 are the least represented.

Reported collections temporal profile The 20th and 21st centuries are by far the most represented collections in this survey (Figure 3b). Collections numbers across centuries increase towards the present time. Although this may be true in most occasions, it is in part an artifact of the fact that most respondents reported the starting century of their collections but not the end century; *i.e.* collections are alive and receiving new specimens. Q10 in the Appendix gives more detail on the specific year in which the collections started and shows an ever increasing number of collections started each following year, from the 15th century up to the present.

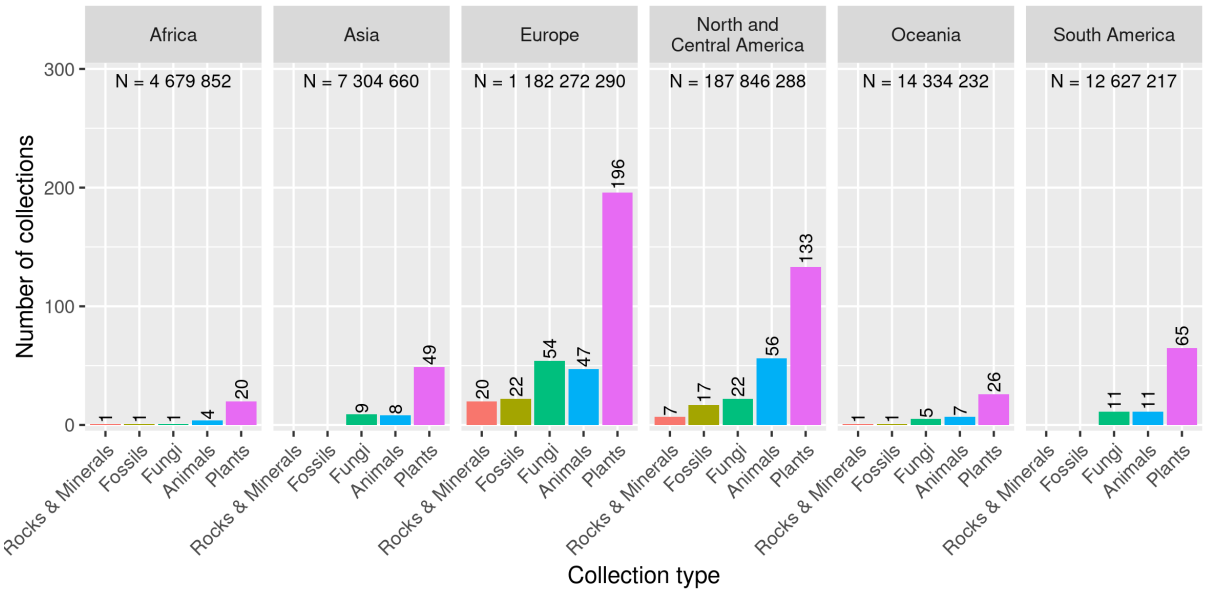
Figure 3: Collections' profile



(a) Scale of reported collections. Facets indicate the continent where the institution is located while the X axis indicates the areal extent of the collections. Areal extents labelled as follows: *Local* — extensions smaller than countries; *Regional* — extensions between local and national; *National* — extensions corresponding to countries; *Continental* — extensions bigger than countries up to continent; *Global* — extensions bigger than continents up to the whole world. Figure based on 616 respondents.



(b) Number of reported collections from different time periods kept at institutions in different continents. Facets indicate in which continent the collections are kept while the X axis indicates the century in which the specimens were collected. Figure based on 608 respondents.



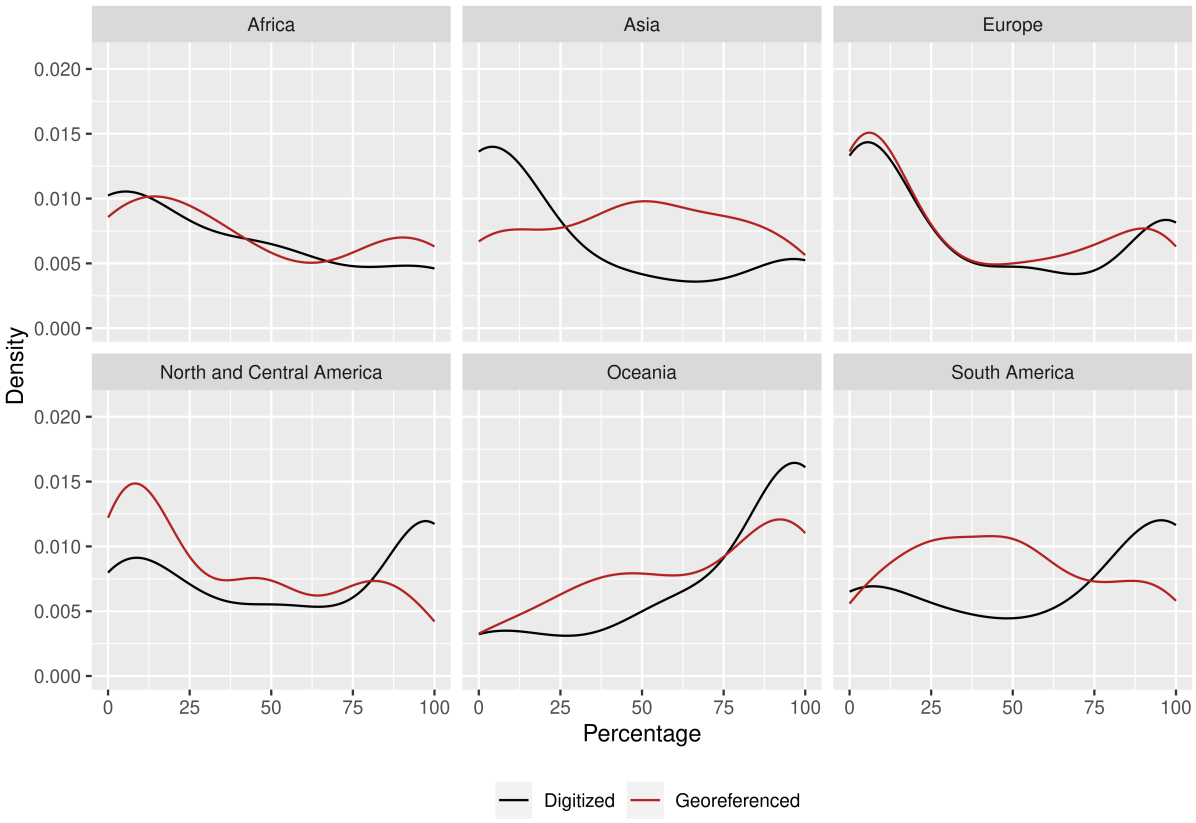
(c) Collection types reported by respondents at institutions in different continents. Sizes given are per continent and comprise all collection types reported by any single respondent. Bar labels indicate the number of collections per type reported for each continent by each respondent. Total number of specimens representing the overall set of collections reported by all respondents within this study equals 1 409 064 539. Figure based on 613 respondents.

Reported collections sizes and types Figure 3c shows that most collections are hosted at institutions in Europe and North and Central America, and they represent the vast majority of specimens in the collections reported in this study. Europe stands out with 1 182 272 290, well above the second, North and Central America, with 187 846 288 specimens. This big difference is mainly due to one single respondent from Europe with a collection of 800M specimens; assumed to be a respondent from one of the large NHC institutions in Europe (the respondent did not give his/her identity). Plants represent the most reported collections followed by animals and fungi. Except for 4 collections in Africa and Oceania, all rocks and minerals and fossils collections were reported from Europe.

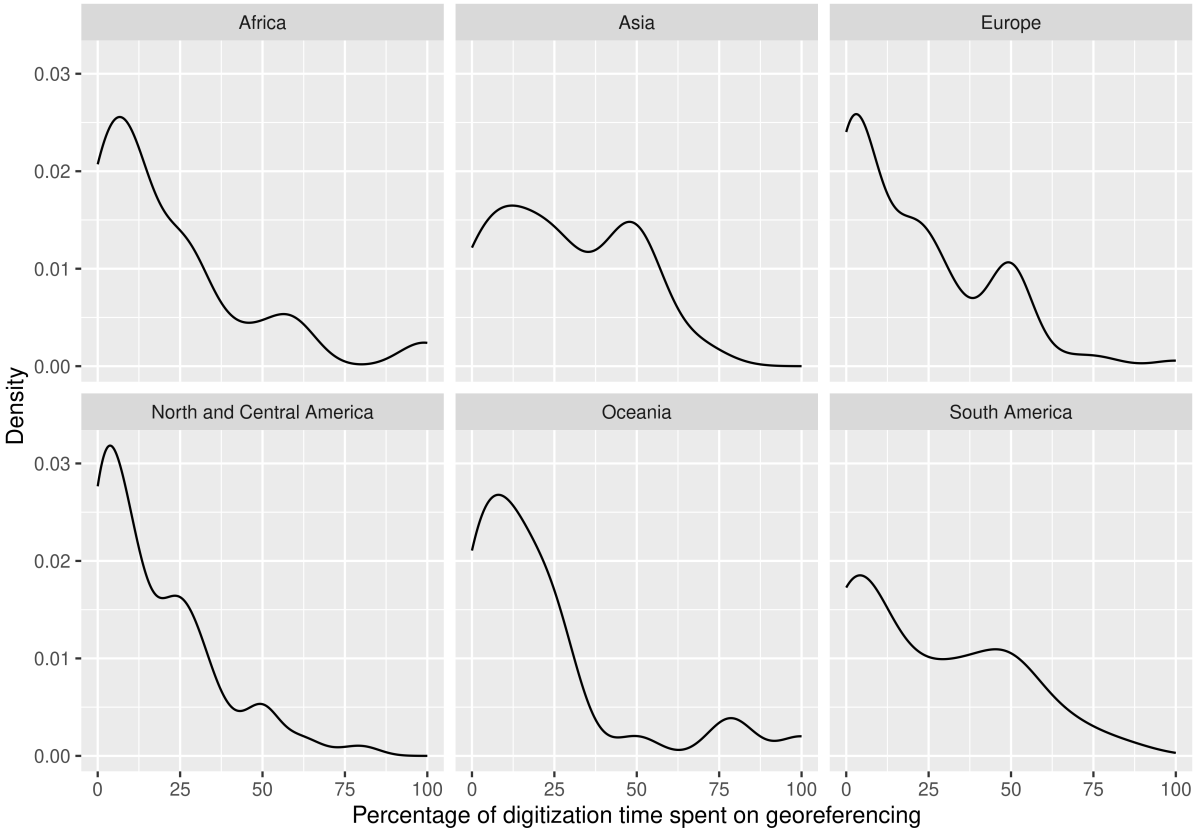
Extent of digitization and georeferencing Figure 4a shows the degree of both digitization and georeferencing of collections in each continent. Curves show densities in number of collections per percentage of digitization (black lines) or georeferencing (red lines); *i.e.* abundance of collections at each percentage of digitization or georeferencing. Both curves need to be interpreted independently since at each x-axis value digitization and georeferencing percentages do not necessarily come from the same collections. While the high density of poorly digitized collections in Europe may certainly be the consequence of the sheer number of specimens held at European institutions, in Asia it may be more a statistical artifact of the collections reported. Also, the U-shaped curves for digitization in all continents except for Africa and Oceania indicate that collections are mostly either non-digitized or fully digitized. This could indicate that the process of dig-

itization is a difficult one to undertake but once it is started it tends to follow all the way up to full digitization. This could explain the relative low prevalence of intermediately digitized collections. The same argument as for digitization in Europe may hold true for georeferencing in Europe and North and Central America; their large number of specimens to be georeferenced may be the cause of having the highest densities of poorly georeferenced collections. On the other hand, the highest densities of highly digitized and georeferenced collections occur in Oceania; the only continent where highly digitized and georeferenced collections predominate over poorly digitized ones. Since most collections in Oceania are in Australia, this may be an indication of the higher success of Australian digitization projects compared to the rest of the world. North and Central America show a peak of highly digitized collections, although not corresponded by being also georeferenced. South America shows the same pattern with a peak of highly digitized collections in correspondence with lower georeferencing density. Finally, in both Africa and Asia, lowly georeferenced collections prevail.

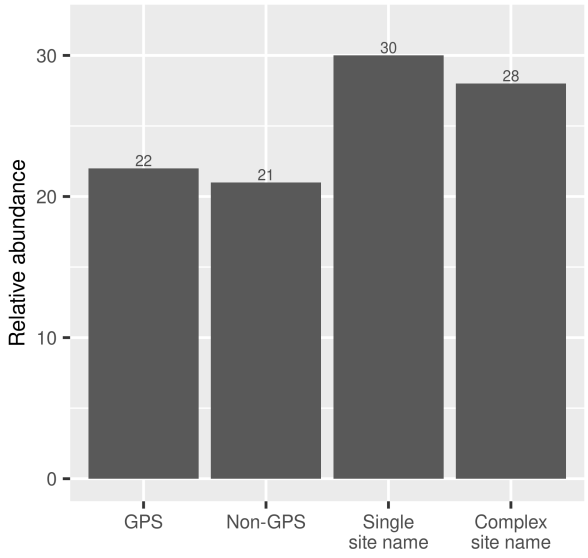
Figure 4: Digitization and georeferencing



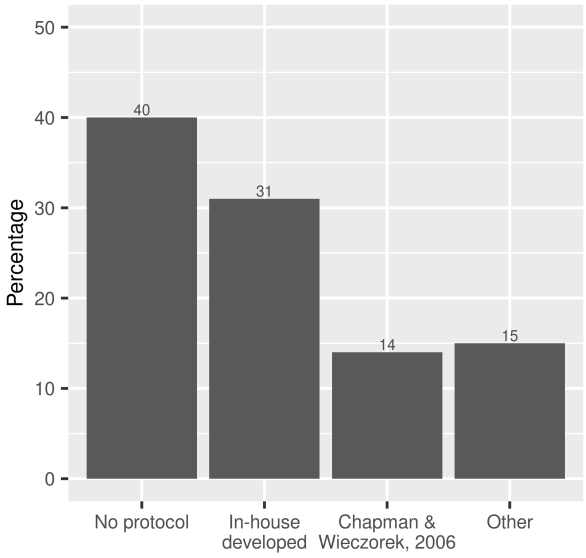
(a) Relative density of number of collections at different percentages of digitization and georeferencing (X axis). Figure based on 589 respondents.



(b) Relative density of number of collections spending a given percentage of digitization time on georeferencing tasks. Figure based on 580 respondents.



(c) Relative abundance of different types of locational information in collections. It should be interpreted as a relative ranking score between types. Figure based on 451 respondents.



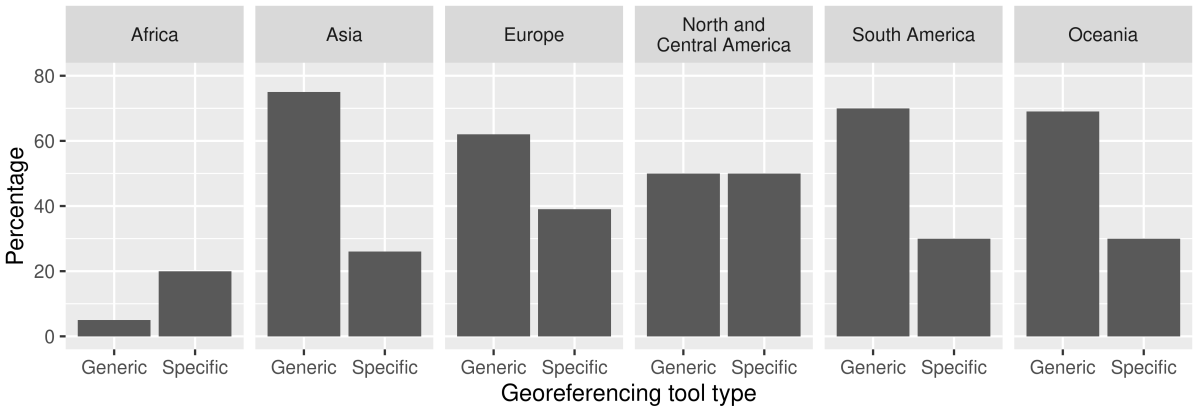
(d) Percentage of use of georeferencing protocols. Figure based on 509 respondents.

Georeferencing effort With respect to the effort put into georeferencing, measured as percentage of digitized time dedicated to it (Figure 4b and Q14 in the Appendix), the pattern is similar worldwide, *i.e.* predominantly a low percentage of time is spent on georeferencing tasks. Over 45% of respondents also acknowledged that there is at least a fair amount of duplication of georeferenced site names across institutions (see Q31 in the Appendix).

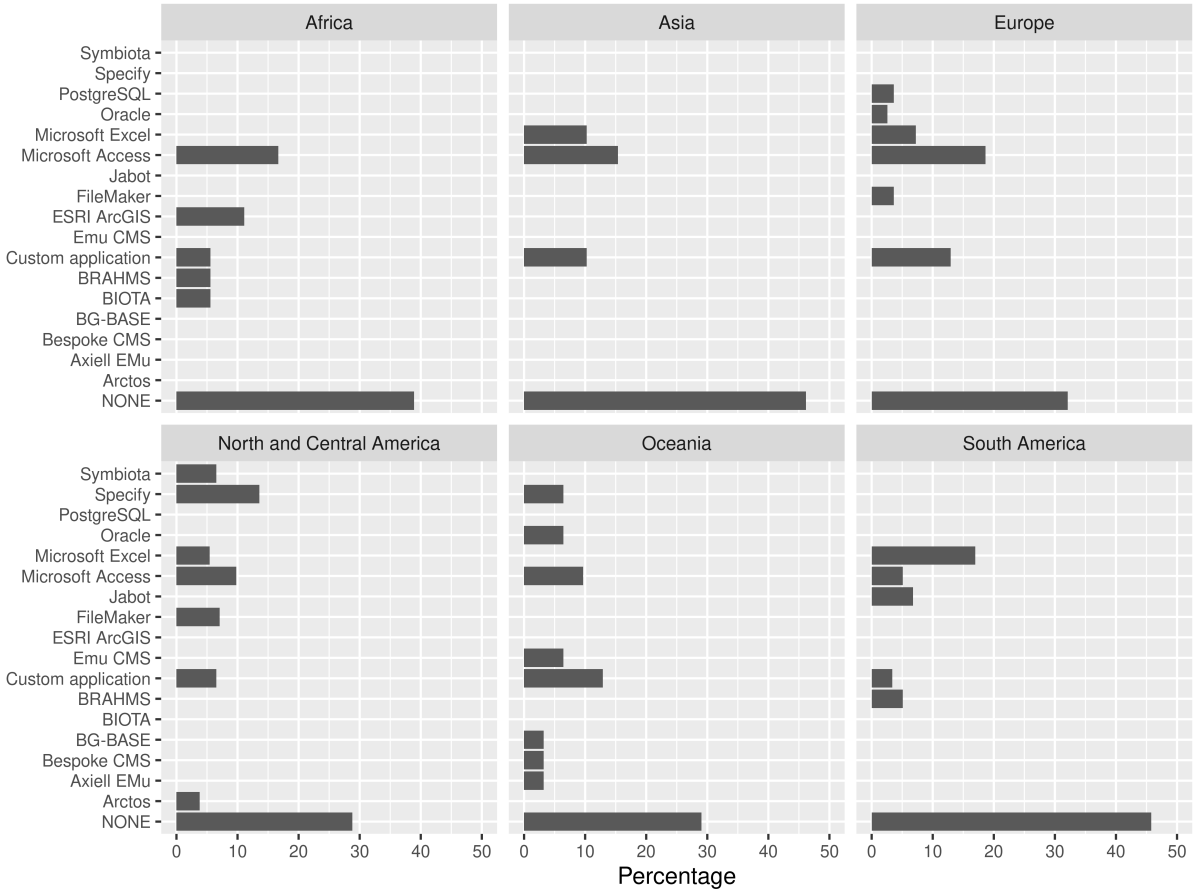
Location types Figure 4c shows the relative abundances of different types of locations. About 22% of specimen locations are reported to be in the form of coordinates taken with a GPS, 21% are coordinates probably recorded manually by the collector, and the remaining are in the form of written descriptions of sites. From these, 30% are single site names and 28% are complex site names which need a much higher degree of interpretation when georeferencing them. The four location types in order of effort needed to georeference are: GPS, Non-GPS, single site-names and complex site-names. The last two require the most effort since the georeferencer needs to locate site on cartography and calculate a representing coordinate and uncertainty; provided there is available cartography. GPS coordinates are straightforward if properly documented with their accompanying metadata such as the datum and, non-GPS coordinates may come in different forms (decimal degrees; degrees minutes and seconds; UTM codes; etc.) with different degrees of effort and difficulty. In summary, the low degree of georeferencing reported for the whole set of collections worldwide can be explained by the complexity of the data at hand.

Georeferencing protocols. 40% of respondents answered that they weren't using any kind of protocol for georeferencing, 31% used their custom protocol, 14% use Chapman and Wieczorek (2006) *Guide to Best Practices for Georeferencing* and 15% reported other protocols and guidelines (Figure 4d and Q16 in the Appendix). Given the difficulty that a rigorous practice of georeferencing entails and the need for standardized protocols which enable repeatability and integration, it is rather surprising that such a big percentage of collections do not follow any sort of protocol. When added to the 31% which use a custom-made protocol, the outlook of the georeferencing work is not hopeful for the future rigorous use of this data in research. However, it must not be discounted that a percentage of the custom-based protocols are actually adaptations of other protocols such as the above mentioned *Guide to Best Practices for Georeferencing*.

Figure 5: Georeferencing resources.



(a) Georeferencing helper tools. The *Generic* type contains *Bing Maps and Google Maps/Earth*, while the *Specific* type refers to tools specifically aimed at providing georeference for site names (*GeoLocate, GeoNames, Getty Thesaurus, Marine Regions and WikiData.*). Figure based on 503 respondents.



(b) Software used to manage georeferenced site names. Figure based on 524 respondents.

Georeferencing resources Figure 5a shows the use of helping tools for georeferencing. The figure shows the predominant tools used, classified into two types. The *Generic* type contains *Bing Maps and Google Maps/Earth*, while the *Specific* type refers to tools

specifically aimed at providing georeference for site names (*GeoLocate, GeoNames, Getty Thesaurus, Marine Regions and WikiData.*). For a complete list of other tools mentioned, yet not predominant, see Q20 in the Appendix. Africa reports the use of *Specific* tools over *Generic* ones, while in the rest of continents the use of *Generic* tools prevails, except for North and Central America were they are evenly used.

When respondents were asked whether they had official cartography available (see Q21 in the Appendix), an important resource for georeferencing the very common specimens whose site name is described as an administrative unit, those from Europe, South America and Oceania reported a higher availability (scores of 3.1, 3.2 and 3.0 over 5, respectively) than those in Africa, Asia and North and Central America (2.6, 2.7 and 2.5 over 5, respectively).

As seen in Figure 5b, with respect to the software tools used for storing and managing georeferenced site names, the majority of respondents in all continents answered they were using none. Microsoft tools (Excel and Access) are the second most used except for institutions in Oceania where custom applications come second. Globally, the top 5 software tools used were: Microsoft Access (19.5%), Custom application (13.8%), Microsoft Excel (10.9%), Specify (9.5%) and FileMaker (5.7%).

Documentation of coordinate uncertainty. The percentage of respondents reporting coordinate uncertainty differs in relation to the types of locations. Uncertainty is less reported when location of specimens are given as GPS coordinates than when they are given as textual information; 47% versus 54%, respectively (see Q26 in the Appendix). Also, 29% of respondents acknowledged that they apply decimal rounding to coordinates before publishing them, thus adding extra uncertainty to the original estimates (see Q27 in the Appendix for the list of original comments on why this practice is carried out). Only about 35% of respondents answered affirmatively to whether uncertainty needs to be calculated according to all factors affecting it during the process of georeferencing (see Q29 in the Appendix). Only 30 respondents reported which tool they use to calculate uncertainty; GEOLocate with 12 answers and the Georeferencing calculator with 7 are the most used tools within these respondents. Finally, 68% of respondents admitted not using any methodology to check for errors after the georeferencing process is finished (see Q30 in the Appendix).

Use of and publishing in data aggregators. 64% of respondents report the use of GBIF data with 78% of these using it exclusively and 22% combining its use with other public repositories. Those not using GBIF report the use of other repositories in 34% of cases and 66 % do not use any repository. Finally, when asked how important they considered that these repositories provided georeferenced information, 62% said it was important or very important (see Q33 in the Appendix).

Acknowledgements

We wish to express our gratitude to all people who have committed some of their time to answering this survey and making it possible. Also, Arthur D. Chapman and Deborah Paul have been specially helpful in completing the list of survey recipients. Mils de Reus and Sharif Islam have provided crucial assistance in making the survey possible with the DiSSCo (`https://www.dissco.eu`) and MOBILISE CA17106 resources. This survey has been conducted as part of the MOBILISE EU Cost Action CA17106 (`https://www.mobilise-action.eu`).

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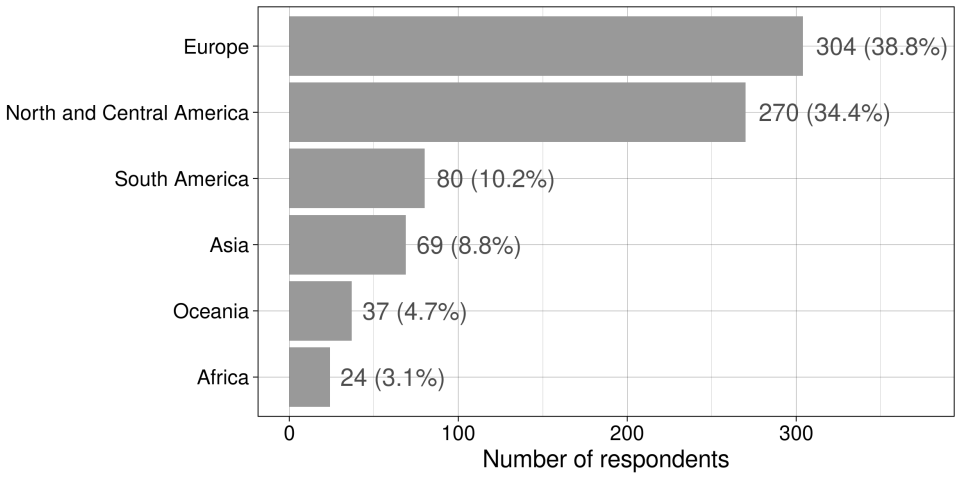
Appendix

Question responses

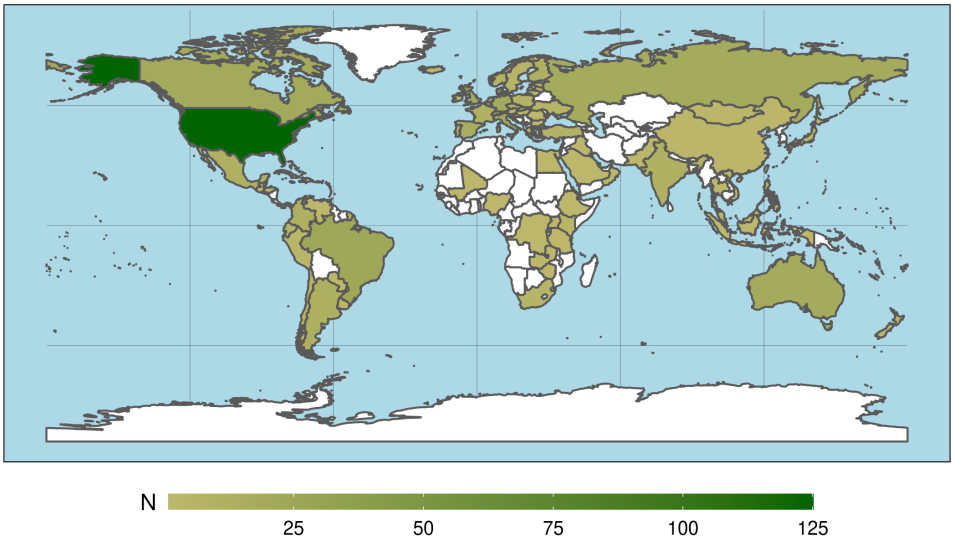
Q1 - Where is your institution located? Please specify country.

Number of respondents : 784.

By continent Responses for the six continents were distributed in three groups of similar number of respondents: Europe and North and Central America with 38.8% and 34.4%, respectively; South America and Asia with 10.2% and 8.8% respectively; and Oceania and Africa with 4.7% and 3.1%, respectively.



By country Number of respondents by country. Answering about the country was optional. We completed the unfilled answers using the institution name and email address to infer the country.



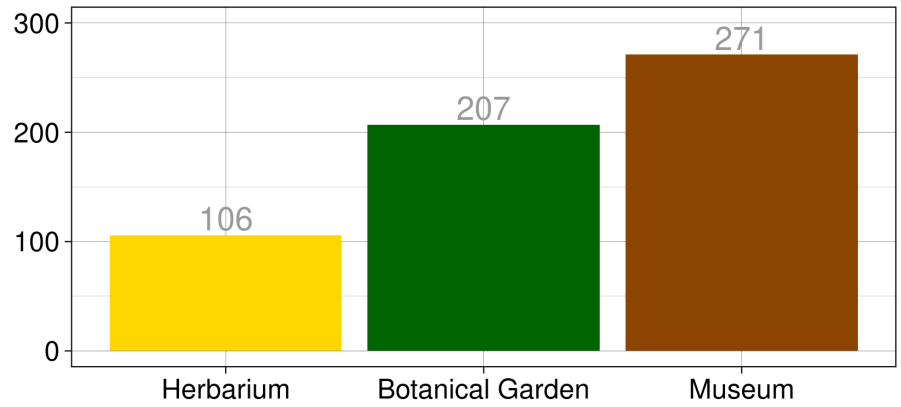
Number of respondents per country United States 125, Brazil 24, Canada 21, Italy 21, Germany 20, Australia 19, Russian Federation 19, United Kingdom 18, Spain 16, Argentina 13, Colombia 11, Finland 11, Mexico 11, France 10, India 10, Norway 8, Poland 8, Turkey 8, Czech Republic 7, Ecuador 6, South Africa 6, Sweden 6, Switzerland

6, Ukraine 6, Chile 5, Netherlands 5, Portugal 5, Austria 4, Denmark 4, Estonia 4, Greece 4, Hungary 4, Israel 4, Belgium 3, Ireland 3, Japan 3, Kenya 3, New Zealand 3, Peru 3, Slovakia 3, Brunei 2, China 2, Croatia 2, Lithuania 2, Malaysia 2, Mongolia 2, Oman 2, Pakistan 2, Philippines 2, Uganda 2, Uruguay 2, Viet Nam 2, Bahamas 1, Barbados 1, Bulgaria 1, Cuba 1, Cyprus 1, Democratic Republic of the Congo 1, Dominican Republic 1, Egypt 1, El Salvador 1, Ethiopia 1, Guatemala 1, Honduras 1, Iceland 1, Indonesia 1, Iraq 1, Jamaica 1, Latvia 1, Luxembourg 1, Mali 1, New Caledonia 1, Nigeria 1, Paraguay 1, Phillipines 1, Puerto Rico 1, Romania 1, Saudi Arabia 1, Slovenia 1, Taiwan 1, Tanzania 1, Thailand 1, Unites States 1, Venezuela 1, Zambia 1, Zimbabwe 1

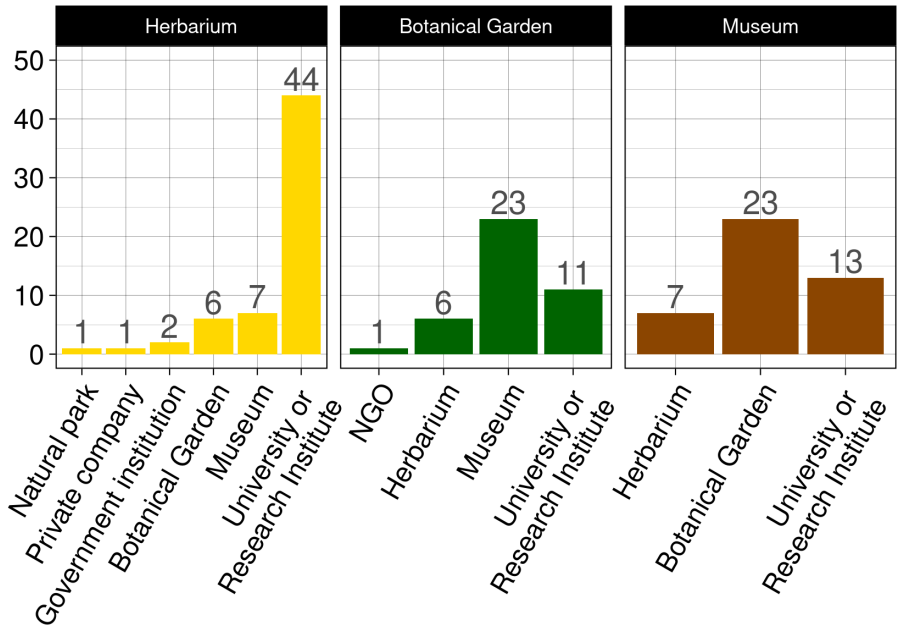
Q2 - Institution type. Other (please specify).

Number of respondents: 784.

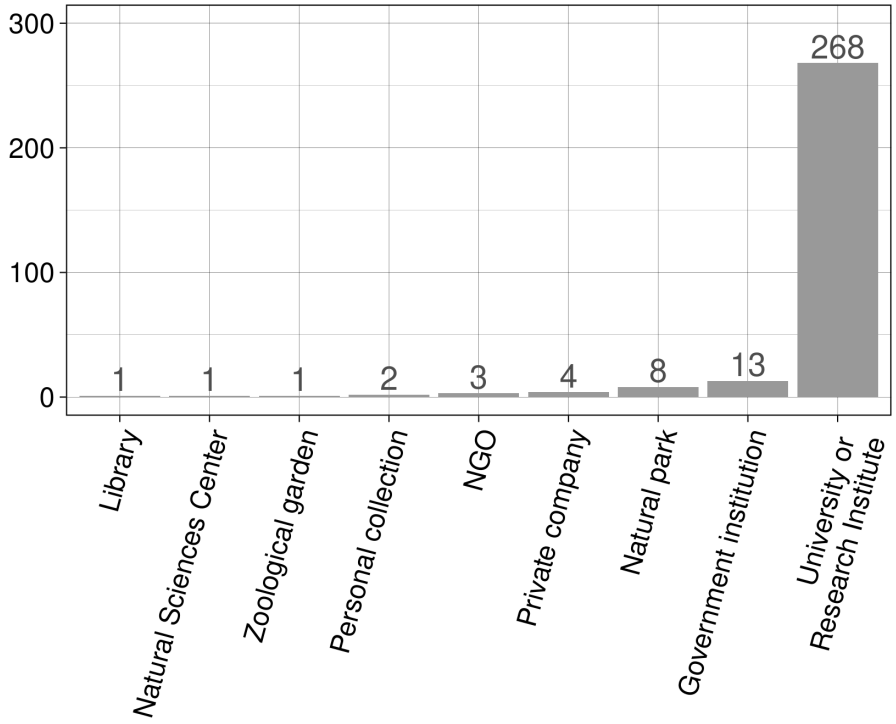
This question allowed for multiple answers since some institutions may belong to more than one type; *e.g.* an herbarium hosted at a university or an institution which is both a museum and a botanical garden. Therefore, numbers do not add up to the total number of respondents. Also note that herbaria are probably most of the time not institutions by themselves but embedded in other types of institutions, *e.g.* a research institute. They are not like museums which are usually a clear institutional entity.



The following graph shows for herbaria, botanical gardens and museums to which other types of institutions they may be associated with.



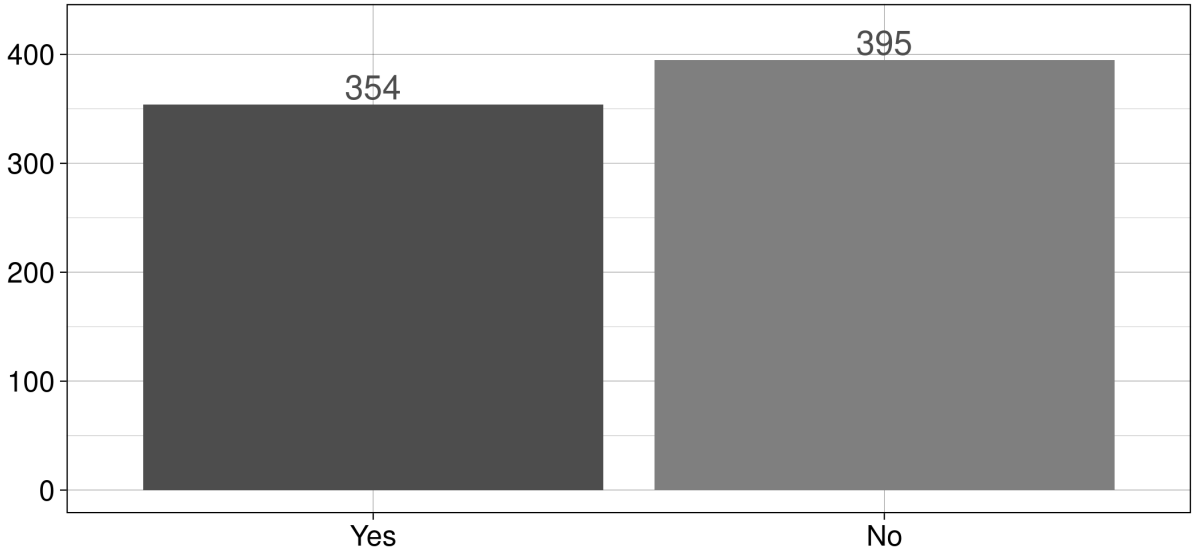
Finally, the following graph shows those respondents which stated that their institution was not of the type herbarium, botanical garden or museum.


300
200
100
0
1
1
1
2
3
4
8
13
268
Library
Natural Sciences Center
Zoological garden
Personal collection
NGO
Private company
Natural park
Government institution
University or Research Institute

Q3 - Is your institution a national reference in natural history collections in your country?. Comments.

Number of respondents: 776.

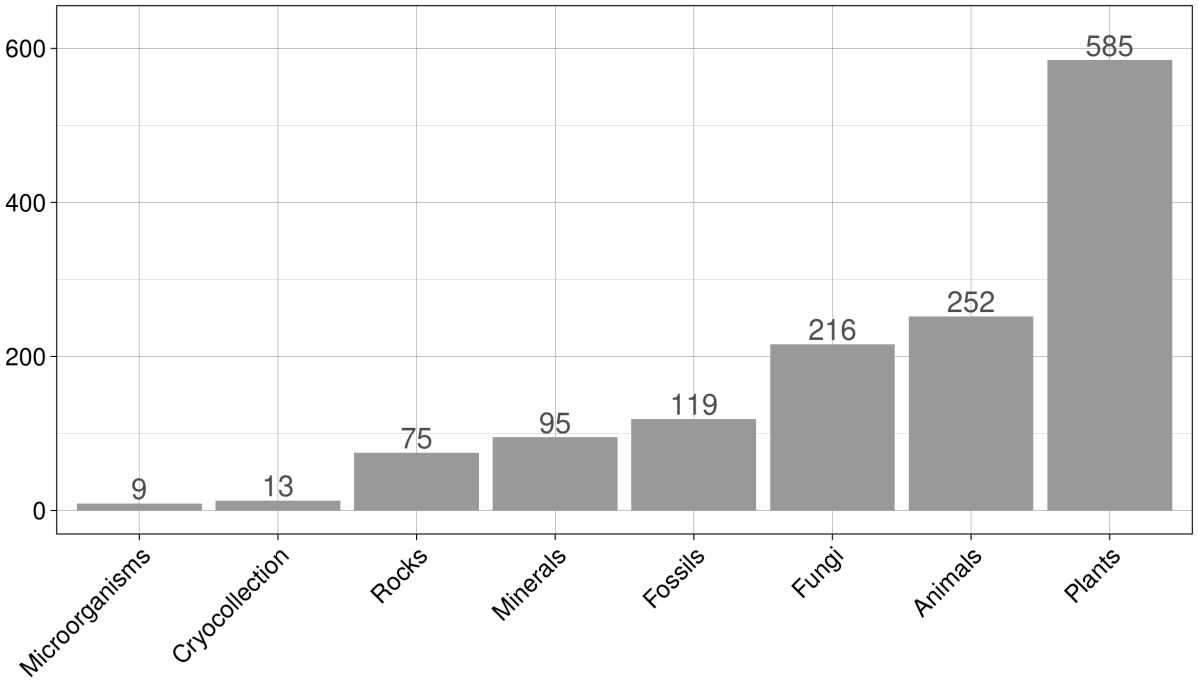
354 respondents affirmed their institution was a national reference in their country while 395 denied it. 27 expressed confusion with this question and said they did not fully grasp its meaning.



Q4 - What kind of collections does your institution host? (*e.g.* animals, plants, fungi, etc.)

Number of respondents: 659 respondents.

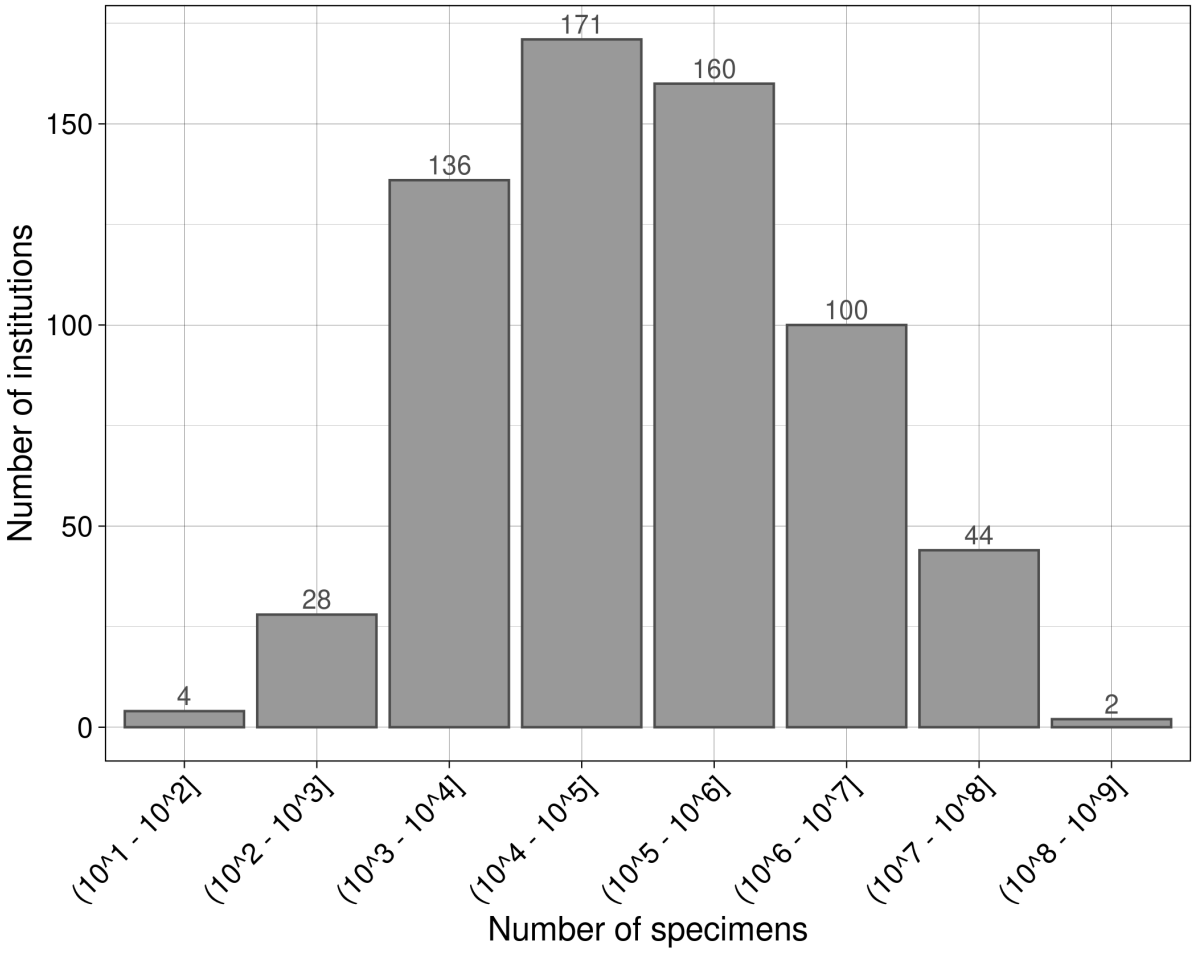
This question allowed multiple answers. Respondents could report more than one collection type. The graph below shows the distribution of types of collections held at institutions. Plant collections are by far the more represented reported collections, more than doubling the number of the second type of collections, animals.



Q5 - Can you give us an estimation of the total number of specimens that your institution holds? (please write a whole number with no thousand separators, *e.g.* 1000000).

Number of respondents: 646.

The graph below shows the distribution of the overall number of specimens held at respondents' institutions. The overall number of specimens held at the institutions of this survey amounts to 2 727 146 818. This estimate means the survey has covered a list of institutions which together account for a vast percentage of the overall number of speciments in Natural History Collections across the world if we take into consideration the figure of 2.1 billion given by Ariño et al. (2010).



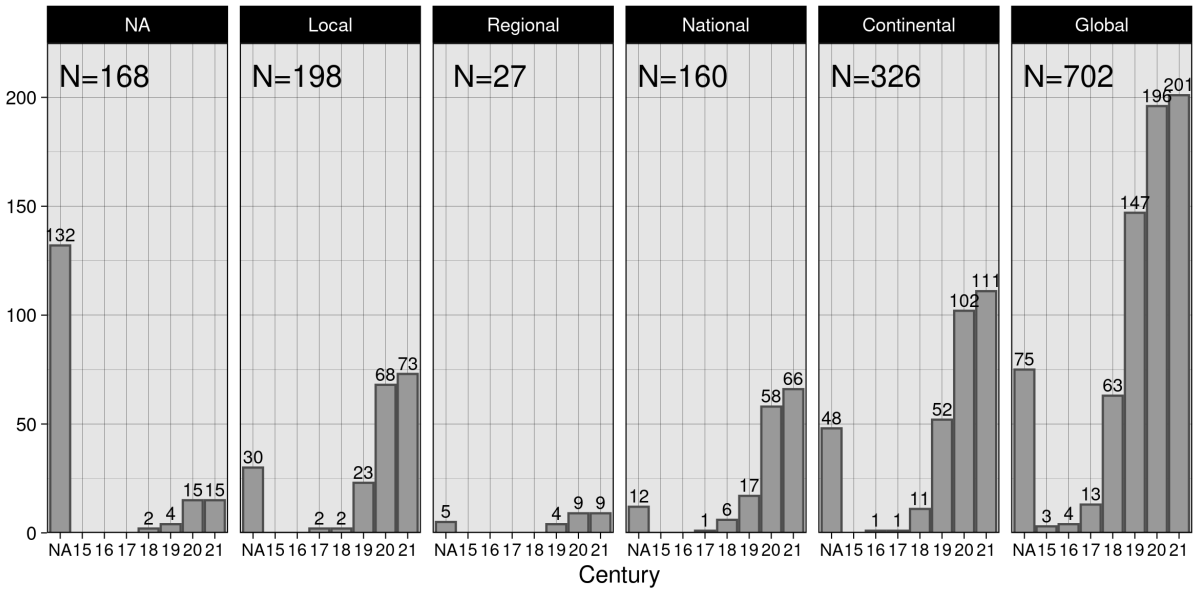
Q6 - What is the geographic and temporal coverage of your institution collections? (*e.g.* South- east Asia, since 1750; South America 1700-1800; . . .)

Number of respondents (geographical coverage): 637.

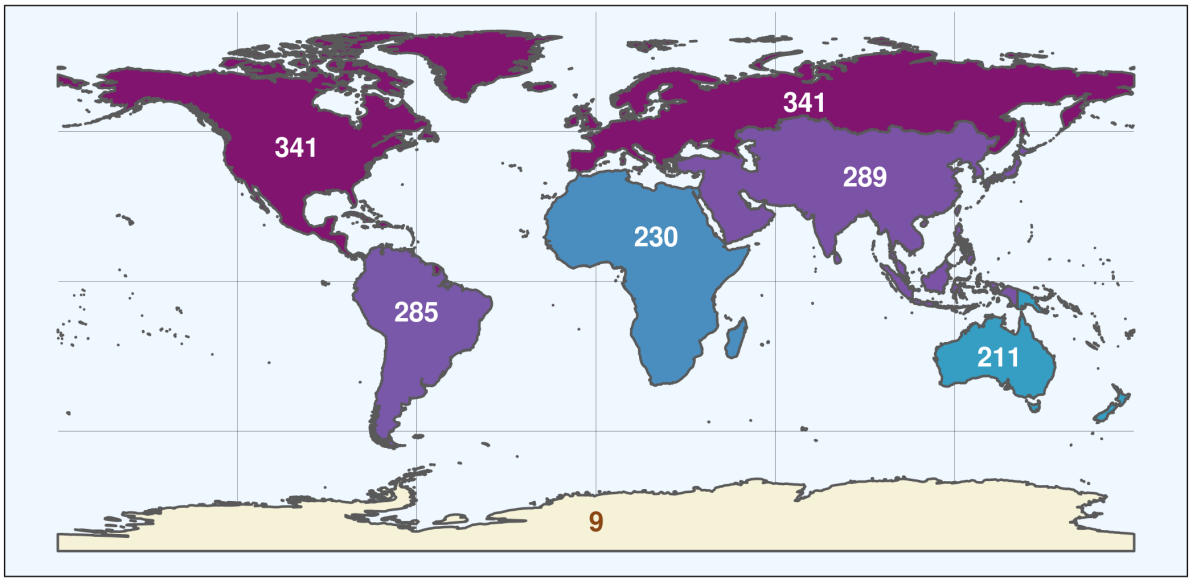
Number of respondents (time coverage): 482.

We have categorized the geographical coverage reported by respondents in the following categories:

- *Local* — extensions smaller than countries; *e.g.* Yosemite National Park.
- *Regional* — extensions between local and national; *e.g.* western Ethiopia.
- *National* — extensions corresponding to countries; *e.g.* New Zealand.
- *Continental* — extensions bigger than countries, up to a continent; *e.g.* South East Asia.
- *Global* — extensions bigger than continents up to the whole world; *e.g.* Eurasia.



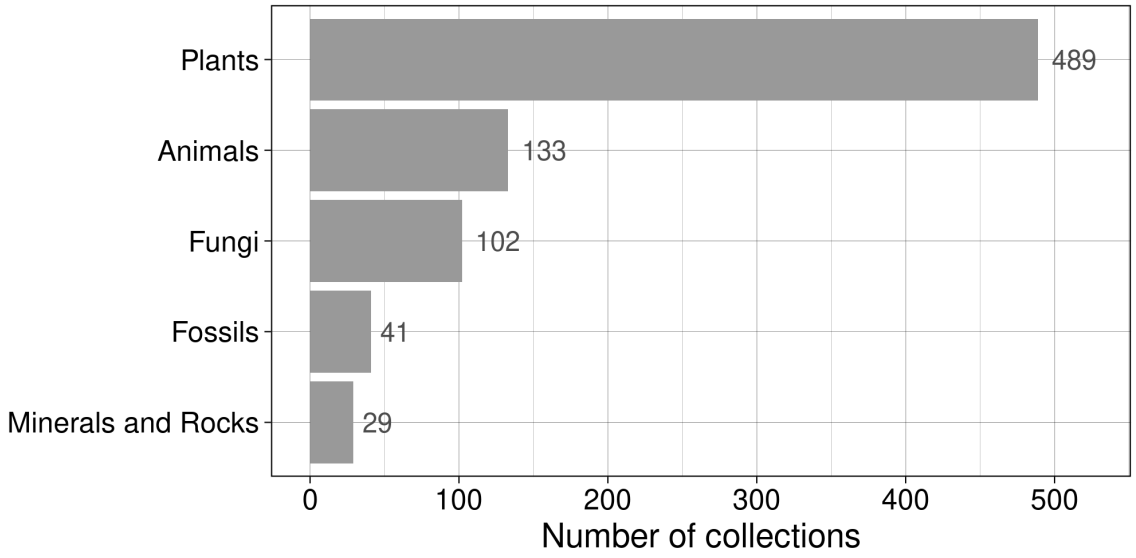
Number of reporting institutions from each continent



Q7 - Please enter the collection for which you are submitting your response. (*e.g.* vascular plants herbaria, insects, etc.).

Number of respondents: 613.

The graph below shows the number of collections reported by groups of organisms. We have grouped all responses into these major groups to give an indication of the major types of collections reported in this survey. Below the graph is an ordered list of the frequencies of all different groups of organisms that have been reported.

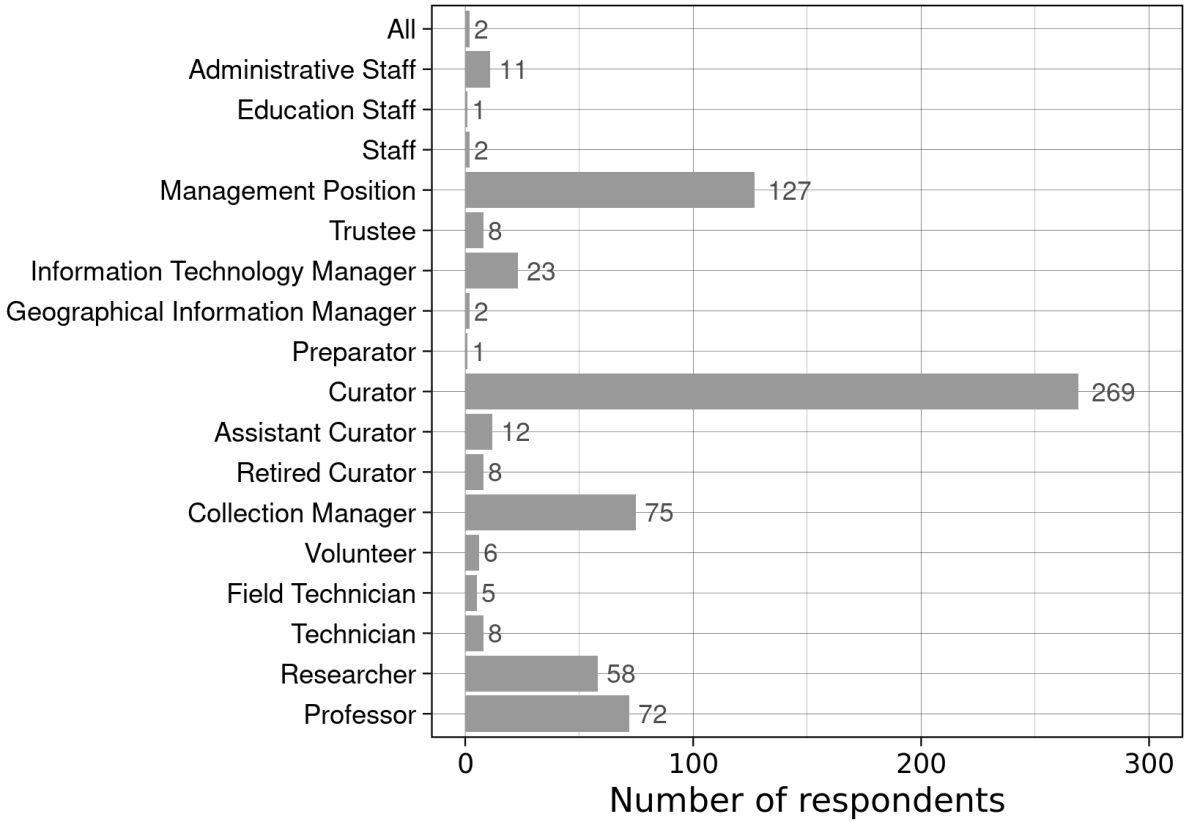


Frequencies of all reported groups: Vascular Plants 331, Plants 127, Fungi 83, Algae 48, Bryophytes 48, Insects 43, Fossils 40, Animals 37, Lichens 32, Fishes 30, Herps 28, Mammals 28, Minerals 28, Birds 27, Rocks 27, Invertebrates 11, Molluscs 11, Arachnids 10, Cryptogams 8, Phanerogams 7, Mosses 6, Seeds 6, Cnidarians 5, Crustaceans 5, Echinoderms 5, Myriapods 5, Sponges 5, Reptiles 3, Worms 3, Bryozoans 2, Tissues 2, Arthropods 1, Bacteria 1, Dna 1, Ferns 1, Microorganisms 1, Protozoans 1, Sounds 1, Tunicates 1

Q8 - What is your role within your institution?

Number of respondents: 615.

Number of respondents per administrative role. Respondents were allowed to report more than one role. Most respondents are collection curators, followed by personnel in management positions, collection managers, professors and researchers.

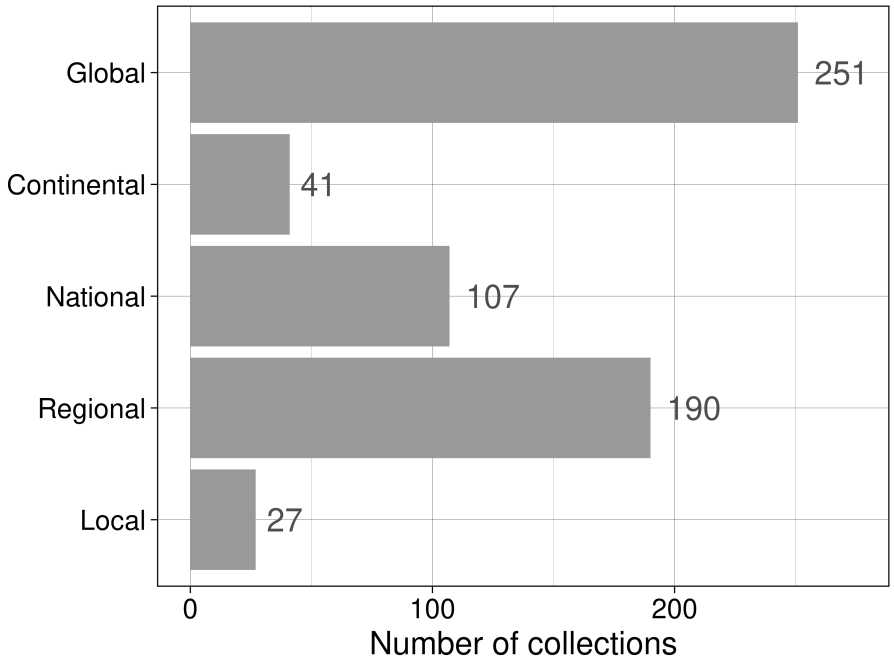


Q9 - What is the geographical extent of this collection?

Number of respondents: 616.

Number of collections reported at each different geographical extent. As in Q6, we have categorized the geographical coverage reported by respondents in the following categories:

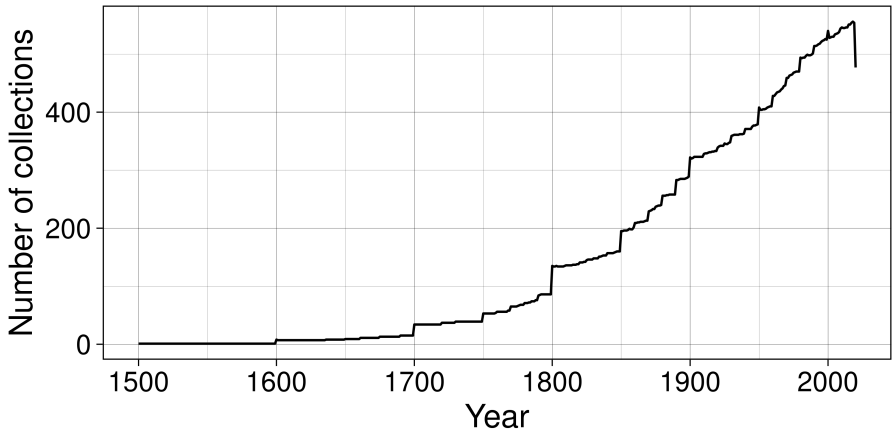
- *Local* — extensions smaller than countries; *e.g.* Yosemite National Park.
- *Regional* — extensions between local and national; *e.g.* western Ethiopia.
- *National* — extensions corresponding to countries; *e.g.* New Zealand.
- *Continental* — extensions bigger than countries, up to a continent; *e.g.* South East Asia.
- *Global* — extensions bigger than continents up to the whole world; *e.g.* Eurasia.



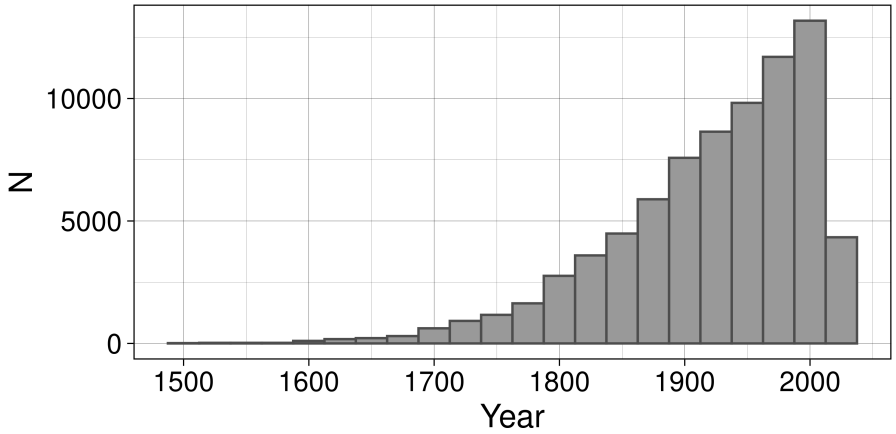
Q10 - What is the temporal coverage of your collection (year range)? (*e.g.* since 1600; 1950- 2000; ...).

Number of respondents: 608.

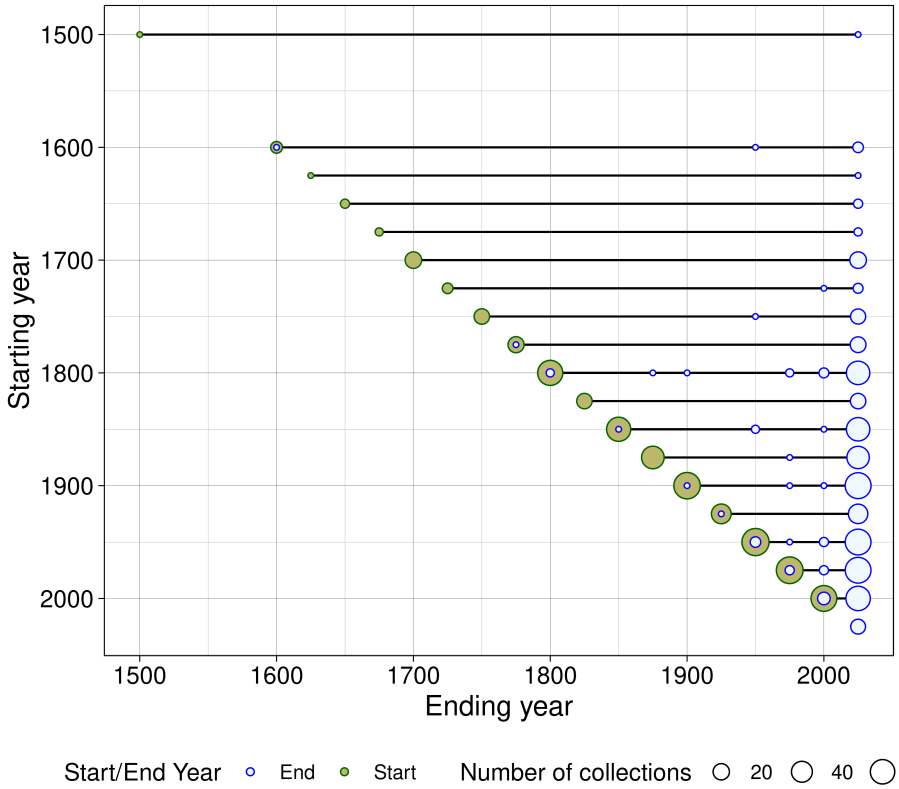
The graph below shows the number of collections with specimens for every year since the 16th century. Although this is not a cumulative curve of number of collections, it shows a cumulative form since collections, once started, are not terminated over time, they remain active.



The following graph is the same as the above graph but with collections binned in 25-year time intervals.



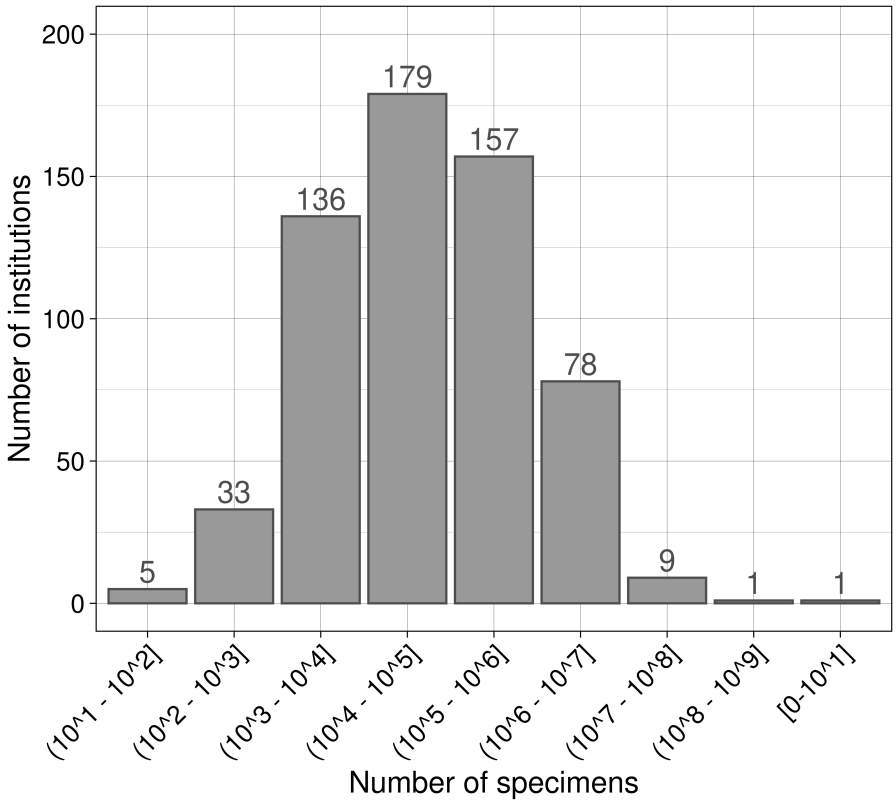
This last graph, shows the time intervals covered by collections, rounded to 25-year sizes. Green dots represent the year a given collection was started while blue dots represent the end year (note that very few collections have been terminated, blue circles at end of lines correspond to the survey's year, *i.e.* 2020). Circle sizes are proportional to the number of collections.


1500
1600
1700
1800
1900
2000
Starting year
1500
1600
1700
1800
1900
2000
Ending year
Start/End Year
End
Start
Number of collections
20
40

Q11 - What is the size of this collection (number of specimens)? If known, just write down the number If approximate, please write 'approx.' before the number).

Number of respondents: 599.

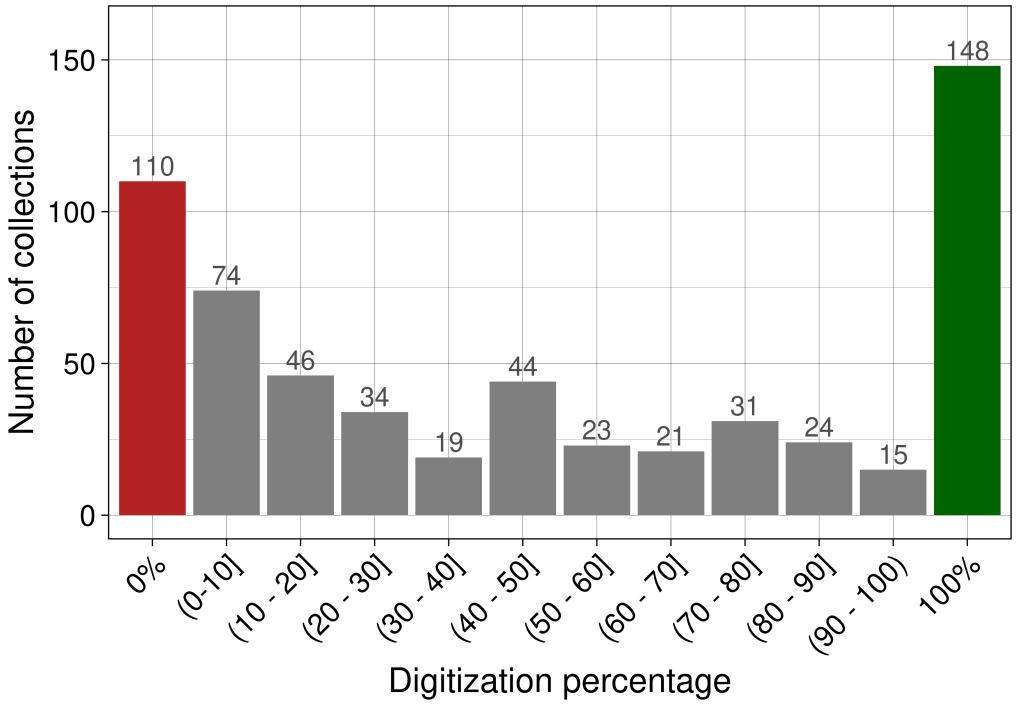
Distribution of sizes for the collections reported in the survey. The overall number of specimens combined for all reported collection is 1 409 064 539. This number represents a 51.7% of the reported 2 727 146 818 specimens for institutions (see Q5).



Q12 - Is this collection digitized? *i.e.* the specimens exist as a digital record, not necessarily including scan and media files.

Number of respondents: 589.

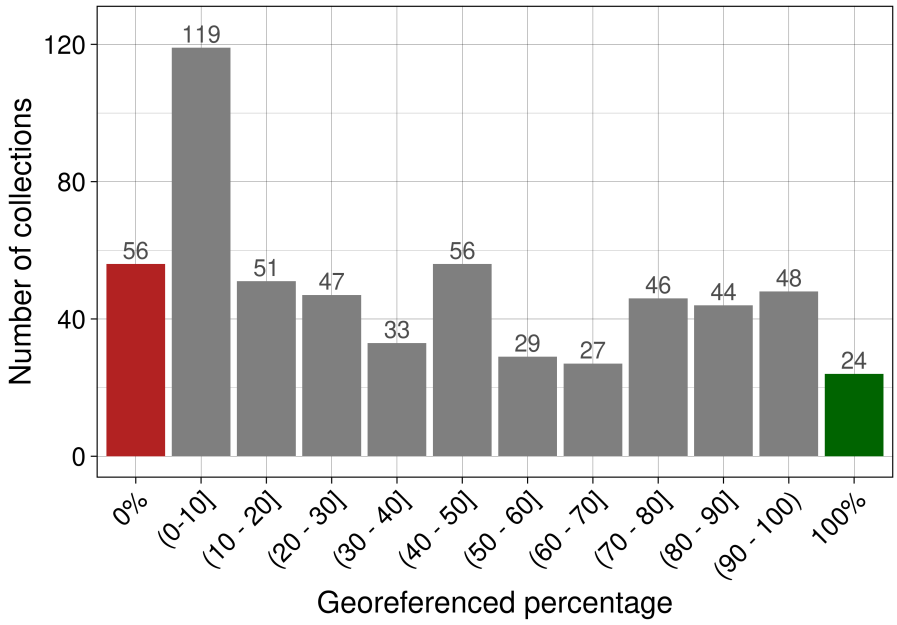
Reported digitization status of collections, in number of collections per increments of 10% digitization. 110 (19%) have not started the digitization process, while 148 (25%) have completed their digitization process. For the partially digitized collections, about two thirds of them are reported as less than half-digitized while one third of them as more than half digitized.



Q13 - Approximately, what percentage of them are georeferenced? In reference to the total collection, not only the digitized part.

Number of respondents: 580.

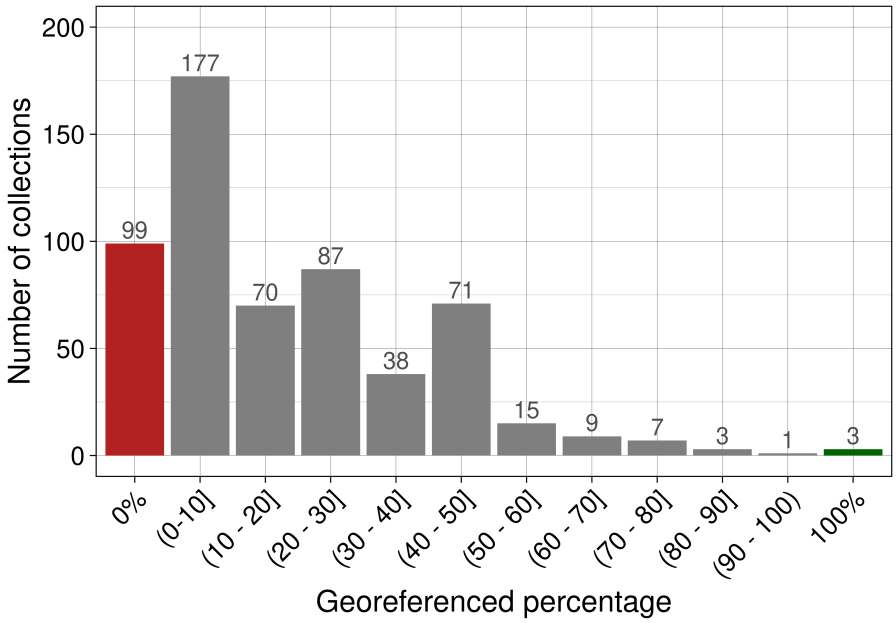
Reported georeferencing status of collections, in number of collections per increments of 10% georeferencing. 56 (10%) have not started the georeferencing process, while 24 (4%) have completed their georeferencing process. For the partially georeferenced collections, about 61% of them are reported as less than half-digitized while 39% of them as more than half digitized.



Q14 - For this collection, of the time dedicated to digitisation, what percentage is spent on georeferencing?

Number of respondents: 580.

Percentage of digitisation time spent on georeferencing tasks, in 10% increments. 99 (17%) do not spend any of their digitization time on georeferencing while 3 (1%) state that their whole digitization time is spent on georeferencing. For those in between, 93% spent half of the digitisation time or less while 7% spent more than half of the time.



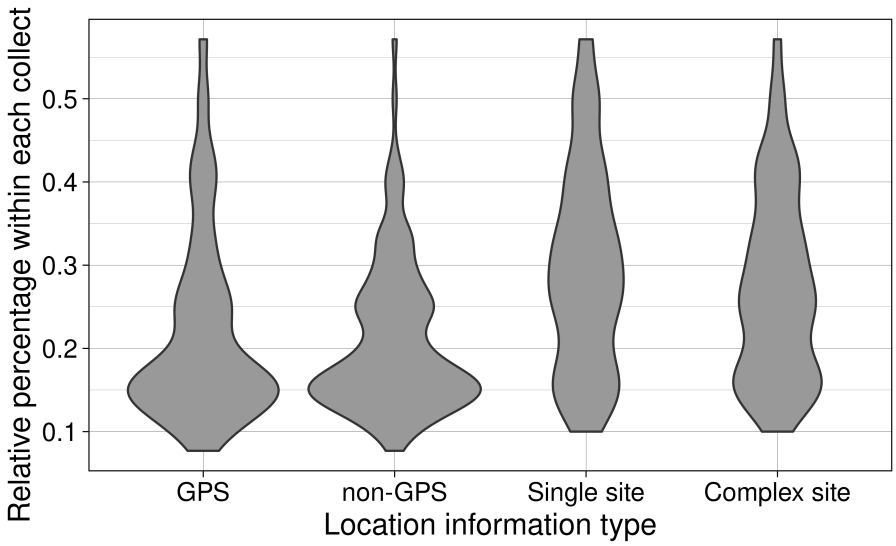
Q15 - Assign an approximate percentage on how many of your specimens come with different types of location information.

Number of respondents: 451.

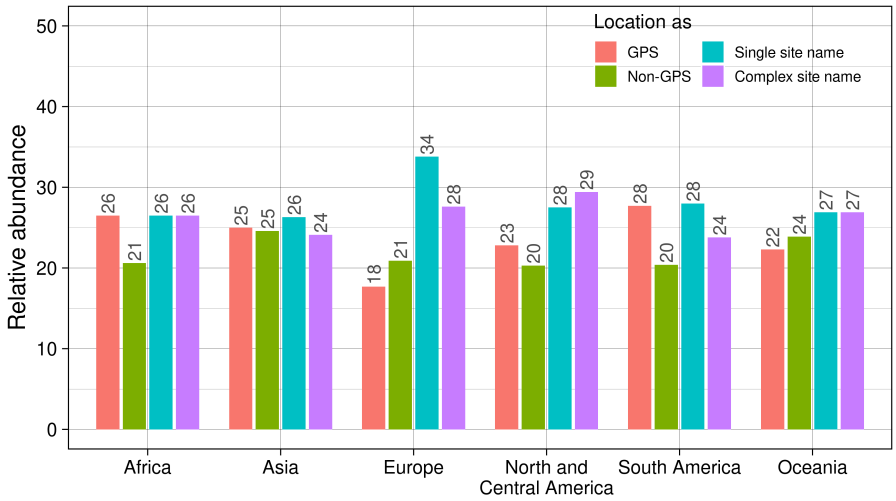
The four types of locations considered are:

- *GPS* — Coordinates directly derived from a GPS.
- *non-GPS* — Coordinates transcribed from written text.
- *Single site* — Coordinates derived from the georeferencing of a single site, *e.g.* a town, a mountain, a lake, *etc.*
- *Complex site* — Coordinates derived from the interpretation of a complex description of a location involving more than one site and/or directions to get to it.

The graph below shows the distribution of percentages of each type of location information within each collection. Each type should be interpreted as the relative abundance of it measured within each collection.



The graph below shows the relative abundances of location types in collections per continent, expressed as score values as follows: *i.e.* 0-25% was assigned score 1, 25-50% score 2, 50-75% score 3 and 75-100% score 4. Scores where then scaled to 0 - 100. The higher the score the higher the number of specimens of that type.


Location as
GPS
Non-GPS
Single site name
Complex site name
Relative abundance
50
40
30
20
10
0
26
21
26
26
25
25
26
24
18
21
34
28
23
20
28
29
28
20
28
24
22
24
27
27
Africa
Asia
Europe
North and Central America
South America
Oceania

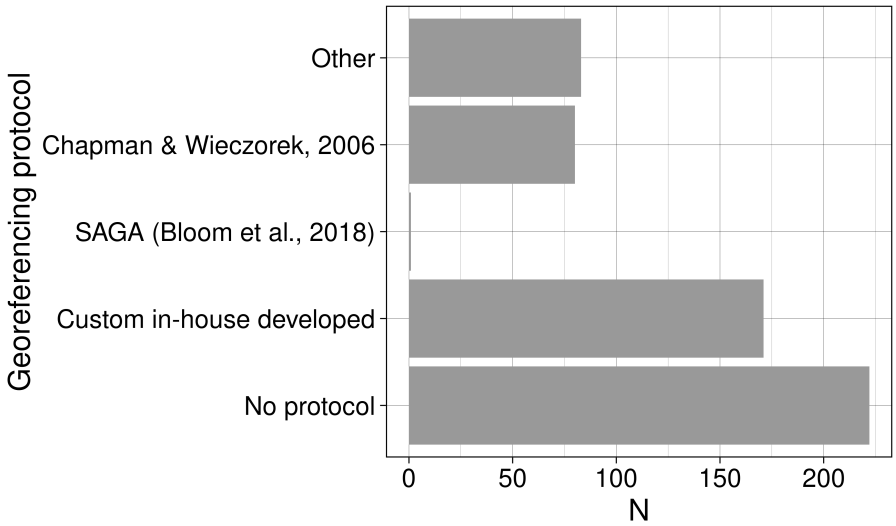
Q16 - Which protocol do you follow to estimate coordinates from textual descriptions of sites?

Number of respondents: 509.

We have asked the respondents which protocol they used in their georeferencing tasks and have considered the two main available protocols for georeferencing:

- Bloom, T. D. S., Flower, A. & DeChaine, E. G. 2018. Why georeferencing matters: Introducing a practical protocol to prepare species occurrence records for spatial analysis. *(Ecology and Evolution)* 8(1), 765–777.
- Chapman, A.D. and J. R. Wieczorek 2006. *Guide to Best Practices for Georeferencing*. Copenhaguen: Global Biodiversity Information Faility.

Custom in-house developed covers all those protocols which have been self-created by each collector or institution, sometimes based and derived on the two above. Chapman and Wieczored (2006) has very recent 2020 update which was not available at the time of the survey and thus, not considered.



Following is the list of comments made by respondents when they answered they used 'Other' protocols. Comments are presented in alphabetical order, non-edited and as they were entered in the form.

- Actually we are only at the beginning of georeferencing our specimens that have recently been digitized (photographed). So we have not yet decided on the protocol to follow
- All collection events are recent, and georeferenced.
- All specimens collected in late 1800 until 1975 contain a label indicating their provenance.
- Chapman & Wieczorek, 2019
- Combined with Geolocate (`https://www.geo-locate.org/`)

- CONABIO
- Consortium protocol based on iDigBIO resources using GeoLocate
- Descripción y estructura de los parámetros para la georreferenciación de localidades en colecciones biológicas (Instituto Alexander von Humboldt, 2014)
- Developed by entomologists at the Illinois Natural History Survey (see below)
- Earthpoint for TRS data conversion
- For species that would qualify as ex-situ conservation holdings, accurate location to better than 250m precision required, unless only known from single locality.
- From gazetteers and search mainly from Google Earth, and estimate locality from the locality names.
- Fungi are georefenced within the Mycological Collections Portal using GeoLocate and the protocol developed for contributors to the Portal
- Garmin Database
- Geo-referencing of locations: a reference guide for biological collections. v.4 July 2016 Alexander von Humboldt Biological Resources Research Institute
- geoLoc tool from speciesLink (CRIA-Centro de Referência em Informação Ambiental, Brazil)
- GeoLocate
- Geolocate in combination with GoogleEarth
- GeoLocate in Specify, but no specific protocol beyond that
- GeoLocate on Arctos
- Geolocator via Symbiota
- Georeferencing system of the State Forests.
- Georeferencing: quick reference guide (Wieczorek et al, 2012)
- Georreferenciación de localidades: Una gu16a de referencia para colecciones biológicas (D. Escobar et al.,2015)
- Get close by reading the labels
- Google Earth
- Google earth and National Land Survey Finland map site
- Google Earth, internet searches, collector's information, best guess, coordinateUncertaintyInMeters probably close to Chapman and Wiecsorek
- `https://www.geo-locate.org/`

- iDigBio
- iDigBio protocols
- Kew Bontaic gardens guide
- Local knowledge of sites
- Macroalgal Herbarium Consortium
- made our own for terrestrial insects, still evaluating terrestrial invertebrates, I have no knowledge of what our vertebrate departments do. Overall, neither planned no coordinated
- MaNIS Georeferencing Guidelines (Wieczorek et al. 2012)
- MaNIS point-radius methodology (which was initially an inhouse developed protocol)
- Manual match of provided collection locality with a digital lat/long using mixed web resources
- map landscape plants with GIS Trimple unit or IrisBG, document wild collected plants/seed from index seminum
- mapping w Google Earth and estimating error based on label information
- Materials obtained from an NSF/iDigBio workshop
- Nearest town
- No effort yet made to georeference from pre-GPS era
- none yet; pending funding, SAGA
- Now we are using the coordinates that are on the sample labels or that we have measured with gps.
- On the old collections the coordinates were recovered from the route indications noted in the field notebooks.
- our institute does not have specific in-house developed guide, but protocols, e.g. use of google-map, retkikartta.fi, karttapaikka.fi
- Our national database has a map which allow to approximate sites
- Our platform, ArcGIS Online, provides automated geolocation information based on the addresses of the organizations from which we collect our materials.
- Protocol by Sociedade Portuguesa de Botânica
- Protocol developped by QFA herbarium
- remark: Cologne public municipal garden; we refer at requests to the plant source institution

- speciesLink: Dados e ferramentas: geoLoc - CRIA
- Specimens collected in the Czech Republic are georeferenced based on the description of the collection site, using the knowledge of the collection, geographic scopes of individual collectors and other types of information related to collectors and the country's flora. The same accounts for specimens from abroad. Here we also rely on specimens georeferenced in other herbaria from abroad using the same database.
- the coordinates are extracted from google earth
- There is actually no ongoing georeferencing activity
- Total station from Hilti (construction instrument) precision in mm/cm
- use of GPS
- via Google Earth
- WALLACE, L. 2015. Using GeoLocate within Symbiota to Georeference Specimens in the MSU Herbarium (unpublished document). Southeast Regional Network of Expertise and Collections (SERNEC), Appalachian State University, Boone, NC. `https://sernec.appstate.edu/sites/sernec.appstate.edu/files/MISSA\_How\_to\_Geolocate\_in\_Symbiota\_0.pdf`.
- We are based in Ireland and do almost no geo-referencing in-house. We do however supply records to our national centre who apply georeferencing as part of their general systems. They publish online and contribute to GBIF as our national node. They are called the National Biodiversity Data Centre `http://www.biodiversityireland.ie/`
- we are try to locate the locality and we use the Google Earth coordinates
- We basically use the MaNIS-HerpNET-ORNIS georeferencing manual, which was used to make Chapman and Wieczorek
- we don't estimate coordinates
- we have not started georeferencing yet. At present we load in the database the name of the collection site without coordinates.
- We have RTK GPS data for all specimens
- We haven't started active georeferencing yet
- We often use GeoLocate
- we use Geolocate with individual look up (not batch jobs)
- we use google earth
- we will be transitioning to a more standard protocol
- WGS-84

Q17 - If your own or other, can you provide details here, including the internet address if available?

Number of respondents: 161.

Following is the list of comments given by respondents in reference to the protocol they used. Comments are presented in alphabetical order, non-edited and as they were entered in the form.

- 1) write the original location; 2) interpret the original location from official maps; 3) obtain the coordinates and its precision according to the point-radius method; 4) validation using DarwinTest.
- A 10 meter grid system.
- adopt municipality coordinates
- After grouping similar locality data, labels are analyzed by a human who consults Google Map & other internet maps and resources, on a case by case basis, a zone of reasonable possible location is estimated, a point is selected exactly in the centre of the zone (databased as georeferenced lat/long), uncertainty in meters is entered (centre to margin of zone), person, date, tools, datum and remarks are entered
- all are on vertnet
- Australian Gazetteer Cartography in house and online Google Earth
- BG-BASE protocol for the Living Collections
- Brgy. Pagatban, Bayawan City
- Come as close as possible to the point mentioned on the lable.
- Currently the site is down and is at has vulnerabilities which are being addressed. `http://ecflora.cavehill.uwi.edu/`
- customised, web-based georeferencing tool that estimates the centroid of a drawn polygon or circle with given radius from publicly available digital maps (Google Maps for international samples [`https://www.google.com/maps]`, Swiss Topo Maps [including historical maps; `https://map.geo.admin.ch/]`
- Eclectic
- estimate based on maps in eFlora
- field note books; norgeskart `https://www.norgeskart.no/`
- For non-GPS'd textual descriptions of sites, we 1) find the centroid coordinates of the site name, 2) determine the location uncertainty distance (in meters) by estimating the distance to neighbouring sites where a different site name would likely have been given. Typically, this involves three fields: latitude, longitude, and location uncertainty distance. This essentially creates a circle polygon in which data interpreters can be 100

- For older specimens, we used the hard copy of the Gazetteer to get approximate latitude/longitude using the nearest place name. Once GPS devices became available, these became the standard. Nowadays we often use satellite images through Google to determine a more accurate latitude/longitude if the collector did not use a GPS.
- for regional maps, mainly
- For specimens collected by our institution, we record the GPS coordinates in the field, and we record the datum used to acquire the coordinates. Everything is done in decimal degrees. For specimens received by 3rd-party donors, they normally do not have coordinate information, so we typically reference Google Earth or GeoLocate to match their location description.
- from GPS = code 1(10 m); post–processed with small town or road crossing and stream name = code 2 (1, 000 m); town name only or large town with stream name = code 3(10, 000 m), county level record = code 4 (100, 000 m); state level record = code 5 (1, 000, 000) m. SEE: doi.org/10.3897/zookeys.178.2616
- GeoLocate
- GeoLocate, `https://www.geo-locate.org/`
- Georeferencing system of the State Forests `https://www.bdl.lasy.gov.pl/portal/mapy`
- Google earth
- google earth / mapy.cz
- Google earth and Regione Toscana/Cartoteca- Geoscopio
- Google Earth, GEOLocate
- Google maps
- Google maps API -¿ Bulk georeferencing for same location
- Greenwich decimal degrees, uncertainity in meter. Label+all available tools
- Herbario regional de Guayana, jardĺ7n botánico del Orinoco, ciudad bolĺ7var, bolĺ7var, Venezuela
- Hierarchial procedure using (1st choice) coordinate on label, (2nd choice) coordinate from our own location database, (3rd choice) centroid coordinate for the district
- Historically, georeferencing has been done according to in-house developed protocols that did not follow best practices. As the new collections manager for these collections, I am implementing the best practices I learned at the iDigBio Train-the-Trainers Georeferencing workshop.
- `http://fossil.swau.edu`
- `http://herb.csbg.nsc.ru:8081`

- http://herbarium.bio.vsu.ru/
- http://repository.humboldt.org.co/handle/20.500.11761/9610
- http://repository.humboldt.org.co/handle/20.500.11761/9610
- http://splink.cria.org.br/geoloc?criaLANG=en
- http://www.biaatr.org/boneandplant
- http://www.conabio.gob.mx/informacion/gis/
- http://www.geonames.org/
- http://www.nbg.kiev.ua/collections_expositions/
- http://www.old.khsu.ru/main/structure/institutes/ienim/ob-institute-ienim/structure-ienim/gerbarij.html
- http://www.simus.unisi.it/it/musei/mb/
- http://www.ynlky.org.cn/
- https://bspm.agsci.colostate.edu/gillette-museum/
- https://diversityworkbench.net/Portal/DiversityCollection with https://diversityworkbench.net/w/media/1/10/DiversityCollectionHelp_3_0_9_4.pdf
- https://doi.org/10.3897/rio.4.e32449
- https://herbariotropical.wixsite.com/inicio
- https://macroalgae.org/portal/index.php
- https://rbgvictoria.github.io/melisr-manual/
- https://www.ars.usda.gov/pacific-west-area/logan-ut/pollinating-insect-biology-management-systematics-research/
- https://www.capturingcaliforniasflowers.org/uploads/1/6/3/7/16372936/7_georeferencing_protocol.docx
- https://www.cnpm.embrapa.br/projetos/relevobr/
- https://www.esri.com/en-us/arcgis/products/arcgis-online/overview
- https://www.gbif.es/wp-content/uploads/2018/01/04_Calidad-datos-espaciales-temporales.pdf https://www.geo-locate.org/
- https://www.hilti.fr/c/CLS_MEA_TOOL_INSERT_7127/CLS_CONSTRUCTION_TOTAL_STATIONS_7127/r4849
- https://www.isa.ulisboa.pt/jba/conhecer-o-jba/colecoes

- https://www.jcu.edu.au/college-of-science-and-engineering/jct-herbarium
- https://www.maanmittauslaitos.fi/en/e-services/mapsite
- https://www.mapmywayfree.com/index.jhtml?partner=\^
- https://yandex.ru/maps
- If I can identify the place on google or bing maps, I sometimes use those coordinates. but mostly I only enter coordinates into our database if provided by the collector/donator
- If, the textual descriptions say what river, highway km that can be used to estimated the locality.
- Information is reserved.
- Institutional georeferencing guide is adapted from Chapman & Wieczorek and other protocols to be implemented within Specify database software.
- Internal guidelines
- Interpretation of descriptions, combined with highly detailed local knowledge.
- Is the new version of Chapman & Wieczorek, 2006
- It is possible, but not now.
- Lat/long Coordinates, geographic description, stratigraphic and lithologic description, reference to cross section position, distance+direction from landmark
- Linhares, Espí7rito Santo, Brazil
- Localities information from mapping authority
- Mainly now using Google Earth to locate the place. Previously use topographic maps and gazeteer at Geoscience Australia government place names.
- Mid-Atlantic Megalopolis project -Symbiota using Geolocate https://908f66e9-10c3-420c-8391-c1c06080c872.filesusr.com/ugd/6f7156_4679ee3db0e341929eaddaec4ea147c2.pdf
- most old textual descriptions are land survey system (US), so we place the point at the center of the reference quarter-quarter-section
- Mostly just using general approximations when applicable/appropriate, but skipping those that do not have enough contextual information to be accurate enough.
- Much of this aspect was done before current staff got here but Google Earth was used a lot. These days we georeference immediately on collection in the field or receipt of salvaged material
- Natural Resource Data Solution (NRDS); owner Sam Aruch

- next town, cardinal point, description of location in case of actual field collections: determination of coordinates with: https://www.orchids.de/haynold/tkq/KoordinatenErmittler.php
- Nowadays GPS coordinates are expected
- Only for national records do we add georeferences based on descriptions, and then I use Google maps.
- our collection ndata are on GBIf
- Our protocol is based on previous references (Wieckzorek et al., 2004; BioGeoMancer, Manis, GBIF, etc.). Our particular perspective responds to three geographical contexts: Catalonia, Spain, and the rest of the World (approximately 50
- Our protocols are a mix of Mapstedi and Biogeomancer (Biogeomances is partially based on Mapstedi)
- Penn at al 2017
- Personal GIS experience, multiple georreferencing tools. Courses by ESRI, mainly using ArcGIS.
- plantsfor lifekenya.org
- Primarily use My Topo (https://www.mytopo.com)
- Priyanka Tyagi Assistant Scientist Patanjali Research Institute, Uttrakhand, India priyanka.tyagi@prft.co.in
- Provided during the project developed for the Red List of Portuguese Vascular Flora
- Readings of maps with decimal degrees settings allowing different accuracy, 50m, 100m, 500m, 1 km, 2 km, 5 km. Also grid system of 10x10 km.
- Region, district, how many km and which way from the village there is a gathering place. What a community. No address
- route mileage
- same document as http://www.herpnet.org/herpnet/documents/GeoreferencingQuickGuide.pdf
- Search for name in https://gazetteer.linz.govt.nz/
- Searching for locations from online maps (googlemaps, googleearth, Geoportal, other local maps), reading the coordinate, estimating the distance between the given georeference and the possible point of the set. https://www.ksib.pl/szukacz/szukacz.php http://geoportal.gov.pl/ Conversion to georeferenced formats http://www.aprs.radom.pl/index.php/przeliczanie-stopni
- See Arctos.museum.database and handbook at http://handbook.arctosdb.org/
- select approximate coordinates using Google Earth

- Since we are not actively georeferncing, but only entering coordinates that are already on labels, anwering the questions below is irrelevant. I am providing answer on what we WOULD do, if we were actively geo-referencing.
- Some documentation for our technical process can be found here: `https://lacmip.github.io/emu/documentation/georeferencing/`
- Stonyhurst.ac.uk
- The Assistant Curator and a volunteer are working on a project to digitise the herbarium specimens. In 99.9
- The coordinates are in the sample labels and some of them have been measured with gps
- The major part of our collection was collected by own researchers (1950-1990) and therefore a file is compiled with expedition data including georeferences and good practices for databasing in our collection. Until now it is not accessible outside, but used by staff working with databasing of fungal specimens.
- The protocol (pdf file) for batch georeferencing records that have been entered into the Portal is available here: `https://www.microfungi.org/index.php/resources/`; the records can be edited (and searched) here: `http://mycoportal.org/portal/index.php`
- Topographic maps at various scales; Satellite imagery (Google earth) through NT Govt Portal; sometimes 1:250,000 Australian Gazetteer
- TRS (Township-Range-Section) conversion to coordinates: `http://www.earthpoint.us/TownshipsSearchByDescription.aspx`
- URL: `http://repository.humboldt.org.co/bitstream/handle/20.500.11761/9610/1224%20Protocolo.pdf?sequence=6\&isAllowed=y`
- Use GIS loaded with historical 10k Ordnance Survey Maps. Estimate grid reference and approximate level of certainty as defined by a circle within which it is 99
- Use google maps in the consortium of midwest US herbaria
- Use GPS or map co-ordinate if available and check on map toaster it is correct. If not adjust if the error is obvious e.g. digits written the wrong way around. Write the original co-ordinate in the database along with the corrected one in the approriate columns. If only written location information given use map toaster to find a approriate co-ordinate to add. For all co-ordinates give a precision for the co-ordinate based on catergories created by the Rotorua herbarium ranging from within 100m to accurate for country only.
- Use Guide to best practices.
- Using GPS instrument
- Using mapping facilities

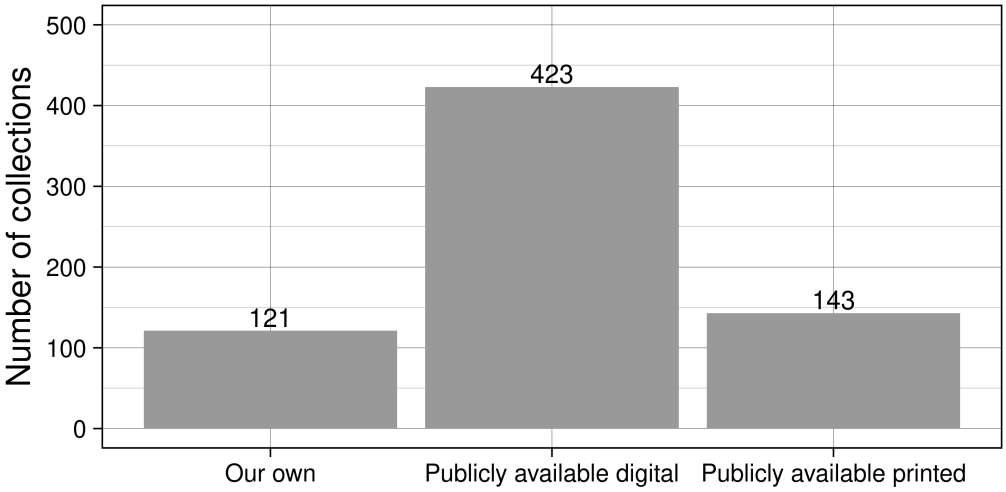
- Utilising google earth as well as google maps and our own knowledge and that of older colleagues knowledge of the region.
- Varies with information provided on label.
- Very few of our specimens have been databased and we currently do not have a standardized protocol for georeferencing. Many specimens in CEL were collected as part of expeditions to collect germplasm of crop plants more than 40 years ago and thus have associated USDA passport information, but much of this data still needs to be databased and georeferenced.
- WALLACE, L. 2015. Using GeoLocate within Symbiota to Georeference Specimens in the MSU Herbarium (unpublished document). Southeast Regional Network of Expertise and Collections (SERNEC), Appalachian State University, Boone, NC. `https://sernec.appstate.edu/sites/sernec.appstate.edu/files/MISSA\_How%20to%20Geolocate%20in%20Symbiota\_0.pdf`.
- We are currently rebuilding our digitization protocol (including georeferencing the geographical location of the specimens- so I am not sure that most of the questions are relevant to us)
- We are developing our own protocol, but currently rely on technician knowledge
- we currently have all specimens on a spreadsheet with photos. Evidently we need to acquire a scan gun and hire someone to scan each specimen. Sorry, it's not on my top 10 list of fires to extinguish at this time.
- We do utilize "Georeference Remarks" field to describe how we attained the point and uncertainty radius. (eg., lat/long = mouth of Tangipahoa River at Lake Pontchartrain; uncertainty = extent of river mouth, extended to include all branches). As well, we record the date and source in "Georeference Source" in order to track when and how the specimen was georeferenced. (eg., 2016-02-23; Google Maps). We have also utilized georeferencing scripts.
- We document the wild collected seed that we share, document seed received with wild collected data; map cultivated, landscape plants
- We don't get a protocol.
- We follow Natural Heritage Program database protocols.
- We input a site centroid with a detailed note explaining that the coordinate is based on an estimate.
- We look for textual descriptions of the place on the map of Google Earth, and then put a mark there and find out its coordinates
- We look in gazateers for the location and also google earth to search the description and estimate the uncertainty around the geocode we assign.
- we numbered the flower beds using the qgis program

- We physically lookup maps for named locations and select the grid reference a the accuracy available from the description, e.g. if a specific feature, such as a bridge is mentioned this will give added accuracy to 100 m square or better. Without specific features we georeferenced to the 10km square.
- We primarily use Geolocate (`https://www.geo-locate.org/`)
- We standardize collectors names and map by following the collectors itinerary; the system uses iterative processes to isolate and correct errors. It is entirely done "by hand", using BRAHMS software.
- We use a national database, so there are great differences between the collections. Our samples are for a great
- We use approximate coordinates to the (full checked) location, following grids of either 1x1 or 10x10 km side
- We use Google earth to set dots on the map and get coordinates
- We use GoogleEarth, including the USGS topo map plugin.
- We use the coordinate of the municipality. `http://splink.cria.org.br/geoloc`
- We usually keep the netto information provided on the labels. We avoid "interpreting" locality info on the labels, because we see this as part of the research done by the experts. We believe that it is not wise to add interpretations (unless they are clearly marked as such), because of the risk that such interpretations may start their own live on the long run.
- Web based tools based on OpenStreetMap maps, on `https://kotka.luomus.fi/`
- www.alexandria-park.com.ua E-mail: alexandriapark@ukr.net index_bc@ukr.net
- www.idigbio.org
- www.kew.org
- Www.unicach.mx
- wwww.ecovida.cu
- Xiamen Botanical Garden Herbarium (XMBG), No.25, Huyuan Load, Siming District, Xiamen, Fujian, 361001, P.R.China
- yes of course. Link `http://herbmalg.biologi.um.ac.id/`

Q18 - When you need to estimate coordinates from textual information, which map and gazetteer resources do you use?

Number of respondents: 687.

The graph below shows the kind of cartographic or gazetteer resources used by collectors to georeference their specimens.



Q19 - If your own, can you provide some details and, if publicly available, can you provide the internetaddress?

Number of respondents: 143

The following are the further details given by respondents when they used their own maps and gazetteers. Comments are presented in alphabetical order, non-edited and as they were entered in the form.

- ACME Mapper 2.0 (`http://mapper.acme.com/`)
- All specimens have RTK GPS data
- Arc GIS
- ARC GIS via Survey 123
- Atlas of Living Australia, Google Earth
- Australian national and state resources
- Available printed resources in our Archives; non-public Collection Details received from third parties
- Brgy. Pagatban, Bayawan City
- Canada: `https://www.nrcan.gc.ca/Earth-sciences/geography/querying-canadian-geographical-names-database/canadian-geographical-names-database/19870` US: `https://www.usgs.gov/core-science-systems/ngp/board-on-geographic-names/domestic-names` Other: `http://geonames.nga.mil/gns/html/index.html`
- CBN Brest databasing prtocol
- Denmark: `https://www.stednavneudvalget.ku.dk/autoriserede\_stednavne/`
- Estonian localities from `https://xgis.maaamet.ee/xgis2/page/app/maainfo`
- Extensive collection of historic maps.
- Floras published many at Kew. e.g. Collecting localities in the Flora Zambesiaca area, by G.V. Pope and D.G. Pope (1998).
- For my research on Lesser Antillean specimens from other herbaria I scanned high resolution maps and overlaid these in Google Earth to get coordinates
- Generally, Google Earth or Google Maps.
- Geoloc.Cria.org.br
- Geolocate
- GEOlocate Geo-locate.org
- GEOLocate, GNIS, oldmapsonline.org, Getty placenames

- Géoportail www.geoportail.gouv.fr
- Google Earth
- Google Earth https://www.orchids.de/haynold/tkq/KoordinatenErmittler.php
- Google Earth Pro
- Google Earth sometimes combined with local gazetteer works for our purposes; topographic maps rarely used now.
- Google Earth, ArcGIS, USGS
- Google maps
- Google Maps for international samples [https://www.Google.com/maps], Swiss Topo Maps [including historical maps; https://map.geo.admin.ch/]
- Google maps, and geoservices (wms, wfs) from national entities (e.g. https://geoportal.igac.gov.co/contenido/geoservicios)
- Hbgpark.com
- Herbario Eizi Matuda facebook
- http://chartae-antiquae.cz/cs/maps/5364
- http://eflora.nt.gov.au/
- http://midwestherbaria.org/portal/
- http://ortho.gis.iastate.edu/
- http://repository.humboldt.org.co/bitstream/handle/20.500.11761/34610/978-958-8141-38-4.pdf?sequence=1\&isAllowed=y
- http://splink.cria.org.br/geoloc?criaLANG=pt
- http://splink.cria.org.br/mapper?criaLANG=en
- http://www.conabio.gob.mx/informacion/gis/
- http://www.etomesto.ru/ https://yandex.ru/maps/
- http://www.geonames.org/
- http://www.splink.org.br/index?lang=pt
- http://www.xiamenbg.com/
- http://www.ynlky.org.cn/
- http://www502.regione.toscana.it/geoscopio/cartoteca.html
- http://wwwsp.inia.es/Investigacion/centros/CIFOR/enlint/Paginas/Herbdig.aspx

- https://asiointi.maanmittauslaitos.fi/karttapaikka/, https://www.retkikartta.fi/
- https://buy.garmin.com/en-US/US/p/575993
- https://data.aad.gov.au/aadc/gaz/scar/
- https://diversityworkbench.net/Portal/DiversityCollection with https://diversityworkbench.net/w/media/1/10/DiversityCollectionHelp_3_0_9_4.pdf
- https://Earth.Google.com/, https://yandex.ru/maps
- https://Earth.Google.com/web/ https://gridreferencefinder.com/
- https://explore.recolnat.org/search/botanique/type=index
- https://laji.fi/map?coordinates=%2B64.256034%2B028.716049%2F
- https://map.geo.admin.ch
- https://map.geoportail.lu
- https://mapasamerica.dices.net/dominicana/
- https://mapy.cz/
- https://norgeskart.no/
- https://opendata.lantmateriet.se/\#apis?api=OpenDataWMTS\&version=v1 https://historiskakartor.lantmateriet.se/historiskakartor/search.html
- https://www.cnpm.embrapa.br/projetos/relevobr/
- https://www.esri.com/en-us/arcgis/products/arcgis-online/overview
- https://www.geo-locate.org/
- https://www.Google.com/Earth/versions/\#Earth-pro8
- https://www.Google.com/maps
- https://www.Google.com/maps https://www.geo-locate.org/
- https://www.Google.it/intl/Earth
- https://www.gps-coordinates.net/; https://www.geo-locate.org/standalone/default.html
- https://www.hilti.fr/c/CLS_MEA_TOOL_INSERT_7127/CLS_CONSTRUCTION_TOTAL_STATIONS_7127/r4849
- https://www.ign.es/iberpix2/visor/ https://www.geoportail.gouv.fr/carte http://sigpac.mapa.gob.es/fega/visor/ https://sitna.navarra.es/navegar/

- https://www.maharashtra.gov.in/
- https://www.nrcan.gc.ca/Earth-sciences/geomatics/canadas-spatial-data-infrastructure/standards-policies/8916
- https://www.orchids.de/haynold/tkq/KoordinatenErmittler.php
- https://www.sj.k12.tr/index.php/tr/dbm-tr/aciklamalar-dbm
- I use resources housed in the University of Illinois Library and Archives, historic maps and gazetteers curated with the herbarium collection, among other publicly available resources as needed.
- Iberpix: https://www.ign.es/iberpix2/visor/
- If available, we will use collection sites marked on field maps from field notebooks in combination with publicly available cartography and gazetteers.
- Information is manily for internal use and is available only from request.
- It depends on the country. too many to list.
- It is a part of our instance of Arctos.
- Just one example for the Czech Republic: the three military surveys of the former Austrian Empire and Austro-Hungary are digitised and available at http://oldmaps.geolab.cz/map_root.pl?lang=en\&map_root=1vm.
- large in-house database of places in Thailand
- LISTmap https://maps.thelist.tas.gov.au/listmap/app/list/map
- mainly GeoLocate for North American locations
- Many resources. Ecuadorian gazettes, DIVA-GIS, fallingrain, etc.
- Map collections Field notebooks
- Map library of maps used in field work
- Maps and Gazetteers located in Mycological Herbarium Library. Geolocate website
- Maptoaster software, DocGIS (for ecological district information) https://www.doc.govt.nz/map/index.html
- Mix of printed road atlases, National Geographic TOPO and Google Earth
- National Biodiversity Data Centre http://www.biodiversityireland.ie/
- Official map collections
- original expedition maps and forest /locality descriptions (eg river sketches in Siberia etc) + the field-notebooks of expedition members - to compare with (several) public available digital maps
- Our herbarium has a map collection of early Midwest and Indiana

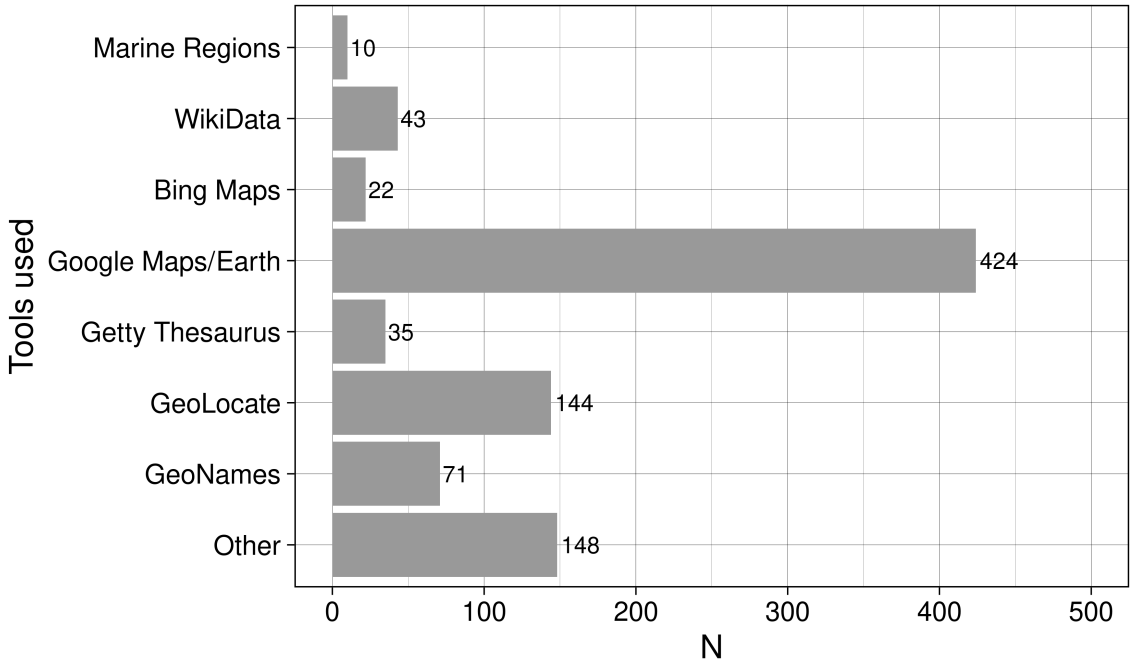
- own is maps received with collections; publicly available from multiple sites: http://geonames.nga.mil/namesgaz/, https://www.usgs.gov/core-science-systems/ngp/board-on-geographic-names, https://www.topoquest.com/, https://ngmdb.usgs.gov/topoview/viewer/\#4/40.01/-100.06, http://www.geo-locate.org/web/WebGeoref.aspx, https://legacy.lib.utexas.edu/maps/
- plantsforlifekenya.org
- Published Peninsular Malaysia, Sabah and Sarawak gazetteers. Printed maps purchased from Map Department
- speciesLink, Gbfit
- The museum has developed a software platform tool, called Georef. Georef is a web application with storage, querying, editing, and visualizing capabilities for both, site names and the cartographic resources applied to the georeferencing process. Here, we manage a database of site names where the samples of collections have been collected. The geoinformation of these localities is kept for future uses. The results are shared: http://www.bioexplora.cat/en/geocoding The code of Georef is in Github: https://github.com/aescobarr/nhc-georef
- These are not professional cartographers but rather staff in the Geography department
- Topographic maps of Oman Soil map of Oman Geology map of Oman
- Usually a Google search for a location name, followed by interpretation based on knowledge of the collector/collection.
- Various ones when available
- We don't get a own cartography
- We have a digital copy of the 1:250,000 Australian Gazetteer, which may be available on line
- We have been building a gazetteer with GPS georreferenced localities in some departments (states) since 2003.
- We have developed our own gazetteer based on our databased specimen localities to create 'Standard Localities'. We are constantly improving the data during our specimen data entry process.
- we have paper maps in files that were marked by collectors
- We have printed files of most historical records.
- We have some hand drawn maps used in expeditions to former territory of Soviet Union. Some details (written, drawn) are given in researchers' field notes. We also use Place Name Database (http://www.eki.ee/knab/knab.htm)
- We look for textual descriptions of the place on the map of Google Earth, and then put a mark there and find out its coordinates

- We occasionally use really old maps in our library to look up places that no longer exist. Usually we use GeoLocate, GoogleEarth, CalTopo or AcmeMapper, Google maps...
- We use BIOTICS, the National Natural Heritage Program database and mapping program.
- We use hand-annotated paper maps from our collection, coordinates determined for existing collecting localities in our registry, as well as publicly available digital (e.g. geospatial files for geologic layers) and print resources (e.g. federal topo maps).
- We use historic layers provided in GeoLocate, and then it may depend on the individual situation.
- When there is no information about the coordinate of the collection, we indicate that of the municipality.
- WV Place Names Gazetteer from WV Geological Survey
- www.alexandria-park.com.ua E-mail: alexandriapark@ukr.net index_bc@ukr.net
- Www.cox gardens.com none
- www.ecovida.cu
- www.fcagr.unr.edu.ar
- www.historischetuinaalsmeer.nl
- www.ign.es/iberpix2/visor www.Google.com / intl /Earth `https://www.usgs.gov/core-science-systems/ngp/board-on-geographic-names`
- www.karttapaikka.fi www.retkikartta.fi
- www.npc.iari.res.in
- www.villaludovica.org
- yes of course. Link `http://herbmalg.biologi.um.ac.id/`

Q20 - When you need to estimate coordinates from textual information, which tools do you use?

Number of respondents: 503.

The graph below shows the different use of tools by respondents to estimate coordinatesfrom textual information. The tools most used are by far Google Maps and Earth and GeoLocate.



The list below are the comments given by respondents to further clarify when the 'Other' tools option was answered. Comments are in alphabetical order, unedited and reported as they were entered in the survey form.

- a variety of websites including Wikipedia and others located by Google Searches
- ACME mapper
- Antarctic Digital Database
- ESRI ArcGIS
- ESRI ArcGIS maps and internal data, USGS quad maps
- ESRI ArcGIS Maps for Office (add-on for Excel) and ArcGIS Online
- Austrian Map
- Baidu map
- Biodiversity Heritage Library, other historic resources found online (newsprints, publications, etc)
- Botanic Garden GIS system.
- BRAHMS tools

- Coordinate finder and converter biology.ie and a National Ordnance Survey of Ireland online maps http://map.geohive.ie/mapviewer.html
- Diccionario Geográfico de Colombia
- different national map/georeferencing resources available in many countries
- eGAZ
- ESRI Resources, own geodatabases
- Fallingrain; national resorces on line
- Fallingrain.com
- for Russian/former Soviet Union areas www.yandex.ru, for Estonia https://xgis.maaamet.ee/maps
- Formerly used Topozone for US localities, before that site went away.
- Gazetteers, field notebooks etc
- geographical dictionary IGAC and IGAC cartography
- Geonet (http://geonames.nga.mil/namesgaz/): university of texas (https://legacy.lib.utexas.edu/maps/)
- Geoportale Nazionale Ministero Ambiente (http://www.pcn.minambiente.it/mattm/)
- Georef
- Georeferencing system of the State Forests: https://www.bdl.lasy.gov.pl/portal/mapy
- georep
- Geoscience Australia Geodesy
- Geoscience Australia http://www.ga.gov.au/
- Geoscience Australia place names (https://placenames.fsdf.org.au/)
- Getty Thesaurus of Geographic Names installed as part of the DWB cloud
- GNIS geonames.usgs.gov
- Google Earth
- Google Eath Pro
- Google searches for locality names that don't pop up in the gazeteers.
- googling place names
- Grab a Grid Reference (UK only)

- Has been builtin gazetteers, maps. Will be more digital with our current shift to a new platform for the collection database.
- Historic USGS database
- http://gn.moi.gov.tw/geonames/index.aspx
- http://isodp.hof-university.de/fuzzyg/query/ http://dma.jrc.it/services/fuzzyg/ http://www.indexmundi.com/ http://www.fallingrain.com/world/index.html
- http://maps.gsi.go.jp/
- http://ortho.gis.iastate.edu/
- http://splink.cria.org.br/geoloc?criaLANG=en
- http://splink.cria.org.br/geoloc?criaLANG=pt
- http://www.conabio.gob.mx/informacion/gis/
- http://www.dgterritorio.pt/a_dgt/
- http://www.icc.cat/vissir3/; https://www.ign.es/iberpix2/visor/; http://www.floraiberica.es/PHP/localidades.php;
- http://www.pcn.minambiente.it/viewer/
- http://www.sasgis.org/
- https://asiointi.maanmittauslaitos.fi/karttapaikka/
- https://asiointi.maanmittauslaitos.fi/karttapaikka/, https://www.retkikartta.fi/
- https://atlas.gc.ca/toporama/en/index.html
- https://atlas.gc.ca/toporama/fr/index.html AND http://www.toponymie.gouv.qc.ca/CT/toposweb/recherche.aspx
- https://geonames.usgs.gov/apex/f?p=gnispq
- https://idecor.cba.gov.ar/ and https://www.ign.gob.ar/
- https://leafletjs.com/
- https://macroalgae.org/portal/index.php
- https://map.geoportail.lu
- https://mapy.cz/
- https://norgeskart.no/
- https://www.cnpm.embrapa.br/projetos/relevobr/

- https://www.davidrumsey.com/view/google-earth ; http://www.earthpoint.us/TopoMap.aspx ; https://ngmdb.usgs.gov/topoview/
- https://www.findlatitudeandlongitude.com/, http://www.fallingrain.com/world
- https://www.ksib.pl/szukacz/szukacz.php; http://geoportal.gov.pl/;
- https://www.maanmittauslaitos.fi/en/e-services/mapsite
- https://www.mytopo.com
- https://www.norgeskart.no/
- https://www.orchids.de/haynold/tkq/KoordinatenErmittler.php
- https://www.usgs.gov/core-science-systems/ngp/board-on-geographic-names
- https://xgis.maaamet.ee/xgis2/page/app/maainfo
- https://yandex.ru/maps/
- Iberpix: https://www.ign.es/iberpix2/visor/
- IBGE
- IGAC (Colombian Geography Agency)
- IGN maps
- IGN Nomenclator /https://www.ign.es/web/ign/portal/rcc-nomenclator-nacional
- In conjunction with high resolution printed maps: Also Geoportail for French Caribbean https://www.geoportail.gouv.fr/
- Institut Cartogràfic i Geològic de Catalunya
- internet search engines
- Just google the location
- Land Information New Zealand Place Names Gazetteer https://gazetteer.linz.govt.nz/; NZ Topo Maps http://www.topomap.co.nz/, MapToaster Topo/NZ http://www.integrated-mapping.com/
- Landmælingar Íslands www.lmi.is map wiever https://kortasja.lmi.is/
- leaflet ? Open Street Map ? (I do not know, I use it without having any idea !)
- LISTmap
- literature references, etc.
- Local maps uploaded on gis program

- MaNIS Georeferencing Calculator (now defunct, apparently)
- Manually
- Mapcarta, paper maps, any reputable reference we have available as names can sometimes by obscure or coloquial.
- maplandia
- Maps or atlas.
- mapy.cz
- memories, old maps on `https://map.geo.admin.ch`
- militar charts
- national digital maps available in the internet
- National Geographic TOPO
- national maps
- Norgeskart (digital map service) - to search for place names; mostly printed maps for coordinates
- NR Maps (NT database)
- official nomenclators (e.g. `https://www.ine.es/nomen2/index.do; http://toponimianavarra.tracasa.es/)`
- openstreetmap
- Ordnance Survey maps Ireland 1:100,000
- OS maps & thesaurus
- our own map resources and webmaps
- Own developed software
- personal communications
- Physical maps
- Printed maps and atlases
- qgis
- Since we have no standard georeferencing protocol currently in place, google earth is helpful to estimate coordinates for specimens with limited textual information
- site maps for national and state parks as well as univeristy site maps
- sketch Plan
- Sometimes a plain old Google Search helps too, especially for ghost towns

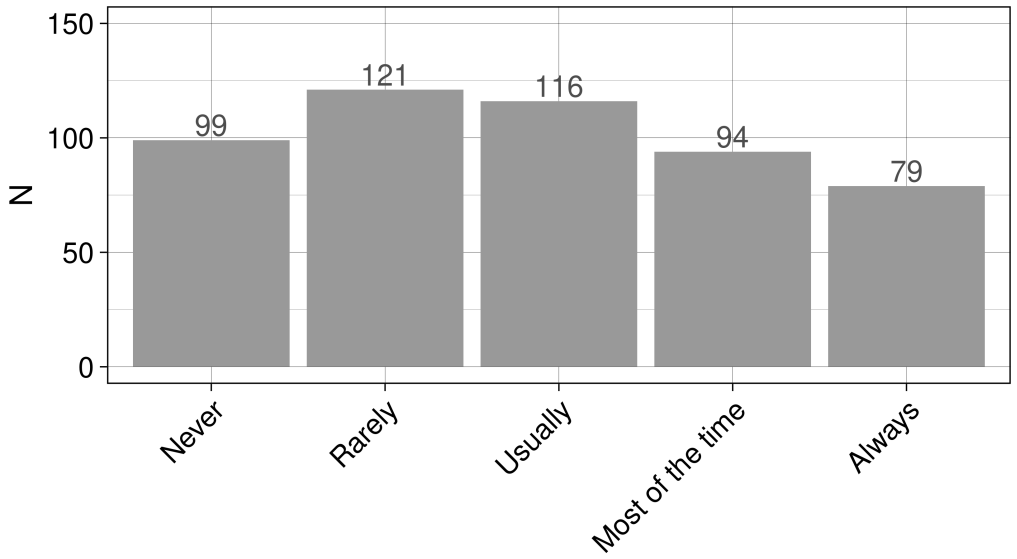
- South Africa place names GIS point data, plus various other spatial websites, e.g. https://gis.elsenburg.com/apps/cfm/
- Specific bibliography
- Swiss Topo Maps [including historical maps] from https://map.geo.admin.ch/
- Those providers cited in question 19 and any other reference in printed maps or web sites if needed
- topographic maps
- Topographic maps at various scales; Topographic maps at various scales; Satellite imagery (Google earth) through NT Govt Portal, not direct; sometimes 1:250,000 Australian Gazetteersometimes 1:250,000 Australian Gazetteer
- Turkey Settlement Data
- USGS Topoquad series (may be digital, e.g., Acmemapper; may be annotated archival paper maps)
- Utah Place Names by John W. Van Cott
- various types of digital maps, e.g. https://mapy.cz/turisticka?x=16.5932000\&y=49.1995000\&z=11,
- We are not dealing in detail with coordinate information as the label information is digitalized.
- We are not estimating coordinates as we have not personnel to do this
- We are not estimating coordinates, for now. We have been restoring our collection, mainly.
- We do not do this.
- we do not estimate coordinates at all
- We do not need to estimate coordinates
- we don't 'estimate' coordinates for plant locations. We either have them or we don't.
- we don't estimate coordinates, we don't georeference our data
- We have a special georeferncing group in our digitalization project. I am unable to answer
- We have not checked the different tools yet, thus we only hypothesize to use Google maps/Earth as it is easily available
- We haven't been doing this work yet.
- whatever available online

- Whatever source we feel helpful and informative
- whatever sources available, often using ArcView etc. with own digitized maps
- wikimapia
- wikipedia
- Wikipedia, Acme Mapper, DeLorme
- Wikipedia, Karttapaikka (Finnish coordinates, `https://asiointi.maanmittauslaitos.fi/karttapaikka/`), Karjalan Kartat (Russia, Karelia, `http://www.karjalankartat.fi/`)
- www.mapy.cz
- yandex map
- Yandex.map; etomesto.ru

Q21 - When georeferencing administrative units, do you have official maps available? Or any other resources available?

Number of respondents: 509.

The graph below shows the number of respondents reporting how often they have access to official maps on administrative units.



Following is the list of commented resources that respondents have available. Comments are sorted in alphabetical order, unedited and presented as they were entered in the survey form.

- A range of administrative units are part of our database.
- Automatically within Moscow Digital Herbarium
- For the world, administrative divisions per Wikipedia; for Quebec, Commission de toponymie (Qc. gov. site)
- Forest guard
- FTEA
- Google Earth + Wikipedia
- Google Earth Pro
- google maps?
- Have a map room but often not enough time time to spend per specimen to look up. Use online resources more
- Historic maps in the University Library and Archives
- `http://splink.cria.org.br/infoxy?criaLANG=pt`

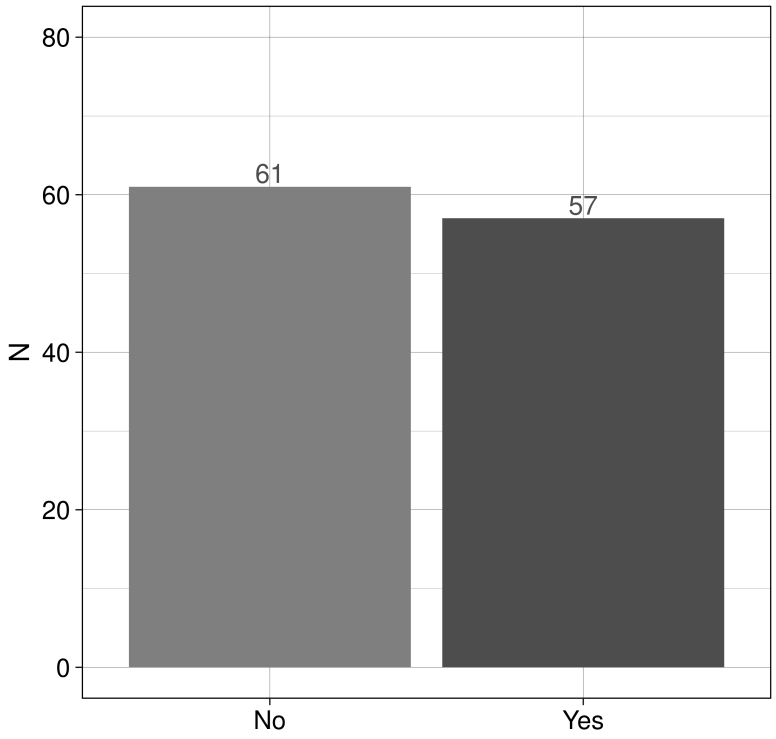
- http://www.igeo.pt/
- http://www.statoids.com/
- https://gadm.org/
- https://hub.arcgis.com/datasets/a21fdb46d23e4ef896f31475217cbb08_1
- https://map.geo.admin.ch
- https://www.orchids.de/haynold/tkq/KoordinatenErmittler.php
- https://yandex.ru/maps
- I'm not sure what you mean by georeferencing administrative units
- IBGE
- IGAC cartography
- In PlutoF biodiversity information platvorm we are using for databasing, the main administrative units are in map, included by locality fields of specimens
- Irish national system of place names online at logainm.ie for our national data points
- Not sure what you mean by administrative units
- NR maps,
- official maps for Sweden; Google Earth and geonames abroad
- our own historical field maps
- Own maps
- Sometimes names are not on maps and local experts had to be consulted
- We are georeferencing organizations' locations, where their digital materials originate.
- We do not georeference
- We use State level atlases and National Geographic TOPO for our home state.
- We use Vice Counties for UK administrative areas. For International, we have our own in house protocol.
- what's are administrative units?
- Wikipedia
- Wikipedia usually has good information about administrative units, believe it or not.
- Wikipedia, GBIF (TDWG)
- Wikppedia is helpful for administrative units

- wkt
- www.alexandria-park.com.ua

Q22 - Are there any mapping resources on administrative units you would like to be available?

Number of respondents: 118.

The graph below shows the number of respondents who expressed their need for extra mapping resources. A slight majority state they do not need extra mapping resources.



Following is the list of comments for those who would like to have extra available resources. Comments are sorted alphabetically, unedited and presented as they were entered in the survey form.

- A nomenclator from all the labels gerorreferenced yet in herbaria. Unic identificator could be collector number or Herbarium id
- A single updated site with top 2 levels of legally accepted administrative divisions for each country (equivalents for province/state and county/district), in local languages (including variants) and in standardized English equivalents for the accepted names
- A standard list of higher level administrative units would be great.
- An overall picture of the administrative levels by country, placed side by side
- As administrative units are so changeable, I'm unsure of how these would be useful. Whatever was available would ideally be integrated into the collections management system.
- Baidu map
- By date so old and new names can be easily checked

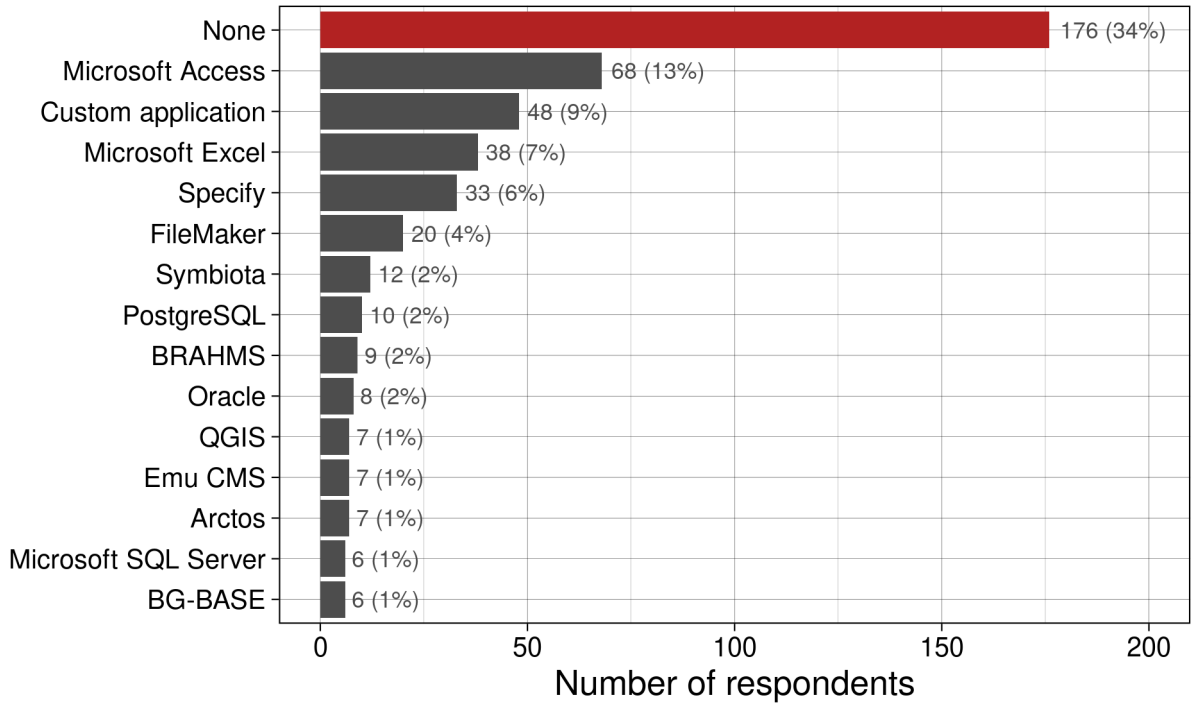
- Canada
- Detailed map of the Republic of Khakassia and Krasnoyarsk territory
- Digital maps for administrative units of some regions, e.g. Central Asia (Kyrgystan, Turkmenistan) are very bad.
- Don't understand what 'administrative units' are.
- Drones
- easy access to GIS shapefiles of global geologic units (created from regional geologic maps) would be very helpful. integration of Geolocate with stratigraphic databases like Macrostrat (`https://macrostrat.org/`)
- Easy to see historical changes in country and provincial boundaries would be good
- For all countries
- For indigenous areas in the country there is no administrative information. It applies other type of catastral information and it is not available in the country, at least in a public repository.
- historical gazzetteers for the regions of 18th/19th century
- I would like all maps included in IrisBG to work all of the time!
- IBGE - Brazil
- In future there will be used national mapping recources.
- It is often hard to find historic maps and place-names
- it is ok for Switzerland. For Europe, I'm looking at the official maps on the net.
- It would be nice to have a map with vegetation types on a large scale.
- It would be nice to have all available layer labels such as geopolitical boundaries, including local provinces, counties, etc as well as administrative units accessible thru Geolocate.
- land ownership
- legacy maps in digital form
- Many specimens were collected in regions of Latin America, Africa and the Middle East with information recorded in multiple languages; some local place names were recorded in local dialects; spelling is sometimes inconsistent, and some administrative units have changed over time.
- Mapa inegi 1:50000
- maps showing administrative and biogeographical provinces of locality names

- more scans of older maps, particularly Aeronautical charts (3 series) produced by US Defence Mapping Agency Aerospace Center and US National Imagery and mapping agency. Some are scanned at Perry Castaneda library at University of Texas but many are still missing :`http://legacy.lib.utexas.edu/maps/jog/latin\_america/`.
- North African localities gazetteer resources and something similar to Iberpix for other countries in the world.
- ocean regions
- official maps for administrative units outside of Luxembourg
- polygons with georeferencing data for each country worldwide
- shape or kml files
- Some from the IGAC (own geographic system)
- there floristic regions available
- Third world country provinces-municipalities etc.
- Township Range Section Maps for the Southeast region of the USA are a bit difficult to navigate online.
- TRS conversion
- We are in the process of establishing a proper GIS department
- We have some gazetteer publications which we sometimes use.
- We use Brahms database for our collection. It would be nice if the units entered as long lat would automatically pop up as our national grid and vice versa as both need to be done manually. It would be good if it popped up with if a co-ordinate entered was our of range of the country as well so we could pick up errors easier.
- We will soon be standardizing all of our data relating to administrative units; therefore, we will be using standard centroid locations from a reputable source (not yet determined).
- www.etomesto.ru
- Yes, it is hardly possible to find areas with a 1: 500 or 1: 2500 sidewalk scale in which you can see and have information on sidewalks, or layers in which the terrain can be well captured without so much roughness and at the same time allow us Perform geospatial analyzes to plan collection tours and priority collection areas since our forests are not completely well defined and resources are limited, we focus primarily on the Andean area (Caldas) but we house plants from all over Colombia and some other countries , the largest distribution is in lichen one of the largest collections in the country.

Q23 - Which software do you use for managing your georeferenced site names database? If none, please say so. (e.g. custom-application, PostgreSQL, Microsoft Access, etc.)

Number of respondents: 474.

The graph below shows the different use of software tools for managing, *i.e.* databasing, site names by respodents. A total of 176(34)% respondents reported not using any software. Microsoft applications (Excel and Access), custom applications and Specify are the most used tools in handling georeferences. Tools shown are those that together make up for 80% of the tools reported. Please note that respondents were able to report more than one tool.

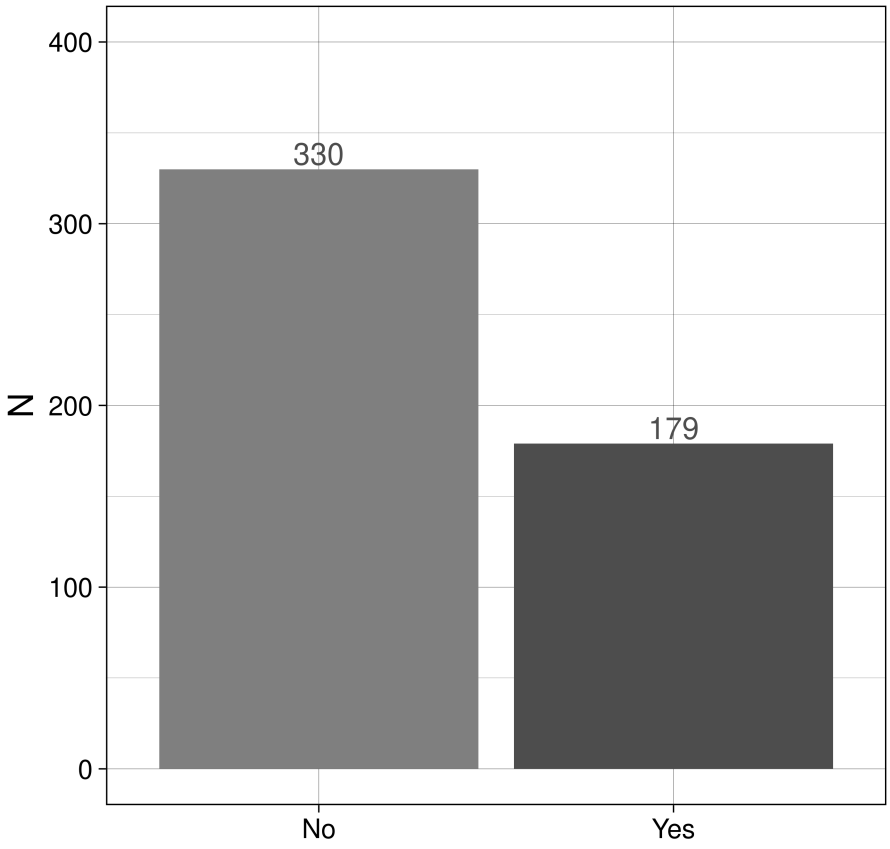


Following is the list of the least used tools, not shown in the graph, ordered by usage: IrisBG [5], MySQL [5], Axiell EMu [4], ESRI ArcGIS [4], Jabot [4], Consortium of Pacific NW Herbaria Software [2], Microsoft [2], Ad-Lib [1], AkelPad [1], Arctos/MCZbase [1], AutoCAD [1], Bespoke CMS [1], BIOTA [1], CALM [1], CRIA [1], Diversity Workbench [1], EMPRESS RDBMS [1], ESRI ArcGIS Maps for Office [1], ESRI ArcMap [1], ESRI ArcView [1], FoxPro [1], Fulcrum [1], Geolocate [1], Google Earth [1], GRIN-Global [1], `http://botsad.ru/en/herbarium/` [1], `http://eflora.nt.gov.au/` [1], `http://kpabg.ru/cris/?q=node/16` [1], `http://midwestherbaria.org/portal/` has, `http://www.geo-locate.org/` [1], `https://emu.axiell.com/` [1], `https://herbarium.univie.ac.at/database/search.php` [1], iDigBio [1], JACQ-System [1], MapInfo [1], MapSource [1], MariaDB [1], MUSE by Btrieve [1], OpenRefine [1], Past Perfect [1], PlutoF [1], PNW Herbarium Consortium Software [1], Publicly available office tools [1], Recorder 6 [1], SEINet [1], SILPweb Zasoby [1], SnBase [1], TMS (Gallery Systems) [1], Turboveg [1], www.anarchive.it [1]

Q24 - Do you have a national grid system for recording biodiversity?

Number of respondents: 509.

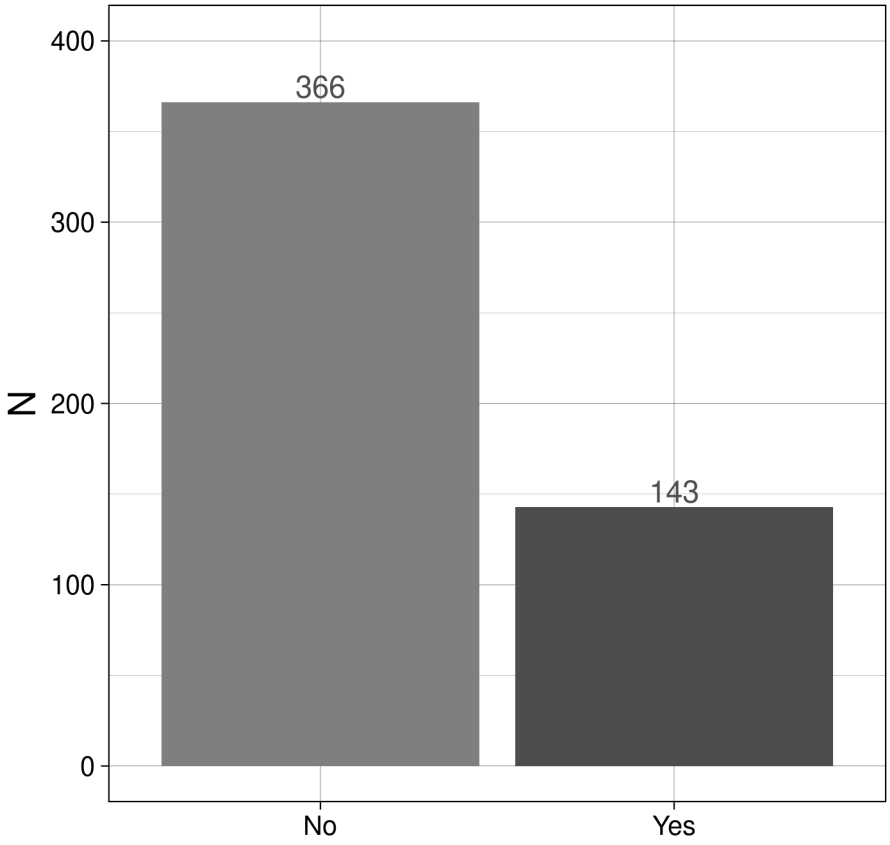
The graph below shows the number of respondents which have a national grid system available and those who do not. About two thirds report having it and one third do not.



Q25 - Do you need to georeference specimens to this grid system?

Number of respondents: 509.

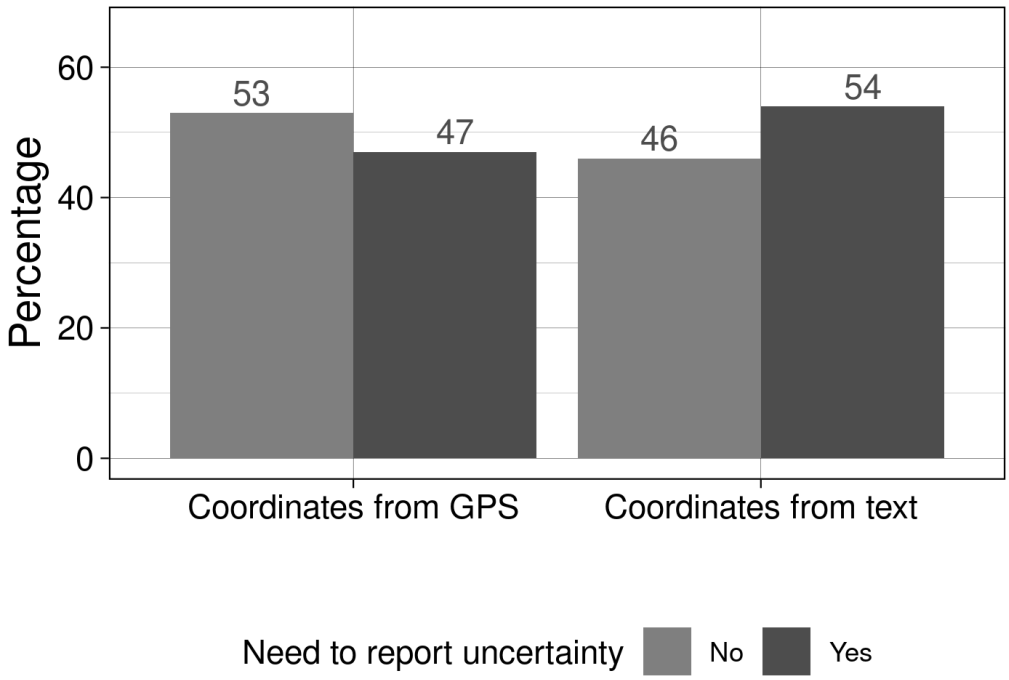
The graph below shows the number of respondents that need to reference the specimens to a national grid system and those that do not. About two thirds need to do so and one third does not.



Q26 - Do you report coordinates uncertainty? Other (please specify)

Number of respondents: 472.

The graph below shows the number of respondents who report coordinate uncertainty when the specimens' location is given as GPS coordinates versus when it is given as textual description.



Following is the list of further comments from respondents in alphabetical order, unedited and presented as entered in the survey form.

- Although we do not currently report this, we are currently undergoing a significant database update which will incorporate uncertainty.
- Coordinates resolution measures the level uncertainty
- For Sweden Yes, abroad No
- GPS coordinates are considered to be correct; we do not record the uncertainity given by the GPS (e.g 3 m) For coordinates estimated from text, that mosty cover larger aereas (e.g. meadow east of the road between X an Y, we record the center coordinate of the aerea and the uncertainity radius, e.g. 2 km)
- I answer no because information has not been databased, but recording uncertainty is very important and will be included when we develop a standardized protocol.
- I may add a comment if needed.
- I prefer not to indicate it if I am not certain. Someone else will do. We indicate if the coordinate are mentionned by the collector, or if they are deduced. We have

so much work to do, with so few people, our priority is to deliver the general data (collector, date, location... and even coordinates). In addition most of samples are very old... so locations are sometimes very wide. Most of the time it is than not possible to be precise.

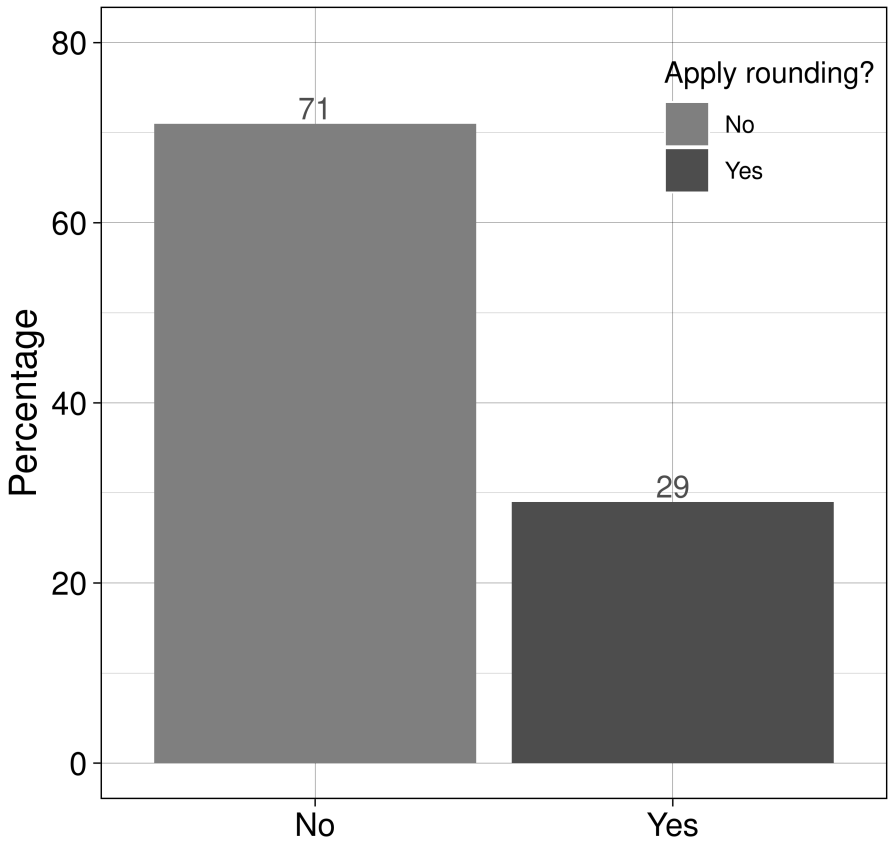
- In the latter case above: uncertainity usually mentioned as comments in the database.
- Ireland is transitioning from Irish Grid to Irish Transverse Mercator. Many collectors fail to state which co-ordinate system they are using
- Mostly it is undergraduates doing this work, so the extent to which uncertainty is captured depends on the individual doing the work
- no protocol, sometimes reported in either case
- not currently, but we will in the future
- Please note again, that as a rule we do not add coordinates (or other interpretations) to the locality information on the labels.
- prefer to say "rarely"- where know there is uncertainty
- Question not clear. If you mean do I report as certain coordinates that are uncertain then no
- Sometimes depending on the person and locality information on label.
- Sometimes not
- Sometimes the coordinates fall into the sea or another state.
- Sometimes we record uncertainty
- There is no practice of collectors placing uncertainty, so it is assigned by verifying that the coordinates coincide with the path, farm, locality and uncertainty is taken out according to the geo-referencing protocol, in few cases with very detailed locations.
- This can only be done for the checked geo-referenced databased specimens, which is not many.
- uncertainty is sub centimeter.
- Uncertainty only assigned if coordinated have been identified.
- Using an locality database with uncertanty radius for each locality
- Using the dataCleaning tool available on the specieslink network, available at `http://splink.cria.org.br/dc/index?setlang=pt\&system=\&colecao=VIES`
- We are right now starting to report uncertainty when dealing with GPS coordinates and location textual information.

- We believe it is more honest to avoid adding an uncertainity range. Indeed, everyone can realize that it is an uncertain coordinate by comparing the record with the notes on the digitized image. However, it could be useful to simply add 'uncertain'
- we try to do this
- We try to do this but we have some georeferences imported from other sources which do not have this information.
- We write that the accuracy of the coordinates is 5000 m or 10000m

Q27 - Do you apply any decimal rounding when publishing coordinates?

Number of respondents: 472.

The graph below shows the percentage of respondents who do round coordinates and that who do not.



Q28 - If so, can you explain the reason for doing so?

Number of respondents: 119.

The following are the reasons fow which respondents applied decimal rounding to coordinate specimens.

- According the journal requirements
- Accuracy is only to 4 decimal places
- All georeferenced coordinates are to nearest 0.00001. GPS coordinates (take in field) are published as they are provided (usually 0.00001 or 0.0001).
- as we put the coordinates of the nearest locality we found on Google Earth, we round the decimanl because we don't know the excat locality. We don't round in case of precise location
- Because anything more than 5 decimals is artificial precision
- Because if we interpretate a coordinate, we can't precisated the decimals of the seconds
- Because it is a small area
- Because the size of the label
- Because there is a lot of rare and threatened species in NC
- By default when switching formats for example degtrees and minutes to decimal degrees it is hard to see how not to. 2 degrees and 30 minutes is 2.33333333333333333.....in decimal degrees.
- calculated from grid net for central european flora NIKLFELD H. 1971. Bericht über die Kartierung der Flora Mitteleuropas. - Taxon 20: 545-571.
- convenience, most records are estimated anyway
- Coordinates are rounded for rare and protected species.
- Database accept up to 9 characters.
- decimal degrees to 4th place, format of labels
- Depending on the scale Data may be published to the square km or 4x4 km. Sensitive data for endangered species may not be displayed to the last digit.
- Depends what you mean by publishing.... we dont on our on-line platform, but the modelling we do needs to be rounded.
- Diminished returns for decimal places beyond 5. 0.00000
- Error inherent in putatively accurate to many decimal points GPS coordinates makes too many decimal points silly anyway

- Estimated uncertainty
- Extraneous "precision" is unnecessary.
- Field limitations for the coordinates. Usually round to 7 places after the decimal.
- for ease of location
- for fossils from public lands, we are not legally allowed to share precise locality data
- For rare collections to obscure the exact locality.
- For the public website the Australasian virtual herbarium it cannot publish the whole co-ordinate. We also don't want people to be able to find sensitive flora so don't want that with a high level of accuracy. If researchers are getting information directly from us it is all the information but they also sign a data agreement.
- For threatened and endangered species.
- For us is easy to use the information
- GPS coordinates are used as available on geolocate
- GPS inaccuracy
- Handheld GPS give more numbers than accuracy/coverage from the satellites. Meaningless to enter millimeters to our database when GPS precision is 10 m. Many users have little understanding of the meaning of GPS coordinates.
- High resolution coordinates need decimals to adjust their accuracy
- Historically we used references such as SP123321 to indicate a 1Km square, but we would now report the middle and an accuracy of 1/2 km, because GIS systems interpreted SP123321 as SP 123000 321000
- `https://www.nps.gov/subjects/fossils/fossil-protection.htm`
- I do not really understand questions 27 and 28
- I just started decimal rounding this past year
- If coordinates were not recorded on data label with specimen(s), then site is estimated based on label data and only coord decimals are used that would not mislead regarding locality precision. We also report uncertainty.
- If the location is named roughly, e.g. a municipality, mountain range name etc.
- In fact I do not know exactly I am not the person doing the referencing
- In some cases (threatened species e.g.) it is necessary to diffuse the coordinates
- in some cases considerations from nature conservation aspects suggest to not provide exact locality informations
- It can only be precise to such a point.

- It depends on the kind of publication, usually coordinates are not published.
- It's automated.
- Keep measurement unit at the same level
- limited space in database field, loss of accuracy when converting among systems
- locations are not recorded very precicsely
- More than 5 decimal units (from converting to decimal coordinates) are usually meaningless.
- National Geographic TOPO reports decimalLatitude and decimalLongitude to 5 digits.
- No, not if we're including (as we normally do) an uncertainty radius.
- Normally to the significant digit or to the reported radius of collections. Also, many time a printed historical locality label will have decimal lat/long to the 6th or 7th digits. In most cases, we find 4 decimal places to be the lowest significance.
- Not consistently - where the textual place name is inherently vague eg "Swansea" then would manually create a georeference just offshore and round the decimal co-ord to indicate inherent uncertainty and also provide a text comment to that effect. An actual GPS co-ord with a descriptor like "large rockpool south end of beach" would not be changed.
- not than important for our collection
- not to pretend accuracy
- Occasionally, for conservation rated taxa
- Only for sensitive taxa for which we do not want to release accurate locality information to the public.
- Only report to 4th decimal place
- Our collection database records in degrees, minutes and seconds.
- Our data transferred to other databases in decimal format : e.g. 50.293622, 18.933815
- Our database truncates after about 6 decimal places.
- Our usual projection system is UTM, with X and Y given in a format like 461954-4458314, where units are metres; then there is no point in using decimals since the source error is greater than 1 metre even with the GPS commonly used.
- Paleontology data are confidential, exempt from FOIA, etc
- Per contracted agreement
- Protecting sites from over collecting and retaining potential funding source through mitigation paleontology.

- Protection of data about endangeres species sites.
- Protection of sensitive areas/localities
- Public display of 4 decimal points
- Rare, threatened taxa (when publically delivering data, otherwise no)
- Round to 5 decimal places as this is about 0.5 to 1 m precision which is sufficiently over precise for locating the center point.
- Rounding is carried out to an appropriate level based on information accuracy and precision; e.g GPS coordinates from a hand-held GPS provide accuracy at about 2-5 m, so decimal degree reporting beyond 5 decimal places (approximately equivalent to 1 m precision) is inappropriate
- Rounding is related to the accuracy of the satellite navigator, usually we round to 6 decimal places
- Rounding to two decimals
- Security and obfuscation of sensitive sites e.g. endangered species
- Security of data
- Sensitive locations e.g. caves and sensitive species.
- sensitivity of some fossil localities
- Several collections are usually made at the same site. Coordinates are given for all of them and not for individual records.
- so exact coordinates are not shown. These are available upon request for qualified users.
- So far, the geoinformation in our database has not been standardized. The relevant fields in the database allow entry of free text, so over the years coordinates had been entered in all possible formats. Therefore, I actually would hesitate to call it "georeferenced" since this information is not ready for machine reading...
- sometimes and then to show that the coordinates are not accurate
- Sometimes for sensitive species or when we cannot share collection site information.
- Sometimes needed for protected species
- Sometimes we do. But not consistently.
- space, avoid meaningless precision
- specified string (numeric) length, some coordinates are provided with too many digits after the decimal
- Standardize data

- takes less resources; when there is no need for great accuracy
- The 2009 Paleontological Resources Preservation Act (http://vertpaleo.org/The-Society/Advocacy/Paleontological-Resources-Preservation-Act.aspx)
- The number of decimals places should reflect the level of precision of the collection locality.
- There is no real concern
- They are sometimes obviously too exact.
- To account for uncertainty
- To avoid false precision (for example: division by 3)
- To avoid generating errors in the database processing.
- To be more precise
- To cover the uncertainty in the location
- To express uncertainty
- to generalize the coordinates of protected species
- to give a larger area
- to protect privacy of private land owners
- To protect sites of rare species
- Usually 5-6 numbers past the decimal: its unclear how much more accurate having 10 or 20 numbers past the decimal would be when georeferencing is estimating the latitude / longitude coordinates of a locality description - sometimes those localities don't allow you to be as precise as one would like.
- usually up to the fourth sign after 0
- Usually, we indicate the locality.
- We are allowed to do it for seconds
- We do it, if the researcher or research group is asking for it. Reasons are nature conservation issues, legal restrictions and privacy concerns.
- We do not publish coordinates.
- We don't round but some of our georeferences from external sources are rounded
- We don't use decimals for local TM coordinate system but when tranforming to WGS84 we round down.
- We round to 5 decimal places in our collection management software (i.e., Specify).

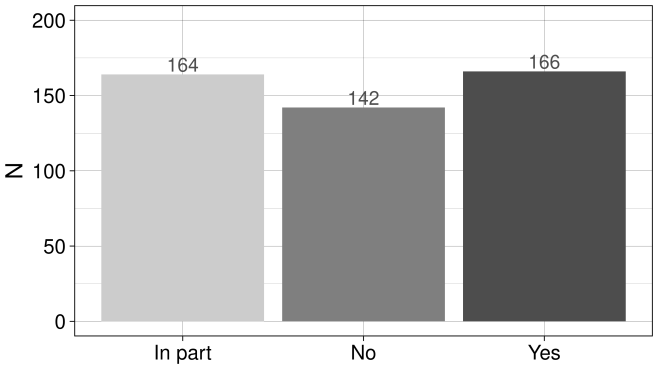
- We round to provide uncertainty.
- We typically round to the sixth decimal for latitude and longitude because this is approximately how accurate GPS units can be.
- When primary information (labels) is crude.

Q29 - Do you consider it important to aggregate all factors contributing to uncertainty? (*e.g.* unknown datum, rounded original units, projection changes, etc.) Which tool do you use to estimate the aggregated uncertainty?

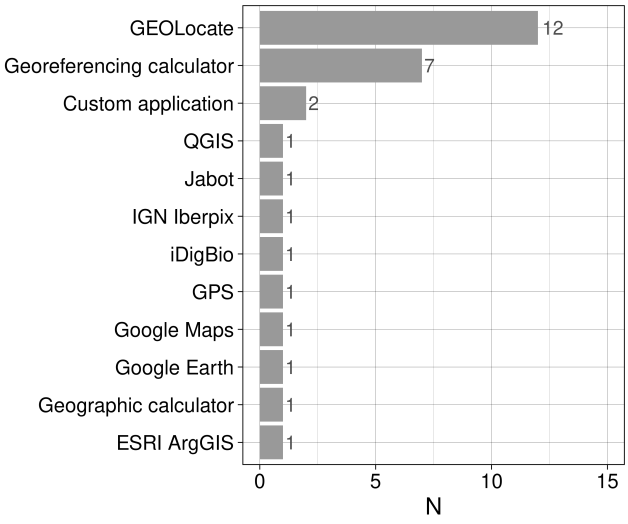
Number of respondents: 472.

Number of respondents saying which tool they use: 26.

The following graph shows the number of respondents who consider it important to aggregate all factors contributing to uncertainty, those that do not and those that only in part.



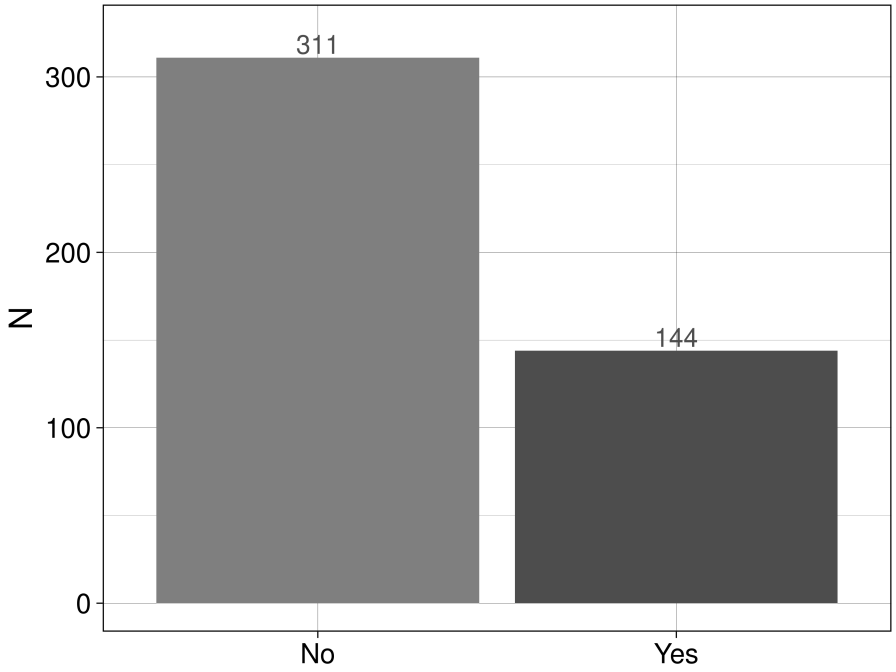
The following graph shows the number of respondents using different tools. Most respondents use GeoLocate and the Geoferencing calculator. Please note that respondents could answer more than one tool.



Q30 - Do you apply a methodology to detect georeferencing errors after the georeferencing process? If yes, can you provide some details, if no, please say so.

Number of respondents: 455.

The graph below shows the number of respondents using a methodology to detect georeferencing errors after the georeferencing process has been completed. Any response stating that some sort of methodology is applied, however scant, is considered as affirmative in the graph. Negative responses refer to answers which clearly indicate that no methodology is applied at all.



The following list include all meaningful comments entered in the survey form. They are shown in alphabetical order, unedited and as entered in the survey form.

- a number of errors appear when the data is plotted on a map
- Administrative boundaries are used for detecting georeferencing errors.
- After cataloged we have students check that all collections are georeferenced to the place described, including the higher geography. We have them use Arctos and GeoLocate. But sometimes they plot things using ArcGIS to check for overall errors.
- Arctos uses a scheduled script that provides automated error detection for points that fall outside of the boundaries of higher geography WKT shapes (e.g. "this locality does not map to Park county"). If I were to implement a retroactive georeferencing project (likely in the next few years), one step would be a verification process to map all points and detect which fall outside of administrative units at various resolutions.

- Automatic matching on google earth
- Bindingbox; Darwin Core Test
- Brahms check and CRIA(dataclean)
- BRAHMS tools and simple programing in Foxpro to identify inconsistences and manually correct them, e.g. same collector in different places on same day; same locality at differing coordenates)
- by "eye"
- Check point on map to see if it appears in right area. The SERNEC portal where we post records can map GPS coordinates associates with selected records.
- check to see if it makes sense
- Consortium of Pacific Northwest Herbaria automatically detects errors if coordinates occur outside boundaries of county in which specimen is reported to occur.
- Cross checking with google maps api
- Currently, we project all of the data onto QGIS or ESRI ArcMap and visually inspect it to look for anomalies.
- Data Cleaner / Specieslink
- Data is uploaded to AntWeb, which performs error checking on upload (e.g. ensuring that coordinates fall within bounds of stated geopolitical units)
- Data visualisation and filtering and cross checking
- DIVA-GIS Tools, visual verification, nearby landmarks
- EPEPorto cohort
- examine maped points for outliers
- First thing is to map and then look at the map and read the locality text. Export to gbif also provides a report for detecting errors using country shape files.
- For new georeferencers, all georeferencing is checked - i.e., I go through each record and copy their coordinates into Google Earth and check that they are correct; if all are correct on their next session I will randomly select 100 to check and will do iterations of this process if they keep georeferencing correctly until I'm at about 20 randomly checked for errors. If there are errors, I will highlight those, walk through the problems with the georeferencer and have them correct their mistake - in those cases I will recheck the records to make sure that they are correct.
- GBIF provides errors in provided coordinate data (i.e. those that plot in ocean, coordinates plot in incorrect country), and we export latitude and longitude data and map using ArcGIS in coordinate data checking as well.
- GEOLocate or Georeferencing Calculator

- GIS assessment; mapping tools on platforms like AVH
- GIS tools
- Gross errors (like a missing "-" for the coordinate) are checked, otherwise only in special circumstances like verifying the coordinates for specific research use
- `http://splink.cria.org.br/infoxy?criaLANG=pt`
- `http://www.conabio.gob.mx/informacion/gis/`
- human inspection.....
- I am not familiar with that
- If Google Maps shows the site as being in the ocean, etc, I mark it as an error.
- In most cases the provided georeferencing is manually checked using a web mapping tool. Small scale of the collection and low rates of specimen acquisition allow for this despite it still being laborious for each specimen.
- In the national system, you will get a warning if the coordinates do not match the administrative area (e.g. municipality) given.
- Jabot
- Just basic visualisation of point on a map to ensure it looks realistic
- Logic or error methodology built into datababase (Symbiota) depending on locality information included with specimen.
- map and look at result
- Map taxa or administrative units and look for outliers
- Map viewing in internal database and searchable web-tool.
- mapping
- Mapping localities directly from the database coordinates (export straight into Google Maps) that mapping is confirmed with field maps, field collectors
- Mostly opportunistic when searching maps of samples and outliers are apparent and need checking
- No - but we track GBIF errors
- No particular methodology. Just make sure the coordinates make sense
- no, aside from finding outliers on maps
- No, but I think we probably should. We do take advantage of errors found by aggregators GBIF and VertNet. It would be most useful to have a tool that connects to our database Specify that would help with error checking.

- No, but obvious errors are sometimes detected once the coordinates are mapped out. These appears outside the normal ranges of the taxon's distribution or located in the wrong habitats, e.g. water bodies for land plants.
- no, but suitables tools to ensure data accuracy, visualize and eliminate errors most welcome
- No, except for checking locations outside Brunei and those that end up in the sea.
- No, except there is some feedback from experts
- No, we look for obviously mistaken outliers but we do not have a systematic process
- No. We are too busy getting them into the database in the first place, and any errors are discovered as label transcriptions are entered, or sometimes when mappign them through the iDigBio portal. No errors searched for in a systematic manner.
- No. We don't have the capability of doing that. Our national herbarium association has given us information on which of our locations show up as being off-shore it help find really bad ones.
- normally not, if data end up in the sea, they seem to be wrong, since we almost exclusively collect land animals (most problems are caused by mixing up W/E coordinates)
- Not yet, but I occasionally sort/scan spreadsheets to find outliers.
- Not yet, but it is important to check georeferences of our collection databased before there appeared the option to see location directly on map after inserting the coordinates - before that the human error was more common.
- not yet, that is planned once we finish a region. We plan to search a unit & see if there are outliers.
- Not yet. We are a new collection, and plan to do it in the future
- Obvious mistakes are detectable by displaying the map of georeferenced data.
- occasional tests using bounding box
- occasionally we look for records georeferenced outside of assigned county.
- Only rudimentary: we plot the coordinates on a map to ensure they land in the right country or province.
- only when it becomes clear that an error was made
- Our biologist are constantly reviewing information in our database and any time they return to accomplish field tasks they collate and add environmental data to the location in which they collect or monitor species, mainly those in risk of extinction or ecologically importante.
- Our geo-referenced information is plotted on maps based on our collaborators' addresses and are visually checked by viewing on a street-level base map.

- Our specimens database is delivered to the The Atlas of Living Australia, and this site has tools to report on location anomalies.
- out of bounds localities, mapped localities
- Period geospatial reports, directed reports on higher geography, manual review, etc.
- periodic query/inspection of database records looking for outliers
- Periodically check localities for accuracy but do not check every entry. No easy methodology.
- Place a subset of georeferencing information in google maps and check whether the point falls in the sea (in the case of marine species) or river, and in the expected geographical area.
- Plotting points on a map and checking those in an unusual place
- Potential geographical outliers are detected by the Atlas of Living Australia when our data is uploaded; we periodically ingest these flags into our database for ease of follow up and data cleaning.
- projection on a map
- Rather limited in past. Mapping tools to look for taxa disjunction, occurrence in unlikely habitat e.g. In water body/sea, etc
- Sometimes we just search for the coordinates that are already attached to a specimen, to determine if they are realistic.
- spot checking for outliers and inconsistencies
- spot-check in the field
- The data base application displays a map of the point as it is entered and a visual check is performed. For older data, checking for georeferencing errors is adhoc, as the data is used for various purposes. We undertook systematic checking for errors (outlier detection) for the entire collection around 15 years ago, using GIS.
- The exposition of the slope, type of vegetation
- the polygons drawn from textual information entail all the uncertainty and we have developed a customised script to convert it to a deviation for each georeferenced locality
- The simple projection on a map, in order to be alerted for the position of outliers
- There is no formalized protocol for this in our collection but we correct all erros detected when records from our database are used for analyses or imported to a database applying a consistency check. We also used incosistency reports from GBIF to correct most of the errors.
- upload to GIS program, check country, state, and county, visually check locality.
- User reports of errors.

- using custom application, run validation tools to review country and state/province listed vs coordinate location
- Validation using Darwin Test
- Visual check on the mapped coordinates in Google Earth or similar.
- visual control on the map view of our collection Information System/database
- Visual inspection of collection sites on map.
- Visual inspection of data on GPS software.
- Visual inspection on GIS, looking particularly for sudden 100km jumps, land sections in the sea, incorrect rock types, etc.
- Visualize on google map
- We apply a note with any coordinate that has been estimated. However, almost all coordinates named in the collections were estimates based on locations on a map.
- We can check by mapping and finding outliers. Also comparing stated georegions and mapped georegions.
- We compare coordinates with iso country information.
- we did check a selected amount of the localities that had geo data. We found a high error rate.
- We do not apply a methodology to detect georeferencing errors after the georeferencing process
- We don't. We don't have human resources to do this
- We georeference one point at a time, so we aren't running into the batch errors that I often see on dot maps (GBIF and the sort).
- We sometimes will check georeferenced coordinates against country by using Kurator tools.
- We try to avoid as many georeferencing errors as possible by using these tools / applications. 1) The database we use (PlutoF.ut.ee) immediately shows the exact point on Map (different maps are united in this database system (OpenStreet Map, MapBox Satellite, Estonian Land Board), so you easily check if the location is correct and avoid typing errors. 2) Also when typing coordinates, you automatically get current adminstrative units (country, state, etc.). 3) We also try to database material by uniting specimens under certain name (e.g. Expedition to Far East in 1969). This diminishes typing errors if you seen expedition route on map 4) If possible, we database sampling sites first, and connect the specimens to sampling sites. There is a special tool in database allowing to create sampling sites first.
- We use the dataCleaning tool from speciesLink (`http://splink.cria.org.br/dc/index?criaLANG=en`)

- We visualise the locality on a map to make sure it falls in the correct county. Experts also provide feedback on any errors they notice and we edit the records to improve them capturing information about what was changed, when and by whom.
- We would like to learn more about this
- When we find obvious errors we try to fix them. We could do much more of this if we had time.
- Will sometimes recheck to make sure correct but usually no
- YES
- Yes - usually plot on a map
- Yes - verification of the coordinates on digital maps.
- Yes by Google earth
- Yes visual mapping.
- Yes, Arctos includes WKT's of higher geography like county or other administrative spatial footprints, so localties that do not fall in stated higher geography are flagged and checked.
- yes, checking the public portal records
- Yes, concerning domestic specimens
- yes, coordinates are checked against (small) administrative areas
- Yes, coordinates are exported into a geospatial analysis program (ArcMap or QGIS) and overlaid with administrative level shapefiles and geologic layers. If the overlay data does not match the text data the coordinates are re-evaluated.
- Yes, eg comparison with current occurrence
- Yes, exporting coordinates into a GIS can help to insure the correct political division with the coordinates.
- Yes, I apply tools provided by cria.org.br for data cleaning, by jabot (Rio de Janeiro Botanical Garden) and some are checked manually in Google Earth.
- yes, I search state and county and then map the specimens. If it is georeferenced wrong it will map to a different state or county.
- Yes, in the SEInet database system you can search for a State and County and then map them and see if any fall out of the county.
- Yes, our collection is purely for our site so we look at the points on GIS and note any errors that are evident. We cross reference to field data sheets to ensure there isn't a transcription error, etc.
- Yes, plant distribution and collection sites

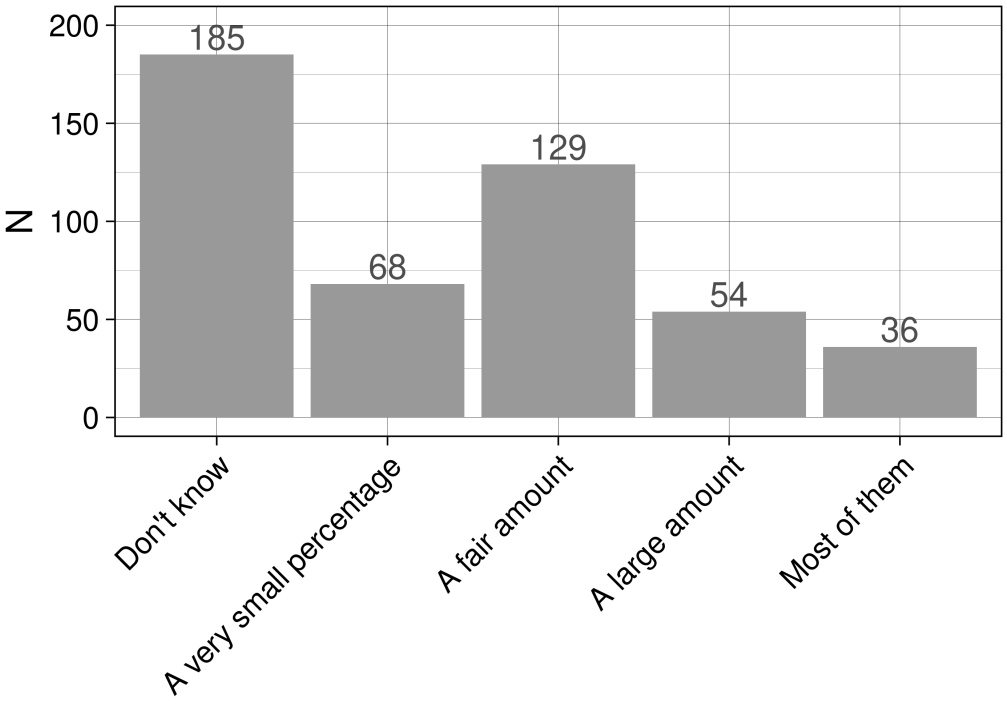
- yes, plot on map to check accuracy
- yes, plot using either google maps or more recently ArcGIS to verify correctness
- Yes, polygons for individual countries.
- Yes, QGis
- yes, sometimes. Line up in numerical order the coordinates and check if the place names fit the area. Line up the date and collectors to check errors
- Yes, SpeciesLink tool
- Yes, the name and coordinate matching is done from the applications managed by the Alexander von Humboldt Institute before being published in the IPT-SIB and GBIF repository, the possible corrections are modified in the original database that I handle
- yes, this one: `http://splink.cria.org.br/dc/index?criaLANG=pt\&colecao=FURB`
- Yes, through multiple ways to correct it.
- Yes, usually just look for outliers in a GIS program
- Yes, visualization on a map compared with geography. Also error reporting on GBIF and iDigBio aggregators.
- yes, We chek all herbaria specimens by map
- Yes, we do occasionally check for egregious errors by searching a state or country and checking for points falling outside of the area.
- Yes, we have a field in our database to enter if the georeference has been verified, usually the coordinates are entered in Google Earth with USGS topomap overlays to see if coordinates fit label description.
- Yes, we plot the coordinates on google maps.
- yes, we plot them if generated by GeoLocate and compare against notes. We periodically check for gross errors (flipped coordinate polarity, etc)
- yes, we screen for locations "out of range" based on bioregions in the California flora
- Yes, we try to clarify it by asking questions and checking from google maps
- Yes. Cross checked manually with secondary map sources.
- Yes. Ad-hoc: Checking for mismatches in administrative units between coordinates and verbatim and GIS layers. Checking for negative or positive coordinates when they're unlikely. Checking for duplicated values. More complicated GIS analyses (eg, localities not grouping in clusters).

- Yes. As a curstor and editir of the Moscow Digital Herbarium, I am visualising on map all dots and inspect all suspicious ones. I.e. those in water, far from documented areas, beyond pledged administrative unit or country, etc. I am doing this 2-3 times a year to clean visible errors.
- Yes. Darwin test provided by GBIF.ES (`https://www.gbif.es/software/darwin-test/`)
- Yes. I check the location on a map (especially on national records) provided by our databasing system
- yes. Lat/Long matches = Admin levels; known bee species distribution; known host plant distribution. Label elevation information matches calculated elevation (DEM) from georeferencing. Entire specimen record is flagged until insect Identification is confirmed followed by flagging locality information.
- Yes. We check if the location is within Slovenia

Q31 - Would you say your georeferenced site names may also be georeferenced by other institutions?

Number of respondents: 455.

The graph below shows how much respondents think their georeferenced site names may have been already georeferenced by other institutions.



Q32 - Do you use data from public biodiversity data repositories?

Number of respondents: 460.

293 (64%) respondents report they use GBIF and 167 (36%) do not. From those using GBIF, 230 (78%) use it exclusively while 63 (22%) combine its use with other repositories.

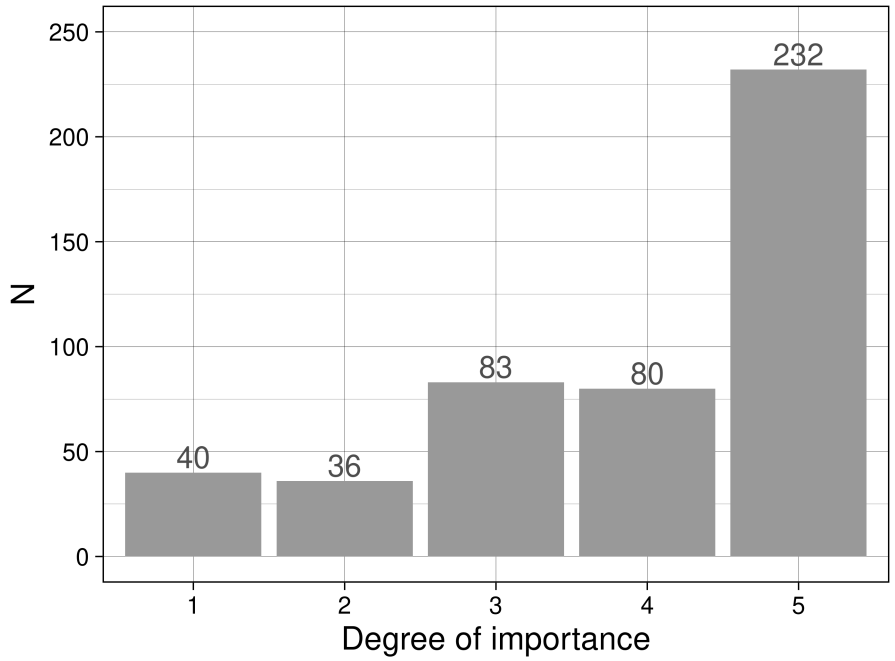
Of those not using GBIF, only 57 (34%) use an alternative repository while 110 (66%) do not use any repository.

Reported repositories other than GBIF, in descending order iDigBio [22], Unspecified [15], Atlas of Living Australia [9], Australasian Virtual Herbarium [8], Symbiota [8], SpeciesLink [7], SEINet [6], VertNet [6], Canadensys [5], iNaturalist [4], REFLORA [4], SERNEC [4], SiB Colombia [4], AlgaeBase [2], Global Plants Database [2], Harvard Herbarium [2], Herbário virtual - INCT [2], Index Fungorum [2], Missouri BG [2], MyCoPortal [2], New York BG [2], Norwegian Biodiversity Information Centre [2], Tropicos [2], WoRMS [2], Aculeata.eu [1], AntWeb [1], Artsdatabanken [1], Australasian Plant Pest Database [1], Banc de dades de Biodiversitat de Catalunya [1], Berlin Herbarium [1], BGCI [1], BioGis [1], BISON [1], BONAP [1], Botanical Garden-Institute FEB RAS [1], Calflora [1], California Native Plant Society [1], CNDDB [1], CONABIO [1], CPNWH [1], Datenbank Schmetterlinge Rheinland-Pfalz [1], Deutschlandflora [1], discoverlife.org [1], eBird.org [1], Edingurgh Herbarium [1], Flora-On [1], floraweb.de [1], Florida Museum of Natural History [1], GB3D Type Fossils Online [1], General Internet sources [1], GeoHive [1], GEOLocate [1], GFBio terminology service [1], infoflora.ch [1], IPNI [1], JSTOR [1], Kew Herbarium [1], Mycobank [1], National system [1], NCBI [1], NHM [1], Paleobiology Database [1], PBDB [1], Red de Herbarios del Noroeste de México [1], SiBBR [1], SIENet [1], SISBBr [1], Smithsonian Institution [1], Tasmanian Natural Values Atlas [1], tela-botanica.org [1], The Plant List [1], U. of Puerto Rico [1], UK Biological Records Centre [1], UK National Biodiversity Network [1], USGS BISON [1], USGS National Digital Catalog [1], USGS National Geologic Map Database [1], WFO [1], Wikidata [1], WikiSpecies [1], WorldFlora Online [1], www.genesys-pgr.org [1]

Q33 - How important do you consider that these repositories provide georeference information?

Number of respondents: 471.

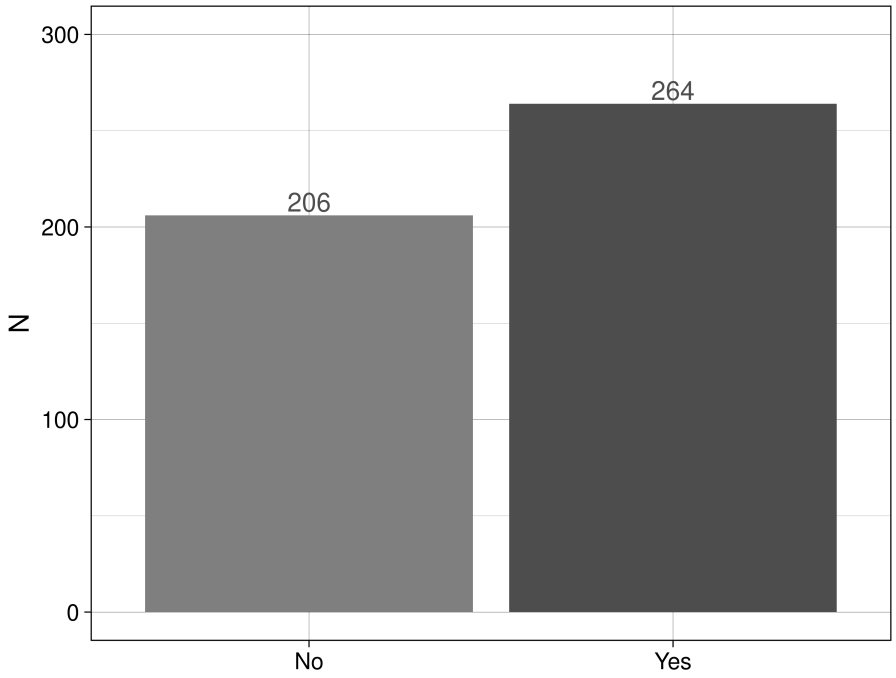
The graph below shows how respondents value the importance of public repositories as providers of georeferenced information on preserved specimens. From 1 (least important) to 5 (most important).



Q34 - Has your collection been uploaded to GBIF / Other? If 'other than GBIF', can you specify?

Number of respondents: 470.

The graph below shows the number of respondents that have uploaded their collections to public data repositories and those who do not.

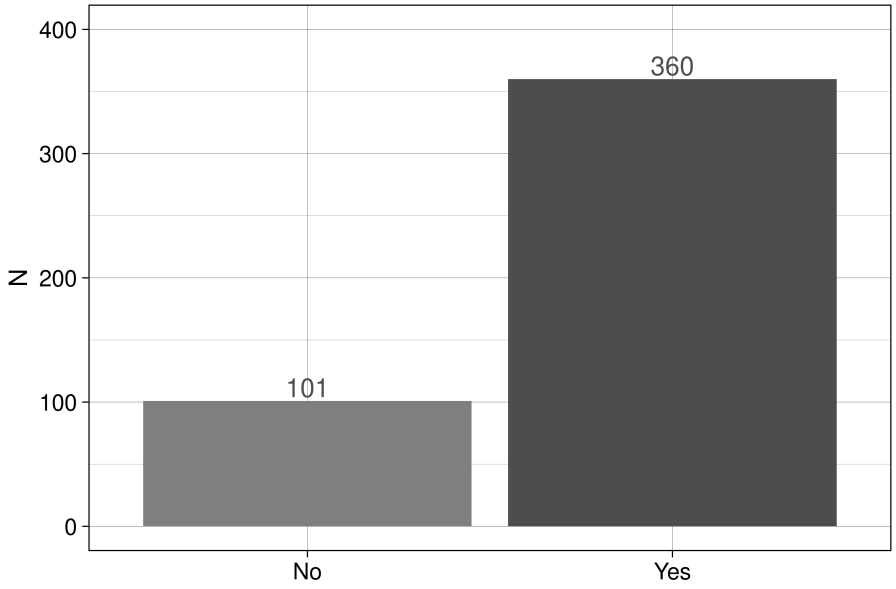


The following are the public repositories other than GBIF to which collections have been uploaded and published. 15 collections have been published to a public repository but not to GBIF.
iDigBio [35], VertNet [15], ALA [11], Symbiota [11], SEINet [7], speciesLink [7], AVH [6], BGCI [5], SERNEC [5], Artskart [4], BISON [4], Canadensys [4], iNaturalist [3], OBIS [3], REFLORA [3], SiBBr [3], Virtual Herbaria [3], Arctos [2], e-ReColNat [2], INCT [2], InvertEBase [2], JSTOR [2], MyCoPortal [2], SCAN [2], SiB Colombia [2], USGS [2], Aculeata.eu [1], AntWeb [1], APPD [1], Atrium [1], BDBC [1], BioGeo Silesia [1], BioGIS [1], CCH2 [1], CONABIO [1], Deutschlandflora [1], Digital collection of Moscow University [1], Discover Life [1], FENSCORE [1], Flora-On [1], GBDB [1], Genesys [1], GFBio [1], GGBN [1], IRIS [1], IUCN Redlist [1], Minnesota Biodiversity Atlas [1], MSB [1], National Biodiversity Data Centre [1], Natural Values Atlas [1], Open Herbarium [1], Pladias [1], Plantarium [1], PlantBase [1], PlantSearch [1], PUPBotany [1], Rhineland-Palatinate Butterflies [1], SANBI [1], Sisbio [1], SONNERAT [1], SoRoHerbaria [1], SVH [1], TanBIF [1], Tropicos [1], WFCC [1], Wikiplantbase [1]

Q35 - Are you interested in receiving a report of the results of this survey, once finished?

Number of respondents: 461.

The graph below shows how many respondents expressed their interest in receiving this report.



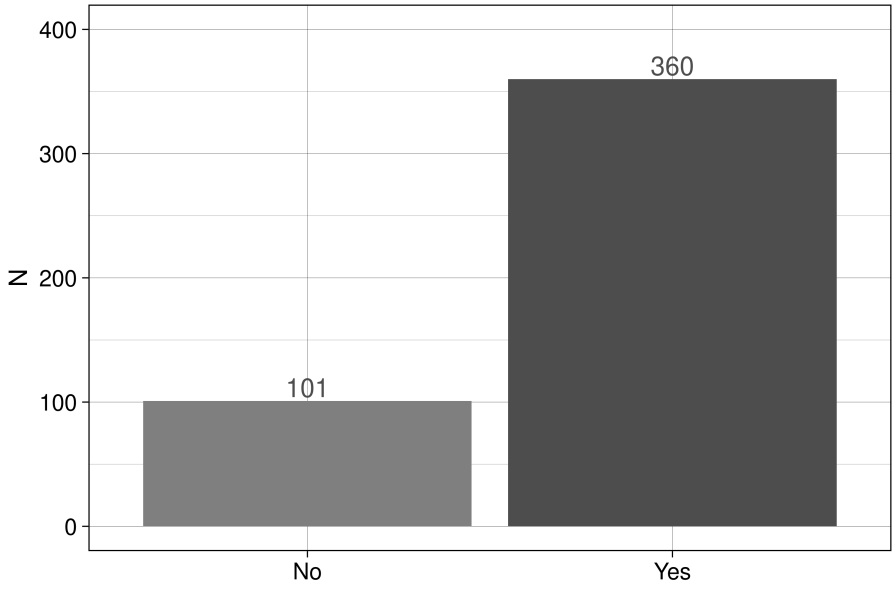
Q36 - If so, please provide us with an email address where to send the report.

Number of respondents who provided their email: 352

Q37 - Do you allow us to associate the answers here provided to your institution?

Number of respondents: 461.

The graph below shows how many respondents allowed to make public the institution for which they were answering the survey.



Q38 - If so, which is the Institution name?

Number or respondents: 296.

This is the list of institutions given by respondents. Note that this field was optional and not all respondents gave the name of their institutions.

AFRICA

Egypt

- Faculty of science Tanta University

Kenya

- Multiplant international medicinal conservation
- Plants for Life International

Nigeria

- Faculty of Pharmacy Herbarium, Ife

South Africa

- AfriBugs CC
- Stellenbosch University Botanical Garden
- University of Limpopo
- University of Pretoria

Tanzania

- Muhimbili Univesity of Health and Allied Sciences

Uganda

- Makerere University Herbarium

Zambia

- University of Zambia, Department of Biological Sciences

ASIA

Brunei

- Universiti Brunei Darussalam Herbarium (UBDH)

China

- Xiamen Botanical Garden, Fujian, China
- Yunnan Academy of Forestry & Grassland Science

India

- BAMU Herbarium, Dr. B. A. M. University, Aurangabad, India - 431004
- Harji-Van Botanic Garden And Psrk
- Iebr
- National Pusa Collection, ICAR-IARI, New Delhi
- PRI
- Punjabi University
- The Zamorin's Guruvayurappan College, Kozhikode, Kerala, India
- Walchand College of Arts and Science, Solapur, Maharashtra, India

Indonesia

- Universitas Negeri Malang

Israel

- Tel Aviv University Botanic Garden
- The National Natural History Collections, The Hebrew University of Jerusalem

Malaysia

- Penang Botanic Gardens

Oman

- Natural History Museum of Oman
- Oman Botanic Garden

Pakistan

- Quaid I Azam university Islamabad
- Quaid-i-Azam University, Islamabad Pakistan

Philippines

- Fresh Sunny Ecology and Organic Plantations Corp.

Russia

- Botanical Garden-Institute
- Central Siberian Botanical garden
- Central Siberian Botanical garden SB RAS
- Khakas State University named after N. F. Katanov, Abakan, Russia

Taiwan

- National Taiwan University

Turkey

- Ege University, Faculty of Fisheries

EUROPE

Austria

- Naturhistorisches Museum Wien

Belgium

- Ghent University Botanical Garden

Bulgaria

- National Museum of Natural Hisotry, Sofia

Croatia

- Natural History Museum Rijeka, Rijeka, Croatia

Cyprus

- Cyprus Herbarium and Natural History Museum

Czech Republic

- Herbarium collections and Department of Botany, Faculty of Science, Charles University, Praha
- Masaryk University, Brno, Czech Republic, herbarium BRNU
- Muzeum Cheb, Czech Republic
- National Museum Prague
- University of South Bohemia, Faculty of Science, Department of Botany, Herbarium

Denmark

- Natural history Museum Aarhus

Estonia

- Department of Geology, TalTech
- Estonian University of Life Sciences, mycological collection
- Natural History Museum and Botanical Garden, University of Tartu

Finland

- Botanical Museum, Finnish Museum of Natural History
- Finnish Museum of Natural History, Luomus.
- Kuopio naural history museum
- Royal Botanic Garden Edinburgh
- University of Turku - Botanic Garden

France

- Chateau Perouse Botanical Garden
- CIRAD
- Institut de Recherche pour Développement
- Museum Henri-Lecoq
- université d'aix-marseille

Germany

- Herbarium Gießen
- Herbarium Hamburgense, Institute of Plant Science and Microbiology, University of Hamburg, Germany
- Herbarium of the Regensburg Botanical Society
- Landesmuseum Natur und Mensch Oldenburg (State Museum of Natural History and Prehistory Oldenburg, Germany)
- Naturhistorisches Museum Mainz/Landessammlung für Naturkunde Rheinland-Pfalz
- Senckenberg Museum of Natural History Görlitz - Herbarium GLM

- Staatliche Naturwissenschaftliche Sammlungen Bayerns, SNSB IT Center
- State Museum of Natural History Stuttgart

Hungary

- Hungarian Natural History Museum

Iceland

- Botanical Garden Akureyri

Ireland

- National Botanic Gardens of Ireland
- National Museum of Ireland - Natural History

Italy

- Botanical Garden and Museum of the University of Pisa
- Botanical Museum- Siena University
- Centro Studi Erbario Tropicale
- Department of Agriculture, Food and Environment, University of Pisa
- Giardino botanico Carsiana
- Museo Civico di Storia Naturale di Verona
- Natural History Museum, University of Florence
- Orto botanico, University of Calabria, Italy
- Tuscia University of Viterbo, Italy
- Università della Basilicata - Herbarium Lucanum
- University of Camerino

Latvia

- University of Latvia Institute of Biology

Lithuania

- Herbarium of Vilnius University, Institute of Biosciences, Life Sciences Center, Vilnius University, Lithuania

Luxembourg

- Musée national d'histoire naturelle Luxembourg

Netherlands

- Historische Tuin Aalsmeer
- Naturalis

Norway

- Norwegian University of Science and Technology, University Museum
- Tromsö museum, Univerisity of Tromsö
- University of Oslo; Natural History Museum

Poland

- KTU Herbarium, University of Silesia, Katowice
- Nicolaus Copernicus University in Torun, Faculty of Biological and Veterinary Sciences,
- The Kostrzyca Forest Gene Bank
- University of Warsaw Botanic Garden

Portugal

- Herbário da Universidade do Algarve - ALGU
- Herbarium of the University of Coimbra
- Museu Nacional de História Natural e da Ciência

Russia

- Academy of Bioresources and Life Management V.I. Vernadsky Crimean Federal University
- Institute of North Industrial Ecology Problems of the Federal Research Centre Kola Science Centre of Russian Academy of Science
- Karachay-Cherkess State University named after U.D. Aliev
- Lomonosov Moscow State University
- Sain-Petersburg state university (Russia), SPSU
- Tula State Lev Tolstoy Pedagogical University
- Volgograd Regional Botanical Garden

Slovakia

- Plant Pathology Herbarium, Department of Plant Pathology and Mycology, Institute of Forest Ecology of the Slovak Academy of Sciences
- Slovak national museum-Natural History Museum

Slovenia

- Slovenian Forestry Institute

Spain

- CECOUAL
- Herbario ABH, Universidad de Alicante, Spain
- Herbarium LEB
- Herbarium, Facultad de Farmacia, Universidad Complutense de Madrid, Spain
- Institut Botànic de Barcelona (CSIC-Ajuntament de Barcelona)
- MAF Herbaria, Faculty of Pharmacy, Complutense University, Madrid, Spain
- Museu de Ciències Naturals de Barcelona
- Universidad de Sevilla
- Universidad Pública de Navarra (UPNA)
- Universitat de Girona (HGI)
- University of Navarra

Sweden

- Biological museum, Oskarshamn
- Department of Ecology and environmental sciencies, Umeå University, 90187 Umeå, Sweden
- Lund University Botanical Museum
- Swedish Museum of Natural History

Switzerland

- Conservatoire et Jardin botaniques de la Ville de Genève
- Musée de la nature du Valais
- United Herbaria of the University (Z) and ETH Zurich (ZT)

Ukraine

- Dendrological Park "Olexandria" NAS of Ukraine
- http://www.lnau.su/about-the-university/history.html
- M.M. Gryshko National Botanic Garden of NAS of Ukraine
- The State Dendrological Park "Alexandria" NAS of Ukraine

United Kingdom

- British Antarctic Survey
- Gallery Oldham (formerly Oldham Museum)
- Natural History Museum
- Royal Botanic Gardens, Kew
- Royal College of Physicians London

- Stonyhusrt College Collections

NORTH AND CENTRAL AMERICA

Bahamas

- Leon Levy Native Plant Preserve

Canada

- E.C. Smith Herbarium (ACAD)
- Herbier du Québec (QUE)
- Herbier Marie-Victorin (MT), Université de Montréal
- Herbier Marie-Victorin, Université de Montréal
- Ontario Parks
- PCYU
- Royal Ontario Museum
- The Manitoba Museum
- The Rooms Corporation of Newfoundland and Labrador, Provincial Museum Division
- UAMH Centre for Global Microfungal Biodiversity
- Université du Québec à Trois-Rivières (UQTR)
- University of Montreal, Ouellet-Robert Entomological Collection

Dominican Republic

- Instituto de Investigaciones Botánicas y Zoológicas, Universidad Autónoma de Santo Domingo

Guatemala

- Herbario USCG de la Universidad de San Carlos de Guatemala

Honduras

- UNAH

Mexico

- CIIDIR Durango, Instituto Politecnico Nacional
- CIIDIR-IPN MICHOACÁN
- Herbario de la Universidad de Sonora
- Instituto de Biolog38a, UNAM
- Jardin Botanico del Charco del Ingenio

- Jard3́8n Botánico Regional de Cadereyta (Science and Technology Council of the State of Queretaro).
- Orquideas Moxviquil Botanical Garden
- Universidad Nacional Autónoma de México - Instituto de Biolog3́8a

Puerto Rico

- University of Puerto Rico, Mayaguez Herbarium

United States

- American Herbal Pharmacopoeia
- Augustana College (IL)
- Biodiversity Institute, University of Kansas
- Brigham Young University
- Cal Poly Robert F. Hoover Herbarium
- Cal Poly State University, Hoover Herbarium OBI
- California academy of Science and missouri Botanical garden
- California State University, Fullerton
- California State University, Northridge
- Carnegie Museum of Natural History
- Carnegie Museum of Natural History - I answered as Collection Manager of Birds but others may also respond.
- Colorado State University
- Cox Arboretum and Gardens
- Daintree Arboretum
- Denver Botanic Gardens
- Denver Museum of Nature & Science
- Emory University
- Essig Museum of Entomology
- Field Museum of Natural History, Chicago
- Florida Museum of Natural History
- Florida Museum of Natural History
- Friesner Herbarium, Butler University
- Georgia Southwestern State Univeristy
- Harvard Museum of Comparative Zoology
- Highlands Biological Station
- Hollister Herbarium
- IDS
- Indiana Geological and Water Survey
- John W. Thieret Herbarium of Northern Kentucky University
- KU Biodiversity Institute
- Louisiana State University, Shirley C. Tucker Herbarium
- Marie Selby Botanical Gardens
- Miami University
- Milwaukee Public Museum
- Missouri Botanical Garden

- Museum of Vertebrate Zoology
- Natural History Museum of Los Angeles County
- Natural History Museum of Utah: Garrett Herbarium
- Nevada State Museum, Las Vegas
- North Carolina State University
- Northwestern Oklahoma State University
- NYBG
- Ohio University
- Oklahoma State University
- Oregon State University Herbarium
- Paleontological Research Institution
- Pepperwood Foundation
- Portland State University
- R.L. McGregor Herbarium, Biodiversity Institute, University of Kansas
- Rancho Santa Ana Botanic Garden
- Raymond M. Alf Museum of Paleontology
- REED
- Robert Bebb Herbarium at the University of Oklahoma (OKL)
- Sam Noble Museum, University of Oklahoma
- Southwestern Adventist University
- Texas State University
- Texas Vertebrae Paleontology Collections
- The Dawes Arboretum
- The Lord and Schryver Conservancy
- University of Alaska Southeast
- University of Colorado Herbarium (COLO)
- University of Illinois at Urbana-Champaign
- University of Illinois Urbana-Champaign
- University of Iowa Museum of Natural History
- University of Louisiana Monroe
- University of Michigan Herbarium and University of Michigan Museum of Zoology
- University of Michigan Museum of Zoology
- University of North Carolina at Chapel Hill Herbarium
- University of Rochester Natural History Museum
- USDA
- USDA-ARS: Pollinating Insect-Biology, Management, Systematics Research: Logan, UT
- UTCI - University of Tennessee at Chattanooga Insect Collection
- Waimea Valley Botanical Garden
- West Virginia University herbarium (WVA)
- Westfield State University

Unites States

- UC Berkeley Sagehen Creek Field Station

SOUTH AMERICA

Argentina

- ACOR herbarium (Facultad de Ciencias Agropecuarias, Universidad Nacional de Córdoba, Argentina)
- Comisión Asesora Parque J.F. Villarino. Facultad de Ciencias Agrarias.UNR. CCNº14 (S2125ZAA) Zavalla, Santa Fe, Argentina.
- FUEDEI
- Herbario Gaspar Xuarez
- Herbario RCVC, Universidad Nacional de Rio Cuarto
- Herbario Trelew
- Instituto de Investigaciones Marinas y Costeras (IIMyC, UNMdP-CONICET/FCEyN)
- INTA - FCA, UNMDP
- Museo Botánico (CONICET-Universidad Nacional de Córdoba)
- Universidad Nacional de la Rioja sede chamical

Barbados

- University of the West Indies, Cave Hill Campus

Brazil

- Federal University of Ceara
- Federal University of Rondônia (UNIR) - Herbarium Rondoniense (RON)
- Fundação Oswaldo Cruz (Fiocruz), Brasil
- Herbário Escola de Florestas Curitiba - EFC
- Herbário Rosa Mochel (SLUI)
- Instituto Nacional de Pesquisas da Amazônia
- Museu de Zoologia, Universidade de São Paulo
- Museu Nacional, Universidade Federal do Rio de Janeiro
- Reserva Natural Vale
- São Paulo State University, Unesp
- Universidade do Extremo Sul Catarinense
- Universidade Federal da Para38ba
- Universidade Federal de São Carlos
- Universidade Regional de Blumenau
- Universidae Federal do Esp38rito Santo
- URI - Erechim

Chile

- Universidad Católica del Norte. Sala de Colecciones Biológicas. Coquimbo.
- Universidad de Valparaiso

Colombia

- Cartagena Botanical Garden
- Colecciones Biológicas Universidad CES
- Herbario MEDEL
- Herbario Universidad de Antioquia - HUA
- Jard3́8n Botánico del Quind3́8o
- Jardin Etnobotanico Villa Ludovica
- Universidad de Caldas
- Universidad Distrital Francisco José de Caldas

Cuba

- Ecovida

Ecuador

- Escuela Superior Politecnica del Chimborazo
- Herbario Azuay, Universidad del Azuay
- Museo de Zoolog3́8a, Pontificia Universidad Católica del Ecuador

Mexico

- Unidad Multidiciplinaria de Docencia e Investigación Sisal, Facultad de Ciencias, UNAM

Paraguay

- Sociedad Cientifica del Paraguay

Peru

- Universidad Nacional del Centro del Peru

Uruguay

- Museo Nacional de Historia Natural, Uruguay

Venezuela

- Herbario regional de Guayana

OCEANIA

Australia

- Australian National Wildlife Collection
- Australian Tropical Herbarium
- Botanic Gardens and State Herbarium of South Australia
- CSIRO Australian National Fish Collection
- Northern Territory Herbarium (DNA)
- NSW DPI Plant Pathology & Mycology Herbarium
- NSW DPIE - ASCT, DAR
- State Herbarium of South Australia (AD), Adelaide, Australia
- The Tasmanian Arboretum
- VPRI

New Zealand

- Eastwoodhill Arboretum, National Arboretum of New Zealand

Norway

- National Seed Bank

Q39 - If you wish, feel free to provide us with any comments or suggestions you may have regarding the georeferencing of digital collections.

Number of respondents: 83.

These are the comments given by the respondents to this final open-ended question, in alphabetical order and unedited and as entered in the survey form:

- A "one-stop-shop" online reference tool for georeferencing would be great to have. Currently volunteers spend hours searching various references to find obscure location names like small towns, local roads, and small creeks and rivers. If all of these could be available in one place would be revolutionary for time spent on this. If a site like Geolocate allowed the user community to submit place labels for inclusion in the layers that would ultimately build a robust location data source. Perhaps something like what iNaturalist does where a person can submit but then it requires a certain amount of vetting before it can be included for the broader user community might be workable.
- A versatile world grid for endangered species is urgently needed, that is specially true for Mexico and Latinamerica.
- Any successful georeferencing is an expert task
- Are the Herbaria included in this survey?
- As I said before what do you mean by digitized. Does that mean databased or imaged.
- ask each herbarium sending their digital data continuously
- Bonjour, For a number of questions I was unsure what to answer and would have liked to have the option to answer N/A or unknown.
- caution should be applied to geo-referencing of sensitive taxa for conservation purposes
- Design your survey better, by giving examples of the format sought (e.g. numerical, w/o commas).
- Don't waste your time and resources; use Geolocate that is built into Symbiota software!
- Easiest to do for local area/home state (or other region of familiarity/expertise) Would like to have other source/facility aggregate data by political unit
- Estamos preparando la colección para poder digitalizarla y georreferenciarla. Tenemos mucho trabajo de curación en este momento.
- For Amazonia, I have not found on line systems very useful. I find that every case is individual, and the best approach is hard work aggregating all the collections of individual collectors, correcting the many, many digitation errors and hard work following their footsteps.

- For my collection, some of the locations are a large area, and not a specific site.
- For now, we have not yet started with systematically georeferencing our digital collections, but we would like to do it in the near future. Therefore, all feedback on the best tools to use is welcome.
- Georeferencing is almost "pie in the sky" for smaller institutions. Curating a medium-sized collection of vascular plants that had lain dormant (or essentially so) for twenty years has been a Herculean task over 7 years, and is not even half completed. For example, previously the family classification followed Cronquist (more or less) alphabetically; now it is APGIV organized phylogentically. The generic classifications were dreadfully out of date. Virtually all folders were acidic and needed replacing. Nothing was data based. Nothing was imaged. Again, georeferencing is important, but in my list of priorities, it is nowhere near the top.
- Good knowledge of the collection history is necessary. Pitfalls always present. Regardless, also skilful coordinates should be treated with skepticism
- Great survey, thanks!
- Hi, I'm not sure if I understand the term "georeferencing" correctly! Within more of the last 20 years we have equipped all specimens we collected with geografical coordinates. Additional we have tiny amounds of specimens older that 20 years which have coordinates. So this is all we do in georeferencing if this is ment. What we do not do is equipping old specimens with coordinates which might be likely to fit the given informations on a lable. If only this is ment by georeferencing we are not participating as given coordinates would give a false impression of geo-accuracy for specimens not pinpointable that way. At least so far, no one convinced us where the benifit of equipping specimens of low data quality and therefor less reliability with referencing suggesting a better accuracy.
- I commented below. As a summary, I am alone to curate, welcome researchers, work on the specimens after their visit (changes in database, sorting, ...) that, for the moment, I do not spend too much time in providing precise coordinates when digitizing. In addition our specimens are old, we have at least 2 millions of vascular plants, and 0.5 to 1 millions of cryptogames. Most have been recently scanned, but the labels have now to be completed in the national database. Searching for precise references is very long, it takes several minutes sometimes to locate European old localities, montains or small villages which are not indicated on maps... So I do my best, but this is not my priority at all for the moment... and for a long time I am affraid.
- I do not trust GBIF andbother dara repositories based on my analysis of fitness for use. However I di feel that these repositories could be hugely important for advancing digitization and "crowd sourcing" error discover.
- I manage a small herbarium since 2018 and I trying to get in the loop with digitalization and georeferenciation. Any guide or comment is always well received. Sometimes it is not easy to adapt the protocols or guides performed for big collections with resources.

- I must confess that I was not always sure about what info you exactly wish to obtain by some questions. Anyway, I PERSONALLY think (so this is not an institutional opinion or point of view) that it would NOT be wise to add interpretations to the info in the collection labels. This means that our primary aim is to enter the label information as correctly as possible in our collection management system. Using this info uncritically in any subsequent analysis is therefore risky. This also applies e.g. to the names used: again we believe that name changes (with respect to the labels) should only be made by experts who revise the collections. After all, we cannot adapt our management system every time a name changes is published. With respect to georeferencing we apply a similar politic: strictly speaking we only enter locality data as they appear on the label, i.e. without georeferencing. This latter is only done in the context of specific research projects or revisions.
- I thought there was an overlap btw questions on age and range of specimens and collection . This may mean that I did not understand the difference btw these questions.
- I would like to point out the geographical reference to a specific geographical object, for example, to indicate small geographical units on the map the Monysh Range, the Taiga tract.
- I would really appreciate if our Herbarium can be assisted with necessary equipment for specimens digitization and georeferencing
- I'm not a georeference expert but this is interesting for us to discover more details. Thank you. yours sincerely, Andik Wijayanto
- If you use specific language in questions you should explain the terms. I have had to guess the answers for some of the mandatory questions as it was unclear what was being asked.
- interesting survey
- Into the future, I envision that there will be several georeferences for a single record since some georeferences are fairly rough (or even automated), while others are done with much attention to detail. Creating a venue for storing these different data and tracking their reliability would be helpful.
- It is important to keep consistent to a georeferencing method and to note the tools used and standards followed in the georeferencing process, so that the work may be repeatable by others.
- It is not clear when asking what
- It would be good to advertise the importance of geo-referencing correctly.
- It would be interesting to participate in training and data management of biological collections, to optimize the quality of the data and the realization of geospatial analysis
- It would be useful a database of ancient toponims of some countries that have language difficulties, like ancient languages, other alphabets or countries or provinces that have changed the administrative delimitation.

- It's very important that it's possibe see where the coordinates originates. Is it original data from the collector or is it georeferences produced from info on the label.

- Lacking a budget for digitization other than what I've managed to "string together" with consortium based grants (like the Consortium of Mycological Herbaria/Fungaria that is contributing data to MyCoPortal) and lacking available personal time and personnel, I struggle with balancing time spent doing georeferencing with simply entering the available label data and linking images (letting users do the georeferencing based on the available label data).

- Links to online maps and gazetteers for all countries would be really helpful- it can take a lot of time to find these. Another idea would be to have people willing to help interpret localities in foreign languages. Or a way to post localities that can't be found so others might be able to help. I'd also like to see a standard about coordinate rounding- I've seen this error flagged for some of our specimens on GBIF but the coordinates in question mostly have 5-6 decimal points, which doesn't seem like they are really rounded.

- Many of the questions on this survey are difficult to understand/interpret. You also should how many collections consider it critical to make their collection data digitally available worldwide via GBIF or other aggregators. Very few arachnological collections in major museums digitize their collections or make the data widely accessible.

- Maps that show georeferenced specimens always show a point at the center of uncertainty. We need to depict this uncertainty on public databases better, such as a grey circle, not a point. It confuses people.

- More information/training on a database of location names would be great

- Most of the questions were difficult to answer accurately. I hope the results of the survey are helpful to you.

- my collection is enormous and entirely developed by myself and my students it contains ¿90

- My collections are only small remnants of a former larger collection, which is now in Herbarium Palermo, or in Munich, or in Göttingen etc. and a few others

- Number of total items listed for entire institution is a rough estimate. Estimates before the fire of 2018 were 20000000. Current number are still being inventoried.

- Old collections with imprecise location info, or very broad concepts of location, are of the biggest challenges in georeferencing. It is mainly a challenge because there is a desire from users for more accuracy or presicion than is ever possible.

- One needs to consider quite carefully the value of georeferencing material and for what purpose. Obviously for ex-situ conservation living collections, precise georeferencing is vital, and without it the material is effectively useless. But in other cases, the need for precision, and thus time investment, varies depending on situation. For many specimens in our living collection we have no location information at all, but

they are still useful for display, education and teaching. With very limited resources our usual approach is not to spend too much time georeferencing from descriptions or place names unless material clearly falls into a important research or conservation category within our collection strategy. Otherwise the georeferencing can always be done post-hoc if needed for research purposes.

- Our collection is a synoptic one taken over a relatively small region (mostly within a 9000-acre watershed). We are intimately familiar with this area, so find it relatively easy to assign georeferences from label descriptions. But it is impossible to be extremely precise in many/most cases.
- OUR COLLECTION IS SMALL BUT IS REPRESENTATIVE FROM THIS STATE REGION. ACTUALLY EXIST FEW PERSONAL RELATED ON IT. WE NEED EQUIPMENT AND PEOPLE WHO SUPPORT THAT WORK COLLECTION. OUR HERBARIUM IS KNOW AS CIMI. THANKS
- Our collection was started as a museum collection in the 1950's when this was common and popular. Since that time, it has become mostly a teaching collection that we use for public education. We may not have been the ideal candidate for this questionnaire. We do have many specimens that we use to keep a running list of the biodiversity of our park. Most specimens have a data label with locality info, however very little of it is digitized. We are looking into doing this in the future, but we are short on funds and labour.
- Our facility has been primarily a resource for K-12 and undergraduate education, public outreach, and informal exhibition to promote interest in plants.
- Pictorially representing the localities of specimens collected during marine trawls poses a challenge because often only one has are data regarding the beginning and end points of a haul.
- Please consider: answers to no. 15 base on datas of specimens included in our database only
- Possibility of getting training in georeferencing
- Question 11 (size of collection in number of specimens): details only reflect UM Herbarium • Herbarium: approx. 1,750,000, Birds: 213,652, Fish: 3,471,359, Insects: approx. 4,500,000, Mammals: 128,105, Mollusks: approx. 5,000,000, Reptiles & Amphibians: 437,763
- Regarding botanic gardens I think the survey should differentiate between the present locations (inside the garden) of the specimens and the collection sites.
- Regional natural history museums lack the resources required to follow any kind of strict protocol on geolocating. There is often one member of staff caring for 100,000s of specimens. Interpreting archaic location names, while important, are not at the top of the list of priorities. Anything that makes the process easier is beneficial, but it will always require a deal of time which may not be available.
- Since I am emeritus, I am not official in charge of our herbarium. So that is why I do not wish to share our name. I will ask current curators if they have taken this survey.

- Since our collections are largely not cataloged we have focused on getting the basics done first and hope to georeferencing done at a later date. We have completed a pilot study of ground truthing of one butterfly that is from the collections and an associated host plant with success (e.g. we were able to relocate the plant based on the description provided and obtained GPS coordinates.
- So how do we get involved in Mobilise?
- Some emphasis should be spent on historically avid collector locations. Using Hymenoptera as an example. Just having geo-referenced locations by day,mon,year for either Bohart would greatly ease geo-referencing for smaller institutions.
- Some of my answers here were estimated because digitisation of our collection is only partially underway and the state of much of the collections is not fully known
- Some of the protocols for georreferencing require specific training, which for some small collections is difficult to achieve. It would be great to develop simple open resources for help to non trained personal to achieve this task.
- Some of the terminology used in your survey is unfamiliar to me, and not used here. Much of our emphasis with georeferncing has focused on California, which is our geographic strength.
- Thank you for considering our institution. Best regards.
- Thank you for conveying our attention on this issue. We will try to improve our standards.
- Thank you for including us in this survey - adding georeferences to the large portion of our collection that doesn't have this data is on our list of things to do, and I have noted the protocols listed in an earlier question.
- The herbarium needs financing to finish digitizing the collection because there are many plants from old collections that are still pending. If you know about funds to digitize we would like you to let us know. Thank you very much.
- The problem is not methods, the actual problem is the lack of money and staff.
- This survey is too complex for our purposes
- To clarify: as a curator of terrestrial arthropods, we have launched a monitored effort to georeference North American terrestrial and aquatic arthropod localities. I have no knowledge of how and when other Field Museum collections were georeferenced, whether they are georeferenced, who did it and how it was done. There is no FMNH collection-wide review of the status of collections.
- Understanding the importance of the issues raised, we plan to develop our work in this area
- very usefull
- We are at the beginning of georeferencing or collections

- We are dealing with subterranean site names for troglobites. We find it very controversial
- We are looking for some free (or affordable) solution for digitizing the herbarium collection.
- We are preparing digitization. So many of the questions do not apply in the moment.
- We have a system of automatic georeferencing ISTRA. Currently, 45
- We need capacitation about the new methods and technics tat you have mencioned here. You must know Peru is a feudal country.
- We simply don't have the resources to address georeferencing as it is not a sufficient priority. We aim to address this by sending data to our national GBIF node who have the software routines to process textual geographic data and prepare georeferences from this. While this data may be useful nationally for Ireland, locality information for other countries is generally too vague (e.g. 'India') to be useful internationally
- While I'd be interested in having georeferenced specimens, and think it is important, I am the only person working at my little herbarium, so I just don't have the time, funding, or manpower to do much of this.
- Would you give me some information about protocol that may be use to estimate coordinates from text descriptions of a site?
- I want to make a digital collection with a spatial reference