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Publications, target groups, methods and applications in the communication of biodiversity

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Abstract

One of the main goals of conservation biology is protection of biodiversity. Some important new tools to achieve this goal are science education and communication to the public, as well as communication of scientific research results for decision makers. Objectives of this study were (1) to investigate what are the main topics in science on communicating the concept of biodiversity, what are the best methods for communicating this concept and (2) to communicate the concept of biodiversity to local community. To obtain more accurate and systematic results, we were working with special settings and metadata of Google Scholar, Web of Science and Scopus. We have analysed the metadata of all the results and 30 highly cited articles, making citation networks using CitationGecko. The results of our analysis showed that we need metaphors, storytelling, strong emotions and framing techniques to reach the policy-makers and non-scientists. To strengthen the nature – people relationship we need local projects. We have started our local work in promoting the notion of biodiversity 2 years ago. Our innovative idea is to present and provide knowledge to local communities not only on diversity of species, but also an ecological diversity using interactive workshops. In this context we have developed a series of games in order to better know and understand our local and regional values.

Keywords: communicating biodiversity; science-communication; nature education; Cluj

1. Introduction

The term ‘biodiversity’ was introduced by Walter G. Rosen in 1986 on “*The National Forum on BioDiversity*” (Maclaurin & Sterelny, 2008). The concept of biodiversity generally refers to variability of life on Earth. In this paper we have used the phrases *taxon diversity* and *ecological diversity*, which were settled by Harper and Hawksworth (Harper & Hawksworth, 1994; Standovár & Primack B., 2001). The biodiversity loss has been recognized as a global problem since the conference in Rio de Janeiro in 1992, and all of the publications since then raise awareness that we need urgent changes both on the level of policy-making and individual action (Cardinale et al., 2012). Pál Juhász-Nagy has a simple explanation for why biodiversity loss is

a problem: „for the sake of development, we need a desirable diversity” (Juhász-Nagy, 1993). The main goal of conservation biology is to reduce biodiversity loss (Standovár & Primack B., 2001).

To implement in practice nature conservation activities, in some cases neither the deficit of experts, nor scientists are the problem, but the conflict of interest between local people, policy-makers and conservationists. These conflicts cannot be solved easily or fast, but some of them can be solved if the communication strategies will change (Casajus et al., 2018; Standovár & Primack B., 2001).

Nature education can be a tool for conservation biology to reach the target 1 (“By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.”) of strategic goal A (“Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society.”) of the Aichi Biodiversity Targets (link1). The students are “woefully lacking in basic ecological knowledge” – this was the main conclusion of a paper, which analysed 110 papers about nature education in elementary and secondary school published between 1993-1999 (Rickinson, 2001). One of the main goals of nature education is to decrease “environmental illiteracy” (Bickford, Posa, Qie, Campos-Arceiz, & Kudavidanage, 2012). New words and concepts which we should use while planning nature education workshops are “plant blindness” (Wandersee & Schussler, 2012), “nature deficit disorder” (Louv, 2010), “nature-based solutions” (Walters, Janzen, & Maginnis, 2017), “citizen science” (Kullenberg & Kasperowski, 2016).

Based on the above-mentioned studies, we can affirm that new methods are needed: (1) in the science-communication of ecology, biology and conservation biology to the policy-makers, and (2) in nature education.

2. Objectives

The objectives of this study were: (1) to overview and evaluate the literature on “communicating biodiversity” in a structured and repeatable way and (2) to communicate the concept of biodiversity to the local community.

3. Methods

3.1. Methods of literature review

To ensure the repeatability of the literature review, we have used the search engines and configurations presented in Table 1.

Table 1. The search engines and configurations used for the literature review

No.	Search engine	Expression searched
A	Google Scholar	" <i>communicating biodiversity</i> " - the exact phrase in the title of the article, without patents and citations, between 1950 – 2018, language: English
B	Google Scholar	" <i>communicating biodiversity</i> " – the exact phrase anywhere in the article, without patents and citations, between 1950 – 2018, language: English
C	Web of Science	" <i>communicating biodiversity</i> " – the exact phrase in the title, abstract or the keywords, " <i>all databases</i> " option, between 1950-2018, language: English
D	Scopus	" <i>communicating biodiversity</i> " – the exact phrase, " <i>all fields</i> " option, all the years except 2019, language: English

In the case of all searches, we have chosen to highlight the results based on the following rules: 1) if the number of results were under 20 results we have highlighted all the results, (2) if the number of results were between 20-1000, then a) in the case of Google Scholar, we have organized the results based on relevancy and have chosen the first 10 results b) in the case of Scopus and Web of Science, we have organized the results based on citation and we have chosen the first 10 highly cited results.

We have made figures about some characteristics of results based on their metadata (fig.1, fig.2, fig.3, fig.4), used software: Mendeley, Zotero, R.

In the case of A, B and D searches (Table 1), we have made citation networks using CitationGecko software. We have ignored citation network of C search, as it didn't bring new information compared to the citation networks of A, B and D searches. The CitationGecko software uses the data from microsoft academic, open citations and crossref (Walker, 2018).

3.2. *Methods of communicating biodiversity to local community*

To communicate biodiversity, one of the easiest approaches is to organize events related to the International Day for Biological Diversity (22 May). In Cluj region the first celebration of Biodiversity Day was in 2005, and since then (between 2005-2017) it had been organized several times by different organizations. The main concept was to make a species list in different areas near Cluj, to present the taxon diversity (link2, link3, link4, link5, link6). Our approach from 2018 was to present ecological diversity, as well, with our “*Varietas delectat*” event, applying museum pedagogy and experiential education methodology (link7, link8). The diversity was presented based on the “Species of the Year” voted in Hungary and Romania (for the full species list what we have used on our workshops see Appendix A, Table A1).

The “Species of the Year” initiative works on the idea that there are some species selected by specialists to which the non-scientists can vote for, and the winner will be the Bird of the Year, for example, in a region or country. The target-group of this initiative are the citizens, not the policy-makers, the aim is to communicate information and correct misconceptions about the species (link9). This initiative is connected to target 1 from strategic goal A of Aichi Biodiversity Targets (link2).

4. Results and discussion

4.1. *Results of literature review*

4.1.1. The review of highlighted results

We have had 30 highlighted results as mentioned in chapter 3. For the list of publications and their detailed analyses, see Appendix B. Based on these publications, the four big topics which are present in the literature are:

(1) the importance of metaphors and framing techniques in communicating biodiversity to the policy-makers and to the citizens (Casajus et al., 2018; I Hellsten, 2002; Iina Hellsten, 2003; Hesselink et al., 2004; Koteyko, Thelwall, & Nerlich, 2010; Kusmanoff, 2017; Kusmanoff, Fidler, Gordon, & Bekessy, 2017; Larson, 2011; Ruiz-Mallén, 2016; Samuels, 2017; Stibbe, 2012; Väliverronen & Hellsten, 2002; Voss, King, & Bernhardt, 2015),

(2) for efficient communication to the citizens, we need emotion-connected knowledge, story-telling, presenting the local biodiversity, organizing nature education programs combined with arts, participatory communication (Bright, Barro, & Burtz, 2002; Casajus et al., 2018;

Chibememe, 2014; Jung & Streit, 2014; Myers A, 2003; Nöske & Zedda, 2014; Opermanis, Kalnins, & Aunins, 2015; Raven & Williams, 1997; Seppänen & Välierronen, 2003; Välierronen & Hellsten, 2002),

(3) for efficient communication to the policy-makers, we need simple figures (Angelstam et al., 2004; Fallding, 2004; Han et al., 2014; Turak, Regan, & Costello, 2017; Voss et al., 2015; Webby, Droser, & Paris, 2004),

(4) the offsetting schemes for companies (Hermansson, 2018; Quétier & Lavorel, 2011).

The focus of this paper and our practical application of it are related to the first two topics mentioned above.

The role of metaphors has been studied by Finnish researcher, Esa Välierronen and Dutch researcher, Iina Hellsten. In the 60's, the environmental problems were presented as war: "the war against nature", "the battle over nature". These metaphors were the most widespread ones used at the time. From the 80's, new concepts and ideas have appeared, for example "sustainable development", "we need relation between nature and man", "the biodiversity as a cultural heritage" (Välierronen & Hellsten, 2002). The "biodiversity as a cultural heritage" is the link between metaphors and framing techniques. Samuels thinks that we must have a cultural framing for biodiversity, otherwise people won't care about it (Samuels, 2017). In the topic of framing techniques, Kusmanoff is one of the main researchers, and one of his most interesting contribution is about the concept of "ecosystem services". For a long time, one huge critique against nature conservationists was that it does not have a monetary value for the biodiversity, and as an answer to this critique, the concept of "ecosystem services" was made. Kusmanoff says that "ecosystem services" is not efficient framing, because based on the "motivation crowding theory" the outer, monetary motivation destroys the inner motivation (Kusmanoff, 2017).

In the topic of communicating with the citizens, the common conclusion of publications was that we need to present the local natural values, because this motivates people to conservation biology actions. Beside this, the artistic component is also very important in its function of presenting the local values. The programs which have both intellectual and artistic components are the most efficient (Opermanis et al., 2015).

In the publication of Hesselink et. al (2004), the word "opinion-leaders" is presented as an important notion. When communicating science, the first step would be to find these opinion-leaders in a community and consult them about further steps (Hesselink et al., 2004).

Even if we were aware of the importance of the third and fourth topics, we didn't go in details, because they were not strongly related to our practical work in communicating biodiversity to the local community.

4.1.2. The results of metadata

The concept of biodiversity communication is present in the literature since 1993. In the case of A, C and D searches the number of publications was not higher in the relation of time, but in the case of B search we can see an increasing tendency (Figure 1). If we are looking to the metadata for searching science communication, we can see an increase in the number of publications and the number of citations, too (Figure 2).

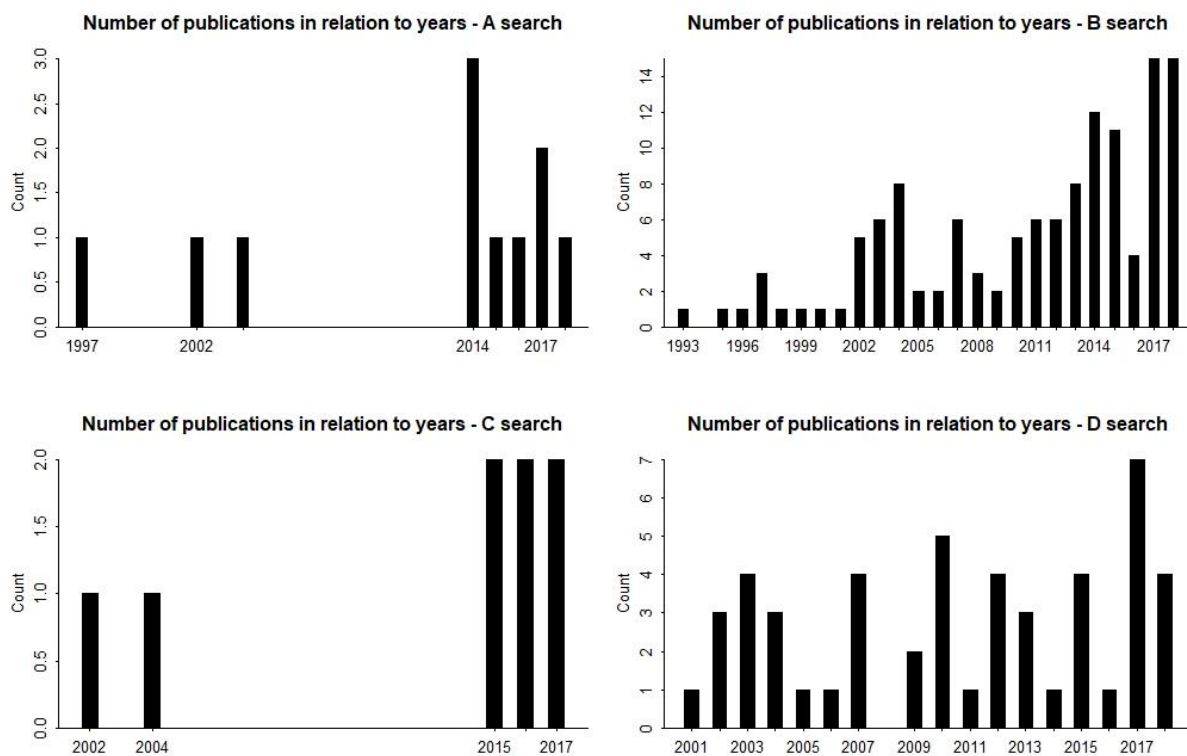


Figure 1. Number of publications per year for A, B, C and D searches (see Table 1)

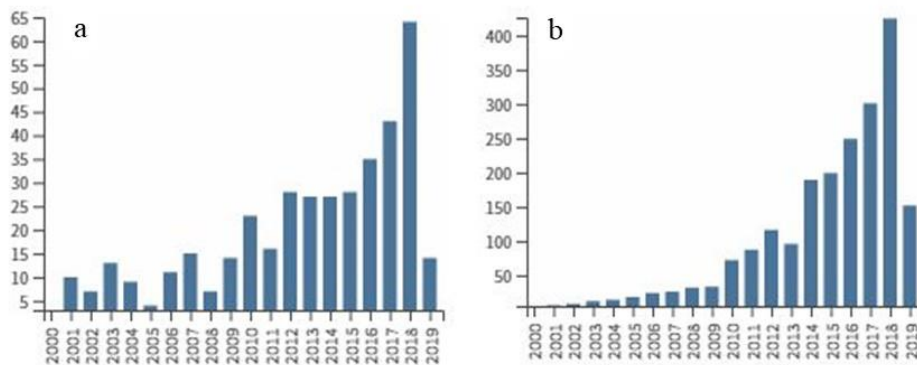


Figure 2. “Communicating science” phrase search in title, abstract and keywords: number of publications per year (a) and sum of times cited by year (b) (figure source: Web of Science)

Regarding to the number of type of publications we can say that a significant part of publications are articles, but to see the whole picture about communicating biodiversity, we cannot narrow the searches just for articles (figure 3).

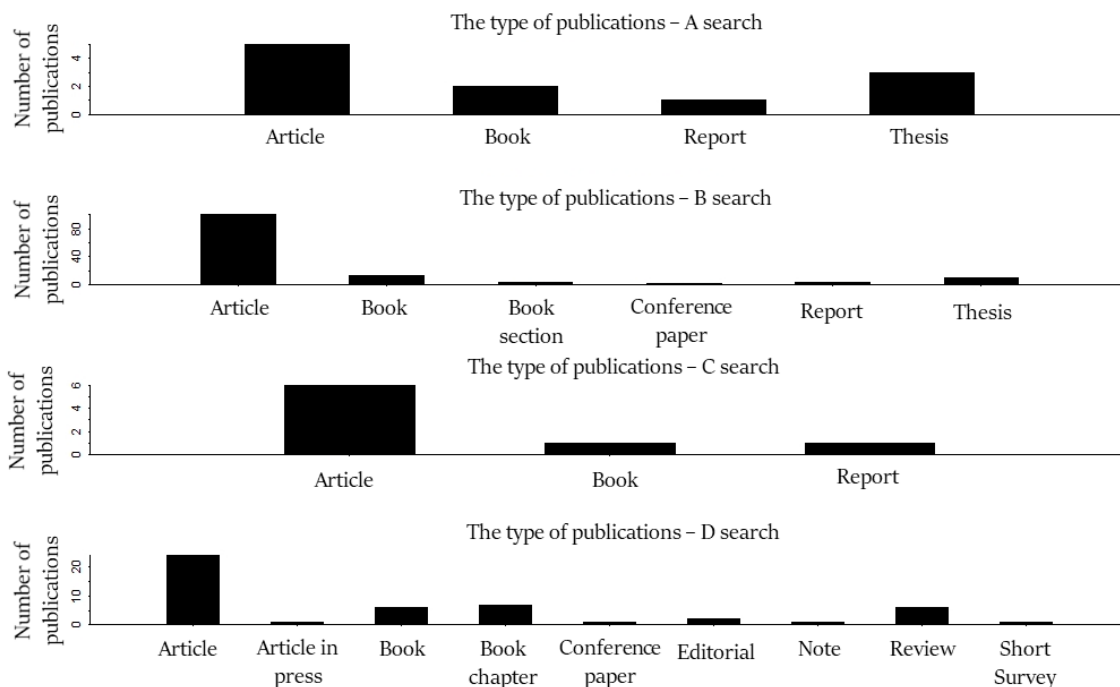


Figure 3. Number of publications in relation to type of publications

Social sciences and environmental sciences are the two main disciplines dealing with this topic (51%), but we cannot ignore agricultural sciences, arts and psychology (the remaining 49%) (figure 4).

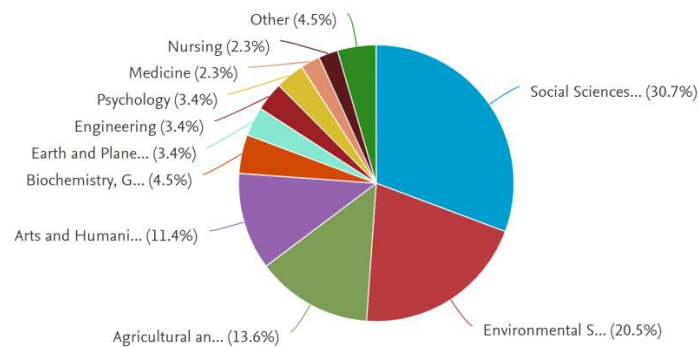


Figure 4. Disciplines in search D (source: Scopus)

4.1.3. Results of Citation Networks

A search: 11 results, 6 data (just the ones with DOI-number) on Citation Networks.

B search: 190 results, 69 data (just the ones with DOI-number) on Citation Networks

D search: 49 results, 38 (just the ones with DOI-number) data on Citation Networks.

We present here in detail the Citation Network of D search, because in that case we had the highest proportion of results with DOI-number (77.55 %). The Citation Networks for searches A and B can be consulted in Appendix C.

Analysing the network of papers cited by results of search D, one can observe one bigger sub-network (figure 5). It is advisable to use citation networks for the future literature reviews, to find related publications, which do not have the exact phrases in their title, abstract or keywords, but can be important. Above mentioned related publications are marked with red (figure 5). The sub-network's (figure 5b) topic is the communication strategy, regardless of the target audience. We have marked with green letters the publications which were highlighted results of the search D, and with red letters the publications which were highlighted in other results (figure 5).

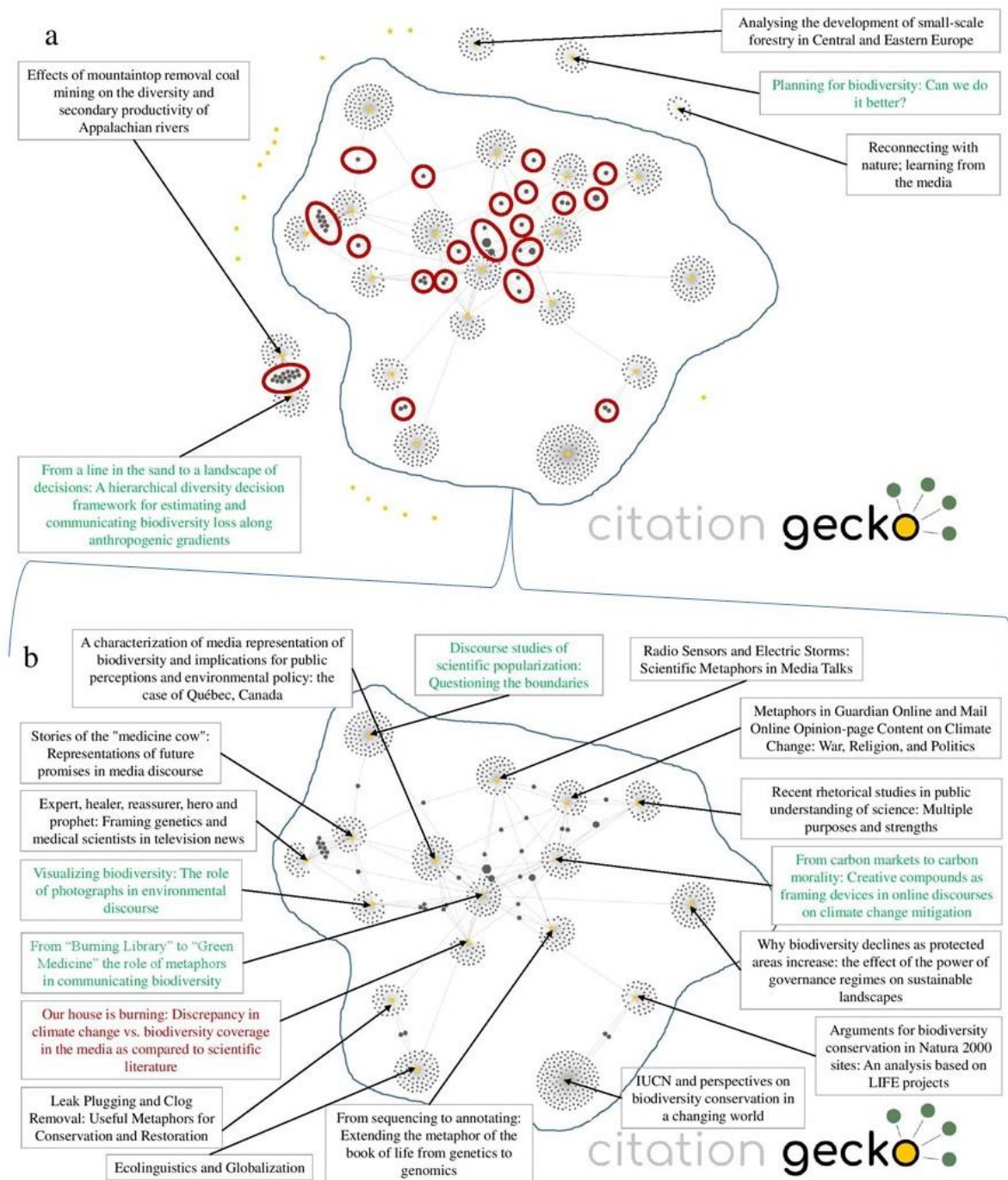


Figure 5. Citation Network 1 of search D; yellow dots – results of search D; **grey dots – papers cited by results of search D**; text-boxes: titles of papers which are hubs a) dots circled with red – papers cited by two or more by papers from the results of search D; b) subnetwork of Citation Network I

In case of search D there is a difference between Citation Network based on papers cited by the results (figure 5) and Citation Network based on papers citing the results (figure 6). At the second Citation Network we still have a sub-network but the hubs are different, mostly about metaphor topic (figure 5, figure 6).

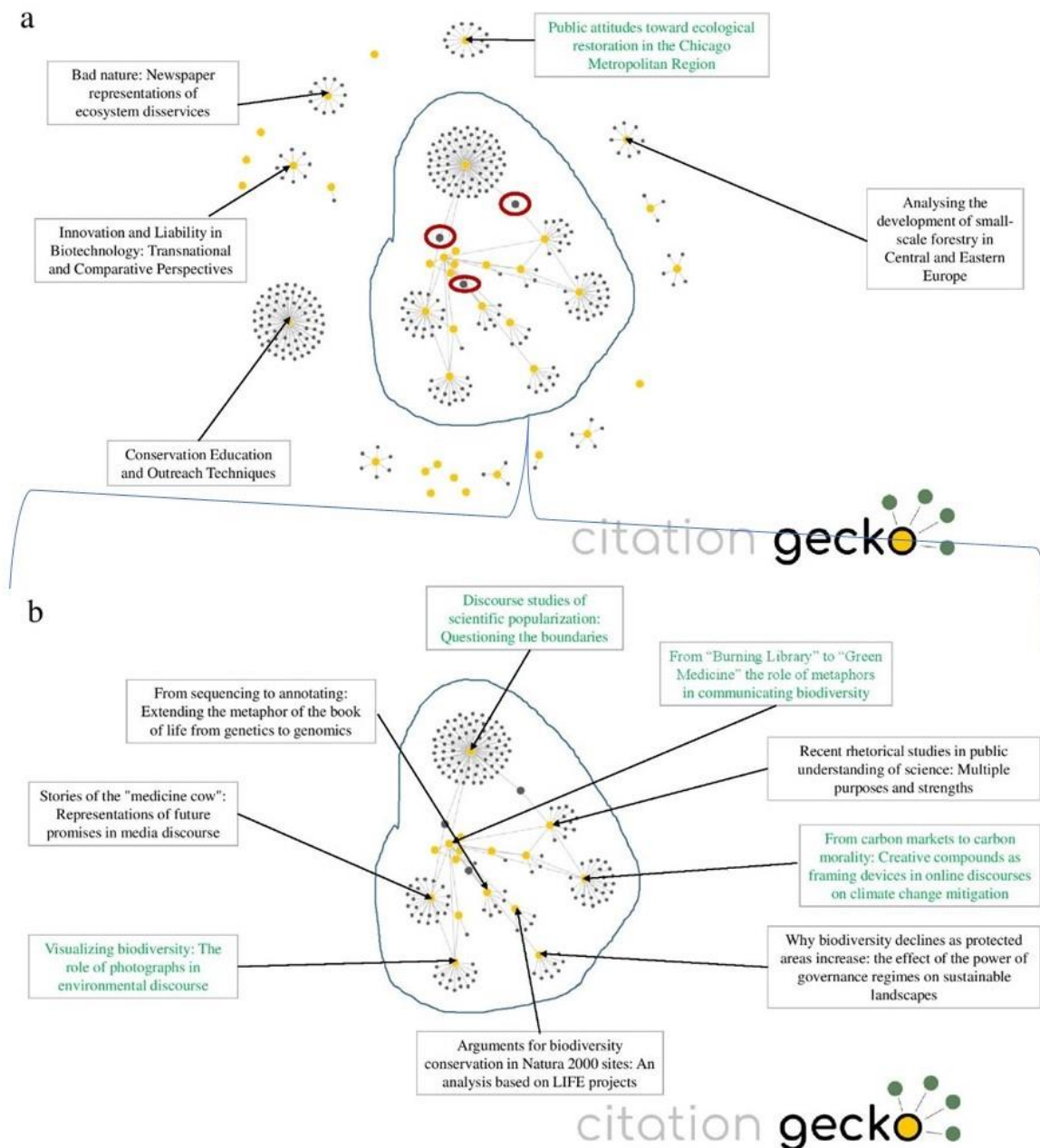


Figure 6. Citation Network 2 of search D; yellow dots – results of search D; **grey dots – papers citing the results of search D**; text-boxes: titles of papers which are hubs a) dots circled with red – papers citing two or more papers from search D; b) subnetwork of Citation Network 2

4.2. Application of theory into practice: nature education workshop and communicating biodiversity in local communities

During our workshops (figure 7), we work closely with the public and non-scientists. Based on literature and our own practical observations, we found that it is best to focus on activities where

participants can use most of their senses (“come in, see it, meddle it, shake it, feel it” – part of the 2018’s workshop description). We have found that if is possible (in case of common species), it is preferable the use of the living organisms or part of these (in case of plants). Otherwise we strongly recommend the use of prepared materials. In lack of these, photos, drawings are useful in order to acquaint the participants with as many features of the species is possible. In addition to these we have used our hand-made mock-ups and interactive games.



Figure 7. The I. “*Varietas delectat*” event and part of our materials in May 26, 2018, photo: Szabó Csilla

After the celebration day ([link7](#), [link8](#)), we brought the workshops to schools and kindergartens, and ultimately 120-150 children and 30-40 adults were attending our workshops. By having smaller groups each time, we have more time with one person and we can have a deeper conversation with participants. There is a higher chance to answer to their questions related to biology and ecology of the organisms concerned. If someone wants to organize nature education workshop or promote biodiversity, it is very important to have a deep knowledge in biology and ecology, because the visitors (especially children) are not always asking about the exact topic of the workshop that had been prepared beforehand.

We have created activities for all the species mentioned in Appendix A. We will present two from each year species in this paper.

4.2.1. Activites

The wild plant of the year 2018, *Gentiana pneumonanthe* is in the same genus as the *Gentiana asclepiadea*. The *Gentiana asclepiadea* appears on the Romanian banknote “1 RON”, which is a banknote with little monetary value and thus widely known by adults and children as well. This banknote gave us the starting idea of this activity, where the players needed to pair the plants with the Romanian banknotes (figure 8). With the adults we had deeper conversations, for example about what is the state of nature conservation in Romania, why these are the first banknotes with the image of plants, about species names, etc. We have explained what is the meaning of the term “genus”, and we were talking about taxonomy. We have a concept and the essence of the activity, but how we frame it, differs from one participant to the other.



Figure 8. The activity based on the Hungarian Plant of the Year 2018. Photo: Udvari Zita
A short video had been projected about the Hungarian Reptile of the Year 2018, *Zootoca vivipara*, from which the visitors could understand why the species has got the *vivipara* name. This activity also functioned as a break for people who did not wish to participate in other activities.

In 2019 our newest activity was a summary table about the Species of the Year, which had served as a good framework for the activities. We have linked one species with a specific object (figure 9). For example the *Hypericum perforatum* was linked with a bell, because one of its

Hungarian folk names is “bell-flower” (“csengővirág”), as shaking the dry fruits sounds like a bell.



Figure 9. The summary table at II. “*Varietas delectat*” event in 2019. Photo: Szabó Csilla

The activity about *Salamandra salamandra* put in practice the participative conversation theory. This game is a board game, where the players needed to ask questions of each other about the species highlighted during the event. The one who needed to answer could use every information in the event and could ask anyone, but not the other players about the problem. Some of us were players, too, so we could control the questions, to have some of them about fire-salamander, even if some of the children always had questions about the cheetah (the cheetah was presented at activity related to *Lynx lynx*, the Mammal of the Year 2019 in Hungary). The next level in this game was that the players needed to answer in 30 seconds. It was a good motivation for the kids to go fast to the other room and see the answers somewhere hanging on the wall or asking the leaders of the activities. This was a semi-structured activity: it was important that we did not have all the questions written, but we still had some questions prepared if the other players could not think of a new one. In addition, the game was home-made, invented by our ideas and the board we can use for numerous activities and topics (figure 6).



Figure 10. The board game for activity about fire-salamander (*Salamandra salamandra*). In the middle the life-sized fire-salamander. Hand-made by: Szabó Márta-Tünde, photo: Szabó Csilla

Based on the *Formica rufa* species group (insect of year 2019 in Romania), the *Ctenophora flaveolata* (Tipuloidea of the year 2019 in Romania) and *Rosalia alpina* (Insect of the Year 2019 in Hungary), we have presented the basic taxonomy of arthropods. For the *Formica rufa* we have made a mock-up with the components: head, thorax, petiole, abdomen (figure 11). We talked with the visitors about what is the difference between insects and spiders, in which group can we put flies, wasps, ants or beetles. When talking about insects, in one of the classroom one kid said that the *Zerynthia polyxena* looks like an Indian-butterfly. This led us to the conclusion that if we leave space for this kind of associations, the visitors remember more of the information. Our practical experience is in consent with the literature: using metaphors while communicating biodiversity is indispensable.

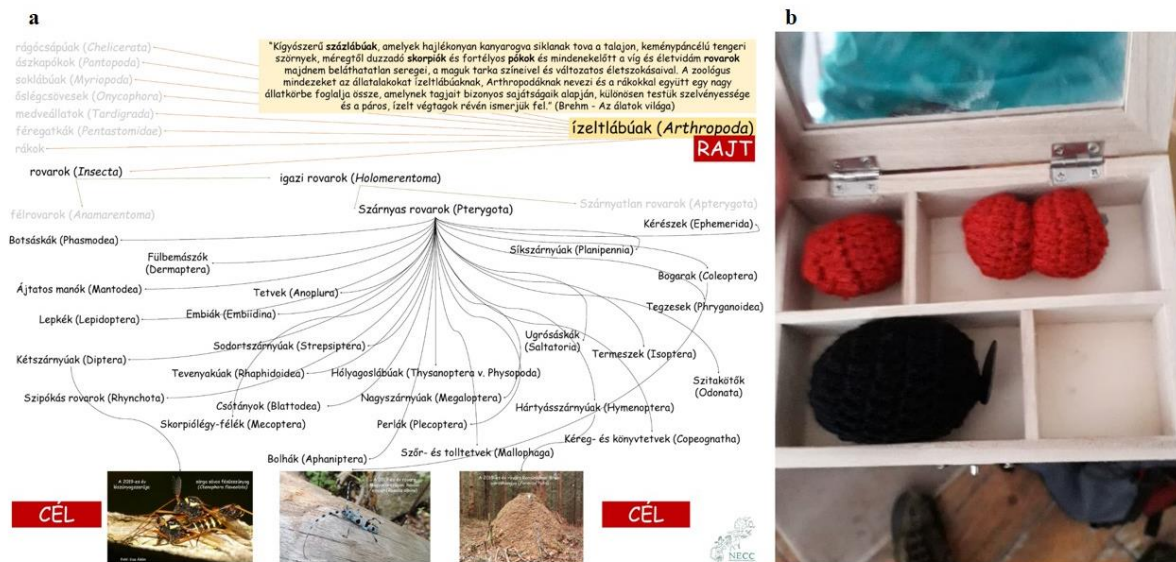


Figure 11. The materials of activities based on *Formica rufa* species group, *Rosalia alpina* and *Ctenophora flaveolata*; a – presentation of the basic taxonomy; b – mock-up for presenting *Formica rufa* and insect-morphology in general. Hand-made by Szabó Márta-Tünde, Szabó László and Szabó Csilla. Photo: Szabó Csilla.

5. Conclusions

The conclusions of the literature review about communicating biodiversity are the following: (1) the main topics found were the metaphors and the framing techniques, the measuring of loss of biodiversity and communicating results to the policy-makers, the offsetting schemes; (2) for efficient communication the right mode of framing is important: scientific, cultural, aesthetic; (3) it is important to: use metaphors; combine science with art; identify opinion-leaders in a community; use participative communication; promote the local natural values.

During our “*Varietas delectat*” workshops we have presented beside taxon diversity the ecological diversity as well. With our work we have been emphasizing the local nature values and urban biodiversity. Long-term positive effects of the workshops and the applied experiential pedagogy methods are at the moment hypothetical and should be tested later.

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link7: <https://www.facebook.com/events/1852076991515575/>

link8: <https://www.facebook.com/events/1209303772567399/>

link9: <https://www.mme.hu/2019-ev-madara-golyatocs>

link10: <https://www.bnr.ro/1-leu---Nicolae-Iorga-8859.aspx>

About Authors

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Appendix A

Table A1. The species which have won the vote

Year and place	Species groups	Species
2018, Hungary	Bird	<i>Falco peregrinus</i>
2018, Hungary	Tree	<i>Fraxinus ornus</i>
2018, Hungary	Insect	<i>Anax imperator</i>
2018, Hungary	Fungi	<i>Hericium erinaceus</i>
2018, Hungary	Mammal	<i>Nannospalax leucodon</i>
2018, Hungary	Wild plant	<i>Gentiana pneumonanthe</i>
2018, Hungary	Reptile	<i>Zootoca vivipara</i>
2018, Hungary	Herb	<i>Lavandula angustifolia</i>
2018, Hungary	Fish	<i>Leuciscus aspius</i>
2018, Romania	Bat	<i>Rhinolophus mehelyi</i>
2018, Romania	Insect	<i>Phengaris teleius</i>
2019, Hungary	Bird	<i>Himantopus himantopus</i>
2019, Hungary	Mammal	<i>Lynx lynx</i>
2019, Hungary	Wild plant	<i>Doronicum hungaricum</i>
2019, Hungary	Fish	<i>Scardinius erythrophthalmus</i>
2019, Hungary	Insect	<i>Rosalia alpina</i>
2019, Hungary	Herb	<i>Hypericum perforatum</i>
2019, Hungary	Amphibian	<i>Salamandra salamandra</i>

2019, Hungary	Fungi	<i>Boletus aereus</i>
2019, Hungary	Tree	<i>Cerasus mahaleb</i>
2019, Hungary	Game species	<i>Perdix perdix</i>
2019, Romania	Bat	<i>Myotis bechsteinii</i>
2019, Romania	Insect	<i>Formica rufa species group</i>
2019, Romania	Diptera, Tipuloidea	<i>Ctenophora flaveolata</i>
2019, Romania	Bird	<i>Athene noctua</i>
2019, Europe	Tree	<i>Prunus dulcis</i>

Appendix B

Abbreviations: A1 - search A, 1. Result; doi-1: it has a DOI-number; doi-0: it doesn't have a DOI-number; sa – scientific article; phd – PhD thesis; b – book; p – poster at a conference; a – article; msc – master's thesis; bc – book chapter; ua – unpublished article.

1. *From “Burning Library” to “Green Medicine” the role of metaphors in communicating biodiversity* (Väliverronen & Hellsten, 2002) (sa, doi-1, A1, B1, C1, D9). Using metaphors is important, but there is no difference between positive and negative ones considering the success of implementation. To reach the target-audience it needs to evoke strong emotions.
2. *From a line in the sand to a landscape of decisions: a hierarchical diversity decision framework for estimating and communicating biodiversity loss along anthropogenic gradients* (Voss et al., 2015) (sa, doi-1, A2, B6, C4, C9). Communication between scientists and policy-makers: presenting the “HiDDeF – Hierarchical Diversity Decision Framework” which is a new method for measuring the diversity of aquatic invertebrates.
3. *Framing the Conservation Conversation: An investigation into framing techniques for communicating biodiversity conservation* (Kusmanoff, 2017) (phd, doi-0, A3). The conservationists should frame the message, in other disciplines this method is very popular and efficient. For example it matters if you frame the problem with hope or with

fear, there is a difference between saying that loss of biodiversity is a healthcare problem or something else.

4. *Biodiversity in World Heritage Cultural Landscapes: Possibilities and Problems for Communicating Climate Change and Mobilizing Mitigation* (Samuels, 2017) (*sa, doi-1, A4*). For the sake of efficient communication the problem of Climate Change should be framed as a cultural problem (“World Heritage Framework”).
5. *Communicating biodiversity conservation to Forest Owners in East-Central Europe – Major Issues and Model Communication Strategies* (Hesselink et al., 2004) (*b, doi-0, A5*). To have efficient communication in a new community, the first step always should be to find the “opinion-leaders” and tell them first about the problems. In numerous projects there is no financial part for designing the communication strategies.
6. *Communicating biodiversity to young generations: examples from German urban areas* (Nöske & Zedda, 2014) (*p, doi-1, A6*). It emphasizes the role of education in science communication.
7. *Communicating Biodiversity and Wilderness to Urban People* (Jung & Streit, 2014) (*a, doi-0, A7*). There is a need in programs with local people as target-audience, instead of wealthy tourists. In some cases the nature areas are far from cities, from this reason it is important to present the urban biodiversity, too. There should be used two strategies in communicating biodiversity: one for the people who already have a connection with nature and one for the people who do not have any connection with nature.
8. *Communicating Biodiversity Offsetting in Sweden* (Hermansson, 2018) (*msc, doi-0, A8*). The main question of study is how can involve more companies into biodiversity offsetting scheme. The essential motive is the legal framework, if it is a law to do biodiversity offsetting, the companies will do it.
9. *Reaching the public: the challenge of communicating biodiversity* (Raven & Williams, 1997) (*bc, doi-1, A9*). The main conclusion of this paper is that local changes should be presented to people to understand the meaning of biodiversity concept.
10. *Communicating biodiversity conservation research Through dialogue and Mutual Learning in Rural and Indigenous Communities* (Ruiz-Mallén, 2016) (*sa, doi-1, A10, C8*). The conclusion of the article is that the communication between scientists and people is important, in developing countries usually this communication is from up to down, but it should be two-way communication, it is presented a project where they have used participatory communication.

11. *Communities managing commons for biodiversity conservation and the enhancement of their livelihoods and strategies for communicating resource management knowledge and skills in Sangwe Communal Lands* (Chibememe, 2014) (ua, doi-0, A11). It emphasizes the importance of presenting the local values combining science and art.
12. *Planning for biodiversity - Can we do it better?* (Fallding, 2004) (sa, doi-1, B2). It is about the connection between scientists and policy-makers in Australia. One of the main components of the urban planning should be biodiversity, but there are two problems with implementation: (1) the policy-makers are undereducated considering biodiversity concepts and (2) there is an information gap between scientists and policy-makers.
13. *Measuring and reporting biodiversity change* (Turak et al., 2017) (sa, doi-1, B3, C3, C6). It is about the connection between scientists and policy-makers, the conclusions are based on 11 studies. It is important to have a common measuring system to present the changes in biodiversity to the policy-makers. In one of the articles is presented a metaphor: the concept of EBV (“*Essential Biodiversity Value*”), which is very similar to “*Stock Market*”, the policy-makers should make decisions based on EBV, like the investors make decisions based on Stock Market.
14. *Targets for boreal forest biodiversity conservation - a rationale for macroecological research and adaptive management* (Angelstam et al., 2004) (sa, doi-0, B4). There is a need to have a network, where conservationists and policy-makers can have a connection, to have efficient active conservation.
15. *Our house is burning: discrepancy in climate change vs. biodiversity coverage in the media as compared to scientific literature* (Casajus et al., 2018) (sa, doi-1, B5). To decrease the human impact on environment, we should have connections between policy-makers, scientists and media experts, because the way the media represents the information influences the political decisions. Between 1991 and 2016 in the USA, Canada and United Kingdom the media representation of climate change was eight times more than the media representation of biodiversity and this difference cannot be explained by the ratio-difference in scientific articles. The communication of climate-change to the public usually was connected to an event, in contrary to the communication of biodiversity. One of the reasons for this is, that the climate-change can be quantified and explained easier to the policymakers. Advices: organizing “*Citizen Science Projects*” and “*reconnecting the people to the nature*”.
16. *A Biodiversity Indicators Dashboard: Addressing Challenges to Monitoring Progress towards the Aichi Biodiversity Targets Using Disaggregated Global Data* (Han et al.,

- 2014) (*sa, doi-1, B7*). The article is about the connection between scientists and policy-makers. They suggest to have an “operationalized online interface” to estimate and explain to policy-makers the impact on biodiversity.
17. *Assessing ecological equivalence in biodiversity offset schemes: Key issues and solutions* (Quétier & Lavorel, 2011) (*sa, doi-1, B8*). It is not strictly related to our topic, because it is about biodiversity offsetting schemes and their issues.
18. *The Politics of Metaphor: Biotechnology and Biodiversity in the Media* (I Hellsten, 2002) (*b, doi-0, B9*). This book's relevant information is the importance of metaphors, what we have mentioned already.
19. *Decline of 'biodiversity' in conservation policy discourse in Australia* (Kusmanoff et al., 2017) (*sa, doi-1, B10*). The study is about the representation of word “biodiversity” and “ecosystem services” between 1995 and 2015 in “3553 media releases Australian Government environment portfolio and 1064 media releases Australian Conservation Foundation”. The usage of word biodiversity has decreased with time and the usage of ecosystem services has increased. The opinion of authors is that because of this the people may have lower connection and commitment to nature, because ecosystem services concept is a monetary one. In this point of view this is a very interesting article, because the concept of ecosystem services was invented to explain easier the value of biodiversity to economic experts.
20. *Final report of IGCP Project 410 (1997-2002) - The great Ordovician biodiversification event* (Webby et al., 2004) (*sa, doi-0, C2*). It is not strongly related to our topic, it was in the results, because there are some diversity measurements which can help to communicate the value of biodiversity to policymakers.
21. *Merging science and arts to communicate nature conservation* (Opermanis et al., 2015) (*sa, doi-1, C5*). They have started the “Nature Concert Hall” project, where they combined science with art. Based on their poll, the 56% of the visitors wouldn't have go to the event if there would be just the scientific component and after the event 80% of visitors said they have learnt something about biodiversity.
22. *Biodiversity and Education for Sustainable Development* (Barrico & Castro, 2016) (*b, doi-1, C7*). The book is about: invasion biology, sustainable development, online educational material, urban biodiversity. The main conclusion is that the society must be implicated to the conservation biology, one of the detailed projects which is strongly related to our project is presented at 10th highlighted result.

23. *Discourse studies of scientific popularization: Questioning the boundaries* (Myers A, 2003) (*sa, doi-1, D2*). The article's conclusion is that scientific communication should be a two-way communication. The public shouldn't be just a "blank slate" in the eyes of scientists.
24. *Metaphors for environmental sustainability: Redefining our relationship with nature* (Larson, 2011) (*b, doi-0, D3*). The science communicators should use metaphors to have more efficient communication.
25. *From carbon markets to carbon morality: Creative compounds as framing devices in online discourses on climate change mitigation* (Koteyko et al., 2010) (*sa, doi-1, D4*). The article is about comparing the framing techniques in the science communication of climate-change through the time: financial framing (1992-1999), lifestyle framing (1992-2004), attitude framing (2004-2008).
26. *Animals erased: Discourse, ecology, and reconnection with the natural world* (Stibbe, 2012) (*b, doi-0, D5*). The book is about why is important to have connection with nature, in principle focuses on animals – people relation and also has the conclusion that using metaphors can help in communication.
27. *Public attitudes toward ecological restoration in the Chicago Metropolitan Region* (Bright et al., 2002) (*sa, doi-1, D6*). The conclusion of article is that in the society there are negative and positive attitudes towards ecological restoration in the Chicago Metropolitan Region, and to have more positive attitudes it is a must to have proper nature education.
28. *Focus on metaphors: The case of "Frankenfood" on the web* (Iina Hellsten, 2003) (*sa, doi-0, D7*). It is not strongly related to our topic, because it is about the metaphor "frankenfood", which is about genetically modified food.
29. *Visualizing biodiversity: The role of photographs in environmental discourse* (Seppänen & Väliö, 2003) (*sa, doi-1, D8*). Using of photographs in communication of biodiversity is important because there can create more emotional connection than simple texts.
30. *On the frontier of science: An American rhetoric of exploration and exploitation* (Ceccarelli, 2013) (*b, doi-0, D10*). It is not strongly related to our topic, it is about the metaphor of "The frontier of science".

Appendix C

Based on Citation Network1 of search A, the results are not citing to each other and they don't have common citations, we can say that they have separated topics, it is useful to read all of them (figure A1).

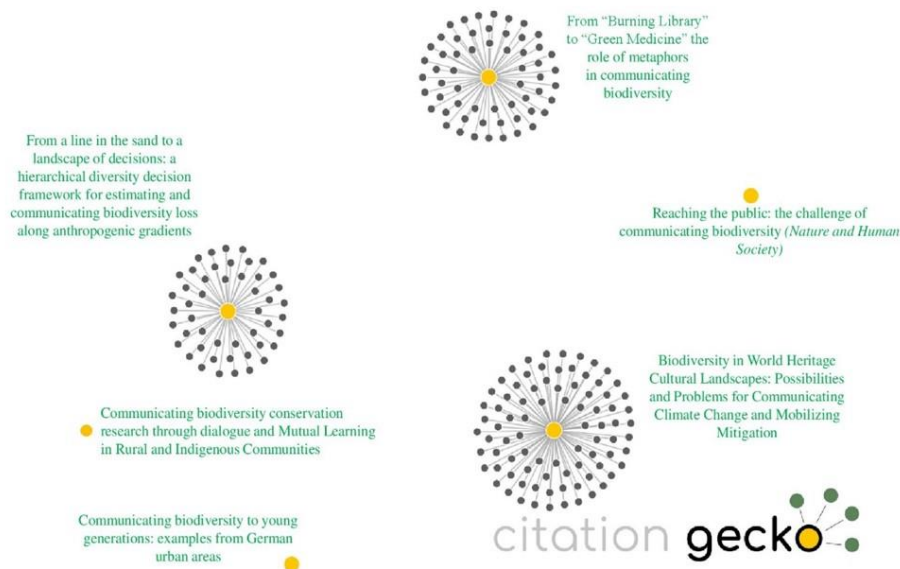


Figure A1. Citation Network 1 of search A; yellow dots – results of search A; **grey dots** – papers cited by results of search A; text-boxes: titles of papers from search A

Based on Citation Network 2 of search A, where the grey dots are the papers which are citing the results, the most important result is a paper which emphasizes that the metaphors are essential in communicating biodiversity, but it can be efficient using strong emotions (figure A2) (Väliverronen & Hellsten, 2002).

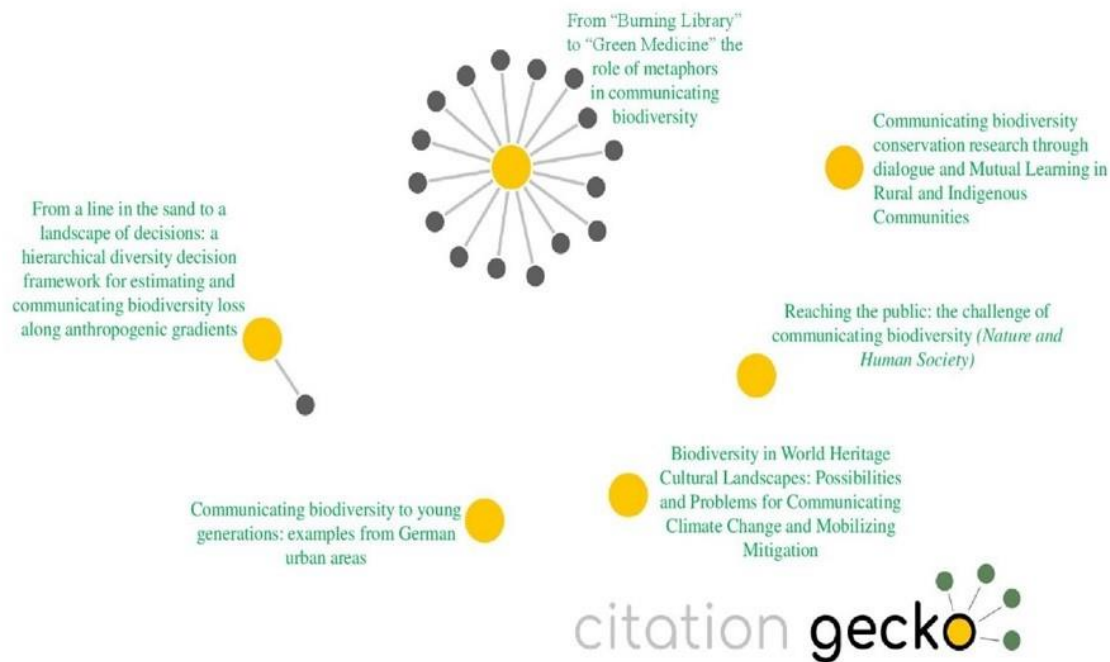
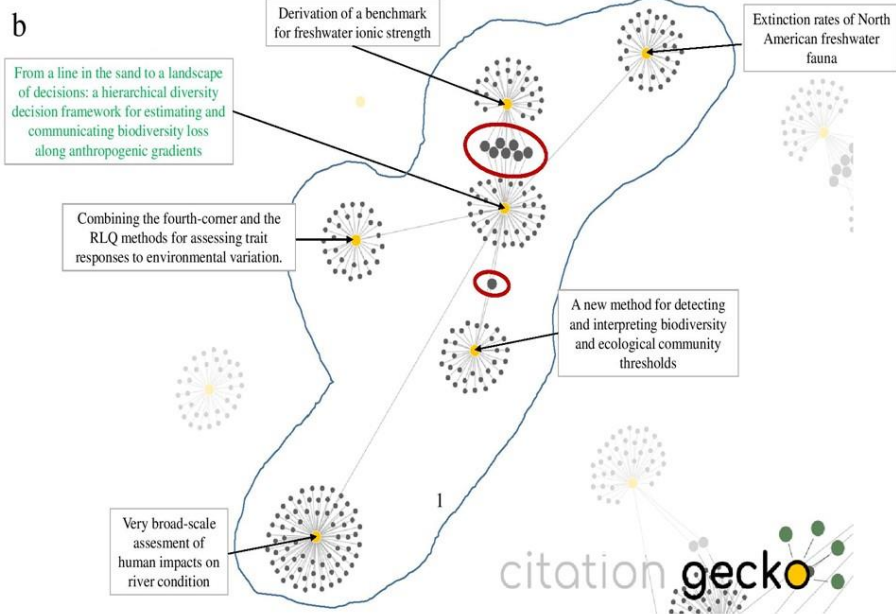
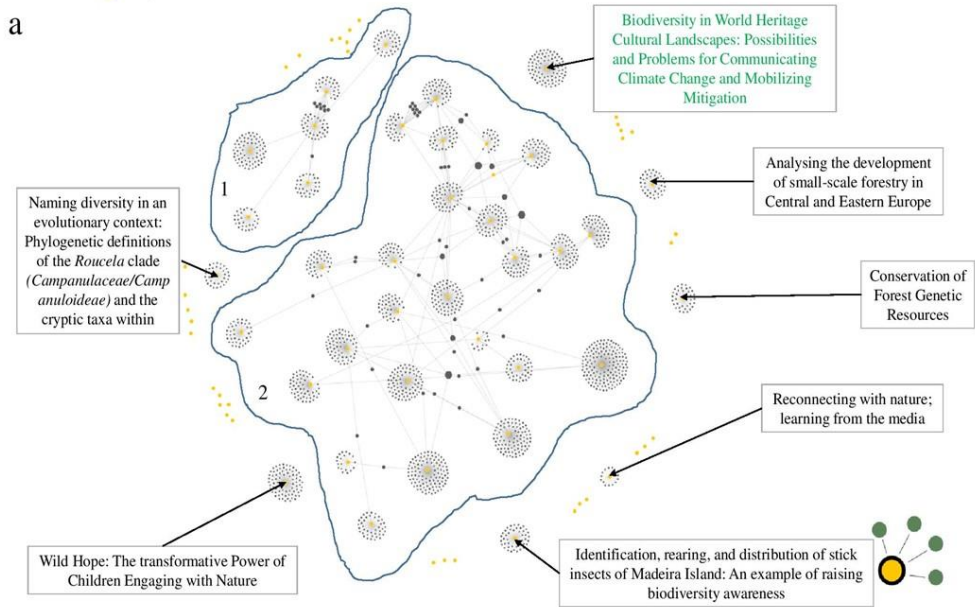


Figure A2. Citation Network 2 of search A; yellow dots – results of search A; **grey dots – papers citing to the results of search A**; text-boxes: titles of papers from search A

In case of search B from 190 results on Citation Networks there are 69 results, which had DOI-numbers (figure A3, figure A4). Based on Citation Network 1, where we can see papers cited by the results of search B, we identified 2 sub-networks and 7 hubs, which are outside of sub-networks. From 7 hubs we have marked with green letters which was in the highlighted results (figure A3 a). The first sub-networks topic is about measuring the biodiversity, we have marked with red circles publications which are important to read, but during advanced search we didn't find them (figure A3 b). The second sub-network is strongly related to our practical implementations, we have written the first 25 hubs title to the figure, with green what the search B found and with red what the search A, B or C found (figure A3 c). The publications which are important to read, but during advanced search we didn't find, we have marked with red circles (figure A3 d).



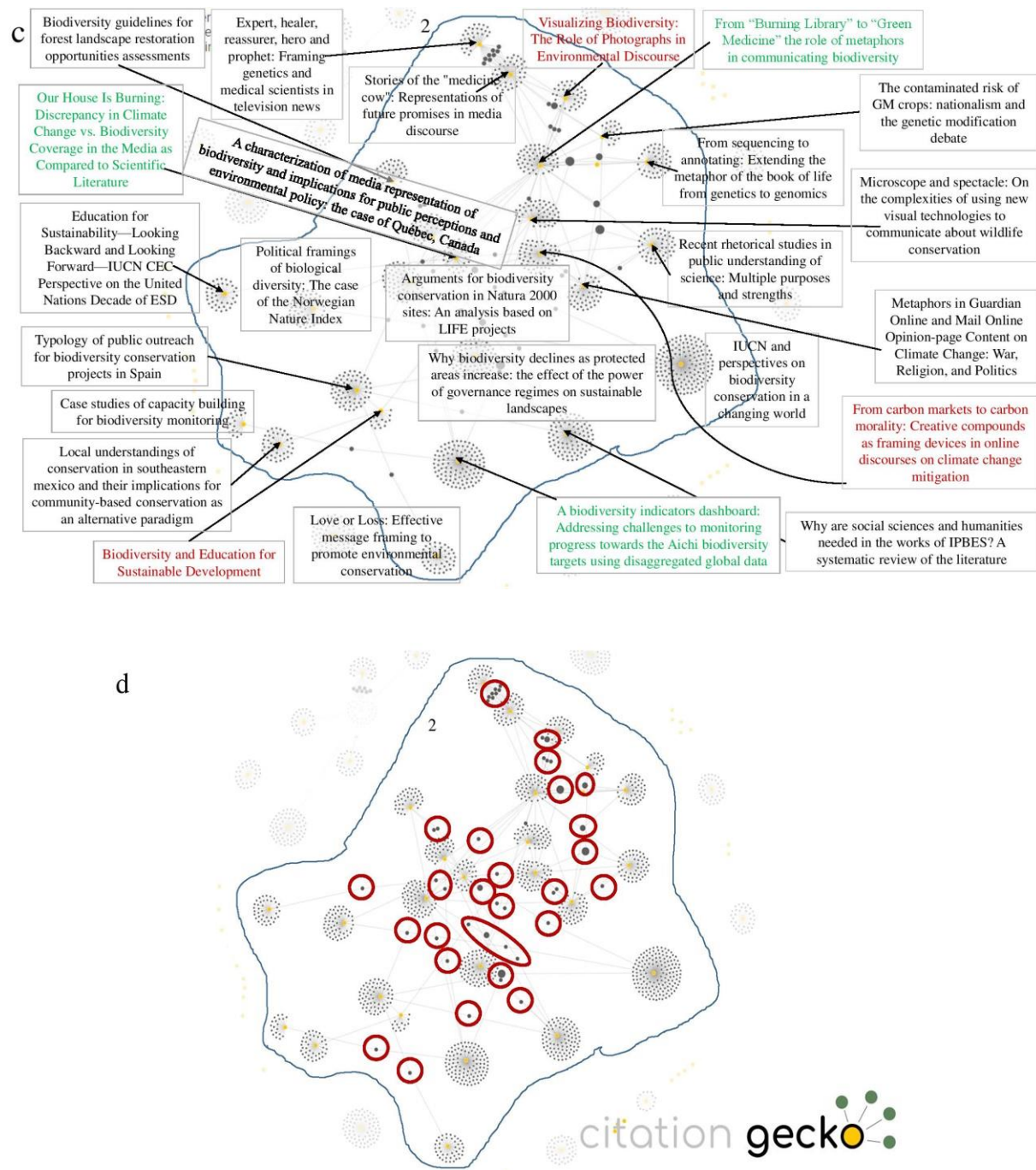


Figure A3. Citation Network 1 of search B. Yellow dots – results of search B, grey dots – papers cited by results of search B; dots circled with red - papers cited by two or more papers from search B; a – the whole network, b – 1. sub-network, c – 2. sub-network with titles, d – 2. sub-network without titles

On Citation Network 2 of search B we have the same sub-networks (topic of metaphors and topic of measuring and communicating the biodiversity to the policy-makers), but the topic of measurements of biodiversity seems more important. We have marked with red circles publications which are important to read but the searches did not find it (figure A4).

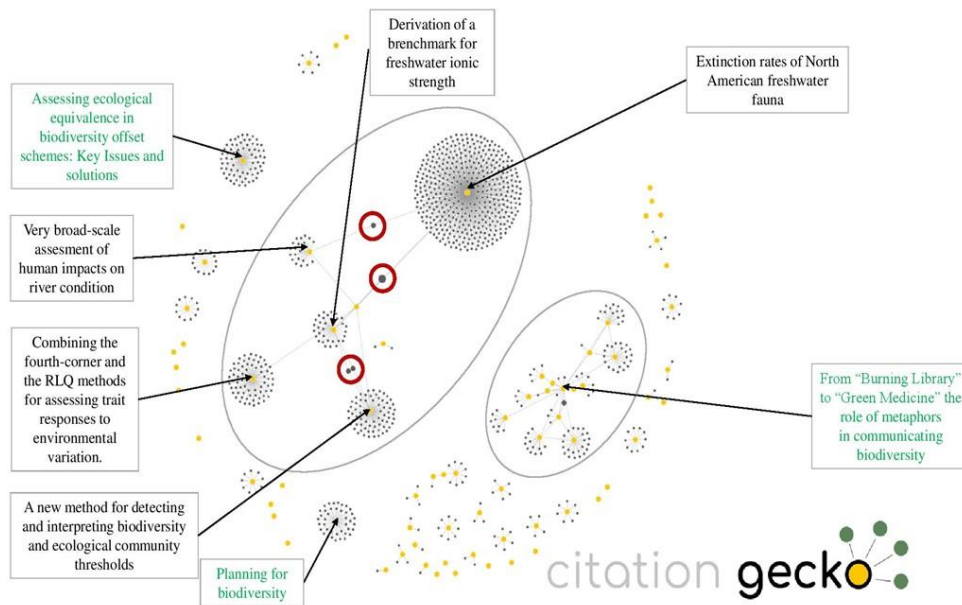


Figure A4. Citation Network 2 of search B. Yellow dots – results of search B, grey dots – papers citing to the results of search B; dots circled with red - papers citing two or more papers from search B;