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LCSH and environmental science

A comparison of subject heading and domain analyses

Abstract
The environmental sciences are characterized by their boundless interdisciplinarity and cannot be discussed independently from other scientific fields such as ecology, engineering, and climatology. The complex nature of the discipline leads to challenges in placing it within a controlled vocabulary such as the Library of Congress Subject Headings (LCSH). However, the placement of a term within a thesaurus hierarchy has potential repercussions for the discoverability of materials assigned that subject heading. As the environmental sciences are rapidly expanding due to global climate change, accurate representation of this discipline within a widely used vocabulary is crucial. In this paper we employ a visual mind mapping technique to examine how the environmental sciences are represented by codified language within the LCSH, then complete a domain analysis of the field to determine how environmental science represents itself. In comparing these two analyses we determine that the LCSH subject headings do not capture the interdisciplinary nature of the field in two primary ways; the term Environmental sciences is not sufficiently connected to the terms representing other major scientific subjects essential for a foundational understanding of environmental science, and key forward-looking topics of concern to environmental scientists such as Climatology are not in direct relationships with Environmental sciences. Correcting these issues is an important task, as ensuring that researchers are able to access a full range of environmental science materials will aid in finding sustainable climate solutions for our planet.

Keywords: environmental science, environment, subject headings, Library of Congress Subject Headings, domain analysis, classification, controlled vocabulary

Introduction

The interdisciplinary classification of environmental science leads to a difficult task in considering how subject headings can best describe and organize the field. It is precisely because of the wide reaching and complex nature of the field of environmental science that the associated subject headings should facilitate the discovery of materials between and within other scientific disciplines. As we can observe in earlier research, these subject headings are significant in ensuring that both researchers and students can access a full range of environmental science materials in their keyword searches. In this paper we examine the Library of Congress Subject Headings (LCSH) that pertain to environmental science and aim to determine whether the LCSH accurately reflects the classification and organization of the environmental sciences, as defined from within the discipline. We focus on the controlled vocabulary of LCSH because it not only is widely used in academic libraries, but is also used by both the Environmental Protection Agency Libraries of the United States and the Federal Science Libraries Network of Canada (EPA, n.d.)

Literature and background

Subject headings are key features of the discoverability of items within databases across disciplines. As Gross & Taylor found in their preeminent 2005 study, over a third (35.4%) of records found through keyword queries at an academic library were successful because of the listed subject headings. They further confirmed that subject headings are essential in a follow-up study where table of contents and summaries had been added to record metadata; 27.7% of keyword search hits would be lost without subject headings (Gross et al., 2015). Additionally, in a study comparing online public access catalog (OPAC) searches and circulation of items in another academic library, keyword searches that matched with subject terms had the third highest correlation to an item then being checked out (following only keyword searches that matched the MARC title and content note fields) (Kirkland, 2013). As the existence of subject headings within item records significantly influences the success of a user search query, it follows that the accuracy and appropriateness of subject headings may also have an impact on record discoverability. This may be especially true in fields which are diverse, complex, and highly interconnected, such as the sciences.

Science, on the whole, has been classified in innumerable ways since the nineteenth century. Perhaps most notably, in 1929 Henry Bliss documented a "scientific and educational consensus" (Bliss, 1929, as quoted in Fisher, 1996, p. 854) regarding the organization of scientific knowledge, with which scientists generally agreed; he asserted that the major scientific disciplines are "well characterized by their subject-matter, as well as by their professional identity" (Fisher, 1996, p. 854P). Though disciplines have been added, adapted, and shifted, Fisher emphasizes that the boundary lines of these main disciplines have remained largely stagnant since Bliss' work (Fisher, 1996). He further asserts that though hybrid disciplines have developed from inter-boundary collaboration, these hybrids do not indicate the breaking of boundaries or any gaps between the boundaries (Fisher, 1996, p. 866).

Environmental science is a key classificatory exception to Fisher's (1996) idea of immobile disciplinary boundaries. Garry Trompf argues that environmental science is the first field to truly break down the categorical barriers between the traditional sciences: "…harsh reality [the global environmental crisis] currently dictates that academic specialization has entered a phase of critical overload…too many subtleties and overlaps require imagination to defeat artificial borders and too many values compete over right order and rank" (2011, p. 122). He emphasizes the essential interdisciplinarity of the environmental sciences, and that researchers must intentionally distinguish which disciplines are required in achieving environmental sustainability (Trompf, 2011). Though Trompf's work is largely theoretical, many other scholars have written practically on strategies to promote and navigate interdisciplinary research within environmental science (Hicks et al., 2010; Perz et al., 2010; Palmer et al., 2005; Proctor et al., 2013).

In the following section, we present and synthesize two approaches to subject heading analysis that form the theoretical basis of our research. From this theoretical grounding we derive a two-stage methodology for examining how well the LCSH represents the field of environmental science: first we map the organization of LCSH terms related to environmental science using a concept mapping technique. This technique expands the subject heading analysis work of previous scholars and allows for a representation of connections between terms within a controlled vocabulary. Though the relationships between thesaurus terms have not been widely studied, the work of Gross, Taylor, and Kirkland leads us to believe that these relationships could be important and warrant their own investigation (Gross & Taylor, 2005; Gross et al., 2015; Kirkland, 2013). Second, we conduct a domain analysis of the environmental sciences by surveying conference schedules and university curricula from the field. We then compare these findings with the organization of the related LCSH terms.

Two conclusions can be drawn from this comparison: 1) the LCSH does not adequately connect the environmental sciences to other major scientific disciplines, and 2) subjects which are key concerns for current environmental scientists are not sufficiently related to the parent term, *Environmental sciences*. These conclusions could be of concern to environmental scientists and researchers because of the aforementioned inherent interdisciplinarity of this important field and could ultimately have repercussions in the discoverability of materials and research which are quickly shifting and evolving in focus and scope.

Methods: subject and domain analyses

In this section we will detail the two analytical methods we synthesize to form our method of inquiry for the *Environmental sciences* subject heading. These methods are developed in the works of Joseph Tennis (2007, 2012) and Jens-Erik Mai (2001, 2005), supplemented by Birger Hjørland (2002). Their methodologies of subject ontogeny, semiotics, and domain analysis, respectively, complement each other well and together shape our consideration of how LCSH reflects the field of environmental science. We will employ them to analyze the mapping of the *Environmental sciences* subject heading in the next section.

Tennis (2012) largely focuses on how subjects change/develop within cataloging systems over time, or what he calls subject ontogeny. He examines "eugenics" as a case study due to its uniqueness in that the subject's meaning within the Dewey Decimal Classification (DDC) has changed in both application and discipline since its introduction in 1911 (Tennis, 2012). His main argument is that if those who design vocabulary systems understand in what ways subject terms change over time, they can incorporate that knowledge so that subject ontogeny does not compromise the functional integrity of the system. Since a subject can shift within the system (including moves within and between classes, as the case of "eugenics" demonstrates), it "has a life of its own;" better understanding this "life" allows us to critique long-lived classification systems such as DDC over time (Tennis, 2012, p. 1352). Tennis (2007) provides concrete methods of documenting the life of a subject in his earlier work on the topic, most notably adapting Dagobert Soergel's (1974) term record into a highly usable "scheme change value record" (Tennis, 2007, p. 96).

To consider subject ontogeny within the context of the domain a subject falls under (for example, how "eugenics" may fall under the broader domain of "pseudoscience"), we can turn to the work of Mai. He highlights the importance of indexers understanding both the information needs of the user and the larger domain of the materials in order to properly assign subject terms (Mai, 2005, p. 600). He advocates for a domain analytic approach "to study the activities and products of domains to gain insights into 'already there' structures and meanings" (Mai, 2005, p. 605). This approach was first coined by Hjørland & Albrechtsen (1995), and Hjørland (2022) later wrote a methodology-focused paper outlining eleven methods to completing domain analysis. One method consists of modeling "structures and institutions in scientific communication," (Hjørland, 2002, p. 446) which involved examining primary, secondary, and tertiary documents created by information producers (institutions) for users. We will return to this method later on.

Mai's (2001) examination of the domain to inform interpretation of materials falls under the first step of his three-step approach to indexing. He defines the three steps as deciding the subject(s) of the document, putting the subject matter into formal language, and then "translating" the subject(s) into the language used by the index (Mai, 2001, p. 592). The language in the third step refers to the codified subject headings, tags, or keywords that the classification system employs. Mai (2001) analyzes these three steps using Charles Peirce's (1955) semiotics framework, and for the sake of clarity we focus only on signs and their objects (his full framework consists of signs/representamens, interpretants, and objects). Peirce defines a sign as "something that stands to somebody for something in some respect or capacity," and an object as the "something" the sign stands for (Peirce, 1955, p. 99, as cited in Mai, 2001). In indexing practice, one might consider the subject terms to be the signs for the objects of materials in a collection.

By focusing on the semiotics of Mai's (2001) third step in materials indexing, we can connect the domain considerations in analyzing a document's subject with how the domain is represented in the codified subject terms Tennis studies. Multiple questions can be raised here, such as, what happens within the system if there are not appropriate signs to best represent an object? In other words, what if an indexing language does not fully or accurately reflect the domains of certain subject terms? Our theoretical approach to this research that seeks to answer these questions is an intersection and combination of the methodologies of Tennis (2007; 2012), Mai (2001; 2005), and Hjørland (2002); analyzing the domain of environmental sciences in comparison to how the subject is represented by codified language within the LCSH will lead to an understanding of whether these subject headings accurately capture the interdisciplinary nature of the field.

Our methodology takes a two-stage approach, each stage mirroring one of the two aforementioned theoretical underpinnings. First, we create a visual concept map of the LCSH subject headings related to *Environmental sciences* and raise points of concern with how the controlled vocabulary represents the discipline. This mapping approach expands the subject ontogeny work of Soergel (1974) and Tennis (2007; 2012) by creating a visual representation of connected subject headings within a thesaurus with the intent to examine relationships between terms instead of the history of individual terms themselves. As mentioned in the Introduction, term relationships have not been explored in the literature, and this concept map method could be employed further by LIS scholars to investigate other sections of the LCSH or similar vocabularies. Second, we conduct a domain analysis of the environmental sciences using Hjørland's (2002) method of examining documents created by institutions which represent the discipline. The institutions we chose to represent the field are universities and scientific conferences, both of which directly represent and promote the interests and focuses of environmental sciences in the present as well as highlight areas of future concern. These institutions also openly publish all materials online, allowing us to complete the domain analysis. We conclude by revisiting our points of concern given the results of this domain analysis.

In their recent work, Furner and Hjørland (2023) employ a similar methodology to examine the LCSH in regard to terms related to LIS; they discuss key subject headings and represent their LCSH entries with tables, then compare this with their own expert knowledge of LIS. In the present study we instead represent the LCSH by visually mapping how key terms relate to one another, allowing for a more robust understanding of subject heading relationships. Additionally, as we are not experts in the domain of environmental science, we rely on documents produced by institutions in the field to complete our domain analysis.

Mapping LCSH subject headings

When first reading the subject heading entry for *Environmental sciences* in the LCSH, it is striking how few terms to which it is directly connected. As can be observed in the excerpt in Figure 1, it only has 6 narrower terms (NT) and no related terms (RT) to any other scientific disciplines.

Environmental sciences *(May Subd Geog)*
[GE]
Here are entered works on the composite of physical, biological, and social sciences concerned with the conditions of the environment and their effects. Works on the interrelationships of organisms and their environment, including other organisms, are entered under Ecology. Works on the relationship of humans to the natural environment are entered under Human ecology. Works on the relationship of humans to their sociocultural environment are entered under Social ecology.
UF Environmental science
BT Science
NT Communication in the environmental sciences
Earth sciences
Ecology
Environmental management
Environmental protection
Offenses against the environment
—Philosophy
[GE40-GE45]
NT Naturalness (Environmental sciences)
—Social aspects
NT Environmental sociology
—Societies, etc.
NT Eco clubs

Figure 1 ***Environmental sciences*** **LCSH entry**

To visualize the effects of this seemingly lacking entry, we mapped how/if it is related to other scientific disciplines and how distant those connections are. We began at *Environmental sciences*, and tracked its broader terms (BT), NT, and RT until we encountered all other major scientific fields and large topics related to environmental science (such as climate change). The first author plotted these connections using a mind map diagramming technique, through a free online software, Miro. Within the map, only terms that are important to the topic of interest are featured as their own entry, and any additional NT are entered in a list format. The map is pictured in Figure 2.

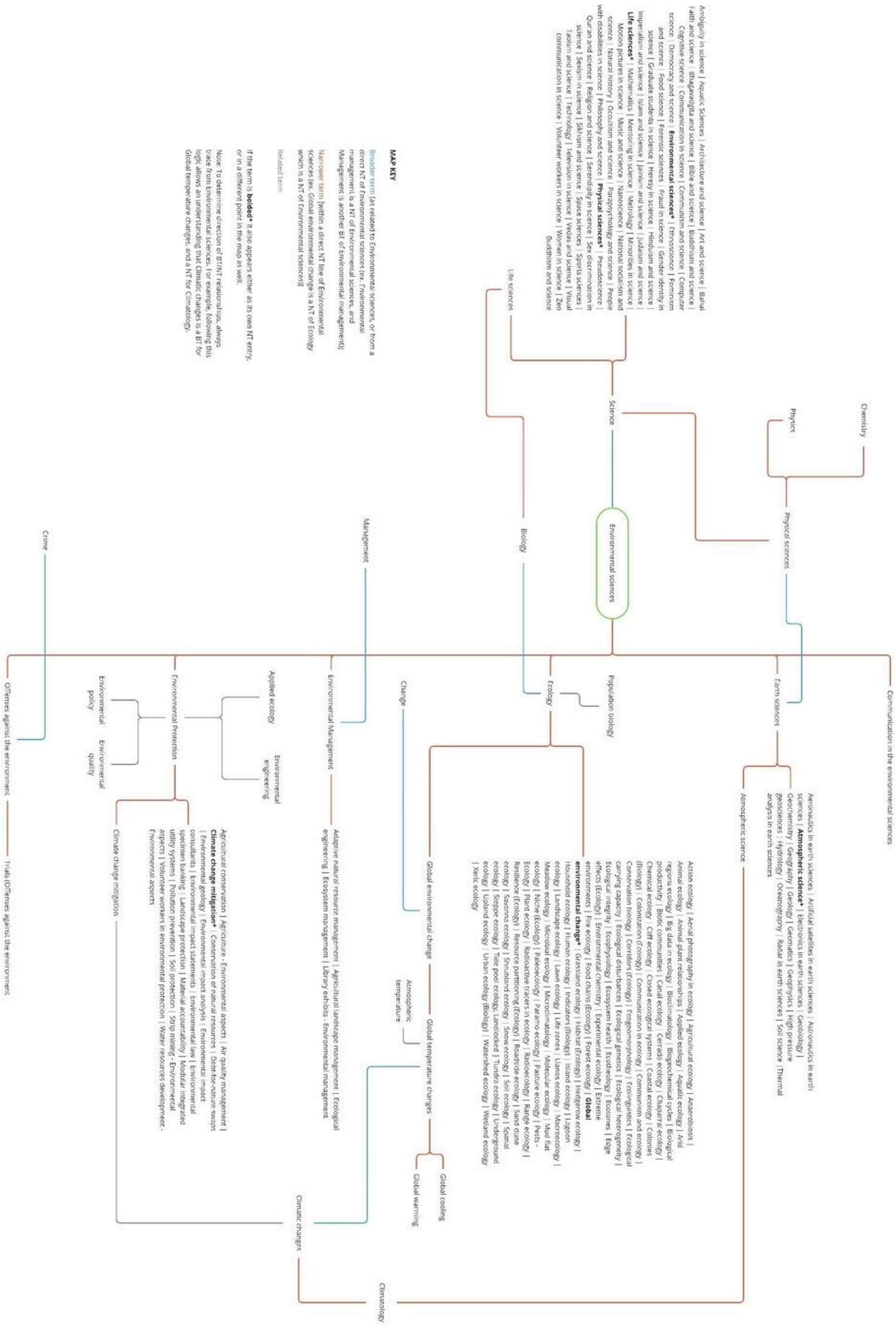

Figure 2 ***Environmental sciences*** **mind map**

As is indicated in the map key (Figure 3), blue lines indicate a BT as related to *Environmental sciences*, or from a direct NT of *Environmental sciences* (ex. *Environmental management* is a NT of *Environmental sciences*, and *Management* is another BT of *Environmental management*).

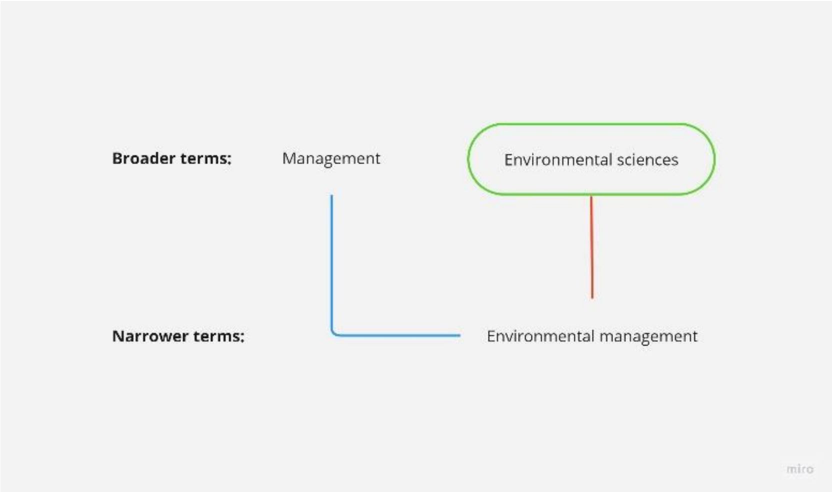

Figure 3 Broader term example

Orange lines (Figure 4) indicate a NT within a direct NT line of *Environmental sciences* (ex. *Global environmental change* is a NT of *Ecology* which is a NT of *Environmental sciences*).

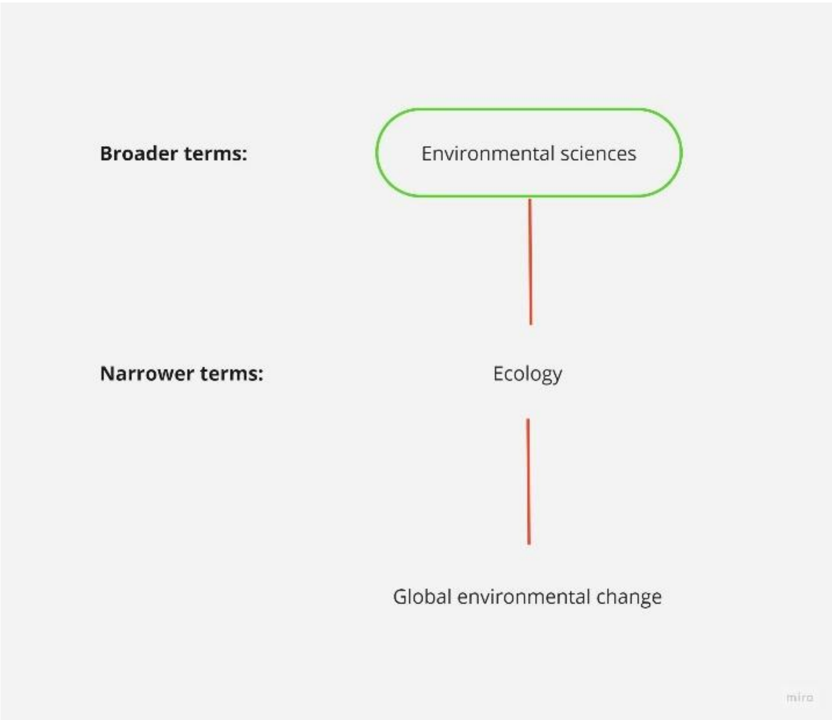

Figure 4 Narrower term example

Grey lines (Figure 5) indicate a RT. To determine direction of BT/NT relationships, always trace from *Environmental sciences*. For example, following this logic allows an understanding that *Climatic changes* is a BT for *Global temperature changes*, and a NT for *Climatology*.

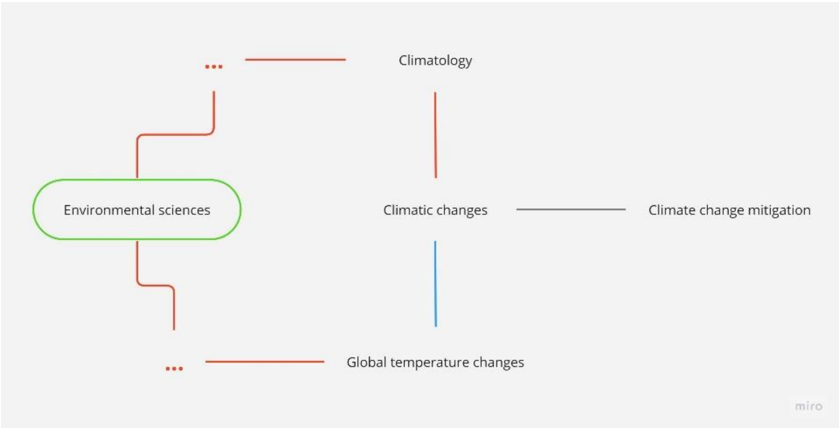

Figure 5 Term relationship directionality example

We discuss the closeness of terms with this section of the LCSH in terms of "steps"; a step is equivalent to one connection line. As an example, *Global environmental change* is two steps from *Environmental sciences*.

Two potential areas of concern are illuminated by Figure 6. First, the LCSH divides the sciences into three major subjects: *Environmental sciences*, *Life sciences*, and *Physical sciences*. The only other broad scientific discipline that *Environmental sciences* has a direct relationship with is *Earth sciences* (BT/NT). The other two major scientific disciplines are two steps removed from *Environmental sciences*. *Life sciences* is related to *Environmental sciences* in two ways; it is also a NT of *Science*, and is a BT of *Biology* which is a BT of *Ecology*, which is itself a NT of *Environmental sciences*. *Physical sciences* is also a NT of *Science*, and is a BT of *Earth sciences*, which is a NT of *Environmental sciences*.

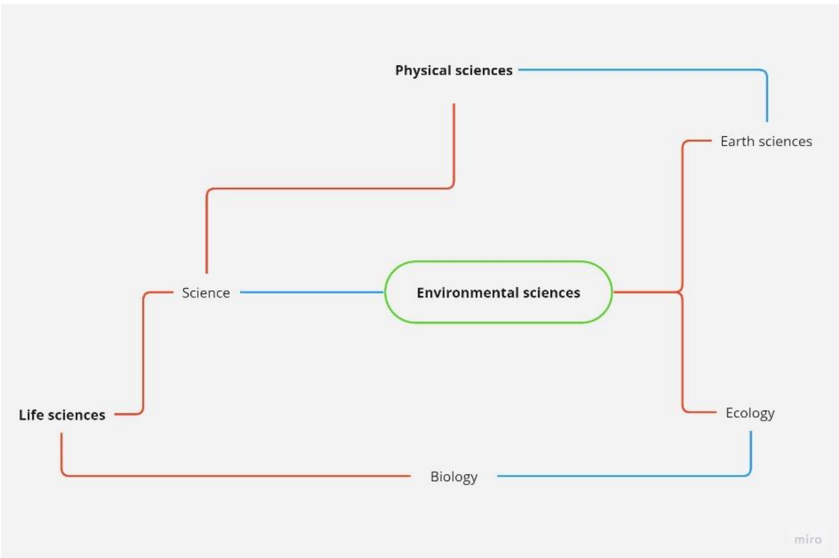

Figure 6 ***Environmental sciences*** **in relation to other major disciplines**

From Figure 7, it is easy to see that while these terms hover around *Environmental sciences*, they are not placed in direct relationships with the subject. This leads us to question why these major scientific discipline categories are not all directly connected, perhaps in RT relationships. In only relating *Environmental sciences* to *Earth sciences* and *Ecology*, users may miss relevant materials that are cross-disciplinary with sub-topics of the other major sciences.

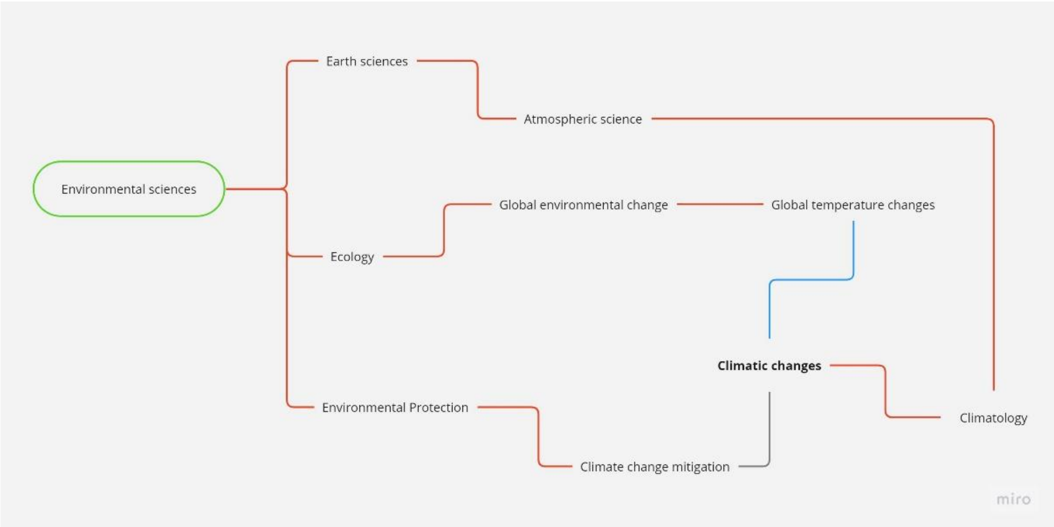

Figure 7 ***Environmental sciences*** **in relation to** ***Climatic changes***

The second concerning and potentially outdated aspect of this group of terms is how distantly related *Climatic changes* and *Environmental sciences* are within LCSH. *Climatic changes* is four steps from *Environmental sciences*, and can be reached by either following NTs from *Ecology* or from *Earth sciences*. It can also be reached by tracing both NTs and RTs from *Environmental protection*.

At this point in the climate crisis, all aspects of the environmental sciences are affected by climate change, which does not seem to be reflected in LCSH. *Climatic changes* is connected to other scientific terms in LCSH through its BT, *Climatology*, but even this term is three steps from the broader discipline of *Environmental sciences*. While we understand why these vast subject areas are broken down and compartmentalized within the controlled vocabulary, it seems as though the escalating climate crisis warrants a reconsideration of the weight of the preferred term *Climatic changes* as it relates to *Environmental sciences*. In the following section we analyze the domain of *Environmental sciences* to determine how the discipline relates itself to other scientific subjects and assess whether these two potential problems within LCSH are substantiated.

Environmental sciences domain analysis

As mentioned in our theoretical framing of subject analyses, we follow Hjørland's (2002) domain analysis methodology of modeling "structures and institutions in scientific communication" to determine how the field of environmental sciences positions itself in relation to other scientific disciplines (Hjørland, 2002, p. 446). We investigate various communicative "documents" from the field to understand the purpose and goals of environmental sciences as a domain, focusing on what Hjørland (2002) would describe as primary documents produced by information institutions. The first materials are conference programs and schedules from five major international conferences specifically pertaining to environmental science. These allow us to observe how the field organizes environmental sub-topics, and which other scientific disciplines are represented within environmentally focused discussions. We then examine the course requirements for Environmental Science/Studies undergraduate degrees at four universities across Canada and the United States: one large research institution and one small undergraduate college from each country. These materials illustrate what knowledge is viewed as integral to understanding the environmental sciences, and which other disciplines are most closely related. Together, both the conference programs and course requirements reinforce the inherent interdisciplinary nature of environmental science. The materials also provide concrete examples of the real-world use of LCSH concepts and indicate the degree of proximity these terms should have within the controlled vocabulary.

Conference programs

The international science conferences we chose vary in scale and specificity, but all encompass topics within environmental science and are well attended by a diverse international community of industry leaders and scientists. Though there are many more annual conferences that include or center environmental science, many are not well documented online or are specific to the issues of the host country. We thus selected the following conferences:

- UN COP26
- ICESA’21: International Conference on Environmental Science and Applications
- CEST2021: International Conference on Environmental Science and Technology
- ICSD 2021: International Conference on Sustainable Development
- WMESS 2022: World Multidisciplinary Earth Sciences Symposium

For each conference, the first author surveyed either the program or schedule and recorded the theme(s) of each discussion session to get an idea of the range of topics the conference covered. We chose not to consider the paper subjects of keynote talks, as they were often highly specialized, and we are more interested in the subjects around which the overall conference was organized.

The interdisciplinary nature of these conferences is apparent on multiple levels. First, the number of distinct session themes (not including topics that spanned multiple sessions) at each conference is significant, with three of five conferences having 29 or more different themes (CEST2021, ICSD 2021, WMESS 2022). Second, only 17 of 77 session themes across all five conferences contain the words “environment” or “environmental,” indicating that the majority of themes are either sub-topics of or related topics to environmental science. Finally, clear patterns in session topics across conferences imply a consistent relationship between the topic disciplines and environmental science. Five of the most commonly covered topics and their potential broader disciplines are outlined below:

Table 1 Environmental science conference themes and disciplines

Session Theme	Conferences	Broader Discipline(s)
Pollution/pollutants	COP26, ICESA, CEST, WMESS	Atmospheric science, energy, oceanography, ecology, climatology
Water resources	COP26, CEST, ICSD, WMESS	Hydrology, oceanography, natural resources, urban planning
Urban development	COP26, ICESA, CEST, ICSD, WMESS	Urban planning, engineering, technology
Greenhouse gases	COP26, ICESA, CEST, ICSD, WMESS	Chemistry, atmospheric science, climatology, public health
Disaster mitigation	COP26, CEST, ICSD, WMESS	Natural hazards, engineering, public health, urban planning, agriculture, forestry, etc.

Environmental science degree requirements
In choosing the second set of materials, we also prioritized variations in scale and specificity. The two large research universities we studied are The University of British Columbia (UBC) and The University of Colorado (CU), and the two smaller undergraduate institutions are Mount Allison University and Oberlin College. Each school offers either an Environmental Science(s) or Environmental Studies major for undergraduate students. Though the two types of institutions vary greatly in terms of structure, size, and focus, the environmental majors of all four schools require very similar coursework.

Each program requires students to take more than one course in the disciplines of chemistry, biology, and math, with UBC, CU, and Mount Allison also requiring physics courses, and each college supplementing with selected earth science courses (Mount Allison University, n.d.; Oberlin College and Conservatory, n.d.; University of British Columbia, n.d.; University of Colorado Boulder, 2015). Similar to other academic majors, the programs require students to pursue a concentration after completing the aforementioned core courses. However, these concentrations/specializations are quite varied and cross many scientific disciplines. For example, at Mount Allison students choose one "science stream" to follow in their program; their options are aquatic environments, environmental chemistry, environmental monitoring and management, and environmental modeling (Mount Allison University, n.d.). At CU the specialization options are more diverse, covering climatology, ecology, hydrology, geology, public and environmental policy, economics, and ethics (University of Colorado Boulder, 2015).

From their curriculum descriptions, it is clear that the environmental science/studies programs at UBC, CU, Mount Allison, and Oberlin are based in an interdisciplinary approach to the field. Given the similarity between the programs at very different institutions, we can assume that most environmental science undergraduate degrees are structured in this way. Students, as emerging researchers and professionals in the field, are thus required to access materials across scientific disciplines simultaneously and in relation to each other. This begins to indicate how gaps in the connection of LCSH terms related to environmental science may affect key users in the field. In the following section, we compare the organization of both environmental science curricula and conferences to the LCSH map to further determine disparities between the LCSH and the domain of environmental science.

Findings: domain and LCSH comparison

From the previous analysis, 11 major disciplines are consistently tied to environmental science: urban planning, hydrology, atmospheric science, oceanography, public health, engineering, climatology, chemistry, biology, earth sciences, and physics. Though this list is not exhaustive, as environmental science is boundlessly interdisciplinary, these subjects consistently emerged across college curricula and professional conferences as either essential for working in the field or major areas of consideration for the future. These subjects therefore have direct ties to environmental science, and would presumably be closely connected within a controlled vocabulary or classification system. To determine whether or not this expectation is fulfilled, the first author revisited the LCSH map and either added or highlighted these 11 topics. They can be observed in bright green in Figure 8.

The only key subject within one step of *Environmental sciences* is *Earth sciences*, as they are in a BT/NT relationship. The other 10 subjects are all at least 2 steps removed from *Environmental sciences*, with *Hydrology*, *Atmospheric science*, *Oceanography*, and *Environmental engineering* at 2 steps; *Climatology*, *Chemistry*, *Physics*, and *Biology* at 3 steps; *City planning* (the UF term for urban planning) at 4 steps; and *Public health* the most removed at 5 steps. It is understandable that LCSH would more closely situate niche subjects such as *Hydrology* under *Earth sciences*, and these most niche subjects are all within two steps of *Environmental sciences*. However, the subjects that have a 3-step or more removal from *Environmental sciences* confirm the concerns we raised when analyzing the LCSH map on its own; first, this discipline is not sufficiently connected to other major scientific subjects that our domain analysis indicates are foundational in understanding *Environmental sciences* as a whole. Within a well-constructed controlled vocabulary, RTs should be assigned to the term in a hierarchy most closely having this relation (Aitchison et al., 2000). It thus follows that, for example, *Environmental sciences* should be related to *Climatology* in a direct RT relationship, though not to its BTs, *Atmospheric science* and *Earth sciences*. Even going by very conservative applications of thesaurus construction, the LCSH falls short in the number of direct connections *Environmental sciences* should have to the identified key scientific subjects.

Second, within LCSH key forward-looking topics of concern to environmental scientists such as *Climatology*, *City planning*, and *Public health*, are far removed from the main term, which may have repercussions in the discoverability of related materials. As mentioned in the Introduction, Gross & Taylor (2005) and Kirkland (2013) notably documented the importance of subject headings in item discoverability using keyword searches. In academic libraries, which is where many scientists would be searching for materials, keyword searches that match with subject headings are one of the most effective ways to find relevant materials (Gross & Taylor, 2005; Kirkland, 2013). *Environmental sciences* materials that also fall under the category of related fields, such as *City planning*, may not be suggested for researchers due to hierarchical distance between these terms in the LCSH. This theory requires further research, which will be discussed in the next section.

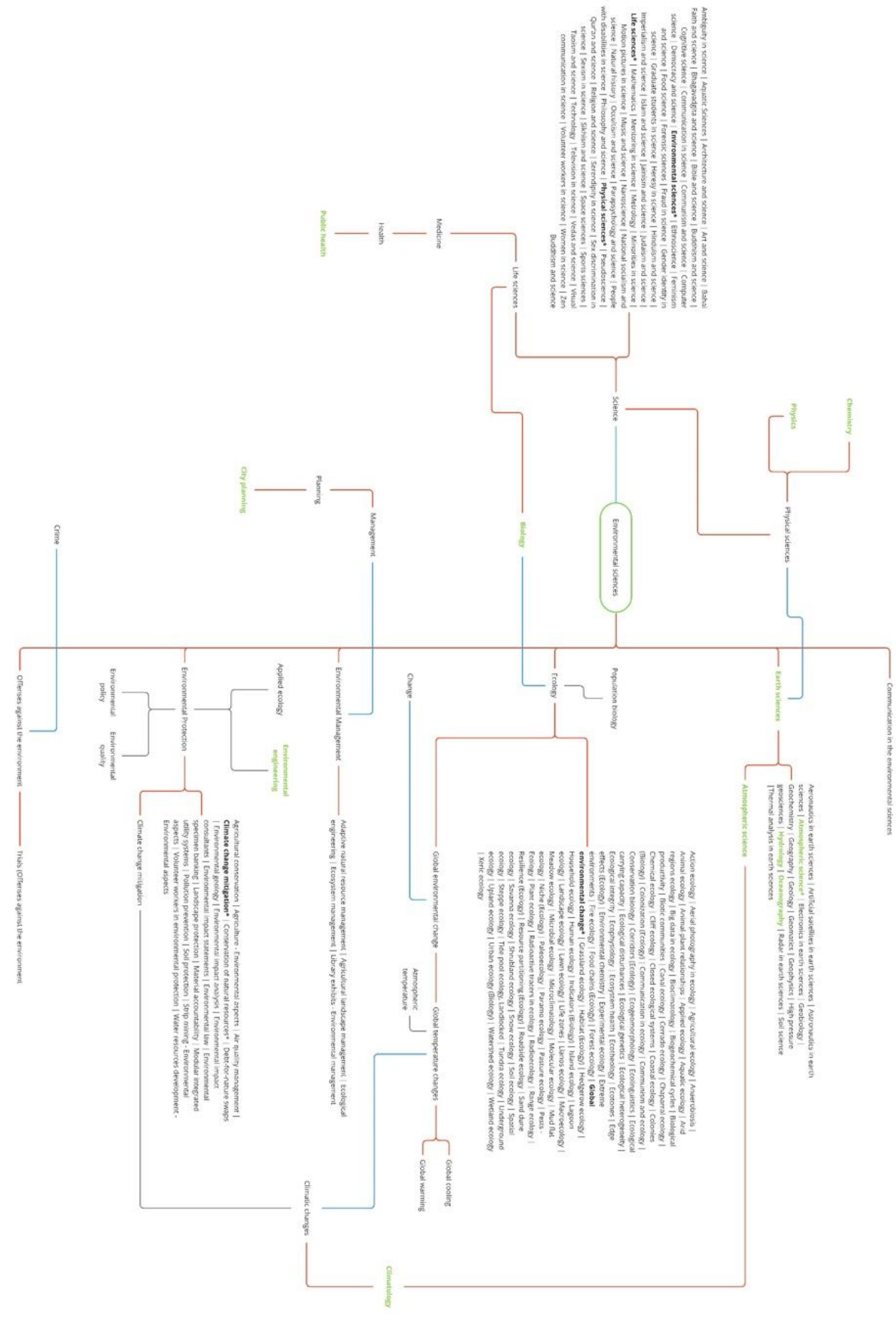

Figure 8 ***Environmental sciences*** **mind map: domain and LCSH comparison**

In addition to a general need to distinguish the many scientific disciplines from one another within the LCSH, there are two main explanations for why *Environmental sciences* may be insufficiently connected to the other identified terms. First, the entry for the term has not been updated since at least 2012, as per the publicly available LCSH archives (Library of Congress, n.d.-a). Given the field's rapid expansion and development, over a decade of term stagnation would likely lead to inadequacies and inaccuracies in the term's description and connections. Second, the scope note (SN) for *Environmental sciences* indicates that the subject contains "works on the composite of physical, biological, and social sciences concerned with the conditions of the environment and their effects," and specifies that works related to the environment and organisms, humans, and sociocultural factors are entered under *Ecology*, *Human ecology*, and *Social ecology*, respectively (Library of Congress, n.d.-b). With this SN the LCSH indicates *Environmental science*'s niche within the controlled vocabulary, attempting to distinguish it from other scientific subjects. However, relegating the subject to a small niche erases its intrinsic interdisciplinary nature. While it has been established that the *Environmental sciences* are a hybrid or composite of many different disciplines, those disciplines are essential to understanding and completing research in environmental sciences. As such, one would expect subjects such as *Physics* and *Biology* to at least have a RT relationship with *Environmental sciences*. Additionally, works that relate humans and sociocultural factors to the environment comprise major areas of emerging research within the field, as the common conference topics of urban planning and public health indicate. They should thus likely be included under the umbrella of *Environmental sciences* itself, instead of being at least 2 steps removed.

These findings have implications for both the study of controlled vocabularies and research in the environmental sciences. Our conclusions indicate that the interdisciplinary field of environmental science is not well represented by LCSH, which leads us to question which other complex fields are misrepresented in the controlled vocabulary. Furner and Hjørland (2023) have determined that LCSH does not accurately describe LIS, another wide-reaching and interconnected discipline. In domains such as these, how can controlled vocabularies such as LCSH adapt to and keep up with highly interconnected and rapidly changing/expanding subjects and therefore subject headings? Additionally, as the climate crisis worsens and the environmental sciences continue to evolve in scope and focus, it is essential that researchers are able to conduct their studies and search for materials efficiently and accurately. The issues we identified of insufficient connections to both other major scientific disciplines and key subjects of concern for environmental scientists could lead to problems with item indexing and discoverability within databases. This is a concern requiring further research, as we will now discuss.

Limitations and future research

There are two main limitations of this research and areas requiring further study. First, the domain analysis of the environmental sciences was relatively limited in this paper. A larger review of the field, preferably in conjunction with environmental science professionals, would be needed to conclusively establish how the field defines itself and should thus be represented in a controlled vocabulary. Second, though this paper indicates that LCSH may not appropriately represent the field of environmental science in terms of its relationship to other scientific disciplines and subjects of major concern for current researchers, the practical impact of these findings remains unknown. Further research is required to determine whether inadequate subject headings may have similar effects on material discoverability as a complete lack of subject headings, though methods from previous studies could be adapted for this research (see Gross & Taylor, 2005; Gross et al., 2015; Kirkland, 2013). In particular, research targeting library user searches for environmental science materials could test whether these conclusions could lead to tangible gaps within environmental science research and education. This future research would be of great value, as the field of environmental science is one of utmost importance in our rapidly deteriorating climate. Ensuring that environmental scientists are able to access a full range of interdisciplinary materials when completing search queries in both academic and governmental libraries meaningfully contributes to their ability to urgently find sustainable solutions for our planet.

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