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The Impact of Grey Literature in Advancing Global Karst Research: An Information Needs Assessment for a Globally Distributed Interdisciplinary Community

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Abstract A survey of the global karst community was conducted in 2006. The survey was distributed via the World Wide Web to known karst researchers. The instrument was designed to generate an initial inventory of core grey information types, to assess levels of usage of grey information by the respondents, and to gauge the karst community's willingness to participate in building and expanding both this collection and the associated controlled vocabularies.

Keywords Grey literature · Information needs assessment · Karst research · Karst topography · Geology · Geoscience · Karst Information Portal

Background

In 2005, an interdisciplinary work group of faculty, librarians, and graduate students was convened under the auspices of the Dr. Kiran C. Patel Center for Global Solutions at the University of South Florida to discuss global information needs. The group quickly focused upon water issues and then more specifically karst, a very complex and vulnerable type of geologic landform [10]. Following these deliberations, the group initiated a study to determine the feasibility of constructing

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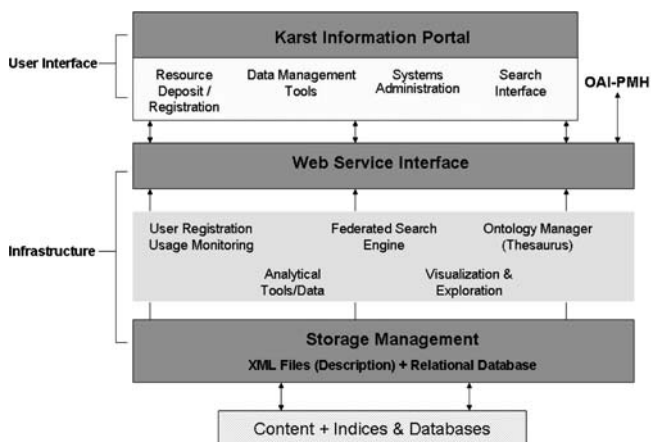
a global information portal to be hosted and maintained by the libraries in collaboration with the Patel Center and related academic departments.

In January 2006, a group of 29 scientists, information specialists, and policy makers representing 18 organizations from across the globe met in Carlsbad, New Mexico to explore development of the Karst Information Portal (KIP) to serve as a repository for karst information, to advance collaboration among the international community of karst researchers, and to promote knowledge discovery through innovative applications of metadata. Figure 1 depicts the architecture of the proposed portal.

The Context

Karst is a globally distributed terrain resulting from the dissolution of soluble rocks such as limestone and dolomite. This dissolution occurs when rainwater infused with carbon dioxide passes through layers of soil and bedrock (see Fig. 2). Karst regions contain aquifers and common geological structures such as sinkholes, springs, and caves. The relationship between karst landscapes and water resources evokes the need for greater understanding of the issues underlying these formations.

The karst research community and its knowledge base are fragmented, globally distributed, highly interdisciplinary, and at the same time, essential to comprehensive understanding of many social, environmental, and health challenges. In a recent study of four widely used indices covering relevant “white” content, 4,300 individual searches using 632 karst-related terms culled from appropriate thesauri found that, over the period 1960–2005, publication on cave and karst themes has increased substantively [13]. Fifteen years earlier, Bichteler [4] found that grey literature was an important component of the information used by geoscientists. As research into the potential of karst for benefit or hazard to humanity intensifies, information integration and linkages promoting collaboration and connectivity among scientists, decision-makers, educators, and the general public are essential.



Adapted from Snow et al. "Cybertools and Archaeology." *Science* 311 (17 Feb 2006): 958-9.

Fig. 1 Graphic representation of the Karst Information Portal

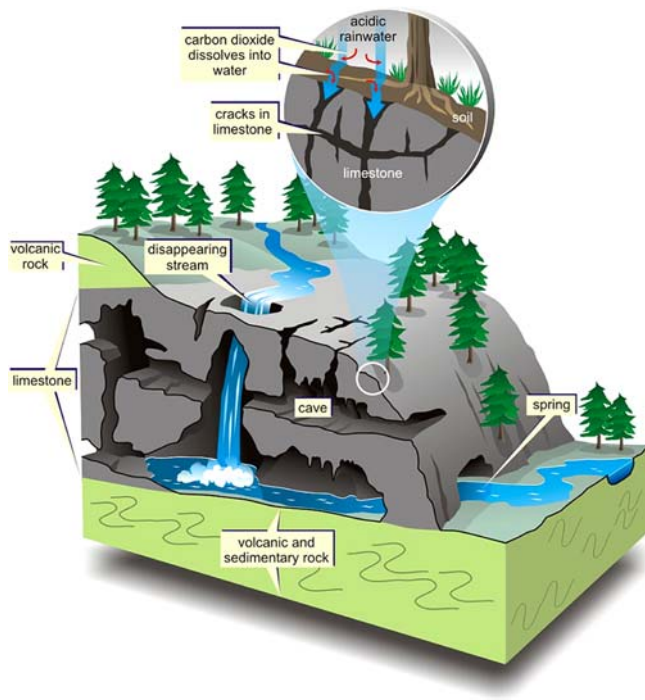


Fig. 2 Karst Terrain (Natural Resources Canada [24])

Karst researchers are faced with three inextricably related challenges: (1) discovering and evaluating relevant information sources, (2) obtaining and preserving “grey” karst information sources, and (3) providing interdisciplinary linkages among karst scientists to bring about knowledge discovery and communication. In order to construct a portal that contained information and services most useful to karst researchers, a needs assessment was performed.

Global Needs Assessment

Information specialists from the Libraries and the School of Library and Information Science at the University of South Florida planned and conducted a global information needs assessment for the KIP. The survey was designed to elicit responses in three categories of information need: (1) information content (e.g. format, subjects, and organization); (2) services (e.g. blogs, newsfeeds, and tagging services); and (3) research tools (e.g. data-mining and computational utilities).

Instrument Design

A questionnaire was constructed in Survey Monkey and distributed using a “snowball” sampling technique through targeted websites to reach the global

interdisciplinary karst community and sent via e-mail to a list of karst researchers compiled during the 2006 KIP Planning Workshop. The recipients of the survey were encouraged to respond and forward the survey on to their colleagues and others interested in karst research in some capacity. It was the hope of the survey team that the list of karst researchers would be enlarged through this process and thus increases the data obtained from the survey.

Results of the Survey

A total of 66 responses were received (it should be noted that seven of the 19 survey questions permitted multiple responses and for this reason response totals may exceed 100%). Although the number of respondents was not large, the sample is broadly representative by geographic region and occupation and interests (see Fig. 3). The countries represented are globally distributed, with the United States and Canada (24) and Australia and New Zealand (17) being the most heavily represented. Responses were also received from six countries in Europe and two responses originated in Malaysia.

The variety of professions or affiliations represented was equally broad, with academic researchers (41%), cavers (20%), resource managers (10%), and students (10%) accounting for the majority of respondents. One of the interesting aspects of the distribution of respondents was the proportion who is not academic researchers, cavers in particular who made up one-fifth of respondents. One of the findings, not unanticipated, is that karst researchers make up a similar universe as to that of grey literature, that is, they are hard to find and not under the personal equivalency of “bibliographic control.”

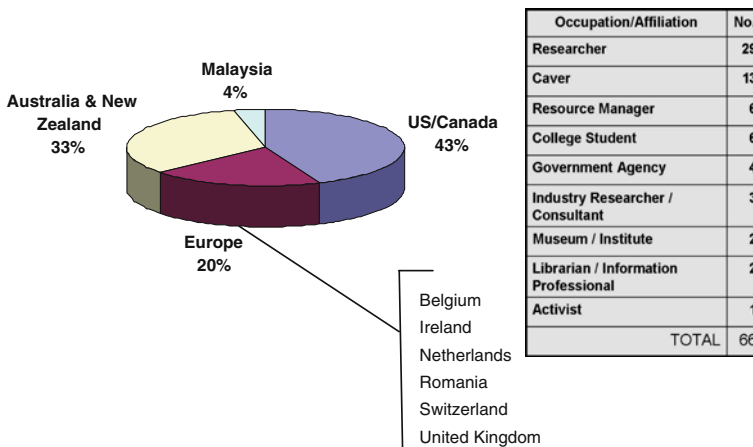


Fig. 3 Geographic and occupational characteristics of respondents

Locating Karst Information

Respondents were asked to report on “channels” used to locate information about karst-related subjects. For sources of information, the Internet was indicated by 98% of respondents. Other sources checked with high frequency were personal correspondence with colleagues (87%), conferences and meetings (82%), and books (80.6%). Of the three types of libraries offered for consideration, personal libraries ranked slightly higher than academic libraries, 84% to 81%. Public libraries had much lower use at 19% (see Table 1).

These findings are consistent with information-seeking behavior research which has shown that people turn to family or friends as their first source of information and only after those close personal sources do they use more formal sources such as libraries [5, 14, 17, 28]. In the specific case of geoscientists, Bichteler [3] found that personal contacts were extremely important sources of information, particularly when time constraints are significant. Among the two most numerous respondent categories, academic researchers and cavers, personal communications are extremely important, with 100% of the cavers and 82.7% of the researchers using personal contacts and colleagues as a source of information.

Although their conclusions are limited to a U.S. context, researchers associated with the Pew Internet & American Life Project report that 73% of all American adults regularly use the Internet to access information, by far the most common source of information after family and friends [20: 3]. This trend was also observed in the present study.

Context for Grey Literature in Karst Research

Using information derived from interviews conducted during the January 2006 KIP Planning Workshop and with reference to the literature [15, 30], an extensive list of 46 information types and formats that could be considered grey literature was compiled for the survey. To build a shared understanding of the terminology,

Table 1 Information channels used by survey respondents

Sources of Karst Information	No.
Internet	61
Personal correspondence w/colleagues	54
Journal articles	53
Personal library	53
Conferences/Meetings	51
Books	50
Academic library	44
Informal discussion	44
Public library	12
Respondents = 62	

respondents were presented with the definition of grey literature adopted during the Third International Conference on Grey Literature:

“[T]hat which is produced by government, academic, business, and industries, both in print and electronic formats, but which is not controlled by commercial publishing interests and where publishing is not the primary activity of the organization” [12].

The phrase “non-refereed and self-published documents generated by speleological groups and other non-governmental groups/individuals such as expedition reports,” was appended to the core definition to accommodate known grey information types of specific relevance to the karst community.

When asked if the respondents had used grey literature in their work or research, out of 58 responding, 56 (96.6%) said they had. The four most commonly used grey information types are conference proceedings/papers, trip and cave reports, theses/dissertations, and maps in any format. The reported incidence of use of conference proceedings and papers is consistent with a 2003 study by Michael Noga [25:19] in which the researcher found that citation frequencies of proceedings in a selection of geoscience journals indicated that “conference papers in journals are used to the same extent as research journal articles and that some proceedings are used even more” (for a competing assessment of the use of conference papers in published research, see [19]).

Two subsequent questions were designed to identify the types of grey literature (1) used and (2) produced by survey respondents. A third question used the same list of potential grey information types to identify those that respondents found difficult to locate. Table 2 lists, in declining order of frequency of use, the responses to the three questions. For comparison purposes, levels of use are accompanied by the number of responses for grey information source producers and for respondents reporting difficulty locating particular information types.

Not surprisingly, academic researchers account for a significant percentage (74.1) of respondents who report producing grey information in some format. Roughly 69% of the researchers contribute to conference proceedings, deliver speeches/invited talks or generate images while 55% produce trip and cave reports and 51.7% create or contribute to cave registries or entrance databases. What is surprising is the finding that 84.6% of self-identified cavers report producing grey literature, with trip and cave reports and cave registries or entrance databases the most frequent contributions. Responses also indicate that five of the six college or university student respondents produce grey information including conference papers, theses/dissertations, trip and cave reports, images, datasets, and maps.

It is interesting to note the correlation between the most frequently used sources and levels of production. For example, 42 of the 52 respondents to the question concerning production of grey information report contributing to conference proceedings while 40 respondents generate trip and cave reports. Comparing the pattern of responses reveals potential areas of emphasis for portal designers.

Consistent with the literature, trip and cave reports are a significant form of grey information for geoscientists generally including 18 of 29 academic karst researchers and 11 of 13 cavers responding and as such illustrate the importance of studies that

Table 2 Responses indicating use, production, and difficulty locating grey information sources

Information type (Listed in order of frequency of use)	Responses (No.)		
	Use type (<i>N</i> = 58)	Produce type (<i>N</i> = 52)	Difficulty locating type (<i>N</i> = 49)
Conference Proceedings and/or papers	50	42	23
Trip and cave reports	49	40	16
Theses/dissertations	47	28	25
Maps (any format)	47	32	14
Non-governmental technical/research reports	44	20	20
Websites with karst/geology content	44	18	4
Government technical/research reports	42	20	21
Images (digital format)	41	34	12
Newsletters	36	24	9
Association and organizational publications and records	34	25	14
Papers and correspondence of researchers	29	22	11
Satellite data	29	3	7
Government documents	28	9	9
Colleague files	28	12	3
Archival materials	28	15	10
Geospatial or GIS data	28	15	9
Modern photograph collections	27	18	8
Cave entrance databases	27	23	18
Files in park service offices	26	19	13
Preprints	25	18	10
Datasets	25	19	9
Historical photograph archives	24	8	11
Translations of foreign-language publications	24	4	15
Monitoring project data	24	15	9
Speeches or invited talks	23	34	3
Working papers (i.e., records of individual or group activities)	23	19	6
Old published karst papers (pre-1923)	23	0	13
Files in government agency offices	22	17	11
Consultant's reports	22	17	12
Management literature	22	13	10
Water-tracing data and databases	22	14	10
Videos (digital or analog)	21	13	3
Cave registries	21	14	12
International Union of Speleology (UIS) abstracting products	19	7	2
Contract reports	18	14	10
Oral histories	18	8	5

Table 2 continued

Information type (Listed in order of frequency of use)	Responses (No.)		
	Use type (<i>N</i> = 58)	Produce type (<i>N</i> = 52)	Difficulty locating type (<i>N</i> = 49)
Catalogs from libraries/collections not linked in any system	16	10	10
Research proposals	15	30	3
Grant applications	14	23	4
Morphology-type databases and collections	13	7	5
Statistical documents or reports	11	7	3
Research permit system information	8	9	3
Databases not linked in any system	8	13	5
Registries of current research initiatives	7	5	7
Realia and artifacts	6	0	1
Audio tapes/files (digital or analog)	4	6	0

focus on specific knowledge domains. Bichteler [3, 4], Corbett [7], Derksen [9], Haner [16], and Walcott [31] have independently addressed the specific case of the geological field trip book. Produced by local experts to support excursions into specific field locations, trip and cave reports typically include coverage of transportation resources and relate information about local cultural, geological and geographic features and conditions at a specific point in time [4: 41–42]. Both grey and “white” publications often contain citations to trip and cave reports or field books, but, because they are often published by organizations lacking an infrastructure to facilitate wide distribution, librarians are hard pressed to acquire copies and once in hand, cataloging is a challenge [16: 166–7; 31]. It is only through efforts such as The Stanford Geological Survey Map and Field Notebook Project and the Cornell Laboratory of Ornithology’s Science Knowledge and Education Network (SKEN)—and potentially the KIP—that critical domain-specific grey information is likely to be systematically accessible and preserved [9, 18].

During the January 2006 KIP Planning Workshop, discussions with participants revealed the importance of visual information in geoscience research. In their own right, images, videos, and maps are key sources of information about geological subjects, and they are often integrated into other information types including trip and cave reports, theses/dissertations, and websites. Responses from the four most numerous respondent categories supported this anecdotal conclusion (see Table 3), and coupled with the fact that these formats pose unique challenges for librarians seeking to exert bibliographic control and thereby enhance information discovery and access, suggest a potential content niche for portal planners.

Respondents reported difficulty locating all of the grey information types presented except audio tapes/files. The positive correlation between use and difficulty in locating grey information is relevant in many information type categories but fails markedly in the case of websites with karst/geology content—many respondents report using them (*n* = 44), but only four indicated that they were

Table 3 Use and production of images and maps

	Images		Maps	
	% Use	% Produce	% Use	% Produce
Academic researchers	68.9	68.9	75.8	55.5
Cavers	46.0	53.8	76.9	61.5
Students	50.0	33.3	83.0	33.3
Resource managers	83.3	33.3	66.6	0.0

encountering difficulties. This bodes well for the directions outlined by KIP planners in that, if properly designed and maintained, the site can have a significant positive impact for karst researchers seeking related information, regardless of format. The number of respondents encountering difficulties in locating theses/dissertations, association publications and records, and pre-1923 karst papers suggests that digitization is an important service dimension, a finding confirmed by responses to subsequent questions.

It was somewhat surprising to learn that relatively few respondents reported difficulty locating karst-related geospatial or GIS data. Just over 43% of respondents use GIS data and 28.8% report producing this information type, but only 18.7% encounter difficulties locating needed geospatial data with academic researchers reporting the lowest level of difficulty (17.2%) and students the highest (33.3%). Possible explanations for this finding include the substantial efforts of the GIS community to ensure that metadata standards are maintained and systematically applied and the proliferation of geospatial portals on the World Wide Web. Because geospatial/GIS data are by definition born digital, dissemination via the World Wide Web is greatly facilitated.

Finally, several questions presented an array of potential activities, services, and capabilities that are being considered for inclusion in the KIP and asked respondents to rank their importance with the context of their research interests. Embedded within these questions were additional queries about grey literature. In all instances, respondents considered treatment of grey information a key function of the portal:

- 99% considered grey literature's inclusion very or somewhat important;
- 96% rated grey literature digitization very or somewhat important; and
- 85% responded that evaluating the authenticity/reliability of karst-related grey literature was an important portal service.

Archiving Grey Literature

Bichteler [4: 49) describes the important role that geologists play in preserving the grey information that they produce. Survey responses suggest that this dimension of grey information management continues to pose challenges. Eighty-nine percent of the respondents to the survey reported that they produce grey information in some form, but an alarming 28.3% do not formally archive their information and just over

75% reported using a personal archiving space. This trend is not limited to a single format of grey information—in 2002, Maples et al. [21:11] warned that the geoscience community must act to preserve data and collections of physical items under a schema that incorporates a standard format for bibliographic citation promoting discovery and access.

Within the four most numerous respondent categories, 68.9% of the academic researchers reported that they formally archive their grey information in some manner, with resource managers reporting archival efforts in 66% of cases. Cavers and college or university students similarly archive grey information (61.5 and 50%, respectively). One observation is warranted: despite likely ease of access to academic libraries, only 12 of 29 academic researchers use libraries or repositories as archival resources, a finding that suggests potential opportunities for librarians (Fig. 4).

Any archival strategies must take into account an issue not anticipated at the onset of the survey, namely the matter of data sensitivity and the potential for improper use of contributed data in two areas of inquiry: cave entrance locations and water-tracing information. According to unsolicited comments, when asked if they would use the KIP as a personal digital repository, a number of respondents were concerned that cave entrance locations remain non-specific to protect fragile cave ecosystems from potentially damaging visits by non-specialists. Similar concerns for water-tracing data were also expressed: precise descriptions of hydrologic systems could endanger the resources by enabling resource destruction through casual and more nefarious activities.

Concerns for copyright protections, attribution, and information authority/reliability were also expressed, and were anticipated when the survey was designed. Mechanisms for managing these concerns are known and are presently within the expertise of the library and information science community.

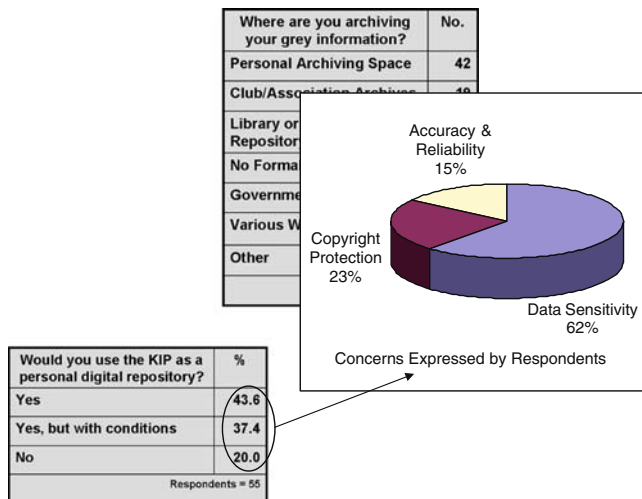


Fig. 4 The KIP as grey information repository

Karst Information Portal Services and Capabilities

In addition to the role of the KIP in preserving and providing physical and intellectual access to grey literature, other questions focused on its potential for developing connectivity and promoting collaboration via services or capabilities such as file sharing, RSS feeds, blogs, data management tools, web indexing, and directory services. The select list of potential services or capabilities was developed during the January 2006 KIP Planning Workshop. Tables 4 and 5 summarize responses to these queries.

Early investigations into the role of grey literature in karst research conducted during the January 2006 KIP Planning Workshop suggested that evaluating the authenticity and reliability of grey information was a controversial portal function. Anecdotal evidence indicated that many workshop participants felt palpable distrust of any attempt to assess levels of authenticity or reliability despite their concerns for

Table 4 Potential Karst activities

KIP activities: Importance to respondent research	Very important	Somewhat important	Not important	No opinion
Digitize key grey literature resources	37	14	1	1
Develop potential Karst DBs	34	17	0	2
Evaluate authenticity & reliability of Karst-related grey information	24	21	7	1
Identify global KIP partners	22	24	6	2
Develop registry of Karst programs & conferences	20	27	6	1
Develop registry of Karst community	19	33	3	1
Build digital collection of Karst policy resources	18	27	9	1
Build digital Karst image collection	14	26	10	3
n = 55				

Table 5 Potential portal content

Materials to include in the KIP: Importance to respondent research	Very important	Somewhat important	Not important	No opinion
Key Karst information sources	39	16	1	0
Grey literature	34	21	1	0
Speleological literature DB	32	16	7	0
Karst community contact information	23	28	3	0
Karst specific GIS data	22	22	8	1
Data	19	25	6	3
Karst image DB	12	26	11	4
Multilingual dictionary & controlled vocabulary (Thesaurus)	9	24	15	4
Respondents = 55				

these qualities in grey literature generally. This finding was borne out by survey responses, with 28% of academic researchers responding to the questioning judging that this function was not an important portal service. In contrast, all of the cavers and four of the five college or university students responding to the query considered evaluation of grey information very or somewhat important.

Although the predominance of interest in services and collections relevant to grey information is readily apparent, significant support for such services as file sharing, analytical tools, and email is documented in the survey results (see Table 6). Given developments in search engine performance, it is notable that such a large percentage of respondents continue to rank searchable link collections and search tools (83.9% and 60.7% respectively) as important for inclusion in the portal. The authors interpret these results as indicators of the continued relevance of domain-specific information portals as mechanisms to promote information discovery in specialized areas.

Participation in and Support for the KIP Project

At the conclusion of the survey, respondents were queried regarding potential involvement in portal design, development, and maintenance activities. Fifty-four percent of the respondents indicated that they would prefer participation as a “General User,” while 34.5% indicated participation preference as a “Minor Contributor.” Only six of the 55 respondents to this question indicated willingness to serve as a major contributor or project partner. Given the sampling methodology, it is difficult to interpret the impact of this distribution of responses in the context of project sustainability.

Table 6 Potential services and capabilities

What types of services or capabilities would make a portal valuable to you?	No.
Searchable collection of Links to Karst information	47
Access to and evaluation of grey literature	45
Search tools	34
File sharing services	30
Member directory	21
Tools for analyzing data	21
Capabilities to export bibliographic data	20
Tools for creating customized DBs	19
Email service	18
Pattern recognition search software	15
Wikis	12
RSS feeds	9
Podcasts	7
Other (journals)	2
Respondents = 56	

Twenty-eight respondents provided a comprehensive list of potential professional meetings and conferences amenable to marketing and promoting the project. When asked to suggest appropriate target audiences for the KIP, 96.2% of the respondents indicated that academic researchers or professors were appropriate, with college or university students (88.7%), cavers (83%), resource managers (69.8%), and museum or institute affiliates (67.9%) completing the top five responses. This was an encouraging finding in that it supports the project planners' goal of designing a resource with broad appeal and utility.

Conclusion and Recommendations

In his piece, "The Role of Grey Literature in the Sciences," Professor Irwin Weintraub [32] asserts that,

In a world in which free trade and instantaneous communication have eliminated many of the barriers to information flow, grey literature is gaining greater importance as a source of information for much of the world's population. It is an indispensable resource for an informed and enlightened public and will undoubtedly continue to serve as a necessary supplement to journal literature well into the future.

This study supported Weintraub's general characterization in the specific case of the interdisciplinary domain of karst studies—the impact of grey information sources on the globally distributed karst research community is significant and, according to their survey responses, growing. This trend is consistent with developments in similarly interdisciplinary research domains including library and information science [1], the health sciences [2, 11], marine and fisheries science [8], economics [22], and transportation studies [26, 27]. Based on the consensus definition presented at the beginning of the instrument, 70.9% of respondents indicated that grey literature is currently a "very important" source of information for karst researchers, with 14.5% stating that it will be more important in the future. Several respondents noted that, like astronomy and ornithology, cave and karst research benefits from the activities of non-academic individuals and as such would continue to generate (and consume) grey information. Citing recent articles in the journal *Nature*, one respondent made specific mention of the "ongoing rebellion" in the peer-review process and its role in promoting the importance of grey information.

Although these responses are consistent with the prevailing trend of increasing use of grey information in geoscience research generally, challenges persist. Fifteen years ago, Bichteler [4] listed limited distribution, poor bibliographic control, and nonstandard formats as the primary challenges for geoscientists as they accessed grey literature (39–40). In 2003, Mary Scott [29] described the state of bibliographic control of pre-1900 geoscience literature as steadily improving, but not yet fully satisfactory (108). The survey respondents' answers to questions concerning difficulties in locating grey information suggest that Bichteler [4] and Scott's [29] conclusions continue to ring true.

Consider the seemingly innocuous role of grey information citation patterns. In their 1993 analysis of references cited in U.S. Geological Survey publications, Butkovich and Musser [6] found that grey information was frequently incorporated in the text, but was often omitted from bibliographies, a condition that they suggested devalued the material's role in the research process. In her subsequent exploration of this phenomenon in 2002, Musser [23] found that the practice continued and "misleads scholars new to the field, historians of science, and other interested in the preservation of the research resources of the geosciences" (6). Simply improving bibliographic control over grey information and enhancing channels for discovery and access—both primary goals of the KIP initiative—will advance karst research, facilitate informed decision-making, and develop future research agendas, in the process transforming global understanding of karst terrains.

One of the primary purposes of the instrument was to generate an initial inventory of core "grey" information resources as well as gauge the karst community's willingness to participate in building and expanding both this collection and the associated controlled vocabularies. Survey results will assist in formulating guidelines for the collaboration-connectivity requirements of a research community spanning the globe. Future research should focus on (1) developing strategies to address concerns surrounding information security/sensitivity and (2) refining the list of key grey information sources for karst researchers with particular emphasis on those unique to the field.

When implemented, the KIP can serve as a model for similar studies of global interdisciplinary communities and the gathering and synthesis of literature to support the research needs of that community.

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