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Does scientific conjecture accurately describe restoration practice? Insight from an international river restoration survey

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Few sources exist to draw generalizations about the incredibly diverse international river restoration community. Generalizations in the restoration literature tend to be grounded on individual experiences or logical conjecture. To fill this perceived gap, an international web-based survey was launched. Over 500 respondents from 37 different countries participated. The results, posted on the web, act as a database of perceptions and individual experiences, from which the restoration community can make their own interpretations. With three examples, we contrast scientific conjecture with the perceptions of the restoration community who participated in this survey.

Key words: *stream rehabilitation, river basin management, questionnaire, web-based survey, restoration community*

Background

The diversity and popularity of stream and river restoration efforts are difficult to overstate. Restoration, rehabilitation, river basin management and their derivatives are practised in at least 21 different countries in response to the exploitation and subsequent deterioration of the riverine environment (Sear 1994; Kondolf 1995; Brookes *et al.* 1996; Nijland and Cals 2000). In Denmark alone, 1068 restoration projects were in place by 1998 (Hansen and Iversen 1998); in the United Kingdom the Restoration Centre's database (RRC 2004) includes over 750 projects; in the United States, Malakoff (2004) reported that over US$10 billion has been spent on more than 30 000 projects.

The popularity and diversity of restoration activities across the world gives rise to an equally diverse restoration community. This community consists of five distinct groups (Table 1). While restoration is carried out to satisfy the interests of stakeholders and advocates, managers and practitioners are those responsible for implementation (McDonald *et al.* 2004). Each group has different perspectives and biases on restoration (Wilcock 1997; McDonald *et al.* 2004).

Accurate generalizations about the activities and perceptions of such a diverse restoration community are difficult to make. Nevertheless, practitioners and policymakers rely on such guidance as to which restoration approaches and strategies they should use. For example, basic statistics and generalizations are used to support proposals to fund further restoration, justify long-term monitoring and craft policy. Indeed, the numerous calls for monitoring in the restoration community are part of an effort to document past experience and provide generalizations that support more successful future projects (e.g. NRC 1992; Brookes 1995). The river restoration

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Table 1 Five distinct groups that comprise river restoration community

Group	Involvement with river restoration
Advocates	No direct involvement, simply supporters of restoration efforts (e.g. taxpayers, voters)
Managers	Involved in planning, permitting, evaluation, policymaking and/or decisionmaking (e.g. consultant, agency personnel, politicians, policymakers)
Practitioners	Involved in planning, design, construction and/or monitoring (e.g. consultant, contractor, agency personnel)
Scientists	Investigators who research restoration, provide restoration tools, recommend approaches and strategies and/or advise practitioners, stakeholders and managers (e.g. academics, researchers, students)
Stakeholders	The local community, landowner and/or special interest groups who are directly influenced by restoration activities (e.g. general public, NGOs, grass-roots organizations)

literature is rich with specific approaches, ideas, criticisms and strategic considerations appropriate to particular settings and circumstances (Wheaton *et al.* 2004a); yet there is a tendency to imply or claim that specific findings are more widely transferable to other settings. Most of these generalizations are properly proposed as conjecture in the introduction or discussion sections of papers (Gopen and Swan 1991). Yet, once they make it past the peer review process, they can be cited by others and carelessly propagated through the literature as common experience, if not fact (Harrison 2004; Shimp 2004). If this literature had no influence on restoration policy or practice, one might simply take note of it and move on. However, because these generalizations do eventually influence policy and practice (e.g. Water Framework Directive) it is worth exploring the basis of these generalizations and their validity (Butler 2004).

In an effort to identify, and learn from, the biases and perspectives of the restoration community, we have created a web-based International River Restoration Survey (Wheaton *et al.* 2004b). The survey is intended to provide the restoration community with a pool of raw data on restoration practice that can be simply summarized and reported. It is assumed that providing a database to the restoration community will provide a stronger, but by no means definitive, basis for the restoration community to make its own assessment of common problems and trends. Herein we report two aspects of the survey:

- First, we highlight methodological differences between interactive, real-time web-based surveys in relation to more conventional survey approaches.
- Second, we discuss how specific generalizations from a few key survey results compare with those found in the restoration literature.

It is important to emphasize the real-time reporting of results as a specific feature of the methodological approach, which enables any individual to draw their own inferences from an evolving survey database. It is for this reason that we only discuss selected survey findings, which highlight how perceptions about certain aspects of river restoration may or may not be justified. Furthermore, although the topic of this paper is river restoration, the survey approach and issues of generalization related to scientific conjecture should be generically applicable to a wider range of subject matters studied by physical and human geographers (e.g. perceptions about climate change; Immerwahr 1999).

Survey approach

Most surveys are designed to run over a narrow time period, and are followed by analysis, selective reporting of the results and interpretations to answer specific questions. The raw data are often proprietary, and kept by the survey investigators for reasons of confidentiality and data protection legislation. As a consequence, the dissemination of results usually emphasizes the investigator's interpretations. Standard techniques exist to analyse such surveys, and these are well suited to address focused research questions (e.g. Morey *et al.* 2002; Herr *et al.* 2003).

For the International River Restoration Survey (IRRS) we adopted a different approach. Our aim was not to try and answer specific hypothesis-driven research questions, but instead to obtain better insight into the experiences and perceptions of the restoration community. Considering the lack of any systematic data from across the entire restoration community, we focused first on seeking to construct

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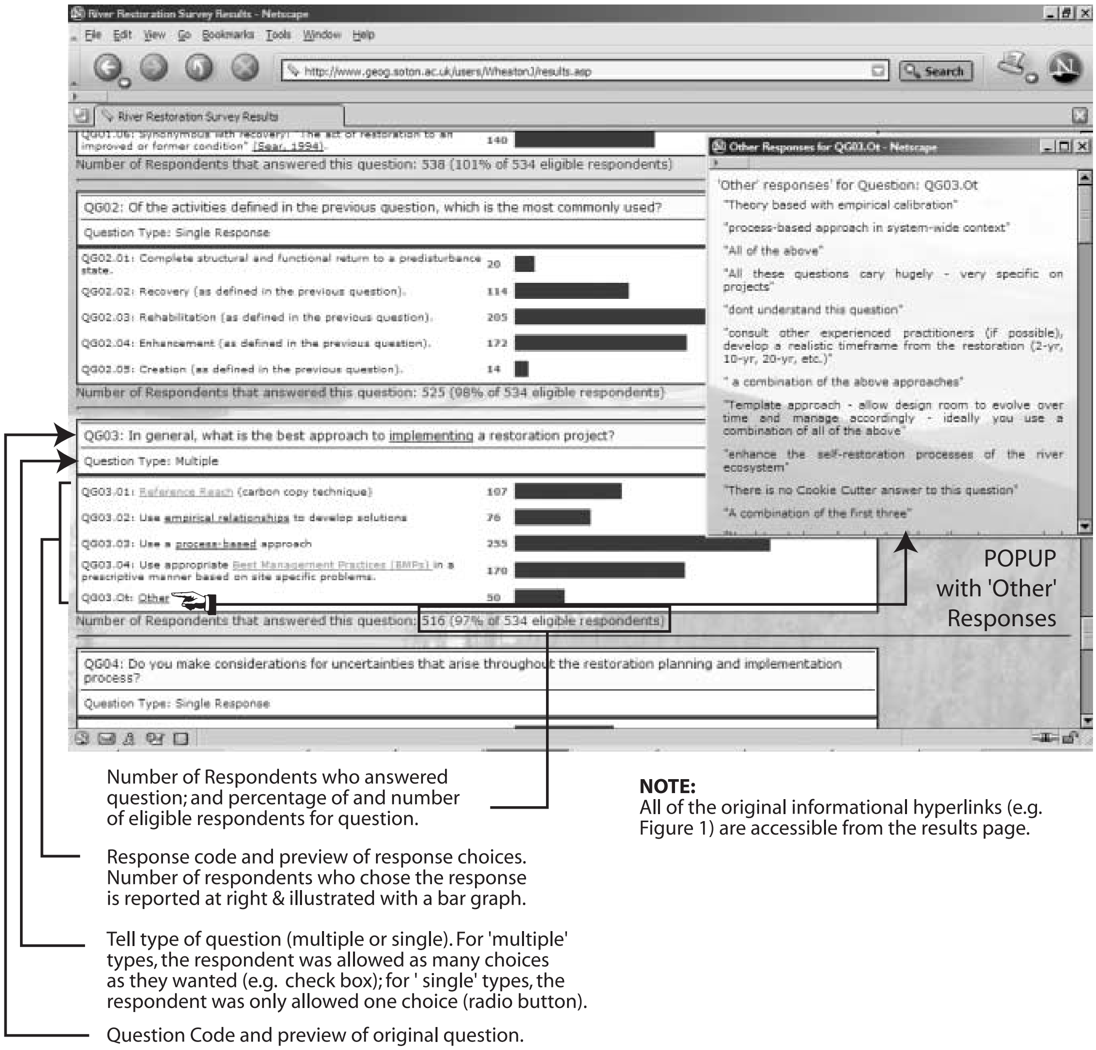

Figure 1 The real-time results web page. The structure and basic features of the results page are highlighted

a database of generic information and perceptions about river restoration. We treat the lumped results as raw public data instead of intellectual property. We also recognize that interpretations from such general questions and data are inherently subjective and/or statistically flawed. While sophisticated techniques by pollsters and social scientists exist to cope with these problems (Witte *et al.* 2000), our core intention was to provide interested parties within the river restoration community with transparent data.

A web-based survey using active server page technology was launched to run indefinitely and provide dynamic real-time results. Upon survey submission, the web server checks the data for errors and, if acceptable, updates the results to a database. The database services dynamically link to a results page on the host website that summarizes basic statistics, and makes the raw data available to download for more detailed analysis (Figure 1). Therefore the user of the data is well positioned to decide how they wish to analyse and interpret the results. From a data processing perspective, the automatic response capture virtually eliminates the need for manual post-processing. The rapid return of processed results also has the advantage that survey results

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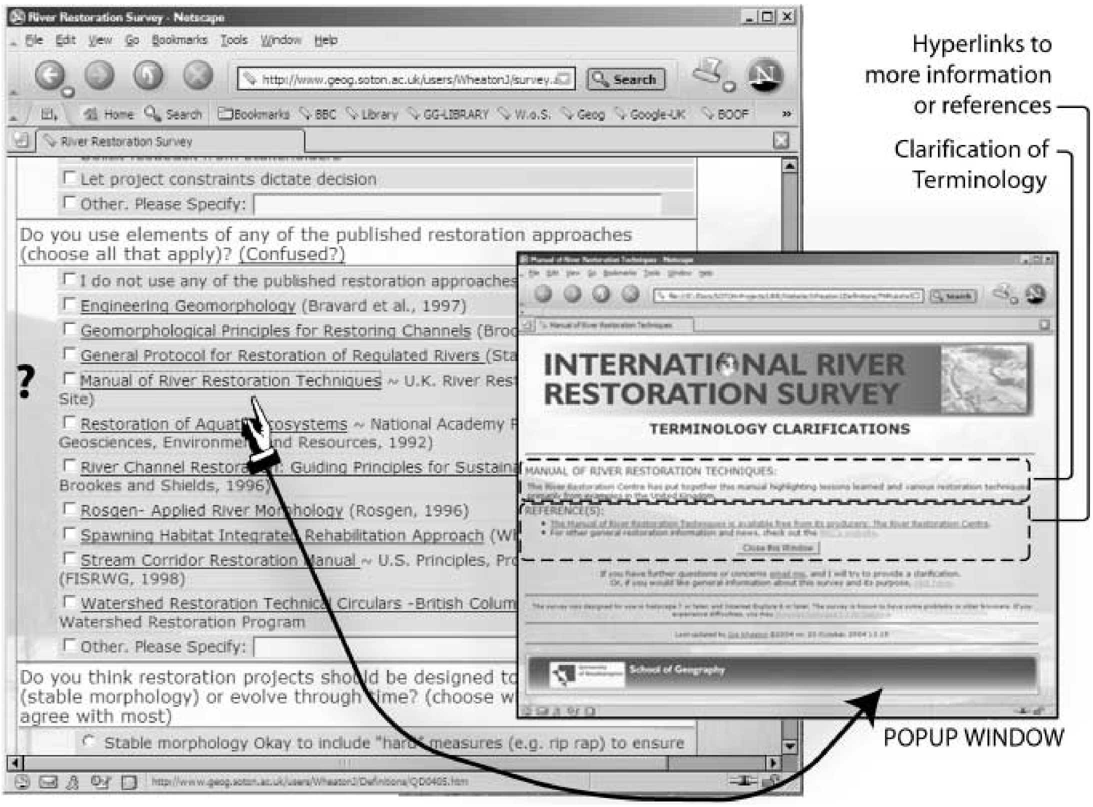

Figure 2 Example of terminology clarifications provided for survey respondents during the survey

can evolve through time with minimal maintenance required.

A secondary objective of the survey was to act as an educational tool for survey respondents. The diverse restoration approaches, strategies, grey literature, peer-reviewed literature, decision support tools, software and confusing terminology are not necessarily familiar to all respondents. Instead of cluttering the content of the survey with verbose questions and explanations, we provided hyperlinked pop-ups to clarify potentially confusing terminology (Figure 2). This ensured that respondents had all the necessary information to answer each question (Immerwahr 1999; Trochim 2000), while simultaneously educating them about alternative approaches (e.g. Figure 2). Importantly, the survey session is not interrupted or closed while the respondent browses this material.

Survey design and dissemination

There are many types of well-established questionnaire survey techniques (e.g. mail, drop-off, group-administered, web-based). A web-based survey was chosen over mail-back surveys because of the notoriously low response rates of mail-back surveys (Trochim 2000). Web-based surveys are not a new idea. For example, Survey2000 (a web-based survey run by the National Geographic Society) collected over 80 000 responses in a two-month period (Witte *et al.* 2000). However, to our knowledge, no one has attempted to target a web-based survey to the international river restoration community (although examples of more targeted and localized surveys exist: e.g. RRC 2000; Tunstall *et al.* 2000; Bash and Ryan 2002; Bernhardt *et al.* 2005).

Convenience for the respondent was heavily emphasized in order to encourage higher response rates. The survey was streamlined to take between 5 and 15 minutes with a structured response format, comprised primarily of radio-button (single choice allowed) and check-box (multiple choices allowed) responses. Respondents were able to complete the survey anonymously. However, an in-depth line of

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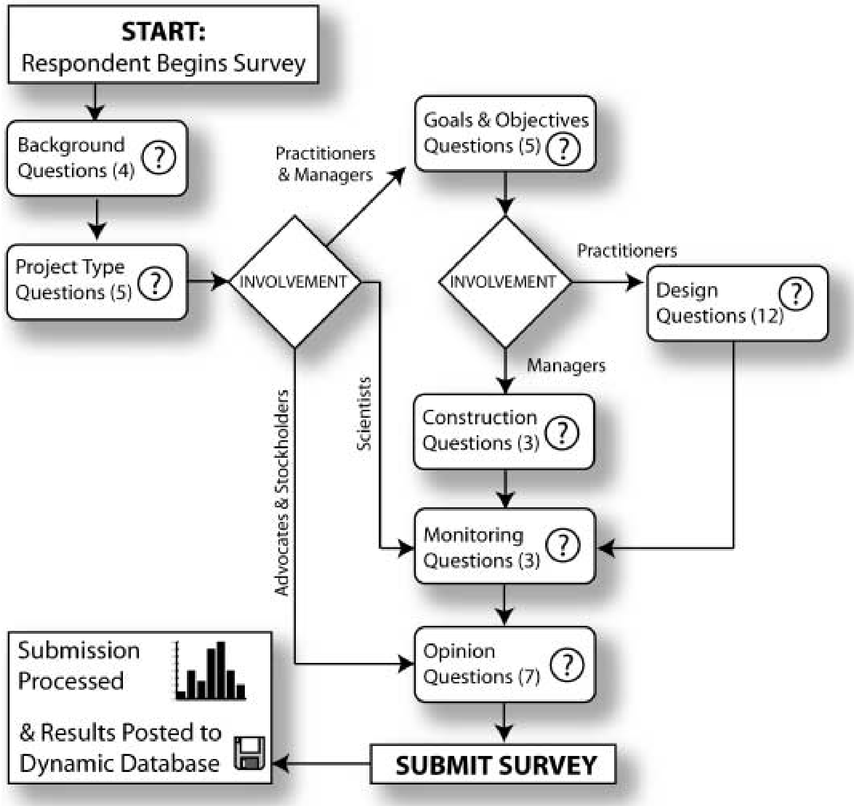

Figure 3 Survey question flow structure based on respondent involvement in restoration

questioning and follow up is sacrificed when the survey questions are streamlined and the survey is kept anonymous (this has since been rectified with a web-based discussion forum: http://www.joewheaton.org.uk/bb/viewforum.php?f=10). Thus, unstructured response formats (e.g. 'other' options) were offered for a number of questions (allowing the respondent to maintain anonymity), and respondents were encouraged to email more in-depth, qualified responses, concerns or complaints.

Different groups of questions were asked of each respondent depending on their involvement in restoration (Figure 3). This was to keep respondents from having to read through questions they would not be qualified to answer, thereby slowing response times and discouraging completion of the survey (Witte *et al.* 2000). The first and only mandatory question segregated respondents between the five primary groups that comprise the restoration community: advocates, managers, practitioners, scientists and stakeholders (Table 1). Each group was asked four 'background' questions, five 'project type' questions, two 'goal and objectives' questions and seven 'theoretical and opinion' questions. In addition, the managers, practitioners and scientists were asked three 'long-term monitoring' questions. Practitioners were asked a further 12 design questions and three 'construction' questions. The background questions included profession, sector (e.g. public, private, education) and practising country. This allows end-users of the survey results to look for trends based on background, or to segregate results and look only at responses from a particular group (e.g. those from the United Kingdom or scientists).

The dynamic structure of the survey means that the target audience can change through time without alienating any particular group of respondents. Respondents were initially invited to participate via

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Table 2 Primary groups survey respondents to

List serve or organization	County or region
River Landscapes (website)	Australia
River Rats (list serve)	Australia
European Centre for River Restoration (email list)	Europe
The River Restoration Centre (email list)	United Kingdom
River Restoration & Assessment Forum (newsgroup and list serve)	United States
American Fisheries Society (list serve)	United States and International
Association of Local Government Ecologists (list serve)	United States
International Association of Hydraulic Engineering and Research (Rivers-List list serve)	International
International Association of Geomorphologists (Geomorph List Serve)	International
International Erosion Control Association (E-Update, News-to-Use & Website)	International
Society for Ecological Restoration (email list)	United States
U.C. Berkeley's Gilbert Club Geomorphology Listserve (list serve)	International

several international list serves and web-sites that were known to contain members actively involved in river restoration (Table 2). Thus, we anticipated that initial dissemination would be biased towards the practitioner, scientist and manager segments of the restoration community. If in the future it becomes important to target primarily the advocate and stakeholder segments of the community, the structure of the survey remains the same and only the dissemination needs to change. Thus, the survey database can continue to change and grow through time based on what segment of the community is targeted. Alternatively, it may be desirable to solicit new responses from the entire community at some later date to see if any change in perceptions, practices and attitudes emerges. This is possible since submission dates are recorded with all responses. The survey was set up modularly so that questions can be added or modified at any time in the future, albeit at the expense of setting up a direct comparison between older and newer responses for those particular questions. It is worth noting the contrast between a survey of this style and a user-forum or discussion board, which users can login to at any time. Unlike web forms and chat-rooms, the survey seeks structured responses (which should be easier to analyse) and participation is actively sought through dissemination.

The 52 questions that comprise the entire survey were formulated based on three primary factors. First, there were a variety of specific generalizations we wished to make about river restoration, but did not have a strong enough basis to make. For example, from our experiences with restoration practice and knowledge of the restoration literature, we did not think (conjecture on our part) that the plethora of approaches in the literature were actually being used in practice. Various authors have commented on this apparent discrepancy and speculated as to why this might be the case (e.g. Wilcock 1997; McDonald *et al.* 2004; Wheaton *et al.* 2004a). Thus, in the survey we asked practitioners whether they actually used any of the published restoration approaches, and followed this up with what they thought of the contributions of science to restoration. Secondly, we wanted to have some basis for supporting or refuting existing generalizations found in the restoration literature. Finally, we tried to ask questions that put some basic statistics behind common groupings and categorizations of restoration activities. For example, how many projects are monitored and for how long? Although we attempted to make the survey questions consistent with standard survey methods from the social sciences (e.g. Trochim 2000), we feel it is equally important to acknowledge the limitations of surveys. The goal of the survey is to provide a stronger basis than individual experience or scientific conjecture, but does not aim to provide a definitive answer. Although some sophisticated statistical analyses are

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Table 3 Demographics of respondents

Involvement in river restoration	Percentage of question respondents (n)	Percentage of total respondents	Discipline	Percentage of question respondents (n)	Percentage of total respondents
Advocate	4 (20)	4	Biological Sciences	30 (116)	24
Manager	18 (86)	18	Engineering	22 (86)	18
Practitioner	49 (234)	49	Earth Sciences	26 (100)	21
Scientists	27 (128)	27	Planning/Architecture	7 (26)	5
Stakeholders	3 (11)	3	Other	15 (57)	12
Response rate	*100 (480)*	*100*	*Response rate*	*80 (385)*	*80*
Sector			Geographic region		
Education	21 (83)	17	Africa	<1 (1)	<1
General Public	1 (6)	1	Asia	1 (6)	1
Non-profit	10 (41)	9	Australia and New Zealand	6 (26)	5
Private sector	24 (95)	20	Europe	37 (151)	31
Public sector	44 (177)	37	Middle East	1 (6)	1
			North America	49 (198)	41
			South America	1 (6)	1
Response rate	*84 (402)*	*84*	*Response rate*	*84 (404)*	*84*

certainly possible with the data, this was not an explicit requisite in the formation of survey questions. Statistical validity aside, value-laden judgements are scientifically meaningful insofar as they strongly influence the direction of research and its subsequent funding.

Basic demographics

The basic demographics of the respondents highlight the diversity of the restoration community described earlier and the expected biases. The survey was launched on 25 November 2003. By 14 December 2003, over 340 respondents from 27 countries had responded; and we had received over 100 email enquiries and respondent comments. Anonymous excerpts from insightful email correspondence have been posted to the results page of the website from 43 of the respondents, representing perspectives from eight different countries (Wheaton *et al.* 2004b). By 1 April 2004 (the cutoff date for responses reported in this article), there were 480 correctly submitted responses from 36 different countries (Table 3). Unsurprisingly, the largest concentration of respondents was from the United States and United Kingdom, representing 46 per cent and 26 per cent, respectively. This bias is probably due to a combination of survey dissemination, language barriers, web-accessibility, as well as actual participation in restoration activities. Practitioners comprised 46 per cent of all respondents. Given the under-representation of practitioner's perspectives in the restoration literature, their views were considered particularly important. Practitioner responses were obtained from 16 different countries spread across Asia, Australia, Europe, the Middle East and North America, but were primarily from the United States (51%), and the United Kingdom (29%). The remaining respondents were split between advocates (4%), managers (18%), scientists (27%) and stakeholders (3%). Thus, the survey was effective at capturing the views of practitioners, scientists and managers. This is not surprising considering the dissemination outlets used (Table 2); nor was the low participation of advocates and stakeholders unforeseen.

There does not seem to be a dominant discipline within the restoration community, with fairly even splits between the biological sciences (24%), engineering (18%) and the Earth sciences (21%). Roughly 37 per cent of respondents were from the public sector (e.g. agencies and government organizations); 20 per cent were from the private sector (e.g. consultants); 17 per cent were in education (e.g. universities); and 9 per cent were from non-profit organizations. The low percentages of respondents

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from the general public (1%) is symptomatic of the low number of advocate and stakeholder responses, and a consequence of poor survey dissemination to these groups.

The diversity of involvements, geographic regions, disciplines and sectors amongst the respondents is also indicative of the diversity within the overall restoration community. The dominance of English-speaking (US and UK) countries is probably related to a generally larger number of projects in these countries, but is a consequence of the survey being in English and being disseminated primarily in English-speaking countries. Thus, the results up until April may be good for highlighting a variety of perspectives, but specific generalizations will be most relevant to those countries with a higher percentage of responses.

How does scientific conjecture compare with the survey results?

To explore how well scientific conjecture compares with the views of the restoration community captured in this survey, we will use three specific topical examples. First we find out what respondents interpret the term 'restoration' to actually mean. Next we asked respondents to specify whether the desired spatial scale of restoration is consistent with practice and what the literature claims it should be. Finally, we look at how respondents view and consider uncertainty in restoration.

What is 'restoration'?

Since 1990, at least 30 different authors have proposed similar but slightly contradictory definitions for the term 'restoration'. These definitions have been repeatedly reviewed elsewhere (e.g. Cairns 1991; NRC 1992; FISRWG 1998; NAP 2002) and were summarized for respondents on the survey web-site. The rather restrictive definition proposed by Cairns describes restoration as 'complete structural and functional return to a pre disturbance state' (1991, 187). Despite the reality that achieving restoration by this definition is nearly impossible, it remains probably the most popular and widely accepted definition in the restoration literature (Shields *et al.* 2003). A number of arguably more appropriate alternative definitions and activities (including rehabilitation, enhancement, improvement, creation, recovery, stabilization and reclamation) have been proposed and are often used as synonyms for restoration. Each author puts forth an equally reasonable, subtly distinct definition of restoration and what it 'should' involve. The origin of these contrasting definitions is largely derived from the distinct legislative, cultural and social frameworks within which restoration is practised. Ironically, we observed restoration practice proceeding with its activities almost unconcerned about this semantic debate. Shields *et al.* (2003) argued that there was no reason to believe that further attempts to clarify the meaning of 'restoration' in the literature would have any real influence. Perhaps, in the context of the scientific literature, which probably is not read by the majority of the restoration community, Shields *et al.* (2003) have a point. However, the semantics of restoration do matter locally for the following reasons. First, the 'consensus' view gains 'power' and will heavily influence the expectations people place on restoration. Secondly, standard definitions provide a legally defensible, consistent and transparent basis from which decisionmakers might work from. For example, the European Commission's Water Framework Directive (WFD) is defining restoration in terms of 'good ecological status'. Individual member states are thus charged with determining what good ecological status means; and suddenly, this semantic debate has real significance.

All survey respondents were asked two questions to tease out the restoration community's views on restoration semantics (Table 4). First, they were asked to choose a definition that most closely matched how they use the term restoration. Only 7 per cent of respondents subscribed to the strict definition put forth by Cairns (1991). Instead, the highest percentage of respondents (46%) use restoration loosely as a 'catch all term' for a variety of river management activities. Roughly 26 per cent of respondents interpret the term river restoration to be synonymous with Sear's (1994) recovery definition. Thus, the apparent consensus in the restoration literature on Cairns' (1991) definition is seemingly contradicted by the restoration community sampled in this survey.

We hypothesized that there may be some reversal in the trend when the results were segregated by the respondent's involvement in river restoration (e.g. scientists vs practitioners). We expected that scientists, being the primary contributors to the restoration literature, might have subscribed more heavily to the Cairns (1991) definition. Contrary to our hypothesis, the general trend of those choosing the Cairns

Table 4 Restoration semantics responses

	Percentage of question respondents (n)	Percentage of total respondents
Which definition most closely matches how you use the term 'river restoration'?		
A catch-all term for river management activities including restoration, rehabilitation, enhancement and/or creation (Brookes 1999)	46 (217)	45
'The complete structural and functional return to a pre-disturbance state' (Cairns 1991)	7 (34)	7
Synonymous with rehabilitation: 'The partial structural and functional return to a pre-disturbance state' (Cairns 1991)	12 (58)	12
Synonymous with enhancement: 'Any improvement of a structural or functional habitat attribute' (NRC 1992)	8 (38)	8
Synonymous with creation: 'The birth of a new (alternative) ecosystem that previously did not exist at the site' (NRC 1992)	>1 (3)	>1
Synonymous with recovery: 'The act of restoration to an improved or former condition' (Sear 1994)	26 (125)	26
Response rate	*99 (475)*	*99*
Of the activities defined in the previous question, which is most commonly used?		
Complete structural and functional return to a pre-disturbance state	3 (16)	3
Recovery (as defined in the previous question)	23 (106)	22
Rehabilitation (as defined in the previous question)	39 (183)	38
Enhancement (as defined in the previous question)	32 (148)	31
Creation (as defined in the previous question)	3 (12)	3
Response rate	*97 (465)*	*97*

(1991) definition was roughly the same between the segregated and lumped results for scientists and practitioners (advocates: 15%; managers: 1%; practitioners: 7%; scientists: 9%; and stakeholders: 8%; vs lumped: 7%). In all cases, the largest number of respondents in each category chose 'restoration as a catch-all term' (advocates: 50%; managers: 52%; practitioners: 47%; scientists: 38%; and stakeholders: 50%; vs lumped: 46%). However, substantially fewer scientists (as a percentage) chose 'restoration as a catch-all term', suggesting that 62 per cent of scientists were more partial to a specific definition. Yet why is the literature biased towards the Cairns (1991) definition when only 9 per cent of scientist respondents agree with this definition? It might be that the literature subsampled is written by a very small subset of scientists in the restoration community. It might also be that the scientific community's views have changed from 1991 to 2004. Additionally, there seems a tendency for a specific generalization (in this case Cairns 1991) in the literature, once accepted by peers, to be propagated through the literature for quite some time regardless of its applicability to practice.

The second question related to restoration semantics was intended as a 'follow up' to see if there was a contrast between what terminology the restoration community uses to describe its activities, and which activities it actually undertakes. The respondents had been provided with definitions to use for restoration, recovery, rehabilitation, enhancement and creation in the previous question. We expected to see a strong contrast between what respondents described as restoration in the previous question, and what they perceived to actually take place. Only 3 per cent of respondents said the Cairns (1991) definition of restoration was undertaken, whereas responses were split roughly between recovery (23%), rehabilitation (39%) and enhancement (32%). Thus, because so few respondents subscribed to the Cairns (1991) definition in the first question, our expectation was not confirmed. This result is quite consistent with generalizations found in the literature (e.g. Brookes and Shields 1996; Kondolf 1996) that claimed most

Table 5 Spatial scale river restoration is identified and planned at versus designed and constructed at

	Identified and planned at this scale		Designed and constructed at this scale	
	Percentage of question respondents (n)	Percentage of total respondents	Percentage of question respondents (n)	Percentage of total respondents
Basin scale	31 (146)	30	13 (62)	13
Landscape scale	23 (105)	22	13 (61)	13
Reach scale	35 (165)	34	51 (239)	50
Sub reach scale	11 (49)	10	23 (108)	23
Response rate	*97 (465)*	*97*	*98 (470)*	*98*

activities the restoration community undertakes are actually recovery, rehabilitation or enhancement as opposed to the strictest definition of restoration.

Spatial scale of restoration

A rather uncontroversial generalization is that river restoration has been focused primarily at rather small reach-scales (10^2–10^4 m), while the restoration literature has overwhelmingly advocated catchment-scale (10^4–10^7 m) considerations for restoration. While the second generalization is substantiated by a review of the scientific literature (e.g. Frissell *et al.* 1993; Kondolf and Downs 1996; Boon 1998; Wissmar and Beschta 1998; Roni *et al.* 2002; Moss 2004), the first generalization has more or less been accepted as true without really sampling the restoration community to confirm it. The complaints and concerns frequently voiced about reach-scale restoration are that it is piecemeal, neglects the larger scale processes necessary for 'self-sustainability' and is simply too small to be effective. Although there is more or less unanimous consensus that basin-scale considerations are essential in river restoration (Pess *et al.* 2003), there is confusion and disagreement over what exactly 'catchment-scale river restoration' should involve (Hillman and Brierley 2005). Wheaton *et al.* (2004a, 5) highlighted three contrasting views:

a) restore the entire catchment (Frissell *et al.*, 1993);
b) use watershed assessments to nest reach scale restoration in a catchment context (Bohn and Kershner, 2002, Walker *et al.*, 2002); or
c) undertake a range of management and restoration activities across various spatial scales but nested within a catchment context (Roni *et al.*, 2002).

Thus, some of this confusion stems from different spatial-scale perspectives during the identification and planning stages of restoration vs the design and construction phases.

We asked all respondents two questions about the spatial scale of river restoration projects they had been involved with (Table 5). Four spatial scales were defined as choices for the respondents based on Maddock (1999). The first question asked respondents to choose the scale that most projects were identified and planned at, whereas the second question asked at what scale most projects were designed and constructed. The responses in this case confirmed the conjecture from the literature that most river restoration projects are built at the reach scale. Over 73 per cent of respondents said that most projects were designed and constructed at the reach or sub-reach scale. However, it appears that the restoration community has started making progress towards at least placing these projects in a catchment-scale context. Over 52 per cent of respondents claimed that most projects were identified and planned at broader landscape and catchment scales. This distinction is something that is apparent in individual case studies from the recent restoration literature, and Hillman and Brierley (2005) proposed that this is now a general trend that deserves critical review. This is important because it implies that, despite the lag-time, the restoration community has 'got the message'. Thus, as restoration scientists we might instead focus our efforts not on continuing to echo a point already well articulated in the literature, but rather helping restoration practitioners and managers accomplish catchment-scale restoration (Wilcock 1997; Wheaton *et al.* 2004a). Indeed, the emphasis on broader catchment-scale perspectives and contexts has transcended the strictly academic and scientific realms and is now at the core of new legislative mandates and policies in Europe, North America and Australia (Brierley and Fryirs 2000; Jungwirth *et al.* 2002; Wissmar and

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Bisson 2003; Moss 2004). The practical challenge lies in shifting from just planning and contextualizing river restoration at the catchment scale to actually restoring entire catchments (Hillman and Brierley 2005).

Uncertainty in restoration

Uncertainty is a very broad and frequently misunderstood topic (Van Asselt and Rotmans 2002; Pollack 2003). Clark (2002) has argued that river restoration suffers not from a plethora of obvious sources of uncertainties, but instead from a fear of admitting these uncertainties. We conjectured that the restoration community is primarily ignoring uncertainty on the basis of the virtual lack of recognition of uncertainty in the restoration literature, restoration policy and restoration project documentation. Within a rich literature on restoration there are only occasional passing mentions of uncertainty (Brookes and Shields 1996) and a handful of explicit treatments (Johnson and Heil 1996; Johnson and Rinaldi 1997; Johnson and Brown 2001; Wissmar and Bisson 2003). Those explicit treatments of uncertainty are important contributions, but tend to focus only on a few fairly specific types of uncertainties (Van Asselt and Rotmans 2002), notably natural variability, socio-political value diversity and unreliability (measurement) uncertainties.

A series of four questions were asked to gauge the extent to which practitioners considered uncertainty in designing restoration projects. The first three questions were kept as simple yes or no answers and intended to determine hierarchically if, and to what extent, uncertainty is even something restoration practice considers (Table 6). Of the 234 practitioner respondents (41% of total survey respondents), 79 per cent claimed to identify sources of uncertainty in design, whereas only 33 per cent tried to quantify sources of uncertainty and 41 per cent tried to constrain sources of uncertainty. This seems to suggest that although many practitioners may acknowledge sources of uncertainty, they do not necessarily know what to do about it. Five philosophical treatments of uncertainty might exist:

1 ignore uncertainty,
2 eliminate uncertainty,
3 reduce uncertainty,
4 cope with uncertainty and
5 embrace uncertainty.

Of the 79 per cent that identify sources of uncertainty, roughly 41 per cent apparently cope with uncertainties by attempting to constrain them. Presumably, the other 59 per cent of practitioners choose to ignore uncertainty. The choice to ignore uncertainty may be out of ignorance to it, or a conscious decision based on a presumed or established insignificance of the uncertainty. The discrepancy between quantified and constrained sources of uncertainty implies that practitioners accept that some sources of uncertainty might be constrained even if they are not quantified or quantifiable. Of the 33 per cent of practitioners who tried to quantify sources of uncertainty, 47 per cent used computer modelling to constrain uncertainty. Of the 41 per cent who tried to constrain uncertainty, 60 per cent used computer modelling to do it. This is interesting given the widespread recognition of uncertainty in computer models themselves (Cardwell and Ellis 1996; Rotmans and Van Asselt 2001; Lempert *et al.* 2003).

Discussion

The IRRS has provided some insightful data on the restoration community's activities and perceptions. From the preceding three examples, we have shown that scientific conjecture about river restoration is not always right or wrong. Thus, in answer to the question, 'does scientific conjecture accurately describe restoration practice?' we can say, 'sometimes, but not always'.

Table 6 Considerations of uncertainty in design by practitioners (n = 234)

	During design, do you___of uncertainty?		
	Identify sources	Quantify sources	Constrain sources
Yes	79% (186)	33% (78)	41% (96)
No	15% (34)	62% (145)	52% (121)
Response rate	*94% (220)*	*95% (223)*	*92% (216)*

More importantly, from this simple survey an interesting paradox arises. That is, the social sciences (e.g. human geography, economics, public policy) are under represented in restoration science (Immerwahr 1999). The overwhelming majority of scientific research into river restoration is carried out by biological and physical scientists (e.g. physical geographers), such as the authors. For example, a simple Web of Science search for 'river restoration' under the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts and Humanities Citation Index yielded 194, 13 and 3 results respectively (note that 5 of the latter 18 also appear in the Science Citation Index Expanded). This trend is confirmed by the survey demographics, which highlight that 78 per cent of those who specified their discipline were from the physical or biological sciences (Table 3). This is despite the fact that the restoration literature frequently deals explicitly with policy issues (e.g. Alario and Brun 2001; Pedroli *et al.* 2002), economic issues (McDonald and Johns 1999; Holl and Howarth 2000) and subjective values (McDonald *et al.* 2004) that feed into restoration objectives and assessment. Its primary technique to do this has been scientific conjecture. We are not criticizing the physical and biological scientists who have made efforts to consider the social science aspects of restoration (e.g. Hillman and Brierley 2005). However, could these social science issues be better addressed with well-established social science methodologies or by drawing on the expertise of the social science community?

Unsurprisingly, the scientific literature on restoration reflects the same biases. Since the early 1980s, primarily physical and biological scientists have produced tools, recommended approaches and strategies, and provided supposedly objective commentaries on restoration. A rich restoration literature has evolved, which includes an unknown number of grey-literature reports (Lacanilao 1997), thousands of peer-reviewed journal articles, many restoration manuals (e.g. Slaney and Zaldokas 1997; Cowx and Welcomme 1998; FISRWG 1998; Rutherfurd *et al.* 2000; RRC 2002) and numerous edited volumes (e.g. NRC 1992; Brookes and Shields 1996; Waal *et al.* 1998; Wood-Gee 1999; Nijland and Cals 2000; Wissmar and Bisson 2003). The restoration literature is further biased in that it primarily reflects the perspectives of restoration scientists (notable exceptions include Brookes *et al.* 1998; Tunstall *et al.* 2000) rather than practitioners, policymakers and stakeholders. From our own reviews of the restoration literature, it is apparent that there are tremendous opportunities for original social science research in restoration and productive collaborations between social, physical and biological scientists. There are a number of papers now advocating or describing the importance of participatory approaches in river restoration and river basin management (e.g. Rhoads *et al.* 1999; Sayer and Campbell 2003; Cowie and Borrett 2005; Hillman and Brierley 2005). It should be noted that more general issues of environmental policy and river basin management, of which river restoration might be considered a subset, are well studied by social scientists (e.g. Sarokin and Schulkin 1992; Bauer 1998; Saleth 2004; Lemos and De Oliveira 2004; Holl and Howarth 2000). There is obvious applicability of some of this research specifically to restoration science. However, these sources of literature appear to be infrequently cited within the river restoration literature.

A respondent survey is among the most basic tools in the social science toolkit (Trochim 2000). Yet to a physical or biological scientist, a respondent survey is arguably not something we would consider as a standard methodology. There is nothing inherently wrong with this discrepancy. However, if as physical or biological scientists studying river restoration we wish to address the social and policy dimensions of restoration, we ought to either learn how to use the standard tools of the trade or collaborate with those who can. Although scientific conjecture and its generalizations can be constructive, there are more robust techniques to document perceptions, trends and attitudes within the restoration community. The IRRS was our attempt to start doing just that.

The practical utility of the database of perceptions and experiences that arise out of the IRRS is worth considering. From the scientist's perspective, at a minimum it provides a basic background check to our conjecture about restoration. Before publishing a paper with our own biased conjecture, it is a simple task to see if data from a survey like this can support or refute our claims. The survey can be updated at any time upon request to include new questions. In the more general field of physical geography, geographers are becoming increasingly involved in policy, planning and decisionmaking contexts. Launching a survey similar to the IRRS may be a prudent way to acquire social data that goes beyond our standard physical data sets. Indeed, a number of free and fee-based survey solutions now

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exist on the web to meet individual users' needs and technical expertise. From a more practical perspective of practitioners, decisionmakers and stakeholders, the IRRS provides a baseline for comparison and might help identify what the standard of practice is. From a policy perspective, the IRRS can highlight trends and problems. However, it is important to emphasize that the IRRS is a rather blunt tool. It should not be used as a substitute for decision-making at the local scale or as a design guide. Simply because the rest of the community is generally doing 'blank' does not necessarily make it an appropriate option in all cases.

Conclusions

In this paper, we explained how a web-based international survey was used to establish a database of the perceptions and experiences of the river restoration community. By de-emphasizing our own conclusions from the results, we encourage users of the data to make their own interpretations. We argued that this is a stronger and less biased basis than the generalizations found in the restoration literature. Many of the generalizations found in the scientific literature about river restoration are reasonable summaries based on individual experience, but are nonetheless conjecture. To illustrate this point, we compared a few such examples with results from the survey. The examples do not highlight a consistent trend of the conjecture propagated through the scientific literature being right or wrong. Instead, we suggest that the conjecture is often very context-specific but propagated and extrapolated through the literature as more broadly applicable generalizations. The survey results provide a more reasonable and robust basis to make such generalizations from. However, the results also underscore the diversity of restoration activities and perceptions. From a scientific perspective, this seems to imply ample opportunities exist in restoration for research from a mix of social, biological and physical sciences.

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