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REVIEW

Questionnaires in ecology: a review of past use and recommendations for best practice

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Summary

1. Questionnaires, or social surveys, are used increasingly as a means of collecting data in ecology. We present a critical review of their use and give recommendations for good practice.

2. We searched for papers in which questionnaires were used in 57 ecological academic journals, published over the period 1991–2003 inclusive. This provided a total sample size of 168 questionnaires from 127 papers published in 22 academic journals.

3. Most questionnaires were carried out in North America and western Europe, and addressed species-level issues, principally focusing on mammals. The majority were concerned with impacts of species and/or their conservation, and just under half with human–wildlife interactions.

4. Postal survey was the method used most frequently to carry out the questionnaires, followed by in-person interviews. Some questionnaires were conducted by telephone, and none was web-based.

5. Most questionnaires were concerned with obtaining factual information or perceptions of facts. Ground-truthing (independent verification of the facts) was carried out in less than 10% of questionnaires.

6. The mean (± SE) sample size (number of respondents) per questionnaire was 1422 ± 261 and the average (± SE) response rate was 63 ± 3%. These figures varied widely depending on the methods used to conduct the questionnaire.

7. The analysis of data was mostly descriptive. Simple univariate methods were the most frequently used statistical tools, and data from a third of questionnaires were not subjected to any analysis beyond simple descriptions of the results.

8. *Synthesis and applications.* We provide recommendations for best practice in the future use of questionnaires in ecology, as follows: (i) the definition of the target population, any hypotheses to be tested and procedures for the selection of participants should be clearly documented; (ii) questionnaires should be piloted prior to their use; (iii) the sample size should be sufficient for the statistical analysis; (iv) the rationale for the choice of survey method should be clearly stated; (v) the number of non-respondents should be minimized; (vi) the question and answer format should be kept as simple as possible; (vii) the structure of the questionnaire and the data emerging from it should be unambiguously shown in any publication; (viii) bias arising from non-response should be quantified; (ix) the accuracy of data should be assessed by ground-truthing where relevant; (x) the analysis of potentially interrelated data should be done by means of modelling. Researchers should also consider whether alternative, interpretative methods, such as in-depth interviews or participatory approaches, may be more appropriate, for example where the focus is on elucidating motivations or perceptions rather than testing factual hypotheses.

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Introduction

Questionnaires, or social surveys, are used in ecology to test research hypotheses when information is required from a specific human target population. A subset of the target population is contacted by the researchers and asked to participate in the questionnaire by providing information. Data are collected from respondents and analysed to test the hypotheses.

The use of questionnaires in ecology has increased over the last decade. This is because questionnaires are particularly suitable tools for approaching certain topics in ecology, such as studies of public or stakeholder perceptions in ecological management, large-scale studies, studies of human impacts on wild species, and interdisciplinary studies that include ecological and non-ecological components.

Stakeholders and the general public are increasingly involved in decision-making on management issues. Many governments are now actively seeking the views of the public before deciding on future environmental policies, for example in the UK the Department for Environment, Food and Rural Affairs has conducted public consultations on hunting with dogs (Burns *et al.* 2000) and on the management of deer species and badgers *Meles meles* L. Quantifying public perceptions is becoming a key component in translating ecology into management. This has already been recognized in the USA (Conover 2002), where consultation and education are important parts of management strategies to reduce human–wildlife conflicts (Chase, Schusler & Decker 2000; Schusler & Decker 2002; Holsman & Peyton 2003). Recognizing and accounting for the human dimension in the application of ecology to decision-making (Knight 2001; Redpath *et al.* 2004) is likely to become increasingly important in the UK and other countries in the future.

Large-scale studies in ecology, at the regional and national scale, frequently require high-resolution data for specific areas. For logistical and cost reasons, indirect means of gathering data are often used (Reading *et al.* 1996; Macdonald & Johnson 2000; Vaughan *et al.* 2003). In these studies, stakeholders may be asked about the status or behaviour of a particular species, or about the species' impact on other species or habitats, via a questionnaire.

In studies concerning human impacts on wild species and human behaviour in relation to wild species, questionnaires often provide the best means of obtaining quantitative data from a large number of sites. While field surveys can be used to provide information on current impacts or management practices, they are normally unsuitable for revealing information on past impacts or management, and in these circumstances questionnaires can be a vital research technique.

Questionnaires are useful for quantifying human behaviour, for example perceptions or attitudes towards conservation strategies and/or the implementation of environmental conservation directives (Kerr & Cullen 1995; White *et al.* 1997; White, Bennett & Hayes 2001; Jim & Xu 2002; Obiri & Lawes 2002; Bouton & Frederick 2003; White *et al.* 2003). Such issues are frequently the focus of interdisciplinary research in applied ecology, which is rising in prominence as researchers realize the limitations of the traditional monodisciplinary approaches in tackling problems and setting priorities in environmental conservation and management (Maguire & Servheen 1992; Pierotti & Wildcat 2000; Riley *et al.* 2002; O'Connor, Marvier & Kareiva 2003; Drechsler 2004).

Where researchers attempt to integrate ecological data with socio-economic or political data, questionnaires are often used in some aspect of the study. In most cases, questionnaires are used to determine actual behaviour, but in some cases hypothetical behaviour is the focus. This is particularly the case where questionnaires are used to provide data for economic valuation studies, for example by using methods such as contingent valuation and attribute-based choice modelling to determine willingness to pay (WTP) for increased utility arising from the provision of a public good, or willingness to accept (WTA) compensation for the loss of utility resulting from a decline in a public good (Loomis & White 1996; Garrod & Willis 1997; White *et al.* 1997; Carson 2000; White, Bennett & Hayes 2001). An increasing number of such studies is directly or indirectly related to ecological issues (Bosetti & Pearce 2003), although the methods themselves, particularly contingent valuation (Mitchell & Carson 1989), are the subject of much criticism. Fundamental objections include those related to the validity of the approach itself, as respondents may not understand what is being asked of them or may not feel that the monetary value they provide captures adequately the value of a specific resource to them (Vadnjal & O'Connor 1994; Clark, Burgess & Harrison 2000). There are also more specific concerns surrounding the effect of various biases on the outcomes (Neill *et al.* 1994; Loomis *et al.* 1996; Foster, Bateman & Harley 1997; Horowitz & McConnell 2002; Venkatachalam 2004). However, the nature of these biases and how they may be reduced, or at least quantified, are now much better understood (Bateman *et al.* 2002).

In this study, we conducted a comprehensive analysis of papers published in peer-reviewed journals in ecology in which questionnaires have been used. We used data from the papers to quantify and describe patterns in the use of questionnaires geographically and over time, subject matter, aims of questionnaire studies, target populations, types of questionnaires used, sample sizes and response rates, question formats, methods for analysis, and the extent to which issues of non-respondent bias and data validity (accuracy) and reliability (consistency) have been addressed. Following this, we have discussed common issues in the use of questionnaires (representativeness of the sample, data collection methods, questionnaire design, validity and reliability of the data, and analysis) and how problems have been overcome by some authors. Finally, on the basis of our results and discussion, we have made recommendations for best practice for the future use of questionnaires in ecology.

Methods

We searched ecological journals with an impact factor > 0·3 at the end of 2003 to retrieve all papers published between 1991 and 2003 inclusive in which questionnaires were used. We did not search 'pure' zoological and botanical journals, or journals that were associated primarily with the social sciences such as economics, even if they had some environmental or ecological focus. We used the search term 'questionnaire*' within title, abstract, and key-words to search a number of different science databases (Web of Science, Science Direct, Ingenta and Geobase) and individual journal homepages. We interrogated each paper we retrieved using a standard form to identify the subject, target population, respondent type, questionnaire design, sampling procedure, response bias, and the analysis and accuracy of the data (see Appendix S1). We stored and analysed all information using Microsoft® Access.

Results

We found 168 questionnaires in 127 papers in 57 ecological journals (see Appendices S2 and S3). We considered the questionnaire, rather than the paper, as the unit of analysis because several papers described results from more than one questionnaire.

The number of questionnaires increased five-fold from four in 1991 to 23 in 2003 (Fig. 1). There was no significant correlation between journal impact factors and the number of questionnaire papers published over this period (Spearman rank, $r_s = -0{\cdot}07$, NS), although no papers involving questionnaires were published in the seven highest-ranking journals that we considered.

Most questionnaires were carried out in North America, followed by the UK, Africa and western Europe excluding the UK (Table 1). Most questionnaires focused on species-level issues, and were concerned with non-human mammals (Table 2). The most frequent concern of questionnaires was impacts of species, with fewer questionnaires addressing species conservation and management (Table 2); many questionnaires fell into more than one subject category. More than half of the questionnaires concerned some form of interaction, human–wildlife interactions being the most common (Table 2).

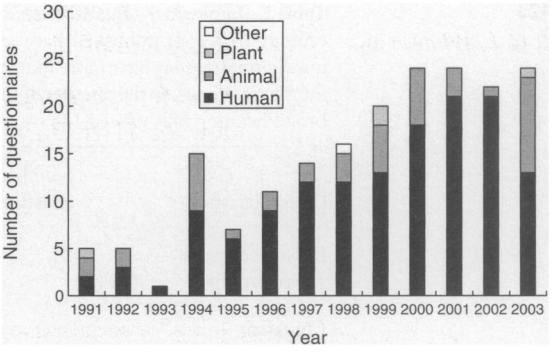

Fig. 1. Change in number and subject focus (human, animal, plant or other) of questionnaires in ecology (n = 168) over time.

Table 1. Geographical focus of questionnaires in ecology (n = 168) published between 1991 and 2003

Geographical area	Number of questionnaires	Percentage of questionnaires
UK	31	18·5
Western Europe (excluding UK)	16	9·5
Eastern Europe	1	0·6
North America	58	34·6
South America	10	5·9
Africa	19	11·3
Australasia	6	3·6
Asia	14	8·3
Other	13	7·7

The target populations in the majority of questionnaires were practitioners (people who carry out practical management of the land or ecological resources, such as farmers and foresters), followed by the general public, and most questionnaires were aimed at consumers or producers of the ecological resources in question (Table 3). Postal surveys were the most common method used to carry out the questionnaires (48·8%), followed by in-person interviews (33·9%). Seven questionnaires were conducted by telephone, and none was web-based. The method of data collection was not stated for 23 questionnaires. The mean (± SE) sample size (number of respondents per questionnaire) was 1422 ± 261 (279 ± 111 for in-person interviews, 1962 ± 383 for postal surveys and 854 ± 357 for telephone interviews). The mean (± SE) response rate was 62·9 ± 2·7% (97·5 ± 1·4% for in-person interviews, 51·9 ± 2·7% for postal surveys and 58·1 ± 5·4% for telephone interviews).

More researchers used closed-format questions (dichotomous, multiple choice, Likert scale or rating scale) rather than open questions, although it was not

Table 2. Ecological characteristics of questionnaires in ecology (n = 168) published between 1991 and 2003. Some questionnaires may have more than one taxonomic, subject or interaction focus, so the number of questionnaires within each broad heading may exceed 168

Characteristics	Number of questionnaires	Percentage of questionnaires
Ecological scale		
Ecosystem	3	1·8
Community	8	4·8
Species	71	42·3
Population	3	1·8
Combination of the above	29	17·3
Other	54	3·2
Taxonomic focus		
Mammal (excluding human)	62	36·9
Bird	15	8·9
Fish	10	6·0
Reptile	2	1·2
Amphibian	2	1·2
Invertebrate	2	1·2
Combination of the above	9	5·4
No taxonomic focus	66	39·3
Subject focus		
Conservation	110	65·5
Impacts	141	83·9
Management and/or control	102	60·7
Other	101	60·1
Interaction focus		
Human–wildlife	76	45·2
Wildlife–livestock	5	3·0
Wildlife–wildlife	4	2·4
Human–human	4	2·4
Human–environment	5	3·0
No interaction	83	4·9

Table 3. Characteristics of respondents to questionnaires in ecology (n = 168) published between 1991 and 2003. Some questionnaires may have more than one respondent type or user characteristic, so the number of questionnaires within each broad heading may exceed 168

Characteristics	Number of questionnaires	Percentage of questionnaires
Type of respondent		
General public	52	31·0
Practitioner	76	45·2
Professional	34	20·2
Other	20	11·9
User characteristics of respondents		
Consumptive user	56	33·3
Non-consumptive user	21	12·5
Non-use value	23	13·7
Producer	41	24·4
Other	44	26·2

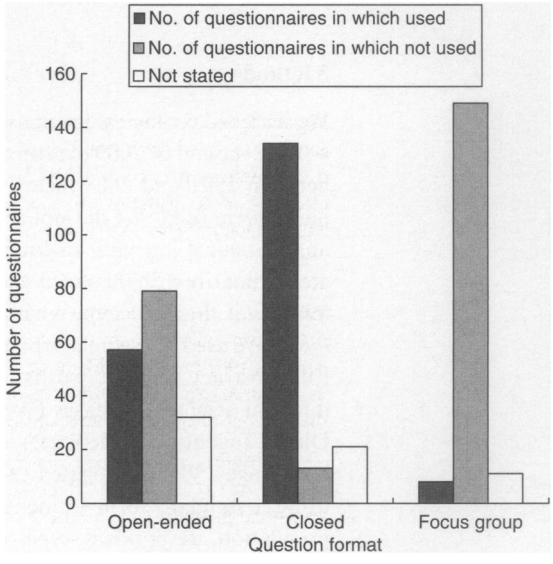

Fig. 2. Question formats used in questionnaires in ecology (n = 168) published between 1991 and 2003. Some questionnaires may contain more than one question format, so the number of questionnaires within each question format may exceed 168.

possible to quantify the relative use of these different forms of closed-format question because of the lack of information provided in many papers. A few researchers used a focus group approach, in which issues are discussed among small groups of respondents (Fig. 2). Most questionnaires were concerned with facts, whether documented or non-documented, or perceptions of actual events. Fewer were concerned with perceptions of hypothetical events (Fig. 3). Ground-truthing (the independent verification, by researchers, of data from respondents) was carried out in only six (6·7%) of 89 questionnaires in which factual information supported by documented records was collected, 13 of 91 (14·3%) concerned with non-documented facts and six of 91 (6·6%) concerned with perceptions of actual events. No ground-truthing was carried out to test the reliability of stated perceptions for any of the questionnaires relating to hypothetical events (from a total of 26 non-WTP and seven WTP studies). Of 168 questionnaires, only 21 (12·5%) involved some attempt to survey non-respondents for comparison with respondents, most commonly by telephone survey.

The sampling procedures for the selection of participants included random in 57 questionnaires (33·9%), systematic in 46 (27·4%), comprehensive in 23 (13·7%) and opportunistic in six (3·6%). The sampling procedure was not clearly explained for 52 of the 168 questionnaires (31·0%). Data were summarized descriptively for 154 questionnaires, and there was no statistical analysis of any type for 56 questionnaires. Simple univariate statistics were used in the analysis of 90 questionnaires; relatively few researchers used multivariate analytical procedures (Table 4).

Discussion

REPRESENTATIVENESS OF SAMPLE

Our exclusion of pure zoological and botanical journals may have resulted in the omission of a few relevant

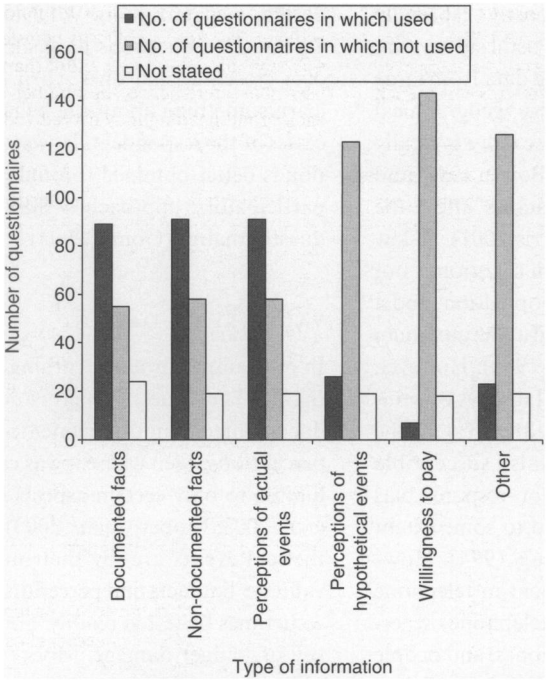

Fig. 3. Types of information obtained from questionnaires in ecology (n = 168) published between 1991 and 2003. Some questionnaires may be concerned with obtaining more than one type of information, so the number of questionnaires within each information type may exceed 168.

Table 4. Statistical procedures used for the interpretation of data from questionnaires in ecology (n = 168) published between 1991 and 2003. More than one statistical procedure may be used to analyse the data from a single questionnaire, so the number of questionnaires in the table exceeds 168

Statistical procedure	Number of questionnaires	Percentage of questionnaires
Simple description of results	154	91·7
Univariate analysis, including ANOVA and correlations	90	53·6
Simple linear regression	15	8·9
Multivariate ANOVA/ ANCOVA	3	2·8
Multiple linear regression	11	6·5
Binary or ordinal logistic regression	16	9·5
Discriminant function analysis	1	0·6
Tobit or probit analysis	0	0·0
Ordination	8	4·8
Cluster analysis	3	1·8
Other multivariate analysis	12	7·1

papers, and our exclusion of economic journals will have meant that the number of WTP papers in particular was an underestimate of their overall contribution to the literature. However, many WTP studies concerned with ecological issues that are reported in economic journals are driven by methodological concerns, and even in those that are not, the actual ecological component in these papers is frequently small. One additional important consideration is that published questionnaires represent only a small proportion of those questionnaires that have been used in ecological studies. Any meta-analysis based on published information only is therefore inherently biased (Raffaelli & Moller 2000). Nevertheless, within the sampling frame that we have specified, we consider our sample to be comprehensive.

GEOGRAPHICAL VARIATION IN USE OF QUESTIONNAIRES

The larger number of North American papers containing questionnaires suggests a geographical bias in methods used for the management of problems in ecology. The general public and other stakeholders tend to be more heavily involved in decision-making in ecology in North America than elsewhere, for example with respect to human–wildlife conflicts such as the management of white-tailed deer *Odocoileus virginianus* Miller and elk *Cervus elaphus* L. (Kilpatrick & LaBonte 2003; Lee & Miller 2003). In North America, obtaining views of different user groups and the general public is seen as a very important part of effective management for wildlife resources (Minnis 2001; Conover 2002). As the interest and participation of the general public in decision-making on wildlife issues is increasing, management is being driven more and more by societal perceptions. This will become increasingly so in the UK and in other western European countries in the next decade. Consultations with stakeholders and the general public to evaluate perceptions, find common ground and resolve conflict (Redpath *et al.* 2004) are likely to become pivotal in ensuring the continued management relevance of ecology.

SAMPLING PROCEDURES

For most questionnaires in which sampling procedures were specified, random, systematic or comprehensive sampling of the target population was used to obtain participants. However, the sampling procedure was not explained for 52 questionnaires (almost a third of those we examined). Where the sampling procedure is not explained, any conclusions arising from the questionnaire have little value because it is not possible to evaluate the reliability of the data or the degree to which the respondents are representative of the target population.

DATA COLLECTION METHODS AND RESPONSE RATES

The most frequent type of data collection method in the questionnaires we surveyed was postal survey, followed by in-person interviews. It has been argued that in-person interviews are preferable overall as a sampling method, especially in relation to WTP studies

(Arrow *et al.* 1993), but they are costly, especially where large sample sizes are needed. Postal surveys are the most economical way of collecting data from large numbers of respondents across large geographical areas, but they suffer from low response rates, typically less than 50% (Weisberg, Krosnick & Bowen 1996) and sometimes as low as 30%. Many factors affect the response rate to questionnaires (Harris 2001). A low response rate suggests that the issue in question is not particularly important to the target population, and a response rate of 50% has been suggested as the minimum that is adequate for analysis (Babbie 1990). However, the average response rate for the postal surveys we sampled was 52%, only a little lower than the 58% for the telephone surveys. Postal surveys are also susceptible to problems with self-selection and non-response bias (Oppenheim 1992), which are avoided to some extent by telephone surveys (Loomis & King 1994). However, some biases may still be present in telephone surveys because of different levels of telephone ownership, the widespread use of mobile phones, and people registering with organizations to prevent unsolicited calls. Both postal and telephone surveys allow greater ease of centralized supervision than in-person interviews (Arrow *et al.* 1993; Schuman 1996), and postal surveys eliminate possible biases associated with different interviewers.

Postal, telephone and face-to-face surveys all have specific advantages and disadvantages associated with them, but there are ways of minimizing these problems by careful survey design, and there appears to be little difference in the outcomes of studies based on well-designed questionnaires using any of these techniques (Gomm 2004). Increasingly, questionnaires are likely to be web-based, but we found no published examples of web-based surveys in ecology. Web-based surveys, although likely to suffer from substantial response biases that are difficult to quantify, can provide large data sets that can be used to examine the interrelationships among variables, employing multivariate techniques.

QUESTIONNAIRE DESIGN

Closed-format questions were the most commonly used in our sample. Although well-designed open-ended questions may provide data of equivalent precision to closed-format ones, closed-format questions generally result in less uncertainty than open-ended questions, for both the respondent and the researcher. However, the lack of information in many of the papers meant that we could not determine whether particular types of closed-format questions were more effective than others. In WTP studies, closed-format questions have been shown to remove the problems associated with very high or very low WTP values being given by respondents (Arrow *et al.* 1993; Bateman *et al.* 1995). However, Loomis & White (1996) found that the format of the questionnaire was relatively unimportant, compared with other factors relating to questionnaire design, in determining WTP for endangered species. Open-ended questions have some distinct advantages over closed-format ones when the primary goal is to learn something about the behaviour or thought processes of the respondent. However, this type of information is better obtained through in-depth interviews or participatory approaches than through survey-type questionnaires (Gomm 2004).

VALIDITY OF DATA

In our sample, ground-truthing was carried out in less than 10% of questionnaire studies, either to validate documented or non-documented facts, or in relation to perceptions; even where it was carried out, it was often limited to only certain aspects of the study (Firbank *et al.* 2003; Moberly *et al.* 2003). Perceptions of hypothetical events are, by their nature, not possible to validate, but facts and perceptions of actual events can sometimes be tested readily. For example, in their survey of badger damage, Moore *et al.* (1999) obtained 1921 responses and ground-truthed 150 of these, although even in this case the ground-truthing was done the year after the questionnaire, so still has some shortcomings as a true test of the reliability of questionnaire responses.

COMPARISON OF RESPONDENTS WITH NON-RESPONDENTS

Comparing respondents with non-respondents to check for non-response bias should be an integral part of any questionnaire-based research. However, it may be difficult, particularly for in-person and telephone interviews, and for postal surveys in which anonymity is allowed (Moberly *et al.* 2003; Vaughan *et al.* 2003). Authors frequently ignore this problem, either simply assuming that respondents are (McDonald & Harris 1999) or are not (Moore *et al.* 1999) representative. Non-response bias is more likely to occur where response rates are low, but it is incorrect to assume that a good response rate is indicative of a lack of non-response bias (Brown & Wilkins 1978). Non-response bias is a particularly important consideration where the intention is to extrapolate the results of a questionnaire across the entire target population (Dalecki, Whitehead & Blomquist 1993). The extent to which the respondents are representative should be quantified, for example by resurveying the non-respondents (Heydon & Reynolds 2000) or by statistical comparison of the respondents with the intended sample population (White & Whiting 2000; Vaughan *et al.* 2003). However, in our study only 21 of 168 (12·5%) questionnaires included any form of analysis of non-respondents. This means that 87·5% of the questionnaires were untested for non-response bias, and thus may have produced invalid, non-generalizable information. This is a particular concern where these questionnaires may have been used to provide background information for policy decisions.

DATA ANALYSIS

Despite the increasing use of questionnaires, most analysis of questionnaire data was restricted to univariate statistics, such as simple ANOVA and correlations, and no statistical analysis at all was applied in a third of the questionnaires we sampled. The use of sophisticated multivariate models is increasing in many areas of applied ecology, especially where categorical presence/absence type data are analysed (Manel, Williams & Ormerod 2001). Such models have been used commonly in WTP studies (White, Bennett & Hayes 2001; Bosetti & Pearce 2003) and offer a powerful way of analysing outcomes in response to a number of potentially influential factors that may be quantified in different ways, as is commonly the case in data from questionnaires. For example, in our sample of questionnaires, logistic regression was used to investigate factors affecting the likelihood of hare *Lepus europeaus* Pallas sightings on farmland (Vaughan *et al.* 2003), fox *Vulpes vulpes* L. predation of lambs (Moberly *et al.* 2003), success (Albert, Bowyer & Miller 2001) or legality (Gray & Kaminski 1994) of hunting, and attitudes towards conservation (Gillingham & Lee 1999; Riley & Decker 2000; Sah & Heinen 2001) and tourism (Walpole & Goodwin 2001). Where the data allow, generalized linear models may be used (Adams & Steen 1997; Macdonald & Johnson 2000; Swensson & Knight 2001).

Techniques such as structural equation modelling or path analysis (Tabachnick & Fidell 1996), which allow the analysis of relations among a number of discrete and/or continuous independent variables, offer much potential for use in the analysis of questionnaire data, and are used commonly in the psychological and health sciences literature. However, for the analysis of questionnaire data in ecology, the uptake of these techniques has so far been limited (Woods *et al.* 1996; Corral-Verdugo *et al.* 2002). Similarly, there has been little use made of power analysis to assist with planning sampling strategies for large-scale questionnaire studies based on the results of pilot studies. Given the effort involved in collecting questionnaire data, and the large amount of information that questionnaires can yield, inadequate sampling and incomplete statistical treatment of the data represent a significant inefficiency in the research process, as well as in respondents' time.

Recommendations for best practice in questionnaire-based studies

(i) The target population should be clearly defined, any specific hypotheses should be explicitly stated and sampling procedures for the selection of participants should be well-documented and justified. Comprehensive, random and systematic sampling procedures are all acceptable, depending on the circumstances. If comprehensive sampling is not possible, a sampling strategy that is both stratified and randomized is recommended.

(ii) Questionnaires should be pre-tested by piloting on a subsample of participants. This frequently highlights potential problems caused by misunderstandings, particularly important for postal surveys, and therefore minimizes the possibility of errors in the data. It should be clearly stated that pilot studies have been carried out.

(iii) The sample size (number of respondents) should be sufficient to yield robust data. It is difficult to state precisely how many participants are required, as this depends on the response rate, the tolerance of error in the response, the nature of the questionnaire, and the choice of sampling method. A power analysis based on the responses from a pilot study may be useful as a guide to the sample size required for some types of questionnaire.

(iv) Careful thought should be given to the survey method. Postal surveys offer a cost-effective way of reaching a large number of participants or potential respondents. However, they tend to be susceptible to low response rates and sampling bias. These biases may be reduced by the use of telephone or in-person interviews, although there can be problems of interviewer bias when using these methods. The optimum survey method may be determined by the study itself, for example the literacy level of respondents or the type of data that the researcher is seeking to obtain, in which case the reasons behind the choice of survey method should be stated. Careful survey design can minimize many of the biases associated with a specific method. Where feasible, a combination of survey methods could be used on a subsample of respondents to quantify any method-dependent biases.

(v) Every effort should be made to minimize the number of non-respondents, so questionnaires should be kept as simple as possible. There is a recognized trade-off between the proportion of non-respondents and the complexity of the questionnaire, which can lead to self-selection of interested or better-informed respondents and consequent response bias.

(vi) A simple question-and-answer format minimizes possible biases caused by misinterpretation by respondents or researchers and therefore maximizes the accuracy of data. This is especially true for postal surveys, but also relevant for in-person and telephone surveys. Where the gathering of factual information is the priority, open-ended questions should therefore be avoided. However, open-ended questions are more suitable where researchers are seeking to understand the behaviour or motivations of respondents. Respondents should always be given the opportunity to decline to answer individual questions.

(vii) A table showing the question and answer format of any questionnaires used (for example see Appendix 1) should be included in any publication, to allow a reader to determine unambiguously how the questionnaire is structured, and the type of data that are derived from it.

(viii) Researchers should demonstrate that respondents are not substantially different from non-respondents. A high response rate is not necessarily indicative of a

lack of response bias. Non-response bias should be tested for by follow-up surveys of non-respondents. If this is not possible for reasons such as confidentiality, the degree to which the respondents are representative should be assessed by indirect means, such as a comparison of their socio-economic or other relevant characteristics with those of the target population. Questionnaires should therefore contain background questions specifically for this analysis.

(ix) The accuracy of data obtained from questionnaires should be assessed by ground-truthing where possible. This is important for both factual data based on documented records and factual data based on non-documented records. It is especially important for the latter, as respondent biases are likely to be greater where no documented records exist.

(x) Questionnaires frequently produce a considerable amount of data, which may be interrelated. Multivariate statistical techniques, such as logistic regression, generalized linear models and structural equation modelling, should be used for the analysis of data in these circumstances. An over-reliance on simple univariate techniques that do not take explicit account of these possible interrelationships may miss important results and/or yield erroneous ones.

Conclusions

In this study, we have focused our analysis and recommendations for best practice specifically on questionnaires as a means of obtaining factual information on the perceptions and/or behaviour (real or hypothetical) of the human population. The use of questionnaires in this way reflects the positivist approach to social science, which follows the traditional approach of the natural sciences, where the emphasis is on obtaining precise, quantitative data and the researcher remains objective and detached (Neuman 1997).

Researchers commonly aim to use questionnaire data to make generalizations or extrapolations about the target population, which is akin to a macro-scale approach (Clarke 2001). However, much research in social science takes an alternative, interpretative approach, where the emphasis is on understanding the interactions between people and how they interpret the world around them (Neuman 1997), more akin to a micro-scale approach (Clarke 2001). Proponents of the interpretative approach tend to take a very different approach to information-gathering, favouring participatory approaches and/or qualitative in-depth interviewing rather than structured questionnaires, and avoiding methods that they feel constrain the respondent artificially, such as closed-format questions (Mason 1996; Patton 2001, 2002).

Traditionally, ecology has focused on the analysis of factual information. However, with the increasing importance of stakeholder perceptions and greater inputs of diverse interest groups into policy-making decisions for the management of ecological resources, ecologists will need to embrace more diverse paradigms. The use of interpretative approaches from the social sciences, such as ethnography (Hammersley & Atkinson 1995), participatory approaches (Pretty *et al.* 1995; Holland & Blackburn 1998; Chambers 2002), in-depth interviews (Rubin & Rubin 1995), action research (Whyte 1991) and focus groups (Barbour & Kitzinger 1999; Bloor *et al.* 2000), is likely to increase in applied ecological research. The integration of these qualitative approaches with quantitative ones (Brannen 1992) to obtain a more holistic picture of the use and management of ecological resources represents a challenge, but also a significant opportunity, for ecologists involved in policy-orientated research.

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Supplementary material

The following supplementary material is available for this article online.

Appendix S1. Variables collected from each questionnaire included in our analysis, and details of data classification.

Appendix S2. Journals searched for papers in which questionnaires were used, and the number of papers from each journal used for analysis.

Appendix S3. Bibliography of papers used for the analysis.

References

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