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Matching a scientific knowledge base with stakeholders' needs The T10Q project as a case study for forestry

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ABSTRACT

The extent and provenance of the existing global knowledge base were qualified in relation to ten specific questions of priority to forestry research. The ten questions were derived from a participatory exercise; the Top Ten Questions for Forestry research (T10Q) completed in 2008. Analysis of the first-ranked question, relating to invasive species, pests and diseases, revealed a lower than expected volume of published European literature, compared with the other nine questions and overall database figures. Analysing the published scientific literature of relevance to the T10Q demonstrated a novel method of using bibliometrics to link stakeholder priorities with the existing knowledge base to provide a richer picture of the state of scientific evidence available for decision-making.

1. Introduction

European science academies view science as being not only central to many aspects of modern life, but a "pre-requisite to wise policy-making" (European Academies Science Advisory Council (EASAC), 2010). The Fifth Ministerial Conference on Environment and Health called for greater use to be made of existing scientific information for policy-making ((World Health Organization, 2010), and the Warsaw Declaration specifically committed European governments to improving understanding between policy makers, practitioners and the scientific community so that better use is made of "scientific knowledge and research results relevant to forests and the forest sector as a sound basis for decision making" (Forest Europe, 2007). The existing body of information lies largely unused after publication: Meho (2007) estimates that some 90% of papers that have been published in academic journals are never cited, and that 50% of papers are never read by anyone other than their authors, referees and journal editors. This must include policy-makers and others tasked with making decisions about research and funding priorities. Such a state of affairs is in Meho's words, a 'sobering fact', particularly in view of the fact that Ravetz made precisely this claim before the advent of widespread access to online information resources (Ravetz, 1987).

Alongside calls for greater use of existing science, there is also growing demand for 'evidence-based policies' in Europe and elsewhere (European Union, 2010). One of the barriers limiting the implementation and adoption of evidence-based frameworks in the field of natural resource management, however, is the notion that scientific research activities are not focused on issues of relevance to decision makers or to policies (Pullin et al., 2004; Pullin and Knight, 2005), and there is no reason to believe the situation is better in forest science.

To overcome this problem, Sutherland et al. (2006) pioneered an approach for generating a list of important research questions. This '100 questions' model has been repeated and adapted a few times since then in ecological fields (Morton et al., 2009; Sutherland et al., 2009), and in forestry by Petrokofsky (2010). Cooke et al. (2010) has introduced the idea to the fisheries community and reports that two other groups are undertaking 100-questions exercises in Canada and the USA. There has been considerable interest in these projects and the questions generated have been used by governmental and non-governmental organisations to refine their own research agendas (Sutherland et al., 2010) or to highlight important priorities (see, for example, Lawrence, 2008). However, apart from Cooke, who critically evaluated the global 100 questions exercise (Sutherland et al., 2009) to identify those of relevance to aquatic and fisheries professionals, there has been very little further work on the types of questions generated by stakeholders or on the body of knowledge that already exists as a potential resource for addressing these questions.

Bibliometric analysis has been used to indicate trends and patterns within scientific disciplines, national and international strengths and biases in areas of research for over a decade, not without controversy, particularly where attempts were made to make comparisons between individual scientists (Calza and Garbisa, 1995). However, May (1997) asserts that bibliometric analysis can be used to take a macro-view of research output, and that comparisons and analysis become more meaningful when directed towards

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institutions, nations and geographical regions. Policy makers in the fields of medicine and public health have used bibliometric analysis to determine research priorities and to assess where knowledge gaps, or research gaps exist (Hofman et al., 2006; Glover and Bowen, 2004; Saxena et al., 2004.)

Given the growing importance of using existing knowledge to improve decision-making and the necessity of finding practical ways of identifying knowledge gaps, bibliometric analysis of questions generated by pariticpatory exercises that examines research priorities is a practical step that can contribute to these two objectives. The approach fits well with the research scoping exercises that are a critical component of evidence-based medicine, and the small number of other disciplines that use systematic reviews to inform decision-making. Here, the amount of existing literature is scoped at an early stage to assess the size and potential relevance of the knowledge base to provide evidence for the review question (Mulrow, 1994; Chalmers, 2003; Davies and Boruch, 2001; Pullin and Knight, 2009). There are only a handful of systematic reviews of relevance to forest and forestry professionals (Petrokofsky and Mills, 2009), but there is a growing interest in adopting them for global problems, such as deforestation and forest degradation, which require collaborative, multi-disciplinary efforts to make the best use of all available evidence (Goetz et al., 2010, 2009; Holmgren and Marklund, 2007). The 'T10Q—Top Ten Questions for Forestry' project, adapted in 2008 from Sutherland's '100 questions' approach, did not set out specifically to generate potential systematic review questions, but it was undertaken in the expectation that it could provide useful inputs to develop an evidence-based approach in forestry (Petrokofsky et al., 2010).

The aim of the current paper is to examine the research base underpinning the ten priority questions determined in the T10Q project to gain a better macro-view understanding of the research which is available currently to stakeholders to take forward these questions. Although the questions were generated mainly by UK-based stakeholders, they represented a wide spread of international experience.

2. Methods

2.1. The T10Q project

The detailed methodology for the T10Q project is described in Petrokofsky et al. (2010). Briefly, the project involved two distinct phases:

First, questions were submitted by 481 individuals with a professional interest in 'forestry' (defined broadly to include the whole forest-based sector, and involving academic researchers, policymakers, NGO personnel, and owners and managers of woodland).

Second, a two-day workshop with 51 people, from 29 different organisations or consultancies, who are involved professionally in UK or Irish forestry, was held on 25th and 26th September 2008 to review the questions submitted and to arrive at the ten most important research questions for forestry using a process of discussion and voting (see Table 1).

Table 1
T10Q project: the top ten questions.

1. What are the most technically and cost effective ways of identifying, monitoring and controlling invasive species, pests and disease?
2. How can we achieve better understanding between foresters and other parts of society?
3. What are the most effective landscape planting schemes to ensure connectivity between woodland fragments whilst maintaining connectivity between other landuse types?
4. How will climate change affect both natural forest ecosystems and forestry and how should management be adapted to minimise adverse impacts and optimise benefits?
5. What is the value of forestry to human health and well-being?
6. Who are the private woodland owners and how can they be engaged and influenced? What are their concerns?
7. Which parts of forest ecosystems form the largest and most stable carbon pools and how are these impacted by forest management and climate change?
8. How can we address the economic, environmental, social and institutional constraints of expanding woodfuel [in the UK]?
9. What species or provenances should we be considering in relation to a range of forestry systems, including urban and agroforestry, in the light of climate change?
10. What are the barriers to knowledge transfer in forestry from research to practice and how can they be removed?

2.2. Analysing the knowledge base for the T10Q questions

An assessment was made of the volume of academic articles on topics related closely to the subject covered by each of the ten questions that emerged as the most important on completion of the stakeholder engagement process. The analyses were not exhaustive reviews of the literature for each question but an indicative assessment using a search strategy to interrogate the forest science subset of CAB Abstracts, a bibliographic database published by CAB International (CABI)[1]. The principal author devised the search strategy in consultation with members of CABI's staff who are responsible for the structure and content of the bibliographic database. Details of the search strategy are in Table 5. This database was chosen in preference to other similarly large bibliographic databases (e.g. Scopus, Web of Knowledge), which are recognised by Vieira and Gomes (2009) to be the two most comprehensive for articles published in academic serials, for two principal reasons:

1). The bibliographic records in CAB Abstracts have been coded and indexed using a widely-used specialist Thesaurus of controlled keyword terms (Ahsan-ul-Morshed and Sini, 2009) and coding schedules that have been applied retrospectively to older records in the database, which enables bibliometric comparisons to be made over time (McDonald and Lassoie, 1996);
2). CAB Abstracts includes 'grey' literature (books, technical reports, and other industry or nongovernmental organisation (NGO) publications not published in academic journals, according to a definition by Clark and Kozar (2011), in addition to articles from academic journals. This grey literature is considered to be of great importance for systematic reviews and meta anlaysis conducted in the fields of health, social policy and environmental conservation to address policy-relevant questions (Higgins and Green, 2011; CRD, 2009; CEBC, 2009; Olsen, 2007) and to identify knowledge gaps and research priorities.

The following analyses were performed for each of the ten literature searches:

The literature search strategy for each question was applied over seven five-year time periods. Decadal analyses have been undertaken previously to track publishing trends (Pasiecznik and Petrokofsky, 2005), but analysing outputs within a shorter time frame offered the possibility of tracking faster-changing trends. The seven periods were:

- 2005–2009;
- 2000–2004;
- 1995–1999;
- 1990–1994;
- 1985–1989;
- 1980–1984;
- before 1980.

Results were analysed for three geographical sets:

- Global
- All European Union countries
- UK only

[1] http://www.cabi.org

The regional subsets were created by selecting research papers conducted in the relevant countries determined by the lead author's home institute, or by the geographical location of the field research. This captured not only European field work but also work carried out in, for example, tropical countries by researchers based in European institutions. Present and historical names of countries currently in the EU were used in the search strategy, e.g. German Federal Republic, Czechoslovakia (see Table 5). The regional data were compared with overall trends within the whole database. Bartol (2010) compared biobliometric data (published outputs indexed in CAB Abstracts) between eight central European countries, which provides finer detail than is possible with the method adopted in the present paper, but the logic of analysing all EU countries as a bloc reflects the policy environment and the integrated nature of much European research (Diedrich et al., 2011) and the EU's vision to be become "the most dynamic and competitive knowledge-based economy in the world" (Lisbon Agenda 2000, cited in European Union, 2011)

In order to look at recent trends in the literature for different topics, the proportion of papers published in the last five years (2005–2009) was calculated for each question as a percentage of the total publications in the database for each question.

The volume of literature for each individual question in the two regions was compared with the overall database proportions for EU and UK literature.

3. Results

3.1. The existing knowledge base for each of the top ten questions

The number of publications retrieved from CAB Abstracts using the search strategy devised for each of the top ten questions is shown in Table 2. Searches were carried out between June and August, 2010 and revised on each occasion to account for database updates.

The knowledge base supporting each question varies widely, largely because the breadth of each question varies considerably. The absolute values are of less interest in the current paper than relative values between geographical regions and changes over time. Fig. 1 shows how the number of publications differed between questions, by presenting the data as the percentage of the total number of publications for all ten questions.

3.2. Publication trends in the EU and the UK for the T10Q knowledge base

The overall proportion of papers from all EU countries in the database is 28.6%; the figure for UK research is 3.6% (12% of the EU total), with slight variations between the different time periods considered in the analysis in Table 2. These proportions were applied to the global figures for each question, so that each question is treated as a subset of the entire database, with a predicted breakdown into similar proportions of literature from different regions. So, for example, for question 1, there were 3,068 relevant publications in the whole database; applying the database average of 28.6% for EU papers would yield an expected 877 publications. The actual search produced 545 publications. Similarly, for UK papers, the expected yield is 109 publications; the actual number was 89. Table 3 gives the actual and predicted figures for each of the ten questions.

Figs. 3 and 4 show differences between the numbers of publications that could be predicted from database average values and the actual figures for EU (Fig. 2) and UK (Fig. 3) publications in each of the 10 question subsets.

A chi-square test on the data showed that there was a significant difference between the 'observed' numbers of publications obtained for the

Table 2
Number of publications for each of the top ten questions from the T10Q project.

T10Q question	Region	<1980	1980–1984	1985–1989	1990–1994	1995–1999	<2000	2000–2004	2005–2009	Total
1. Invasive, pests, disease	Global	105	100	123	249	366	943	568	1557	3068
	EU	10	10	9	20	59	108	107	330	545
	UK	3	5	3	3	12	26	22	41	89
2. Improved understanding	Global	138	69	100	161	360	828	448	441	1717
	EU	38	24	26	44	166	298	161	141	600
	UK	17	8	6	11	36	78	27	21	126
3. Landscape connectivity	Global	206	69	75	163	500	1013	1154	1716	3883
	EU	87	39	38	63	151	378	482	652	1512
	UK	22	16	9	12	18	83	93	125	301
4. Climate change effects	Global	198	41	91	580	1619	2529	2407	4519	9455
	EU	14	6	22	171	890	1103	999	1989	4091
	UK	2	2	10	42	204	260	211	373	844
5. Forest and human health	Global	339	53	47	69	128	636	290	348	1274
	EU	90	28	20	18	41	197	80	104	381
	UK	14	4	11	7	9	45	21	19	85
6. Who owns woodland?	Global	1,074	235	328	529	1021	3187	1461	1416	6064
	EU	429	124	128	192	369	1242	518	477	2237
	UK	45	29	29	34	65	202	74	44	320
7. Carbon pools	Global	5	4	4	59	339	411	750	1084	2245
	EU	1	1	1	16	151	170	256	414	840
	UK	0	0	0	1	36	37	58	71	166
8. Expanding woodfuel	Global	1074	418	573	555	893	3513	888	854	5255
	EU	274	103	120	126	352	975	390	386	1751
	UK	21	20	35	31	61	168	24	38	230
9. Provenances for climate change	Global	6	1	3	35	160	205	168	242	615
	EU	3	0	2	17	75	97	83	125	305
	UK	0	0	0	3	14	17	19	19	55
10. Knowledge transfer	Global	34	7	15	50	98	204	185	183	572
	EU	11	4	5	15	50	85	57	64	206
	UK	3	0	0	5	16	24	12	9	45
All T10Q questions	Global	3179	997	1359	2450	5484	13,469	8319	12,360	34,148
	EU	957	339	371	682	2304	4653	3133	4682	12,468
	UK	124	84	103	144	455	940	561	760	2261
Total for all database	Global	249,230	60,494	70,530	78,890	109,993	569,137	135,580	173,083	877,800
	EU	39,032	21,093	24,634	29,486	41,912	156,157	43,157	51,719	251,033
	UK	7337	3492	4385	4249	1941	21,404	4887	4882	31,173

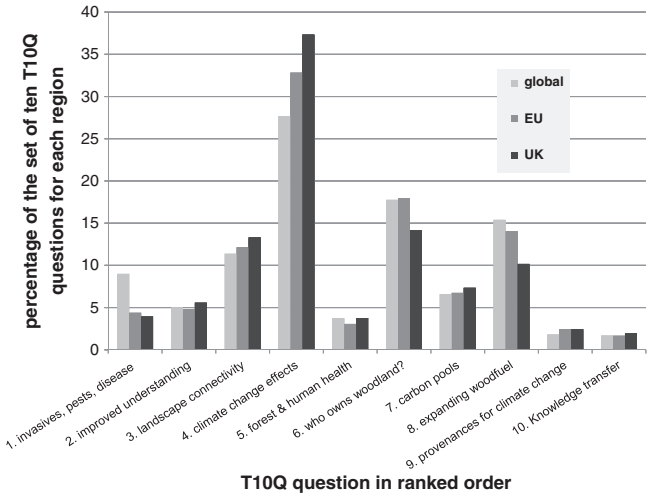

Fig. 1. Size of knowledge base for each T10Q question as a percentage of the knowledge base for all questions, for global, EU and UK research.

set of top ten questions and the 'expected' numbers for both EU publications and UK publications, with the highest variance present for question 4 (climate change effects), in both EU and UK sets (Table 4).

3.3. Publications of the most recent five years

Fig. 4 shows data from the last five-year period (2005–2009) plotted as a percentage of the whole dataset available for each question, which provides an indication of topics that are growing most rapidly in terms of number of publications.

4. Discussion

4.1. How representative are the T10Q priorities?

It is important to establish whether, collectively, the stakeholders' decisions can be considered broadly representative of the sector or not (Lawrence, 2008). The question of how representative of the broad UK forestry sector T10Q participants were was discussed in earlier work (Petrokofsky et al., 2010). The participants themselves raised questions about the amount of existing information there was while prioritising the questions during the workshop, and the rapporteurs of some sessions noted that some topics were rejected by some groups on the grounds that there was already enough published and the area was not deserving of priority listing. Other groups took a different stance and prioritised topics according to their perceived value as research topics. One of the key objectives of the phase of the project reported here was to find a practical way of gauging whether the participatory process adopted in the T10Q project resulted in a set of questions that could be viewed as meaningful for the sector. The first phase of theT10Q project had already established that the top ten questions mapped very closely in relation to existing national research priority themes, and could therefore justly be considered at least broadly representative of contemporary thinking (Petrokofsky et al., 2010). Looking at the number of existing research publications which have relevance to these questions enabled a more detailed level—below that of 'theme'—to be analysed. The results of the literature analysis showed that no question had fewer than 570 articles of potential relevance, and most questions greatly exceeded 1000. It was clear from this analysis that issues raised as priority questions were supported by substantial volumes of research and were not narrowly-framed pressure-group topics of limited general interest. These findings were in line with those reported in similar participatory excercises to prioritise research questions by Sutherland et al. (2009, 2006) and Cooke et al. (2010).

Table 3
Actual and predicted number of publications in the CAB Abstracts database for each T10Q question. Predictions are on the basis of database averages for EU and for UK publications in this database.

T10Q question	Region	Actual	Predicted	Difference between actual and predicted	Difference as % of global number of publications for question
1. Invasive, pests, disease	Global	3068			
	EU	545	877	−332	−10.8
	UK	89	109	−20	−3.7
2. Improved understanding	Global	1717			
	EU	600	491	109	6.3
	UK	126	61	65	10.8
3. Landscape connectivity	Global	3883			
	EU	1512	1110	402	10.4
	UK	301	138	163	10.8
4. Climate change effects	Global	9455			
	EU	4091	2704	1387	14.7
	UK	844	336	508	12.4
5. Forest and human health	Global	1274			
	EU	381	364	17	1.3
	UK	85	45	40	10.5
6. Who owns woodland?	Global	6064			
	EU	2237	1734	503	8.3
	UK	320	215	105	4.7
7. Carbon pools	Global	2245			
	EU	840	642	198	8.8
	UK	166	80	86	10.2
8. Expanding woodfuel	Global	5255			
	EU	1751	1503	248	4.7
	UK	230	187	43	2.5
9. Provenances for climate change	Global	615			
	EU	305	176	129	21.0
	UK	55	22	33	10.8
10. Knowledge transfer	Global	572			
	EU	206	164	42	7.3
	UK	45	20	25	12.1
All T10Q questions	Global	34,148			
	EU	12,468	0.37[a]		
	UK	2261	0.07[a]		
Total for all database	Global	877,800			
	EU	251,033	0.286[b]		
	UK	31,173	0.036[b]		

[a] Proportion of T10Q global total.
[b] Proportion global total for whole database.

4.2. Recent research trends

There was some speculation before the workshop phase of the T10Q project that the issue of climate change was so central, in the research literature, the media and policy arenas, that discussions would be

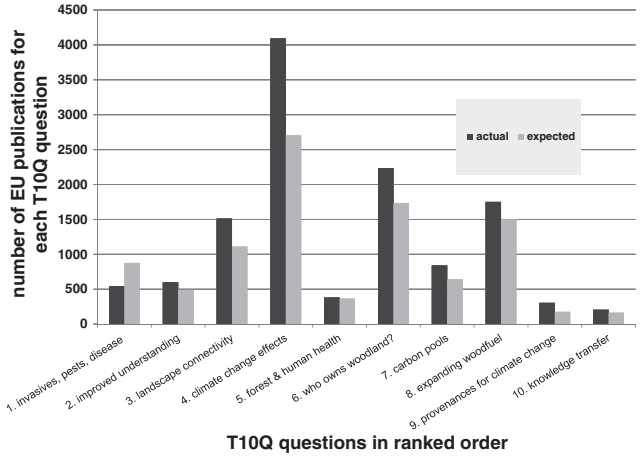

Fig. 2. Actual vs. expected numbers of publications from all EU countries.

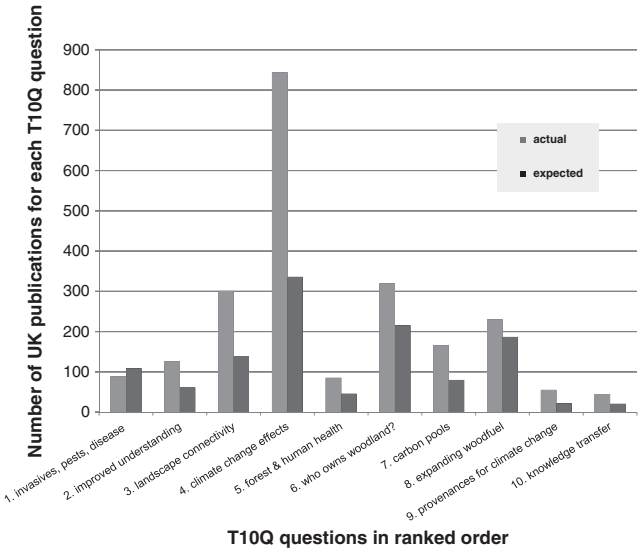

Fig. 3. Actual vs. expected numbers of publications from the UK.

dominated by the subject, as it was in Morton's work in Australia (Morton et al., 2009). Three of the top ten questions (numbers 4,7 and 9) did indeed relate to aspects of climate change: a total of 294 questions (ca. 18%) submitted were classified as 'climate change' or 'carbon sequestration', a topic that is closely connected with climate change in current debates in forestry (Fig. 1), which does reflect a heightened concern with this research area. The knowledge base for these questions, particularly question 4, was large (Table 1), with a particularly high proportion of articles published in the last five years (ca. 48% for questions 4 and 7, compared with a database average of ca. 20%).

Looking at the most recent five-year period (Fig. 2), all the top ten questions, apart from number eight concerning woodfuel, had higher than expected values compared with all knowledge in the database as a whole. A little over half the available literature for the top-ranked question to emerge from the workshop was published in the past five years: well above the 19% database average. In terms of a rapid assessment of the validity of the method, it does appear that a question of very high importance (in 2008) did emerge from the rigorous process of question submission, refinement and prioritisation and is supported by a large body of research, which could bear greater analysis and review. It may be a matter of concern, for example, that the

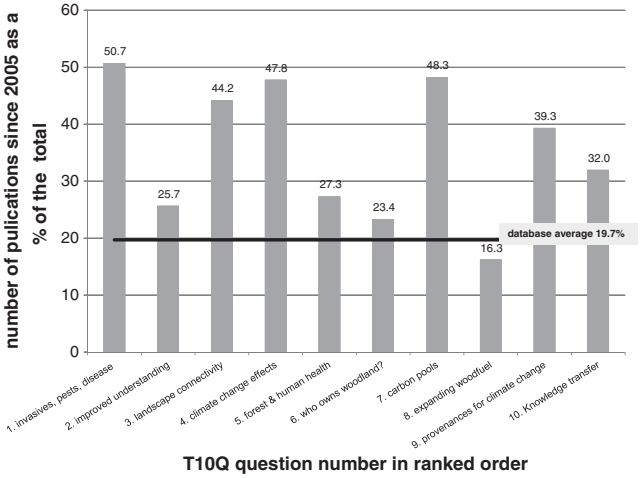

Fig. 4. Recent publications as a percentage of the total number of publications for each T10Q question. The horizontal black line shows the database average for all publications in the period 2005–2009 as a percentage of the total number of publications in the database.

proportion of European (and UK) based research in this area has not kept pace with global research on invasive pests and diseases. At the other end of the spectrum, it is interesting to note how the topic of woodfuel has had a resurgence recently. There is a large body of research in this field, but much of it is from previous decades, which points to a need to review what is known already before embarking on new research.

4.3. European research trends

That climate change emerges as a high priority and is supported by a large, and growing, knowledge base was consistent with the rapid rise in interest in this topic in academic research (Li et al., 2011, Stanhill, 2001) and in the mainstream media (Boycoff and Boycoff, 2007). Looking at the set of ten questions as a whole, however, other less predictable findings emerge. The question on invasive pests and diseases, that emerged with the most number of votes from Workshop delegates and is considered the 'top' question in the final T10Q list, was the only one of the ten whose knowledge base was smaller for both EU and UK research than expected on the basis of database proportions for these two regions. The knowledge base for all other questions showed higher numbers for EU and UK than could have been predicted from database average figures applied to each question. The research base for the topic of invasive pests is dominated by the USA. Research from, or focussed on, the USA comprised 16% of the database on average, but for this topic it was 55%. The EU produced twice as many research papers as the US but there were almost three times as many US papers as EU papers on the question relating to invasives, pests and diseases. Based on this, it would appear to be a strong candidate topic for greater EU and UK collaborative research.

Analysis of the literature supporting the top ten questions shows that there were no major differences between relative outputs from the UK and those from the EU or elsewhere. Where differences did exist, these could be explored further to determine whether research effort is falling behind. There was not a very large pool of research literature emanating from the UK for any of the questions, with the exception of question 4—on climate change effects on forestry—where there were 844 potentially relevant papers, compared with fewer than 100 papers each for four of the ten questions. However, the potentially less well-known articles from non-UK institutions form a sizeable body of knowledge to consult when considering where knowledge gaps exist and subsequently constructing research agendas.

4.4. Using the T10Q process to link research with policy

The policy cycle is not a linear process, where good science is fed in at one end and good policy comes out at the other, but rather a cycle of events, with science contributing at all stages and, importantly, knowledge gaps emerging as pointers for new research. For forestry, particularly, this process can take decades, with issues gaining and falling from prominence, and research following these trends (Pasiecznik and Petrokofsky, 2005). These are strong reasons to look at long-term trends in published scientific research when constructing agendas for policy-relevant research. The best way to maximise the impact of scientific input in the policy process is through "continuous, routine engagement … in the context of long-term, mutually beneficial partnerships with decision makers, policy analysts, and program implementers" (Pouyat et al., 2010). The authors point to the case of acid rain, where the issues were framed and reframed over years as the public debate changed and the science base continued to expand until finally a workable policy was implemented. Overcoming the research implementation gap and improving practice requires collaboration between researchers and practitioners during the 'process of collaborating with and empowering stakeholders in strategy development and implementation (Cowling et al., 2008).

T10Q demonstrated a practical means of constructing a meaningful list of high-priority research questions, which can be further explored in terms of existing knowledge and prominent knowledge gaps.

4.5. Limitations of the process and next steps

Caution is needed in making direct comparisons between the figures obtained for the knowledge sets supporting each question, given that the scope of the questions varied widely and the search strategies (Table 5) cannot therefore be standardised so as to be equally efficient for each question. The searches, compiled by a former senior forestry database editor at CABI, provide indications of potentially interesting publications within the CAB Abstracts database. The searches will inevitably have retrieved publications that would be of little use in answering the questions posed. However, differences in the volume of research literature published in this extensive database are evident and observations on these differences are almost certainly indicative of trends in the wider knowledge base which lies outside the scope of CAB Abstracts. Questions 4, 6 and 8 were each linked to an extensive volume of literature, with over 5000 publications (from 1939 to 2009) of potential relevance to each (Table 2). Questions 9 and 10 were very much smaller, with fewer than 1000 publications in total, and fewer than 100 each from the UK, reflecting the much narrower scope of these two questions, compared with the broader scope of other questions.

This project did not explore the quality of the literature extracted for each question, nor did the project seek to determine what research papers (or other forms of evidence) were influencing stakeholders' decisions at any stage of the process. Neither did it seek to determine what evidence is being used selectively or non-selectively in a non-biased manner to answer or frame policy questions of the type discussed during the project. These would be important topics to explore in future work that may examine how research outputs can best contribute to robust evidence of the sort needed for systematic reviews, which are widely regarded as the most robust tools for analysing evidence in medicine, social policy (Petticrew, 2001), and, increasingly, environmental conservation, and that are much needed in forestry.

5. Conclusions

The bibliometric approach of the T10Q project provided a rapid assessment method for examining the existing knowledge base in relation to ten specific questions of priority to forestry research. Literature analysis, even at this rather broad level of detail, provided a useful first check to validate the likely relevance of the prioritsed research agenda agreed by stakeholders in a participatory process. The method shows clear differences in research effort (as measured by published outputs) between geographical regions and these differences could form the basis of detailed anlaysis for planning national research agendas in the context of global or European research. Analysing trends over time and between regions provides some indications about where knowledge gaps may occur and where topics are receiving attention in different regions.

Bibliometric analysis has been used in other fields to take a macro-view of research output, and to make comparisons between nations and geographical regions, and the current research demonstrates how forestry can utilise this apporach to enhance stakeholder involvement.

Clearly, there would need to be more detailed analyses of priority topics which emerge through consultative, participatory processes of the type exemplified by the T10Q project, before developing national priorities for research, including funding priorities, but an examination of the existing knowledge base of relevance to research quesitons identified by stakeholders is a necessary part of the process. Further work should examine whether collaborative priority-setting could be improved if stakeholders have access to better knowledge resources during their deliberations.

Recent global economic pressures affecting science funding in Europe and elsewhere make it imperative to ensure that funded research is meeting the needs of stakeholders and, moreover that the quality of that research is of sufficient calibre to allow policy decisions to be taken on that basis. Policy makers in the fields of medicine and public health have used bibliometric analysis to determine research priorities and to assess where knowledge gaps, or research gaps occur. The method offered here could contribute to the process of improving the knowledge base which underpins decision-making in forestry.

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Appendix A

Table 4
Observed and expected number of publications for each T10Q question in the database.

T10Q question	Number of publications in database				EU	UK
	Observed	Expected	Observed	Expected	$(O-E)^2/E$	
1. Invasives, pests, disease	545	877	89	109	125.9	3.7
2. Improved understanding	600	491	126	61	24.2	69.3
3. Landscape connectivity	1512	1110	301	138	145.2	192.9
4. Climate change effects	4091	2704	844	336	711.5	769.3
5. Forest and human health	381	364	85	45	0.8	34.9
6. Who owns woodland?	2237	1734	320	215	145.8	50.9
7. Carbon pools	840	642	166	80	61.0	93.4
8. Expanding woodfuel	1751	1503	230	187	41.0	10.1
9. Provenances for climate change	305	176	55	22	94.8	50.3
10. Knowledge transfer	206	164	45	20	11.0	30.0

Table 5
Search strategy for each T10Q question in the forest science subset of CAB Abstracts database.

T10Q question	Search strategy
1	Descriptor: "invasive alien species" OR Descriptor: "invasive species" OR Descriptor: pests OR Descriptor: "plant diseases" OR Descriptor: weeds AND Descriptor: "introduced species" OR Descriptor: invasions
2	Title: forest AND title: management OR title: forestry OR title: forester OR title: foresters OR abstract: forestry OR abstract: forester OR abstract: foresters AND "public opinion" OR "public relations" OR attitude AND attitudes
3	Descriptor: land AND Descriptor: use OR title: fragmentation OR Abstract: fragmentation OR Descriptor: fragmentation OR title: landscape OR Abstract: landscape OR Descriptor: landscape AND title: connectivity OR Abstract: connectivity OR Descriptor: connectivity
4	Title: ecosystem* OR Descriptor: ecosystems OR Descriptor: "forest ecology" OR Descriptor: "forest management" OR title: forestry OR Descriptor: forestry OR Subject Category (CABICODE): kk100 OR Subject Category (CABICODE): kk110 OR Subject Category (CABICODE): pp720 AND title: "climate change" OR Abstract: "climate change" OR Descriptor: "climatic change"
5	Subject Category (CABICODE): PP720 AND title: woodland OR title: woodlands OR title: forest OR title: forests OR Subject Category (CABICODE): KK100 OR Subject Category (CABICODE): KK110 AND "public health" OR "mental health" OR "community health" OR "health protection" OR illness OR "health beliefs"
6	Title: woodland* OR Abstract: woodland* OR title: forest* OR Abstract: forest* AND "land ownership" OR landowners OR ownership OR "public ownership" OR "forest ownership"
7	"Carbon sequestration" OR title: carbon OR carbon AND pools AND Descriptor: forest AND Descriptor: management OR title: climate AND title: change OR Abstract: climate AND Abstract: change OR Descriptor: climatic AND Descriptor: change OR Descriptor: forest AND Descriptor: management AND "carbon sequestration" OR title: carbon OR carbon AND pools
8	Title: fuel AND title: wood OR Descriptor: fuelwood
9	Descriptor: geographical AND Descriptor: distribution OR Descriptor: biogeography OR Descriptor: choice AND Descriptor: of AND Descriptor: species AND Specific Topic: "choice of species" OR Descriptor: provenance OR title: provenance AND Abstract: "climate change" OR Descriptor: climatic AND Descriptor: change OR title: global AND title: warming OR title: climate AND title: change
10	Subject Category (CABICODE): pp720 OR Subject Category (CABICODE): kk600 OR Subject Category (CABICODE): kk140 OR Subject Category (CABICODE): kk120 OR Subject Category (CABICODE): kk110 OR Subject Category (CABICODE): kk100 AND Abstract: "research into practice" OR Abstract: "research TO practice" OR title: "research TO practice" OR "research TO practice" OR title: "information dissemination" OR Abstract: "information dissemination" OR Descriptor: "diffusion of information" OR Descriptor: "diffusion of research" OR Abstract: knowledge AND Abstract: transfer OR title: knowledge AND title: transfer
Region	
EU	Author affiliation: Austria OR Author affiliation: Belgium OR Author affiliation: Bulgaria OR Author affiliation: Cyprus OR Author affiliation: Czech AND Author affiliation: Republic OR Author affiliation: Czechoslovakia OR Author affiliation: Denmark OR Author affiliation: Estonia OR Author affiliation: Finland OR Author affiliation: France OR Author affiliation: Germany OR Author affiliation: German AND Author affiliation: Federal AND Author affiliation: Republic OR Author affiliation: German AND Author affiliation: Democratic AND Author affiliation: Republic OR Author affiliation: Greece OR Author affiliation: Hungary OR Author affiliation: Irish AND Author affiliation: Republic OR Author affiliation: Italy OR Author affiliation: Latvia OR Author affiliation: Lithuania OR Author affiliation: Luxembourg OR Author affiliation: Malta OR Author affiliation: Netherlands OR Author affiliation: Poland OR Author affiliation: Portugal OR Author affiliation: Romania OR Author affiliation: Slovakia OR Author affiliation: Slovenia OR Author affiliation: Spain OR Author affiliation: Sweden OR Author affiliation: UK OR Author affiliation: Yugoslavia OR Wider descriptor: Europe OR Location: Europe
UK	Author affiliation: UK OR Location: UK

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