

**ERFF/NERC POSTGRADUATE AND PROFESSIONAL SKILLS NEEDS REVIEW  
OUTPUT 2 – THE SKILLS FRAMEWORK FOR THE ENVIRONMENT SECTOR, OCTOBER 2010**

**INTRODUCTORY NOTE ON THE FRAMEWORK**

This Framework shows the postgraduate and professional knowledge and skills areas which the Environment Sector has told us are most needed to address the challenges which it faces over the next decade. The Sector has reported that many of these postgraduate and professional skills are in shortage for particular challenges and these *Areas of Concern* are listed in Sections A and B of the Framework. In addition, many skills areas are important because they are needed to address many of the challenges facing the Sector. These are the *Key Skills Areas* and those not already in Sections A or B are shown in Sections C and D. The Framework is complex and designed to be a “living” document; it will evolve and develop as we receive feedback from you. In order to get the most out of it, you are strongly encouraged to read the brief Guide to the Skills Framework (Output 1). This gives details on its development, interpretation and potential uses. Particularly important points to bear in mind when considering the Framework are:

1. This is a living document and is not yet fully comprehensive. It is the most recent version of a Framework which we hope will be a useful source of reference for the Environment Sector; we would like your help in taking it forward.
2. There are links and in some cases partial overlaps between the various skills/knowledge areas. Some obvious ones are shown in Column C. We would encourage you to look at all the skills areas (including those on the Skills Inventory) and combine them as appropriate for your particular interests or requirements.
3. Please note carefully the details of the criteria used to select the knowledge and skills areas in each of the four sections of the Framework; these criteria are shown under the section headings.

<b>EXPLANATION OF FRAMEWORK COLUMNS</b>		
<b>Column</b>	<b>Heading</b>	<b>Explanation</b>
A	F/W POS.	Position of knowledge/skill area on the Framework.
B	NO OF CS.	Total number of challenges for which the specified knowledge/skill is needed.
C	AREA OF CONCERN/KEY SKILL AREA	Description of knowledge/skill area, skill ref. number and cross-references to linked skills areas.
D	SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/REVIEW GROUP COMMENTS	Summary of knowledge/skills needs in specified skills area with examples of views from the respondents to the public consultation and from the Review Group members.
E	CHALLENGES FOR WHICH SKILL/KNOWLEDGE IS REQUIRED	Reference numbers of each of the challenges faced by the Sector which require the specified knowledge/skill. C, P or O denotes a critical, priority or other challenge. See Paragraph 10 in the Guide to the Framework and the complete list of challenges in Annex 6 for further information.
F	EXAMPLES OF EXISTING TRAINING PROVISION	Examples of existing training provision/training initiatives in the specified area.
G	ADDITIONAL EVIDENCE FROM THE PUBLISHED LITERATURE	Cross-references to additional evidence in the published literature. See Paragraph 13 in the Guide to the Framework and the Bibliography in Annex 7 for further information.

## SECTION A: PRIORITY ONE AREAS OF CONCERN

### IDENTIFIED BY THE ES AS BEING IN SHORTAGE WITH RESPECT TO AT LEAST ONE CRITICAL CHALLENGE

Areas of concern are ordered by the number of challenges of all types that the skills or knowledge are needed for. Where there is a tie, the order is alphabetical

A. F/W POS.	B. No Of Cs	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS	E. CHALLENGES FOR WHICH SKILL/ KNOWLEDGE IS REQUIRED	F. EXAMPLES OF EXISTING TRAINING PROVISION	G. ADDITIONAL EVIDENCE FROM PUBLISHED LITERATURE
1	84	<p style="text-align: center;"><b>MODELLING A014</b></p> <p>See also:  Numerical/ mathematical modelling (D019) Spatial analysis and GIS (B010)</p>	<p><b>A particularly commonly theme in the feedback from the ES was the general shortages of modelling skills in a wide range of disciplines and interdisciplinary areas. There is a high demand for and consequent lack of people able to develop high-level models. Particularly difficult to recruit are modellers with an adequate appreciation of the scientific discipline in which they are working.</b></p> <p><b>Issues also exist in the interpretation of models both in terms of understanding the underlying philosophy and in communicating their inherent uncertainty.</b></p> <p><b>Need ecologists with modelling skills.</b></p> <p><b>Carbon modellers are few and far between.</b></p> <p><b>Need to ensure modellers understand physical, chemical and biological aspects of the Earth System, rather than being specialist modellers “interfacing” with others.</b></p> <p><b>Lack of soil scientists, and environmental modellers. Needs ecological modellers with spatial analysis skills. Negligible doctoral training in UK in permafrost modelling Global coastal models needed but lacking.</b></p> <p><b>General shortage of graduates with modelling skills and breadth of experience.</b></p> <p><b>Inadequate skills in the field of extreme event modelling.</b></p> <p><b>Improve models of climate change versus human responses.</b></p> <p><b>Philosophy of model interpretation.</b></p>	<p>002 (C) 004 (P) 005 (C) 006 (C) 007 (P) 009 (P) 011 (P) 012 (P) 013 (P) 014 (C) 015 (C) 016 (P) 017 (C) 018 (C) 019 (C) 021 (P) 022 (C) 025 (C) 027 (P) 028 (P) 031 (P) 032 (P) 033 (C) 034 (C) 035 (C) 036 (P) 037 (P) 038 (P) 039 (P) 042 (C) 043 (O) 044 (P) 045 (P) 048 (P) 050 (P) 054 (P) 055 (P) 056 (P) 057 (P) 058 (P) 059 (C) 060 (P) 063 (P) 066 (P)</p>	<p>Around 170, (26%) of the PhD projects supported by NERC over the last two years involve models and modelling to some extent and modelling is integral to many areas of environmental research.</p> <p>There is wide sector support for the four-year PhD that incorporates one-year masters in computational science. Graduates coming into modelling may lack the computational skills required and short courses at an elementary level may be needed. NERC already employs computational scientists at many of its Centres, but there is no formal group to share knowledge and provide support. There is, however, a Cluster Computing Forum, comprising IT technical staff, which organised a</p>	<p>LR.22 (2008) – University of Exeter identify need for PG skills in modelling impacts of climate change.</p> <p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies needs for expertise in predictive modelling across many of their remit areas.</p>

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			<p>Use physical reasoning to interrogate models and extract useful information.</p> <p>Coupled climate – earth surface process models.</p> <p>Integration of models and spatial data.</p> <p>Rigour in model versioning.</p> <p>Mathematics required for modelling.</p> <p>Skills required at the interface of modelling and data.</p> <p>Robustness of models and predictions.</p> <p>Shortage of skills in climate modelling.</p> <p>Difficulty recruiting people skilled in modelling.</p> <p>Skills gap in the field of modelling.</p> <p>Skills gap for every type of biologically based scientist, especially ecologists skilled in nitrogen modelling.</p> <p>Need for climate modelling at multiple scales.</p>	<p>068 (P) 069 (P) 070 (P) 072 (C) 076 (P) 077 (C) 078 (P) 079 (P) 080 (P) 081 (C) 083 (C) 084 (P) 087 (P) 094 (C) 095 (C) 096 (C) 091 (P) 092 (P) 093 (O) 097 (P) 098 (P) 100 (C) 101 (P) 102 (C) 103 (C) 104 (C) 105 (C) 106 (C) 107 (C) 108 (C) 110 (P) 111 (P) 113 (P) 114 (P) 117 (P) 119 (P) 121 (C) 122 (P) 123 (C)</p>	<p>summer school in 2009.</p> <p>Interrogation of the ERFF Research Database indicates that 258 studentships have been funded since September 2005 in Modelling Techniques and Models (C.13.10.3) by NERC (255), BBSRC (3) and Defra (1).</p> <p>It is expected that advanced training provision for modelling will be located in several ESRC Doctoral Training Centres. The training pathways are expected to feature interdisciplinary links to Computer Science, Mathematics &amp; Psychology.</p> <p>The ESRC Researcher Development Initiative (RDI) supports the training and development of researchers in the social sciences at all stages of their career. Four rounds of awards have been commissioned, with a significant proportion focusing on quantitative</p>	

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					<p>methods, modelling and statistical analysis.</p> <p>The ESRC National Centre for Research Methods (NCRM) forms part of the Economic and Social Research Council's (ESRC) strategy to improve the standards of research methods across the UK social science community. NCRM provides a focal point for research, training and capacity building activities.</p> <p>The Call for the third phase of the Centre's nodes was recently announced – decisions will be announced in December. Previous nodes have featured areas such as computing statistical models, and Bayesian methods.</p>	
2	50	<p><b>INTER-/ MULTI-DISCIPLINARITY A010</b></p> <p>See also:</p>	<p><b>A widely recurring theme in the responses from the Sector is the lack of inter- and multi-disciplinary skills. These were identified particularly between: <i>environmental sciences and engineering, environmental sciences and business, environmental sciences and social sciences; and environmental sciences and mathematics, statistics, and computing.</i></b></p>	<p>001 (C) 002 (C) 003 (C) 004 (P) 005 (C) 006 (C) 008 (C) 010 (C) 012 (P) 014 (C)</p>	<p>NERC and ESRC co-fund 20 PhD studentships per year through an interdisciplinary competition. The</p>	<p>LR.29 (2009) – Defra's Survey of External Capabilities to meet their Strategic Requirements identifies a requirement for the development of a more</p>

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		<p>Natural Science – social science interface/ translation (A015)            Science/ engineering interface (D028)            Science – policy interface/ translation (A018)</p>	<p><b>Better interdisciplinary working and communication is vital spanning the physical sciences, social sciences, economics and engineering disciplines. The sector reports that, at present, such working is not adequately supported / encouraged and is a significant impediment to progress.</b></p> <p><b>Inter-disciplinary working spanning not only physical sciences but also social sciences, economics and communications is needed.</b></p> <p><b>There is a lack of appropriately inter-disciplinary researchers with an appreciation of geographical concepts and themes.</b></p> <p><b>Interdisciplinary communication remains a fundamental impediment to significant progress.</b></p> <p><b>Interdisciplinary skills are undoubtedly in short supply.</b></p> <p><b>Interdisciplinarity not supported or encouraged enough.</b></p> <p><b>Requirement for interdisciplinary skills with social scientists and engineers.</b></p> <p><b>Need interdisciplinary scientists who can engage with socio-economists.</b></p> <p><b>Interdisciplinary modelling approaches ie. Integrated assessment.</b></p> <p><b>Need to develop linkages between multidisciplinary and engineering.</b></p> <p><b>Lack of skills in interfacing the physical / environmental and social sciences.</b></p> <p><b>Need to address cross-cutting issues and support inter-disciplinary science.</b></p>	<p>017 (C)            019 (C)            021 (P)            023 (C) 024 (C)            027 (P)            028 (P) 029 (P)            030 (P)            033 (C)            034 (C) 035 (C)            042 (C) 044 (P)            058 (P) 059 (C)            061 (C)            066 (P)            070 (P)            072 (C) 073 (C)            074 (C) 075 (C)            076 (P) 077 (C)            078 (P)            079 (P)            081 (C)            084 (P)            088 (P)            089 (P) 090 (P)            094 (C)            100 (C)            103 (C) 104 (C)            105 (C)            107 (C) 108 (C)            112 (C)</p>	<p>projects funded in the 2010 competition addressed LWEC objectives.</p> <p>It is expected multidisciplinary advanced training will be located across the ESRC Doctoral Training Centres infrastructure</p>	<p>interdisciplinary approach and improved collaboration.</p>

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			<p>Understanding of multi-disciplinary sciences.</p> <p>Experience of working in multi-disciplinary teams and dealing with multi-disciplinary outputs.</p> <p>Need to integrate multi-disciplinary aspects into engineering qualifications.</p>			
3	42	<p><b>DATA MANAGEMENT A004</b></p> <p>See also:</p> <p>Data Mining (D023) Environmental informatics (C012) Paramaterisation and Assimilation (D025)</p>	<p><b>Feedback from the Sector indicates that there is an inadequate culture of data management and centralisation in the ES. A need for stronger postgraduate skills in all aspects of data collection, data use and data management is widely identified.</b></p> <p><b>Ability to manage and interpret large amounts of data is lacking.</b></p> <p><b>Poor culture of data management and centralisation.</b></p> <p><b>This area in general is being addressed .... to understand the skills shortages / development needs within the bioscience Sector, especially with respect to large datasets.</b></p> <p><b>Need for strong data integrity protocol.</b></p> <p><b>Need to avoid unnecessary data collection or overly high collection costs. Centralisation.</b></p> <p><b>Large datasets need integrating into mathematical models.</b></p> <p><b>New computational algorithms need to be developed to handle high volume data.</b></p> <p><b>Large scale bioinformatics data manipulations necessary.</b></p> <p><b>Data mining.</b></p> <p><b>Skills shortage in data collection, assurance and archiving.</b></p> <p><b>Need for graduates who have experience and competence with raw scientific data.</b></p>	<p>009 (P) 016 (P) 019 (C) 022 (C) 025 (C) 029 (P) 030 (P) 032 (P) 033 (C) 037 (P) 038 (P) 039 (P) 040 (P) 041 (P) 042 (C) 043 (O) 044(P) 046 (C) 047 (C) 048 (P) 049 (C) 050 (P) 051 (P) 052 (P) 054 (P) 055 (P) 059 (C) 066 (P) 067 (P) 072 (C) 075 (C) 080 (P) 081 (C) 088 (P) 091 (P) 094 (C) 096 (C) 102 (C) 107 (C) 108 (C)</p>	<p>The Digital Curation Centre (<a href="http://www.dcc.ac.uk">www.dcc.ac.uk</a>) is the UK's leading centre of expertise in digital data curation and was a key recommendation of the Joint Information Systems Committee (JISC). It is primarily funded by HEFCE and the other Funding Councils. They have recognised the need for greater up-skilling of the community and have already developed a range of training courses. They are starting to try to target specific communities and are working with NERC to progress this.</p> <p>Early indications from the Environmental Research Funders Forum (ERFF) skills training review are that specialist</p>	<p>LR.11 (2008) – IEEM. Concerns over the level of data handling capability of undergraduates.</p> <p>LR.3 (2009) – An evaluation of the UK skills base for Toxicologists and Ecotoxicologists identifies the ability to analyse data as a critical skill.</p> <p>LR.29 (2009) – Defra's Survey of External Capabilities to meet their Strategic Requirements identifies data analysis/management as a key area for development of capabilities.</p>

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			<p>Lack of skills in using / integrating scientific data / results in regulator, policy or management frameworks.</p> <p>There is currently significant under-investment in data assimilation.</p> <p>Training in database management and time series analysis required.</p>	<p>114 (P) 124 (P)</p>	<p>computer skills are in short supply and that competencies are required in data management and visualisation, and in writing and parallelising computer code.</p>	
4	41	<p><b>STATISTICAL ANALYSIS A020</b></p> <p>See also: Mathematics/ Applied Mathematics (A011)</p>	<p><b>Along with the limited availability of mathematical skills, the Sector reports a serious skills shortage in environmental statistics. This limits the ability of those working in the environmental sciences to handle large datasets and use successfully such techniques as statistical inference.</b></p> <p><b>Shortage in environmental statistics.</b></p> <p><b>Serious skills shortage in environmental statistics.</b></p> <p><b>Most biologists have insufficient statistics and most statisticians have insufficient biology</b></p> <p><b>Statistical models of rainfall fields.</b></p> <p><b>Advanced Geophysical Statistics.</b></p> <p><b>Combination of advanced statistical skills and meteorology.</b></p> <p><b>Statistical analysis of agricultural/soils/climate data to aid food security under environmental change.</b></p> <p><b>Statistical methods for handling large data sets.</b></p> <p><b>Statistics of extreme events.</b></p> <p><b>Statistical Inference.</b></p> <p><b>Difficulties experienced in recruiting people with skills in</b></p>	<p>004 (P) 007 (P) 009 (P) 011 (P) 012 (P) 013 (P) 015 (C) 016 (P) 019 (C) 022 (C) 029 (P) 030 (P) 032 (P) 033 (C) 035 (C) 038 (P) 040 (P) 041 (P) 042 (C) 045 (P) 060 (P) 063 (P) 066 (P) 067 (P) 068 (P) 072 (C) 075 (C) 078 (P) 080 (P) 081 (C) 088 (P) 094 (C) 096 (C) 100 (C) 105 (C) 106 (C) 107 (C)</p>	<p>NERC funds a course on Statistics for Environmental Evaluation at the University of Glasgow. The course provides training in statistical analysis and modelling skills and can take around 35 participants but is always over subscribed.</p> <p>It is expected that advanced training provision for statistical analysis will be located in several ESRC Doctoral Training Centres. The training pathways are expected to feature interdisciplinary links to mathematics, social science research methods and computer science.</p> <p>The ESRC Researcher</p>	<p>LR.58 (2008) – A paper on Skills Needs for Biomedical Research identifies skills needs in the sector in disciplines such as statistics.</p>

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			<p>statistics.</p> <p>Skills gap evident in field of statistics.</p> <p>Mathematical skills required, in particular, statistics.</p>	<p>108 (C) 111 (C) 113 (P) 124 (P)</p>	<p>Development Initiative (RDI) supports the training and development of researchers in the social sciences at all stages of their career. Four rounds of awards have been commissioned, with a significant proportion focusing on quantitative methods, modelling and statistical analysis.</p>	
5	34	<p><b>COMMUNICATION A003</b></p> <p>See also: Science communication (A003) Media Skills (A012)</p>	<p><b>There is wide report from the Sector of a lack of communication skills among postgraduates. This hampers communication across the sciences and in inter- and multi- disciplinary areas. It also limits the ability to express complex issues to lay people. For instance more top scientists, who are also excellent communicators, are needed to communicate the complexity of climate change and predictions effectively. Additionally, being able to communicate the issues surrounding “uncertainty” more effectively is critical to addressing the challenges facing the ES.</b></p> <p><b>What is needed are top scientists who are excellent communicators.</b></p> <p><b>Communication of science to layman also a key skill requirement.</b></p> <p><b>Communicating uncertainty is critical.</b></p> <p><b>Interdisciplinary communication remains a fundamental impediment to significant progress.</b></p> <p><b>Many students at all levels do not have adequate writing skills and struggle with communicating numerical data to non-experts.</b></p>	<p>001 (C) 002 (C) 003 (C) 005 (C) 007 (P) 010 (C) 011 (P) 012 (P) 013 (P) 015 (C) 027 (P) 040 (P) 041 (P) 044 (P) 046 (C) 065 (P) 067 (P) 069 (P) 074 (C) 075 (C) 076 (P) 079 (P) 082 (C) 083 (C) 086 (C) 090 (P) 101 (P) 102 (C) 103 (C) 105 (C) 107 (C) 108 (C) 123 (C) 124 (P)</p>	<p>The ESRC National Centre for Research Methods (NCRM) forms part of the Economic and Social Research Council's (ESRC) strategy to improve the standards of research methods across the UK social science community. NCRM provides a focal point for research, training and capacity building activities.</p> <p>The Call for the third phase of the Centre's nodes was recently announced – decisions will be announced in December. Previous nodes have featured</p>	<p>LR.22 (2008) - University of Exeter identifies need for communication skills in climate science</p> <p>LR.44 (2006) – Lantra Sector Skills Agreement: Environmental Conservation states that communication skills needed across job roles.</p> <p>LR.52 (2002) – Skills Information Gateway document states that generic skills in communication and numeracy are required.</p> <p>LR.67 (2009) – UK Low Carbon Industrial Strategy states that skills in communication are necessary to drive culture change or overhaul existing</p>



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			<p>Communication training needed so that the forecasting can be communicated reliably to policy makers etc</p> <p>It will be particularly important for natural scientists to develop communication skills to enhance their ability to work at the interface of multiple disciplines.</p> <p>Understand and communicate the complexity of climate change.</p> <p>Science communication (below).</p> <p>Ability of scientists to communicate in effective and appropriate ways to a wide range of audiences.</p> <p>Require postgraduates and masters students across most if not ALL of challenge areas in this framework to have access to written and oral communication skills training (including media training).</p> <p>An MSc placement in a relevant Government Dept to strengthen communication and translation of outputs to policy makers would be beneficial</p>		<p>areas such as computing statistical models, and Bayesian methods</p>	<p>business practices.</p> <p>LR.92 (2009) - ENDS Report identifies Corporate Policy, CSR and Communication as in the top 20 environmental skills in demand by employers.</p>
6	34	<p><b>FIELDWORK A008</b></p> <p>See also:</p> <p>Field observation (C019)</p>	<p><b>Feedback from the ES indicates that the number of people available to conduct skilled field research is decreasing. Stronger field to laboratory, and field to theory skills would enhance the Sector's capability to understand and model environmental issues and appropriate responses.</b></p> <p><b>Current shortage of people with fieldwork and taxonomic skills.</b></p> <p><b>Shortage of taxonomic and identification skills plus field survey and analytical techniques.</b></p> <p><b>Field identification skills essential to complement academic learning - key skills gap.</b></p> <p><b>Field techniques and technology use.</b></p> <p><b>Field to lab skills and capacity to create a model of the response required.</b></p> <p><b>Ability to relate field data with which individuals are familiar</b></p>	<p>007 (P) 014 (C) 022 (C) 024 (C) 025 (C) 028 (P) 035 (C) 038 (P) 039 (P) 040 (P) 041 (P) 045 (P) 053 (C) 060 (P) 061 (C) 062 (P) 063 (P) 068 (P) 070 (P) 071 (P)</p>	<p>NERC will fund NERC PhD students to go on certain courses run by the BGS School of Field Geology although the take-up for these places has been relatively low to date.</p> <p>The majority of NERC PhD projects involve some element of fieldwork and NERC has always recognised this and provided extra funding to pay for fieldwork costs.</p>	<p>LR.11 (2008) – IEEM suggest that fieldwork experience is now less available through the education system.</p>

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			to ecological theory with which they are also familiar.	088 (P) 092 (P) 096 (C) 097 (P) 098 (P) 099 (P) 103 (C) 109 (P) 111 (P) 114 (P) 116 (P) 117 (P) 121 (C) 124 (P)	As part of the Training Allocation Review, NERC should review the costs it provides for PhD training, in particular with respect to ensuring that PhD students are able undertake appropriate fieldwork and get the skills they need.	
7	28	<b>SCIENCE-POLICY INTERFACE /TRANSLATION A018</b>  See also:  Policy Awareness (D002) Legislation/ legislative process (D001)	<p><b>A recurring theme in the feedback from the ES, linked to communication skills, is the need for stronger postgraduate skills in translating scientific evidence into effective policy and legislation.</b></p> <p><b>Need to close the gap between scientific evidence and policy / legislation.</b></p> <p><b>Ability to communicate complex modelling techniques and results to policy makers.</b></p> <p><b>Lack of science communication skills and policy making.</b></p> <p><b>Research happens at a slower pace than policy changes, and the issues of global responsibility are not articulated in UK environmental science contexts. ESF-RESCUE, EU has identified this issue (e.g., May 2009 DG Research conference, Sust Dev – a challenge for EU research).</b></p> <p><b>Need to ensure that science informs policy and that scientists and practitioners are able to input to optioneering.</b></p> <p><b>Translate science into feasible land use / development options.</b></p> <p><b>Translating science into policy.</b></p> <p><b>Ability to translate science into feasible, pragmatic, measurable and effective legislation.</b></p>	001 (C) 003 (C) 005 (C) 007 (P) 008 (C) 010 (C) 015 (C) 024 (C) 031 (P) 032 (P) 034 (C) 045 (P) 058 (P) 060 (P) 073 (C) 074 (C) 075 (C) 076 (P) 078 (P) 082 (C) 085 (P) 086 (C) 087 (P) 088 (P) 090 (P) 103 (C) 104 (C) 110 (P)	<p>NERC supports a number of masters courses that train individuals for policy roles, including the UEA Climate Change: Science, Impacts and Policy masters and a number of environmental management and conservation masters courses.</p> <p>NERC funds around 8 internships per year where NERC PhD students spend 3 months in an organisation involved in the scrutiny of government policy. Internships are available at one of four partner organisations (eg. POST &amp; SPICe)</p>	LR.29 (2009) - Defra's Survey of External Capabilities to meet their Strategic Requirements reports on issues relating to meeting their policy needs with science skills.

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			<p>Capability to translate science into policy.</p> <p>Need people with skills to develop scientific understanding into a form where it is understood and acted on by both the public and by policy makers and Government.</p> <p>Communicating science into policy.</p> <p>Awareness of the science-policy interface.</p>		<p>The NERC Policy Placement Scheme allows researchers involved in environmental science research to work for between 3 and 12 months in a policy making organisation or undertake a work shadow placement of a month. NERC plans to expand this scheme in the future.</p> <p>NERC co-funds two Science to Policy Workshops a year, one with the ESRC and one with the British Ecological Society. Around 30 PhD students and early career researchers can attend each workshop.</p>	
8	25	<p><b>RISK ASSESSMENT AND MANAGEMENT A017</b></p> <p>See also:</p> <p>Dealing with uncertainty (A005) Hazard and risk assessment (D005)</p>	<p><b>The Sector reports that greater literacy in the field of risk assessment and management is vital. Policy makers for the environmental sciences and other stakeholders need to both understand and be able to assess, predict and communicate risk better. One Review Group member noted that decision-making about risk is linked to Society's willingness to pay to avoid it.</b></p> <p><b>We need policy makers who have sufficient knowledge of scientific principles and are risk management literate.</b></p> <p><b>Evaluation of risk is crucial to geoengineering.</b></p> <p><b>Linked to decision-making through societies' willingness to pay to avoid risk.</b></p>	<p>001 (C) 003 (C) 009 (P) 015 (C) 023 (C) 056 (P) 060 (P) 066 (P) 073 (C) 074 (C) 075 (C) 077 (C) 078 (P) 083 (C) 086 (C)</p>	<p>NERC funds a number of masters courses with a focus on Environmental Assessment and management and the majority of students go into employment following the masters.</p> <p>Interrogation of the ERFF Research Database indicates that 26 studentships have been</p>	<p>LR.3 (2009) – An evaluation of the UK skills base for Toxicologists and Ecotoxicologists identifies the ability to perform risk analysis as a critical skill.</p> <p>LR.29 (2009) – Defra's Survey of External Capabilities to meet their Strategic Requirements identifies needs for expertise in risk assessment</p>

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			<p>Risk assessment is probably under-represented in most training strategies.</p> <p>Quantitative risk analysis of natural resources.</p> <p>Natural hazard and disaster risk reduction</p> <p>Robust risk reduction.</p> <p>Risk assessment of chemicals in the environment.</p> <p>Shortage of skills in complexity (new area of risk and uncertainty).</p> <p>Difficulty recruiting in the field of Quantitative Risk Assessment.</p> <p>Skills gap in the field of risk evaluation.</p>	<p>090 (P) 092 (P) 094 (C) 095 (C) 097 (P) 098 (P) 099 (P) 102 (C) 105 (C) 123 (C)</p>	<p>funded since September 2005 in Risk, Probability &amp; Uncertainty Assessment Methods by, NERC (24) and BBSRC (2).</p> <p>Flood and coastal risk management professional development scheme run by the Environment Agency for their staff. Aimed to provide conversion courses or new knowledge to existing graduates already employed by the Environment Agency.</p>	<p>in the Marine &amp; Fisheries field.</p> <p>LR.67 (2009) – UK Low Carbon Industrial Strategy states that skills in risk management are necessary.</p> <p>LR 92 (2009) – Hazard Risk Management identified by ENDS as in top twenty most sought after skills for ESC.</p>
9	19	<p><b>TAXONOMY AND SYSTEMATICS A022</b></p>	<p><b>The ES widely reports a serious shortage of taxonomic skills both at the theoretical and field level. Recruitment issues in taxonomy, and taxonomy combined with other subjects such as monitoring and biomathematics, are reducing the UK’s potential for detailed ecological understanding.</b></p> <p>Lack of taxonomy skills results in an inability to understand the Biological Pump</p> <p>Identification skills and taxonomy are needed.</p> <p>Lack of taxonomic and mathematical skills.</p> <p>Current shortage of people with fieldwork and taxonomic skills.</p> <p>Few applicants with sufficient taxonomic skills applying for jobs in conservation.</p>	<p>006 (C) 017 (C) 018 (C) 023 (C) 028 (P) 039 (P) 041 (P) 053 (C) 056 (P) 057 (P) 060 (P) 061 (C) 062 (P) 068 (P) 071 (P) 085 (P) 109 (P) 112 (C) 115 (P)</p>	<p>NERC currently funds two Masters Courses in Taxonomy and Systematics and other ecology-based courses will include some elements. Very few PhD projects specifically mention taxonomy.</p> <p>There is a UK Taxonomy and Systematics Review which is due to report in June and will help to inform how this area is addressed.</p> <p>Taxonomy Response to Avril Allman suggests</p>	<p>LR.11 (2008) – IEEM. People with good field skills and interpretation skills are difficult to recruit and taxonomic skills on entry to organisations have declined. Concerns expressed by House of Lords Science &amp; Technology Committee about the decline in taxonomy.</p> <p>LR.27 (2008) – Select Committee on Science &amp; Technology Fifth Report. Systematics &amp; Taxonomy: Follow Up</p>

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			<p>Reference made to report from the House of Lords Select Committee on Science &amp; Technology 2008 ‘Systematics and Taxonomy Follow up’.</p> <p>Unable to recruit people with requisite taxonomy and biomathematics skills.</p> <p>Wide consensus on there being a taxonomic skills crisis. See House of Lords report on taxonomic skill shortage from 2008, plus a number of associated documents on House of Lords Science and Technology Committee web pages:  <a href="http://www.publications.parliament.uk/pa/ld/ldsctech.htm">http://www.publications.parliament.uk/pa/ld/ldsctech.htm</a> (use their search facility)</p> <p>Core skills in terms of taxonomy and biological monitoring.</p> <p>Linking taxonomy to ecological function.</p> <p>Linking pure taxonomy with understanding physiology.</p> <p>Skills gap for every type of biologically based scientist, especially ecologists skilled in taxonomy.</p> <p>Lack of Taxonomic Skills.</p> <p>Core practical taxonomic skills.</p> <p>FBA runs short courses in taxonomic and identification skills.</p>		<p>that:</p> <ul style="list-style-type: none"> <li>- Funding for MSc training in Taxonomy is a problem.</li> <li>- There is no clear career path following training.</li> <li>- PhDs are more available in ecological disciplines, attracting people away from taxonomy.</li> <li>- Dedicated Masters-PhD streamlined funding would be desirable to develop a distinct subject group.</li> <li>- Competition for fellowships is intense.</li> <li>- Despite high demand for taxonomic and evolutionary information and application of phylogenetics, there has been a decrease in related grant applications from academia.</li> </ul>	<p>LR.44 (2006) – Lantra Sector Skills Agreement: Environmental Conservation states that identification skills for flora and fauna are needed.</p> <p>LR.57 (2004) – Skills Audit of Horticultural R&amp;D suggests that there is increasing demand for skills in the taxonomy of pests and diseases.</p>
10	17	<p><b>DEALING WITH UNCERTAINTY A005</b></p> <p>See also:</p> <p>Risk assessment and management (A017)</p>	<p><b>There are shortages of postgraduates with the skills to understand and quantify uncertainty and complexity in models and observations. Allied to this, there is also a dearth of people able to communicate the uncertainties associated with complex issues such as climate change.</b></p> <p><b>From the experience of a Social Scientist interfacing with natural scientists, probably not enough skills relating to managing uncertainty in the development of policy solutions to</b></p>	<p>003 (C)  013 (P)  030 (P) 031 (P)  032 (P)  033 (C)  057 (P)  067 (P) 069 (P)  070 (P)  074 (C) 075 (C)</p>	<p>Interrogation of the ERFF Research Database indicates that 26 studentships have been funded since September 2005 that deal with uncertainty by NERC (24) and BBSRC (2).</p>	

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			<p>CC.</p> <p>Communicating uncertainty is critical.</p> <p>Need training in uncertainty. The skills are in short supply.</p> <p>Disseminate to policy-makers, local government and businesses the uncertainties associated with climate change fundamentals.</p> <p>Ability to quantify uncertainty in models and observations.</p> <p>It is important to understand that any modelling and empirical studies are subject to a degree of uncertainty. We need to be able to quantify it and communicate it to the public.</p> <p>Shortage of skills in complexity (a new area of risk and uncertainty).</p>	<p>084 (P)</p> <p>086 (C)</p> <p>092 (P)</p> <p>105 (C)</p> <p>106 (C)</p>	<p>NERC and ESRC co-fund 20 PhD studentships per year through an interdisciplinary competition. The projects funded in the 2010 competition addressed LWEC objectives.</p> <p>It is expected that advanced training provision related to dealing with uncertainty will be available through the ESRC Doctoral Training Centre infrastructure.</p>	
11	17	<p><b>MATHEMATICS/ APPLIED MATHEMATICS A011</b></p> <p>See also:</p> <p>Computer science/high performance computing (B002)</p> <p>Statistical analysis (A020)</p>	<p><b>Shortages in mathematical and numeracy skills are widely reported across all disciplines in the environmental sciences. This is attributed to both a lack of adequate training within the field and a lack of people converting from mathematical disciplines to the environmental sciences.</b></p> <p><b>Lack of graduates with necessary computational and mathematical skills converting to environmental sciences.</b></p> <p><b>Mathematical skills are in short supply in all disciplines across the biosciences</b></p> <p><b>Lack of taxonomic and mathematical skills.</b></p> <p><b>Lack of physics, chemistry &amp; mathematics graduates results in more qualitative work.</b></p> <p><b>Development of predictive mathematical models.</b></p> <p><b>Biomathematics</b></p> <p><b>Shortages of skills in Mathematics &amp; Biomathematics.</b></p>	<p>011 (P) 014 (C)</p> <p>027 (P)</p> <p>043 (O)</p> <p>045 (P)</p> <p>048 (P)</p> <p>049 (C)</p> <p>053 (C)</p> <p>059 (C)</p> <p>068 (P) 069 (P)</p> <p>094 (C)</p> <p>097 (P) 098 (P)</p> <p>099 (P)</p> <p>120 (P)</p> <p>122 (P)</p>	<p>NERC is piloting a new scheme (Research Experience Placements), to give undergraduates with quantitative skills (in maths, physics, computing etc) the opportunity to do an environmental research project for a 10-week period during their degree, the aim being to encourage them to consider an environmental research career.</p> <p>NERC and EPSRC</p>	<p>LR.11 (2008) – IEEM. Concerns over the level of numeracy of undergraduates.</p> <p>LR.21 (2008) – Policy Watch identify a general lack of basic mathematical skills in undergraduates entering university.</p> <p>LR.30 (2009) – The Demand for STEM Skills report outlines concern with mathematical skills needs at both graduate and postgraduate levels.</p>

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			<p>Need for mathematical and statistical training particularly in the area of reducing uncertainty.</p> <p>Lack of numeracy skills.</p> <p>Mathematical and computational skills needed.</p>		<p>jointly funded the now completed Environmental Mathematics &amp; Statistics Programme to attract mathematicians and statisticians to environmental research.</p>	<p>LR.44 (2006) – Lantra Sector Skills Agreement: Environmental Conservation states that numeracy is needed in the sector now and in the future.</p> <p>LR.52 (2002) – Skills Information Gateway documents states that generic skills in communication and numeracy are required.</p>
12	17	<p><b>SOIL SCIENCE A019</b></p> <p>See also: Agriculture (A001)</p>	<p><b>A general shortage of postgraduates with adequate skills in soil science is widely reported. Specific skills needs within the discipline and associated subjects include soil carbon monitoring and modelling, soil, agriculture and food production, and understanding soil systems</b></p> <p><b>Particular need for soil scientists to ensure sustainable food production.</b></p> <p><b>There is a need for more soil carbon scientists and modellers.</b></p> <p><b>Limited availability of soil scientists.</b></p> <p><b>Need for soil scientists and agronomist.</b></p> <p><b>Decline in soil science as a discipline in the UK.</b></p> <p><b>Lack of soil scientists and environmental modellers.</b></p> <p><b>See Defra (2003) UK soil research audit (CTE0211) - SP0524</b></p> <p><b>Modelling of soil function in response to climate.</b></p> <p><b>Improve methodologies for soil carbon monitoring.</b></p> <p><b>Effects of agriculture on soil systems.</b></p> <p><b>Understanding of soil systems and how they function across spatial and temporal scales.</b></p>	<p>006 (C) 007 (P) 009 (P) 016 (P) 018 (C) 022 (C) 023 (C) 025 (C) 033 (C) 048 (P) 054 (P) 055 (P) 059 (C) 063 (P) 080 (P) 092 (P) 099 (P)</p>	<p>Only one of the masters courses supported by NERC is specific to soils (soils and environmental pollution masters at Reading University) and there will be aspects of soil science in some of the other NERC funded masters courses.</p> <p>Soil is mentioned in 44 (7%) of the PhD projects supported by NERC over the last two years, although the extent to which the project focuses on soils varies.</p> <p>Interrogation of the ERFF Research Database indicates that 122 studentships have been</p>	<p>LR.93 (2005) – The Agriculture and Environment Biotechnology Commission report that the redirection of resources in soil science has had an important and unintended negative consequence for the skills base. The rapid pace of change in soil science has meant that not enough care has been taken to protect the full range of soils science skills and expertise.</p>

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			<p>Skills gap for every type of biologically based scientist, especially ecologists skilled in soil science.</p> <p>Significant skills gap in soil science.</p> <p>Detailed fundamental knowledge in individual soil sub-disciplines.</p> <p>Environmental scientists need more exposure to the behavioural and social sciences.</p>		<p>funded since September 2005 in Soils &amp; other Natural Loose Materials on the Land Surface by, NERC (94) and BBSRC (28).</p>	
13	13	<p><b>ENVIRONMENTAL EPIDEMIOLOGY A007</b></p> <p>See also: Health impact assessment (D018) Public Health and Wellbeing (D026)</p>	<p><b>A skills shortage is reported by the ES in the field of environmental epidemiology, the branch of public health that deals with environmental conditions and hazards that may pose a risk to human health. Skills in this area are important for understanding the effects of climate change on disease and predicting emergent diseases.</b></p> <p><b>Very substantial skill shortage in environmental epidemiology in the UK.</b></p> <p><b>Understanding population fluxes (eg. epidemiology of plant and animal diseases).</b></p> <p><b>Understanding the effects of climate change on disease.</b></p> <p><b>Predicting emergent diseases.</b></p> <p><b>Difficulties recruiting in the field of epidemiology.</b></p>	<p>043 (O) 072 (C) 077 (C) 080 (P) 111 (P) 112 (C) 113 (P) 117 (P) 118 (O) 119 (P) 120 (P) 121 (C) 123 (C)</p>	<p>There is currently very little specifically funded by NERC in this area. Only two of over 600 PhD projects over the last two years mention epidemiology and no masters courses are supported in this area.</p> <p>Environment and human health is however a priority for NERC, MRC, ESRC, DEFRA and the Department of Health. There has been a recent call out for proposals under their jointly funded Environmental Exposure and Health (EEH) Programme. In August, it was agreed to fund 3/4 PhDs. Further details to follow.</p>	
14	12	<b>BUSINESS AWARENESS</b>	<p><b>The ES reports that postgraduates need a much better awareness of business issues. Improved business skills would</b></p>	<p>007 (P) 010 (C) 015 (C)</p>	<p>Around 30% of NERC funded PhD's involve</p>	<p>LR.44 (2006) – Lantra Sector Skills Agreement:</p>



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		<p><b>A002</b></p> <p>See also:</p> <p>Emerging Technologies (C016)</p> <p>Innovation (C008)</p>	<p><b>facilitate more effective communication between science and business enabling, for example, more efficient movement of technologies from the research-stage to market. Better business knowledge would also help companies to make sound decisions which underpin low carbon and climate change ambitions (eg in terms of meeting emissions reduction targets and making adaptations).</b></p> <p><b>Working with businesses is needed.</b></p> <p><b>Needs a basic understanding of Business as CPD to enable the science to business communication to be productive.</b></p> <p><b>Leadership and management in business wrt to low carbon activities and resource efficiency.</b></p> <p><b>Business skills required to move technologies from research to a development stage and hence to market.</b></p> <p><b>Decisions made in core business need to reflect an organisation’s climate change ambitions in both meeting emissions reduction targets and adaptations.</b></p>	<p>024 (C) 025 (C) 026 (C) 028 (P) 030 (P) 031 (P) 046 (C) 051 (P) 081 (C)</p>	<p>collaboration with a non-academic organisation (CASE partner). Many partners are industrial employers with which students spend a period of time.</p> <p>The Environment Young Entrepreneurs Scheme (YES) competition aims to raise levels of entrepreneurial awareness. It is run as a three-day residential course and includes practical training and practise in all aspects of technology transfer and the commercialisation of science ideas.</p> <p>One part of the Public Sector Exploitation Fund is the Entrepreneurial Training Programme, which will deliver a range of entrepreneurial training across NERC Research and Collaborative Centre communities.</p> <p>Emergence of relevant courses such as Environmental Science with Business Management at Queen Mary University of</p>	<p>“Environmental Conservation” states that business strategy is needed in the sector now and in the future.</p> <p>LR.12 (2007) – Employers’ Views of Researchers’ Skills reports that PhD students are generally lacking commercial awareness.</p>

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					London.	
15	12	<p><b>SUSTAINABILITY SCIENCE A021</b></p> <p>Links to many areas including:</p> <p>Environmental change (D024)</p> <p>Futures thinking/ planning (C001)</p> <p>Inter- multi disciplinarity (A010)</p> <p>Natural science- social science interface ... (A015)</p> <p>Social science (C002)</p>	<p><b>The ES reports a need to develop postgraduate skills in the relatively new discipline of sustainability science. This is a broad area bringing together knowledge of Earth systems with knowledge of human interrelationships, gained from the social sciences, to address human impacts on the environment and society. However, there is a widespread lack of the necessary technical skills necessary to ensure that sustainability and promoting sustainable behaviour is at the heart of policy and economic activity.</b></p> <p><b>Limited Technical Skills in Sustainable Development and Environmental Sustainability especially in the financial services sector, in retail, and management more generally.</b></p> <p><b>Sustainability should be at the heart of policy.</b></p> <p><b>Lack of cohesion on ways to promote sustainable behaviour.</b></p> <p><b>Clear need to develop the skills base to grow the nascent discipline of ‘sustainability science’.</b></p> <p><b>Additional training is needed in sustainability appraisal.</b></p> <p><b>Developing indicators for sustainable consumption.</b></p> <p><b>Develop and evaluate innovative social responses to global sustainability.</b></p>	021 (P) 026 (C) 027 (P) 075 (C) 079 (P) 081 (C) 084 (P) 085 (P) 086 (C) 087 (P) 116 (P) 117 (P)	NERC and ESRC co-fund 20 PhD studentships per year through an interdisciplinary competition. The projects funded in the 2010 competition addressed LWEC objectives.	<p>LR.17 (2007) – Academy for Sustainable Communities report on the skills gap finds that there is a present but likely decreasing gap in the availability of environmental experts but a present and increasing shortage of sustainable development specialists.</p> <p>LR.59 (2004) – Egan Review on skills for sustainable communities identifies skills needs for the sector.</p> <p>LR.92 (2009) – Sustainable development identified by ENDS as third most sought after skill for ESC.</p>
16	7	<p><b>AGRICULTURE A001</b></p> <p>See also:</p> <p>Soil science (A019)</p>	<p><b>A general lack of postgraduate knowledge of and skills in agriculture is reported which is impinging on the environment sector. Such skills are required to address food security issues, appropriate adaptation to climate change and the links with soil science. There is a need for more agronomists and modellers able to combine agricultural, environmental and biological concepts.</b></p> <p><b>Lantra have a New AgriSkills Strategy available at: <a href="http://www.lantra.co.uk/">http://www.lantra.co.uk/</a></b></p>	002 (C) 021 (P) 022 (C) 033 (C) 035 (C) 053 (C) 063 (P)	Interrogation of the ERFF Research Database indicates that 91 studentships have been funded since September 2005 in Agriculture, Horticulture, Forestry & Land Management (C2) by BBSRC (50), NERC (40) and Natural England (1).	<p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements states that numerous skills within the agricultural sector require close following and possible follow-up to ensure continued provision.</p> <p>LR.57 (2004) – Skills</p>

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			<p>Agricultural skills highlighted by BBSRC as a lacking niche. Need for agronomists.</p> <p>Relevant to food security and therefore of high importance.</p> <p>Opportunities to combine agricultural knowledge with pure biology models and environmental analysis.</p> <p>Agriculture and land management play a role in adapting to and reducing climate change.</p> <p>Links between agriculture and soil science – effect of agricultural processes on soil properties.</p> <p>Innovative application of agricultural practice to ensure food security.</p> <p>New AgriSkills Strategy at <a href="http://www.lantra.co.uk">http://www.lantra.co.uk</a></p>			<p>Audit of Horticultural R&amp;D suggests that there is increasing demand for practical agronomy, plant production and crop science skills.</p> <p>LR.94 (2009) – Royal Society report on an impending skills shortage in agricultural science putting world food supply at risk.</p>
17	7	<p><b>MICROBIOLOGY/ MICROBIAL PHYSIOLOGY A013</b></p> <p>See also:  Biodiversity (C017) Ecology/ ecological sciences (B003)</p>	<p><b>A requirement for stronger postgraduate skills in microbiology and microbial physiology is identified. Such skills are needed by the ES to understand the effects of ecosystem change on plant, animal and microbial diversity. Another application of these skills is in understanding the role of anaerobic digestion in agricultural production. The area has already been identified by BBSRC as an area of UK weakness.</b></p> <p>Microbial physiology and basic microbiology are important, and the BBSRC Plant &amp; Microbial Sciences portfolio evaluation identified this as an area of UK weakness (with students preferring to do medical microbiology)</p> <p>Microbiology is required for anaerobic digestion a major government initiative for the agricultural sector see Accelerating the Uptake of Anaerobic Digestion in England: an Implementation Plan’ launched by DEFRA 25/03/10.</p> <p>Modelling to link microbial community dynamics with emergent properties of systems / processes.</p> <p>Analysis of effects of ecosystem change on plant, animal and microbial diversity.</p>	<p>015 (C) 019 (C) 025 (C) 046 (C) 053 (C) 066 (P) 117 (P)</p>		<p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies needs for underpinning skills in microbiology.</p>

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			Less acute problems in recruiting people with microbiology skills.			
18	6	<b>MEDIA SKILLS A012</b>  See also:  Communication (A003) Science Communication (D012)	<p><b>A specific aspect of <i>communication</i> identified as an area of concern in its own right is better media skills. More effective communication of science and its key messages on issues such as climate change via the media is essential to avoid ‘media corruption’. Postgraduates need to be prepared for the unique challenges they face when dealing with the press.</b></p> <p>Access to written and oral communication skills training (including media training) is required.</p> <p>Media corruption of the climate change message is ubiquitous so skills needed in this area</p> <p>BBSRC runs media training for some of its students but there is a need for greater awareness of how to communicate science to a lay audience. Mature scientists are generally not good at it so training the next generation would be a good way to redress the balance</p>	001 (C) 003 (C) 074 (C) 075 (C) 105 (C) 124 (P)		
19	6	<b>NATURAL SCIENCE – SOCIAL SCIENCE INTERFACE / TRANSLATION A015</b>  See also:  Inter-/ multi-disciplinarity (A010) Social Science (C002)	<p><b>This area is linked to the <i>inter- and multi-disciplinary</i> area of concern higher up in the Framework. A group of respondents identified the natural and social sciences boundary quite specifically. A need for better integration of natural and social science postgraduate skills is required – either in the same individual or through people working together more effectively.</b></p> <p>From the experience of a social scientist, there is a need to interface with natural scientists.</p> <p>Need for interdisciplinary approach relating to social science and natural sciences.</p> <p>Social and natural scientists need to work together.</p> <p>Shortage of natural scientists with an understanding of the social sciences</p>	002 (C) 007 (P) 010 (C) 013 (P) 029 (P) 072 (C)	Interrogation of the ERFF Research Database indicates that 9 studentships have been funded since September 2005 that relate to the Natural Science – Social Science interface by NERC.	

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			<p>Lack of ability of scientists to identify and empathise with the natural environment in a connected, holistic way.</p> <p>BBSRC would generally encourage the integration of skills in the social and natural sciences.</p>			
20	4	TOWN AND COUNTRY PLANNING A023	<p><b>Knowledge of town and country planning and associated areas is increasingly important to some members of the ES. One cause of its increasing significance is growing urbanisation and the consequent pressures on the environment resulting in the growing significance of planning control, environmental impact assessment and strategic environmental assessment.</b></p> <p><b>Skills shortages in planning control.</b></p> <p><b>There is a need for EIA and SEA training, particularly for planners.</b></p> <p><b>Increasing urbanisation and pressure on the urban environment – more megacities.</b></p> <p><b>Change in demographics.</b></p> <p><b>Economics analysis used to inform decision making in all aspects of environmental management.</b></p>	001 (C) 021 (P) 078 (P) 083 (C)	<p>Interrogation of the ERFF Research Database indicates that 3 studentships have been funded since September 2005 in Urban &amp; Land Use Planning / Planning &amp; Design of the Built Environment by NERC (2) and EPSRC (1).</p> <p>It is expected that advanced training provision related to Town &amp; Country Planning will be located in several ESRC Doctoral Training Centres. The training pathways are expected to provide advanced interdisciplinary training, related to Town and Country Planning in areas such as environmental planning, human geography and urban planning.</p>	<p>LR.17 (2007) – Academy for Sustainable Communities report on the skills gap finds that there is a present and increasing gap in availability of town planners, particularly those with development control expertise and those in middle management.</p> <p>LR.96 (2010) – Public Property UK report that planning authorities need to recruit more young people if the UK is to avoid a skills shortage.</p>
21	3	ENERGY PROVISION A006	<p><b>As far as energy provision is concerned, feedback from the ES indicates that there is a need to ensure that energy specialists have a better knowledge of environmental science and issues.</b></p>	024 (C) 046 (C) 047 (C)	<p>NERC supports a number of geoscience masters courses which</p>	<p>LR.13 (2008) – Energy &amp; Utility Skills report that the energy sector is facing</p>

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		<p>See also:</p> <p>Renewable energy technology (A016)</p>	<p><b>Energy sustainability and energy security were identified as key challenges. However, environmental considerations are often seen as an “add-on” as opposed to a central consideration.</b></p> <p><b>The ES also needs postgraduates better able to tackle challenges connected with different energy sources and the economics of energy supply and demand.</b></p> <p>Technological pool in energy arena rarely comes from the environmental sciences so the environment remains an add on rather than a central consideration.</p> <p>Energy sustainability is one of the key challenges to man and the planet.</p> <p>There is a need for wider perspective re energy security / energy production, and transfer of relevant technologies to industry.</p> <p>Understanding conventional energy resource limitations – peak oil.</p> <p>Understanding the impact of energy by-products (rising CO<sub>2</sub>, tropospheric ozone etc.) on natural systems.</p> <p>Understanding the impact of the growth of market economies re: energy supply, distribution and use.</p> <p>Sustainable extraction of fossil energy resources from unconventional sources. Energy Security a priority.</p> <p>Impact of waste creation from energy production.</p> <p>Growth of market economies re energy supply, distribution and use.</p> <p>Energy Security a priority.</p> <p>There should be a dedicated postgraduate focus on the domains of fossil fuels and radioactive minerals and their application. This requires knowledge of geoscience, nuclear physics and engineering, commerce and politics.</p> <p>BBSRC is addressing energy research by supporting targeted</p>		<p>provide trained people for the petroleum and mining industries.</p> <p>EPSRC is the main funder of PhD studentships in energy provision and technologies, in particular through its more recent Centres for Doctoral Training, but also through the research programme - Towards a Sustainable Energy Economy (TSEC) and the UKERC. There are five EPSRC Energy Centres for Doctoral Training.</p>	<p>some serious skills challenges.</p> <p>LR.51 (2007) – Energy Research Partnership report on high level skills shortages in the energy industry.</p> <p>LR.92 (2009) - ENDS Report – Energy Management identified by ENDS as second most sought after skill for ESC.</p> <p>LR.95 (2009) – Renewable Energy Focus report on the uncertainty relating to the availability of appropriate skills to underpin a renewable energy revolution as part of a low carbon future.</p>

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			studentships in bioenergy.			
22	3	<b>INTEGRATED FRESHWATER SCIENCES A009</b>  See also:  Hydrological sciences (DO11)	<p><b>The ES has identified a shortage of postgraduate skills in the integrated freshwater sciences which bring together the physical, chemical and biological aspects of the subject. Such skills are needed to, for example, evaluate and understand freshwater ecosystems.</b></p> <p>Freshwater sciences (integrating physical, chemical, biological processes) are not well supported.</p> <p>Freshwater science skills appear to be declining.</p> <p>Recognising the importance of evaluating and interpreting indicators of the state of freshwater ecosystems.</p>	034 (C) 036 (P) 062 (P)	Interrogation of the ERFF Research Database indicates that 148 studentships have been funded since September 2005 in the field of Freshwater Sciences by NERC (144), BBSRC (2) and Natural England (2).	<p>LR.11 (2008) – IEEM report on increasing concern regarding our ability to provide the scientific understanding required to meet the scale of the problems we face.</p> <p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies shortages of freshwater taxonomists / ecologists.</p>
23	3	<b>RENEWABLE ENERGY TECHNOLOGY A016</b>  See also:  Energy provision (A016)	<p><b>Linked to energy provision, renewable energy technology emerged as a distinct theme in the feedback from the ES. Better training in technical skills combined with an environmental understanding is needed to keep pace with technological developments in the field and ensure sustainability. For example, a knowledge of ecology is needed to help decide where renewable energy technology should be sited.</b></p> <p><b>Skills in renewable energy have recently been assessed by a DECC project which was due to report in Summer 2010.</b></p> <p>Ecology is important to the siting of renewable energy technology.</p> <p>Skills in renewable energy currently being assessed by a DECC project due to report in Summer 2010.</p> <p>Training seems to lag technical developments eg there is now adequate training in wind energy, but not enough in marine energies which are starting to become commercial prospects,</p>	008 (C) 024 (C) 046 (C)	<p>NERC provides funding for a masters course in Renewable Energy: Technology and Sustainability.</p> <p>EPSRC is the main funder of PhD studentships in energy provision and technologies, in particular through its more recent Centres for Doctoral Training, but also through the research programme - Towards a Sustainable Energy Economy (TSEC) and the UKERC. There are five EPSRC Energy</p>	<p>LR.51 (2007) – Energy Research Partnerships’ investigation into high level skills shortages in the energy sector identifies need for experience in renewable energy technology development.</p> <p>LR 92 (2009) – Renewable energy and clean energy identified by ENDS as in top ten most sought after skills for ESC.</p> <p>LR.91 (2009) – ENDS Report 406 suggests that lack of skills in manufacturing supply chain for wind turbine technology</p>

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			<p>and thus need work on their impacts</p> <p>Technological pool in energy arena rarely comes from the environmental sciences so the environment remains an add on rather than a central consideration.</p> <p>Exploitation of renewable resources.</p> <p>Developing renewable energy sustainability.</p>		<p>Centres for Doctoral Training.</p> <p>Interrogation of the ERFF Research Database indicates that 11 studentships have been funded since September 2005 in Renewable Energy by NERC.</p>	<p>could hold the UK back.</p>



## SECTION B: PRIORITY TWO AREAS OF CONCERN

### IDENTIFIED BY THE ES AS BEING IN SHORTAGE WITH RESPECT TO AT LEAST ONE PRIORITY CHALLENGE

(Note that, in addition to being in shortage for at least one priority challenge, these knowledge/skills areas are needed to address a range of both critical and priority challenges)

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24	43	<p style="text-align: center;"><b>ECOLOGY/ ECOLOGICAL SCIENCES (INCL. CONSERVATION) B003</b></p> <p>See also:  Introduced/invasive species (B006) Biodiversity (C017)</p>	<p><b>A need for more postgraduate skills in ecology, ecological sciences and conservation is widely identified by the ES. People adequately skilled in general ecology, in ecology combined with other subject areas, and in specific areas such as nitrogen modelling, field identification or soil ecology can be difficult to find.</b></p> <p><b>Training required for interdisciplinary researchers with an appreciation of ecological concepts.</b></p> <p><b>Need ecologists with modelling skills.</b></p> <p><b>Ongoing need for fundamental research linking ecological and evolutionary processes, to allow us to predict how animals and plants (etc) will respond to climate change.</b></p> <p><b>Ecology is important for the siting of renewable energy technologies.</b></p> <p><b>Ecological consultants bemoan the lack of basic identification skills in graduates.</b></p> <p><b>Few applicants with sufficient knowledge of conservation are applying for jobs.</b></p> <p><b>Few applicants with necessary skills in taxonomy are applying for jobs in conservation</b></p> <p><b>Use of knowledge of biodiversity and ecology to inform response to drivers of change.</b></p>	<p>002 (C) 004 (P) 005 (C) 011 (P) 012 (P) 016 (P) 017 (C) 018 (C) 019 (C) 024 (C) 025 (C) 034 (C) 053 (C) 054 (P) 055 (P) 056 (P) 057 (P) 058 (P) 059 (C) 060 (P) 061 (C) 062 (P) 063 (P) 064 (O) 066 (P) 067 (P) 068 (P) 069 (P) 070 (P) 071 (P) 078 (P) 080 (P) 081 (C) 092 (P) 101 (P) 107 (C) 108 (C) 112 (C) 113 (P) 114 (P) 117 (P) 122 (P) 123 (C)</p>	<p>Interrogation of the ERFF Research Database indicates that 245 studentships have been funded since September 2005 in subject areas related to Ecology (largely ecosystems and habitats) by, NERC (219), BBSRC (15) and Natural England (11).</p>	<p>LR.92 (2009) - ENDS Report identifies Ecology and Nature Conservation as in the top 20 environmental skills in demand by employers.</p>

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			Skills gap for every type of biologically based scientist, especially ecologists skilled in taxonomy, soils science and nitrogen modelling.			
25	37	<b>SPATIAL ANALYSIS AND GIS B010</b>  See also:  Modelling (A014) Numerical/ mathematical modelling (D019)	<p><b>Feedback from the sector indicates that skills in spatial analysis and GIS are in relatively high demand across the environmental sciences. Furthermore, high level GIS modelling skills are in short supply, especially when combined with expertise in other subject areas. Potential exists to better understand the spatial impacts of climate change by incorporating GIS and remote sensing into the existing climate models.</b></p> <p><b>We need ecological modellers with spatial analysis skills.</b></p> <p><b>GIS skills are lacking.</b></p> <p><b>Spatial analysis and modelling skills are in medium supply, but becoming less available as demand for this grows.</b></p> <p><b>Improve spatial analysis and understanding of climate change risks and impacts.</b></p> <p><b>Geographical Information Science including spatial analysis &amp; remote sensing</b></p> <p><b>GIS &amp; Remote Sensing skills linked to modelling.</b></p>	002 (C) 004 (P) 006 (C) 016 (P) 017 (C) 022 (C) 032 (P) 033 (C) 037 (P) 038 (P) 039 (P) 040 (P) 041 (P) 042 (C) 045 (P) 059 (C) 060 (P) 063 (P) 066 (P) 070 (P) 076 (P) 078 (P) 080 (P) 083 (C) 088 (P) 092 (P) 100 (C) 106 (C) 109 (P) 115 (P) 116 (P) 117 (P) 119 (P) 120 (P) 121 (C) 123 (C) 124 (P)	NERC currently funds four masters courses in GIS and/or Remote Sensing. Evidence from the Interim Masters Review suggested that these courses struggled to attract students more than in any other area. The fifth course that NERC used to fund had closed as it was running under capacity. NERC did increase its support for some other courses that had expanded their GIS element to try and compensate.	LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies remote sensing as a key area for developing capability in order to assess areas likely to be affected by climate change flooding.
26	33	<b>ECONOMIC APPROACHES B004</b>  See also:	<p><b>Feedback from the ES points to a widespread need for postgraduates with a better understanding of economics and economic approaches.</b></p>	002 (C) 003 (C) 008 (C) 010 (C) 022 (C) 023 (C) 024 (C)	NERC and ESRC co-fund 20 PhD studentships per year through an interdisciplinary competition. The projects funded in the 2010 competition	LR 22 identifies need for economic approaches associated with climate change studies

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		Environmental valuation (C018) Socioeconomics (DO29)	<p><b>The following branches of economics are highlighted.</b> <i>Economics. Agricultural Econ. Behavioural Econ. Institutional Econ. Resource Econ</i></p> <p><b>Economic approaches make an increasingly valuable contribution to inter- and multidisciplinary research. People are required who can bridge disciplines by combining economics with other fields of expertise. Modelling economic impacts of factors such as resource availability and climate change adaptations is becoming a crucial skill set. Combining scientific research with an appreciation of world markets and economics is also increasingly important.</b></p> <p><b>Interdisciplinary working required spanning not only the physical sciences but also the social sciences, economics and communications.</b></p> <p><b>Particular expertise in econ. and comp. science required.</b></p> <p><b>Need people who can bridge disciplines by combining economics with other fields of expertise.</b></p> <p><b>It is essential to identify the potential economic impact of future environmental change forecasts.</b></p> <p><b>Modelling the economic impact of resource availability in terms of affordability will be an essential skill set.</b></p>	025 (C) 028 (P) 029 (P) 030 (P) 031 (P) 032 (P) 033 (C) 035 (C) 055 (P) 058 (P) 060 (P) 062 (P) 063 (P) 064 (O) 065 (P) 067 (P) 073 (C) 077 (C) 079 (P) 081 (C) 084 (P) 085 (P) 086 (C) 087 (P) 088 (P) 090 (P)	<p>addressed LWEC objectives. NERC and ESRC co-fund 20 PhD studentships per year through an interdisciplinary competition. The projects funded in the 2010 competition have to address LWEC objectives. Interdisciplinary PhDs are also funded through cross-council programmes such as Rural Economy and Land Use (RELU).</p> <p>Interrogation of the ERFF Research Database indicates that 2 studentships have been funded since September 2005 that relate to economics approaches by NERC.</p> <p>It is expected that advanced training provision for economic approaches will be located in several ESRC Doctoral Training Centres. The training pathways are expected to feature interdisciplinary links to economics and econometrics, epidemiology and public health, and geography.</p>	LR25

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			<p>Key will be the awakening of scientists to the realities of the worlds markets and economics.</p> <p>Environmental Economics is particularly relevant in evidencing the economic value of sound environmental management.</p> <p>Integrated modelling from climate to economics.</p> <p>Economics of soils loss and sediment impacts on river ecology.</p> <p>Huge gap in environmental and ecological economics.</p> <p>Economic and social data collection and analysis.</p> <p>Integrating economics, soc. sci. and ecology.</p> <p>Economics models of risk.</p> <p>Globalisation of economics and society.</p> <p>Mechanism for calculating / evidencing economic and / or social impact of sound env. management.</p> <p>More skills required in env. Economics.</p>			
27	9	<b>CARBON SCIENCES B001</b>	<p><b>The ES has highlighted the increasing importance of skills in the area of carbon sciences particularly:</b> <i>Carbon Accounting, Carbon Cycle, Carbon Modelling, Carbon Reduction, Carbon Sequestration, Carbon Trading.</i> <b>This need reflects the rise of the ‘Low</b></p>	<p>008 (C) 023 (C) 031 (P) 035 (C) 048 (P) 054 (P) 055 (P) 082 (C)</p>	<p>Interrogation of the ERFF Research Database indicates that 63 studentships have been funded since September 2005 in subjects related to Carbon by NERC (60) and BBSRC (3).</p>	<p>LR.22 (2008) - University of Exeter identifies carbon management/ footprinting skills as required for climate change work.</p> <p>LR.29 (2009) – Defra’s Survey</p>

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			<p><b>Carbon Economy’ and the increased emphasis placed on carbon monitoring and trading activities.</b></p> <p><b>A need for more soil carbon scientists and modellers as well as individuals with skills in sequestration and appropriate carbon reduction strategies is identified.</b></p> <p><b>Carbon accounting skills in the Public and Private sector were identified as lacking in a study carried out for NWDA on the ‘Assessment of the Skills Provision for a well adapted and Low carbon NW.’</b></p> <p><b>There is a need for more soil carbon scientists and modellers.</b></p> <p><b>There is too much focus on new technologies, with not enough thought given to natural sequestration approaches.</b></p> <p><b>There is a need to train and develop people to consider carbon reduction strategies at macro and micro levels.</b></p> <p><b>High-tech geophysics required within the field of carbon monitoring post sequestration.</b></p> <p><b>Rarity of carbon modellers often creates bottlenecks for other work.</b></p> <p><b>Improve methodologies for soil carbon monitoring.</b></p> <p><b>Harnessing microbes to recycle carbon.</b></p>	084 (P)		<p>of External Capabilities to meet their Strategic Requirements identifies expertise in carbon sequestration as a key area for development of capabilities.</p> <p>LR.92 (2009) - ENDS identify GHG and carbon management as seventh most sought after skill for ES.</p>

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			<p>Carbon cost of land use change.</p> <p>Modelling carbon processes in environmental compartments</p> <p>Need to ensure that carbon accounting is applied at a strategic and project level using agreed tools.</p> <p>MSc programmes on Carbon Management and Carbon Capture and Storage are now available which provide multidisciplinary expertise built around the geosciences.</p> <p>Carbon and water are linked – there are real opportunities here for integrated thinking and skills.</p>			
28	8	<p><b>PALAEONTOLOGY B009</b></p>	<p>Skills in the fields of micropalaeontology and palynology are reported to have all but disappeared with other traditional palaeontological skills also declining. However, there is a contemporary need for both palaeodata and people with palaeontology skills to work on areas such as climate model testing and creating analogues to contextualise the extent of recent and future human impacts on the environment.</p> <p>Testing skill of climate models in a palaeoclimate capacity are presently ok but numbers may rapidly diminish following the completion of QUEST.</p> <p>Micropalaeontology and palynology have all but disappeared.</p> <p>Palaeo skills are disappearing, as are</p>	<p>004 (P) 007 (P) 017 (C) 057 (P) 059 (C) 070 (P) 091 (P) 109 (P)</p>	<p>Interrogation of the ERFF Research Database indicates that 128 studentships have been funded since September 2005 in Earth History Evidence by NERC.</p>	

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			<p>taxonomy and systematics.</p> <p>Palaeontology is an area of particular concern because of the loss of skills but there are threats across the whole sector.</p> <p>There is a need for quality palaeodata to provide analogue information related to projected ice sheet decline.</p> <p>Skills in interpreting palaeoenvironmental records and using this to place the magnitude and extent of recent and future human impacts in context.</p> <p>Analysis of palaeosol sequences.</p>			
29	5	<p><b>LIFE CYCLE ASSESSMENT B008</b></p>	<p>Another specific skills shortage highlighted by the Sector is a need for postgraduates with an understanding of life cycle assessment of products including waste.</p> <p>Product composition and life cycle impacts.</p> <p>Understanding the full life cycle of waste including outward effects of handling, transporting and disposing of waste.</p>	<p>026 (C) 027 (P) 030 (P) 031 (P) 122 (P)</p>		<p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies developing a comprehensive but time/cost efficient approach for LCA as a key are for capability development.</p>
30	4	<p><b>COMPUTER SCIENCE/ HIGH PERFORMANCE COMPUTING B002</b></p> <p>See also:  Mathematics, applied mathematics (A011), Programming (D006)</p>	<p>As with the related subject of Mathematics, there is a lack of postgraduates either acquiring the required computing skills within the environmental sciences or transferring to the field from a computing background. The current market and demand for computing skills makes it difficult to recruit and retain programmers and software developers.</p>	<p>011 (C) 012 (C) 054 (P) 055 (P)</p>	<p>NERC is piloting a new scheme (Research Experience Placements), to give undergraduates with quantitative skills (in maths, physics, computing etc) the opportunity to do an environmental research project for a 10-week period during their degree, the aim being to encourage them to consider an environmental research career.</p> <p>The High End Computing Plan which went to SISB in 2007 included the</p>	

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			<p>Lack of cross over of students from computer science.</p> <p>Lack of students with necessary computational and mathematical skills converting to environmental sciences.</p> <p>Shortage of genuine and combined computation and biology skills.</p> <p>Shortage of computing skills.</p> <p>Current market makes it difficult to retain programmers and software developers.</p> <p>High performance computing necessary.</p>		<p>following at paragraph 27: The sector has identified a skills gap in trained computational scientists. We will develop offering PhD students the opportunity to attend one of the national HEC Training Centres at Warwick and Edinburgh to take modules in computational science and engineering or complete an additional MSc.</p> <p>Early indications from the Environmental Research Funders Forum (ERFF) skills training review are that specialist computer skills are in short supply and that competencies are required in data management and visualisation, and in writing and parallelising computer code.</p> <p>It is expected that advanced training provision for computer science will be located in several ESRC Doctoral Training Centres. The training pathways are expected to feature interdisciplinary links to psychology, stats analysis and modelling.</p>	
31	4	GEOENGINEERING B005	<p>Still in its infancy, geoengineering is a skill which the ES predicts will grow in importance in the next decade. (Geoengineering is loosely defined as the manipulation of the Earth's climate to counteract the effects of global warming from greenhouse gas emissions.) As the discipline expands it is also likely to draw upon expertise from other areas such as biological assessment and risk assessment.</p> <p>Biological assessment and evaluation of</p>	007 (P) 008 (C) 009 (P) 050 (P)	Interrogation of the ERFF Research Database indicates that 2 studentships have been funded since September 2005 in Geoengineering related areas by NERC.	



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			<p>risks is crucial to geoengineering.</p> <p>Although in its infancy, skills in the field of geoengineering would be valuable.</p>			
32	2	<p><b>LANDSCAPE SCIENCES B007</b></p> <p>See also:</p> <p>Geomorphology and earth surface processes (C010) Environmental Management (D007)</p>	<p><b>Understanding current and past landscape changes can be used as an analogue to help identify and interpret the key uncertainties in landscape response to changes in climate. Such knowledge also helps the ES to develop strategies to manage the natural landscape effectively.</b></p> <p><b>There is a need to promote sustainable engineering with no adverse impact on natural landscapes.</b></p> <p><b>Lack of geostatistical skills and integration with landscape science.</b></p> <p><b>Identify the key uncertainties in landscape responses to changes in climate. Landscape understanding to discern past responses to landscape change as analogues for the future.</b></p> <p><b>Placements with landscape management organisations likely to be of considerable value, especially ref understanding of practical application / transfer of knowledge</b></p>	021 (M) 092 (M)	Interrogation of the ERFF Research Database indicates that 104 studentships have been funded since September 2005 in Landscape related topics by NERC (97) and BBSRC (7).	<p>LR.17 (2007) – Academy for Sustainable Communities report on the skills gap finds that there is an occupational skills gap for landscape architects, urban designers and architects.</p> <p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies land use management as a key area for development of capabilities.</p>
33	1	<p><b>INTRODUCED/ INVASIVE SPECIES B006</b></p> <p>See also:</p> <p>Ecology/ ecological sciences (incl. conservation) (B003)</p>	<p><b>A Review Group member identified postgraduate skills shortages in the area of predicting, detecting and monitoring invasive species - an area linked to ecology, another Priority B Area of Concern. Managing invasive species and changing species distributions in response to changing climate is seen as an area of increasing importance and skill shortage.</b></p>	056 (M)	Interrogation of the ERFF Research Database indicates that 34 studentships have been funded since September 2005 in Introduction of Alien Species or Conservation and Control of Specific Species by NERC (22), Natural England (9) and BBSRC (3).	LR.27 (2008) – Select Committee on Science & Technology Fifth Report. Systematics & Taxonomy: Follow Up reports on Taxonomy skills being essential in providing identification of newly introduced species.

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		Biodiversity (C017)	<p>Existing skills shortages in the area of predicting, detecting and monitoring invasive species.</p> <p>Managing invasive species and changing species distributions in response to climate change.</p> <p>Biology and ecology of introduced species in their new environment.</p>			

## SECTION C: PRIORITY 1 KEY SKILLS AREAS

### IDENTIFIED BY THE ES AS NEEDED TO ADDRESS BETWEEN 10 AND 44 DIFFERENT CHALLENGES

(These areas were not highlighted by contributors as being in shortage for any specific priority or critical challenge; however, general feedback may have indicated that some are in shortage or they may be closely linked subject-wise to other areas where there are reported shortages with respect to specific challenges)

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34	44	<p><b>FUTURES THINKING/ PLANNING C001</b></p> <p>Links to many areas including notably:</p> <p>Sustainability science (A021)</p>	<p><b>Postgraduate skills in futures thinking/planning are identified particularly by one Review Group member as key to successfully addressing many of the challenges facing the ESS. For example, the ability to envisage scenarios for a more sustainable future helps the sector to identify appropriate adaptation measures for addressing climate change.</b></p> <p><b>Most occurrences recommended by a Review Group Member.</b></p>	<p>001 (C) 002 (C) 012 (P) 015 (C) 022 (C) 024 (C) 025 (C) 028 (P) 030 (P) 031 (M) 032 (P) 033 (C) 034 (C) 037 (P) 038 (P) 039 (P) 040 (P) 044 (P) 046 (C) 047 (C) 048 (P) 049 (C) 050 (P) 051 (P) 052 (P) 055 (P) 056 (P) 057 (P) 058 (C) 060 (P) 063 (P) 064 (O) 066 (P) 067 (P) 069 (P) 072 (C) 073 (C) 077 (C) 081 (C) 083 (C) 089 (P) 102 (C) 116 (P)</p>		

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				117 (P)		
35	37	<p><b>SOCIAL SCIENCE C002</b></p> <p>See also:</p> <p>Inter-/multi disciplinarity (A010) Natural science – social science interface/ translation (A015)</p>	<p><b>The ES identified a need for more postgraduate skills in the social sciences generally. This was in addition to inter-/multi disciplinary skills and skills at the natural and social sciences boundary although there are clear links to these Areas of Concern. A stronger social science dimension would facilitate more effective integration of the human element in understanding and tackling the challenges the sector faces.</b></p> <p><b>Social science is fundamental in terms of understanding behavioural change and how to understand this.</b></p> <p><b>More effective presentation and representation of modelling assisted by social scientists to allow more effective knowledge transfer.</b></p> <p><b>Understanding of social science research methods.</b></p> <p><b>Identify political and social systems and mechanisms to ensure mitigation developments translate into practice.</b></p> <p><b>Social aspects of consumption.</b></p> <p><b>Understanding the social construction of environmental data.</b></p> <p><b>Understanding of social acceptability of technology research.</b></p> <p><b>Agent based modelling of social interactions with ecological processes.</b></p> <p><b>The social science of public health.</b></p> <p><b>More effective presentation and representation of modelling assisted by social scientists to allow more effective knowledge transfer.</b></p> <p><b>Understand the social and political constraints of mitigation</b></p>	<p>001 (C) 002 (C) 003 (C) 007 (P) 008 (C) 009 (P) 010 (C) 012 (P) 018 (C) 023 (C) 025 (C) 028 (P) 030 (P) 049 (C) 050 (P) 051 (P) 058 (P) 059 (C) 065 (P) 067 (P) 068 (P) 072 (C) 073 (C) 076 (P) 077 (C) 079 (P) 084 (P) 089 (P) 090 (P) 092 (P) 100 (C) 101 (P) 102 (C) 103 (C) 105 (C) 116 (P) 124 (P)</p>	<p>It is expected that advanced training provision for interdisciplinary approaches to the social sciences will be located across the ESRC Doctoral Training Centres infrastructure. Social Science pathways are expected to be linked to a wide variety of disciplines and areas.</p>	<p>LR ? (Def invest strat) Defra’s plans on developing skills for “evidence” work identifies strong need for more social scientists in view of rising profile of behavioural change. LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies an anticipated increase in demand for social science expertise.</p>

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			<p>options.</p> <p>Understanding of the social construction of much environmental data.</p>			
36	29	<p><b>PSYCHOLOGY C003</b></p> <p>See also:</p> <p>Behavioural change (D022) Community engagement (C007) Social Sciences (C002)</p>	<p>Linked to the need for more postgraduate skills in the social sciences, psychology was identified as a key requirement. The ES values these skills for increasing the significance of its research through a greater understanding of areas such as behavioural change, consumer behaviour, and the uptake of new technology (in, for example, the field of energy provision.)</p> <p>Skills at the interface of psychology, history and ethno-biology are needed to improve our understanding of human responses to change.</p> <p>Psychology of behaviour and change.</p> <p>Psychology of consumer behaviour.</p> <p>A greater depth of study is required on the ways in which psychology can contribute to changing societal behaviour.</p> <p>Psychology of behaviour and change.</p>	<p>001 (C) 002 (C) 007 (P) 008 (C) 010 (C) 018 (C) 028 (P) 037 (P) 038 (P) 039 (P) 040 (P) 044 (P) 046 (C) 047 (C) 048 (P) 049 (C) 050 (P) 051 (P) 052 (P) 057 (P) 058 (P) 065 (P) 074 (C) 075 (C) 077 (C) 083 (C) 089 (P) 090 (P) 100 (C)</p>	<p>It is expected that advanced training provision for Psychology will be located across the ESRC Doctoral Training Centres infrastructure. The training pathways are expected to feature interdisciplinary links to disciplines / areas including urban living, computer science, and human geography</p>	
37	23	<p><b>GEOMORPHOLOGY &amp; EARTH SURFACE PROCESSES C010</b></p> <p>See also:</p> <p>Earth sciences (D013) Geosciences (D010) Hydrological sciences (D011) Landscape sciences (B007)</p>	<p>Geomorphology and Earth Surface processes were identified as necessary for a range of challenges. One Review Group member noted that geomorphology has an important role to play in understanding the impacts of climate change.</p> <p>Geomorphology has an important role to play in understanding the impacts of climate change.</p>	<p>002 (C) 004 (C) 005 (C) 006 (C) 012 (P) 014 (C) 015 (C) 016 (P) 021 (P) 037 (P) 038 (P) 039 (P) 040 (P) 061 (C) 062 (P) 063 (P) 066 (P)</p>		

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				068 (P) 069 (P) 092 (P) 094 (C) 095 (C) 120 (P)		
38	22	<p><b>BIOLOGY/ BIOLOGICAL SCIENCES C004</b></p> <p>See also:</p> <p>Inter-/multi-disciplinarity (A010)</p>	<p><b>In accordance with increasing interdisciplinarity within the environmental sciences, incorporating biological sciences into subject areas where they are not so commonly applied is seen as valuable by the ES. Expertise within the biological sciences and an area such as statistical analysis or computer science is seen as rare. In addition, synthetic biology is anticipated to be of increasing importance in the future.</b></p> <p><b>Most biologists have insufficient statistics and most statisticians have insufficient biology.</b></p> <p><b>Shortages of genuine and combined computation and biology skills</b></p> <p><b>Important to develop coupled models of the physical and biological environment.</b></p> <p><b>Knowledge of biology and ecology of specific species.</b></p> <p><b>Core skills in terms of taxonomy and biological monitoring.</b></p> <p><b>Numerate, quantitative biologists needed. Also physical scientists and engineers with biological skills.</b></p> <p><b>Bioinformatics &amp; Quantitative Biology</b></p> <p><b>Environmental Biology coupled with Environmental Economics.</b></p> <p><b>Synthetic Biology will be important in the future.</b></p> <p><b>Some problems recruiting people with molecular biology skills.</b></p>	002 (C) 004 (P) 009 (P) 017 (C) 018 (C) 024 (C) 047 (C) 053 (C) 054 (P) 055 (P) 056 (P) 058 (P) 059 (C) 066 (P) 068 (P) 077 (C) 090 (P) 096 (C) 101 (P) 112 (C) 113 (P) 115 (P)		
39	22	<b>ENGINEERING</b>	<b>Engineering was identified as a key skill area by the ES for a</b>	002 (C)	Environment Agency	LR.30 (2009) – The

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		<p><b>C006</b></p> <p>See also:</p> <p>Inter-/multi-disciplinarity (A010)</p>	<p><b>number of challenges. This was another example of where synergies can be gained by the involvement of another discipline. For example, environmental scientists with engineering backgrounds could play a significant role in civil engineering by understanding the relationships between infrastructure and climate change. Engineering skills are also needed to develop new technologies.</b></p> <p><b>Environmentalists with Engineering or scientific background could play a significant role in the future. E.g. Civil Engineers identifying the ability of infrastructure to work under future climate conditions.</b></p> <p><b>Really need inter-disciplinary training with the engineering and social science fields</b></p> <p><b>Engineers needed to develop new technologies.</b></p>	<p>007 (P) 008 (C) 021 (P) 023 (C) 024 (C) 026 (C) 028 (P) 029 (P) 034 (C) 035 (C) 038 (P) 039 (P) 040 (P) 048 (P) 049 (C) 073 (C) 079 (P) 080 (P) 095 (C) 102 (C) 104 (C)</p>	<p>run a Graduate Diploma Rivers and Coastal Engineering, a conversion programme for graduates from a non-engineering background with proven scientific, technical and numerical ability. 4 year course for eg. Geography or environmental science graduates seeking an engineering qualification.</p> <p>Environment Agency run a Graduate Scheme (currently closed) on Rivers and Coastal Engineering for new or recent MEng and BEng civil engineering graduates.</p> <p>Environment Agency schemes have been agreed with ICE and CIWEM.</p>	<p>Demand for STEM Skills report outlines concern with engineering skills needs at both graduate and postgraduate levels.</p> <p>LR.92 (2009) - ENDS Report identifies Process Engineering as in the top 20 environmental skills in demand by employers.</p> <p>LR.97 (2010) – The Government-approved shortage occupation list identifies shortages in many engineering disciplines, including those relevant to the Environmental Sciences.</p>
40	22	<p><b>REMOTE SENSING C005</b></p> <p>See also:</p> <p>Earth Observation (C021) Sensor Design (D021)</p>	<p><b>The sector identified remote sensing as key skill/knowledge need. For example, potential exists to better understand the spatial impacts of climate change by incorporating GIS and remote sensing into existing climate models. Skills in remote sensing can be applied to many disciplines within the environmental sciences.</b></p> <p><b>Listed as required for numerous challenges but no additional</b></p>	<p>002 (C) 004 (P) 016 (P) 017 (C) 037 (P) 038 (P) 039 (P) 040 (P) 055 (P)</p>		

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			relevant comments.	063 (P) 066 (P) 067 (P) 068 (P) 094 (C) 095 (C) 097 (P) 098 (P) 099 (P) 100 (C) 102 (C) 103 (C) 121 (C)		
41	19	<p><b>COMMUNITY ENGAGEMENT C007</b></p> <p>See also:</p> <p>Behavioural change (D022) Psychology (C003) Social science (C002)</p>	<p>Feedback suggested that sector engagement is a distinct theme with the broader area of the social sciences. For instance, engaging communities in consultations that relate to developments that may affect their lives can help bring about change. By involving stakeholders in the development process, cost-saving can be achieved by reducing subsequent challenges the project may face.</p> <p>Listed as required for numerous challenges but no additional relevant comments</p>	002 (C) 008 (C) 037 (P) 038 (P) 039 (P) 040 (P) 044 (P) 046 (C) 047 (C) 048 (P) 049 (C) 050 (P) 051 (P) 052 (P) 065 (P) 075 (C) 083 (C) 090 (P) 118 (O)	NERC and ESRC co-fund 20 PhD studentships per year through an interdisciplinary competition. The projects funded in the 2010 competition addressed LWEC objectives.	LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies an anticipated increase in demand for social science expertise, including public and stakeholder engagement.



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42	19	<p><b>ECOSYSTEM SERVICES C009</b></p> <p>Links to many areas including:</p> <p>Socio-economics (D029) Environmental valuation (C018) Natural science – social science interface/translation (A015) Social science (C002)</p>	<p>Ecosystem services are a relatively new skills area identified as important by the ES. Ecosystem services can be described as all the resources and processes that are supplied by natural ecosystems and from which mankind benefits. The term has come into common usage in the last decade and four broad categories have been identified: <i>provisioning</i>, such as the production of food and water; <i>regulating</i>, such as the control of climate and disease; <i>supporting</i>, such as nutrient cycles and crop pollination; and <i>cultural</i>, such as spiritual and recreational benefits. includes products like clean drinking water and processes such as the decomposition of wastes.</p> <p>While it overlaps with other skills areas in the Framework such as those related to energy it was mentioned specifically in relation to 19 challenges.</p> <p>Need to apply ecosystem services at the organisational / business level.</p>	<p>018 (C) 021 (P) 036 (P) 053 (C) 055 (P) 067 (P) 068 (P) 069 (P) 070 (P) 078 (P) 079 (P) 084 (P) 085 (P) 086 (C) 087 (P) 102 (C) 103 (C) 116 (P) 117 (P)</p>		<p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies expertise in defining/assessing ecosystem services and assessing societal value of the environment is a key area for future development of capabilities.</p>
43	19	<p><b>INNOVATION C008</b></p> <p>See also:</p> <p>Business awareness (A002) Emerging Technologies (C016)</p>	<p>Understanding innovation is also identified, as an important skills need for a range of challenges. Understanding the process of innovation and product development is important for bringing new products to market in the private sector. Fostering innovation leads to the faster development of novel techniques and technologies.</p> <p>Understanding the process of innovation and product development.</p>	<p>007 (P) 008 (C) 022 (C) 023 (C) 037 (P) 038 (P) 039 (P) 040 (P) 044 (P) 046 (C) 047 (C) 048 (P) 049 (C) 050 (P) 051 (P) 052 (P) 065 (P) 081 (C) 090 (P)</p>		<p>LR.48 (2008) – Higher Education at Work, a document produced by the Dept. for Innovation, Universities and Skills, aimed to raise the skills and capacity for innovation and enterprise of those already in the workforce.</p>
44	18	<p><b>POLITICAL SCIENCE/ POLITICS</b></p>	<p>Political science/politics is another area identified by the ES where synergies can be gained by the involvement of another discipline in</p>	<p>002 (C) 007 (P) 008 (C)</p>	<p>It is expected that advanced training</p>	

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		<p><b>C011</b></p> <p>See also:</p> <p>Geopolitics (D017)</p>	<p><b>addition to the environmental sciences. Incorporating political science approaches / perspectives enables greater understanding of the real-world application of research. As one respondee put it, “there is a huge a gap in being able to see through the politics to the science ....</b></p> <p><b>There is a huge gap in being able to see through the politics to the science and people need to see that a more radical approach is needed.</b></p>	<p>010 (C) 022 (C) 031 (P) 032 (P) 033 (C) 058 (P) 060 (P) 064 (O) 074 (C) 075 (C) 077 (C) 081 (C) 082 (C) 085 (P) 100 (C)</p>	<p>provision for Political Science / Politics will be located across the ESRC Doctoral Training Centres. The training pathways are expected to feature interdisciplinary links to areas / disciplines including environmental planning, public policy, and economic development research.</p>	
45	15	<p><b>ENVIRONMENTAL INFORMATICS C012</b></p> <p>See also:</p> <p>Data management (A004) Data mining (D023)</p>	<p><b>Environmental informatics can be described as the science of information applied to environmental science. As such, it provides an information processing and communication infrastructure to the interdisciplinary field of environmental sciences. Feedback indicated that such skills are needed to deal with vast, fragmentary datasets through the application of computational intelligence.</b></p> <p><b>We need bioinformatics systems to deal with vast but incomplete fragmentary datasets.</b></p> <p><b>People with Bioinformatics skills (particularly data interpretation, management and visualisation.</b></p> <p><b>More skills required in Environmental Informatics (analysis and interpretation of environmental data).</b></p>	<p>037 (P) 038 (P) 039 (P) 040 (P) 041 (P) 042 (C) 043 (O) 044 (P) 046 (C) 047 (C) 048 (P) 049 (C) 050 (P) 051 (P) 052 (P)</p>		
46	14	<p><b>DELIBERATIVE TECHNIQUES C014</b></p>	<p><b>Deliberative techniques/ democracy is identified as being needed to address fourteen of the challenges. This describes a process of decision-making using consultation and is another aspect of the social sciences. It was noted by one respondee that “there is still</b></p>	<p>037 (P) 038 (P) 039 (P) 040 (P) 044 (P) 046 (C) 047 (C)</p>		

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		See also  Social sciences (C002) Community engagement (C007)	<p>little research and experience in methods of expert elicitation, expert judgment in deliberative processes, and appropriate aggregation of expertise”.</p> <p>There is still little research and experience in methods of expert elicitation, expert judgment in deliberative processes, and appropriate aggregation of expertise.</p>	048 (P) 049 (C) 050 (P) 051 (P) 052 (P) 065 (P) 074 (C)		
47	14	<p><b>SYSTEMS APPROACH C013</b></p> <p>By its nature, the systems approach is linked to many of the other areas on the Framework including:</p> <p>Futures thinking (C001) Sustainability Science (A021)</p>	<p>A systems approach encompassing such concepts of systems thinking, systems analysis, systems engineering, amd systems dynamics is another theme which is consistently highlighted as a skills/knowledge need by the Sector. Understanding how the different components of the environment operate and influence one another within the whole is key to addressing many of the challenges. Breaking processes down into their constituent parts is advantageous and increasingly used as an accepted technique in parallel with futures thinking.</p> <p>Link up between earth systems and ocean systems.</p> <p>Systems thinking, systems analysis, systems engineering, systems dynamics, earth system science</p>	007 (P) 008 (C) 009 (P) 010 (C) 015 (C) 018 (C) 021 (P) 023 (C) 027 (P) 029 (P) 031 (P) 035 (C) 066 (P) 103 (C)		
48	12	<p><b>BIOGEOCHEMISTRY C015</b></p> <p>See also:</p> <p>Geochemistry (D008)</p>	<p>The ES identified biogeochemistry as a key skill need in the environmental sciences area. Understanding chemical, physical, geological and biological processes and reactions that govern the composition of the natural environment is seen as necessary to provide a strong basis for understanding Earth processes.</p> <p>A doctoral school on carbon management alone could be misplaced but one on biogeochemical cycles could prepare the skills based for the complexity of the challenges ahead.</p>	002 (C) 006 (C) 007 (P) 009 (P) 011 (P) 022 (C) 091 (P) 096 (C) 114 (P) 115 (P) 122 (P) 123 (C)		
49	12	<p><b>EMERGING TECHNOLOGIES C016</b></p>	<p>Linked with Innovation, the need for skills to address and support new and emerging technologies was mentioned in connection with a number of challenges. This brings new technologies to common use more rapidly.</p>	037 (P) 038 (P) 039 (P) 040 (P) 044 (P) 046 (C) 047 (C)		

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		See also: Business awareness (A002) Innovation (C008)	<b>Listed as required for numerous challenges but no additional relevant comments</b>	048 (P) 049 (C) 050 (P) 051 (P) 052 (P)		
50	12	<b>FIELD OBSERVATION C019</b>  See also:  Fieldwork (A008)	<b>Linked with Fieldwork (a008), strong field observation skills are important in addressing many challenges; for example, in the establishment of base lines from which to gauge future environmental changes.</b>  <b>Listed as required for numerous challenges but no additional relevant comments</b>	038 (P) 039 (P) 040 (P) 097 (P) 098 (P) 099 (P) 103 (C) 107 (C) 109 (P) 114 (P) 117 (P) 124 (P)		
51	11	<b>BIODIVERSITY C017</b>  See also:  Ecology/ ecological sciences (incl conservation) (B003) Environmental change (D024)	<b>Postgraduate knowledge of and skills in understanding and assessing biodiversity are identified as a key skill area for the environmental sciences. Such knowledge underpins understanding environmental change, encouraging conservation, and minimising adverse impacts of human activities.</b>  <b>Listed as required for numerous challenges but no additional relevant comments</b>	004 (P) 005 (C) 016 (P) 018 (C) 019 (C) 053 (C) 056 (P) 058 (P) 059 (C) 062 (P) 070 (P)		LR.27 (2008) – Select Committee on Science & Technology Fifth Report. Systematics & Taxonomy: Follow Up reports that Taxonomy skills underpin biodiversity conservation policy in the UK.  LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies expertise in assessing impacts of changes upon biodiversity and ecosystems (including soils) as a key area for capability

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						development.
52	11	<b>EARTH OBSERVATION SYSTEMS C021</b>  See also:  Remote sensing (C013)	<b>Knowledge of/ skills in Earth observation are identified as another key area for the ES. Skills in measuring and monitoring of Earth from space using satellites are vital to understanding current environmental phenomena and changes in the future.</b>  <b>Significant advances have been made in the last decade in earth observation capture and dissemination.</b>	037 (P) 038 (P) 039 (P) 040 (P) 094 (C) 097 (P) 098 (P) 099 (P) 107 (C) 108 (C) 109 (P)		
53	11	<b>ENVIRONMENTAL VALUATION C018</b>  See also:  Ecosystem services (C009) Economic approaches (B004)	<b>Knowledge of environmental valuation is specified for eleven of the challenges facing the ES. Note is made of the fact that a valuation system that measures the value of the environment to societies worldwide is important in encouraging conservation. Environmental valuation seeks to measure both the monetary value and the intrinsic advantages of the natural environment.</b>  <b>Alternatives to monetary valuation needed. Ecosystem services valuation.</b>	022 (C) 055 (P) 058 (P) 060 (P) 064 (O) 084 (P) 085 (P) 086 (C) 087 (P) 088 (P) 116 (P)		
54	10	<b>CHEMISTRY/ CHEMICAL SCIENCE C022</b>  See also:  inter-/multi-disciplinarity (A010)	<b>The need for postgraduate skills in chemistry and chemical sciences together with skills in the environmental sciences is identified for a range of challenges. This is important to enable a greater understanding of the chemical nature of environmental processes.</b> . <b>Application of analytical chemistry skills is lacking</b>  <b>Lack of physics, chemistry &amp; mathematics graduates.</b>  <b>Some difficulty recruiting people with analytical chemistry skills.</b>	002 (C) 016 (P) 022 (C) 029 (P) 039 (P) 040 (P) 102 (C) 109 (P) 115 (P) 122 (P)		LR.30 (2009) – The Demand for STEM Skills report outlines concern with chemistry skills needs at both graduate and postgraduate levels.  LR.92 (2009) - ENDS Report identifies Chemistry and Chemical Engineering as in the top 20 environmental skills in demand by employers.
55	10	<b>COST-BENEFIT ANALYSIS</b>	<b>Skills in cost-benefit analysis are identified by the ES as being needed for ten challenges. The ability to appraise the economic</b>	015 (C) 023 (C)		

A. F/W POS.	B. No Of Cs	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS (NB: any comments referring to shortages will have been received as part of general feedback)	E. SKILL/ KNOWLEDGE IS REQUIRED TO ADDRESS THESE CHALLENGES	F. EXAMPLES OF EXISTING TRAINING PROVISION IN AREA	G. ADDITIONAL EVIDENCE FROM PUBLISHED LITERATURE
		<p style="text-align: center;"><b>C020</b></p> <p>See also:</p> <p>Economic approaches (B004)</p>	<p><b>efficiency of different options, by weighing costs against the benefits, has many potential applications. These include novel technologies such as carbon capture and storage, and geoengineering.</b></p> <p><b>Carbon Capture &amp; Storage is getting a lot of media hype and there is a need to identify the costs, benefits and risk of what is being considered.</b></p> <p><b>Our experience is that a significant barrier in developing appropriate adaptation strategies (in organisations) is development of a business case. Traditional methods of cost benefit analysis don't always make sense in terms of financial viability – so developing economic and financial models (relevant to both the public and private sector) which will help to ensure that action is taken to reduce vulnerability and improve climate change resilience is essential.</b></p>	<p>031 (P) 055 (P) 058 (P) 060 (P) 063 (P) 064 (O) 072 (C) 081 (C)</p>		

## SECTION D: PRIORITY 2 KEY SKILLS AREAS

### IDENTIFIED BY THE ES AS NEEDED TO ADDRESS BETWEEN 5 AND 9 DIFFERENT CHALLENGES

(These areas were not highlighted by contributors as being in shortage for any specific priority or critical challenge; however, general feedback may have indicated that some are in shortage or they may be closely linked subject-wise to other areas where there are reported shortages with respect to specific challenges)

A. F/W POS.	B. No Of Cs	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS (NB: any comments referring to shortages will have been received as part of general feedback)	E. SKILL/ KNOWLEDGE IS REQUIRED TO ADDRESS THESE CHALLENGES	F. EXAMPLES OF EXISTING TRAINING PROVISION IN AREA	G. ADDITIONAL EVIDENCE FROM PUBLISHED LITERATURE
56	9	<b>POLICY AWARENESS D002</b>  See also:  Science/policy interface (A018) Legislation/ legislative process (D001)	<p>The ES identifies a need for postgraduates with a greater <i>Policy Awareness</i> as it relates to environmental issues. This is required so that work is undertaken with an understanding of the issues that are important to society (eg in terms of global responsibility).</p> <p>From the experience of Soc Sci interfacing with natural scientists, probably not enough skills relating to managing uncertainty in the development of policy solutions to CC.</p> <p>Lack of science communication skills and policy making.</p> <p>Research happens at a slower pace than policy changes, and the issues of global responsibility are not articulated in UK environmental science contexts.</p>	001 (C) 022 (C) 025 (C) 032 (P) 052 (P) 055 (P) 057 (P) 060 (P) 074 (C)	It is expected that advanced training provision for policy awareness will be located in several ESRC Doctoral Training Centres. The training pathways are expected to feature interdisciplinary links to environmental and spatial planning and economic development policy.	
57	8	<b>ENVIRONMENTAL IMPACT ASSESSMENT D004</b>  See also:  Environmental management (D007)	<p>Skills in assessing the likely <i>Environmental Impact</i> of projects / developments are identified for some challenges eg to ensure that decision makers consider the environmental perspective prior to passing judgement on development proposals.</p> <p>Listed as required for some challenges but no additional relevant comments</p>	074 (C) 080 (P) 082 (C) 083 (C) 088 (P) 090 (P) 110 (P) 111 (P)		LR.92 (2009) - ENDS Report identifies Environmental Impact Assessment & Planning as in the top 5 environmental skills in demand by employers.
58	8	<b>GEOCHEMISTRY D008</b>	<p>Feedback indicates that postgraduate skills in <i>Geochemistry</i> (study of the chemical composition of the Earth and other planets, chemical processes and</p>	008 (C) 023 (C) 024 (C) 046 (C) 047 (C)		

		<p>See also:</p> <p>Geosciences (D010) Earth sciences (D013)</p>	<p>reactions that govern the composition of rocks and soils and related areas) are required to meet a number of challenges.</p> <p>While comments did not suggest a shortage with respect to a specific critical or priority challenge, there was some supplementary feedback that skills in this area are in decline and lacking, particularly in the field of petroleum geochemistry. One responder noted that the basics of geology, geochemistry and geophysics at Masters level are a key attribute for skilled people in the physical sciences.</p> <p>Petroleum geochemists and coal geologists.</p> <p>It is the basics of geology, geochemistry and geophysics that are key at the Masters level.</p>	<p>117 (P) 118 (O) 122 (P)</p>		
59	8	<p><b>HAZARD AND RISK ASSESSMENT D005</b></p> <p>See also:</p> <p>Risk assessment and management (A017) Dealing with uncertainty (A005)</p>	<p>Linked to <i>Risk Assessment and Management (a017)</i>, <i>Hazard and Risk Assessment</i> captures the skills needed of postgraduates to address challenges concerned with the risk posed to humans by natural hazard events. Expertise is needed to assess the degree of risk posed by these hazards and take appropriate action to mitigate their impact.</p> <p>Listed as required for some challenges but no additional relevant comments</p>	<p>077 (C) 078 (P) 083 (C) 090 (P) 092 (P) 098 (P) 123 (C)</p>		
60	7	<p><b>ARCHAEOLOGY D003</b></p> <p>See also:</p> <p>Landscape sciences (B007) Environmental change (D024)</p>	<p>For some challenges, the Sector identifies a need for skills in <i>Archaeology</i>. The study of past human societies and their role in environmental change provides an analogue / context from which to consider the future eg on appropriate climate adaptation strategies.</p> <p>Listed as required for some challenges but no additional relevant comments</p>	<p>052 (P) 059 (C) 070 (P) 076 (P) 078 (P) 089 (P) 118 (O)</p>		
61	7	<p><b>ENVIRONMENTAL MANAGEMENT D007</b></p> <p>See also:</p>	<p><i>Environmental Management</i> is an important skill for some challenges as it contributes to both the preservation of natural environments and habitats (by managing human-environment interaction) and builds on the notion of the environment as a valuable resource to society.</p>	<p>023 (C) 024 (C) 041 (P) 056 (P) 077 (C) 081 (C) 090 (P)</p>		



		Environmental impact assessment (D004) Environmental valuation (C018)	<p>Listed as required for some challenges but no additional relevant comments except for the linked:</p> <p>Environmental economics is particularly relevant in evidencing the economic value of environmental management.</p>			
62	7	<p><b>GEOPHYSICS D009</b></p> <p>See also: Geosciences (D010) Earth sciences (D013)</p>	<p>Postgraduate expertise in <i>geophysics</i>, the study of the Earth by quantitative observations of its physical properties, is identified as necessary to address some challenges. For instance, high technology geophysics is needed to monitor sequestered carbon.</p> <p>While it was not identified as a shortage with respect to specific challenges, there was some report in supplementary feedback that this geophysics skills are lacking.</p> <p>High tech geophysics to monitor carbon once sequestered. This remains a post graduate requirement linked with industry.</p> <p>It is the basics of geology, geochemistry and geophysics that are key at the Masters level.</p> <p>Need for numerate graduates with skills in geophysics.</p> <p>Anecdotal shortages of people with geophysics skills.</p>	008 (C) 012 (P) 023 (C) 028 (P) 046 (C) 047 (C)		<p>LR.79 (2006) – The Geophysics Education Review identifies the fact that geophysics skills are in serious decline due to a lack of undergraduate entrants with the necessary physics and mathematical skills.</p> <p>LR.97 (2010) – The Government-approved shortage occupation list identifies a need for geophysicists.</p>
63	7	<p><b>GEOSCIENCES D010</b></p> <p>See also: Earth Sciences (D013)</p>	<p><i>Geosciences</i>, while the same broad skills area as <i>Earth Sciences</i> (see D013), is used as a term by some respondents. These included a contributor who noted that geosciences skills, with geology and monitoring techniques, are particularly required in the management of radioactive waste.</p> <p>The management of radioactive waste particularly requires deeply skilled postgraduate geoscientists knowledgeable in geology and monitoring techniques.</p> <p>The basics of geoscience must be a part of the skills base.</p>	023 (C) 024 (C) 028 (P) 034 (C) 046 (C) 047 (C) 080 (P)	<p>Environment Agency has developed a series of training modules to support the Groundwater and Contaminated Land teams. The Geoscience components are incorporated within their Environmental Management Postgraduate programme accredited UWE.</p>	<p>LR.97 (2010) – The Government-approved shortage occupation list identifies a need for geoscientists.</p>

64	7	<p><b>HEALTH IMPACT ASSESSMENT D018</b></p> <p>See also:</p> <p>Environmental epidemiology (A007) Hazard and risk assessment (D005) Public health and wellbeing (D026)</p>	<p>The need for postgraduates with skills in Health Impact Assessment is also highlighted as a requirement for some challenges. Being able to judge the potential health impacts of a policy, programme or project is important to deciding the most appropriate approach is take on issues. Knowledge and skills within this area required to, for example, address links between environmental pollution and human health.</p> <p>Links between environmental pollution and human health.</p> <p>Knowledge and skills in health impact assessment are required.</p> <p>Practical skills in pathology and virology difficult to find.</p>	<p>110 (P) 111 (P) 116 (P) 117 (P) 119 (P) 121 (C) 123 (C)</p>		<p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies a future capability need in assessing the societal and economic impacts of climate change, including health impacts.</p> <p>LR 93 – Health, safety and environmental management identified by ENDS as in top ten most sought after skill for ES.</p>
65	7	<p><b>HYDROLOGICAL SCIENCES D011</b></p> <p>See also:</p> <p>Earth sciences (D013) Geosciences (D010) Integrated freshwater sciences (A009)</p>	<p>Postgraduate skills in the hydrological sciences (studying the movement, distribution and quality of water) are important to a number of challenges, for example, in the efficient and sustainable use of water resources. This skills area is closely linked to Integrated Freshwater Sciences (A009)</p> <p>As with other skills in Section D of the Framework, although hydrological sciences was not identified as a shortage with respect to specific challenges, there was some report in supplementary feedback that this is also a shortage</p> <p><i>Hydrology, Hydrogeology, Hydrochemistry</i></p> <p>Hydrological Sciences need to be more engaged.</p> <p>Anecdotal shortages of people with hydrogeology skills.</p>	<p>018 (C) 022 (C) 047 (C) 048 (P) 062 (P) 063 (P) 092 (P)</p>		<p>LR.92 (2009) - ENDS Report identifies Hydrology and Hydrogeology as in the top 20 environmental skills in demand by employers.</p> <p>LR.97 (2010) – The Government-approved shortage occupation list identifies a need for hydro geologists.</p>
66	6	<p><b>EARTH SCIENCES D013</b></p> <p>See also:</p> <p>Geosciences (D010)</p>	<p>Earth sciences are identified by some contributors as an important skills area required of postgraduates to address 6 of the challenges. It is broadly the same category as Geosciences (see D010) – an alternative term used by some respondents.</p>	<p>002 (C) 053 (C) 057 (P) 070 (P) 108 (C) 121 (C)</p>		

			<p>Sciences related to Earth form much of the basis of our understanding of the natural world. Amongst other areas, skills in the geosciences are particularly required in the management of radioactive waste. See also Geosciences (d010).</p> <p>There needs to be a focus on applying the climate change science to the earth sciences to derive reliable prediction of events, be they progressive change or episodic impacts.</p>			
67	6	<p><b>ENVIRONMENTAL CHANGE D024</b></p> <p>See also:</p> <p>Environmental management (D007)</p>	<p>Environmental change was identifies as a specific skills area needed by postgraduates to address 6 of the challenges. Understanding past and current environmental change is regarded as important in predicting future change and man’s role in this.</p> <p>Listed as required for some challenges but no additional relevant comments.</p> <p>There is a lack of post-graduate and doctoral funding sources on understanding past environmental change and impacts.</p>	054 (P) 055 (P) 056 (P) 057 (P) 060 (P) 069 (P)		
68	6	<p><b>ENVIRONMENTAL ETHICS D014</b></p> <p>By its nature, environmental ethics is linked to many of the other areas on the Framework including:</p> <p>Sustainability science (A021)</p>	<p>Environmental Ethics was identified as a specific skills area needed by postgraduates to address 6 of the challenges. It requires exploration of the questions of moral right and wrong relating to the management, protection, or endangerment of the natural environment and, as such, requires the traditional boundaries of ethics to be extended to include the non-human world. Areas of application include mining and exploration geology.</p> <p>Listed as required for some challenges but no additional relevant comments</p>	056 (P) 058 (P) 059 (C) 064 (O) 065 (P) 077 (C)		
69	6	<p><b>FORESTRY D015</b></p>	<p>Postgraduate skills in Forestry including managing forests, plantations and related natural resources are identified as essential to preserving natural ecosystems and producing raw materials, such as hardwood, sustainably. Forestry is also identified as being increasingly important as a biological technique for carbon management.</p>	021 (P) 023 (C) 033 (C) 035 (C) 053 (C) 054 (P)		

			<b>Forestry as a biological technique for carbon management.</b>			
70	6	<b>GENOMICS D016</b>  See also:  Environmental informatics (C012)	<b>Genomics (study of genomes of organisms) is identified by the ES as an important skill in extending understanding of species and environments. A lack of people skilled in bioinformatics limits our capability to undertake research within this field.</b>  <b>Listed as required for some challenges but no additional relevant comments</b>  <b>Lack of individuals trained in Bioinformatics (important Genomics tool – see “c012 Environmental Informatics”)</b>	019 (C) 022 (C) 043 (O) 053 (C) 066 (P) 101 (P)		LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies genomics / proteomics for diagnostics within the field of chemicals and nanomaterials as an area where significant growth of existing capabilities will need to be considered.
	6	<b>GEOPOLITICS D017</b>  See also:  Political science/ politics (CO11)	<b>The ES identified the need for postgraduates with a knowledge of geopolitics to address 6 of the challenges. An awareness of the relationship between geography and politics as they influence and relate to a country's power and position in the world can help lead and promote environmentally sustainable behaviour on a global scale.</b>  <b>Listed as required for some challenges but no additional relevant comments.</b>	024 (C) 025 (C) 028 (P) 029 (P) 030 (P) 031 (P)		
71	6	<b>NUMERICAL/ MATHEMATICAL MODELLING D019</b>  See also:  Modelling (A014) Spatial analysis and GIS (B010)	<b>Some contributors make specific mention of the need for postgraduate skills in Numerical/Mathematical modelling – a specific technique within the more generic realm of ‘Modelling’ (A014) with which it could be combined. While not identified as a particular shortage for the six challenges for which it is required, general feedback indicates that there is lack of skills in the area particularly when combined with an understanding of the science being modelled. Inadequate numbers of numerical modellers are converting to the environmental sciences as this skills area becomes increasingly important.</b>  <b>Numerical modelling of pollutants transport by fluids.</b>  <b>Numerical modelling of the atmosphere.</b>	011 (P) 023 (C) 025 (C) 045 (P) 092 (P) 105 (C)		

			<p><b>Numerical modelling of channel change.</b></p> <p><b>Requirement for more modellers and numerate graduates.</b></p> <p><b>Modelling / Mathematical skills required.</b></p> <p><b>Lack of graduates with necessary computational and mathematical skills converting to environmental sciences</b></p>			
72	6	<p><b>PARAMETERISATION AND ASSIMILATION D025</b></p> <p>See also:</p> <p>Data Management (A004) Data Mining (D023) Environmental informatics (C012)</p>	<p><b>The ES identified Parameterisation and Assimilation of Data as a specific skills set within Data Management (A004) necessary for addressing six of the challenges. Such skills maximise the value of data to the environmental sciences</b></p> <p><b>Currently a significant under investment in data assimilation.</b></p>	<p>022 (C) 042 (C) 093 (O) 094 (C) 101 (P) 107 (C)</p>		
73	6	<p><b>PHYSICS D020</b></p> <p>See also:</p> <p>Inter-/multi-disciplinarity (A010)</p>	<p><b>Postgraduate skills in <i>Physics</i> are identified as needed to address several of the challenges faced by the Sector. While not identified as a shortage for a particular challenge, general feedback indicated that there are low numbers of graduates with first degrees in physics entering postgraduate training in the environmental sciences.</b></p> <p><b>Lack of physics, chemistry &amp; mathematics graduates.</b></p> <p><b>Low numbers of students from physics, chemistry and mathematics first degree courses entering postgraduate training.</b></p>	<p>002 (C) 016 (P) 097 (P) 098 (P) 099 (P)</p>		
74	6	<p><b>SENSOR DESIGN D021</b></p> <p>See also:</p> <p>Remote sensing (C005)</p>	<p><b><i>Sensor Design</i> is indicated as a specific skill required of postgraduates for six challenges. Designing devices that measure a physical quantity and convert it into a signal that can be read and recorded is extremely useful in the environmental sciences as a means of observation and monitoring. One Review Group member observes that linking sensors with analytical interpretation would enable “normal” conditions to be defined and therefore change to be assessed and</b></p>	<p>038 (P) 039 (P) 040 (P) 041 (P) 042 (C) 121 (C)</p>		<p>LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies the development of sensors for in-situ measurement as an area where significant growth will need to be considered.</p>

			<p><b>benchmarked.</b></p> <p>Listed as required for some challenges but no additional relevant comments.</p> <p>Links between sensors and analytical interpretation would enable “normal” conditions to be defined.</p>			
75	5	<p><b>BEHAVIOURAL CHANGE D022</b></p> <p>See also:</p> <p>Community Engagement (C007) Psychology (C003) Social science (C002)</p>	<p><b>Behavioural change is a specific area of expertise closely linked to <i>Psychology</i> (C003) and <i>Social Science</i> (C002). Understanding human behaviour is key to influencing the way people interact with the environment and embrace sustainability.</b></p> <p><b>Social science is fundamental here in terms of understanding behavioural change and how to influence this.</b></p> <p><b>Understanding the drivers of behavioural change is of generic importance (e.g. in the healthy ageing arena)</b></p>	025 (C) 065 (P) 075 (C) 076 (P) 077 (C)		
76	5	<p><b>DATA MINING D023</b></p> <p>See also:</p> <p>Data management (A004) Environmental informatics (C012) Paramaterisation and Assimilation (D025) Programming (D006)</p>	<p><b>The ES identifies <i>Data Mining</i> as a specific skills set within <i>Data Management</i> (A004) necessary for addressing five of the challenges. Extracting patterns from data through data mining is an important tool for transforming data into useful information to understand environmental processes. However, the programming skills required to undertake high level data mining are in short supply across the Sector.</b></p> <p>Listed as required for some challenges but no additional relevant comments.</p>	041 (P) 054 (P) 055 (P) 083 (C) 091 (P)		
77	5	<p><b>LEGISLATION/ LEGISLATIVE PROCESS D001</b></p> <p>See also:</p> <p>Science-policy interface/ translation (A018)</p>	<p><b>Knowledge of Legislation/Legislative process is a key skill for addressing five of the challenges and relevant to both developing appropriate legislation and implementing it once in place.</b></p> <p><b>Insufficient skills available to develop new tools for legislation such as the Water Framework Directive.</b></p>	021 (P) 030 (P) 032 (P) 062 (P) 085 (P)		
78	5	<p><b>PROGRAMMING D006</b></p>	<p><b>Postgraduate skills in <i>Programming</i>, a specific skills set within <i>Computer Science</i> (B002), is identified as</b></p>	037 (P) 039 (P)		

		<p>See also:</p> <p>Computer science/ high performance computing (B002)</p>	<p>necessary for five of the challenges. <b>High level and parallel programming skills are regarded as important for underpinning computational expertise in the environmental sciences.</b></p> <p>Listed as required for some challenges but no additional relevant comments.</p>	<p>042 (C) 043 (O) 045 (P)</p>		
79	5	<p><b>PUBLIC HEALTH AND WELLBEING D026</b></p> <p>See also:</p> <p>Environmental epidemiology (A007) Health impact assessment (D018)</p>	<p>Linked to <i>Health Impact Assessment (D018)</i>, postgraduate skills in promoting and protecting <i>Public Health and Wellbeing</i> are important for five of the challenges. Such skills help prevent environmental issues or phenomena from having a negative impact on public health. These skills can also help realise the positive impacts the environment can have on human wellbeing and visa versa.</p> <p>Listed as required for some challenges but no additional relevant comments.</p>	<p>111 (P) 113 (P) 116 (P) 117 (P) 118 (O)</p>		
80	5	<p><b>SAMPLING TECHNIQUES D027</b></p> <p>See also:</p> <p>Fieldwork (A008) Field Observation (C019)</p>	<p>The Sector identified expertise in sampling techniques as necessary for five of the challenges. Such skills underpin environmental observation and monitoring leading to a greater understanding of environmental issues.</p> <p>Listed as required for some challenges but no additional relevant comments.</p>	<p>023 (C) 024 (C) 124 (P) 040 (P) 063 (P)</p>		
81	5	<p><b>SCIENCE COMMUNICATION D012</b></p> <p>See also:</p> <p>Communication (A003) Media skills (A012)</p>	<p>Closely linked to general <i>Communication Skills (A003)</i>, some contributors referred specifically to <i>Science Communication</i> in the context of the ability of researchers/scientists to communicate their outputs to a layperson. The need for further training was identified and one respondent noted the need to pay more attention to the public understanding of science (now generally known as science and society)</p> <p>Lack of science communication skills and policy making.</p> <p>More attention should be paid to the public understanding of science.</p>	<p>003 (C) 010 (C) 075 (C) 076 (P) 083 (C)</p>	<p>NERC and ESRC co-fund 20 PhD studentships per year through an interdisciplinary competition. The projects funded in the 2010 competition addressed LWEC objectives</p>	

			<b>Training in scientific communication is essential.</b>			
82	5	<b>SCIENCE- ENGINEERING INTERFACE D028</b>  See also:  Inter-/multi-disciplinarity (A010)	This skills area is linked to the <i>inter- and multi-disciplinary</i> area of concern (A010). A group of respondents reported quite specifically that skills are required at the science-engineering interface to address 5 challenges. Bringing together expertise in the physical sciences and engineering can foster innovation and enhance understanding. Successfully linking engineering expertise with environmental problems is vital with reference to issues such as increased flooding and sea level rise, and promotes environmental engineering.  Listed as required for some challenges but no additional relevant comments.	009 (P) 029 (P) 034 (C) 035 (C) 046 (C) 047 (C)		
83	5	<b>SOCIOECONOMICS D029</b>  See also:  Economic approaches (B004) Social sciences (C002)	Postgraduate skills in <i>Socioeconomics</i> are identified as necessary for five challenges. Incorporating a socioeconomic perspective into, for example, climate change models can increase the value of the outputs eg as by identifying more appropriate adaptation strategies. Increased socioeconomic awareness across the environmental sciences will generate a broader understanding and increase the value of research and enterprise.  Not enough skills in developing climate change models which incorporate socioeconomic drivers. Refer to <a href="http://www.britishecologicalsociety.org/public-policy/policy-events/past-events/past-events-2008/">http://www.britishecologicalsociety.org/public-policy/policy-events/past-events/past-events-2008/</a> for further information	018 (C) 054 (P) 055 (P) 100 (C) 103 (C)		LR.29 (2009) – Defra’s Survey of External Capabilities to meet their Strategic Requirements identifies integration of socio-economic analysis into ecosystem management as a key area for capability development.