NERC POSTGRADUATE AND PROFESSIONAL SKILLS NEEDS REVIEW
THE SKILLS FRAMEWORK FOR THE ENVIRONMENT SECTOR, OCTOBER 2010, UPDATED MAY 2012

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 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. The feedback from the 2012 refresh is included in this document; it is highlighted in yellow. In order to get the most out of it, you are strongly encouraged to read the brief Guide to the Skills Framework. 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.

EXPLANATION OF FRAMEWORK COLUMNS		
Column	**Heading**	**Explanation**
A	F/W POS.	Position of knowledge/skill area on the Framework.
B	AREA OF CONCERN/KEY SKILL AREA	Description of knowledge/skill area, skill ref. number and cross-references to linked skills areas.
C	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.

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. AREA OF CONCERN	C. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
1	**MODELLING A014** See also: Numerical/ mathematical modelling (D019) Spatial analysis and GIS (B010)	**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.** **Issues also exist in the interpretation of models both in terms of understanding the underlying philosophy and in communicating their inherent uncertainty.** **Recently recruited for an environmental modelling post and though there were a large number of applications, those with mathematical and modelling skills blended with an environmental science (biogeochemistry) background were relatively few in number.** **Incoming students still have poor math and non-existent programming skills.** **difficult to recruit scientists with expertise in hydrodynamic modelling, sediment transport modelling and in the development of "process models" used to quantitatively interpret data and the results from complex numerical models** **Continuing shortage of forest modellers** **Increasing industrial salaries for staff with modelling skills suggests a skills shortage in this area… very difficult to appoint GIS specialists or hydorgeologists because I am unable to compete on salary** **roles seen as business critical as exceptions for recruitment against freeze for external recruitment** **Still too few people with low-level modelling skills required for model development as opposed to application.** **Modelling is a key element of scenario planning for ecosystems and their interactions with species (including humans) that rely on them.** **Continued problems recruiting modellers to projects** **Need ecologists with modelling skills.** **Carbon modellers are few and far between.** **Need to ensure modellers understand physical, chemical and biological aspects of the Earth System, rather than being specialist modellers "interfacing" with others.**

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		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. **General shortage of graduates with modelling skills and breadth of experience.** **Inadequate skills in the field of extreme event modelling.** **Improve models of climate change versus human responses.** **Philosophy of model interpretation.** **Use physical reasoning to interrogate models and extract useful information.** **Coupled climate – earth surface process models.** **Integration of models and spatial data.** **Rigour in model versioning.** **Mathematics required for modelling.** **Skills required at the interface of modelling and data.** **Robustness of models and predictions.** **Shortage of skills in climate modelling.** **Difficulty recruiting people skilled in modelling.** **Skills gap in the field of modelling.** **Skills gap for every type of biologically based scientist, especially ecologists skilled in nitrogen modelling.** **Need for climate modelling at multiple scales.**
2	**INTER-/ MULTI-DISCIPLINARITY A010** See also: Natural Science – social science interface/ translation (A015) Science/ engineering interface	**A widely recurring theme in the responses from the Sector is the lack of inter- and multi-disciplinary skills. These were identified particularly between: *environmental sciences and engineering, environmental sciences and business, environmental sciences and social sciences; and environmental sciences and mathematics, statistics, and computing.*** **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.** **Although there is some collaboration, it tends to be between similar institutions**

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	(D028) Science – policy interface/ translation (A018)	as subjects fragment into smaller subdisciplines the problem of transfertilisation of ideas may become more acute. Despite years of interdisciplinary rhetoric, it is still difficult to find people who are able to move easily between social and environmental sciences. We usually have to train our scientists "in house" to be effective in inter/multi-disciplinary research. I see few people working between environmental sciences and other areas. Solutions to future problems needs a multi-disciplinary approach. Inter-disciplinary working spanning not only physical sciences but also social sciences, economics and communications is needed. There is a lack of appropriately inter-disciplinary researchers with an appreciation of geographical concepts and themes. Interdisciplinary communication remains a fundamental impediment to significant progress. Interdisciplinary skills are undoubtedly in short supply. Interdisciplinarity not supported or encouraged enough. Requirement for interdisciplinary skills with social scientists and engineers. Need interdisciplinary scientists who can engage with socio-economists. Interdisciplinary modelling approaches ie. Integrated assessment. Need to develop linkages between multidisciplinarity and engineering. Lack of skills in interfacing the physical / environmental and social sciences. Need to address cross-cutting issues and support inter-disciplinary science. Understanding of multi-disciplinary sciences. Experience of working in multi-disciplinary teams and dealing with multi-disciplinary outputs. Need to integrate multi-disciplinary aspects into engineering qualifications.

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3	**DATA MANAGEMENT A004** See also: Data Mining (D023) Environmental informatics (C012) Paramaterisation and Assimilation (D025)	**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.** **Skills required in relation to managing and presenting data sets for public access increasingly important to support evidence base and inform decision-makers** **new opportunities for the analyses of large spatial and temporal datasets in different contexts, and therefore we need scientists comfortable with the latest computing techniques for storing, analyzing and modelling these data, linked to data management systems.** **This is becoming more of an issue in the age of big data, open data, etc., and bioinformatics training is much much needed. As genomics data becomes more readily available, and applied more regularly to environmental questions, the need to teach basic computer scripting skills will become still more pronounced.** **As large data sets grow, there is a potential skills gap emerging in this area** **for large molecular datasets/bioinformatics there is still a gap** **The ability to generate one's own data has declined** **Stored data volumes increased faster than curricula do.** **too many people are used to using application software based on closed data formats and there is certainly a need for better grasp of low-level data storage as well as the challenges posed by large datasets.** **Data collection and management are vital skills for all researchers.** **Ability to manage and interpret large amounts of data is lacking.** **Poor culture of data management and centralisation.** **This area in general is being addressed …. to understand the skills shortages / development needs within the bioscience Sector, especially with respect to large datasets.** **Need for strong data integrity protocol.** **Need to avoid unnecessary data collection or overly high collection costs. Centralisation.** **Large datasets need integrating into mathematical models.** **New computational algorithms need to be developed to handle high volume data.**

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		Large scale bioinformatics data manipulations necessary. **Data mining.** **Skills shortage in data collection, assurance and archiving.** **Need for graduates who have experience and competence with raw scientific data.** **Lack of skills in using / integrating scientific data / results in regulator, policy or management frameworks.** **There is currently significant under-investment in data assimilation.** **Training in database management and time series analysis required.**
4	**STATISTICAL ANALYSIS A020** See also: Mathematics/ Applied Mathematics (A011)	**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.** **important that people have an appreciation of modern statistics** **skills are needed to support data mining specifically but also more broadly for a general understanding of the robustness of data interpretation.** **definite increase in the use of very complex statistical models is evidenced in publications; but we are not convinced that this has been associated with a real increase in statistical understanding** **We need more trained bioinformaticians too particular with the recent advances in next gen sequencing.** **Statisticians are often attracted to the field of medical research (e.g. clinical trials) where the salaries exceed what is available in the field of environmental sciences** **We recently managed to fill a vacant post with a very good new statistician, but from a very limited pool of applicants.** **in ecology in particular, the large amount of data that can be collected and handled with current computer power has brought rapid development in ecologically applied statistics and especially spatial statistics; a greater knowledge of maths, statistics, data handling is a necessity to be able to handle the arising complexities.** **Shortage in environmental statistics.** **Serious skills shortage in environmental statistics.** **Most biologists have insufficient statistics and most statisticians have insufficient biology** **Statistical models of rainfall fields.**

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		Advanced Geophysical Statistics. **Combination of advanced statistical skills and meteorology.** **Statistical analysis of agricultural/soils/climate data to aid food security under environmental change.** **Statistical methods for handling large data sets.** **Statistics of extreme events.** **Statistical Inference.** **Difficulties experienced in recruiting people with skills in statistics.** **Skills gap evident in field of statistics.** **Mathematical skills required, in particular, statistics.**
5	**COMMUNICATION A003** See also: Science communication (A003) Media Skills (A012)	**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.** **Continued need to communicate, both written and verbal, with a wide spectrum of stakeholders remains critical.** **Continued need to communicate, both written and verbal, with a wide spectrum of stakeholders remains critical.** **this is still a major gap - helping to communicate with and ensure that the public are informed and can make informed choices** **Some scientists still have difficulty in communicating their knowledge in terms which lay people can engage with** **increasing emphasis on scientific communication, which highlighted in the increasing interest displayed by the popular media of environmental issues.** **being able to get the message across is essential and is becoming a massive element of the work to encourage behaviour change** **There has never been a greater need than there is now for improved communication of science to the general public** **Postgraduates need to learn transferable skills early and become good communicators**

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		What is needed are top scientists who are excellent communicators. **Communication of science to layman also a key skill requirement.** **Communicating uncertainty is critical.** **Interdisciplinary communication remains a fundamental impediment to significant progress.** **Many students at all levels do not have adequate writing skills and struggle with communicating numerical data to non-experts.** **Communication training needed so that the forecasting can be communicated reliably to policy makers etc** **It will be particularly important for natural scientists to develop communication skills to enhance their ability to work at the interface of multiple disciplines.** **Understand and communicate the complexity of climate change.** **Science communication (below).** **Ability of scientists to communicate in effective and appropriate ways to a wide range of audiences.** **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).** **An MSc placement in a relevant Government Dept to strengthen communication and translation of outputs to policy makers would be beneficial**
6	**FIELDWORK A008** See also: Field observation (C019)	**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.** **Field investigation and monitoring are needed to understand soil systems on a site or within a catchment** **graduates are no longer learning basic ecological skills - field identification etc** **to make post-doc appointments with the right field- and laboratory skills, then the short-list tends to include many applicants trained outside the UK** **reduced fieldwork tuition on various taught degrees** **science becomes dominated by experimental and theoretical as opposed to field-based approaches** **Students are graduating with less lab and field skills.** **skills shortage in ecological survey, sampling, data assessment, evaluation and monitoring skills for fish and invertebrates** **Many postgraduates recruited appear to lack practical transferable field based skills**

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		Many new employees appear to be less inclined and used to working in the field particularly where conditions are extreme **It is harder to financially support field work due to rising costs of transportation, lodging, and health & safety obligations.** **Soil mapping skills declining rapidly (main group of skilled practitioners (ex Soil Survey of England and Wales) have now retired) both general purpose soil mapping and site/impact specific mapping skills** **We usually have to provide "in house training" in these areas** **Due to government cutbacks our field skills team is reducing in size.** **I do not believe we are able to do as much fieldwork as we need to develop the requisite postgraduate field skills** **Fieldwork skills are being lost in young scientists, and this is a continuation of a long-standing trend.** **I have seen no significant movement in enhancing training or providing further funds for new students to do fieldwork.** **Current shortage of people with fieldwork and taxonomic skills.** **Shortage of taxonomic and identification skills plus field survey and analytical techniques.** **Field identification skills essential to complement academic learning - key skills gap.** **Field techniques and technology use.** **Field to lab skills and capacity to create a model of the response required.** **Ability to relate field data with which individuals are familiar to ecological theory with which they are also familiar.**
7	**SCIENCE-POLICY INTERFACE /TRANSLATION A018** See also: Policy Awareness (D002) Legislation/ legislative process (D001)	**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.** **Carries an increasing focus and expectation. Will become increasing important** **Increasing need to show evidence for science into policy, but very little skills base in how to do it.** **Need to close the gap between scientific evidence and policy / legislation.** **Ability to communicate complex modelling techniques and results to policy makers.** **Lack of science communication skills and policy making.** **Research happens at a slower pace than policy changes, and the issues of global responsibility are not articulated in UK environmental science**

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		contexts. ESF-RESCUE, EU has identified this issue (e.g., May 2009 DG Research conference, Sust Dev – a challenge for EU research). **Need to ensure that science informs policy and that scientists and practitioners are able to input to optioneering.** **Translate science into feasible land use / development options.** **Translating science into policy.** **Ability to translate science into feasible, pragmatic, measurable and effective legislation.** **Capability to translate science into policy.** **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.** **Communicating science into policy.** **Awareness of the science-policy interface.**
8	**RISK ASSESSMENT AND MANAGEMENT A017** See also: Dealing with uncertainty (A005) Hazard and risk assessment (D005)	**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.** **Critical to communicating strength of evidence to decision-makers and striking the right balance between conservation and sustainable economic growth** **we have to provide "in house training" on how to clearly communicate environmental risk** **The insurance industry is now looking for science based advice in themes such as flooding.** **We need policy makers who have sufficient knowledge of scientific principles and are risk management literate.** **Evaluation of risk is crucial to geoengineering.** **Linked to decision-making through societies' willingness to pay to avoid risk.** **Risk assessment is probably under-represented in most training strategies.** **Quantitative risk analysis of natural resources.** **Natural hazard and disaster risk reduction** **Robust risk reduction.** **Risk assessment of chemicals in the environment.** **Shortage of skills in complexity (new area of risk and uncertainty).** **Difficulty recruiting in the field of Quantitative Risk Assessment.**

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		Skills gap in the field of risk evaluation.
9	TAXONOMY AND SYSTEMATICS A022	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. The difficulties of attracting and then retaining students in this key area is one of growing concern The topic is considered dry unless taught in context. Particularly a problem on the plant/algal side rather than animals. Sometimes they have the theory but no practice a dearth of good systematics/taxonomic training especially given the number of specialised taxonomists with such expertise is decreasing. continues to be in decline, particualrly in areas such as phycology, and that it will soon become impossible to reverse this trend as the very small number of excisting experts in these fields retire Particularly in fish, inverts, lower plants - identification and census Taxonomy skills in marine science are few and far between....it is not a skill that is taught at the postgraduate level We are rapidly coming to a time when taxonomists are a dying breed, but their skills are needed now, more than ever before. Lack of taxonomy skills results in an inability to understand the Biological Pump Identification skills and taxonomy are needed. Lack of taxonomic and mathematical skills. Current shortage of people with fieldwork and taxonomic skills. Few applicants with sufficient taxonomic skills applying for jobs in conservation. Reference made to report from the House of Lords Select Committee on Science & Technology 2008 'Systematics and Taxonomy Follow up'. Unable to recruit people with requisite taxonomy and biomathematics skills. 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: http://www.publications.parliament.uk/pa/ld/ldsctech.htm (use their search facility)

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		Core skills in terms of taxonomy and biological monitoring. **Linking taxonomy to ecological function.** **Linking pure taxonomy with understanding physiology.** **Skills gap for every type of biologically based scientist, especially ecologists skilled in taxonomy.** **Lack of Taxonomic Skills.** **Core practical taxonomic skills.** **FBA runs short courses in taxonomic and identification skills.**
10	**DEALING WITH UNCERTAINTY A005** See also: Risk assessment and management (A017)	**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.** **A general increase in awareness of this issue as a result of climate science/ banking risk events.** **Politicisation of scientific uncertainty is pernicious thorough the actions of special interest groups.** **A relatively new area of science with relatively few practitioners.** **An understanding of uncertainty is fundamental to translate science into policy** **This is a fundamental aspect of science that needs to be taught at PG level.** **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 CC.** **Communicating uncertainty is critical.** **Need training in uncertainty. The skills are in short supply.** **Disseminate to policy-makers, local government and businesses the uncertainties associated with climate change fundamentals.** **Ability to quantify uncertainty in models and observations.** **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.** **Shortage of skills in complexity (a new area of risk and uncertainty).**

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11	**MATHEMATICS/ APPLIED MATHEMATICS A011** See also: Computer science/high performance computing (B002) Statistical analysis (A020)	**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.** **experience with recent recruitment for hydro-meterological and environmental modelling posts, shows that there are few candidates with the right skills sets for this type of work.** **Maths is a particular challenge for environmental scientists yet is so important.** **still a major weakness due to the poor UK schooling system re maths** **remains challenging to recruit mathematicians of nay flavour into environmental sciences. Mathematicians have many career paths open to them, many of which lead to high financial rewards** **this skills gap is increasing** **not enough Earth Science graduates and post graduates with good mathematical ability, nor enough graduates from other areas who want to enter the Earth Sciences.** **Need not keeping pace with demand** **Numeracy is on the decline amongst students** **Lack of graduates with necessary computational and mathematical skills converting to environmental sciences.** **Mathematical skills are in short supply in all disciplines across the biosciences** **Lack of taxonomic and mathematical skills.** **Lack of physics, chemistry & mathematics graduates results in more qualitative work.** **Development of predictive mathematical models.** **Biomathematics** **Shortages of skills in Mathematics & Biomathematics.** **Need for mathematical and statistical training particularly in the area of reducing uncertainty.** **Lack of numeracy skills.** **Mathematical and computational skills needed.**
12	**SOIL SCIENCE A019**	**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**

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	See also: Agriculture (A001)	**Soil mapping skills declining rapidly (main group of skilled practitioners (ex Soil Survey of England and Wales) have now retired) both general purpose soil mapping and site/impact specific mapping skills** **decline in soil science provision in the UK has continued, yet the capability to understand the soil as system is critical to determine energy and food security not only in the UK but globally** **Still a large gap, and it is very difficult to find people with the requisite understanding of both the physical and the biological properties of soil.** **Field investigation and monitoring are needed to understand soil systems on a site or within a catchment** **Possibly linked to the impact of climate change - especially in areas of drought and/or pressures such as sea level ingress or the development of climate resistant crops.** **Particular need for soil scientists to ensure sustainable food production.** **There is a need for more soil carbon scientists and modellers.** **Limited availability of soil scientists.** **Need for soil scientists and agronomist.** **Decline in soil science as a discipline in the UK.** **Lack of soil scientists and environmental modellers.** **See Defra (2003) UK soil research audit (CTE0211) - SP0524** **Modelling of soil function in response to climate.** **Improve methodologies for soil carbon monitoring.** **Effects of agriculture on soil systems.** **Understanding of soil systems and how they function across spatial and temporal scales.** **Skills gap for every type of biologically based scientist, especially ecologists skilled in soil science.** **Significant skills gap in soil science.** **Detailed fundamental knowledge in individual soil sub-disciplines.** **Environmental scientists need more exposure to the behavioural and social sciences.**
13	**ENVIRONMENTAL EPIDEMIOLOGY A007** See also:	**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.** **Many of the current staff inpost are nearing the end of their careers. Recruitment and financial constraints are making succession planning very**

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	Health impact assessment (D018) Public Health and Wellbeing (D026)	**difficult, and universities are not producing enough graduates with these skills.** **As human population continues to grow exponentially, so the odds of epidemic disease continue to increase.** **Very substantial skill shortage in environmental epidemiology in the UK.** **Understanding population fluxes (eg. epidemiology of plant and animal diseases).** **Understanding the effects of climate change on disease.** **Predicting emergent diseases.** **Difficulties recruiting in the field of epidemiology.**
14	**BUSINESS AWARENESS A002** See also: Emerging Technologies (C016) Innovation (C008)	**The ES reports that postgraduates need a much better awareness of business issues. Improved business skills would 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).** **A competitive market exists for people with these skills....few are attracted into environmental sciences** **Companies are increasingly looking for advisors in this remit.** **Especially those relating to entrepreneurial skills and attributes generally poorly developed in the curriculum offer** **People interested in science-related business always find a way of marketing their skills.** **Working with businesses is needed.** **Needs a basic understanding of Business as CPD to enable the science to business communication to be productive.** **Leadership and management in business wrt to low carbon activities and resource efficiency.** **Business skills required to move technologies from research to a development stage and hence to market.** **Decisions made in core business need to reflect an organisation's climate change ambitions in both meeting emissions reduction targets and adaptations.**
15	**SUSTAINABILITY SCIENCE A021** Links to many areas including: Environmental change (D024)	**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.** **Increasing emphasis on sustainability in all fields**

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	Futures thinking/ planning (C001) Inter- multi disciplinarity (A010) Natural science- social science interface … (A015) Social science (C002)	**As responsible global citizens, we need to teach sustainability at every level.** **Limited Technical Skills in Sustainable Development and Environmental Sustainability especially in the financial services sector, in retail, and management more generally.** **Sustainability should be at the heart of policy.** **Lack of cohesion on ways to promote sustainable behaviour.** **Clear need to develop the skills base to grow the nascent discipline of 'sustainability science'.** **Additional training is needed in sustainability appraisal.** **Developing indicators for sustainable consumption.** **Develop and evaluate innovative social responses to global sustainability.**
16	**AGRICULTURE A001** See also: Soil science (A019)	**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.** **With the decline in soil science in the UK, then it is generally more difficult to make the integration between agriculture and soil physical, chemical and biological concepts.** **Environmental management based on a good understanding of the environmental sciences, current environmental legislation and agriculture is much needed in order to enact and improve environmental legislation in a rationale manner.** **Lantra have a New AgriSkills Strategy available at: http://www.lantra.co.uk/agriskills/launch/** **Agricultural skills highlighted by BBSRC as a lacking niche.** **Need for agronomists.** **Relevant to food security and therefore of high importance.** **Opportunities to combine agricultural knowledge with pure biology models and environmental analysis.** **Agriculture and land management play a role in adapting to and reducing climate change.** **Links between agriculture and soil science – effect of agricultural processes on soil properties.** **Innovative application of agricultural practice to ensure food security.** **New AgriSkills Strategy at http://www.lantra.co.uk/agriskills/launch/ relevant**
17	**MICROBIOLOGY/ MICROBIAL**	**A requirement for stronger postgraduate skills in microbiology and microbial physiology is identified. Such skills are needed by the ES to**

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	PHYSIOLOGY A013 See also: Biodiversity (C017) Ecology/ ecologocial sciences (B003)	**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.** **There still appears to be relatively few people conversant in the techniques for quantitative microbial community analysis.** **Bioinformaticians and people sufficiently skilled to analyse large data sets of microbial/environmental data are very limited in number.** **fewer environmental microbiologists around with good microbial physiological skills** **Microbial physiology and basic microbiology are important, and the BBSRC Plant & Microbial Sciences portfolio evaluation identified this as an area of UK weakness (with students preferring to do medical microbiology)** **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.** **Modelling to link microbial community dynamics with emergent properties of systems / processes.** **Analysis of effects of ecosystem change on plant, animal and microbial diversity.** **Less acute problems in recruiting people with microbiology skills.**
18	**MEDIA SKILLS A012** See also: Communication (A003) Science Communication (D012)	**A specific aspect of *communication* 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.** **Remains essential for communicating and influencing public and decision-makers - use of social media increasingly important** **Need has increased, given the need to inform and enthuse the public** **Getting the message across is critical.** **Access to written and oral communication skills training (including media training) is required.** **Media corruption of the climate change message is ubiquitous so skills needed in this area** **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**
19	**NATURAL SCIENCE – SOCIAL SCIENCE INTERFACE / TRANSLATION A015**	**This area is linked to the *inter- and multi-disciplinary* 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.**

A. F/W POS.	B. AREA OF CONCERN	C. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
	See also: Inter-/ multi-disciplinarity (A010) Social Science (C002)	**Increasingly importance, e.g. in relation to developing and applying ecosystem approach** **Particularly important where urban sustainability and issues such as equality and diversity are involved. The environment supports choice and this needs to be understood in terms of everything from access to funds to belief system Particularly important where urban sustainability and issues such as equality and diversity are involved. The environment supports choice and this needs to be understood in terms of everything from access to funds to belief systems.** **From the experience of a social scientist, there is a need to interface with natural scientists.** **Need for interdisciplinary approach relating to social science and natural sciences.** **Social and natural scientists need to work together.** **Shortage of natural scientists with an understanding of the social sciences** **Lack of ability of scientists to identify and empathise with the natural environment in a connected, holistic way.** **BBSRC would generally encourage the integration of skills in the social and natural sciences.**
20	**TOWN AND COUNTRY PLANNING A023**	**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.** **Increased complexity in this policy area and re-design of Marine Bill and PPG/S notices has meant a period of instability of knowledge in this area which will take a few years to settle down.** **Skills shortages in planning control.** **There is a need for EIA and SEA training, particularly for planners.** **Increasing urbanisation and pressure on the urban environment – more megacities.** **Change in demographics.** **Economics analysis used to inform decision making in all aspects of environmental management.**
21	**ENERGY PROVISION A006** See also: Renewable energy technology (A016)	**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. 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.** **The ES also needs postgraduates better able to tackle challenges connected with different energy sources and the economics of energy supply and demand.** **Still need field or lab based expertise, e.g. range of issues relating to marine renewables affected marine species Rapidly expanding field within the context of fast paced social and political change.**

A. F/W POS.	B. AREA OF CONCERN	C. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
		Science and technology probably hold the key to the development of low-impact energy sources. **Technological pool in energy arena rarely comes from the environmental sciences so the environment remains an add on rather than a central consideration.** **Energy sustainability is one of the key challenges to man and the planet.** **There is a need for wider perspective ref energy security / energy production, and transfer of relevant technologies to industry.** **Understanding conventional energy resource limitations – peak oil.** **Understanding the impact of energy by-products (rising CO2, tropospheric ozone etc.) on natural systems.** **Understanding the impact of the growth of market economies re: energy supply, distribution and use.** **Sustainable extraction of fossil energy resources from unconventional sources. Energy Security a priority.** **Impact of waste creation from energy production.** **Growth of market economies re energy supply, distribution and use.** **Energy Security a priority.** **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.** **BBSRC is addressing energy research by supporting targeted studentships in bioenergy.**
22	**INTEGRATED FRESHWATER SCIENCES A009** See also: Hydrological sciences (DO11)	**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.** **Fish identification, survey, sampling and monitoring skills** **experience of recent recruitment for someone who could bridge between the physical, chemical and biological aspects of freshwater sciences, it was not possible to find such a person, but is much needed given the terms of the Water Framework Directive which aims to improve the chemical and ecological status of European freshwaters.** **The maintenance of fresh water resources has never been more important.** **Freshwater sciences (integrating physical, chemical, biological processes) are not well supported.** **Freshwater science skills appear to be declining.** **Recognising the importance of evaluating and interpreting indicators of the state of freshwater ecosystems.**
23	**RENEWABLE ENERGY**	**Linked to *energy provision*, renewable energy technology emerged as a distinct theme in the feedback from the ES. Better training in technical**

A. F/W POS.	B. AREA OF CONCERN	C. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
	TECHNOLOGY A016 See also: Energy provision (A016)	**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.** **Skills in renewable energy have recently been assessed by a DECC project which was due to report in Summer 2010.** **Science and technology probably hold the key to the development of renewable energy sources.** **many companies in the area of renewable energy are operating on a tight budget and put environmental impact studies on the back burner** **As with energy specialists, this is a growing field which industry is recognising requires particular skills** **Ecology is important to the siting of renewable energy technology.** **Skills in renewable energy currently being assessed by a DECC project due to report in Summer 2010.** **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, and thus need work on their impacts** **Technological pool in energy arena rarely comes from the environmental sciences so the environment remains an add on rather than a central consideration.** **Exploitation of renewable resources.** **Developing renewable energy sustainability.**

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)

A. F/W POS.	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
24	**ECOLOGY/ ECOLOGICAL SCIENCES (INCL. CONSERVATION) B003** See also: Introduced/invasive species (B006) Biodiversity (C017)	**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.** **I think that the gap here is broader than just nitrogen modelling since ecosystems are driven by carbon, phosphorus and the cycling of other elements.** **Ecosystem modelling is becoming increasingly important in understanding the structure and function of both modern and ancient ecosystems.** **People tend to enter this field with a biology, rather than ecology background, and ecology is in decline at the undergraduate level** **See this as a further fundamental skill.** **Training required for interdisciplinary researchers with an appreciation of ecological concepts.** **Need ecologists with modelling skills.** **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.** **Ecology is important for the siting of renewable energy technologies.** **Ecological consultants bemoan the lack of basic identification skills in graduates.** **Few applicants with sufficient knowledge of conservation are applying for jobs.** **Few applicants with necessary skills in taxonomy are applying for jobs in conservation** **Use of knowledge of biodiversity and ecology to inform response to drivers of change.** **Skills gap for every type of biologically based scientist, especially ecologists skilled in taxonomy, soils science and nitrogen modelling.**
25	**SPATIAL ANALYSIS AND GIS B010** See also: Modelling (A014)	**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.** **Importance remains for capture, management and presentation of spatial data, e.g. surveillance strategy** **Many postgraduates have an ability to use GIS at a basic level but few seem to be able to undertake more advanced processing of datasets.**

A. F/W POS.	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
	Numerical/ mathematical modelling (D019)	**I am aware that it is still an area in much demand amongst biology postgrads** **The gap here is created by the vastly increased demand for such specialists - too often those trained in this area can go straight from their undergraduate degree into well paid jobs** **GIS is a very useful tool in the geographic analysis of spatial data. This needs to be taught at PG level.** **We need ecological modellers with spatial analysis skills.** **GIS skills are lacking.** **Spatial analysis and modelling skills are in medium supply, but becoming less available as demand for this grows.** **Improve spatial analysis and understanding of climate change risks and impacts.** **Geographical Information Science including spatial analysis & remote sensing** **GIS & Remote Sensing skills linked to modelling.**
26	**ECONOMIC APPROACHES B004** See also: Environmental valuation (C018) Socioeconomics (DO29)	**Feedback from the ES points to a widespread need for postgraduates with a better understanding of economics and economic approaches. The following branches of economics are highlighted.** ***Economics. Agricultural Econ. Behavioural Econ. Institutional Econ. Resource Econ*** **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.** **Increasing focus on ecosystem approach requires people with a broad understanding of complex systems, including societal and economic impacts.** **An area in which we found it difficult to recruit to PhD positions due to a lack of suitable qualified persons.** **Lots of rhetoric, little evidence of effective collaborations.** **Still a major gap especially around an understanding of the green economy** **Interdisciplinary working required spanning not only the physical sciences but also the social sciences, economics and communications.** **Particular expertise in econ. and comp. science required.** **Need people who can bridge disciplines by combining economics with other fields of expertise.**

A. F/W POS.	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
		It is essential to identify the potential economic impact of future environmental change forecasts. **Modelling the economic impact of resource availability in terms of affordability will be an essential skill set.** **Key will be the awakening of scientists to the realities of the worlds markets and economics.** **Environmental Economics is particularly relevant in evidencing the economic value of sound environmental management.** **Integrated modelling from climate to economics.** **Economics of soils loss and sediment impacts on river ecology.** **Huge gap in environmental and ecological economics.** **Economic and social data collection and analysis.** **Integrating economics, soc. sci. and ecology.** **Economics models of risk.** **Globalisation of economics and society.** **Mechanism for calculating / evidencing economic and / or social impact of sound env. management.** **More skills required in env. Economics.**
27	**CARBON SCIENCES B001**	**The ES has highlighted the increasing importance of skills in the area of carbon sciences particularly:** ***Carbon Accounting, Carbon Cycle, Carbon Modelling, Carbon Reduction, Carbon Sequestration, Carbon Trading.*** **This need reflects the rise of the 'Low Carbon Economy' and the increased emphasis placed on carbon monitoring and trading activities.** **A need for more soil carbon scientists and modellers as well as individuals with skills in sequestration and appropriate carbon reduction strategies is identified.** **As there is money involved there is a lot more interest in this area and again I believe demand is outstripping supply** **Absolutely essential - not many can actually do this competently and yet there is a huge demand for these skills** **Science and technology probably hold the key to the management of carbon dioxide emissions** **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**

A. F/W POS.	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
		Provision for a well adapted and Low carbon NW.' There is a need for more soil carbon scientists and modellers. There is too much focus on new technologies, with not enough thought given to natural sequestration approaches. There is a need to train and develop people to consider carbon reduction strategies at macro and micro levels. High-tech geophysics required within the field of carbon monitoring post sequestration. Rarity of carbon modellers often creates bottlenecks for other work. Improve methodologies for soil carbon monitoring. Harnessing microbes to recycle carbon. Carbon cost of land use change. Modelling carbon processes in environmental compartments Need to ensure that carbon accounting is applied at a strategic and project level using agreed tools. MSc programmes on Carbon Management and Carbon Capture and Storage are now available which provide multidisciplinary expertise built around the geosciences. Carbon and water are linked – there are real opportunities here for integrated thinking and skills.
28	PALAEONTOLOGY B009	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. Database analysis, morphometric techniques, and phylogenetic skills are becoming increasingly important in palaeobiology, but are not being taught in a uniform fashion. This area is looking weaker and weaker, with the possible exception of micropalaeontology - which needs supporting to deliver the skills sets in palaeocology and palaeoclimate sciences. In specific micro-palaeo skills required for petroleum geoscience

A. F/W POS.	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
		Demographics will increase the gap as current experts retire. **I frequently see job adverts for micropalaeontologists with increasingly high salaries attached** **There has been a significant drop in people skilled in this area** **Like taxonomy, this is in danger of becoming a dying art in many universities. But an understanding of the past is key to our ability to predict the future.** **Testing skill of climate models in a palaeoclimate capacity are presently ok but numbers may rapidly diminish following the completion of QUEST.** **Micropalaeontology and palynology have all but disappeared.** **Palaeo skills are disappearing, as are taxonomy and systematics.** **Palaeontology is an area of particular concern because of the loss of skills but there are threats across the whole sector.** **There is a need for quality palaeodata to provide analogue information related to projected ice sheet decline.** **Skills in interpreting palaeoenvironmental records and using this to place the magnitude and extent of recent and future human impacts in context.** **Analysis of palaeosol sequences.**
29	**LIFE CYCLE ASSESSMENT B008**	**Another specific skills shortage highlighted by the Sector is a need for postgraduates with an understanding of life cycle assessment of products including waste.** **Product composition and life cycle impacts.** **Understanding the full life cycle of waste including outward effects of handling, transporting and disposing of waste.**
30	**COMPUTER SCIENCE/ HIGH PERFORMANCE COMPUTING B002** See also: Mathematics, applied mathematics (A011), Programming (D006)	**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.** **As there is money involved there is a lot more interest in this area and again I believe demand is outstripping supply** **Absolutely essential - not many can actually do this competently and yet there is a huge demand for these skills** **Lack of cross over of students from computer science.** **Lack of students with necessary computational and mathematical skills converting to environmental sciences.** **Shortage of genuine and combined computation and biology skills.** **Shortage of computing skills.**

A. F/W POS.	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
		Current market makes it difficult to retain programmers and software developers. High performance computing necessary.
31	GEOENGINEERING B005	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. Shortage of hydrogeologists and petroleum geoscientists compared with demand Extremely difficult to employ graduates (geologist or geotechnical engineers) with the correct skills - most training has to be done on the job. Often skills are highly theoretical. A subject area that needs to expand but there are few postgraduates coming through with this expertise Biological assessment and evaluation of risks is crucial to geoengineering. Although in its infancy, skills in the field of geoengineering would be valuable.
32	LANDSCAPE SCIENCES B007 See also: Geomorphology and earth surface processes (C010) Environmental Management (D007)	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. Existing provision is about the same but I can foresee a skills shortage developing as demand for the subject increased with increased awareness of environmental issues in the construction industry Becoming harder to attract really top quality PhD applicants into disciplines such as geomorphology - especially those with the necessary modelling skills to tackle the really pressing problems of predicting impacts of climate change at the coast and elsewhere. There is a need to promote sustainable engineering with no adverse impact on natural landscapes. Lack of geostatistical skills and integration with landscape science. 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. Placements with landscape management organisations likely to be of considerable value, especially ref understanding of practical application / transfer of knowledge
33	INTRODUCED/ INVASIVE SPECIES B006	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. Lack of skills in techniques to control the spread of invasive species and wildlife diseases.

A. F/W POS.	C. AREA OF CONCERN	D. SUMMARY OF AREA AND EXAMPLES OF CONSULTEE/ REVIEW GROUP VIEWS
	See also: Ecology/ ecological sciences (incl. conservation) (B003) Biodiversity (C017)	**Several clear and present dangers to UK have been widely publicised.** **Subject to the impact of climate change and the seriousness of the perceived danger.** **This is another rapidly growing problem in all ecosystems, and students must be taught the importance of this.** **Existing skills shortages in the area of predicting, detecting and monitoring invasive species.** **Managing invasive species and changing species distributions in response to climate change.** **Biology and ecology of introduced species in their new environment.**

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)

A. F/W POS.	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)
34	**FUTURES THINKING/ PLANNING C001** Links to many areas including notably: Sustainability science (A021)	**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.** **Most occurrences recommended by a Review Group Member.**
35	**SOCIAL SCIENCE C002** See also: Inter-/multi disciplinarity (A010) Natural science – social science interface/ translation (A015)	**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.** **Social science is fundamental in terms of understanding behavioural change and how to understand this.** **More effective presentation and representation of modelling assisted by social scientists to allow more effective knowledge transfer.** **Understanding of social science research methods.** **Identify political and social systems and mechanisms to ensure mitigation developments translate into practice.** **Social aspects of consumption.** **Understanding the social construction of environmental data.** **Understanding of social acceptability of technology research.** **Agent based modelling of social interactions with ecological processes.** **The social science of public health.**

A. F/W POS.	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)
		More effective presentation and representation of modelling assisted by social scientists to allow more effective knowledge transfer. **Understand the social and political constraints of mitigation options.** **Understanding of the social construction of much environmental data.**
36	**PSYCHOLOGY** **C003** See also: Behavioural change (D022) Community engagement (C007) Social Sciences (C002)	**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.)** **Skills at the interface of psychology, history and ethno-biology are needed to improve our understanding of human responses to change.** **Psychology of behaviour and change.** **Psychology of consumer behaviour.** **A greater depth of study is required on the ways in which psychology can contribute to changing societal behaviour.** **Psychology of behaviour and change.**
37	**GEOMPORPHOLOGY & EARTH SURFACE PROCESSES** **C010** See also: Earth sciences (DO13) Geosciences (D010) Hydrological sciences (D011) Landscape sciences (B007)	**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.** **Geomorphology has an important role to play in understanding the impacts of climate change.**
38	**BIOLOGY/ BIOLOGICAL SCIENCES** **C004** See also: Inter-/multi-disciplinarity (A010)	**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.**

A. F/W POS.	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)
		Most biologists have insufficient statistics and most statisticians have insufficient biology. **Shortages of genuine and combined computation and biology skills** **Important to develop coupled models of the physical and biological environment.** **Knowledge of biology and ecology of specific species.** **Core skills in terms of taxonomy and biological monitoring.** **Numerate, quantitative biologists needed. Also physical scientists and engineers with biological skills.** **Bioinformatics & Quantitative Biology** **Environmental Biology coupled with Environmental Economics.** **Synthetic Biology will be important in the future.** **Some problems recruiting people with molecular biology skills.**
39	**ENGINEERING C006** See also: Inter-/multi-disciplinarity (A010)	**Engineering was identified as a key skill area by the ES for a 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.** **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.** **Really need inter-disciplinary training with the engineering and social science fields** **Engineers needed to develop new technologies.**
40	**REMOTE SENSING C005** See also:	**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.**

A. F/W POS.	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)
	Earth Observation (C021) Sensor Design (D021)	**Listed as required for numerous challenges but no additional relevant comments.**
41	**COMMUNITY ENGAGEMENT C007** See also: Behavioural change (D022) Psychology (C003) Social science (C002)	**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.** **Listed as required for numerous challenges but no additional relevant comments**
42	**ECOSYSTEM SERVICES C009** Links to many areas including: Socio-economics (D029) Environmental valuation (C018) Natural science – social science interface/translation (A015) Social science (C002)	**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 identifed: *provisioning*, such as the production of food and water; *regulating*, such as the control of climate and disease; *supporting*, such as nutrient cycles and crop pollination; and *cultural*, such as spiritual and recreational benefits.includes products like clean drinking water and processes such as the decomposition of wastes. http://en.wikipedia.org/wiki/Ecosystem_services#Economics** **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.** **Need to apply ecosystem services at the organisational / business level.**
43	**INNOVATION C008** See also:	**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.**

A. F/W POS.	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)
	Business awareness (A002) Emerging Technologies (C016)	**Understanding the process of innovation and product development.**
44	**POLITICAL SCIENCE/ POLITICS C011** See also: Geopolitics (D017)	**Political science/politics is another area identified by the ES where synergies can be gained by the involvement of another discipline in 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 ….** **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.**
45	**ENVIRONMENTAL INFORMATICS C012** See also: Data management (A004) Data mining (D023)	**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.** **We need bioinformatics systems to deal with vast but incomplete fragmentary datasets.** **People with Bioinformatics skills (particularly data interpretation, management and visualisation. More** **skills required in Environmental Informatics (analysis and interpretation of environmental data).**
46	**DELIBERATIVE TECHNIQUES C014** See also Social sciences (C002) Community engagement (C007)	**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 little research and experience in methods of expert elicitation, expert judgment in deliberative processes, and appropriate aggregation of expertise".** **There is still little research and experience in methods of expert elicitation, expert judgment in deliberative processes, and appropriate aggregation of expertise.**
47	**SYSTEMS APPROACH C013**	**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**

A. F/W POS.	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)
	By its nature, the systems approach is linked to many of the other areas on the Framework including: Futures thinking (C001) Sustainability Science (A021)	**down into their constituent parts is advantageous and increasingly used as an accepted technique in parallel with futures thinking.** **Link up between earth systems and ocean systems.** **Systems thinking, systems analysis, systems engineering, systems dynamics, earth system science**
48	**BIOGEOCHEMISTRY C015** See also: Geochemistry (D008)	**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.** **Difficult to recruit PDRA's with a strong biogechemical and chemistry background, always seemed to be biased towards biology and not geochemistry/chemistry.** **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.**
49	**EMERGING TECHNOLOGIES C016** See also: Business awareness (A002) Innovation (C008)	**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.** **Listed as required for numerous challenges but no additional relevant comments**
50	**FIELD OBSERVATION C019** See also: Fieldwork (A008)	**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.** **Listed as required for numerous challenges but no additional relevant comments**
51	**BIODIVERSITY C017** See also: Ecology/ ecological sciences (incl conservation) (B003)	**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.** **Listed as required for numerous challenges but no additional relevant comments**

A. F/W POS.	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)
	Environmental change (D024)	
52	**EARTH OBSERVATION SYSTEMS C021** See also: Remote sensing (C013)	**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.** **Significant advances have been made in the last decade in earth observation capture and dissemination.**
53	**ENVIRONMENTAL VALUATION C018** See also: Ecosystem services (C009) Economic approaches (B004)	**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.** **Alternatives to monetary valuation needed.** **Ecosystem services valuation.**
54	**CHEMISTRY/ CHEMICAL SCIENCE C022** See also: inter-/multi-discplinarity (A010)	**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.** **.** **Application of analytical chemistry skills is lacking** **Lack of physics, chemistry & mathematics graduates.** **Some difficulty recruiting people with analytical chemistry skills.**
55	**COST-BENEFIT ANALYSIS C020** See also: Economic approaches (B004)	**Skills in cost-benefit analysis are identified by the ES as being needed for ten challenges. The ability to appraise the economic 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.** **Carbon Capture & 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.** **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.**

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.	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)
56	**POLICY AWARENESS D002** See also: Science/policy interface (A018) Legislation/ legislative process (D001)	**The ES identifies a need for postgraduates with a greater *Policy Awareness* 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).** **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.** **Lack of science communication skills and policy making.** **Research happens at a slower pace than policy changes, and the issues of global responsibility are not articulated in UK environmental science contexts.**
57	**ENVIRONMENTAL IMPACT ASSESSMENT D004** See also: Environmental management (D007)	**Skills in assessing the likely *Environmental Impact* 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.** **Listed as required for some challenges but no additional relevant comments**
58	**GEOCHEMISTRY D008** See also: Geosciences (D010) Earth sciences (D013)	**Feedback indicates that postgraduate skills in *Geochemistry* (study of the chemical composition of the Earth and other planets, chemical processes and reactions that govern the composition of rocks and soils and related areas) are required to meet a number of challenges.** **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 respondee noted that the basics of geology, geochemistry and geophysics at Masters level are a key attribute for skilled people in the physical sciences.** **Petroleum geochemists and coal geologists.** **It is the basics of geology, geochemistry and geophysics that are key at the Masters level.**

59	**HAZARD AND RISK ASSESSMENT D005** See also: Risk assessment and management (A017) Dealing with undertainty (A005)	**Linked to *Risk Assessment and Management* (a017), *Hazard and Risk Assessment* 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.** **Listed as required for some challenges but no additional relevant comments**
60	**ARCHAEOLOGY D003** See also: Landscape sciences (B007) Environmental change (D024)	**For some challenges, the Sector identifies a need for skills in *Archaeology*. 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.** **Listed as required for some challenges but no additional relevant comments** **It is also important to continue to train scientists with an appreciation of both environmental science, earth sciences and archaeology. This is to ensure that the latest measurement techniques and understanding of each subject is embedded in the other, and that discipline of Geoarchaeology remains strong given the need to understand past environmental change and the interplay with the human environment.**
61	**ENVIRONMENTAL MANAGEMENT D007** See also: Environmental impact assessment (D004) Environmental valuation (C018)	***Environmental Management* 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.** **Listed as required for some challenges but no additional relevant comments except for the linked:** **Environmental economics is particularly relevant in evidencing the economic value of environmental management.** **Environmental management based on a good understanding of the environmental sciences, current environmental legislation and agriculture is much needed in order to enact and improve environmental legislation in a rationale manner.**
62	**GEOPHYSICS D009** See also: Geosciences (D010) Earth sciences (D013)	**Postgraduate expertise in *geophysics*, 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 sequestrated carbon.** **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.** **High tech geophysics to monitor carbon once sequestrated. This remains a post graduate requirement linked with industry.** **It is the basics of geology, geochemistry and geophysics that are key at the Masters level.** **Need for numerate graduates with skills in geophysics.**

		Anecdotal shortages of people with geophysics skills.
63	**GEOSCIENCES** **D010** See also: Earth Sciences (D013)	***Geosciences,* while the same broad skills area as *Earth Sciences* (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.** **The management of radioactive waste particularly requires deeply skilled postgraduate geoscientists knowledgeable in geology and monitoring techniques.** **The basics of geoscience must be a part of the skills base.**
64	**HEALTH IMPACT ASSESSMENT** **D018** See also: Environmental epidemiology (A007) Hazard and risk assessment (D005) Public health and wellbeing (D026)	**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.** **Links between environmental pollution and human health.** **Knowledge and skills in health impact assessment are required.** **Practical skills in pathology and virology difficult to find.**
65	**HYDROLOGICAL SCIENCES** **D011** See also: Earth sciences (D013) Geosciences (D010) Integrated freshwater sciences (A009)	**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)** **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** ***Hydrology, Hydrogeology, Hydrochemistry* Hydrological** **Sciences need to be more engaged. Anecdotal shortages** **of people with hydrogeology skills.**
66	**EARTH SCIENCES** **D013** See also: Geosciences (D010)	**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.** **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).** **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.
67	**ENVIRONMENTAL CHANGE D024** See also: Environmental management (D007)	**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.** **Listed as required for some challenges but no additional relevant comments.** **There is a lack of post-graduate and doctoral funding sources on understanding past environmental change and impacts.**
68	**ENVIRONMENTAL ETHICS D014** By its nature, environmental ethics is linked to many of the other areas on the Framework including: Sustainability science (A021)	**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.** **Listed as required for some challenges but no additional relevant comments**
69	**FORESTRY D015**	**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.** **Forestry as a biological technique for carbon management.**
70	**GENOMICS D016** See also: Environmental informatics (C012)	**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.** **Listed as required for some challenges but no additional relevant comments** **Lack of individuals trained in Bioinformatics (important Genomics tool – see "c012 Environmental Informatics")**
	GEOPOLITICS D017 See also: Political science/ politics (CO11)	**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.** **Listed as required for some challenges but no additional relevant comments.**
71	**NUMERICAL/ MATHEMATICAL**	**Some contributors make specific mention of the need for postgraduate skills in Numerical/Mathematical modelling – a specific technique**

	MODELLING **D019** See also: Modelling (A014) Spatial analysis and GIS (B010)	**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.** **In my area, specifically the development of hazard and risk assessments linked to earth evolution models there is a now severely limited pool of experienced lecturers who have practical experience of geomorphological mapping, geotechnical analyses, physical testing and physical modelling.** **Numerical modelling of pollutants transport by fluids.** **Numerical modelling of the atmosphere.** **Numerical modelling of channel change.** **Requirement for more modellers and numerate graduates.** **Modelling / Mathematical skills required.** **Lack of graduates with necessary computational and mathematical skills converting to environmental sciences**
72	**PARAMETERISATION AND ASSIMILATION** **D025** See also: Data Management (A004) Data Mining (D023) Environmental informatics (C012)	**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** **Currently a significant under investment in data assimilation.**
73	**PHYSICS** **D020** See also: Inter-/multi-disciplinarity (A010)	**Postgraduate skills in *Physics* 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.** **Lack of physics, chemistry & mathematics graduates.** **Low numbers of students from physics, chemistry and mathematics first degree courses entering postgraduate training.**
74	**SENSOR DESIGN** **D021**	***Sensor Design* 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**

	See also: Remote sensing (C005)	**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 benchmarked.** **Listed as required for some challenges but no additional relevant comments.** **Links between sensors and analytical interpretation would enable "normal" conditions to be defined.**
75	**BEHAVIOURAL CHANGE D022** See also: Community Engagement (C007) Psychology (C003) Social science (C002)	**Behavioural change is a specific area of expertise closely linked to *Psychology* (C003) and *Social Science* (C002). Understanding human behaviour is key to influencing the way people interact with the environment and embrace sustainability.** **Social science is fundamental here in terms of understanding behavioural change and how to influence this.** **Understanding the drivers of behavioural change is of generic importance (e.g. in the healthy ageing arena)**
76	**DATA MINING D023** See also: Data management (A004) Environmental informatics (C012) Paramaterisation and Assimilation (D025) Programming (D006)	**The ES identifies *Data Mining* as a specific skills set within *Data Management* (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.** **Listed as required for some challenges but no additional relevant comments.**
77	**LEGISLATION/ LEGISLATIVE PROCESS D001** See also: Science-policy interface/ translation (A018)	**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.** **Insufficient skills available to develop new tools for legislation such as the Water Framework Directive.**
78	**PROGRAMMING D006** See also: Computer science/ high	**Postgraduate skills in *Programming*, a specific skills set within *Computer Science* (B002), is identified as necessary for five of the challenges. High level and parallel programming skills are regarded as important for underpinning computational expertise in the environmental sciences.** **Listed as required for some challenges but no additional relevant comments.**

	performance computing (B002)	
79	**PUBLIC HEALTH AND WELLBEING D026** See also: Environmental epidemiology (A007) Health impact assessment (D018)	**Linked to *Health Impact Assessment* (D018), postgraduate skills in promoting and protecting *Public Health and Wellbeing* 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.** **Listed as required for some challenges but no additional relevant comments.**
80	**SAMPLING TECHNIQUES D027** See also: Fieldwork (A008) Field Observation (C019)	**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.** **Listed as required for some challenges but no additional relevant comments.**
81	**SCIENCE COMMUNICATION D012** See also: Communication (A003) Media skills (A012)	**Closely linked to general *Communication Skills* (A003), some contributors referred specifically to *Science Communication* 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 at science and society)** **Lack of science communication skills and policy making.** **More attention should be paid to the public understanding of science.** **Training in scientific communication is essential.**
82	**SCIENCE- ENGINEERNG INTERFACE D028** See also: Inter-/multi-disciplinarity (A010)	**This skills area is linked to the *inter- and multi-disciplinary* 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.**
83	**SOCIOECONOMICS D029**	**Postgraduate skills in *Socioeconomics* 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**

	See also: Economic approaches (8004) Social sciences (C002)	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 http://www.britishecologicalsociety.org/public-policy/policy-events/past-events/past-events-2008/ for further information