Short Form Skills Framework

Following the 2012 refresh of the skills review, it was recognised that many of the 83 skills identified had areas of overlap and the skills framework was further redacted and condensed into 30 priority skills areas for easier reference.

Blue boxes indicate that this is a transferable research skill.

Reference numbers refer directly to the skills framework – they are colour coded to indicate hierarchy in the Skills Framework[1]:

Red = A: Critical skills - Amber = B: Critical skills - Green = C: Key skills areas - Blue = D: Key skills areas

Quotes in italics are taken directly from feedback during the 2012 consultation

Postgraduate Skills Area	Description of skills area and feedback from the 2012 Skills Review
Modelling Modelling - A014 Spatial Analysis and GIS - B010 Numerical/ Mathematical Modelling - D019	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. Furthermore, high level GIS modelling skills are in short supply, especially when combined with expertise in other subject areas. A need for postgraduate skills in Numerical/Mathematical modelling is also highlighted. *The UK needs people with appropriate skill sets to explore these data sets using techniques from other science disciplines, such as information theory from engineering, and to build the next generation of process-based environmental models to help understand the interactions between the principle mechanisms operating. I 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.* *Still too few people with low-level modelling skills required for model development as opposed to application. Too many people only have experience of using closed source propriety models.* *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.*
Multi-disciplinarity Multi-disciplinarity - A010 Natural science/ social science interface - A015	A 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.

[1] Skills Framework: http://www.nerc.ac.uk/skills/postgrad/policy/skillsreview/

Science/ engineering interface - D028	*Although there is some collaboration, it tends to be between similar institutions* *Despite years of interdisciplinary rhetoric, it is still difficult to find people who are able to move easily between social and environmental sciences.*
Data Management Data Management - A004 Environmental Informatics - C012 Genomics - D016 Parameterisation and assimilation - D025 Data Mining - D023	A need for stronger postgraduate skills in all aspects of data collection, data use and data management is widely identified. 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. A lack of people skilled in bioinformatics limits our capability to undertake research within genomics (study of genomes of organisms). The ES identified Parameterisation and Assimilation of Data as a specific skills set within Data Management, such skills maximise the value of data to the environmental sciences. Extracting patterns from data through data mining is an important tool for transforming data into useful information to understand environmental processes. *The continual increase in computing power is providing 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, analysing and modelling these data, linked to data management systems.* *Bioinformaticians and people sufficiently skilled to analyse large data sets of microbial/environmental data are very limited in number.* *Biodiversity: combination of natural history skills and ecoinformatics skills in short supply* *Data Mining as the key area that requires advanced training and improved national capability in terms of storage/access*
Numeracy Statistical Analysis - A020 Mathematics – A011 Computer Science – B002 Programming - D006	A serious skills shortage in environmental statistics is reported; this limits the ability of those working in the environmental sciences to handle large datasets and use successfully such techniques as statistical inference. Shortages in mathematical and numeracy skills are widely reported, 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. The current market and demand for computing skills makes it difficult to recruit and retain programmers and software developers. High level and parallel programming skills are regarded as important for underpinning computational expertise in the environmental sciences. *It 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. Many undergraduate maths students are not aware of the exciting careers available to them in environmental sciences* *(computer science) Absolutely essential - not many can actually do this competently and yet there is a huge demand for these skills*

	Again based on recruitment of post-doctoral scientists, it has often been difficult to find those that have a blend of environmental science with mathematical and programming skills.
Translating Research Communication – A003 Science/ Policy interface – A018 Business Awareness – A002 Media Skills – A012 Innovation –C008 Emerging technologies – C016 Science communication - D017	A lack of communication skills among postgraduates hampers communication across the sciences and in inter- and multi-disciplinary areas. It also limits the ability to express complex issues to lay people. Linked to communication skills, is the need for stronger postgraduate skills in translating scientific evidence into effective policy and legislation. 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. More effective communication of science and its key messages on issues such as climate change via the media is essential to avoid 'media corruption'. Understanding the process of innovation and product development is important for bringing new products to market in the private sector. 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. Some contributors referred specifically to *Science Communication* in the context of the ability of researchers/scientists to communicate their outputs to a layperson. *Size of the gap has increased because of the increased demands for communication on complex energy-related environmental issues e.g. shale gas, deep water exploration and development* *In my disciplines there is an increasing emphasis on scientific communication, which highlighted in the increasing interest displayed by the popular media of environmental issues.* *This remains an area of high concern. We have to spend a long time up-skilling new members of our team to be able to move the science from knowledge to policy appropriate information.* *Skills needed in order to maximise the impact of large public databases, engage with open science initiatives, etc.*
Field science Fieldwork - A008 Field observation – C019 Sampling techniques - D017	Feedback indicates that the number of people available to conduct skilled field research is decreasing. 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. Sampling techniques are also in shortage, such skills underpin environmental observation and monitoring leading to a greater understanding of environmental issues. *recent recruitment in the School suggests that 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* *This is a real concern; postgraduate research fieldwork is not funded as generously as it used to and whilst they should not be a restriction health and safety issues can be daunting. Overall I do not believe we are able to do as much fieldwork as*

	we need to develop the requisite postgraduate field skills *Fewer students are engaging in field-based projects. Supplemental funding for fieldwork has decreased making training in this important area much more difficult.* *Field skills are weak in many young scientists, and this is an increasing skills gap.*
Risk and Uncertainty Risk assessment and management – A017 Dealing with uncertainty – A005 Hazard and risk assessment - D005	Greater literacy in the field of risk assessment and management is vital. 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. 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. *Again we have to provide "in house training" on how to clearly communicate environmental risk* *Possibly going to increase as themes such as climate change become a tradable commodity and the impacts of climate change are felt. The insurance industry is now looking for science based advice in themes such as flooding.* *As society becomes more complex and inter disciplinary approaches to science are required, and science budgets are reducing, scientists feel that quantifying uncertainty adds to the workload and takes time away from the 'core science'.*
Taxonomy and Systematics 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. There is a real need for NERC to provide LEADERSHIP in supporting this area. I would dearly like to see (and would freely contribute myself) to an annual training event in this area for all Natural Sciences students - that raises awareness of the value of fundamental skills such as taxonomy. I believe there is a crisis looming on the horizon and that we need to think carefully about training, supporting and developing the careers of the next generation. I would gladly give up my time to help NERC and others work on this area of training need.* *Taxonomy skills in marine science are few and far between....it is not a skill that is taught at the postgraduate level* *This never goes away. It is the fundamental basis upon which science is communicated.*

Soil Science 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. *The 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. With the decline in soil science in the UK, it is unclear who will train the next generation of UK and overseas soil scientists.* *Field investigation and monitoring are needed to understand soil systems on a site or within a catchment. Very few reports (commercial or academic) indicate a clear understanding of what are the key soil properties and how to adequately monitor/measure them. Understanding of impacts of land use on soils - how to identify and monitor. The impact of soil 'health' on flood risk and generation.*
Environmental health Environmental Epidemiology – A007 Health impact assessment – D018 Public Health and wellbeing - D026	A skills shortage 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. 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. Postgraduate skills in promoting and protecting Public Health and Wellbeing are important. Such skills help prevent environmental issues or phenomena from having a negative impact on public health. *Many of the current staff in post are nearing the end of their careers. Recruitment and financial constraints are making succession planning very 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.*
Sustainability Science and Planning Sustainability science - A021 Land and country planning –A023 Futures Thinking/ Planning – C001 Systems approach – C013 Environmental Change – D024 Environmental ethics - D014	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. Knowledge of town and country planning and associated areas is increasingly important. 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. Postgraduate skills in futures thinking/planning are identified, for example, the ability to envisage scenarios for a more sustainable future helps the sector to identify appropriate adaptation measures for addressing climate change. A systems approach encompassing such concepts of systems thinking, systems analysis, systems engineering, and systems dynamics is another theme which is consistently highlighted as a skills/knowledge need by the Sector. Understanding how the different components of the environment operate and influence one another within the whole is key to addressing many of the challenges. Breaking processes down into their constituent parts is advantageous and increasingly used as an

	accepted technique in parallel with futures thinking. Environmental change was identified as a specific skills area; understanding past and current environmental change is regarded as important in predicting future change and man's role in this. Environmental Ethics 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. *High profile over previous 2 years and growth in jobs market.* *As responsible global citizens, we need to teach sustainability at every level.*
Biological sciences Microbiology – A013 Ecology – B003 Introduced/ invasive species - B006 Biodiversity – C017 Biological sciences - C004	A requirement for stronger postgraduate skills in microbiology and microbial physiology is identified. Such skills are needed by the ES to understand the effects of ecosystem change on plant, animal and microbial diversity. 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 particularly difficult to find. Also, managing invasive species and changing species distributions in response to changing climate is seen as an area of increasing importance and skill shortage. 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. 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. *Microbial ecology is poorly understood, especially in relation to biosecurity and ecosystem processes.*
Food Supply Agriculture - A001	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.*
Energy Supply Energy Provision – A006 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. Linked to energy provision, renewable energy technology emerged as a distinct theme in the feedback from the ES. Better training in technical skills combined with an environmental understanding is needed to keep pace with technological developments in the field and ensure sustainability. For example, knowledge of ecology is needed to help decide where renewable energy technology should be sited.

	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. *As with energy specialists, this [renewable energy technology] is a growing field which industry is recognising requires particular skills*
Freshwater science Integrated Freshwater Science – A009 Hydrological sciences - D011	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. 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. *The maintenance of fresh water resources has never been more important.* *following the 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.*
Policy Science Policy/ Interface – A018 Policy awareness – D001 Legislation - D002	A recurring theme in the feedback from the ES is the need for stronger postgraduate skills in translating scientific evidence into effective policy and legislation. Greater *Policy Awareness* as amongst postgraduates is identified. Knowledge of Legislation/Legislative process is a key skill and relevant to both developing appropriate legislation and implementing it once in place. *There is increasing need to show evidence for science into policy, but very little skills base in how to do it.*
Economics Economic Approaches - B004 Environmental valuation – C018 Ecosystem services – C009 Cost benefit analysis - C020 Socio-economics – D029	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. Ecosystem services are a relatively new skills area identified and can be described as all the resources and processes that are supplied by natural ecosystems and from which mankind benefits. Environmental valuation seeks to measure both the monetary value and the intrinsic advantages of the natural environment. Skills in cost-benefit analysis are identified; the ability to appraise the economic efficiency of different options, by weighing costs against the benefits, has many potential applications. Increased socioeconomic awareness across the environmental sciences will generate a broader understanding and increase the value of research and enterprise. *I think this remains a long-standing skills gap*

	Still a major gap especially around an understanding of the green economy
Carbon Sciences 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. *Absolutely essential - not many can actually do this competently and yet there is a huge demand for these skills*
Palaeontology Palaeontology - B009	Skills in the fields of micropalaeontology and palaeontology 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. *Our palaeontologist keeps going only via support from the petrochemical industry.* *In specific micro-palaeo skills required for petroleum geoscience*
Environmental assessment/ management Life cycle assessment – B008 Environmental impact assessment – D004 Environmental management - D007	Another specific skills shortage highlighted by the Sector is a need for postgraduates with an understanding of life cycle assessment of products including waste. Skills in assessing the likely Environmental Impact of projects / developments are identified for some challenges e.g. to ensure that decision makers consider the environmental perspective prior to passing judgement on development proposals. 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. *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.*
Geo-engineering Geo-engineering - 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.

Landscape sciences Landscape sciences – B007 Geomorphology and earth system processes – C010	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. Geomorphology and Earth Surface processes were identified as necessary for a range of challenges. These skills pay an important role to play in understanding the impacts of climate change. *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.*
Social sciences Social science – C002 Psychology – C003 Community engagement – C007 Deliberative techniques - C014 Behavioural change – D022 Archaeology - D003	A stronger social science dimension would facilitate more effective integration of the human element in understanding and tackling the challenges the sector faces. Linked to the need for more postgraduate skills in the social sciences, psychology was identified as a key requirement 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). Sector engagement, for instance, engaging communities in consultations that relate to developments that may affect their lives can help bring about change. Deliberative techniques/ democracy is identified as being needed, 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". Behavioural change is a specific area of expertise within social science, understanding human behaviour is key to influencing the way people interact with the environment and embrace sustainability. Archaeology, specifically the study of past human societies and their role in environmental change, provides an analogue / context from which to consider the future. *Geoarchaeology remains strong given the need to understand past environmental change and the interplay with the human environment.*
Engineering Engineering - C006	Engineering was identified as a key skill area; 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. *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*
Earth observation Remote sensing – C005 Earth observation systems - C013 Sensor design – D021	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 measuring and monitoring of Earth from space using satellites are vital to understanding current environmental phenomena and changes in the future. Designing devices that measure a physical quantity and convert it into a signal that can be read and recorded is extremely useful in the environmental sciences as a means of observation and monitoring.

Political science Political science/ politics – C011 Geopolitics - D017	Incorporating political science approaches / perspectives enables greater understanding of the real-world application of research. 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.
Chemical sciences Bio-geochemistry – C015 Chemistry/ chemical science- C022 Geochemistry - D009	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. The need for postgraduate skills in chemistry and chemical sciences together with skills in the environmental sciences is identified; this is important to enable a greater understanding of the chemical nature of environmental processes. 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. *Difficult to recruit PDRA's with a strong biogeochemical and chemistry background, always seemed to be biased towards biology and not geochemistry/chemistry.*
Earth sciences Geophysics – D009 Earth sciences - D013 Geosciences – D010	Postgraduate expertise in *geophysic*s, the study of the Earth by quantitative observations of its physical properties, is identified as necessary to address some challenges. Earth sciences are identified by some contributors as an important skills area required of postgraduates to address 6 of the challenges. Geosciences, while the same broad skills area as Earth Sciences, is used as a term by some respondents.
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.
Physics - D020	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.