Institution: 10007822

Unit of Assessment: 6

a. Overview

Cranfield is a specialist university leading postgraduate education and transformational research in applied science and engineering and management to support business, government and wider society. Within the agriculture, food and environment sectors, the 27 staff submitted to UOA 6 are located in the Department of Environmental Science and Technology in the School of Applied Sciences (with one exception who transferred to the School of Management in 2012 and continues to work closely with other members). Although staff are organised within four institutes, interdisciplinary teams are common, so the submission is presented as a single agriculture, food and land systems group with strengths in soil chemistry, soil biology and ecology, environmental informatics, soil-plant systems, agricultural water management, agricultural engineering, agricultural systems modelling, agro-forestry, post-harvest biology and technology, and food safety (applied mycology and microbiology).

b. Research strategy

Cranfield's institutional strategy is to deliver our mission through a distinctive platform of research across the technology readiness levels, blending fundamental research with the co-creation of new knowledge through deep engagement with the strategic agendas of our business partners. Cranfield's curiosity-driven research, funded principally by the Research Councils, plays a major role in delivering to their strategic sub-themes. For example, members of UOA 6 have been awarded three BBSRC grants in sustainable agriculture, are partners in one of only four BBSRC Horticulture and Potato Initiative grants and two of the four NERC Biodiversity & Ecosystem Service Sustainability (BESS) consortia, leading one of them. Our strategy shapes key aspects of our institution, including our staffing strategy, capital investment, our approach to impact, and knowledge transfer.

Our RAE2008 research strategy placed a re-emphasis on agriculture, defined in a multifunctional context, with our research focused on land-based natural resources to better exploit the strengths of Cranfield in agricultural science and engineering. Through new appointments, development and internal regrouping, we have built a coherent, trans-disciplinary capability conducting basic and applied research throughout the agriculture and food supply chain. Our REF2014 strategy places these systems in a wider landscape and ecosystem service context, considering environmental impacts spanning the supply chain. New appointments that have strengthened our capability include **Mouazen** (agricultural engineering), **Corstanje** (environmental informatics), **Tibbett** (soil ecology) and **Thompson** (molecular plant science). These have been supported with investments in new infrastructure for globally significant growth areas, notably pilot-scale laboratories for terramechanics and soil erosion, unique lysimeters for measuring whole-soil carbon balances and greenhouse gas fluxes, and one of Europe's largest post-harvest laboratories to support research in food safety and security. The group seeks to increase our understanding of agriculture, food and land systems in the context of the rural environment, agro-ecosystems and societal influences, extending from upstream inputs, through agriculture and other land-based industries to post-harvest storage and the distribution of produce. The combination of basic science and close engagement with business and government allows us to respond to national and international priorities in sustainable intensification, climate change mitigation and adaptation, and in promoting the ecosystem service paradigm for policy appraisal. This extends to our research students, where we continue to maintain a blend of Research Council, government and business funded, and co-funded students. We sustain a critical group of over 40 permanent researchers in the disciplines above. Scholarly contributions have been made in five themes.

Environmental change science and policy. **Audsley** and **Williams** have pioneered the use of systems models for life cycle analysis of agriculture and food production to evaluate environmental impacts, including greenhouse gas emissions; their models have been downloaded over 800 times for use worldwide. These models can be used to compare the environmental impacts of different production systems, including hypothetical systems. **Williams** is Science Director for the new

inventory of greenhouse gas emissions from agriculture. Operational research methods are also used to model agricultural systems and predict their responses to change. By connecting these to regional land classifications, insights have been gained on possible trajectories for agriculture under climate change. These have been developed with **Holman** who models the impact of climate change on water resources (specifically groundwater) at local to continental scales, complementing **Hess**, **Knox** and **Weatherhead** on agricultural water resource modelling and management. They are researching methods for improving water use in irrigation and have assessed the impacts of climate change on irrigated vegetable production (especially potato) and contributed to the National Climate Change Risk Assessment for Defra.The largest stock of terrestrial organic carbon is in soil and **Kirk** models the dynamics of carbon to, from, and within the soil system, and the changes in soil carbon at national scale in response to land use change and other factors. **Corstanje** is investigating counterfactuals for global biofuel production.

Food science and security. **Mouazen** has developed sensors using near infrared spectroscopy to measure soil properties in real time, during cultivation. This technology can be used to reduce nutrient inputs without a loss of yield for precision-farmed systems. **Ritz** has used expertise in soil biology and soil health to develop company-scale soil information and management systems whereas **Knox** and **Thompson** have developed novel precision irrigation approaches including soil mapping, variable rate application and wireless sensor networks to improve irrigation efficiency in horticulture. **Thompson** has also applied molecular genetics to improve crop water use efficiency and vegetable rootstock vigour. **Kirk** has uncovered new knowledge on zinc uptake in rice, and is developing germplasm to ensure zinc levels are more adequate in the future. **Terry** provides a substantive capability in post-harvest technology and biology which has delivered novel protocols and technologies that extend storage and shelf-life of fruits and vegetables. This research has provided a deeper understanding of the physiological, biochemical and molecular mechanisms that control dormancy, quality loss and senescence after harvest. Complementary work by **Magan**, a leading expert on the effect of environmental pre- and post-harvest factors on mycotoxin prevalence in durable foods, and by **Lambert's** expertise in predictive microbiological modelling has improved the safety of food products. Life cycle assessments of crop and livestock commodities by **Audsley** and **Williams** have informed policy appraisal on the environmental limits of agriculture.

Soils and land systems. **Corstanje** and **Littler** combine advances in geostatistics with pedology, contributing new digital modelling techniques for spatial variations in soil, applying these at national scale (e.g. to produce a national soil properties database for the Republic of Ireland) and international scale (the Global Soil Partnership, soil atlases of Europe and Africa). New insights into soil ecosystems have been developed by **Ritz**, **Harris** and **Tibbett** including appreciation of the importance of soil habitat 'architecture' at the micron to millimetre scales as the controlling factor on expression of the soil genome. **Rickson** and **Deeks** research soil erosion control and conservation measures, including to control sediment generation in catchments. **Harris** and **Tibbett** work on the recovery of soil resources degraded by industrial activity (e.g. mining and quarrying) focussing on the restoration of soil abiotic factors. **Sakrabani** researches the impacts of organic and other materials (e.g. sewage sludge, animal slurries, biochar) on soil systems and the associated response, such as altered emissions of greenhouse gases. **Burgess** has advanced tools for integrated land management, addressing the conflicts and tensions between the use of land for food, feed, fibre and renewable energy production, informing EU land use policy and regulation.

Ecosystem services. Our research in ecosystem services extends from basic investigation of the mechanisms underlying ecosystem functions (building on the soil and land systems theme) to the valuation of services and their implications for policy. **Ritz**, **Harris** and **Tibbett** start from the characterisation and quantification of soil biota to study the structure and function of soil microbial communities, their biodiversity and ecology, and the impact on soil function. These underpin an understanding of the ecosystem services provided by soils, which are modelled by **Corstanje**. Spatially distributed models of the effect of land use on services (biodiversity, carbon sequestration and recreation) have been developed by **Rivas Casado**, who works with **Burgess** on agricultural and forestry systems, leading to the recognition that energy production and distribution is an important ecosystem service that is not captured in current ecosystem service classifications. **Graves** and **Angus** apply economics and social psychology to study the application of valuation

within an ecosystem framework, including mixed quantitative and qualitative methods to assess cultural services, as a tool to inform policy.

Natural resource economics and management. **Angus**, **Graves** and **Burgess** undertake economic analysis, including on externalities, and design stakeholder engagement tools to guide the use of agricultural resources to maximise societal benefit. They develop and use methods ranging from quantitative modelling of production, through economics to stakeholder analysis, for which improved formalised methods have been developed, including network analysis to understand stakeholder relationships. **Audsley** and **Parsons** develop models of agricultural systems, which use optimisation approaches to predict responses to external pressures, such as future land use under different economic and climatic scenarios, and to underpin decision support systems. Work within this theme also considers the relationship between agriculture and other land uses, such as drinking water extraction and recreation.

Research delivery at Cranfield employs a "define, design, deliver, develop" model. The generation of hypotheses within and across themes *defines* our curiosity-driven research. In response to specific calls (from a Research Council, European Commission etc.), definition is coordinated between institutes, with peer evaluation by Professorial staff to ensure high quality proposals. Mentoring supports the effective *design* of projects, with objectives and methods peer-reviewed internally. Resource planning is structured, with management review from heads of institutes. Responsibility for *delivery* is devolved to principal investigators. Written outputs are subject to internal review. Staff and resource inputs are monitored, including by timesheet completion, with all projects subject to quarterly review in respect of completion and resource consumption. *Development* of this process is informed by the self-reflection by investigators and post-completion review. During the assessment period, improvements have included:

- A more formalised evaluation of research opportunities, matched to uniqueness and pedigree of expertise, leading to greater discipline in the definition process.
- Greater consideration of whether, and where, external collaboration is needed to enhance the quality of research activities.
- A stronger emphasis on the prompt publication of research outputs, both as an input to the wider research community and to elicit feedback on science.
- A strengthened emphasis on existing and new strategic collaborations.

c. People, including:
(i)Staffing strategy and staff development

Cranfield University is a research-intensive postgraduate Institution. The University's strategy supports trans-disciplinary teams and relationships by grouping staff according to relevant societal challenges (Cranfield's strategic themes). UOA 6 lies within the environment theme and contributes to several others. This breadth of research requires an interdisciplinary approach and is supported through a mix of income streams including research councils, government, EU and industry. This balance of income generation has been essential to fulfil our ambition of working at the leading edge of fundamental, strategic and applied research in our selected niche areas whilst being able to sustain a critical mass of permanent researchers. Our staffing strategy complements this research funding strategy, delivering a set of fundamental and applied research staff that secures the required mix of income streams. It aims to enhance Cranfield's strengths in working closely with industry using appropriate modes of research ranging from fundamental through to strategic applied research with well-defined objectives, while establishing a substantial critical mass of research staff to carry out curiosity-driven research.

UOA 6 staff are part of a larger Department of Environmental Science and Technology consisting of 170 researchers. They are located in the following institutes:

- The Cranfield Water Science Institute (Hess, Holman, Knox, Weatherhead, White)
- The Institute for Energy and Resource Technology (Harris, Sakrabani)
- The Institute for Environment, Health, Risks and Futures (Angus (to 2012), Audsley, Burgess,

Gill, Graves, Parsons, Rivas Casado, Williams)

- The Cranfield Soil and Agrifood Institute (Corstanje, Deeks, Littler, Kirk, Mouazen, Rickson, Ritz, Tibbett , Magan, Terry, Lambert, Thompson)

The configuration of staff within multi-disciplinary, sector-facing institutes ensures colleagues are embedded in large groups of critical mass. For example, staff in the Water Science Institute focus on agriculture water management alongside water technology, supply and sanitation and water governance; and staff in the Institute for Energy and Resource Technology work alongside those in waste management, including spreading to land, and biofuel production.

The group has a long provenance, reaching back to the former National College of Agricultural Engineering (opened 1962) and the Soil Survey of England and Wales (founded 1945). We continuously adapt to the evolving research agenda, in line with the University's strategy. At the start of the assessment period, as entered in RAE2008, a Natural Resources Department existed alongside a Department of Sustainable Systems concerned with environmental engineering. The post-harvest and food safety team were in Cranfield Health and not entered in the Agriculture, Veterinary and Food UOA. During the assessment period, re-grouping has delivered a cohesive capability based broadly on agriculture, food and land systems, allowing for the all-important connectivity to environmental engineering. We collaborate closely with the School of Management including **Angus**, an environmental economist entered in UOA 6, and its supply chain experts.

This strategy complements our research aims, delivering a mix of fundamental and applied oriented staff securing the blend of income streams described. We frequently recruit from the research institutes, from industry and Government. We have had substantive success in developing home-grown talent, with Cranfield staff progressing to senior levels (**Knox**, **Sakrabani**, **Burgess**, **Hess**, **Terry**). Teams are sustained through judicious professorial recruitment in strategic areas (e.g. **Tibbett**) and from below through our Academic Fellow scheme, early career lectureships (e.g. **Rivas Casado**) and continuing promotion of high-performing early researchers to positions of responsibility (e.g **Corstanje**, **Graves**). Early career staff receive extensive support, consistent with the RCUK "Concordat to Support the Career Development of Researchers". They have mentors for independent advice, with postdoctoral researchers aligned to established academics and members of a self-managed postdoctoral community that arranges any support necessary over and above the University provision. The latter includes proposal writing, business skills, and a host of development topics. Mentoring in scholarship and the 'academic craft' is in place and most postdoctoral researchers will lecture, co-supervise informally, draft portions of proposals and present to industrialists or government scientists. For our most promising postdoctoral researchers, we offer an Academic Fellow route, akin to the RCUK Roberts' Fellows scheme (2004), which provides a stable career paths to an early career lectureship.

Actions to enliven the research culture for UOA 6 have included:

- Contribution to the research strategies of the Institutes to which individual UOA 6 staff belong.
- Research group leadership by reference to seminal groups under 'research strategy' above.
- Contributions to weekly DTC seminars, prestige lectures and professional institute events (e.g. IAgrE, BSSS, SocEnv).
- Frequent mentoring on manuscript preparation, submission and revision, and proposal structuring and presentation, with preparation for grant and tender 'interviews' (e.g. industrial fellowships, Leverhulme/early career Fellowships, institutional awards).

The group entered into UOA 6 comprises 27 research-active staff including 9 professors: **Harris** (microbial ecology), **Kirk** (soil chemistry), **Magan** (applied mycology), **Rickson** (soil conservation), **Ritz** (soil biology), **Terry** (plant sciences), **Tibbett** (soil ecology), **Weatherhead** (agricultural water management) and **White** (catchment management). The number of postdoctoral researchers in the group stands at 25. Research staff are supported by 15 technical staff (4 geographical information specialists, 4 technicians in terramechanics, erosion and farm equipment, and 7 in the environmental and analytical laboratories).

Equality and Diversity. Cranfield has demonstrated its commitment to Equality & Diversity for over a decade, led by the Deputy Vice-Chancellor, assisted by the Diversity Manager and our

Professional Development Team. The Diversity Manager supports staff to develop, implement and review our diversity objectives to ensure that the University is promoting equality of opportunity for all and to prevent unlawful discrimination. Our Council ensures delivery of our Equality & Diversity agenda, and the diversity team monitors our approach across all characteristics protected by the Equality Act 2010. We are working closely with others in the sector on the long-term need to improve the level of female representation. The University is an active member of the Higher Education Equal Opportunities Network and of Opportunity Now. It publishes an annual report that includes statistical data on gender, ethnicity, disability and related issues. Research areas and the University are benchmarked against the HE sector and the relevant disciplines in the UK. Diversity is embedded in staff development activities including training on the Equality Act and supporting students from diverse backgrounds.

(ii) Research students

Our research student experience is strongly influenced by our direct engagement with business. Most PhD and EngD students in UOA 6 are partially or wholly industrially or government funded, enjoying high levels of contact with the agriculture, food and environment sectors. For researchers, we have aligned a suite of doctoral training centres (DTCs) to the strategic themes of the University, with 'Environment' being the one most UOA 6 scholars are members of. Oversight of the DTCs is provided by the Pro Vice-Chancellor. DTCs foster a significant component of student-initiated, peer-to-peer learning. Alongside them, a STEM core skills programme promotes mixing between DTCs and supports the compilation of personal development portfolios. Researchers based in industry also benefit from a sponsor's professional development and obtain additional sector-focused competencies.

During the assessment period 70 EngD and PhD students related to the UOA graduated. There are 80 current full-time or part-time research students (71.5 FTE). Of these 16 are funded solely by charitable trusts or Research Councils, usually through Doctoral Training Accounts or the BBSRC Agriculture Advanced Training Partnership (6 students). A further 18 also receive charitable trust or research council funding through CASE, EngD or similar arrangements, and 40 are funded entirely by business or government. The remainder are self-funded or staff candidates. Research students enjoy high staff-student ratios and have access to near-industrial scale facilities. We recruit for organisational fit and an aptitude for independence, and insist on high levels of delegated responsibility, providing stipends above the sector average. Researchers frequently manage their sponsor-project interface, progress meetings, portions of experimental budgets and their periodic PhD reviews. They raise income for conference attendance from professional and learned societies, and are called upon to present to industrialists and government scientists. Research students experience the full technology train or policy development cycle, from fundamental enquiry to prototype, commercial or practical solutions for industry and government. They learn to manage constraints such as budgets and sponsors' expectations, preparing them for postgraduate life. They are expected to deliver excellent science, publish in international journals and present at national and international conferences.

d. Income, infrastructure and facilities

Academic and research staff are expected to demonstrate a capability for winning intellectually challenging, exciting and commercially-viable work, and delivering to our research partners' expectations. Unique experimental facilities are maintained and enhanced to high standards through access to margin generated from research and external capital funds. In pursuit of a leading edge pedigree for our niche areas, we seek peer-reviewed research income as the hub around which other projects and activities are supported. We manage a mixed platform *curiosity-driven science* (RCUK), *strategic and applied science* for long term policy design and delivery (e.g. Defra, EU, Environment Agency, Natural England), *critical appraisal and evidence analysis* for policy development and regulation (Defra, Environment Agency etc.) and *near market product and service development* (e.g. Unilever, PepsiCo, Syngenta, Sainsbury's). These components are mutually supporting, so research gaps identified by a piece of policy analysis are fed back as fundamental questions for future research council proposals, while EU and other income is sought for the implementation challenges raised by theoretical enquiry. On-going contract research and consultancy, more immediate in its objectives, acts as a reality check on the practicability of our

theoretical insights.

This purposeful blend of research income makes for a rich landscape across the technology readiness levels, ensuring the progression of science fundamental to the disciplines, its relevance to end users, timely policy design and industrial application, and utility for the practical implementation of research findings. Our close proximity to government and industry continually challenges the relevance of our work, and the strategic management of the overall income mix supports the long term financial sustainability of the activity. Our scholarship over the REF2014 assessment period has been supported by income secured from Research Council grants (£1.8 million), grants from Research Foundations and Charities (£0.3 million), UK government departments (£6.8 million), EU government bodies (£1.7 million) and from industry (£4 million). Since RAE2008, and employing the income generation and investment strategy above, we have sought to maintain the highest levels of discipline-oriented intellectual endeavour, with staff and facilities to underpin our work. Research council income increased strongly in the second half of the assessment period, due to increased focus on developing this type of research.

Our strategy is to undertake research across the spectrum of technology readiness levels. As a consequence, we invest in a distinctive range of facilities at, or near industrial scale (e.g. soil management facilities, the University farm at Silsoe). These allow us to create new knowledge across the spectrum from fundamental enquiry-driven research to the co-creation of knowledge with our strategic industrial partners. We hold and develop many of these facilities as national capability, for example national and international soil reference data and samples publically accessible through the Land Information System (LandIS) and the World Soil Survey and Archive Catalogue (WOSSAC) on behalf of Higher Education, Government and key business sectors in the wider economy. This critical mass of facilities has created an innovation habitat for the University that includes other national assets ranging from the Wolfson field laboratory to our real time respirometry and controlled atmosphere facility.

Strategically important investments during the assessment period

- The construction of nationally-important *pilot scale facilities* for terramechanics and erosion studies within the new soil and water management laboratory (Hudson Building), comprising a re-furbished processor and ‘soil bin’ for studying interactions between soil and mechanical devices (wheels, tines) and the effectiveness of soil management technology (e.g. geotextiles).
- The award of a Royal Society/Wolfson Foundation grant of £0.55 million, including matching funding from the Science Research Investment Fund, for refurbishing and developing *unique lysimeter facilities*, with a real-time stable isotope mass spectrometry for studying the dynamics of soil carbon and the connected emissions of greenhouse gases.
- Establishing one of Europe’s largest *post-harvest laboratories*, equipped with unique gas handling and storage capabilities allowing the simulation and analysis of optimal storage regimes that minimise food waste, whilst maintaining product quality.

These have enhanced the existing suite of facilities for this group.

Laboratories and field resources

- The *Cranfield soil management laboratory* (full-scale facilities for studying the dynamics of soil-machine interactions, unique in Europe; full scale rigs for studying soil erosion processes including for generating rainfall of different types and intensities; a ‘rain tower’ allowing very precise control of precipitation form (droplet size) and intensity for detailed studies of soil erosion.
- *Soil and plant laboratory*, providing a full range of equipment and processes for soil and plant characterisation; comprehensive equipment for soil physical and hydrological measurements (e.g. particle size distribution, nutrients, etc.)
- *Soil microbiology laboratory*, for measuring respiration, PLFA, and other parameters
- Instrumental laboratory, comprehensive analytical facilities, including GC-MS, LC-MS, ICP-MS, electron microscopy, etc.
- The *Wolfson lysimeters facility*, an array of 12 large lysimeters with contrasting soils and real

time sampling of emitted gases via automated closure systems connected to gas measurement (CO_2, N_2O, CH_4) and stable isotope mass spectrometry.

- *Plant sciences laboratory and research-grade glasshouses*, comprising full analytical capability (coupled chromatography and mass spectrometry including UPLC QToF-MS, TD-GCToF-MS, TD GC MS-MS analysis) for targeted and non-targeted metabolomics and research on genetically-transformed horticultural crops, for example.
- A University-owned, commercial 120 ha *arable and agro-forestry farm* at Silsoe for field experimentation and an associated agricultural equipment centre at Wilstead, Bedfordshire.

Data holdings

- *LandIS*. Cranfield holds the national soil information for England and Wales, including the entire data derived from the former Soil Survey of England and Wales, which it has integrated in to a searchable vector data system.
- The *World Soil Survey Archive and Collection*. Cranfield is the custodian of more than 20,000 maps, reports and other soil information collated from studies made worldwide by British scientists over the past century. This unique global resource covers a large part of the terrestrial surface of the planet.
- Cranfield holds the archive of the former *Soil Survey of England and Wales* including many thousands of geo-referenced soil samples of increasing value to cutting-edge development of pedometric analysis.

e. Collaboration and contribution to the discipline or research base

A summary is provided in the table. (Note: the statistics for publications etc, do not distinguish between cases where there are multiple internal or external co-authors because of the difficulties in allocating fractional authorships.)

Indicator	Number
Fellowships of learned societies	6
Committee members for learned societies	8
Members of Research Council Committees	8
Grant reviewers for Research Councils	8
Grant reviewers for charities, Royal Society and non-UK bodies	30
Journal Editors/Guest Editors/Editorial Boards	1/2/16
Refereed Journal Papers	330
Keynote and Invited Lectures	53
Conference Chairs and Organising Committees	2
Books (author or editor)	8
Book chapters	54
Members of standards committees	3

Examples of leadership of large Research Council projects are:

- Integrated land and water management in floodplains: Revisiting agricultural flood defence schemes in England and Wales (ESRC, BBSRC & NERC with Open University, 2006–9, £0.3 million) – **Hess**
- Transforming Water Scarcity through Trading (EPSRC with University College London, Leeds and Heriot Watt, 2011–15, £0.6 million) – **Weatherhead**
- Fragments, functions and flows – the scaling of biodiversity and ecosystem services in urban ecosystems (NERC BESS with Sheffield and Exeter, 2012–16, £2.5 million) – **Harris**

The staff entered in UOA 6 published about 330 peer-reviewed articles in the assessment period, cited about 3000 times; 27 were published in peer-reviewed journals with an Elsevier SCImago Journal Rank above 2.5 (the top 3% of journals). Examples of highly-cited papers include

- Hobbs RJ, Higgs E & **Harris JA** (2009) Novel ecosystems: implications for conservation and

restoration, Trends in Ecology & Evolution, 24 (11) 599-605. [**135**]

- Reed MS, **Graves AR**, et al (2009) Who's in and why? A typology of stakeholder analysis methods for natural resource management, Journal of Environmental Management, 90 (5) 1933-1949. [**92**]
- Bever JD, ..., **Tibbett M** & Zobel M (2010) Rooting theories of plant community ecology in microbial interactions, Trends in Ecology & Evolution, 25 (8) 468-478. [**84**]
- **Harris JA** (2009) Soil Microbial Communities and Restoration Ecology: Facilitators or Followers? Science, 325 (5940) 573-574. [**63**]

Additional dissemination routes for the group's work over the assessment period have included 53 invited or keynote presentations at International Conferences, 8 books as authors or editors and 54 book chapters. **Tibbett** co-chaired the organising committee for the Mine Closure Conference series and co-edited the proceedings. **Terry** was convenor of ISHS conference 2013 on Managing quality in Chains.

The group includes one Fellow of the Higher Education Academy (**Burgess**), two Fellows of the Institute of Agricultural Engineers (**Harris**, **Rickson**), one Fellow of the Society of Biology (**Harris**), and two Fellows of the Royal Society of Chemistry (**Kirk**, **Lambert**). **Magan** was President of British Mycological Society (2011, 2012), **Rickson** is a Vice-President of the Institution of Agricultural Engineers and **Harris** was Chair of the Society for Ecological Restoration (2009–11). **Harris**, **Littler** and **Tibbett** have been or are currently elected Council members of the British Society of Soil Science, and **Hess** is a member of the British Hydrological Society National Committee.

Ritz is a chief editor of Soil Biology & Biochemistry, and **Tibbett** was invited guest editor of issues of Plant and Soil (2012) and Agriculture Ecosystems Environment (2012). In addition, members of the group are associate editors or editorial board members of Australian Journal of Botany, Biosystems Engineering, Computers and Electronics in Agriculture, European Journal of Soil Science, FEMS Microbiology Ecology, Hydrogeology Journal, Fungal Biology (formerly Mycological Research), Postharvest Biology and Technology, Quarterly Journal of Engineering Geology and Hydrogeology, Restoration Ecology (2 members), Soil Research , Soil Science Society of America, Soil and Tillage Research Journal and World Mycotoxin Journal.

Staff are active on research council committees and as grant reviewers in the UK and abroad. **Ritz** was a member of the BBSRC Sustainable Agriculture Strategy Panel (2009–10) and Chair of the BBSRC:NERC Soils Research Advisory Committee (2006–8). **Kirk** is a Core Member of BBSRC Research Committee B (2011 on) and **Harris** has been a member of four NERC panels. Four staff have been members of the NERC peer review college, and others have acted as reviewers for NERC programmes and BBSRC grants. Reviewing for other UK bodies includes the Royal Society (**Littler**, **Tibbett**) and the Leverhulme Trust (**Ritz**). Internationally, staff have acted as panel members and reviewers for bodies in 13 countries including the US National Science Foundation (**Holman**, **Tibbett**), the Canadian Natural Sciences and Engineering Research Council (**Hess**, **Holman**) The Finnish Academy of Sciences (**Ritz**, chair of Environment Panel, Grants and Awards), the National Research Foundation South Africa (**Terry**), and for organizations such as the European Research Council (**Ritz**).

Members of the group also have advisory and other non-academic appointments. **Hess**, **Littler** and **Rickson** are members of ISO, European and BSI standard committees respectively. **Harris** has advised on Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas and **Tibbett** on matters related to mine closure for the governments and regulators of India, Australian and Papua New Guinea. Other examples include **Hess**, Co-Chair, International Life Sciences Institute (Europe) Environment and Health Task Force, and **Magan**, International Commission for Food Mycology committee member.

Collaborative research is the usual practice at Cranfield, promoted by seeking partners for projects from other institutions, working together to develop intellectual capital, publishing jointly and exploiting partnership working through repeat collaborations. Partnerships are in place with other institutions in the UK including Aberdeen, Bangor, Bristol, Cambridge, Durham, East Anglia, Exeter, Harper Adams, Imperial College, Nottingham, Leeds, Oxford, Southampton and Swansea

Universities, the British Geological Survey, the Centre for Ecology and Hydrology, the James Hutton Institute, East Malling Research and Rothamsted Research. A formal research collaboration has been in place with Teagasc (Ireland) throughout the assessment period, which has supported 7 PhD studies. Other European partnerships include Federal Geological Institute (Germany), INRA (France), Joint Research Centre (Ispra, Italy), Wageningen University (Netherlands), University of Leuven (Beligium) and Umweltbundesamt (Austria). International partnerships include Embrapa (Brazil), Connacyt (Mexico), Texas A&M (USA), Tocklai Experimental Station (India), Landcare Research (New Zealand), Stellenbosch University (South Africa). Notably, we also host the offices of the British Society of Soil Science and the Institution of Agricultural Engineers, providing a base for exceptionally close relationships and support.

Our research, both fundamental and applied, contributes to the discipline across a range of institutional scales. At the highest *international level*, the group's research contributes to the achieving the UN Millennium Development Goals and the aspirations of the Rio+20 meeting. An example, is support for the emerging FAO Global Soil Partnership, through attendance at initial meetings and sharing of expertise in large-scale digital soil mapping (e.g. of Africa). At the *continental level*, research informs policy development by the European Commission and its agencies in pursuit of the overarching 'Framework' policies. Examples for the EC include the Thematic Strategy for Protection of Soil, the Blueprint to Safeguard Europe's Water Resources, development of risk-based methodologies for priority areas of soil protection (with DGENV, JRC and Defra) and reporting on the state of contaminated land in Europe (with EU Joint Research Centre and European Environment Agency). *Nationally*, our research informs the development of UK policy in response to climate change and, increasingly, future food security in the UK and beyond, which we anticipate will strengthen in response to demands from the policy community. Connected to this, the national evaluation of options for the future management of land resources (including water) is drawing on our research. Examples include agricultural water demand (for the Environment Agency and regional development agencies) and the future management of biodiversity in urban habitats (NERC).