

Institution: University of Exeter
Unit of Assessment: 17a (Geography & Environmental Studies)
Title of case study: Use of soil erosion and soil quality research to inform development of DEFRA (Department for Environment Food and Rural Affairs) and international agricultural land management policy
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Geography at Exeter has a well-established reputation for research on the effects of soil erosion and land management on soil quality, diffuse pollution, and on water quality in UK river systems. Since 2008, this research has been used to inform DEFRA policy, in relation to soils, water, and the DEFRA code of good agricultural practice. Dissemination of effective approaches to land management, most especially through the Catchment Sensitive Farming Initiative has resulted in clearly demonstrable changes in farming practice by landowners in several priority river catchments within the UK, demonstrating a positive change in behaviour and improved management of environmental risk. In addition, research on agricultural erosion has been used in the development of new agricultural policy practices in Canada.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>The 2011 Food and Agricultural Organization of the United Nations (FAO) report 'State of the World's Land and Water Resources for Food and Agriculture' states that 33% of global agricultural land is moderately or highly degraded. Consequently the need to address soil erosion and diffuse water pollution, as major threats to food security, are recognised as priorities within EU (Water Framework Directive and Soil Thematic Strategy) and Global (UN Food and Agriculture Organization and Committee on World Food Security) policy agendas. Understanding the processes (both natural and anthropogenic) that accelerate degradation of land and water is thus of paramount importance for policymakers and land managers alike.</p> <p>The impacts from this case study are underpinned by decades of research quantifying soil erosion at Exeter, initially by Walling, who pioneered the use of sediment geochemistry and, with Quine, the application of radionuclides to trace soil and sediments in the landscape, and more recently by Quine and Brazier who have developed this research to focus on the on-site and off-site impacts of soil erosion, both of which relate to land management practices. Research quantifying soil redistribution by tillage and the associated impact on soil properties (1999 onwards) has contributed extensively to the body of knowledge surrounding onsite soil erosion, soil quality, and land management practices. This work led to a paradigm shift in erosion research, identifying the equal importance of tillage erosion to that of water, with respect to onsite impacts (Govers et al., 1996; Quine et al., 1997). Research using the radionuclide caesium-137 resulted in the construction of a tillage erosion database for Europe (TERON, a European Community Specific Programme, 1994-98) and the development of a new technique for assessing the extent of tillage erosion, a method confirmed by empirical tests in China, Lesotho, and Zimbabwe (Quine et al., 1999). The strong control on within-field spatial distributions of soil nutrients and crop production that is exercised by tillage erosion has subsequently been demonstrated in the UK (Quine & Zhang, 2001), Greece (Kosmas et al., 2001) and Denmark (Heckrath, et al., 2005). Up-scaling of this research then led to examination of the impact of water and tillage erosion on the global carbon cycle (Van Oost et al., 2007). This research used radionuclides and carbon inventory measurements to assess the significance of these processes on the global carbon budget and directly challenged the view that agricultural erosion represents an important source or sink for atmospheric CO₂.</p> <p>From 2004, research funded by the NERC and DEFRA was expanded to examine the off-site effects of erosion on the quality of surface water resources in the UK. Brazier's research highlighted the importance of soil erosion as a source of pollutants in water bodies, yet identified a discernible lack of data with which to inform government policy (Brazier, 2004). Brazier and co-workers at Exeter consequently developed a suite of novel monitoring tools to quantify sediment and nutrient fluxes from lowland grassland catchments, demonstrating the significance of erosion</p>

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from these landscapes and the resulting impact of sediment and colloid (both carriers of nutrients) pollution on freshwater bodies (Brazier et al., 2007). This research highlighted the need to change the way in which grasslands are perceived, monitored and managed. It also demonstrated the importance of studying the onsite impacts of grazing (on soil properties) in conjunction with the offsite impacts on water quality. Resulting datasets and modelling tools permitted prediction of the effects of changing land management practices on rates of erosion, a process instrumental in changing the advice disseminated by DEFRA via the Catchment Sensitive Farming Initiative (see Section 4). Most recently, the first catchment-scale study of grassland erosion has been completed in Devon, UK, confirming the erodible nature of agricultural grasslands (Bilotta et al., 2010) and their previously overlooked role as a source of pollutants. In addition, the development of a new method for assessing the ecological threat posed by suspended solids in water has demonstrated that catchment outputs frequently exceed water quality guidelines dictated by the EU Freshwater Fisheries Directive (78/659/EC). Ongoing research, funded by DEFRA (SP1303 and SP1311) and led by Brazier is now building on the relationship between land management techniques, soil erosion rates and water quality, to inform government policy by developing a national erosion monitoring capability for England and Wales (Brazier et al, 2011).

Key researchers:

Prof. Richard Brazier, currently Associate Professor (employed at the University of Exeter since 2006).

Prof. Timothy Quine, currently Professor (employed at the University of Exeter since 1987).

Prof. Desmond Walling, currently Emeritus Professor (employed at the University of Exeter since 1971).

3. References to the research (indicative maximum of six references)

Evidence of the quality of the research that underpins this case study is provided through the following peer-reviewed publications and related grant funding.

Bilotta, G., Brazier, R.E, Haygarth, P. 2007. The impact of grazing animals on the quality of soils, vegetation, and surface waters in intensively managed grasslands. *Advances in Agronomy* 94.

Bilotta, G., Krueger, T., Brazier, R.E, Butler et al. 2010. Assessing catchment-scale erosion and yields of suspended solids from improved temperate grassland. *Journal of Environmental Monitoring* 12, 731-739.

Brazier, R.E. 2004. Quantifying soil erosion by water in the UK: a review of monitoring and modelling approaches. *Progress in Physical Geography* 28, 340-365

Quine, T.A., Govers, G., Walling, D.E., Zhang, X., Desmet, P.J.J., Zhang, Y. 1997. Erosion processes and landform evolution on agricultural land - new perspectives from caesium-137 measurements and topographic-based erosion modelling. *Earth Surface Processes and Landforms*, 22, 799-816.

Van Oost, K., Quine, T. A., Govers, G., De Gryze, S., Six, J., Harden, J. W., Ritchie, J. C., McCarty, G. W., Heckrath, G, Kosmas, C., Giraldez, J. V., da Silva, J. R. Marques, Merckx, R. (2007). The impact of agricultural soil erosion on the global carbon cycle, *Science*, 318, 626-629.

Quine, T.A. and Zhang, Y. 2002. An investigation of spatial variation in soil erosion, soil properties and crop production within an agricultural field in Devon, UK, *Journal of Soil and Water Conservation*, 57, 55-65.

Key supporting grants

- DEFRA PEO113 (10/03-12/07) Delivery of phosphorus from agricultural sources to watercourses. Brazier as Co-I with co-investigators at the Universities of Exeter and Lancaster, IGER and ADAS (total awarded: £449,954).
- DEFRA PEO120 (01/05-12/08). Quantifying grassland erosion and nutrient fluxes from lowland agricultural catchments. Brazier as Co-I with scientists from the Institute of Grassland and Environmental Research, Devon; Plymouth University, Lancaster University and the Centre for Hydrology and Ecology, Wallingford (total awarded: £701,000).
- NERC CASE PhD award (02/07-12/11). Multi-scale predictions of soil erosion and water quality

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- from intensively managed grasslands (£60,000). Brazier as lead supervisor
- NERC CASE PhD award (02/10-01/13). Impacts of farm-scale ecosystem management on water quality in intensively managed grasslands (£66,945). Brazier as lead supervisor
 - 01/10/2010 DEFRA SP1303 (£49,656 to Brazier as PI; Quine CoI) Developing a cost effective framework for monitoring soil erosion in England and Wales.
 - 2007-2009 NERC EHFI (£57,271 to Exeter) Impacts of Climate Change on Erosion, Sediment Transport, and Soil Carbon in the UK and Europe.
 - 2010-13. ESRC-NERC Studentship. An investigation into farming practice and the maintenance or improvement of soil organic carbon levels.
 - 01/06/2013. DEFRA (£604, 837) Piloting A Cost-Effective Framework For Monitoring Soil Erosion In England And Wales; Brazier (PI), Anderson and Quine (Co-I).

4. Details of the impact (indicative maximum 750 words)

Research outlined above has: (i) impacted on **DEFRA policy development** and **RCUK research policy** with respect to soil erosion, land management, and water quality; and (ii) resulted in **increased awareness and operational change** in the UK and international farming communities, in relation to effective agricultural land management practices. Much of the underpinning research has been conducted in conjunction with DEFRA and has led to significant and wide-ranging involvement in a number of **DEFRA expert advisory roles**. These have included the DEFRA National soil erosion policy meeting (Brazier, Quine, Walling, July 2008; Exeter one of 5 Universities represented), DEFRA Integrated Water and Agricultural Management Scheme (March 2009, Exeter only UK University involved), DEFRA indicators of soil quality workshop (September 2012) and steering roles on the Phosphorus Export and Delivery from Agricultural Land Project (November 2009, February 2012, only UK University involved on the steering group alongside representatives from DEFRA, Environment Agency and Nature England). Research into on-site processes has also increased knowledge and understanding of erosion rates, the contribution of tillage erosion to soil erosion, the impact of erosion on soil properties and recognition of the erosive nature of lowland grasslands (evidence **items #1 and 2**). Crucially, this research has resulted in Exeter Geography being invited to build a new cost-effective **national erosion monitoring capability in the UK**. This capability will be unique in the EU and will support the UK's response to the forthcoming EU Soils Framework Directive (evidence **item #3**). As a result Brazier was also invited to contribute to the NERC Sustainable Agriculture Task Force, to help develop **research policy** for sustainable food production research over the next decade (evidence **item #4**).

Significant advances in understanding of off-site impacts, and especially quantification of the contribution of agricultural erosion to diffuse pollution of surface waters in England and Wales, has also had a direct impact on **environmental policy changes** made by national government. This research has underpinned the adjustment of grassland management practices to reduce the likelihood of contravening EU water quality guidelines, and evidence of this impact is confirmed by written correspondence from both the soil research and water quality research teams at DEFRA (see letters; evidence **item #5**). This body of research has also directly influenced the working practices of DEFRA's 'arms-length' bodies, the Environment Agency (EA) and Natural England (NE). Both agencies commissioned Brazier to talk directly with farmers and advise on a range of soil management techniques, including direct advice on which subsoiling approaches can be used to combat soil compaction (Field workshop with >40 farmers from the Otter and Exe catchments at the National Trust's Killerton Estate, July 2008) and Brazier was asked to report directly back to the EA and NE on the lessons learnt from these workshops (evidence **item #6**).

In addition to contributing to policy direction and development, **environmental awareness** has been enhanced through the dissemination of knowledge relating to effective land management practices to the UK farming community via Catchment Sensitive Farming (CSF), an initiative funded by DEFRA and the Rural Development Programme, and delivered by the Environment Agency and Natural England. Brazier has been funded via DEFRA's Integrated Water and Agricultural Management (IWAM) program, to deliver workshops to land users and CSF officers on grassland erosion and land management (for example, Rothamstead Research, North Wyke workshop, March 2010 – evidence **item #7**). Through the CSF officers, priority catchments in Devon have also been targeted, resulting in the dissemination of key research findings that support changes in farming practice to directly reduce diffuse water pollution and achieve healthier river

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systems. Resultant changes in management approaches demonstrate the impact of this research in **changing awareness and operational activities** relevant to the environment and improved **management of environmental risks**. The reach and significance of these impacts has been verified by written correspondence from CSF officers in the Taw, Torridge, Otter and Exe river catchments (for example see evidence **item #8**).

In addition to influence on UK policy, work on tillage erosion with International partners (TERON group in Europe; Lobb, Manitoba, Canada) has led to incorporation of tillage erosion in international indicators of environmental sustainability (e.g. OECD, evidence **item #9**) and underpinned **international policy change**. In Canada, Lobb and Quine received AUCC (Canadian Government) funding to support soil redistribution within cultivated landscapes research and the emission of greenhouse gases, a collaboration that has supported **engagement with policy-makers** in Canada, and resulted in widespread acknowledgement of the importance of tillage erosion. Agriculture and Agri-Food Canada now use tillage erosion models for national agricultural assessments, with two such assessments since 2008 (evidence **item #10**). Tillage erosivity data tables have also been developed for use in these modelling exercises, and all provinces in Canada now include control of tillage erosion in their Environmental Farm Plan initiatives that farmers must carry out to receive government "green" subsidies (examples are provided as evidence **item #11**).

5. Sources to corroborate the impact (indicative maximum of 10 references)

#1. Haygarth, P., Bol, R., Macleod, C., Butler, P., Hawkins, J., Brazier R.E. et al. 2009. Final Report to Defra Project PEO120 – Phosphorus mobilisation with sediment and colloids through drained and undrained grasslands.

#2. Quine, T.A., Van Oost, K., Walling, D.E. and Owens, P.N. (2006). Development and application of GIS-based models to estimate national rates of soil erosion by tillage, wind and root crop harvest. Univ. of Exeter Report to DEFRA, Project SP08007.

#3. Brazier, R.E., Anderson, K.A., Quine, T., Quinton, J., Evans, M., Rickson, J, Bellamy, P., Rawlins, B., Ellis, M. (2011) Developing a cost-effective framework for monitoring soil erosion in England and Wales. Final report to Defra for project SP1303

#4. NERC – invitation to be part of NERC Sustainable Agriculture Task Force, from Manager, NERC Knowledge Exchange Programme on Sustainable Food Production Attendance at first workshop in Cambridge, January 2013.

#5. DEFRA – letters from the soil and water quality research team to verify the impact of this research in influencing policy direction and development.

#6. Brazier, R.E. (2011) Understanding the impact of subsoiling on soil quality – the Elbury Farm pilot project. Final Report to the Environment Agency, Natural England and the National Trust.

#7. IWAM – DEFRA initiative, letter from organising committee inviting Brazier to participate in training workshops with CSF officers and farmers

#8. Catchment Sensitive Farming – letter demonstrating the contribution of Dr Brazier and team, and the changes in farming practice resulting from this engagement.

#9. Environmental Performance of Agriculture in OECD Countries since 1990: Other Agri-environmental Indicators(2008) <http://www.oecd.org/tad/sustainableagriculture/40673129.pdf> p. 200-206

#10. National recognition of tillage erosion importance & severity in Canada: Agriculture & Agri-food Canada, 2010, Environmental Sustainability of Canadian Agriculture, Agr-Environmental Indicator Report Series, p. 45-53. (http://publications.gc.ca/collections/collection_2011/aqr/A22-201-2011-eng.pdf)

#11. Examples of provincial soil management guides including tillage erosion:

Manitoba: <http://www.gov.mb.ca/agriculture/soilwater/soilmgmt/fsm01s07.html>

Ontario: Guides #02 and #06: <http://www.omafra.gov.on.ca/english/environment/bmp/series.htm#3>