# Research Summary

# Effect of Soil Structure and Field Drainage on Water Quality and Flood Risk

Scotland's centre of expertise for waters

## MAIN FINDINGS

The project provided evidence for Scotland on the state of field drainage and soil structure in Scotland during the autumn and winter where the impacts on flooding and water quality can be greatest. The project found severe soil structural degradation in 18% of topsoils and 9% of subsoils for 120 fields in four catchments across Scotland: the Ugie (Aberdeenshire), the South Esk (Angus), East Pow (Perthshire) and Coyle (Ayrshire). The severe 2015/2016 winter precipitation caused a 30% increase in occurrence of severely degraded topsoils, as determined from sampling some of the same fields before and after this unprecedented weather event. Run-off, erosion and nutrient losses were about 10 times greater from degraded parts of fields such as tramlines than either within the field or at less trafficked boundaries. There was some agreement between areas identified as structurally degraded and those ranked as being susceptible to topsoil compaction using a simple model. Farmers suggested widespread degradation of artificial drainage, with a visual assessment confirming poorly functioning systems.

## BACKGROUND

Key question: are degraded agricultural drains and soils affecting flood risk and water quality in the winter in Scotland?
The maintenance of soil structure and functional field drainage has a large impact on runoff, water storage and potentially water quality. Scotland's climate, machinery traffic and livestock trampling on agricultural soils, could make it very vulnerable the impacts of degraded soil structure and field drainage. Based on a questionnaire to Scotland's farmers, field monitoring from SEPA Catchment Coordinators and evidence from other regions, there is visual evidence of standing water on agricultural fields, degraded soil structure and poor investment in drain maintenance. Farmers identified drainage and soil compaction as the greatest threats that soils face in Scotland (Munday, 2013). Studies dating back to the 2000 floods in England and Wales reported that autumn land management when soils are wet cause's damage, and that drains are less effective due to decreased investment.

Data integrating field drainage, soil structure degradation and water quality are scarce in Scotland. This has been emphasised in numerous reports, including the supporting material used to develop the Scottish Soils Framework Directive (Scottish Government, 2009) and the State of Scotland Soil report (Dobbie et al., 2011). Recent desk studies commissioned via CREW that gathered data on agricultural drainage and its impact on flood risk in Scotland also identify a lack of available data (Lilly et al., 2012). There is wider UK evidence of widespread soil structural degradation associated with cropping practice (Palmer and Smith, 2013), and increasing debate amongst hydrologists linking soil structural degradation and flood risk (Holman et al., 2003; O'Connell et al., 2007). These studies also link poorer drainage to overland flow and water quality, which has been the subject of far greater research.

## RESEARCH UNDERTAKEN

The project linked field survey data with existing modelling approaches that identify compaction and drainage risks. The full report uses data from sampling of 120 fields from 4 catchments in Scotland to describe the state of soil structure in the winter. The study uses the increasingly popular and easily interpretable Visual Evaluations of Soil Structure (VESS) and Subsoil Structure (SubVESS). The study was conducted in winter 2015/2016, which was the wettest on record, with Eastern Scotland receiving 228% its average rainfall in January. A total of 42 fields were sampled before and after intense and prolonged precipitation to observe soil structure changes resulting from winter rainfall.

## RECOMMENDATIONS

Soil structure and drainage degradation are serious threats to farming and the environment in Scotland. Incentives and education could improve soil structure of many farms. Less autumn/winter traffic, more organic matter incorporation and avoiding root crops on vulnerable soils are potential mitigation practices. Farm specific surveys and management plans should be implemented in areas identified at being at risk. Some drains appear to be poorly functioning, but only cursory evidence is provided in this report, so greater monitoring is needed before deciding on action. Moreover, a broader evidence base, backed with more quantitative data such as hydraulic conductivity, would greatly benefit environmental monitoring in Scotland. A major outcome from this project was the training of non-experts in assessing soil structure in the field, to assist with such monitoring.

## KEY WORDS

- Soil structure
- Field drainage
- Flood risk
- Water quality
- Compaction,
- Degradation

## RESEARCH TEAM

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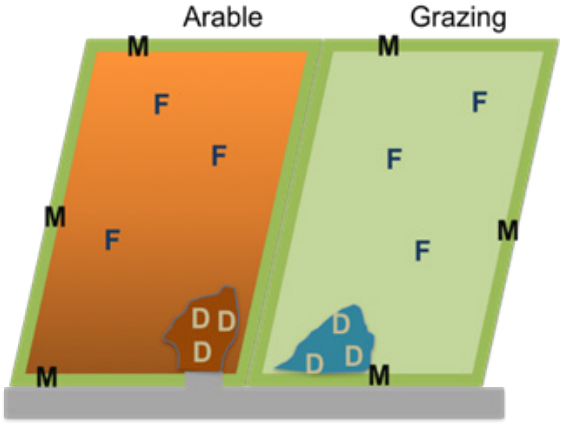
Location of the four catchments sampled during this project and specific sampling locations. Symbols in red indicate sampling locations




Sampling locations in a typical Arable or Grazing field. The symbols refer to F – within the operation field, D – areas of heavy traffic that are visibly degraded on the surface, and M – less trafficked regions at the field margin. We refer to these areas as In Field, Margin and Damaged, respectively in the remainder of the report.


Evidence of structural degradation of the surface soil [a].Poached topsoil [b] Topsoil erosion [c] Waterlogging [d] slaked topsoil