The impact of cattle access and exclusion from watercourses on freshwater geochemical and microbial parameters

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BACKGROUND

Cattle access to watercourses can result in the contamination of surface waters with nutrients, sediments and faecal pathogens. This is particularly relevant to Ireland, where cattle-based agriculture is the dominant land use.

Whilst there have been several studies in the USA, Australia and New Zealand on the impacts of cattle access to water quality parameters, there have been limited studies in an Irish or European context. Despite this, measures to exclude cattle from watercourses (e.g. fencing) have been included in all Irish agri-environment schemes to date, including the current Green Low Carbon Agri-environment Scheme.

Fig. 1 – 3 – Cattle access points in different locations across Ireland, where it is possible to see the erosion of stream banks and direct deposition of faecal matter on stream banks and in the stream. Photos: Paul O'Callaghan.

The current study is part of the project *Cattle exclusion from watercourses: environmental and socio-economic implications* (COSAINT) (EPA funded under the Research Programme 2014-2020), and is focused on the impacts of cattle access on nutrient loading, sediment loading, and indicators of faecal contamination. Cattle access points were sampled in five different catchments. Sediments will be characterised upstream of and at access sites, while sediment incubations will provide information on nutrient exchange with stream waters. High resolution sampling for nutrients, motion sensor cameras to monitor cattle activity, and sediment sensors will be used to quantify the contribution of cattle in-stream activity to changes in nutrient and sediment concentrations. Sampling of sites after cattle access restriction measures implementation will allow a "before and after" comparison. Collected data will then be used in a dynamic catchment model to estimate nutrient, bacterial and sediment loadings at the catchment scale and allow for scenario testing.

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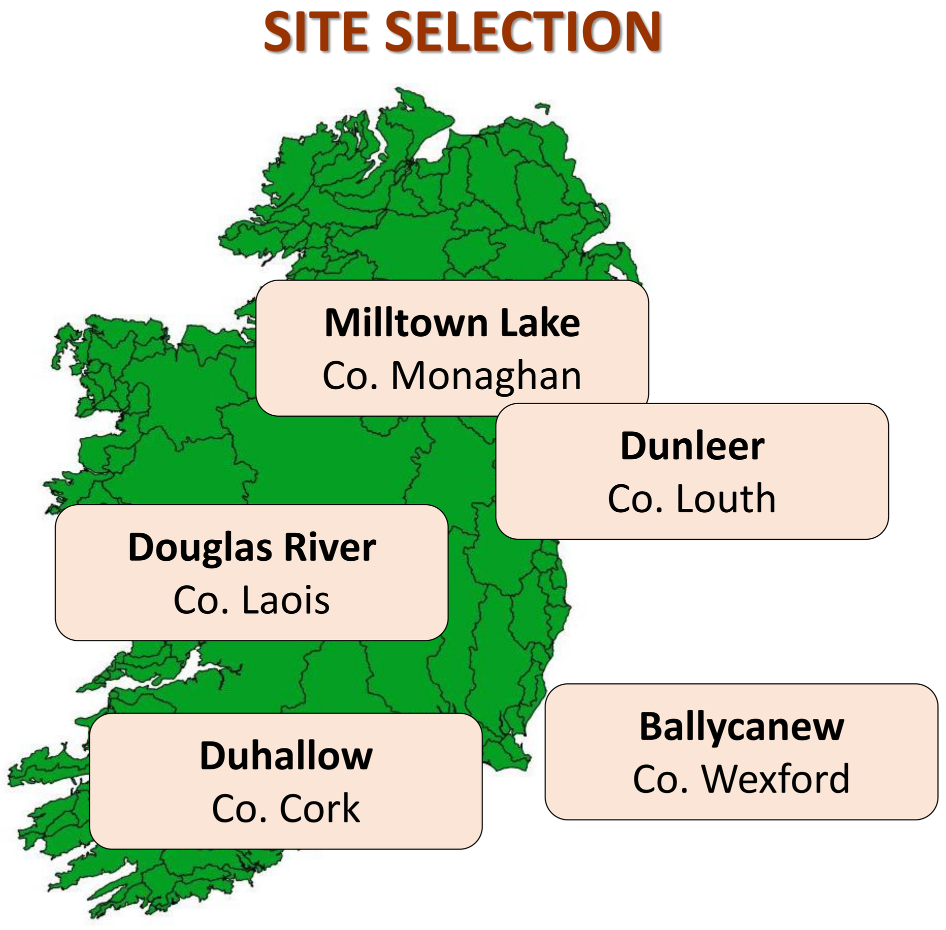
RESEARCH QUESTIONS

- What is the impact of cattle access to watercourses and cattle in-stream activity on freshwater **geochemical parameters** (e.g. water and sediment nutrient levels, sediment organic matter content)?
- How does cattle access to watercourses and cattle in-stream activity affect **sediment export and dynamics**?
- What is the impact of cattle access to watercourses and cattle in-stream activity on the **delivery and distribution of FIB in streams**?
- What is the **impact of cattle exclusion measures** on the observed effects of cattle access to watercourses on freshwater geochemical and microbial parameters?
- What can be the impact of cattle access to watercourses **at the catchment scale**?

SITE SELECTION



Across Ireland, three catchments with intensive stocking density and two catchments with extensive stocking density were selected for this study. Three cattle access points were sampled at each catchment.

METHODS

Task 1. Low resolution catchment scale evaluation of cattle access to watercourses and cattle in-stream activity on water geochemical and microbial parameters

Water Grab samples were collected upstream and at cattle access points to be analysed for total and dissolved nutrients (nitrogen and phosphorus).

Sediments Samples were collected upstream, downstream and at the sites to determine nutrient content, organic matter content and sediment particle size.

Faecal indicator bacteria (FIB) Sediment samples will be collected upstream and at the sites to evaluate contamination with faecal bacteria (*Escherichia coli*, other coliforms).

Fig. 4 – Pre-sampling of the selected sites.

Task 2. High resolution sampling to assess the impact of cattle access to watercourses and cattle in-stream activity on freshwater geochemical parameters

This task will focus on events – cattle in-stream activity and high flow periods – along with baseflow periods, in order to capture nutrient, sediment and FIB levels dynamics at cattle access points during disturbance.

Fig 5 – High resolution hydrometric station of the Agricultural Catchments Programme (Teagasc) at the Ballycanew catchment; Fig.6 – Motion-activated infrared camera to be used in this study.

Nutrients Autosamplers will be deployed upstream and downstream the cattle access point, sampling water at hourly/subhourly frequency. Motion-activated infra-red cameras will record the number of cattle in stream and frequency of defecation/urination to allow estimation of direct nutrient inputs. Sediment-water incubations will be performed to estimate nutrient exchange between water and sediment/OM-bound fractions.

Sediments Nephelometers will be positioned upstream and downstream of the cattle access point to assess sediment losses from direct disturbance of the stream bed and stream banks.

Faecal indicator bacteria (FIB) Water samples will be collected to determine water levels of faecal contamination due to direct contamination and resuspension of bacteria in sediments.

Task 3. The impact of cattle restriction measures (under GLAS) on freshwater geochemical parameters

Selected sites that have been sampled in Task 1 and fenced under GLAS will be resampled to assess the effectiveness of the measure. Additionally, the effects of watercourse fencing in the longer term will be evaluated at a fenced stream in the Milltown Lake catchment.

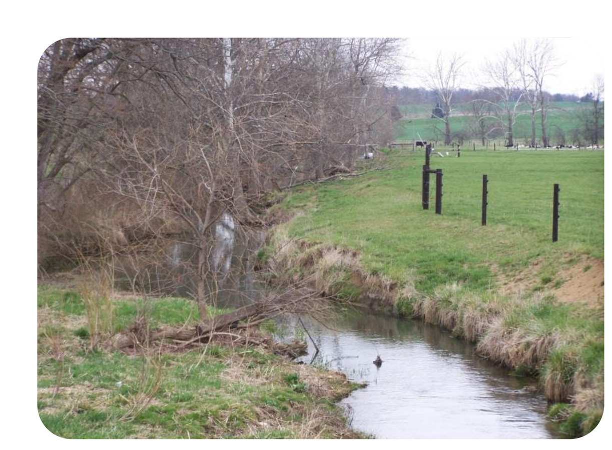


Fig. 7 – Fencing has been applied as a cattle exclusion measure.

Task 4. Modelling the impact of cattle access at the catchment scale and assessment of management scenarios

The Generalized Watershed Loading Functions (GWLF) model will be used to obtain estimates of nutrient, sediment and bacterial loadings in the context of the whole catchment for the Milltown Lake catchment (Co. Monaghan). This task will build on previously collected data, including high frequency data for nutrients collected at the outflow of the catchment. The model will allow for scenario testing for management options.

REFERENCES

Collins, R., M. McLeod, M. Hedley, A. Donnison, M. Close, J. Hanly, D. Horne, C. Ross, R. Davies-Colley, C. Bagshaw and L. Mathews (2007). "Best Management Practices to mitigate faecal contamination by livestock of New Zealand waters." New Zealand Journal of Agricultural Research **50**: 267-278.

Collins, R. and K. Rutherford (2004). "Modelling bacterial water quality in streams draining pastoral land." Water Research **38**(3): 700-712.

Davies-Colley, R. J., J. W. Nagels, R. A. Smith, R. G. Young and C. J. Phillips (2004). "Water quality impact of a dairy cow herd crossing a stream." New Zealand Journal of Marine and Freshwater Research **38**(4): 569-576.

Evans, D. J., C. E. Gibson and R. S. Rossell (2006). "Sediment loads and sources in heavily modified Irish catchments: A move towards informed management strategies." Geomorphology **79**(1–2): 93-113.

Miller, J., D. Chanasyk, T. Curtis, T. Entz and W. Willms (2010). "Influence of streambank fencing with a cattle crossing on riparian health and water quality of the Lower Little Bow River in Southern Alberta, Canada." Agricultural Water Management **97**(2): 247-258.

Vidon, P., M. a. Campbell and M. Gray (2008). "Unrestricted cattle access to streams and water quality in till landscape of the Midwest." Agricultural Water Management **95**(3): 322-330.

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