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Cattle access to watercourses: Environmental and socio-economic implications

Key external stakeholders:

Policy-makers, land-owners, water-managers, stakeholders involved in water quality.

Practical implications for stakeholders:

Cattle access to watercourses can significantly impact on a number of environmental variables associated with water quality, particularly at a local scale.
Exclusion of cattle from watercourses can help improve the quality of environmental indicators over the short and long term. Removal of animal access to watercourses can also reduce the quantity of faecal indicator bacteria in the water and associated bed-sediment.
Multiple, targeted, mitigation measures should be incorporated and incentivised. Incentivising provision of alternative water supplies, to avoid the need for cattle to access watercourses for drinking water, could be considered in future revisions of the Common Agricultural Policy.

Main results:

- Cattle access points resulted in significant increases in the deposition of fine bed sediment, which acted as reservoirs for faecal bacteria and phosphorus. Near real-time monitoring showed increases in suspended sediment, *E. coli,* total phosphorus and ammonium when cattle were in the stream. Increased sediment deposition was a driver of macroinvertebrate community change.
- Exclusion of cattle from watercourse can help improve the quality of environmental indicators over the short and long term.
- The majority of farmers already prevent livestock from accessing watercourses and most of the remainder intend to exclude livestock from watercourses in the future. Providing greater knowledge to farmers improves confidence in their ability to perform water protection measures.

Opportunity / Benefit:

Key points to help inform policy include:

- Cattle exclusion from watercourses can improve the ecological quality of watercourses
- Multiple, targeted, mitigation measures should be incorporated and incentivised.
- Incentivising provision of alternative water supplies, to avoid the need for cattle to access watercourses for drinking water, could be considered in future revisions of the Common Agricultural Policy
- Providing greater knowledge to farmers on the environmental impact of cattle exclusion, coupled with information on appropriate, cost-effective approaches to prevent livestock access to watercourse improves confidence in their ability to perform water protection measures such as fencing watercourses. Additionally, farmers could be encouraged or incentivised to join group learning environments.

Collaborating Institutions:

University College Dublin; Dundalk Institute of Technology; Dublin City University

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1. Project background:

Loss of pollutants from grassland systems to waterbodies is a significant threat to water quality and represents one of the main environmental problems facing agri-ecosystems in Ireland. The EU Water Framework Directive requires Member States to achieve or maintain at least 'good' ecological and chemical status in all waters by 2027. Previous studies suggest that unrestricted cattle access to watercourses can result in deteriorating water quality; however, conflicting studies have indicated that cattle do not have a significant effect on some aspects of stream water quality. Despite some divergence of opinion in the literature, cattle exclusion measures, typically in the form of fenced riparian buffers, have been included in most European AES, including Ireland's (e.g. REPS; AEOS; GLAS), and are amongst the commononest mitigation measure to prevent cattle access to watercourses. Whilst the effectiveness of riparian buffers as a multi-functional management tool has been widely researched, few studies have specifically assessed the impact of cattle exclusion on water quality parameters, especially within Europe.

2. Questions addressed by the project:

The aim of this project was to assess the environmental, ecological and socio-economic impact of existing and potential measures that prevent cattle access to watercourses. Specific objectives were to:

- Assess the impact of cattle access and cattle in-stream activity on freshwater geochemical, sediment and biological parameters (including macroinvertebrates, diatoms and faecal indicator bacteria).
- Evaluate impact of cattle exclusion measures (under GLAS) on freshwater geochemical, biological and ecological (in-stream and hyporheic) parameters.
- Evaluate the cost-effectiveness of fencing (and critically assess natural alternatives to fencing) as measures to improve the hydro-morphological condition of watercourses.
- Evaluate the cost-effectiveness of existing and novel water provision mechanisms.
- Determine the proportion of farms that have flowing or still water on or adjacent to their land parcel, thus potentially impacted by cattle exclusion measures.

3. The experimental studies:

The research approach used was a combination of analysis of existing datasets, and collection of new field and experimentation datasets (temporal and spatial). These datasets were coupled with analysis of existing and newly collected data in relation to farmer attitudes to the environment, their perception of estimated costs associated with cattle exclusion measures and their likelihood of adopting specific existing and potential measures to prevent cattle access, or novel water provision mechanisms.

The experimental design focused on five catchments (incorporating both intensively and extensively managed catchments), Inclusion of a variety of sites (i.e. three cattle access sites per catchment) facilitated the evaluation of local/reach scale effects in relation to catchment-scale effects.

Water column samples (grab samples) were collected and analysed for dissolved (filtered) and particulate nutrients at all sites. The study also provided estimates of the level of contamination (nutrient and biological) of stream bed sediment from cattle access. Intensive sampling of stream-water for both dissolved and particulate nutrients (N and P) was undertaken at a selected cattle access point. Autosamplers were positioned both upstream and downstream of access sites, sampling at sub-hourly time intervals during events. Cattle numbers accessing these sites, and the frequency of urination/defecation, were captured using motion sensor infrared cameras positioned at key points, supplemented by direct observation in the field. These data were also used to inform on estimates of nutrient loading from direct inputs from cattle, together with literature values and frequency of defecation/urination.

Samples of deposited sediment were taken from riffle habitats at control, pressure and recovery points using the 'Quorer' resuspendable sediment sampling technique and analysed for total biomass and organic content. A habitat assessment was carried out at all sites.

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Biological sampling was undertaken in autumn and spring. Sites were located upstream and downstream of cattle access points in each of five catchments and at a distance downstream to determine the extent of any impact and incorporate the cumulative influence of multiple access points. The impact of cattle access on stream ecology was assessed through the use of macroinvertebrate and diatom bioindicators.

Benthic macroinvertebrates were investigated at control, pressure and recovery points using six replicate macroinvertebrate samples taken using a standard Surber sampler. Variations in macroinvertebrate richness, abundance, water quality and functional metrics and community structure were assessed.

Diatoms sampling, preparation and analysis was undertaken following standard techniques.

Periphytic algal biomass was measured by assessing the chlorophyll *a* content of algal scrapings from substrate cobbles at each of the 15 study reaches.

Macrophytes were surveyed in July 2016 over 40m reaches upstream and downstream of each cattle access points.

Stable Isotopes were used to distinguish between signals originating from potential sources (e.g. animal manure, domestic sources etc.) and to assess the impact on ecological communities and their functioning.

The project used statistical matching techniques pioneered by Teagasc, to create a national map of synthetic farms from real parcels boundaries, the population statistics of which will match those of the actual national farm population. A spatial intersection of the synthetic farm boundaries with the National OSI water body layer was used to calculate a suite of statistics of on farm water courses, including total length, number of farms affected, average area and length on farm etc. An accuracy assessment of the results was carried out, with particular attention paid to attempt to address shortcomings in the OSI water data with some watercourses not being mapped completely.

The project determined the attitude of farmers towards agri-environment measures and their willingness to adopt, and their perception of the estimated costs associated with cattle exclusion measures. This task built on the work of Teagasc researchers who completed a questionnaire of over 1,000 respondents in late 2012. The task developed and completed new attitudinal/economic survey focusing on agri-environment measures associated with *Protection of Watercourses*.

Main results:

- There are 129,600 farms with 2.9 million fields in Ireland. 95,000 farms and 382,000 fields adjoin a watercourse; 73% of all farms have an on-farm watercourse.
- Cattle access to watercourses resulted in a:
  - significant increase in deposited sediment in streams.
  - negative impact on riparian habitat condition.
  - Higher concentration of fine sediments in the hyporheic zone
  - Higher concentrations of sediment *E. coli* concentrations (in the mid-grazing season)
  - Higher concentrations of bed sediment phosphorus
  - Macroinvertebrate responses at certain sites in both autumn and spring sampling seasons.
- A significant correlation was found between cattle numbers in the stream and the difference between upstream and downstream turbidity. A moderate correlation was seen between the length of time of cattle in a stream and the difference in upstream and downstream turbidity.
- The bed sediments at all sites, even those upstream of cattle access points were contaminated with *E. coli*. These results highlight the widespread contamination of stream sediments with *E. coli* in agricultural catchments.
- There was no evidence of a cumulative impact of cattle access points on, sediment deposition, sediment nutrient parameters, habitats and biodiversity or on indicators of faecal contamination.
- Exclusion of cattle from watercourses can help improve the quality of environmental indicators over the short and long term. One year of full cattle exclusion resulted in improvements with regard to deposited stream sediment, phosphorus concentrations in sediment, macroinvertebrate communities (in a number of sites). Improvements in environmental parameters also persisted over a longer period of fencing (e.g. ten years post fencing), particularly with regard to macro-invertebrate communities with significant improvements in sensitive bio-indicators.
- Targeting cattle exclusion to derogation farms is more cost effective (at removing direct faecal material) than by focusing on non-derogation farms.
- Socio-economic, demographic and psychology variables all contribute to influence farmers' intentions to fence watercourses.
  - Farmers who feel a large degree of social pressure from important reference groups are more likely to fence watercourses.

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- Farmers who feel they have the necessary knowledge and information to undertake fencing and provide alternative water supplies are more likely to intend to fence.
- Participatory and collective approaches are likely to have a positive influence on the intention to fence.

4. Opportunity/Benefit:

It is anticipated that results from the project will provide important information for policymakers in relation to the Nitrates and Water Framework Directives. It will also help guide agri-environmental policy and facilitate sustainable intensification objectives under Food Wise 2025. Key points to help inform policy include:

- Cattle exclusion from watercourses can improve the ecological quality of watercourses in the short, and long-term
- Multiple, targeted, mitigation measures should be incorporated and incentivised.
- Incentivising provision of alternative water supplies, to avoid the need for cattle to access watercourses for drinking water, could be considered in future revisions of the Common Agricultural Policy
- Providing greater knowledge to farmers on the environmental impact of cattle exclusion, coupled with information on appropriate, cost-effective approaches to prevent livestock access to watercourse improves confidence in their ability to perform water protection measures such as fencing watercourses. Additionally, farmers could be encouraged or incentivised to join group learning environments

5. Dissemination:

Main publications:

O'Callaghan, P., Kelly-Quinn, M., Jennings, E., Antunes, P., O'Sullivan, M., & Ó hUallacháin, D. (2018) The environmental impact of cattle access to watercourses: a review. *Journal of Environmental Quality*, 48: 340-351

O'Sullivan, M., Ó hUallacháin, D., Jennings, E., Antunes, P. & Kelly-Quinn, M. (2019) The impacts of cattle access points on deposited sediment levels in headwater streams in Ireland. *River Research and Applications*. 35, 146-158

Kilgarriff, P., Ryan, M., O'Donoghue, C., Green, S., and Ó hUallacháin, D. (2020) Livestock Exclusion from Watercourses: Policy Effectiveness and Implications. *Environmental Science and Policy*. Accepted

Stutter, M., Kronvang, B., Ó hUallacháin, D., Rozemeijer, J. (2019) Current insight into the effectiveness of riparian management attainment of multiple benefits and potential technical enhancements. *Journal of Environmental Quality* 48: 236-247

O'Sullivan, M., Ó hUallacháin, D., Antunes, P., Jennings, E., & Kelly-Quinn, M. (2019) The impacts of cattle access to headwater streams on hyporheic zones. *Biology and Environment* 119B, 13-27

O'Sullivan M. (2019) *The ecological impacts of cattle access to headwater streams on freshwater ecosystems*. Unpublished PhD thesis.

O'Callaghan, P., Kelly-Quinn, M., Jennings, E., Antunes, P., O'Sullivan, M., Fenton, O. and Ó hUallacháin, D. (2018) *Impact of Cattle Access to Watercourses: Literature review on behalf of the COSAINT project*. EPA report No. 260.

Selection of Conference presentations

Antunes P.A., Jennings, E., Ó hUallacháin, D., Kelly-Quinn, M., O'Sullivan, M. & Regan, F. (2018) A real-time sampling experiment to assess the impacts of cattle access on freshwater biogeochemical parameters in a farmland stream. *International Society of Limnology Congress 34*, China, August, 2018

Kilgarriff, P., Ryan, M., O'Donoghue, C., Green, S. and Ó hUallacháin, D. (2018) Cattle exclusion: policy effectiveness, adoption and implication. *EAAE seminar on sustainability in the Agri-Food sector*. Galway, August 2018.

Kilgarriff, P., Ryan, M., Green, S., O'Donoghue, C., and Ó hUallacháin, D (2018). Spatial analysis of the geography of Irish farms. *Conference of Irish Geographers, Maynooth, May 2018*

O'Sullivan, M., Ó hUallacháin, D., Antunes, P., Jennings, E., Linnane, S., Murnaghan, S., Regan, F., and Kelly-Quinn, M. (2017) The ecological impacts of cattle access on freshwater ecosystems. *Symposium for European Freshwater Sciences*, Olomouc, Czech Rep. July 2017

Antunes, P.O., Jennings, E., Ó hUallacháin, D., Kelly-Quinn, M., Linnane, S., Murnaghan, S., O'Callaghan, P., O'Sullivan, M., Regan, F. (2016) The impact of cattle access and exclusion from watercourses on freshwater geochemical and microbial parameters. *Global Lake Ecological Observatory Network (GLEON)* Lunz & Gaming, Austria, July 2016.

Kilgarriff, P., Ryan, M., O'Donoghue, C., Green, S. and Ó hUallacháin, D. (2018) Cattle exclusion: policy effectiveness, adoption and implication. *Presentation to the Luxembourg Institute of Socio-Economic Research* 2018.

6. Compiled by:

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