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Extent and role of ditches in affecting hydrological connectivity in agricultural landscapes

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The ease of nutrient transfer from agricultural sources to downstream watercourses is partly dependant on the hydrological connectivity of the landscape which is influenced by surface and sub-surface ditch networks. Approaches to understanding, testing and quantifying hydrological connectivity in the environment have centered on models and indices, many of which have not been tested for their ability to account for surface ditch networks, such as the 'network index' (NI) model (Lane et al., 2004, Lane et al 2009). This model estimates of the time–averaged spatial variability in surface and near-surface connectivity, in terms of both the propensity and generation of hydrological connection. An evaluation of this model as a metric for surface and near-surface connectivity with and without the inclusion of the ditch network is being undertaken in two agricultural watersheds (∼12 km2) in Ireland: well drained Catchment A and poorly drained Catchment B.

A field survey of the ditch networks in both catchments was conducted to map their extent, and physical characteristics. Results were digitised in ArcGIS and subsequently 'burned' into a 5m x 5m digital elevation model (DEM) by reducing the elevation to the recorded depth for ditches. The NI model was applied to both the original and modified DEMs. These were compared for direction and magnitude of connected flows at the field, ditch network and subcatchment scales using GIS tools. Validation is underway and consists of hydrograph analysis of flow discharge data from 3 locations in each catchment and field surveys across scales and seasons mapping percentage areas of fields and lengths of ditches with observable surface flowing water.

Ditch density (excluding streams) was much higher in Catchment B (5,865m km-2) than Catchment A (1,271m km-2) illustrating their widespread nature on poorly drained soils. The ability of the original NI model to predict direction of flow (represented by the surveyed ditch network) improved as the scale increased; however, mis-alignment at the field scale was substantial. The modified NI model provided a more accurate representation of observed flow direction at all scales largely because alignment with the ditch network was substantially improved at the field scale. This demonstrates that inclusion of ditch networks may provide a better metric for surface connectivity at this scale. Comparison of mean connectivity scores between the original and modified NI for catchment A, illustrated that 'burning' ditches into the DEM reduced the connectivity within fields, ditch networks and subcatchments, while increasing the connectivity within the ditch and stream channels. Therefore the original NI model may be over-estimating the presence of critical source areas (CSAs) and underestimating the role of within-channel connectivity (which may connect other parts of the landscape). On-going work will validate these trends which are important for identifying CSAs for nutrient loss in the landscape.

References

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