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

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1.Introduction

Understanding the hydrological connectivity of agricultural landscapes is important for the identification of critical source areas for nutrient loss.

Aim: to evaluate a topographic-based hydrological connectivity model (Network index (NI) of Lane *et al.* 2004) as a metric for surface connectivity. The NI model was tested with and without the inclusion of the ditch network in the digital elevation model (DEM), in two agricultural watersheds (~12km2) in Ireland; well drained Catchment A & poorly drained Catchment B.

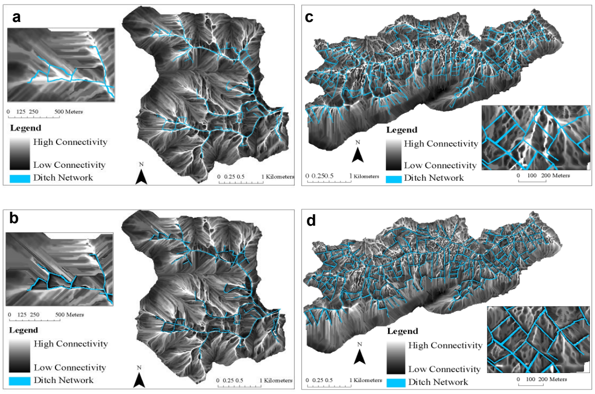

Figure 1. NI values at 5 m pixel resolution and observed channel locations for Catchment A, original DEM (a) and modified DEM (b) and Catchment B, original DEM (c) and modified DEM (d).

2.Methods

- Catchment DEMs at 5 m resolution were topographically corrected to include the observed channel networks.
- The NI model was applied to the original and modified (topographically corrected) DEMs.
- Observations of **structural (flow direction)** and **functional (flow magnitude)** connectivity were used to validate the models at the field, ditch network and subcatchment (includes1st - 3rd order streams) scales.
- Ditch locations were the observed indicators of structural connectivity. Extent and degree of connection (standing/flowing) of surface water within fields and channel densities were the observed indicators of functional connectivity.

3.Results

Structural connectivity

Original NI model

Accurate at the subcatchment scale for Catchment A, but may cause erroneous CSA identification in Catchment B. Misalignment was substantial at smaller scales (Fig.1 a & c).

Modified NI model

Accurate at all scales largely due to substantial improvements at the field scale (Fig. 1b & d).

Functional connectivity

Original NI model

Reliable only at the subcatchment scale for Catchment B (Fig.2). Unreliable predictions were due to:

- Over estimation of surface connectivity on naturally and artificially well drained soils.
- Effects of misalignments in flow-direction.

Modified NI model

Topographic correction for the ditches reduced surface connectivity within the landscape and increased surface connectivity within channels (Fig. 3).

Reduction may be over-exaggerated due to the slope values at the ‘trenched’ channel edges being distorted over 5 m pixels, as well as exaggeration of ditch widths during digitisation to ensure capture by the 5 m DEMs.

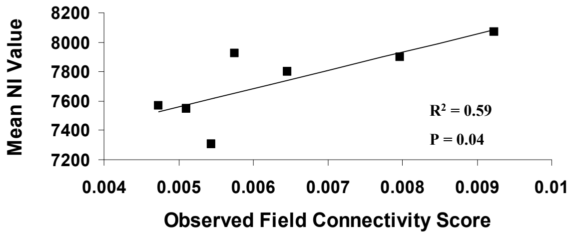

Figure 2. Predicted NI values without topographic correction vs. observed field connectivity scores between subcatchments in Catchment B

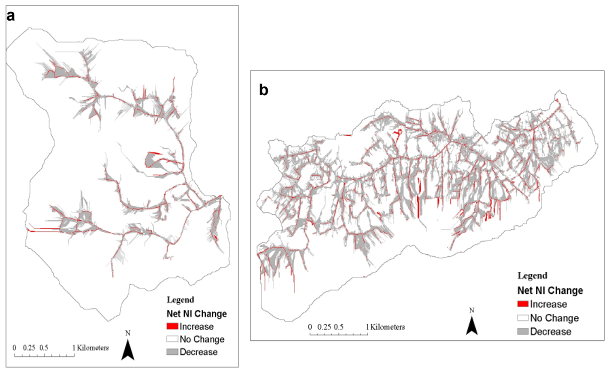

Figure 3. Net NI value change as a result of topographic correction for ditches for a) Catchment and b) Catchment B.

4.Conclusion

Information on drainage features is required to accurately identify surface structural and functional connectivity at scales smaller than 1st - 3rd order stream watersheds. For 1st - 3rd order stream watersheds, the NI model provides;

(i) Accurate prediction of surface structural connectivity in Catchment A. However errors observed in Catchment B (largely attributed to its high proportion of ‘flat’ areas and high ditch densities) may lead to erroneous CSA identification.

(ii) A reliable prediction of the relative functional connectivity between subcatchments where surface flow dominates flow paths.

Scales of drainage features need to be greater than or equal to the scale of the DEM (e.g. from LIDAR data) to avoid distorting their impact on modelled connectivity.

Reference

Lane, S.N., Brookes, C.J., Kirkby, M.J., Holden, J. (2004) A network-index-based version of TOPMODEL for use with high-resolution digital topographic data. *Hydrol. Proc.* **18**, 191-201.