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Identifying hydrologically sensitive areas using LiDAR DEMs to mitigate critical source areas of diffuse pollution: development and application

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Identifying critical source areas (CSAs) of diffuse pollution in agricultural catchments requires the accurate identification of hydrologically sensitive areas (HSAs) at highest propensity for generating surface runoff and transporting pollutants such as phosphorus (P). A new GIS-based HSA Index is presented that identifies HSAs at the sub-field scale. It uses a soil topographic index (STI) and accounts for the hydrological disconnection of overland flow via topographic impediment from flow sinks such as hedgerows and depressions. High resolution (0.25-2 m) LiDAR Digital Elevation Models (DEMs) are utilised to capture these microtopographic controls on flow pathways and hydrological connectivity. The HSA Index was applied to four agricultural catchments (∼7.5-12 km2) with contrasting topography and soil types. Catchment HSA sizes were estimated using high resolution rainfall-quickflow measurements during saturated winter storm events in 2009-2014, and mapped using the HSA Index. HSA sizes ranged from 1.6-3.4% of the catchment area during median storm events and 2.9-8.5% during upper quartile events depending on whether well or poorly drained soils dominated, which validated HSA Index value distributions. Total flow sink volume capacities ranged from 8,298-59,584 m3 and caused 8.5-24.2% of overland-flow-generating-areas and 16.8-33.4% of catchment areas to become hydrologically disconnected from the open drainage channel network. HSA maps identified ‘delivery points’ along surface runoff pathways where transported pollutants such as P are delivered to the open drainage network. Using these as proposed locations for targeting mitigation measures such as riparian buffer strips (RBS) reduced costs compared to blanket implementation within an example agri-environment scheme by 66% and 91% over 1 and 5 years respectively, which included LiDAR DEM acquisition costs. Considering that HSAs are often the dominant P CSA factor in agricultural catchments and can override source pressures, targeting measures at HSAs is potentially a more sustainable, cost-effective and policy-applicable strategy for mitigating diffuse pollution.