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ASSESSING THE INHERENT VULNERABILITY OF SCOTLAND TO NITRATE POLLUTION AS A FUNCTION OF CLIMATE

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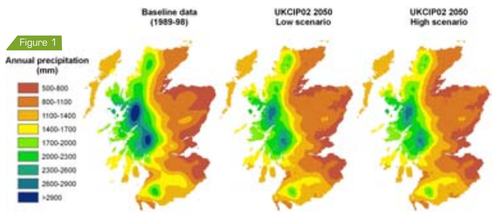
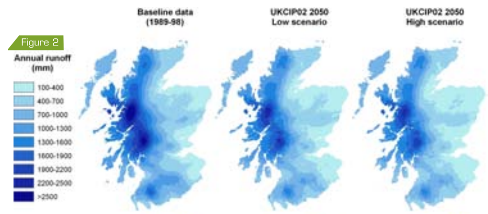
INTRODUCTION: Climate exerts an important role in determining losses of nitrate from the land to surface- and ground-water bodies. As well as influences on the nitrogen cycle it has important controls on the hydrological processes that determine not just the amount of nitrate leached, but also the ability of systems to cope with leached nitrate through dilution. A consequence of this is that some areas have a much greater inherent vulnerability than others to high nitrate concentrations in surface- and ground-waters, regardless of land management activities.

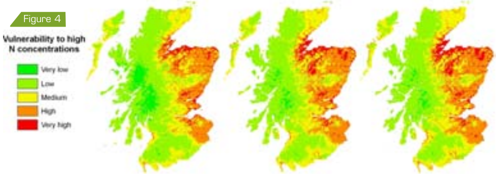
APPROACH: A national water balance model (Dunn et al., 2004a) has been applied together with a simple nitrate leaching model (Dunn et al., 2004b) to examine the vulnerability of different parts of Scotland to nitrate pollution as a consequence of climate. Weekly, spatially interpolated, historic meteorological data have been used to represent a baseline period from 1989-1998. Note that this baseline encompassed a period of drier weather than the standard 1961-90 baseline. The climatic influence on N leaching has been assessed by applying a spatially uniform residual N input (of 25kg/ha), assumed to be available for leaching at the start of autumn. The implications of climate change have been examined through the application of UKCIP02 climate change scenarios for the 2050s. Scenarios for monthly precipitation and potential evapotranspiration have been applied to the water balance and nitrate leaching models to estimate the corresponding changes in runoff and nitrate leaching.

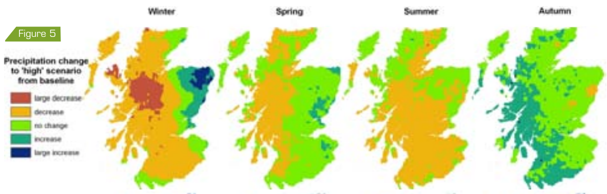
RESULTS: ***Mean annual effects***

The UKCIP02 2050 scenarios predict a decrease in mean annual precipitation in the west of Scotland and an increase in the east (Figure 1). This leads to a corresponding decrease in the modelled mean annual runoff in the west. However, runoff in the east is not increased because of higher predicted evapotranspiration rates (Figure 2). The potential flux of N leached is higher in the wetter areas, where it approaches 100% of the residual N. The effect of the climate change scenarios is to reduce the flux of N leached in areas of the north and east of the country (Figure 3). Although the leached fluxes of N are greatest in the west, the concentrations are low because of high runoff, leading to a lower inherent vulnerability to N pollution in the west compared with the east of Scotland (Figure 4). The average impact of climate change on potential mean N concentrations is relatively small due to counter-acting influences. A slight increase in vulnerability occurs in the central north.









Seasonal effects

The climate change scenarios indicate significant seasonal changes in precipitation, with the greatest impact in winter, when a large decrease is predicted for the west and a large increase for the east (Figure 5). Similar less significant effects occur in spring, and there is a general decrease in summer precipitation. Autumn precipitation increases in the west and is largely unchanged elsewhere. Changes in winter runoff mimic the precipitation changes (Figure 6). In spring and summer higher evapotranspirtaion rates exacerbate the effect of reduced precipitation in lowering runoff, particularly in the central north. Although relative amounts of summer runoff are greatly reduced this represents only a small volumetric change. The reduced precipitation in the early part of the year together with increased evapotranspiration rates, mean that the soils take longer to recharge in the autumn, resulting in reduced autumn runoff. The seasonal variability in potential N leaching largely follows the seasonal variability in runoff patterns (Figure 7). There is a notable delay in the autumn release of N for the climate change scenarios, which varies across the country as a function of the total precipitation. The inherent vulnerability to high N concentrations in winter and spring runoff is increased in the north and west due to the decreased runoff (Figure 8). Values in the east are less affected due to higher winter runoff. The delay in runoff generation in the autumn leads to a reduction in N concentrations in the east of the country during the autumn months.

CONCLUSIONS: Model simulations of runoff and potential N leaching have shown that climate change is likely to modify the seasonality of Scotland's inherent vulnerability to nitrate pollution. The results obtained from the simulations were not intuitive from the raw climate change scenarios.

References: Dunn,S.M., Lilly,A., DeGroote,J., and Vinten,A.A. (2004a) Nitrogen risk assessment model for Scotland: II. Hydrological transport and model testing. Hydrology and Earth System Sciences 8 (2), 205-219; Dunn,S.M., Vinten,A.J.A., Lilly,A., DeGroote,J., Sutton,M.A., and McGechan,M. (2004b) Nitrogen risk assessment model for Scotland: I. Nitrogen leaching. Hydrology and Earth System Sciences 8 (2), 191-204.

Acknowledgements: This research was funded by the Rural and Environment Research and Analysis Directorate of the Scottish Government.