Hydrology and Earth System Sciences
An Interactive Open Access Journal of the European Geosciences Union

Hydrol. Earth Syst. Sci., 8, 764-777, 2004
www.hydrol-earth-syst-sci.net/8/764/2004/

Water quality improvements from afforestation in an agricultural catchment in Denmark illustrated with the INCA model

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Abstract. Intensive agricultural land use across Europe has altered nitrogen (N) budget of catchments substantially, causing widespread N pollution of freshwater. Although the N cycle in forests has changed due to increased N deposition, most forest soil waters in Europe have low nitrate concentrations. The protective function of forests on water quality has led to increasing interest in the planting of new forests on arable land as a measure to protect valuable or sensitive freshwater resources. The paper illustrates the effects of afforestation on water and N cycling using the Integrated Nitrogen Catchment (INCA) model. The model was calibrated on the Horndrup catchment in the eastern part of Jutland, Denmark, which is dominated by agricultural land use but also covered by 18% of forest land. The dynamics of nitrate concentrations in the stream water were simulated successfully by INCA over a three-year period. The simulation of the dynamics of nitrate concentrations in the soil water is closely linked to the simulation of the hydrological dynamics and especially to the rainfall. The best fit was achieved for both arable and forest land during the wettest year of the study period. The model was then used to simulate the effect of afforestation of a catchment dominated by agriculture on N fluxes with seepage and runoff. Scenarios of whole catchment conversion to forest were run, based on observations of evapotranspiration and N deposition from other Danish sites. The simulated conversion to mature forest reduced runoff by 30–45% and reduced the nitrate concentrations in the soil water by 50–70%. The simulated effect of afforestation on N leaching was an almost direct reflection of the change in the N input: substantial changes in the plant demand and soil N dynamics over the afforestation period were not simulated. To simulate the N dynamics over longer time-scales, appropriate for the study of afforestation, it is suggested that the INCA model be run with transient scenarios and linked to more detailed plant and soil models.

Keywords: afforestation, arable land, forest hydrology, INCA, modelling, nitrogen, nitrate leaching

Final Revised Paper (PDF, 1092 KB)

Citation: Bastrup-Birk, A. and Gundersen, P.: Water quality improvements from afforestation in an agricultural catchment in Denmark illustrated with

the INCA model, Hydrol. Earth Syst. Sci., 8, 764-777, 2004. Bibtex EndNote Reference Manager