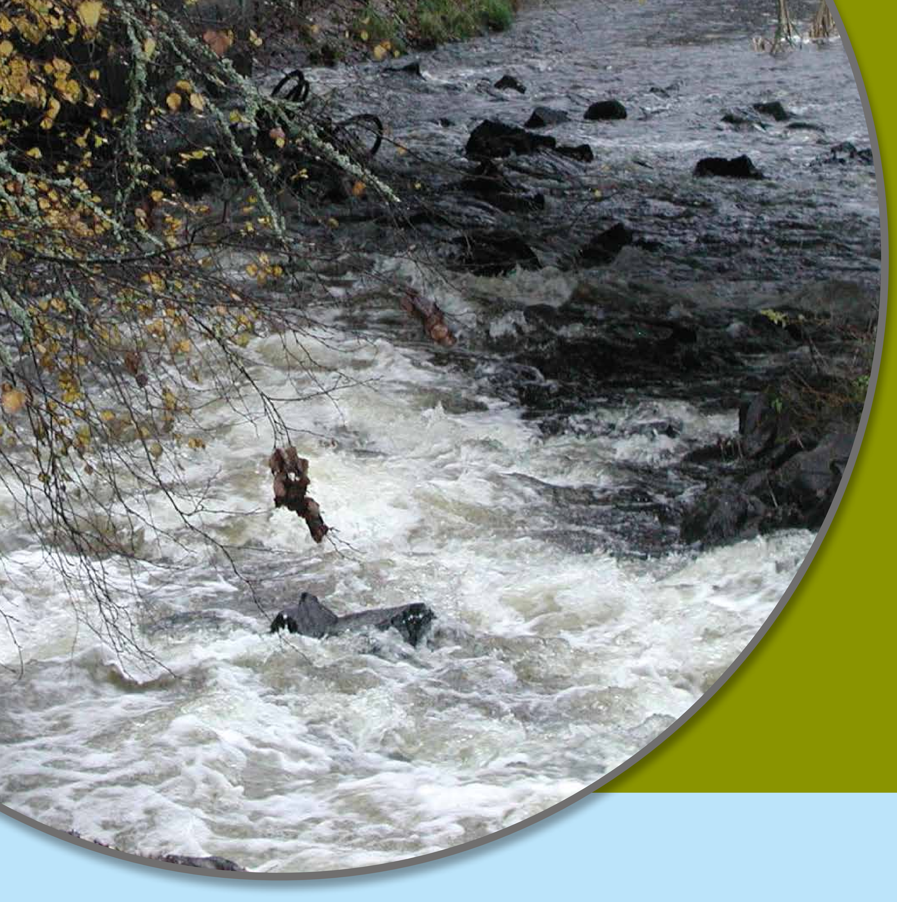

Vulnerability of boreal zone for increased nitrogen loading due to climate change

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Background

The observed rapid warming of the boreal zone is expected to continue. Also precipitation is assumed to increase in future. These changes may increase nitrogen loading from terrestrial environments to water bodies by accelerating soil organic matter decay and by increasing runoff. Nitrogen (N) is limiting nutrient in the Baltic Sea but also in some lakes where these changes may increase eutrophication. Further, high nitrate levels in drinking water may cause methaemoglobin anemia for humans, and nitrate is also connected to increased risk of diabetes and cancer. Thus EU has set upper limits to nitrate concentration in drinking water. These upper limits are mainly exceeded in well waters, but there are also observed occasionally high concentrations in ground waters in Finland.

Material and methods

We simulated N loading from two boreal catchments Lepsämänjoki and Mustajoki (Fig. 1) to the receiving waters by the dynamic, catchment scale model INCA (1,2) in different climate change and land use change scenarios in which increased temperature sum was assumed to favor winter cereal production. We calculated land use and soil type specific N loading values using climate scenario input from years 1980-2009 and 2020-2049. We upscaled the N-loading values to the larger Vanajavesi river basin, combining them with the information of population density of 14 municipalities of the area, to assess the future exposure to increased nitrate concentrations. Exposure was assessed as the product of the population density and the difference in nitrate load between the base line and the future scenario.

Results

In the scenario runs for the years 2020-2049, the peak runoff due to snow melt shifted to earlier spring, and the runoff in late autumn and winter increased (Fig. 2). The growing season was prolonged in response to warming climate in spring (Table 1), allowing more efficient vegetation uptake of nutrients. In general, land use change had higher influence on N loading than increase in precipitation and temperature alone. Small groundwater aquifers and private wells in the middle of agricultural fields proved to be in the risk of increased N concentrations, but increases may occur also in forested areas on permeable soil types (Fig. 3).

References

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2) Wade, A., Durand, P., Beaujoan, V., Wessels, W., Raat, K., Whitehead, P.G., Butterfield, D., Rankinen, K., Lepistö, A. (2002) Towards a generic nitrogen model of European ecosystems: New model structure and equations. Hydrology and Earth System Sciences 6, 559-582.

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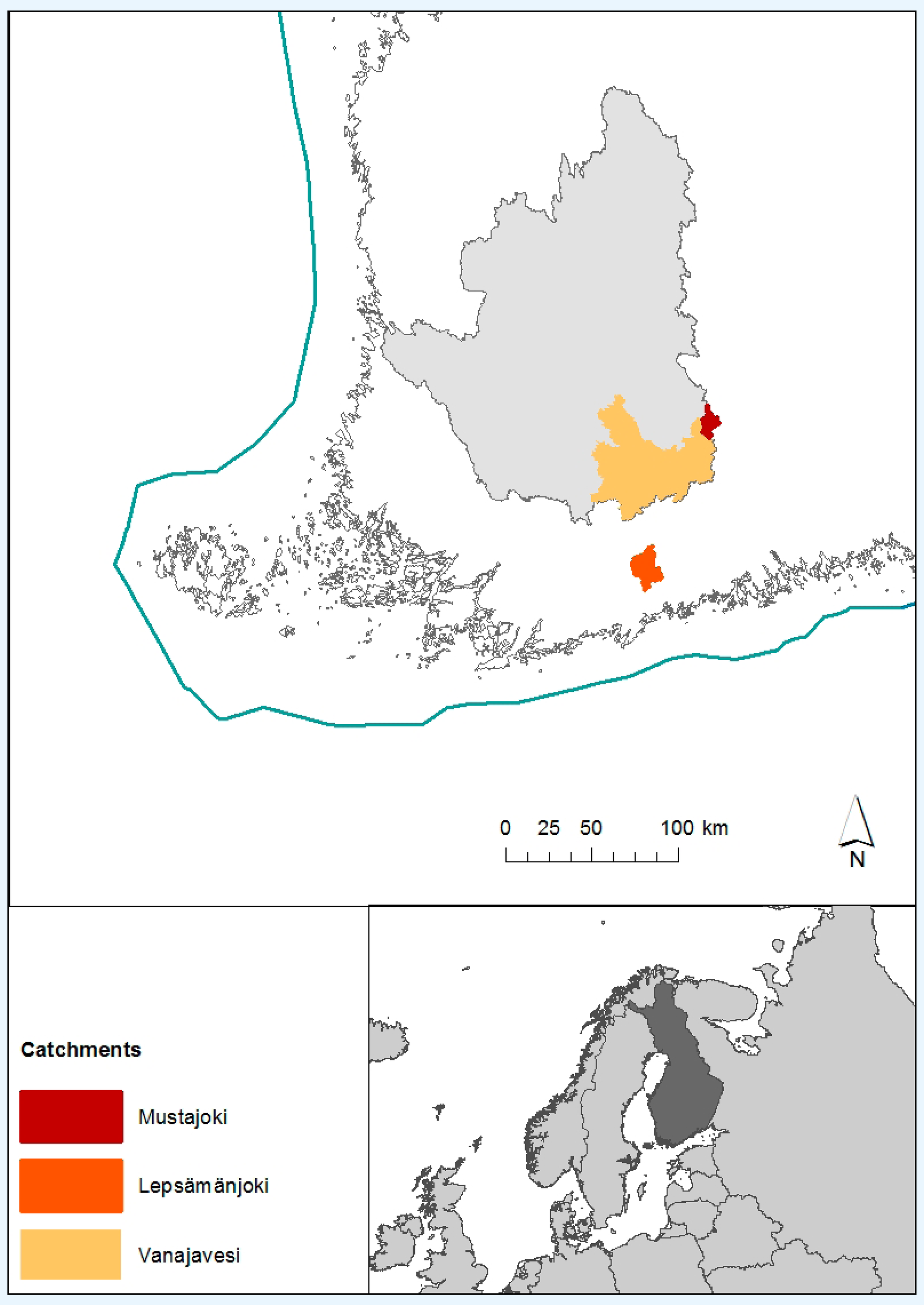

Figure 1. Location of the study catchments.

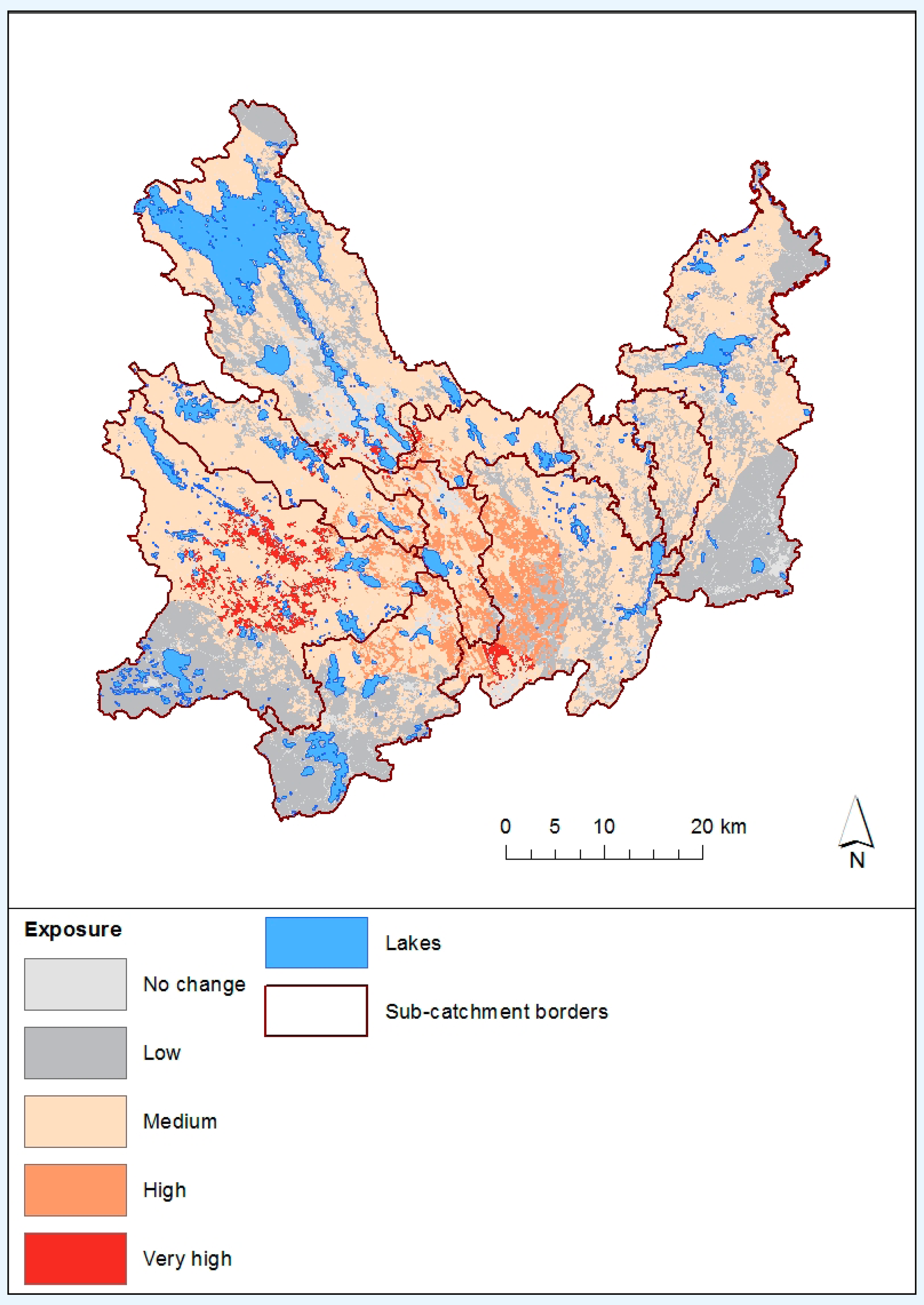

Figure 2. Exposure for increased nitrogen loading due to climate change in the Vanajavesi river basin.

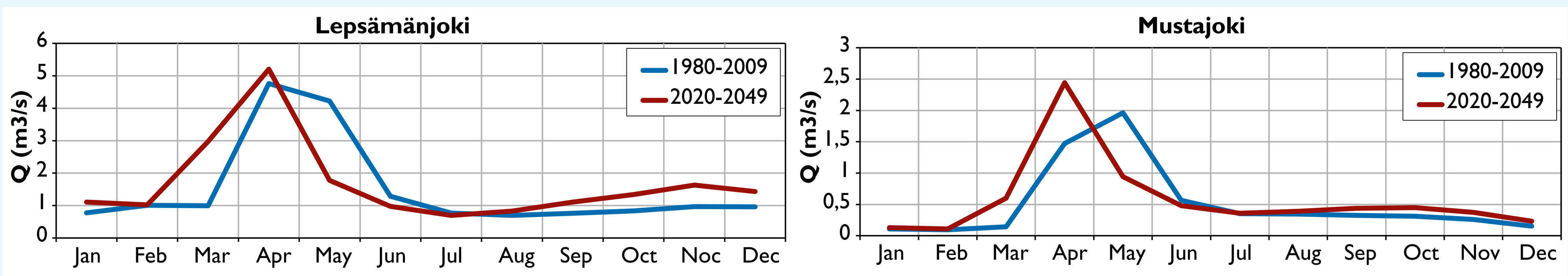

Figure 3. Mean discharge in the river Lepsämänjoki and in the river Mustajoki.

Table 1. Seasonal mean temperatures.

Catchment	Period	Winter DJF	Spring MAM	Summer JJA	Autumn SON
Lepsämänjoki	1980–2009	-6.62	4.44	21.34	4.89
Lepsämänjoki	2020–2049	-6.37	9.01	22.02	4.20
Mustajoki	1980–2009	-8.75	3.28	20.66	3.83
Mustajoki	2020–2049	-8.52	8.02	21.49	3.07

Photos by Katri Rankinen