Relationships between biodiversity and environmental drivers in Fenno-Scandian Lakes

Willem Goedkoop[1], Danny Lau[2], and others[3]

[1]Dept of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, SWEDEN

[2]Dept of Ecology and Environmental Sciences, Umeå University, Umeå, SWEDEN

RESULTS

Biodiversity of FECs responded inconsistently to climatic variables (T and precipitation) that were also reflected by lake geographic location and catchment vegetation. Responses differed among trophic levels, and clung to orthogonal gradients in RDA with %Share data of all 5 FECs (Fig. 1A,B) or only consumer groups (Fig. 1C,D). Along the decreasing latitudinal and/or altitudinal gradients, biodiversity of fish and primary producers generally decreased, but that of the intermediate trophic levels increased.

Avg%Share and %Share of fish were strongly correlated (Fig. 1B,D), and increased with increasing lake total-N and taiga forest in the catchment. Apart from the climatic drivers, %Share of BMI and zooplankton were also mediated by lake area and catchment geology (fig. 1D).

RDA of BMI and zooplankton biodiversity was dominated by data from Finnish lakes (Fig. 2A). Results corroborated that evenness of the invertebrate groups increased with decreasing diversity and richness, and that climate, land-cover changes, and catchment geology were important drivers for biodiversity (Fig. 2B). Based on their biodiversity metrics lakes formed distinct groups based in ordinations. Three Swedish lakes were characterized by markedly higher diversity and richness of consumers.

Taiga forest cover was a strong driver for fish diversity and richness (Fig. 2D) as it was for %Share in fish (Fig. 1D). Yet, diversity and richness of fish also increased with increasing catchment area, annual variability in precipitation, and intrusive igneous bedrock in the catchment, while those of BMI decreased with increasing lake area.

F1

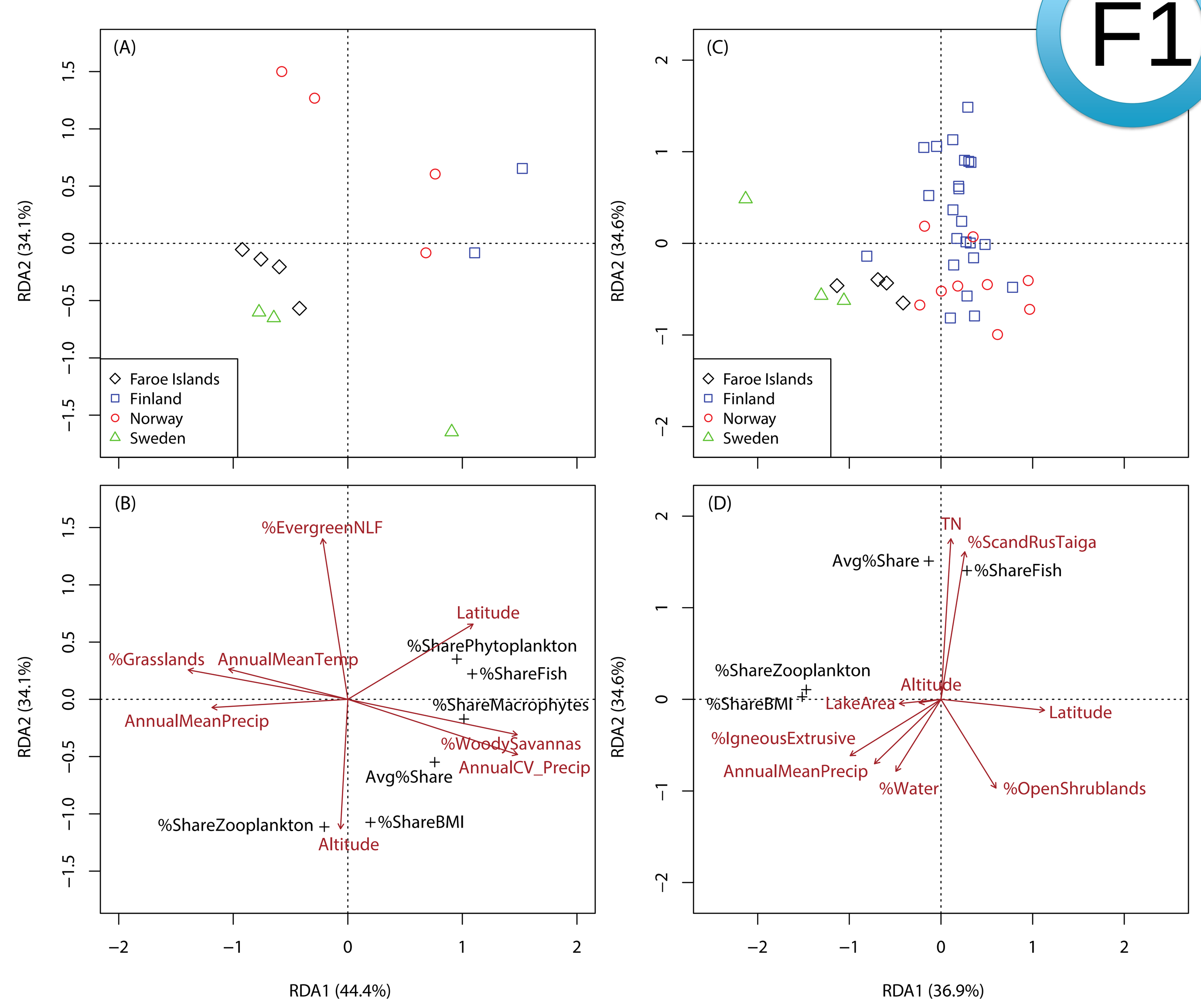


Fig. 1. RDA of %taxa share among 5 FECs in 13 lakes (A and B) and among 3 FECs in 39 lakes (C and D). Upper panels show lake ordinations, while bottom panels show explanatory environmental variables (red arrows, p < 0.05).

F2

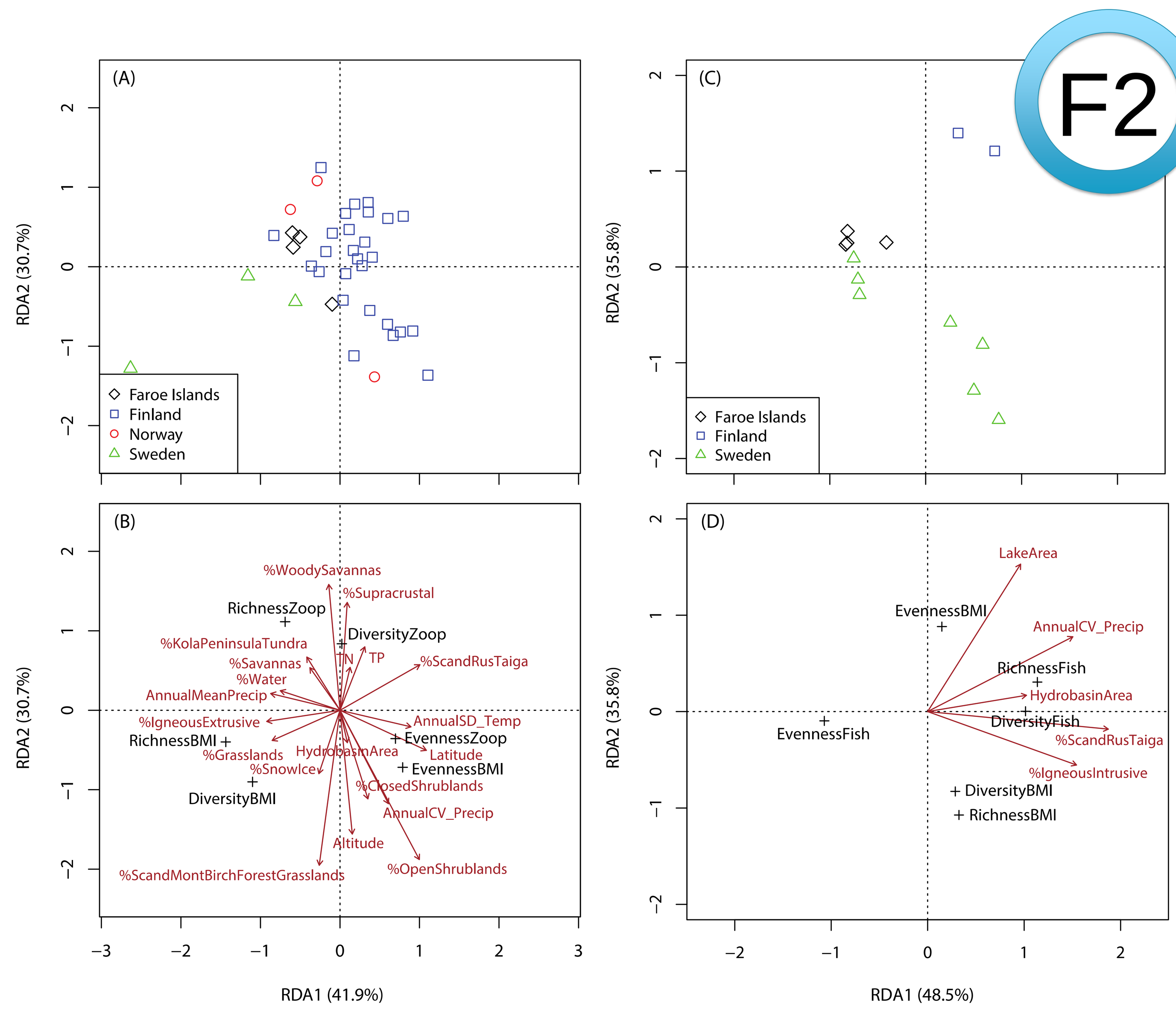
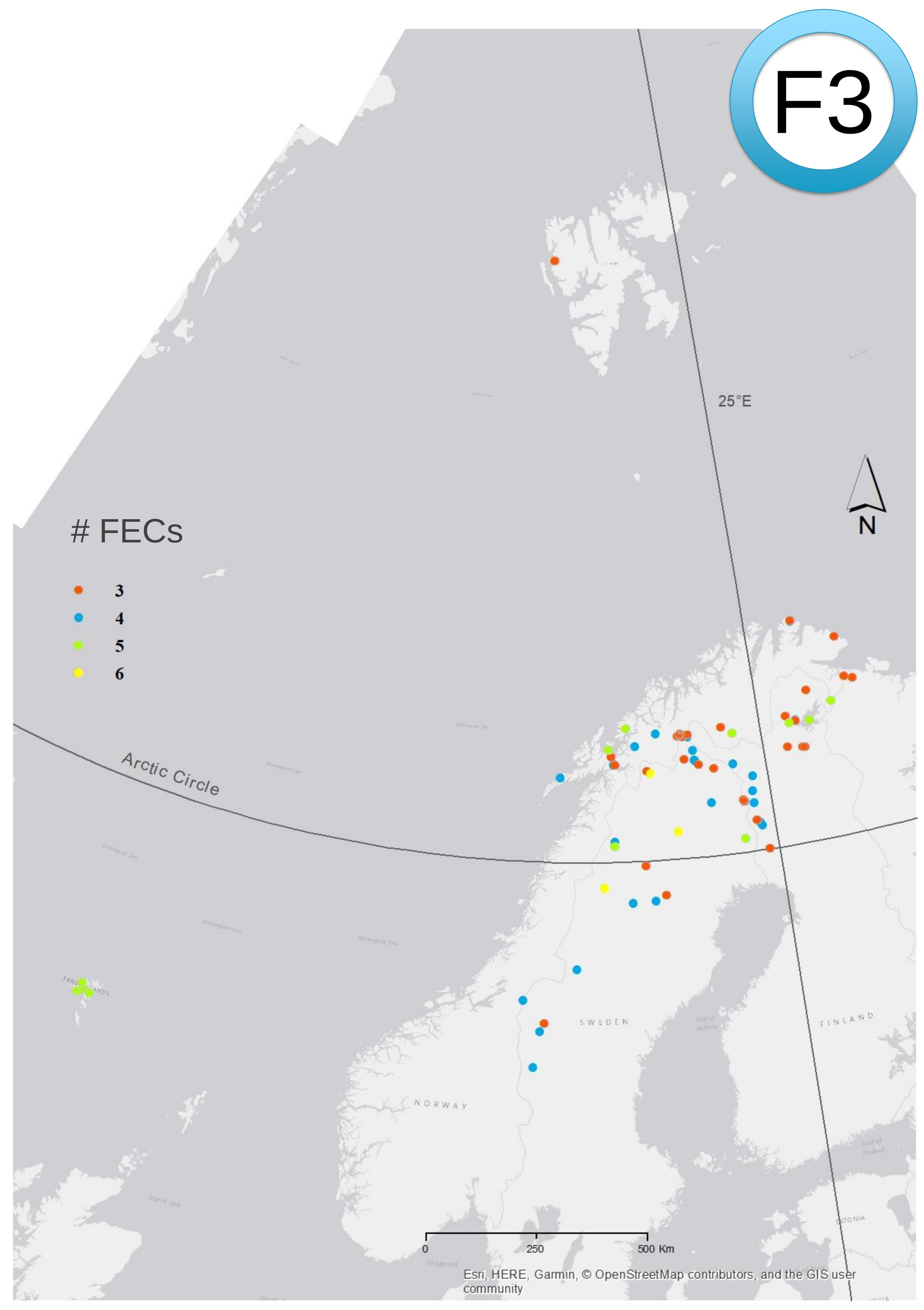


Fig. 2. RDA of biodiversity metrics of BMI and zooplankton (A and B; 37 lakes) or fish (C and D; 14 lakes). Upper panels show lake ordinations, while bottom panels show explanatory environmental variables (red arrows, p < 0.05).

F3



APPROACH

Data for 74 lakes with at least 3 focal ecosystem components (FEC) among macrophytes, phytoplankton, littoral benthic macroinvertebrates (BMI), zooplankton, fish were used (Fig. 3). Species/genus-level data were used for all FECs, except for BMI, where genus and higher levels were used. Data were produced using national standard methods and taxonomic resolution commonly used in Fennoscandia.

Both presence-absence and relative abundance data were used, except for macrophytes (only presence-absence data). Using presence-absence data, we calculated the taxa share (%Share) for each FEC, i.e. richness in each lake relative to the total richness in all lakes. This allowed us to avoid bias due to differences in size of species pool among FECs.

We also calculated the average taxa share among FECs or Avg%Share, which was used to indicate biodiversity hotspots and coldspots. Relative abundance data were used to calculate the biodiversity metrics.

RDA was run to examine biodiversity patterns and relationships to environmental drivers using R (version 3.3.3).

[1]Other contributors:
Ann Kristin Schartau *(Norwegian Inst. Nature Res.)*, Brian Hayden *(Univ. New Brunswick)*, Jaakko Erkinaro *(Natural Resources Institute Finland)*, Jan Karlsson *(Umeå Univ.)*
Jani Heino *(Environment Finland)*, John Brittain *(Norwegian Water Resources and Energy Directorate)*, Jukka Ruuhijärvi *(Natural Resources Institute Finland)*,
Kerstin Holmgren *(Swedish Univ. Agricult. Sci)*, Kimmo Kahilainen *(Helsinki Univ.)*, Kirsten Christoffersen *(Univ. Copenhagen)*, Laura Forsstrom *(Environment Finland)*,
Maria Kahlert *(Swedish Univ. Agricult. Sci)*, Marit Mjelde *(Norwegian Institute for Water Research)*, Martin Svenning *(Norwegian Inst. Nature Res.)*
Petri Liljaniemi *(Environment Finland)*, Satu-Maaria Karjalainen *(Environment Finland)*, Seppo Hellsten *(Environment Finland)*, Steinar Sandøy *(Norwegian Environment Agency)*, Tobias Vrede *(Swedish Univ. Agricult. Sci)*.