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A cost-efficient riverscape methodology for GIS characterisation and planning of river restoration in Scandinavia

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Fundamental assessment and understanding of fluvial geomorphological processes are crucial for a sustainable management of riverine ecosystems. There is a huge riverscape diversity across Scandinavia; from low gradient river habitats in the lowland (e.g. meanders and river delta in South of Sweden) to high alpine, post-glacial and morphologically highly variable rivers with water falls in West-Norway.

River basin managers in Sweden and Norway, are facing many of the same challenges related to types of pressures, biogeography, restoration needs and a huge number of water bodies. We have in this project exemplified how unbiased science-justified descriptors and indicators that are realistic to generate for many thousand rivers according to the EU Water Framework Directive (WFD), can be used as basis for ecosystem-based management.

The coverage of high-resolution laser-scanning-data (lidar) surveyed for mapping purposes are soon covering most of the river basin districts in both countries. Green lidar penetrating water is so far only surveyed only in limited pilot areas. Therefore, we have mainly generated riverscape features from grey LIDAR in all the characterised catchments, like e.g. i) river slope, iii) sinuosity, iv) valley confinement and v) substrate composition.

Cluster riverscape analysis and assessment of more than 7100 unique river segment and ca 2041 km of rivers in 10 diverse catchments in Norway, and about 11 000 river segments and ca 1930 km of rivers in three catchments in Sweden have been included in the GIS databases. These rivers have different management regimes (e.g. several permanent protected rivers in Norway) and key species in focus (several national salmon rivers). Still some of the same hygro pressures (e.g. lack of lateral and/or longitudinal river continuum) seems to be quite prominent across management regimes, and therefore an intensified action plan for river restoration seems to be needed.

We have demonstrated that our GIS-techniques by combining high resolution lidar data and the river continuum concept is a cost-efficient methodology for assessing river habitats for both riparian and riverine biota in riverscapes of Scandinavia. By combining lidar with other

georeferenced data publicly available like geomorphological maps, pressure data (e.g., road culverts), segmentations and semi-automatic GIS-techniques, huge areas (like catchments of several thousand km² and hundreds of river water bodies) can be assessed in an objective transparent way already publicly available.

Application

The methodology and GIS database we have generated in this project are relevant for managements issues such as

- a) defining **reference conditions** (to classify ecological conditions)
- b) large scale analysis of habitat degradation of riverine and riparian biodiversity, (consistent river typologies – "**digital twins**")
- c) pressure index to pinpoint more accurate and **sustainable restoration** strategies and measures, that also acknowledge climate adaptation (e.g. natural flow retention measures)
- d) **identifying significance of physical alterations (hymo pressures** - e.g. longitudinal barriers for fish) vs climate change effects (e.g. due to changes in ice break up)
- e) **biodiversity management**; habitat fragmentation, rare vs common habitat types (for updating next version of national Red lists of nature types and/or endangered riverine species)