Long term changes in riverscapes in rivers regulated for hydropower.

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SUSHP 2023
Sustainability in Hydropower

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Objectives

- Purpose
  - Quantify changes in rivers over time
  - Understand the effect different pressures have on the riverscapes
  - As a part of river restoration plans
  - Evaluate protection schemes

Possible drivers of change

Natural factors: Floods, erosion, sedimentation, vegetation, climate, ice runs…

Anthropogenic factors: Hydropower, agriculture, roads/railroads, river training works, urbanisation, pollution, climate,…

Drivers of change

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Challenges

- Lack of data describing the historical conditions, particularly quantitative descriptors
- Old aerial images and maps are potential sources – manual digitization tedious and time consuming

- Possible solution: utilize machine learning for automatic delineation of area types.
  - Must be done on black and white images

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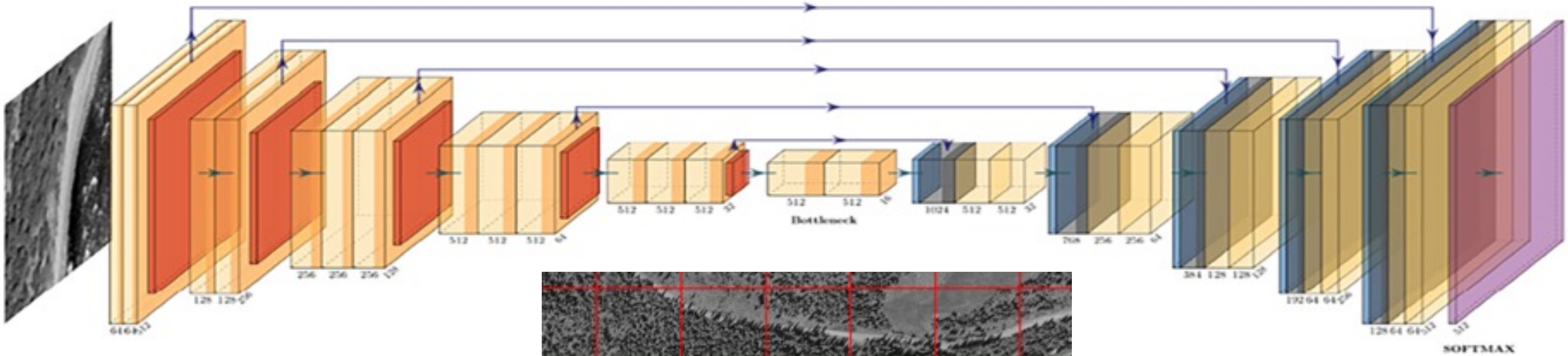
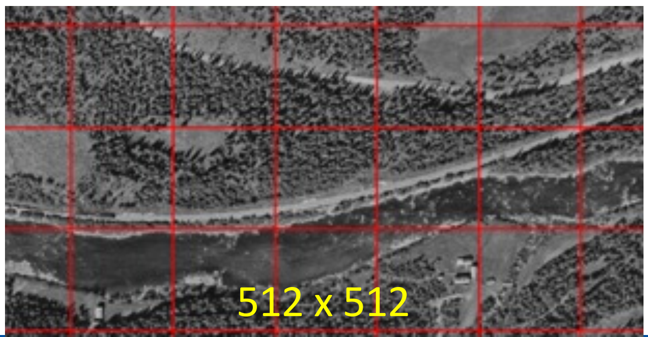
The neural network

- Deep convolutional network

- Encoder – reduce dimensionality, internal representation
- Decoder – scale to orginial dimension, segmentation

- Pre-trained VGG16 model used as ”encoder”





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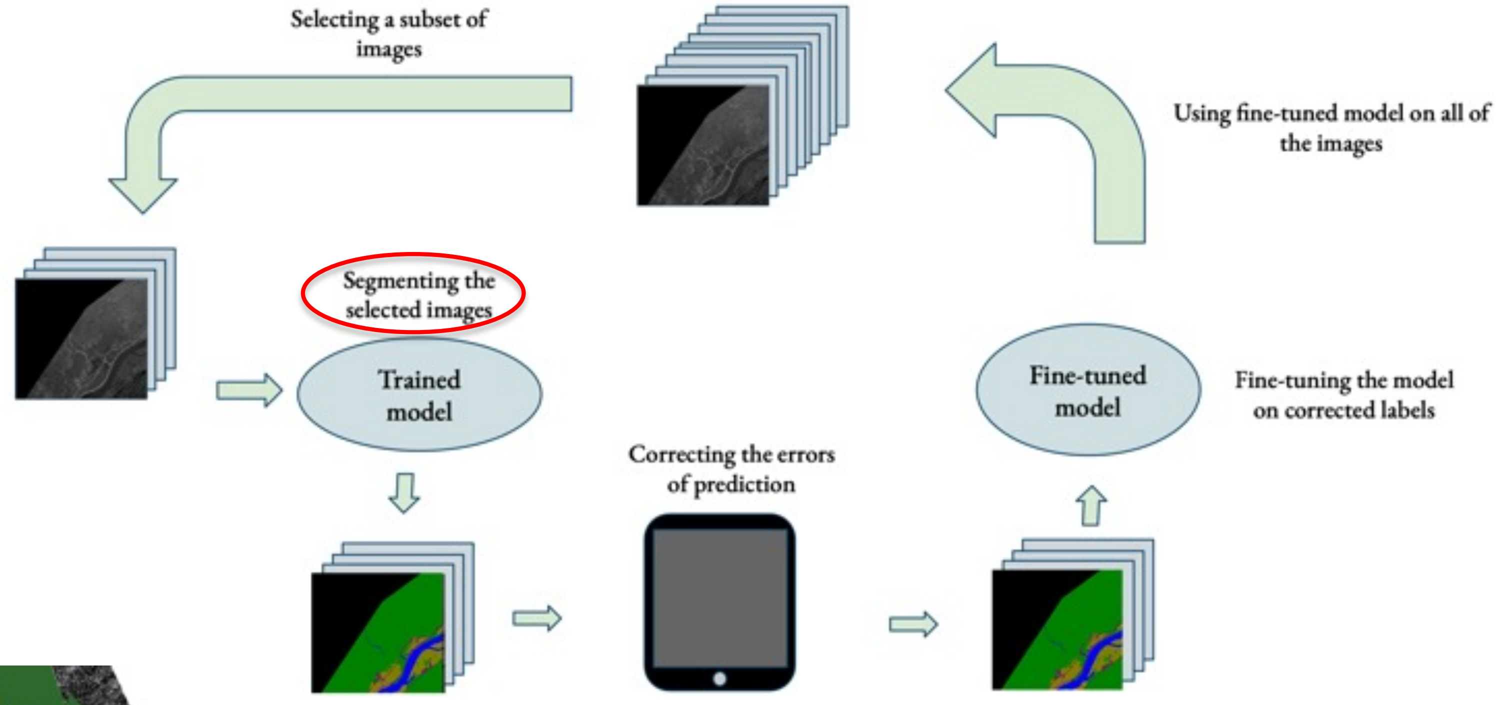
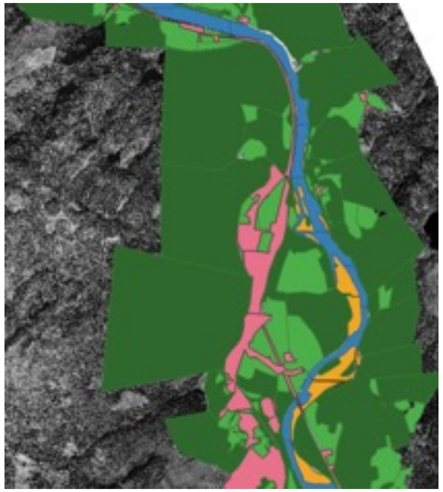
Training data development





Class		Description
W		Water
G		Gravel
V		Forest
F		Agricultural
H		Anthropogenic
U		Unknown

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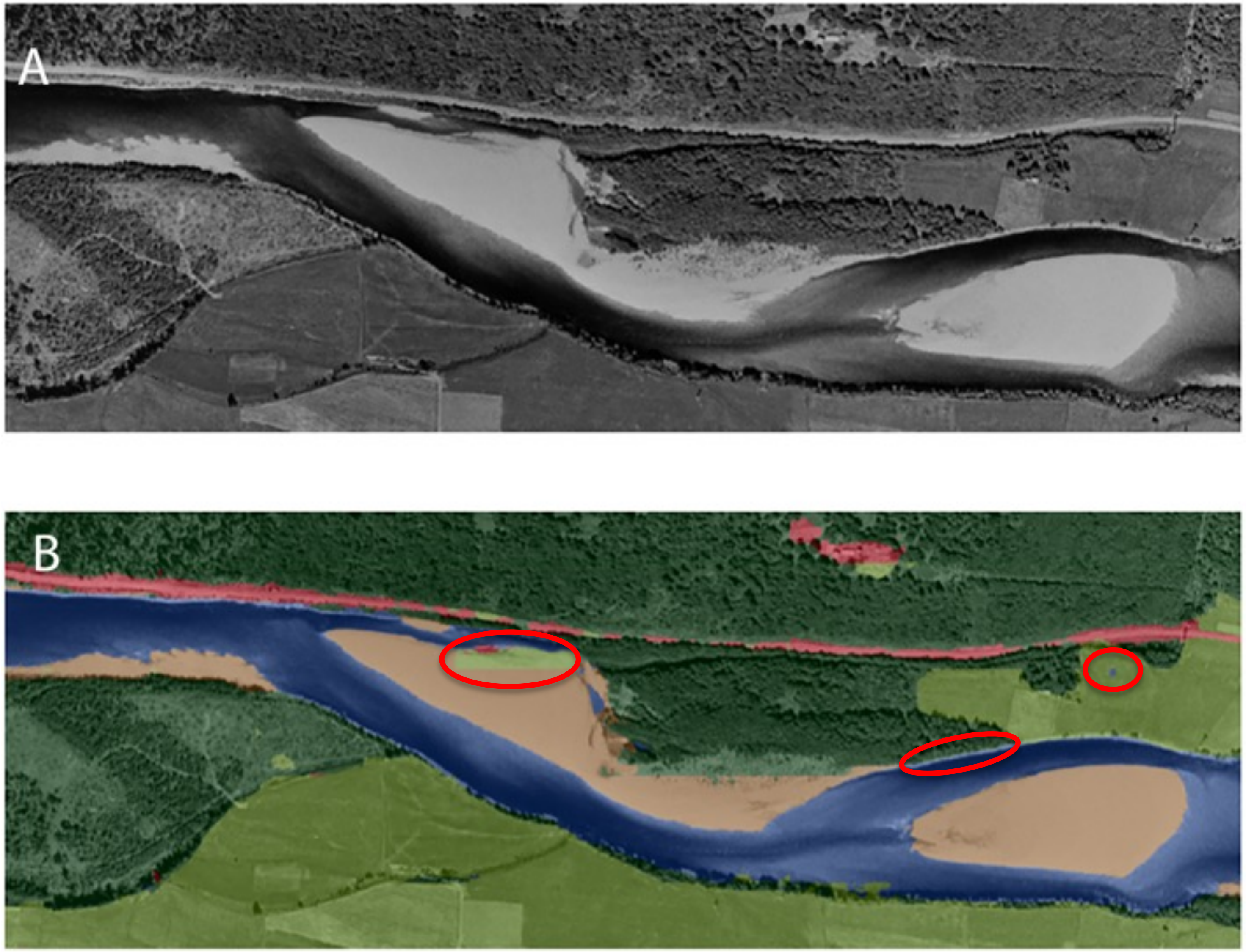
Gaula: Classification



Alfredsen et al. (2021) RRA

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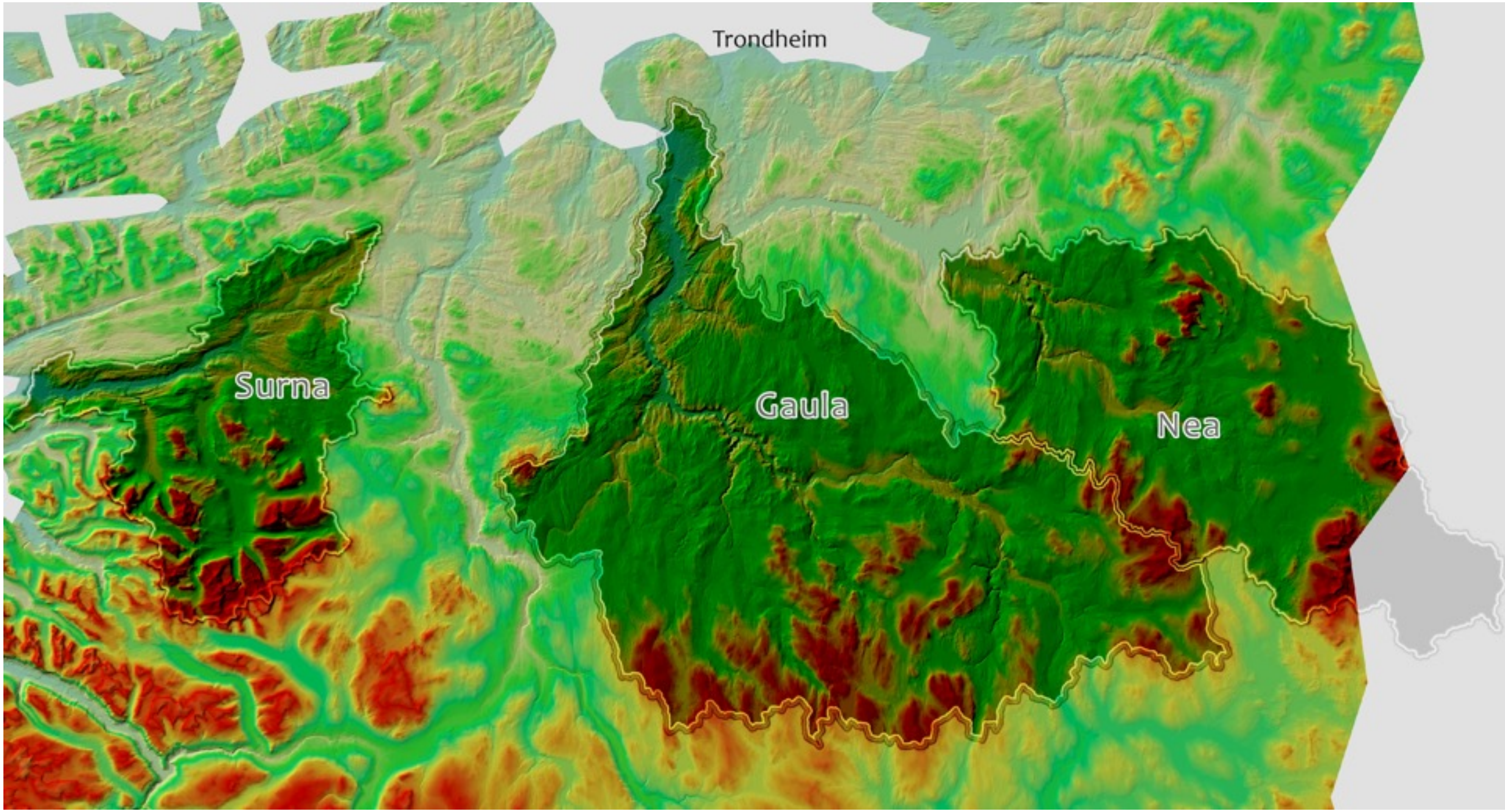
Results from test runs

GAULA 1963		Predicted class				
		Water	Gravel	Vegetation	Farmland	Human
True class	Water	**91.31%**	0.38%	1.38%	6.93%	0.00%
	Gravel	7.84%	**76.73%**	6.72%	6.10%	2.60%
	Vegetation	2.10%	1.75%	**88.96%**	2.30%	4.90%
	Farmland	0.60%	2.49%	8.37%	**88.12%**	0.42%
	Human	2.85%	2.19%	7.34%	9.15%	**78.47%**

NEA 1962		Predicted class				
		Water	Gravel	Vegetation	Farmland	Human
True class	Water	**95.36%**	0.14%	1.83%	2.39%	0.28%
	Gravel	22.68%	**53.15%**	8.04%	10.07%	6.05%
	Vegetation	3.14%	0.11%	**90.51%**	4.59%	1.64%
	Farmland	1.78%	0.03%	1.12%	**96.79%**	0.27%
	Human	0.09%	0.00%	2.80%	14.15%	**82.96%**

Alfredsen et al. (2021) RRA

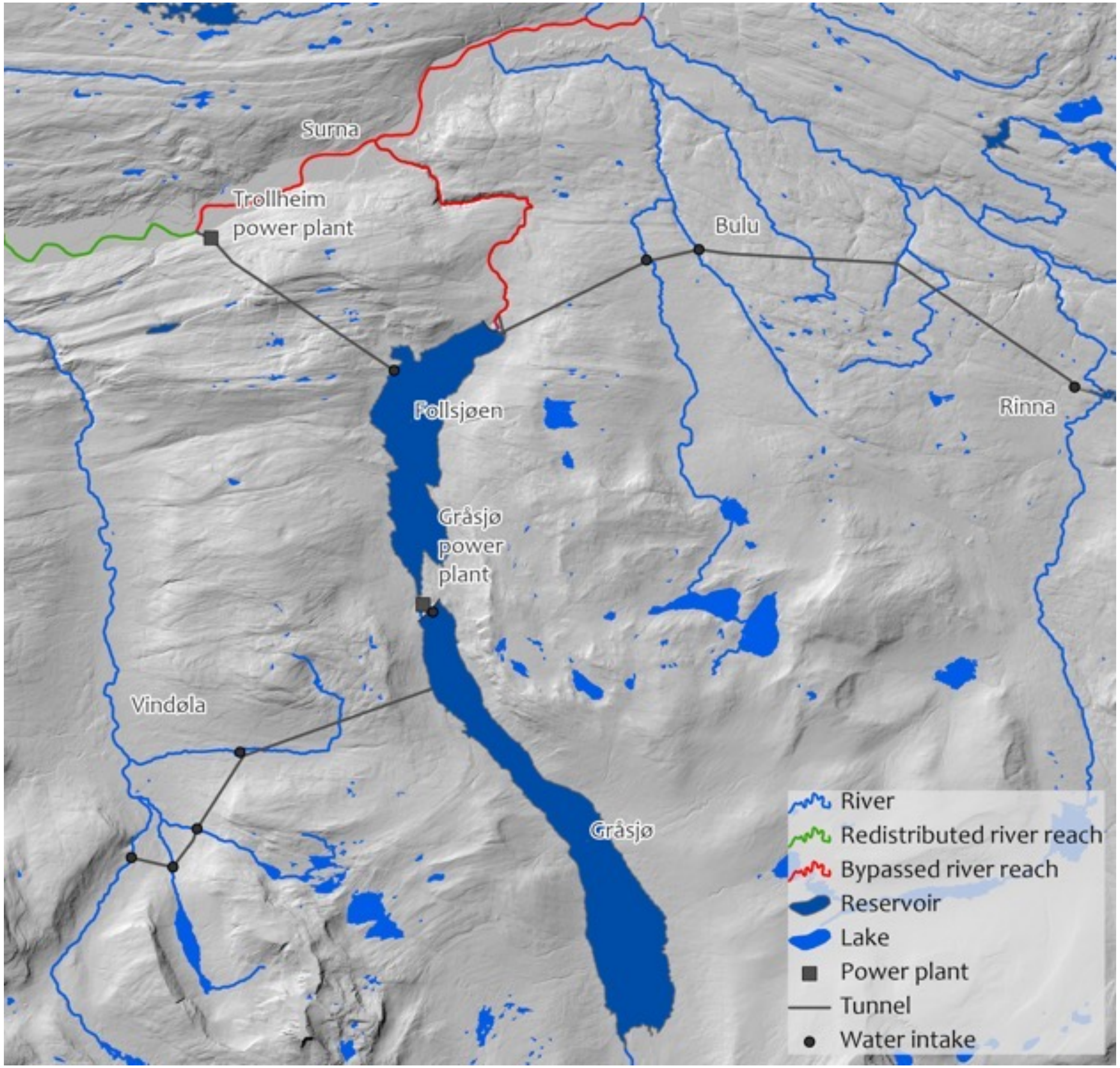
Study sites



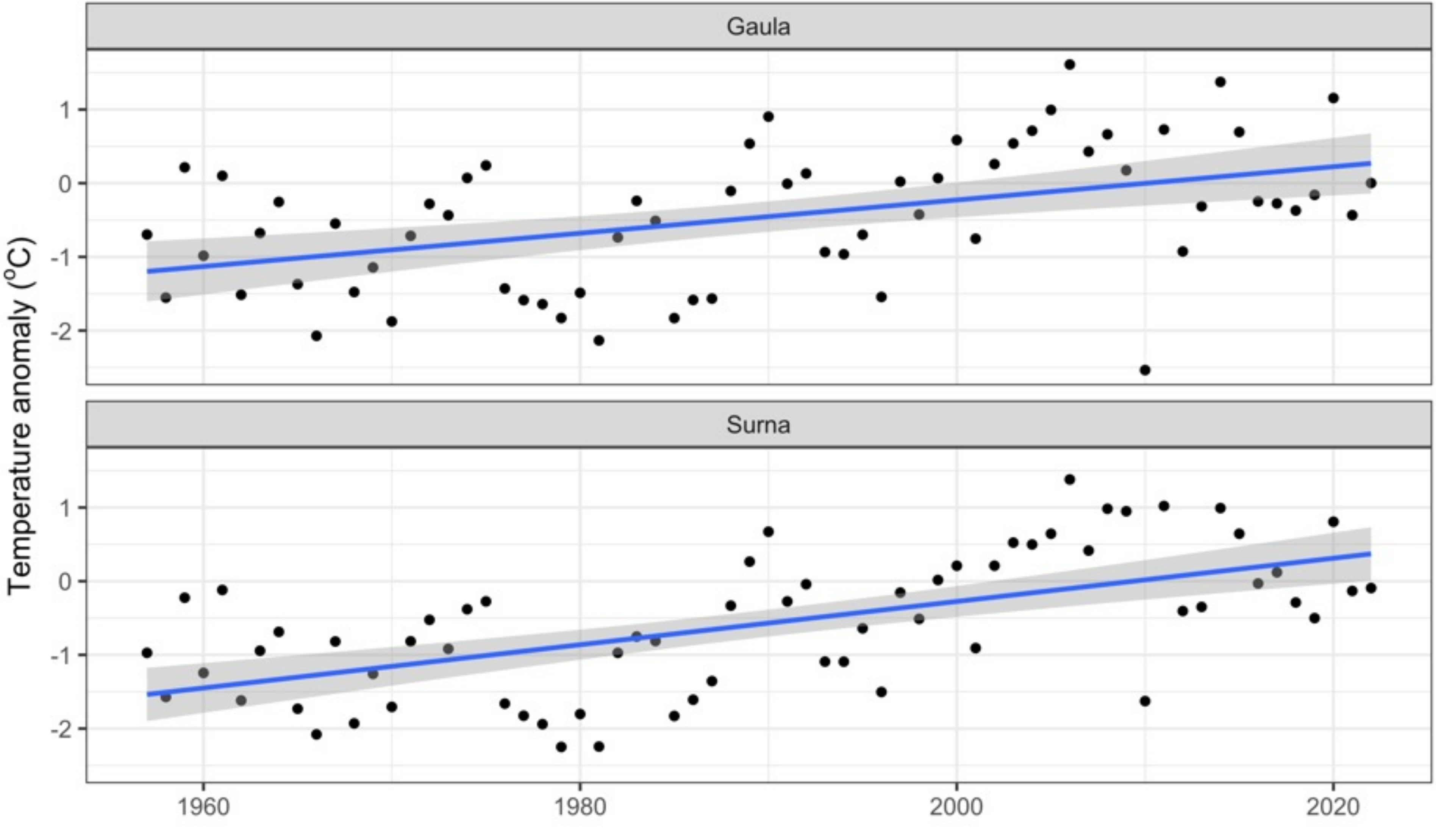
Surna: 1200 km^2, Gaula 3655 km^2, Nea 2081 km^2. Nea and Surna is regulated for hydropower

Surna

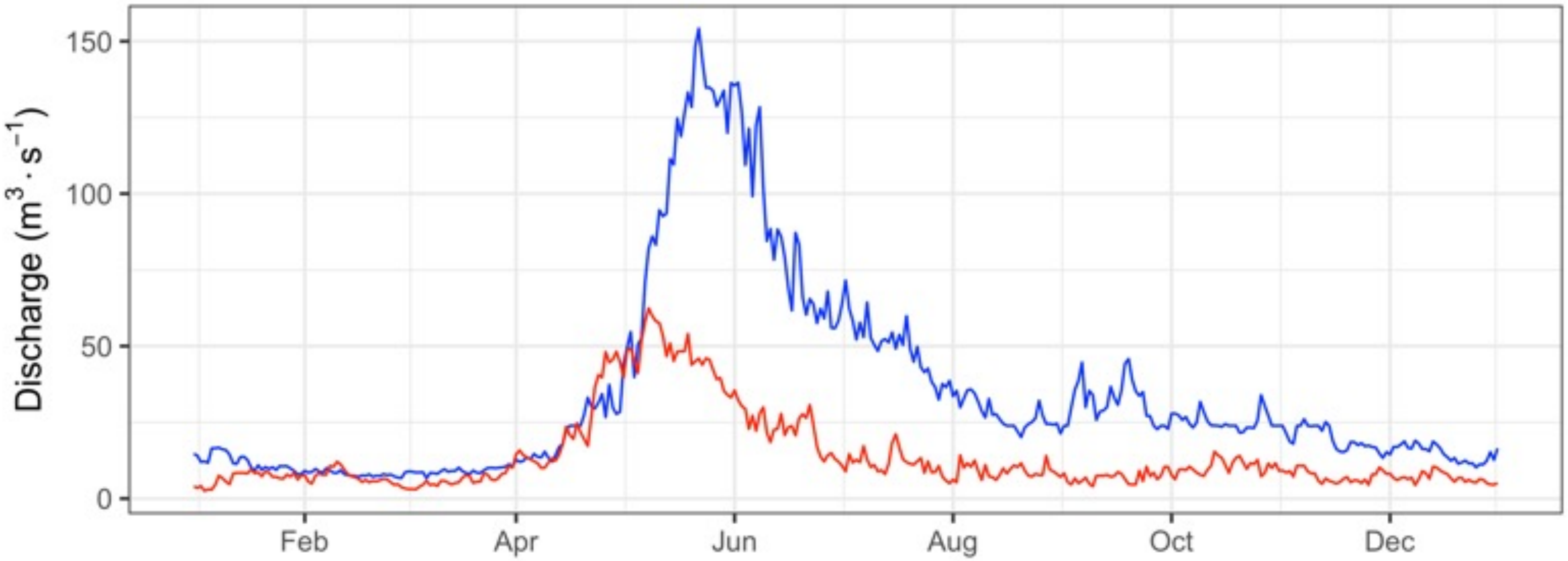
- Regulated 1968
  - Trollheim power plant
  - Two reservoirs
  - 7 brook intakes
  - 402 m head
- National salmon river
- Images used:
  - 1963
  - 2006

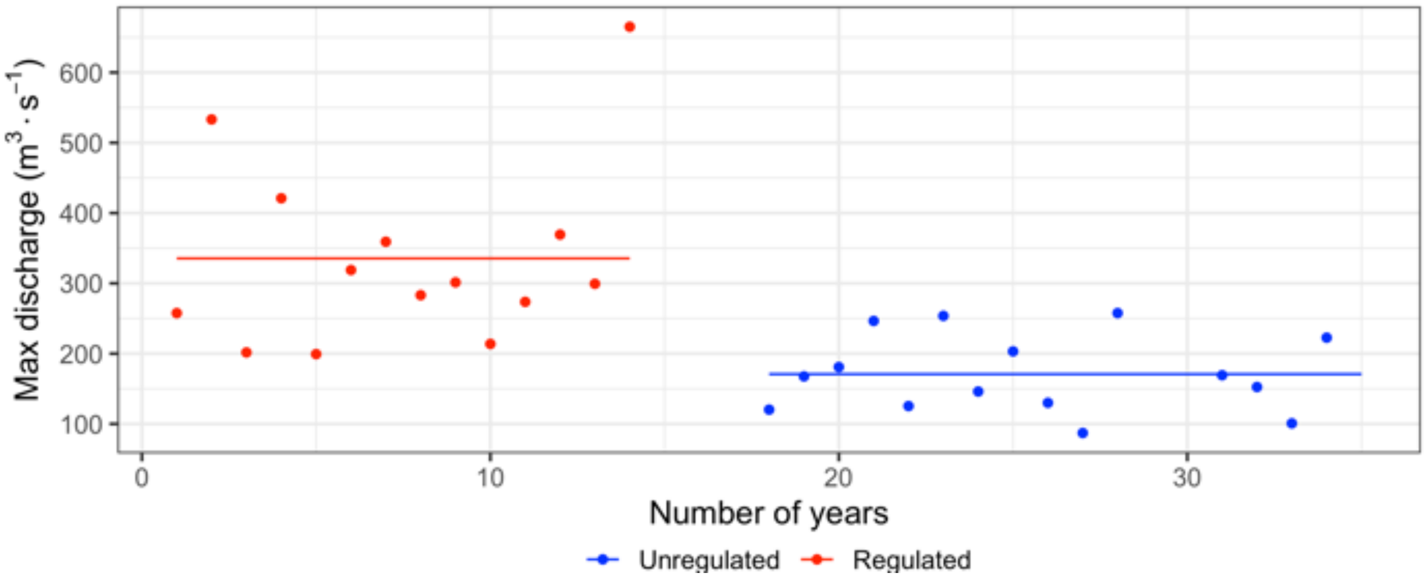


Climate (1991 – 2020 normal)

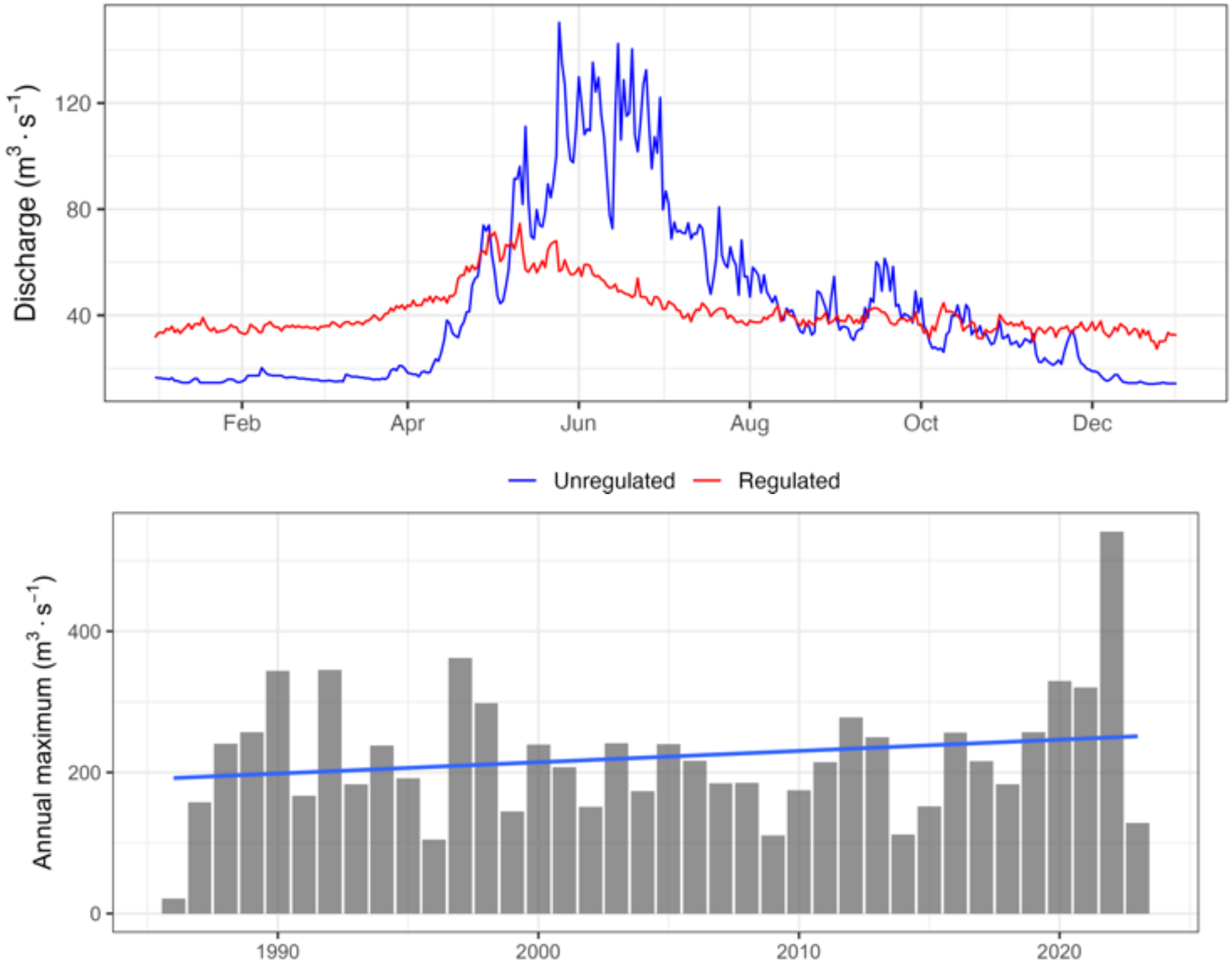


Surna – bypass section





Surna – downstream of outlet



Unregulated –
Scaled Vindøla

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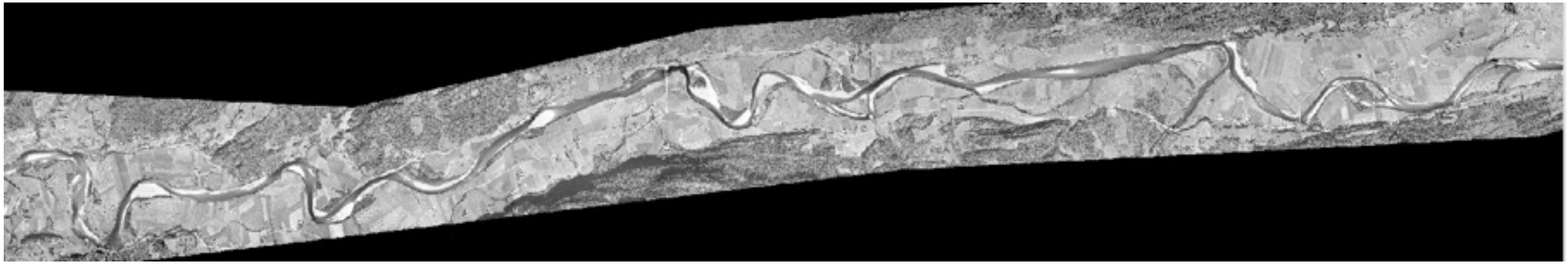
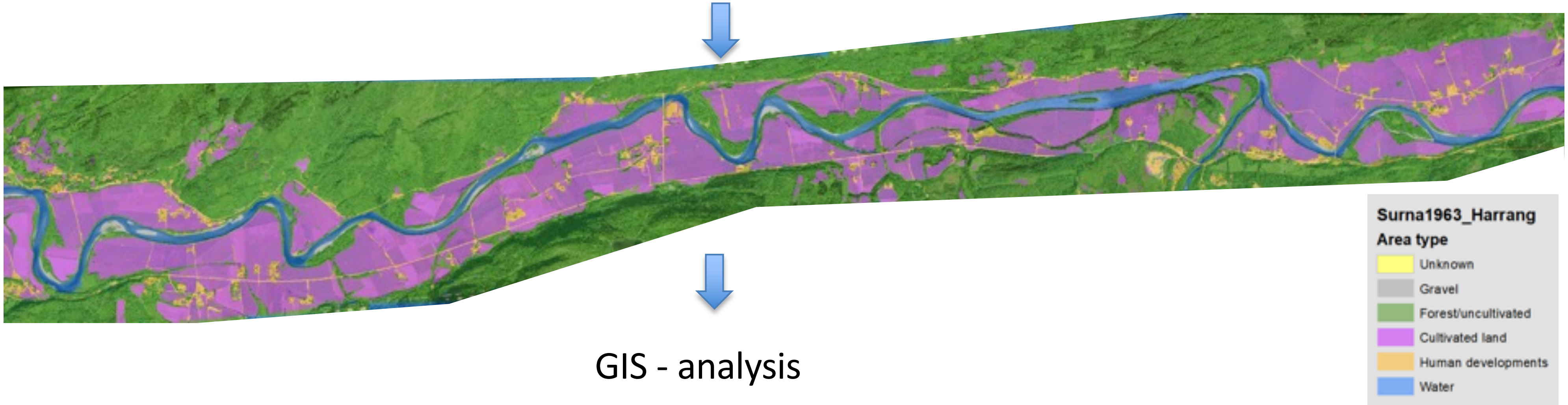
Surna classification



Feature classification (CNN)

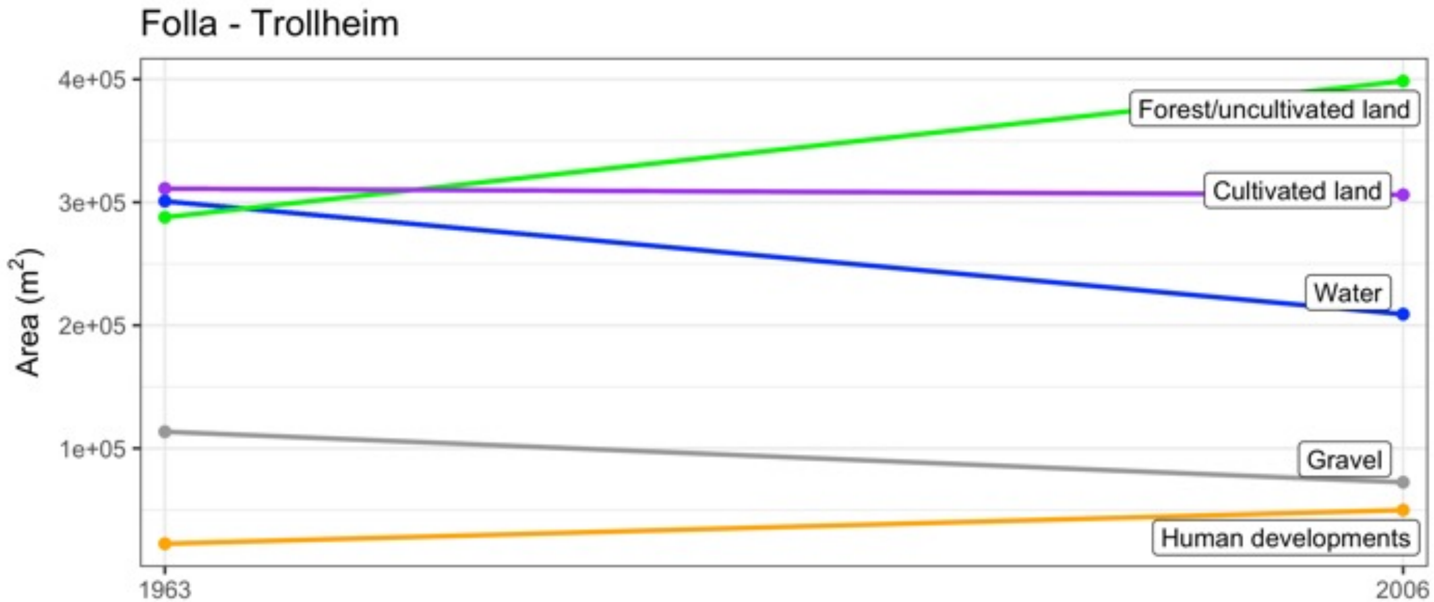
Postprocessing



GIS - analysis

Surna - bypass reach, changes in areas

Folla - Trollheim

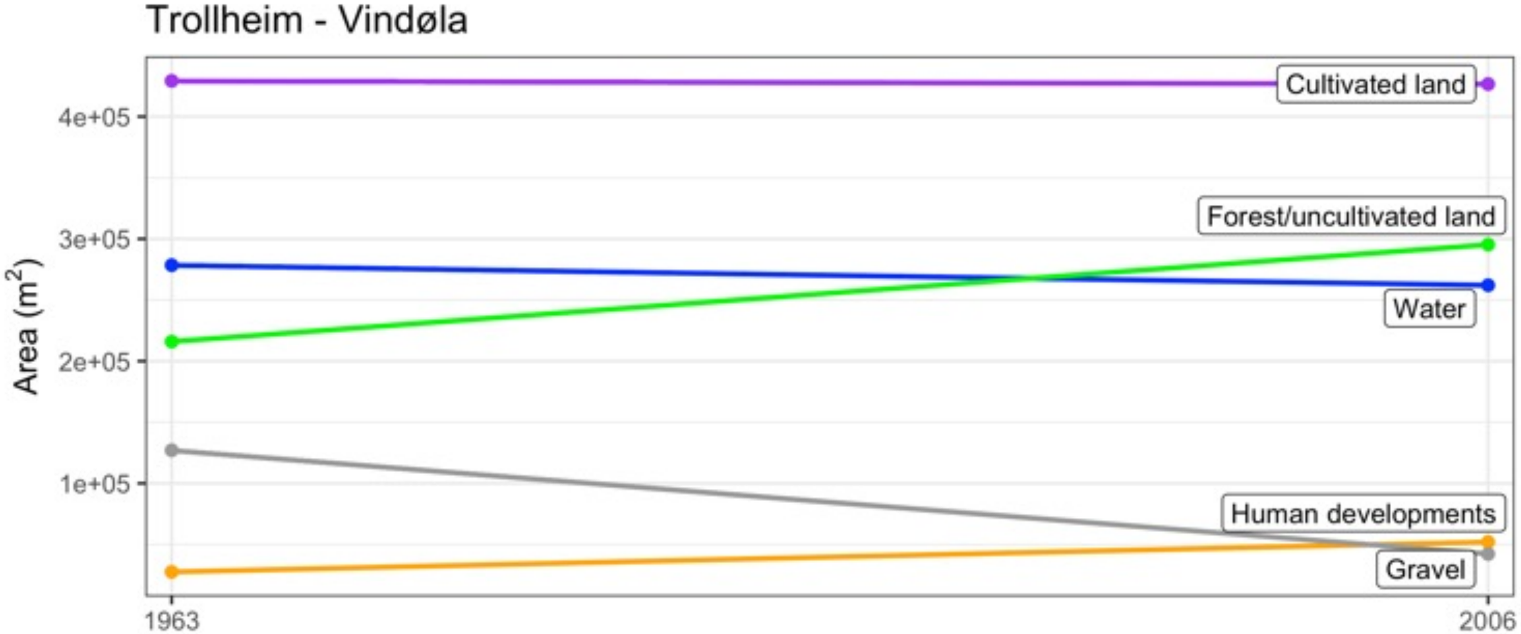


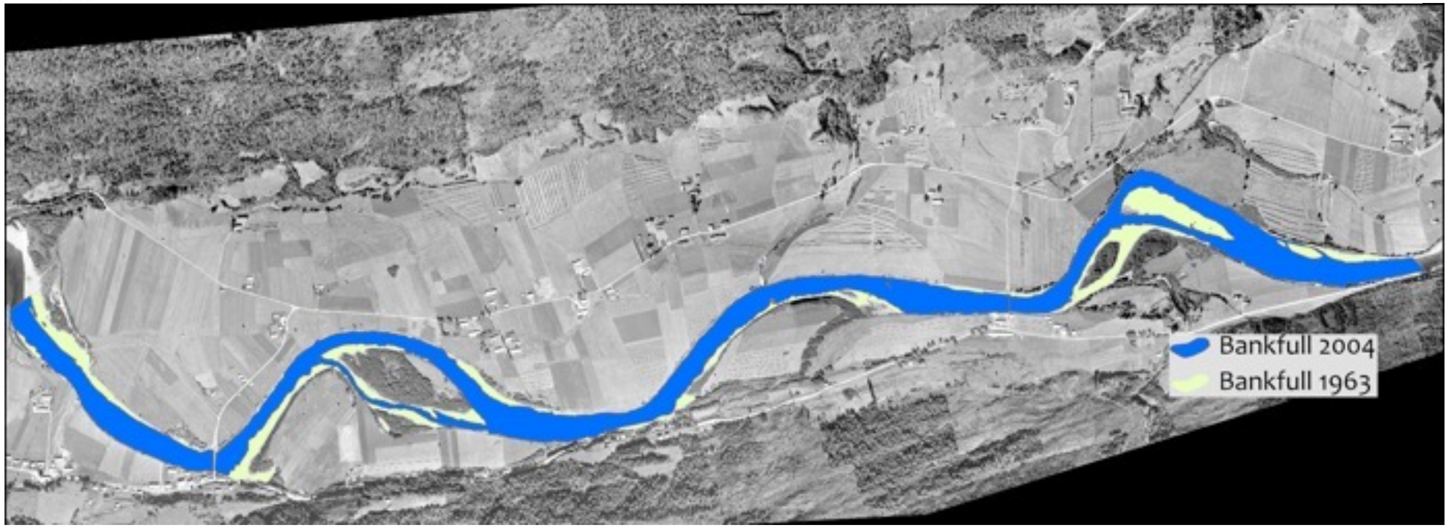
2006: 22 m^3/s

1963: 16 m^3/s

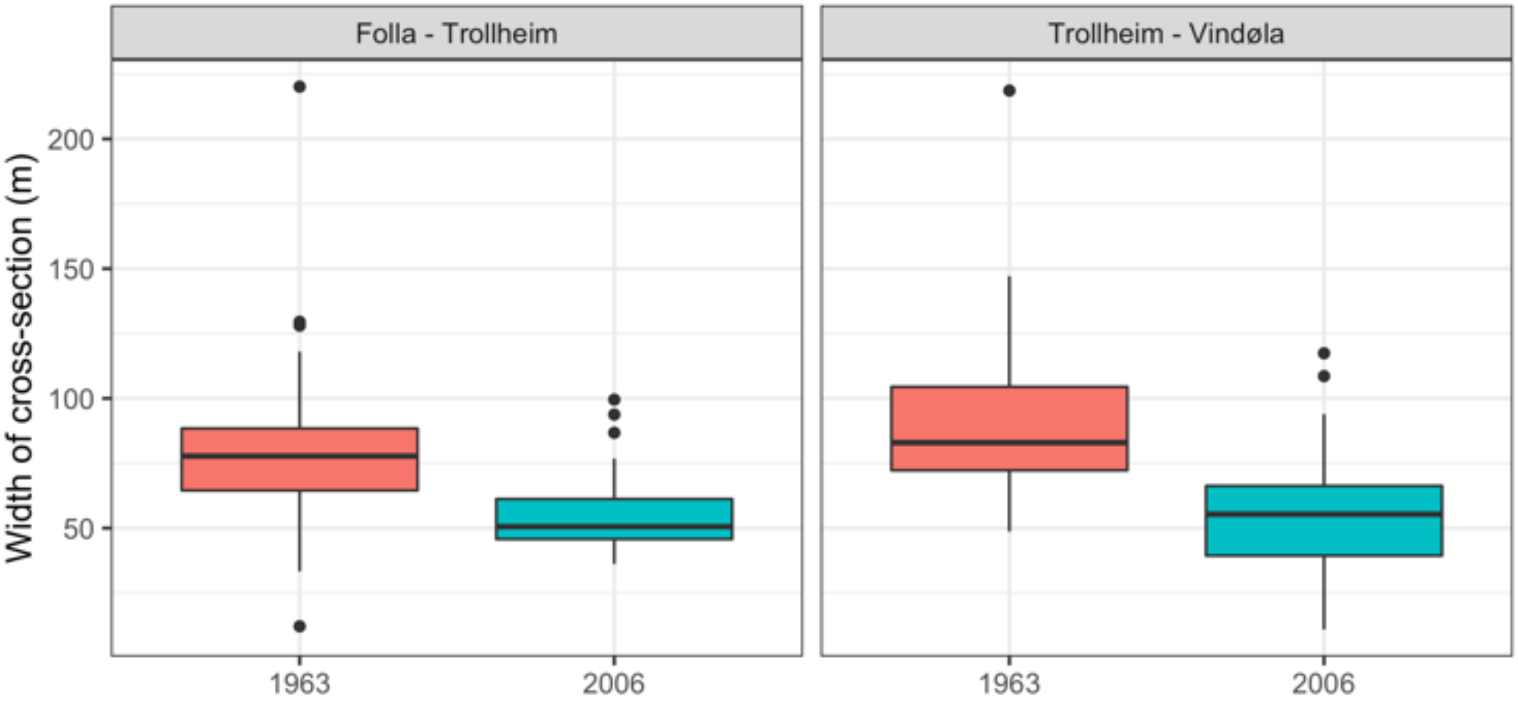
Surna – redistributed, changes in areas

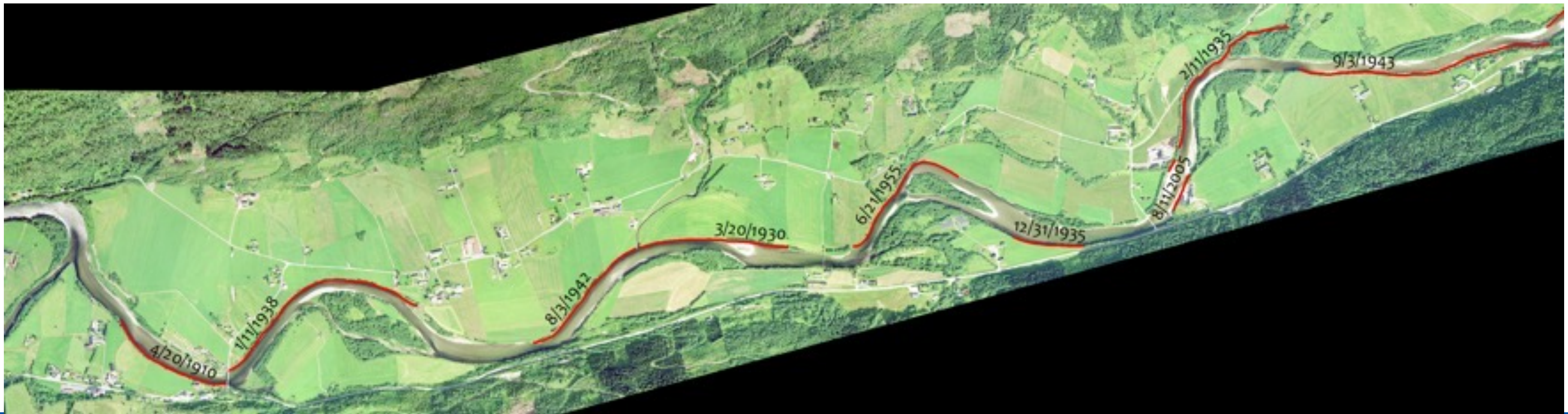
Trollheim - Vindøla

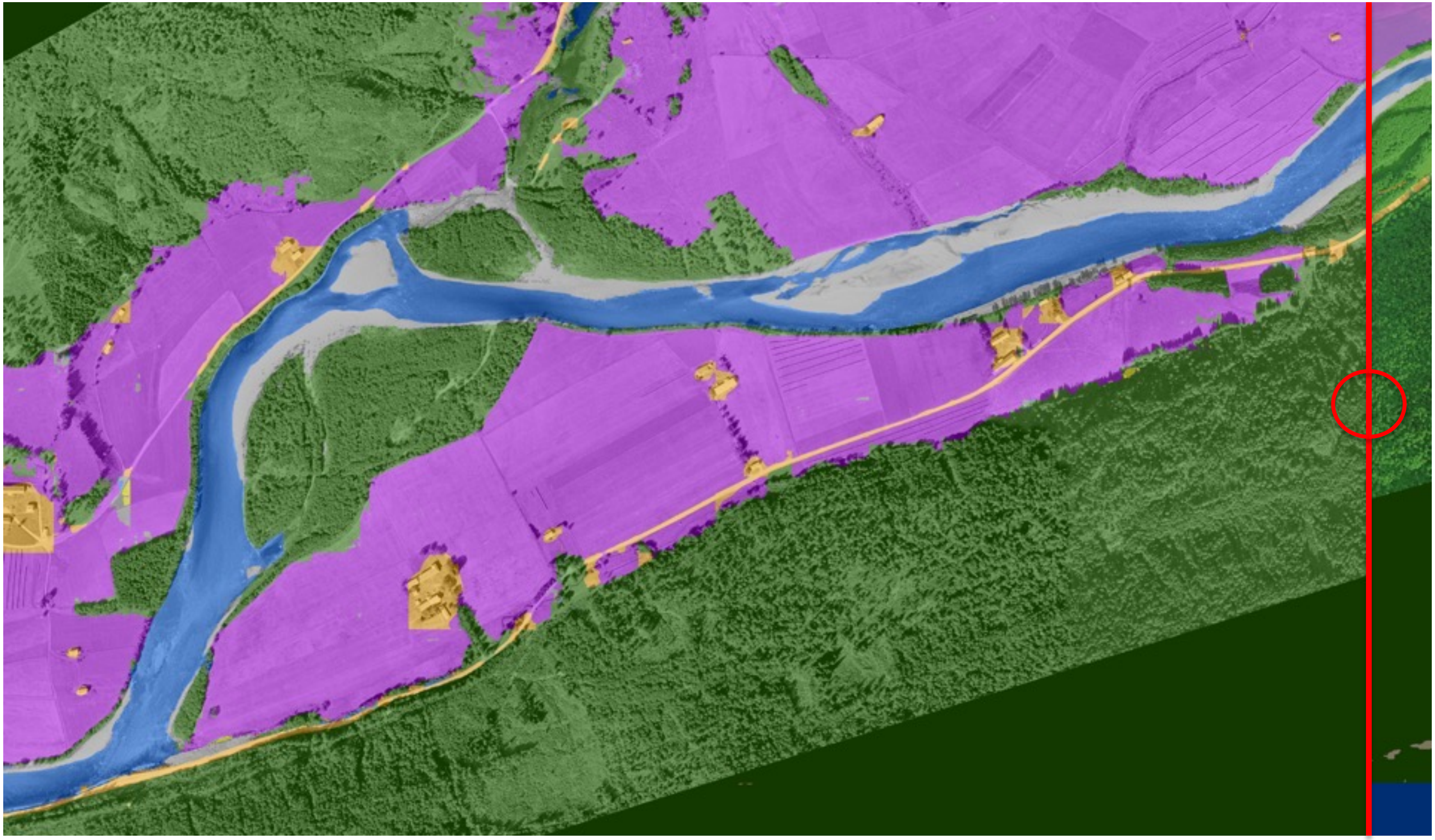


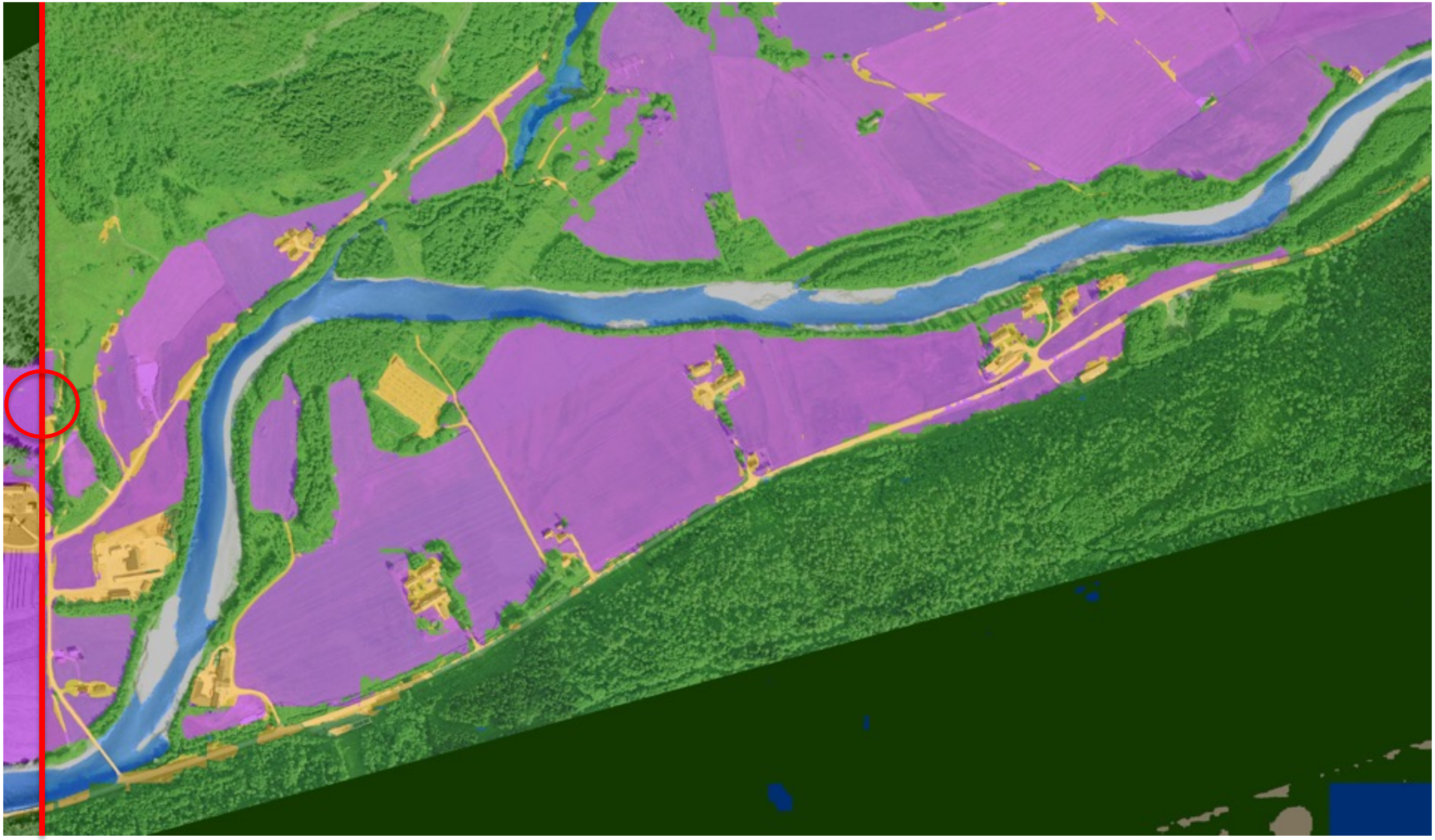


Surna – bankfull width.

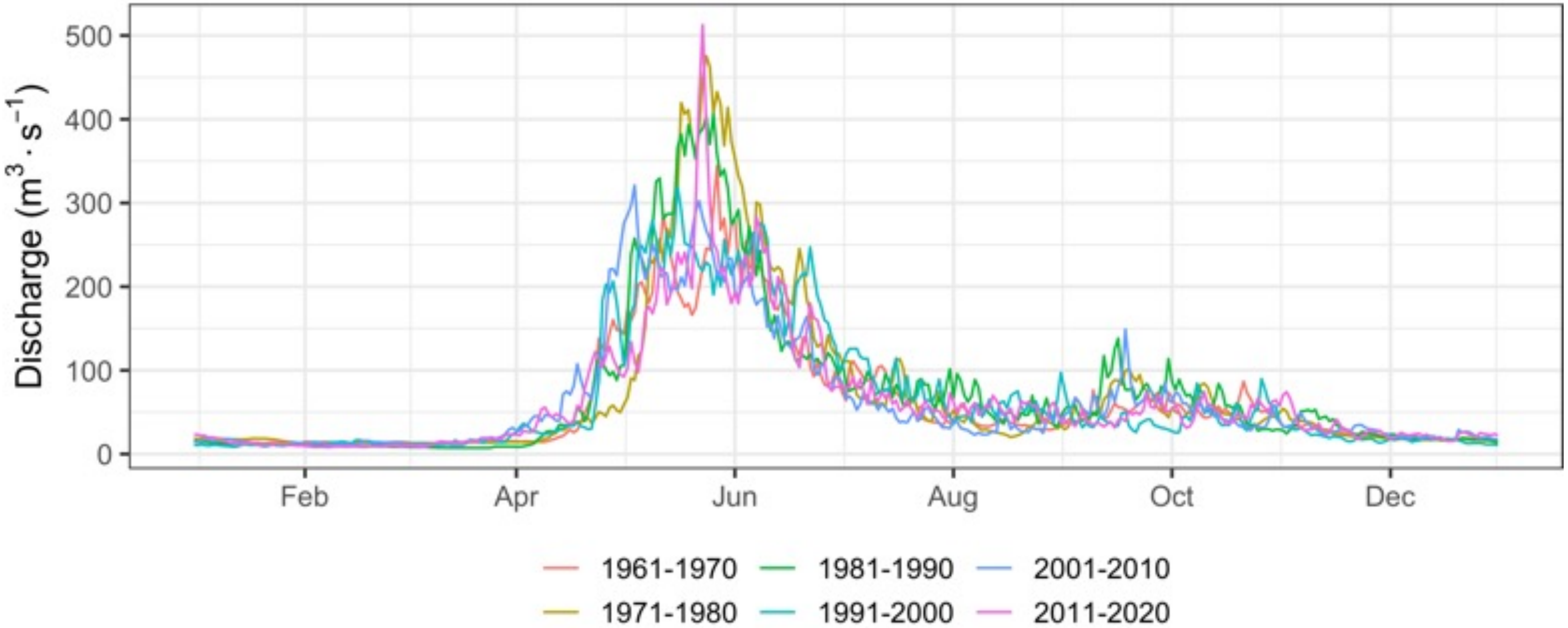


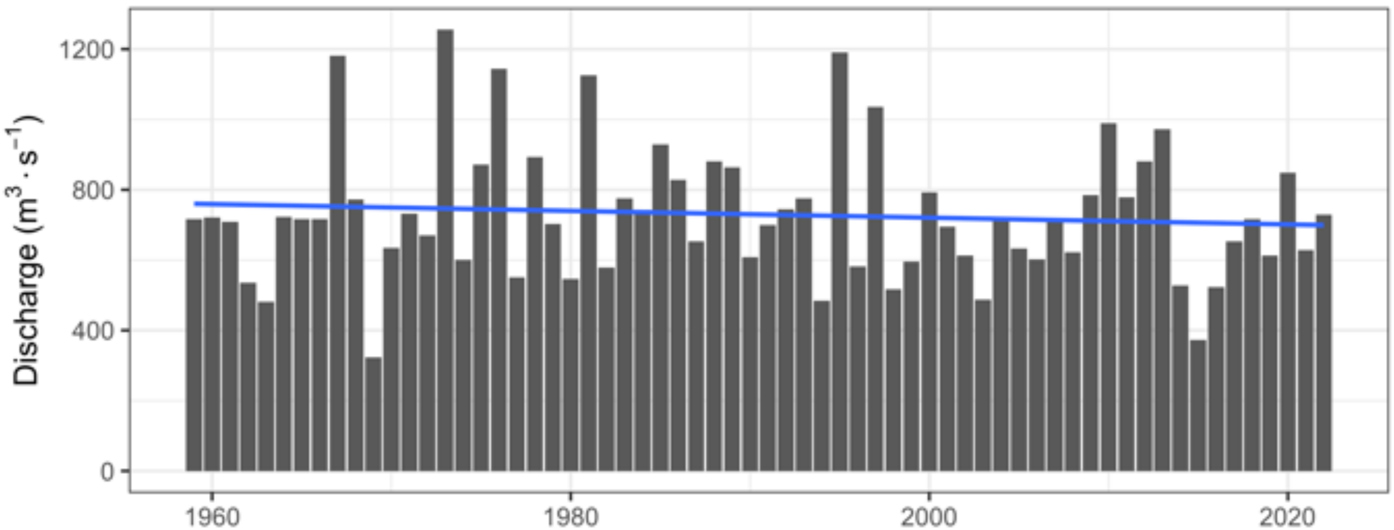






Gaula flow regime





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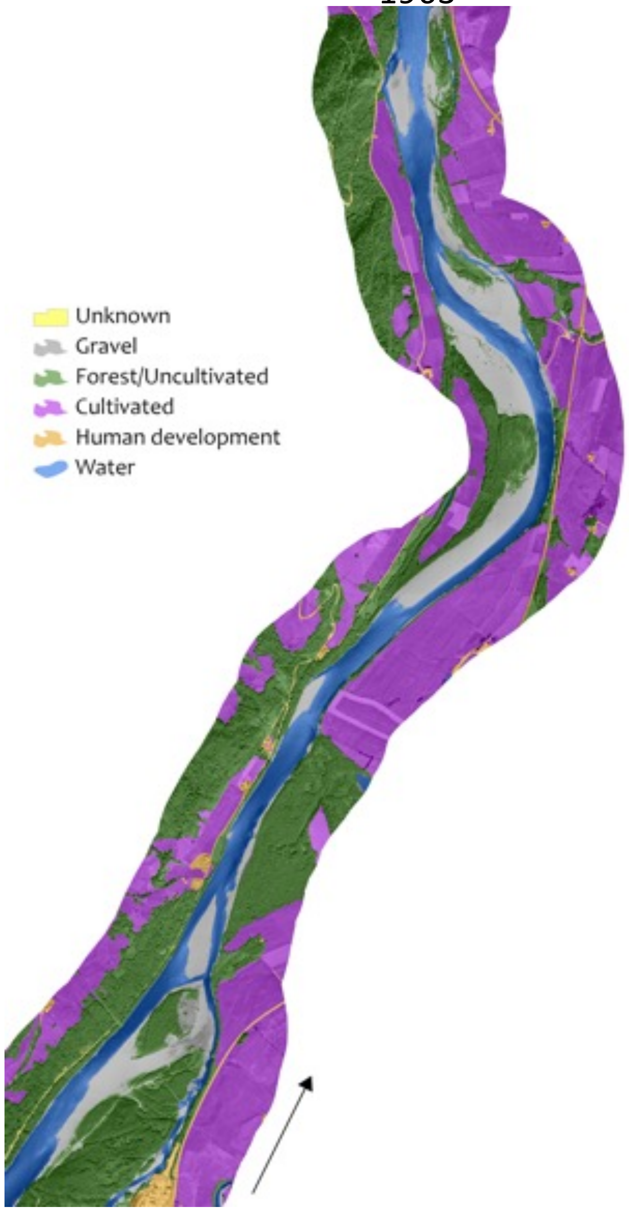
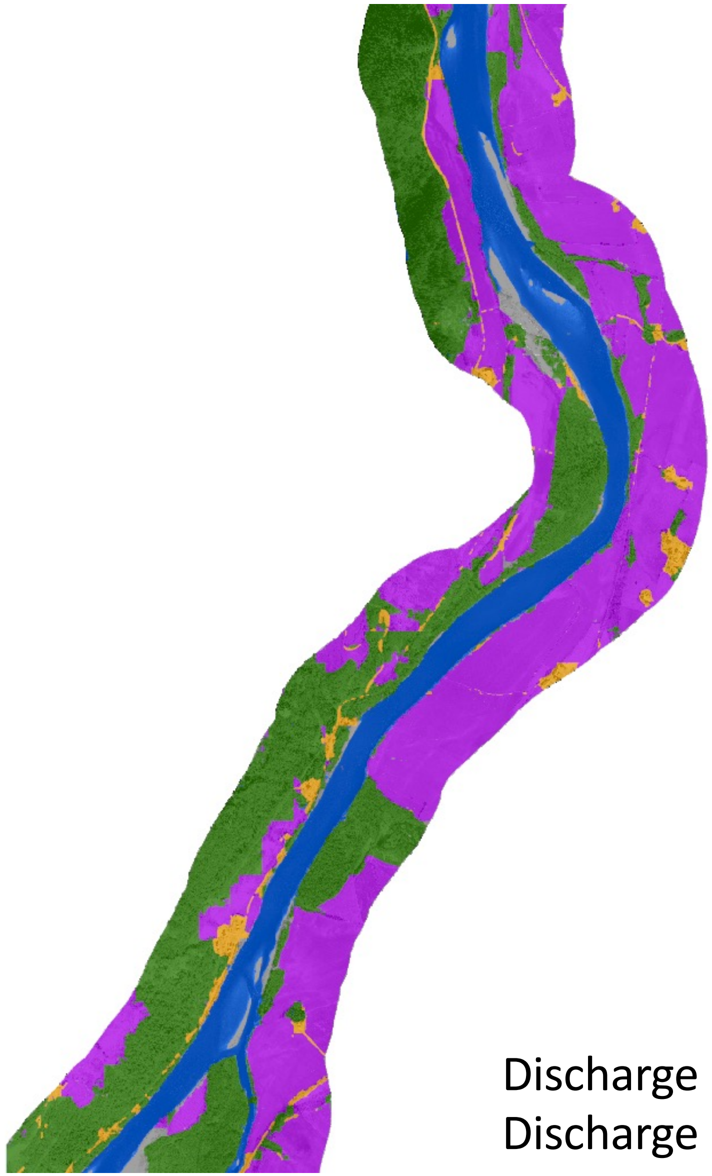
Gaula river

1963

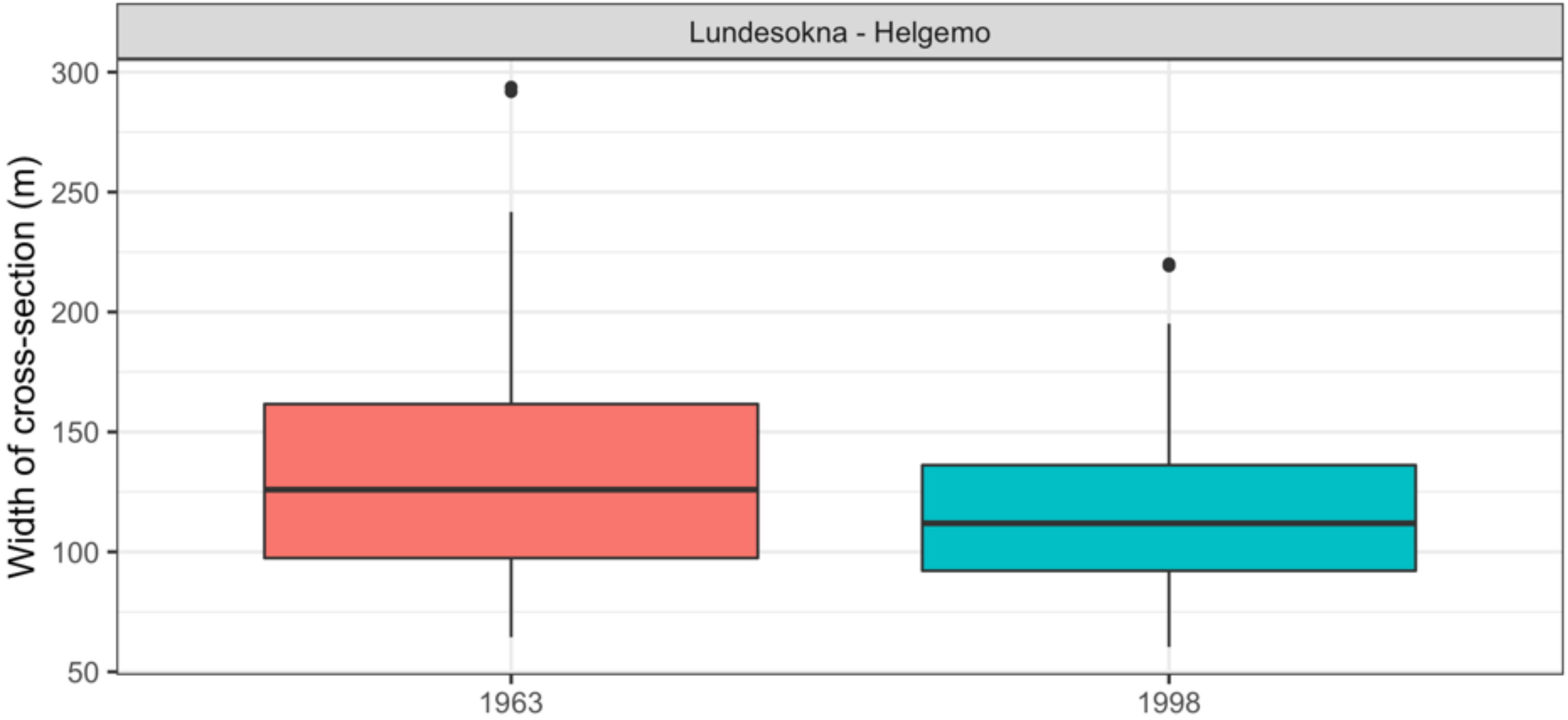


1998

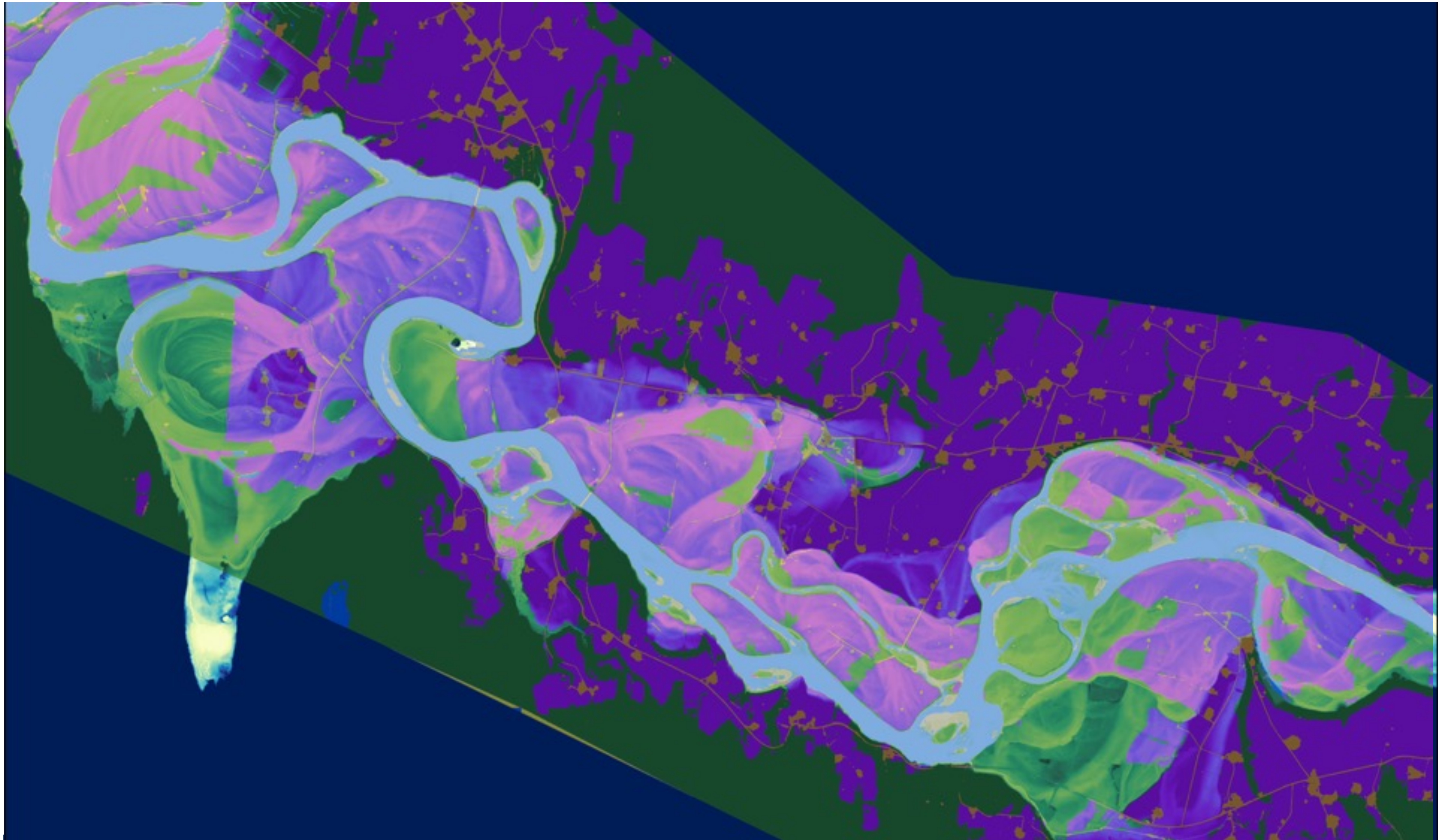


Discharge 1963: 76 m^3/s
Discharge 1998: 293 m^3/s

Gaula, changes



Nea



Summary

- Historical imagery contains interesting information on rivers of the past.

- The machine learning approach provides a fast way of quantifying river types.
  - We can speed up a slow manual process, and even with some post-processing it is still considerably faster than manual annotations.
  - Potential for extracting even more information about features of the rivers.

- River regulation and river training works have an effect on the development of the river morphology.

- Dalsgård, A. (2020) “Segmentation of river ecology using deep learning on aerial images”, Master thesis, NTNU
- Shamsaliei, S. (2022) “Improving the semantic segmentation of historical aerial images of riverscapes using both data-centric and model-centric approaches.” Master thesis, NTNU
- Alfredsen, K., Dalsgård, A., Shamsaliei, S., Halleraker, JH., Gundersen, OE. (2022) “Towards an automatic characterization of riverscape development by deep learning.” River Research and Applications, 38(4):810-816.