

FutureHydro

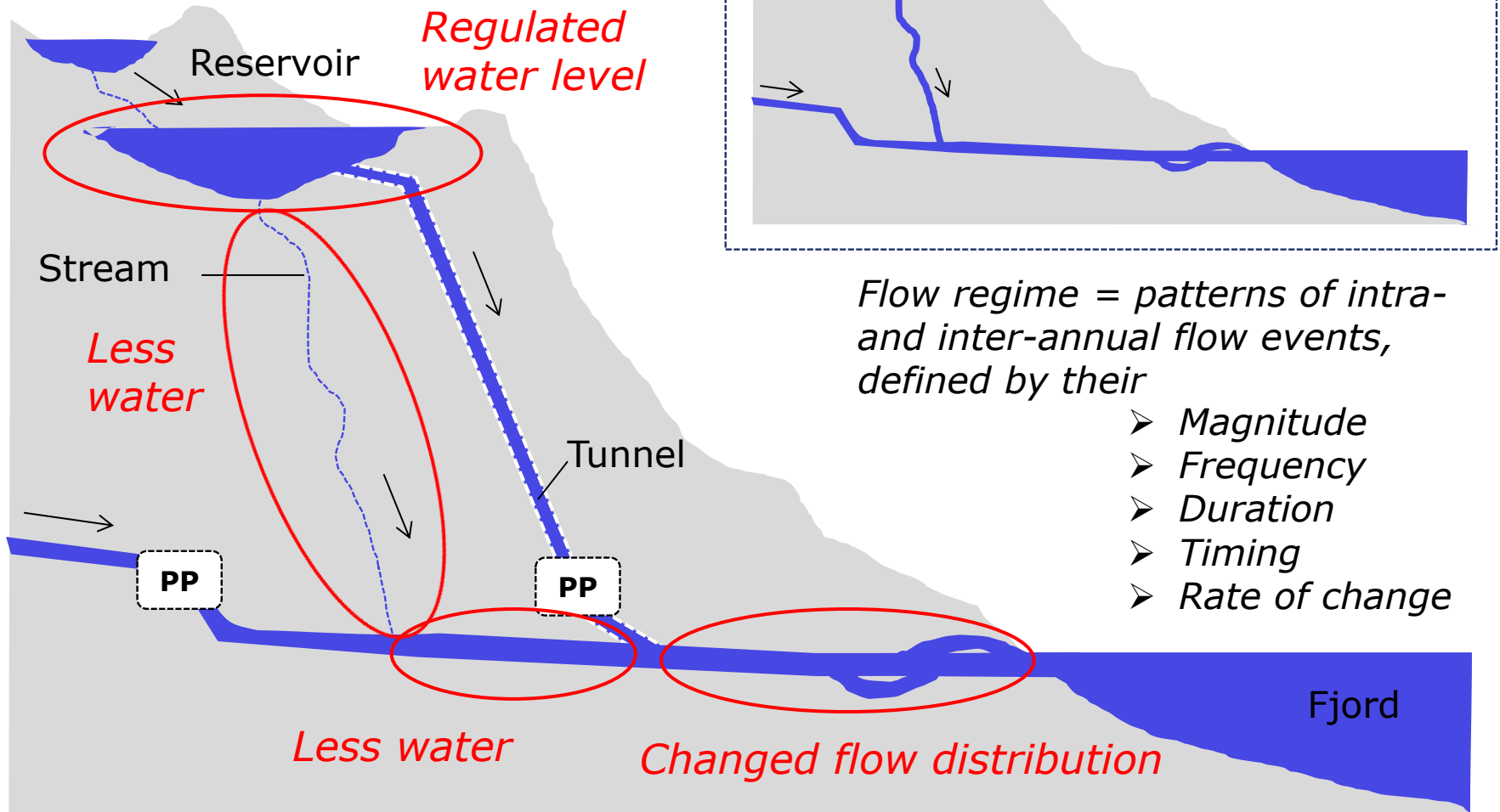
Sustainable hydropower development in China and Norway to meet future demands

The influence of hydropower on morphological processes and vegetation

Short overview and examples from Scandinavia

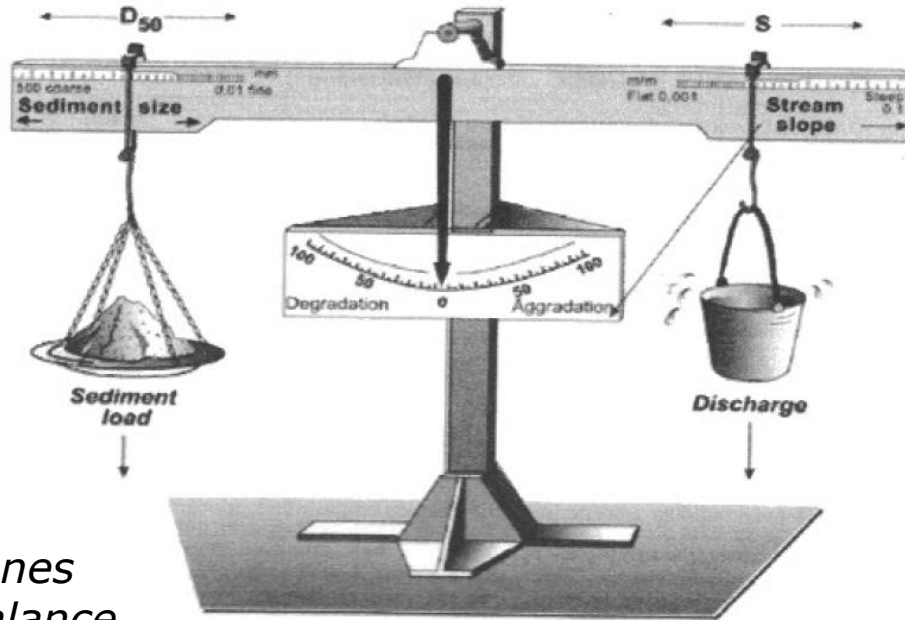
Peggy Zinke, SINTEF Energy Research

Introduction

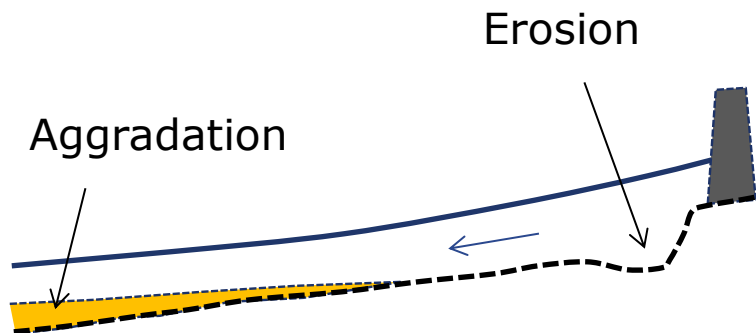


Scheme of a Norwegian river system **after regulation**

Regulation effects on morphology and vegetation – short overview



Lanes
Balance



- ❑ *Transport capacity > available sediment supply: sediment deficit; the channel evacuates sediment from its bed and/or banks.*
- ❑ *Transport capacity < available sediment supply: the channel accumulates sediment.*

First-Order Impacts:

- Flow
- Sediment

Second-Order Impacts:

- Degradation and Erosion
- Aggradation and Deposition

Regulation effects morphology and vegetation at different scales

Habitat

Microhabitat

Mesohabitat

Macrohabitat

Spawning
habitat ass.

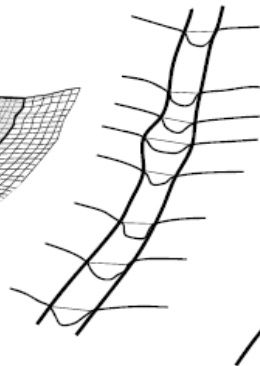
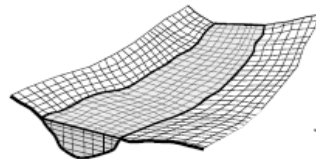
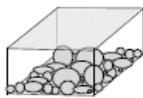
Environmental flow
settings

**Hydrodyn.
model**

2D/3D

1D

DNS/LES



Scale

Point

Local

Reach

Catchment

Continent

Area

1

10

10^3

10^6

10^9

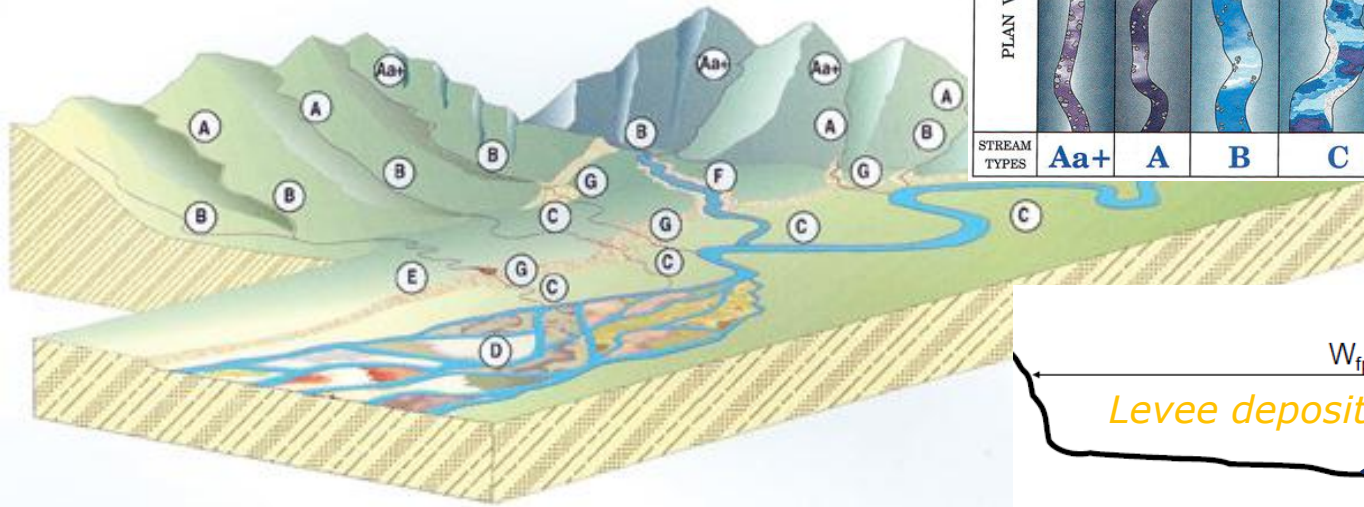
10^{12}

m^2

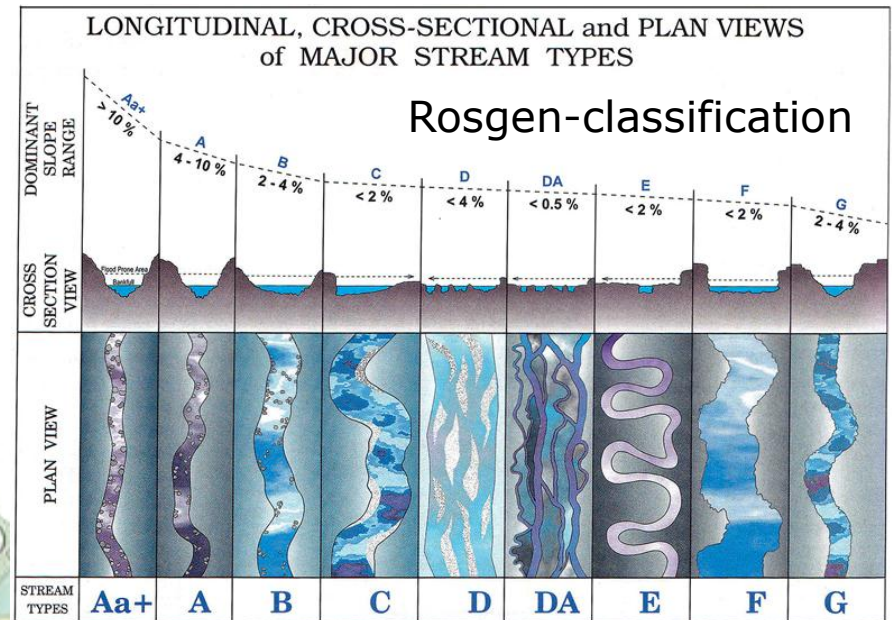
Geomorphological Adjustments:

- Cross-section and capacity
- Slope
- Planform / pattern (i.e. stream type)
- Roughness (Bedforms, vegetation)

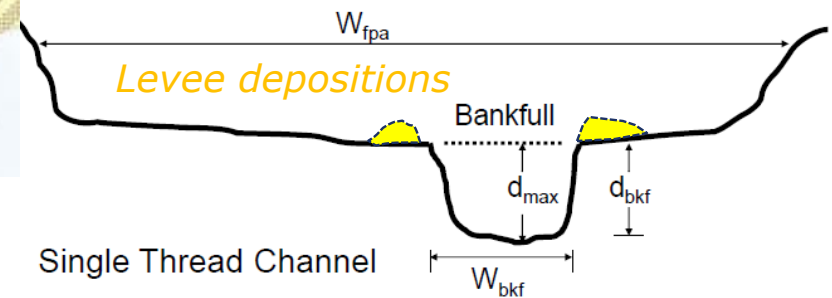
<http://www.fs.fed.us/t-d/pubs/htmlpubs/htm10232808/images/fig23.jpg>



Bankfull $Q \approx$ Mean annual flood



Rosgen Type E

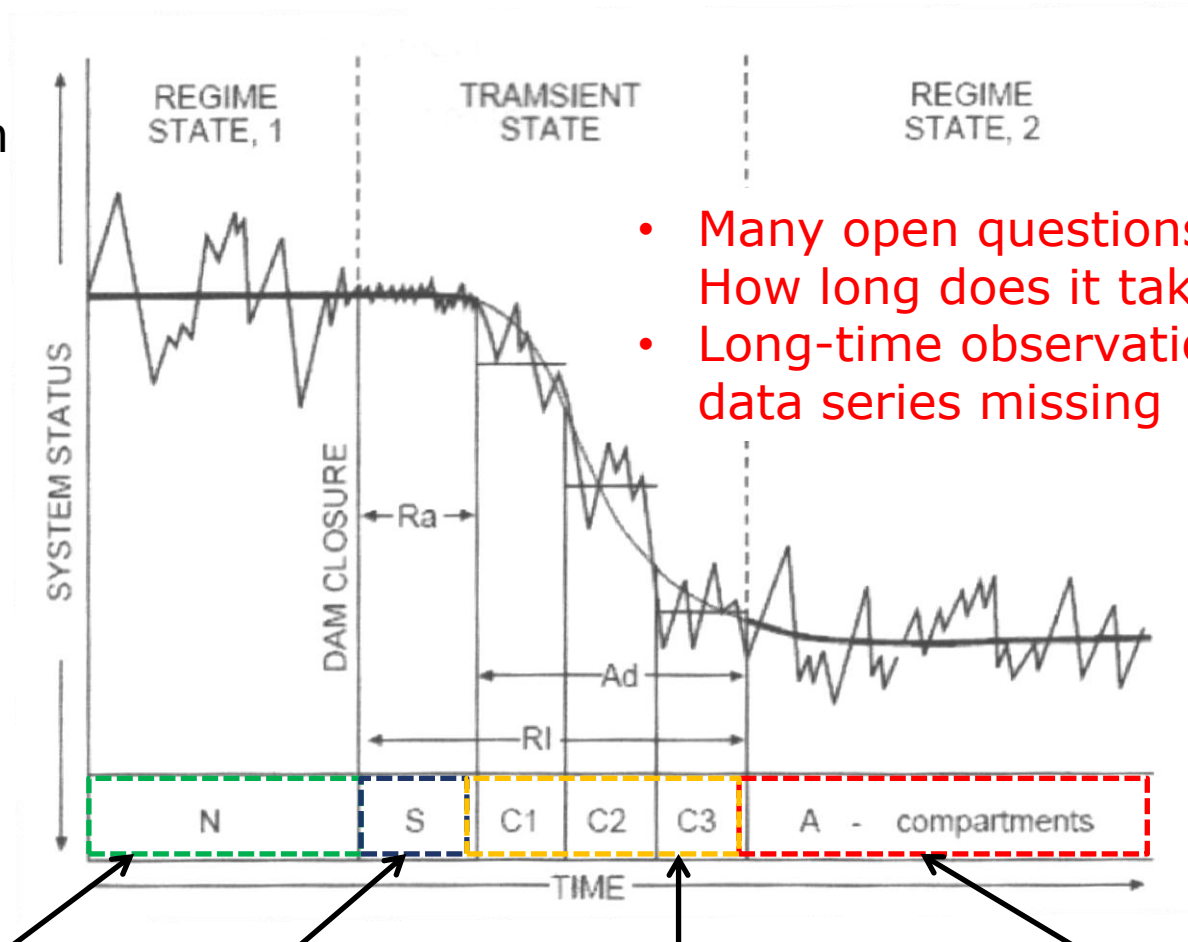


"The channel endeavours to maintain or establish quasi-equilibrium in relation the newly imposed flow and sediment regime."

Concept of a new equilibrium

Time lag between first and second order changes and adjustment stages.

Petts & Gurnell (2005)



- Many open questions, e.g. How long does it take?
- Long-time observations / data series missing

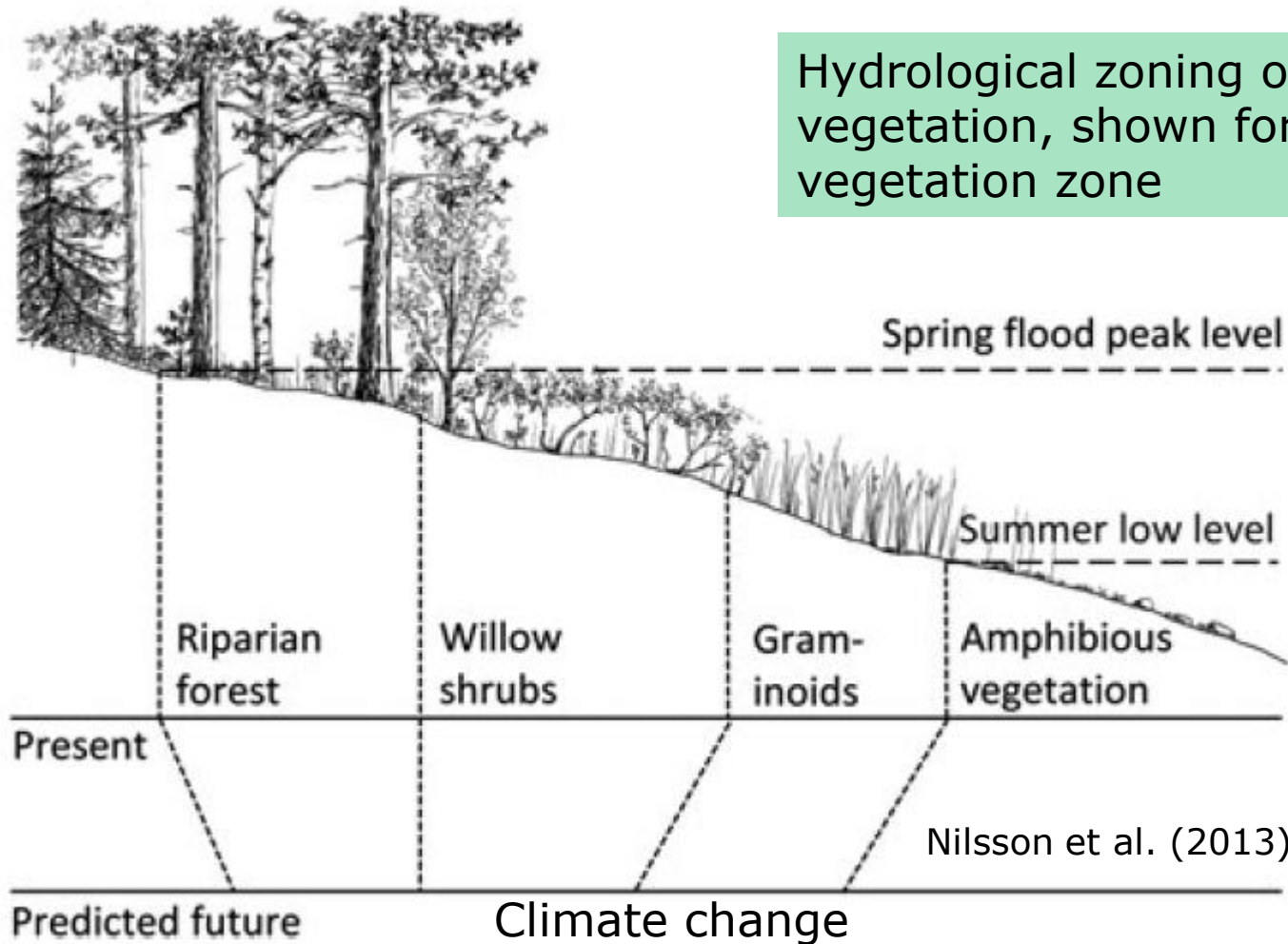
Natural fluctuation around an equilibrium stage

Accommodation stage

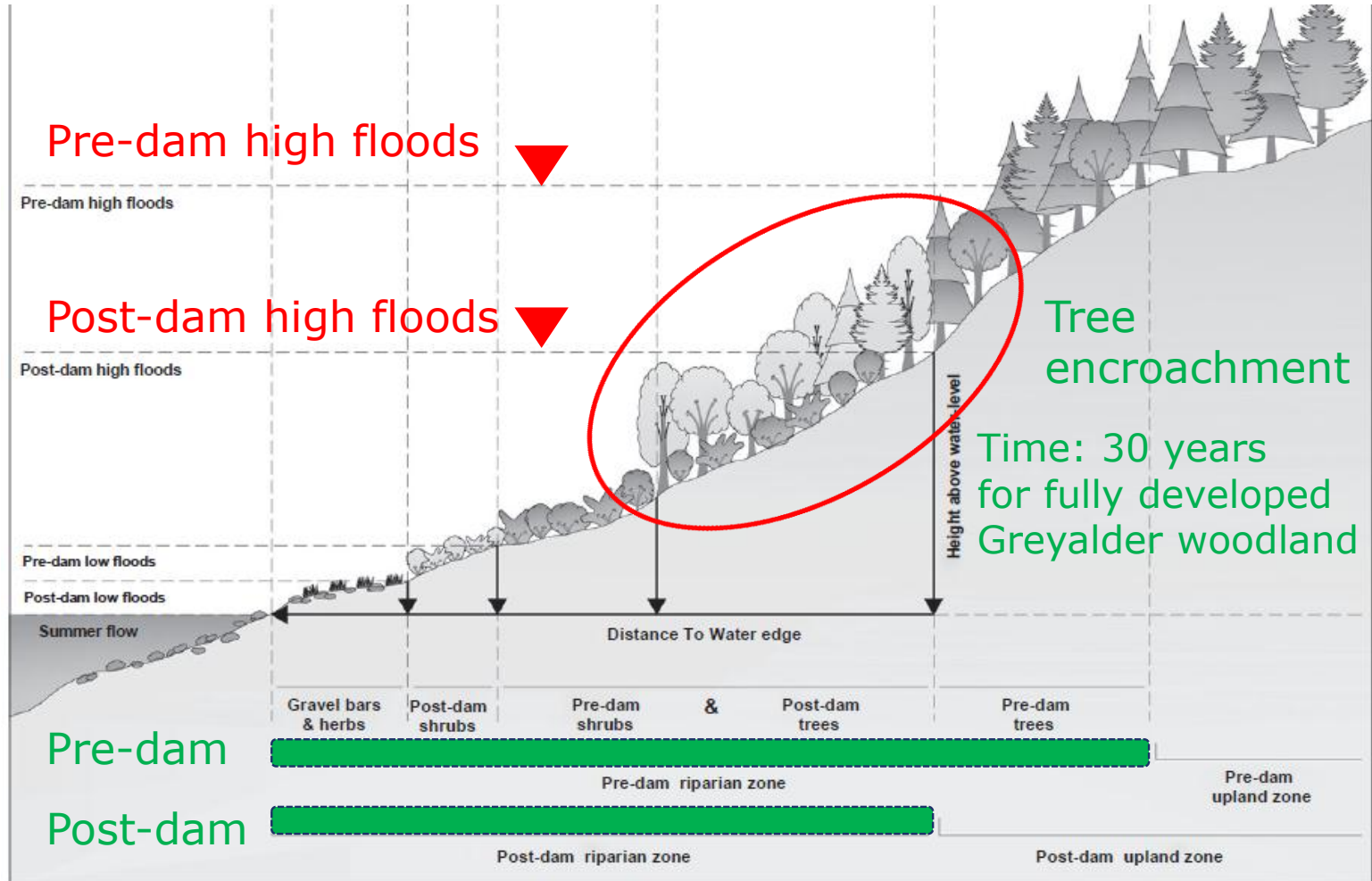
Several stages of adjustment to new F&S regime

Fluctuation around a new equilibrium stage

Effects of flow regulation on vegetation



Effects of flow regulation on vegetation



Extent of the riparian zone

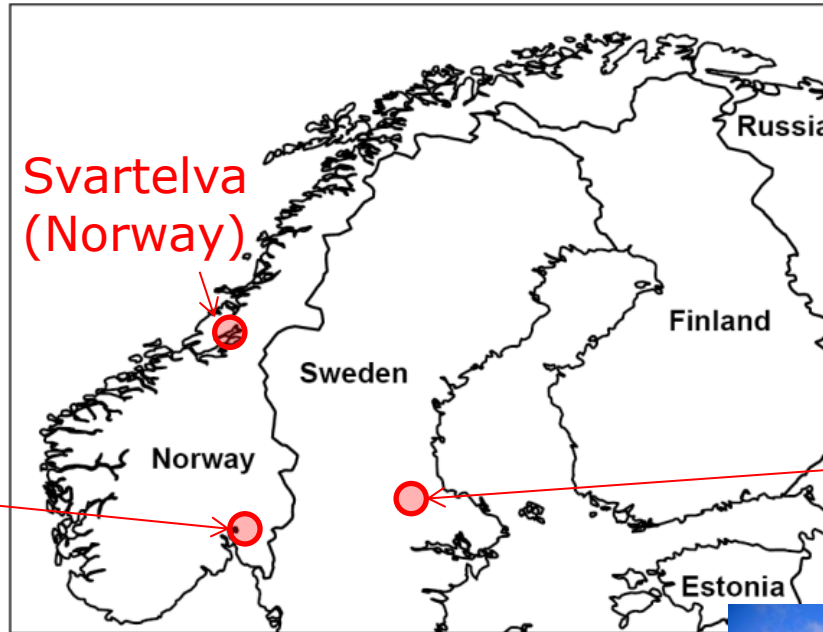
Bejarano et al. (2011), Sweden

Examples from Scandinavia



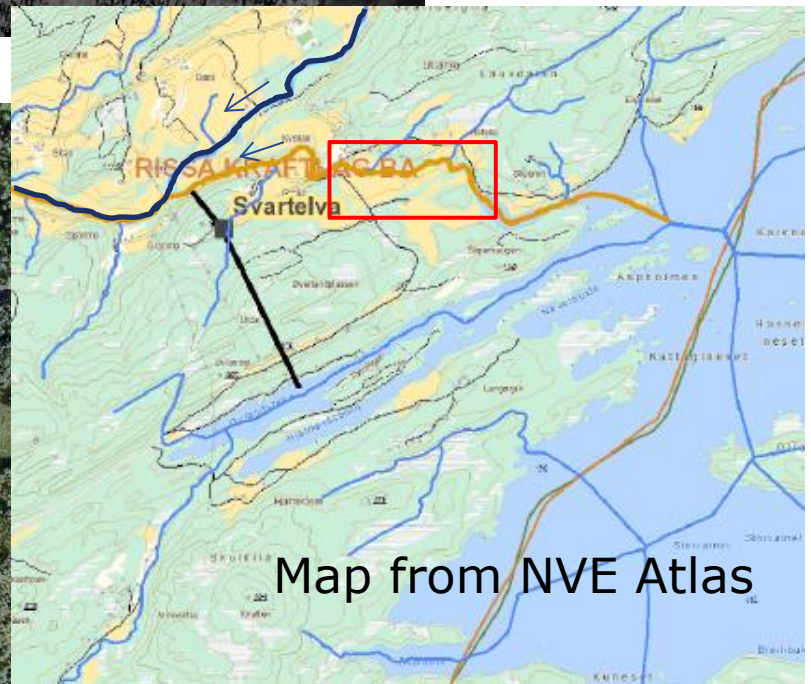
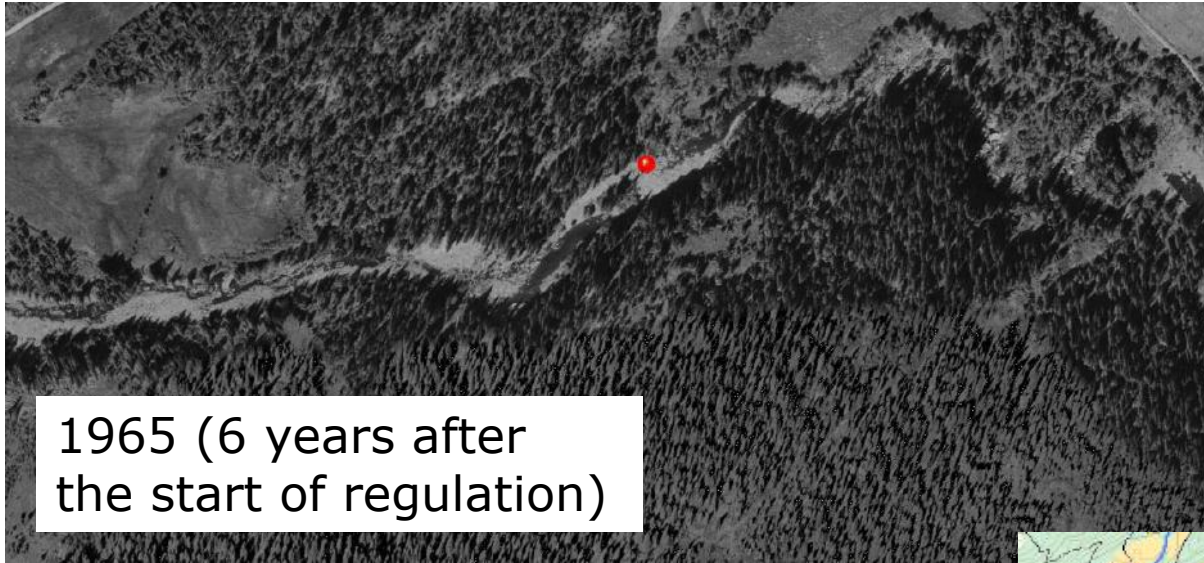
Foto: Fjellanger Widerøe AS ©

Lake Øyeren's delta (Norway)



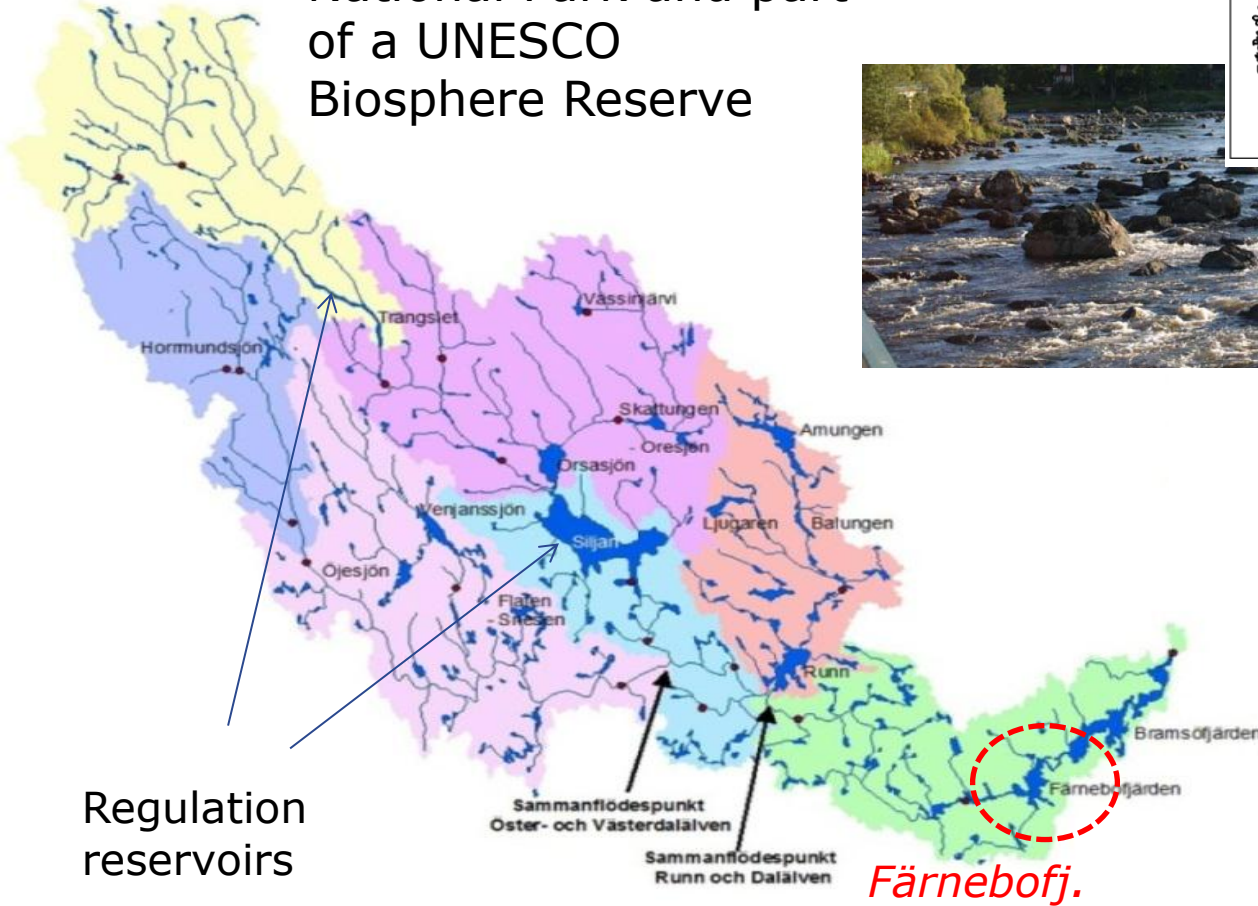
Lake Färnebofjärden (Sweden)



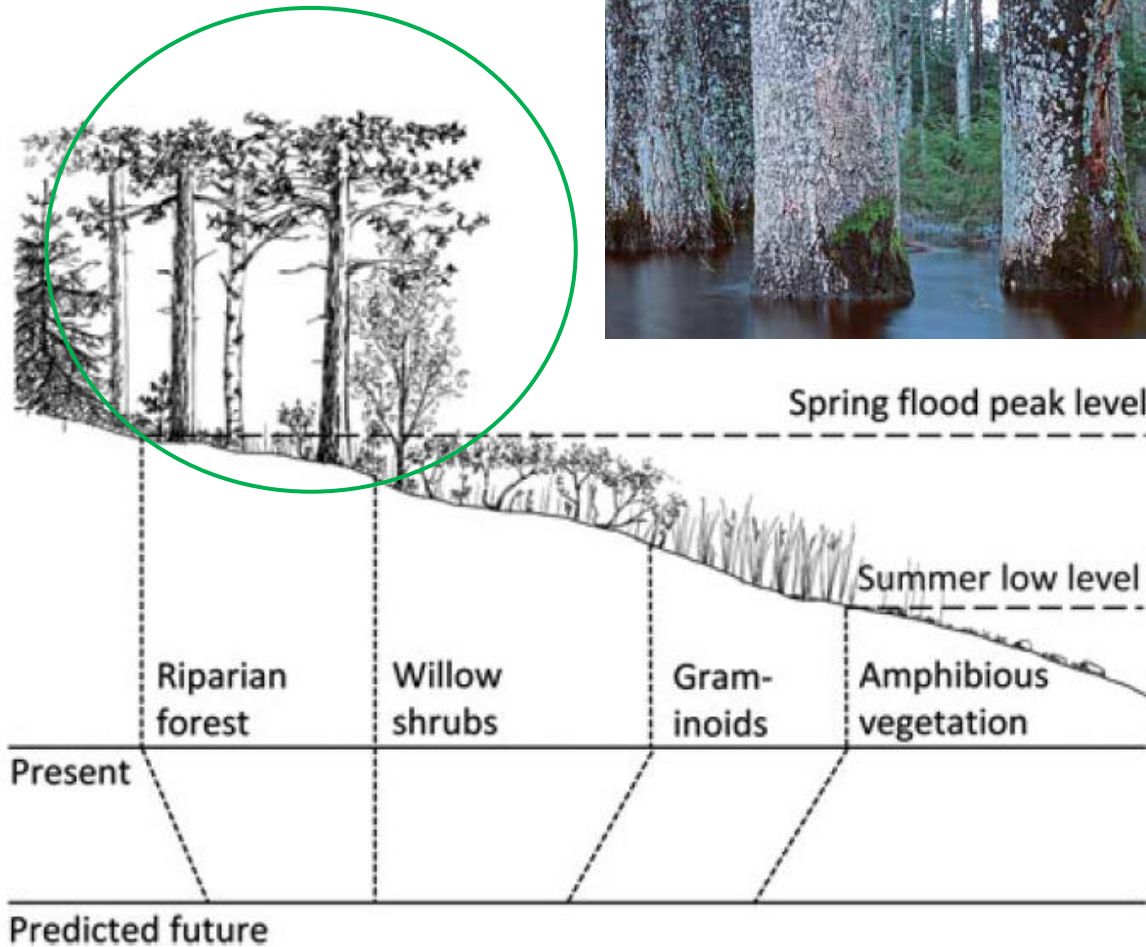


Lake Färnebofjärden

National Park and part
of a UNESCO
Biosphere Reserve



Alluvial forest,
home for many
endangered species



Problem:

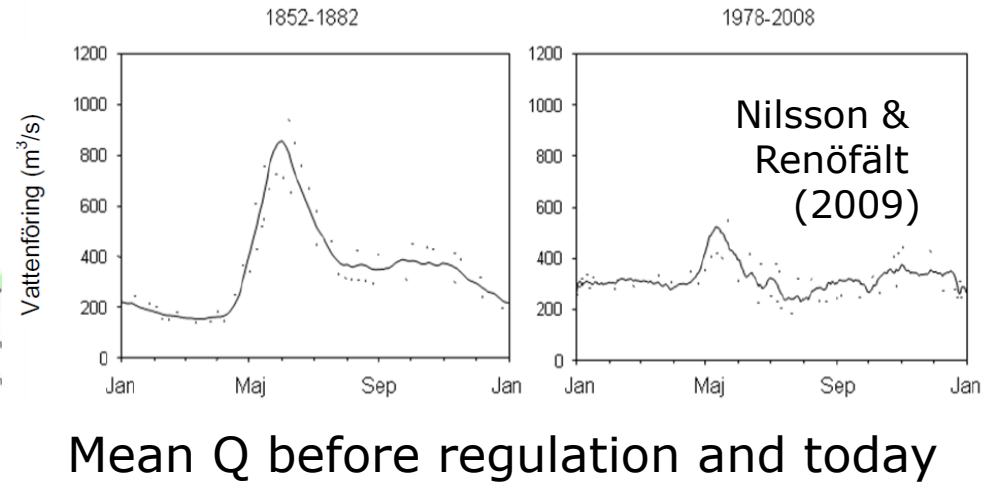
Spruce has started to
establish in the riparian
forest – a consequence
of river regulation?

Central
Sweden

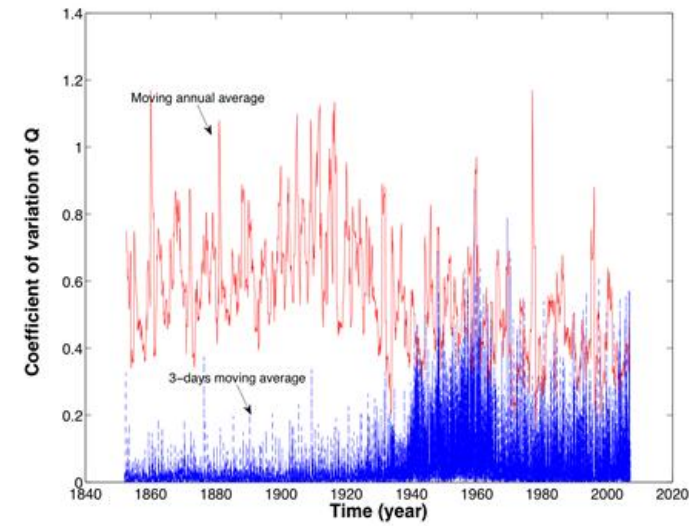
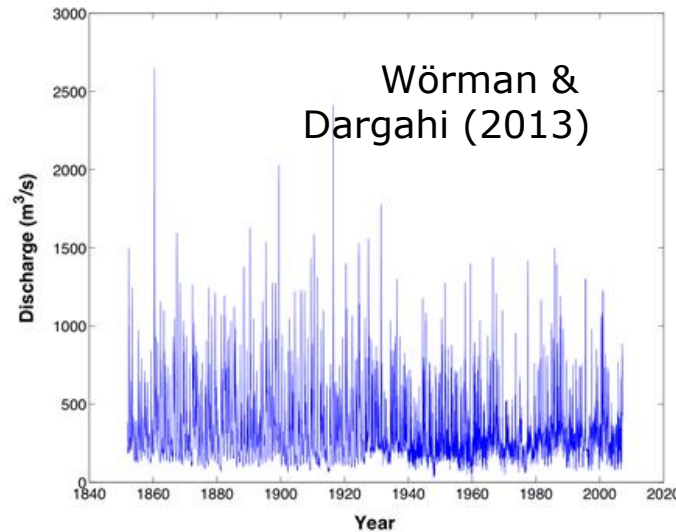
Lake Färnebofjärden

Regulation
reservoirs

Färnebofj.



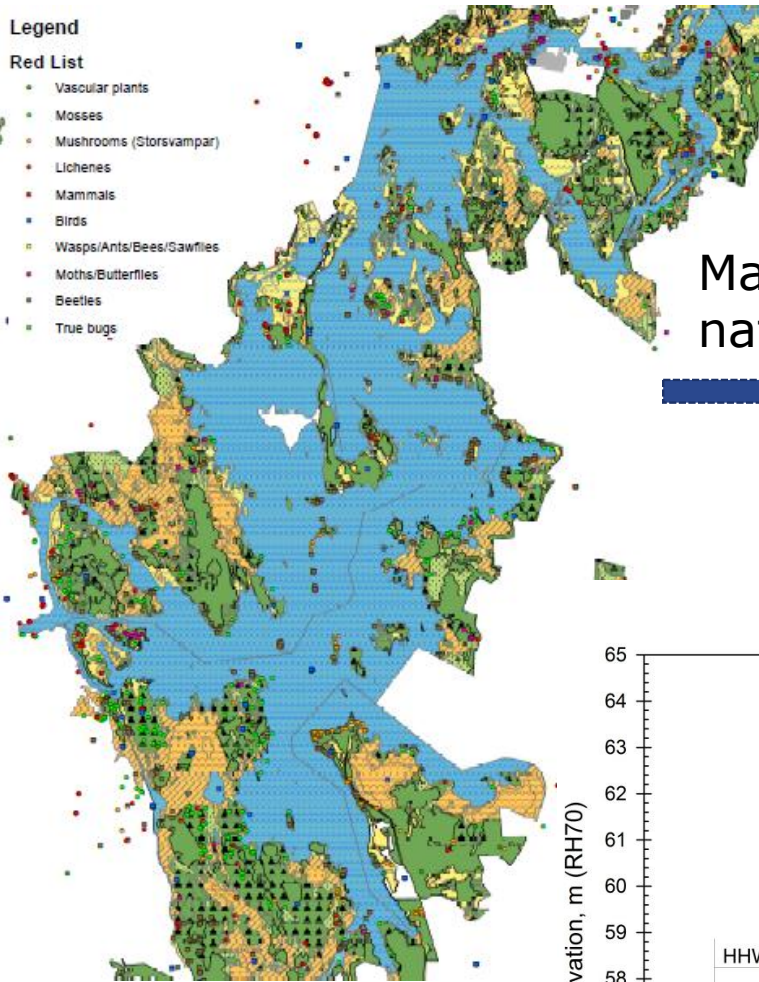
Maximum daily
discharges
and variations
reflecting the
hydropower
regulation
practice



Legend

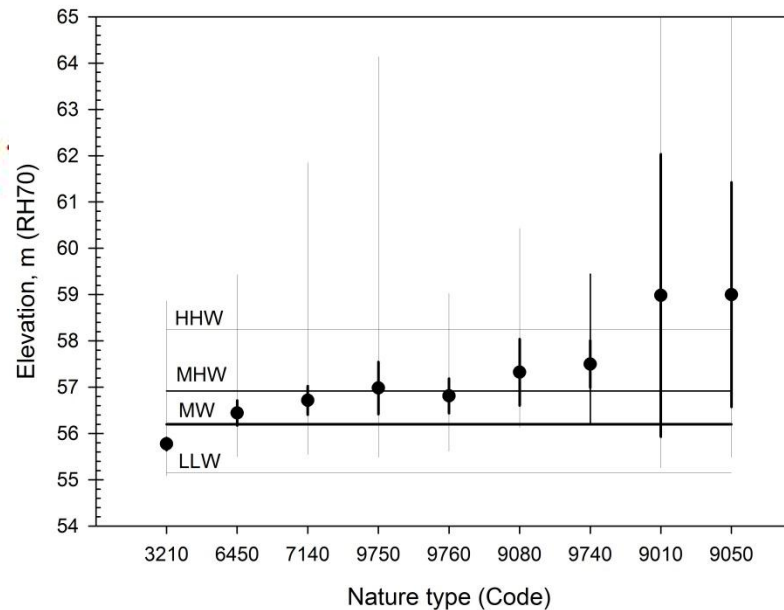
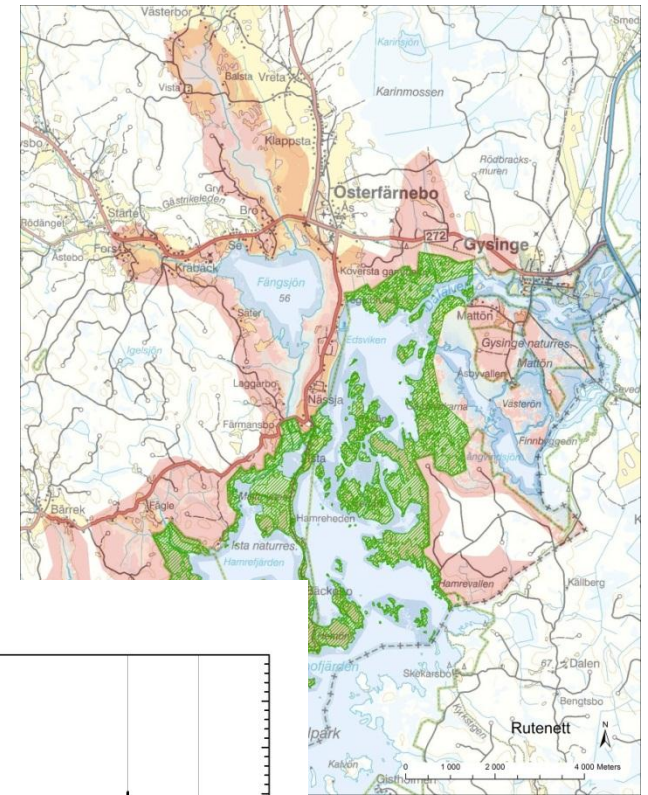
Red List

- Vascular plants
- Mosses
- Mushrooms (Storsvampar)
- Lichenes
- Mammals
- Birds
- Wasps/Ants/Bees/Gawflies
- Moths/Butterflies
- Beetles
- True bugs



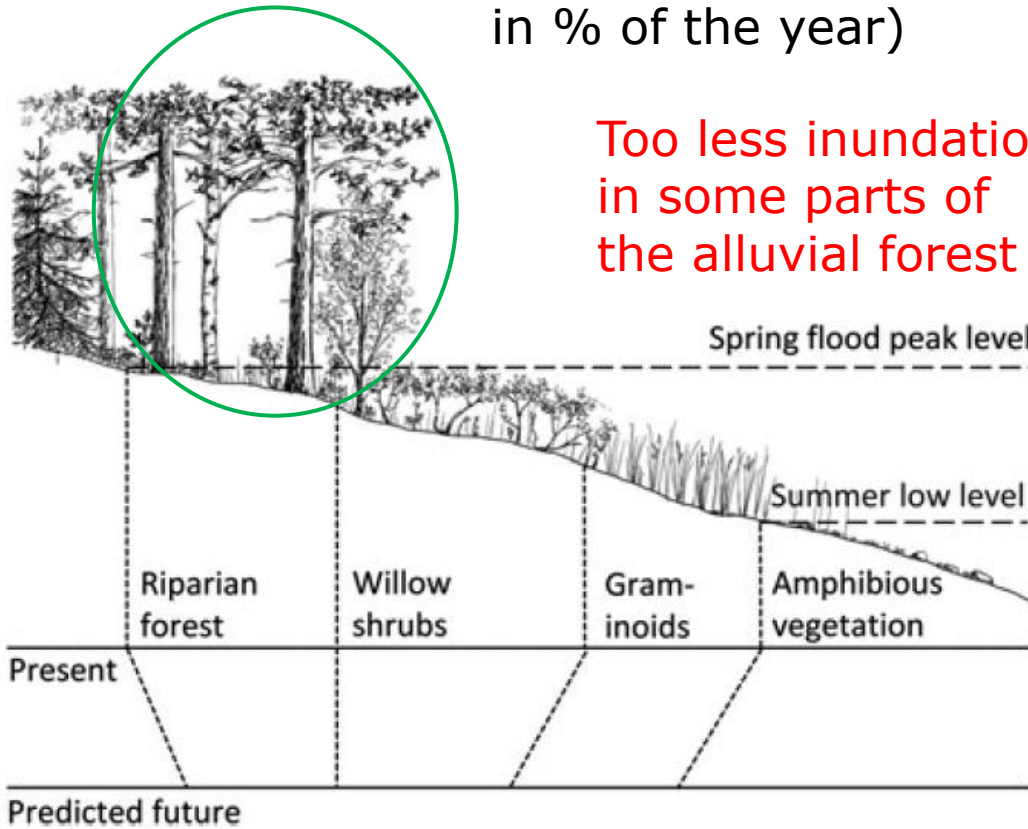
Map of
nature types

GIS analysis
of elevation
distribution



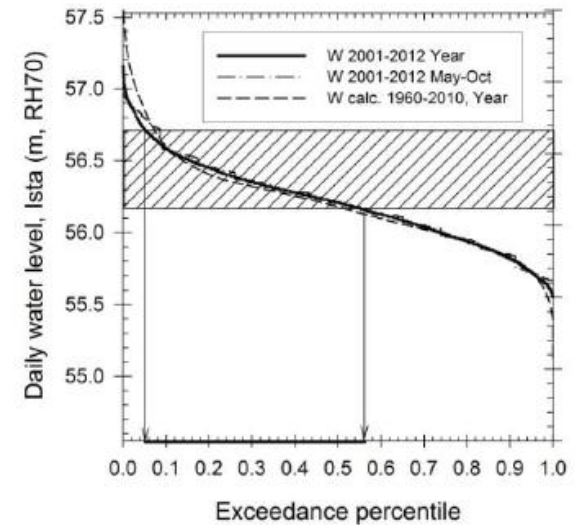
Lake Färnebofjärden

Duration curve,
(inundation duration
in % of the year)

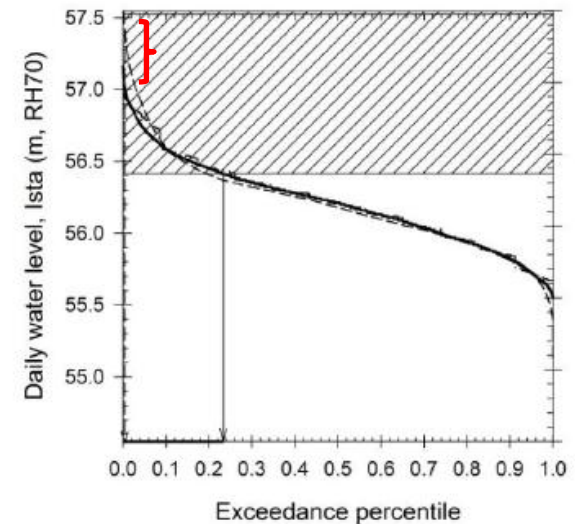


Too less inundation
in some parts of
the alluvial forest

Alluvial meadows (6450)



Alluvial forests (9750)



Lake Øyeren's Delta

Bingsfoss (1978)



Solbergfoss (1924)

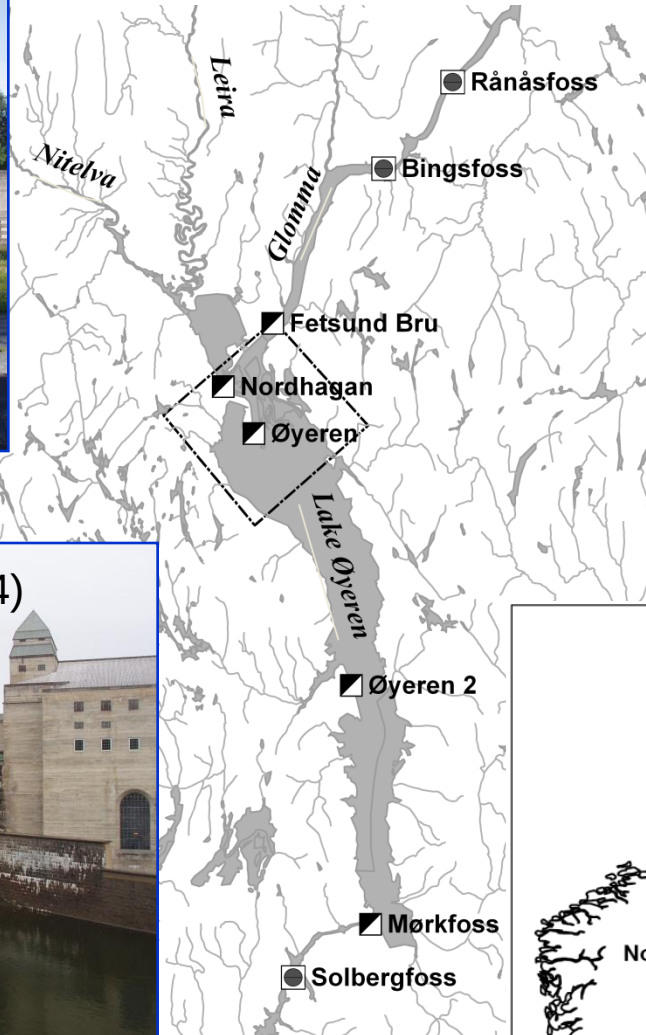
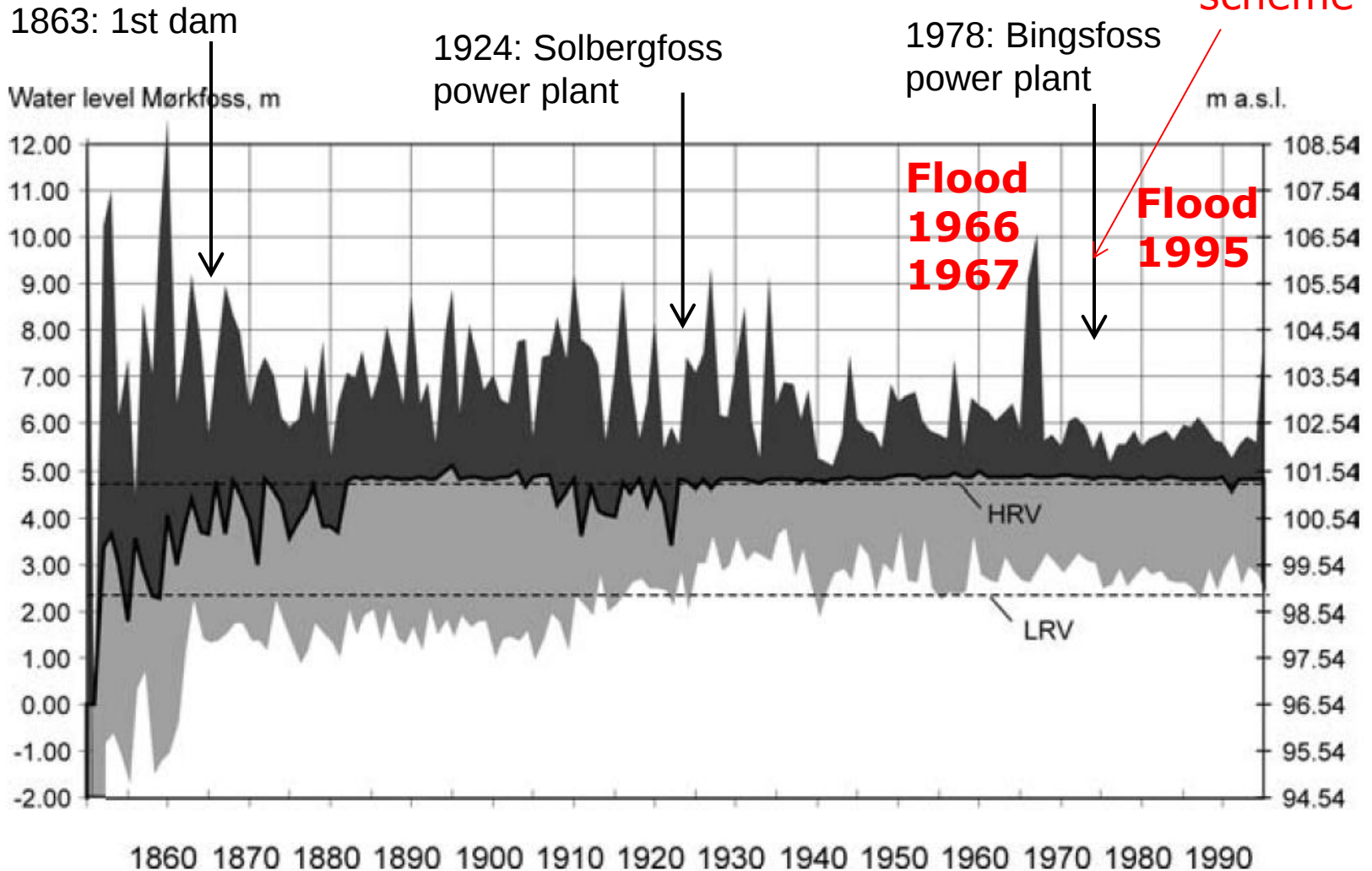


Foto: Fyllanger-Widerøe AS ©



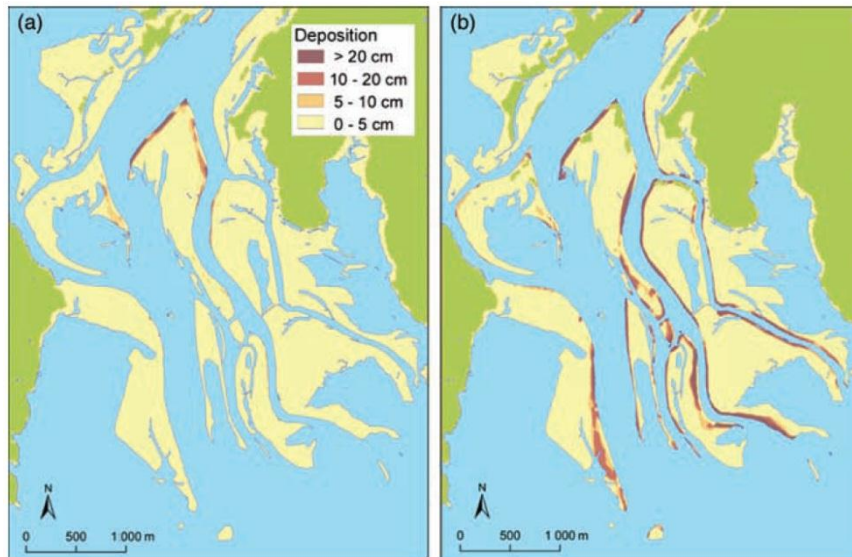
Lake Øyeren's Delta

New flood
regulation
scheme



The flood regulation scheme affects the position of sedimentation areas in the delta.

Results of single-event simulations for the flood 1995

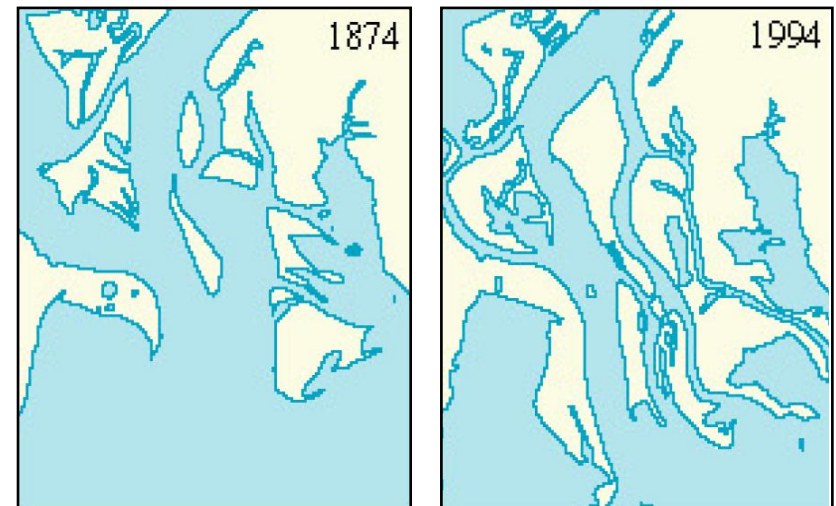


Previous flood reg. New flood reg. scheme

Observed morphological development between 1874 and 1994 →

Tendencies in the delta development after the start of regulation in 1860:

- More levees aggrading to the surface,
- Enhanced deposition at the lower parts of the delta plain,
- Increased number of lagoons and bays.



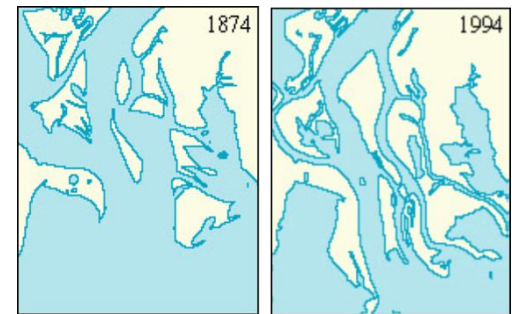
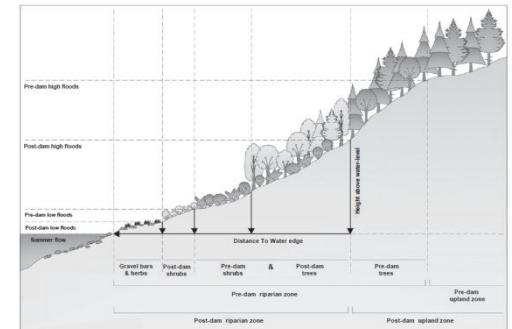
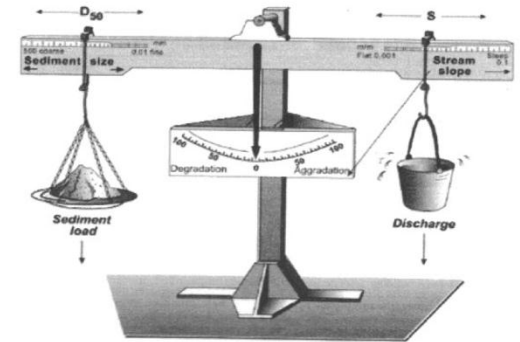
Summary

Hydro power regulation changes the flow and sediment regime of rivers. This leads to hydromorphological adjustments and vegetation changes.

Regulation has led to tree encroachment on formerly open riparian zones in many Norwegian rivers.

Reduced magnitude and duration of floods has reduced the alluvial forest at Lake Färnebofjärden.

Hydro power regulation has affected the development of Lake Øyeren's delta, in particular levee depositions during floods.





Thank you!

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