Defining reference conditions and environmental objectives for the heavily modified watercourses in Northern Finland

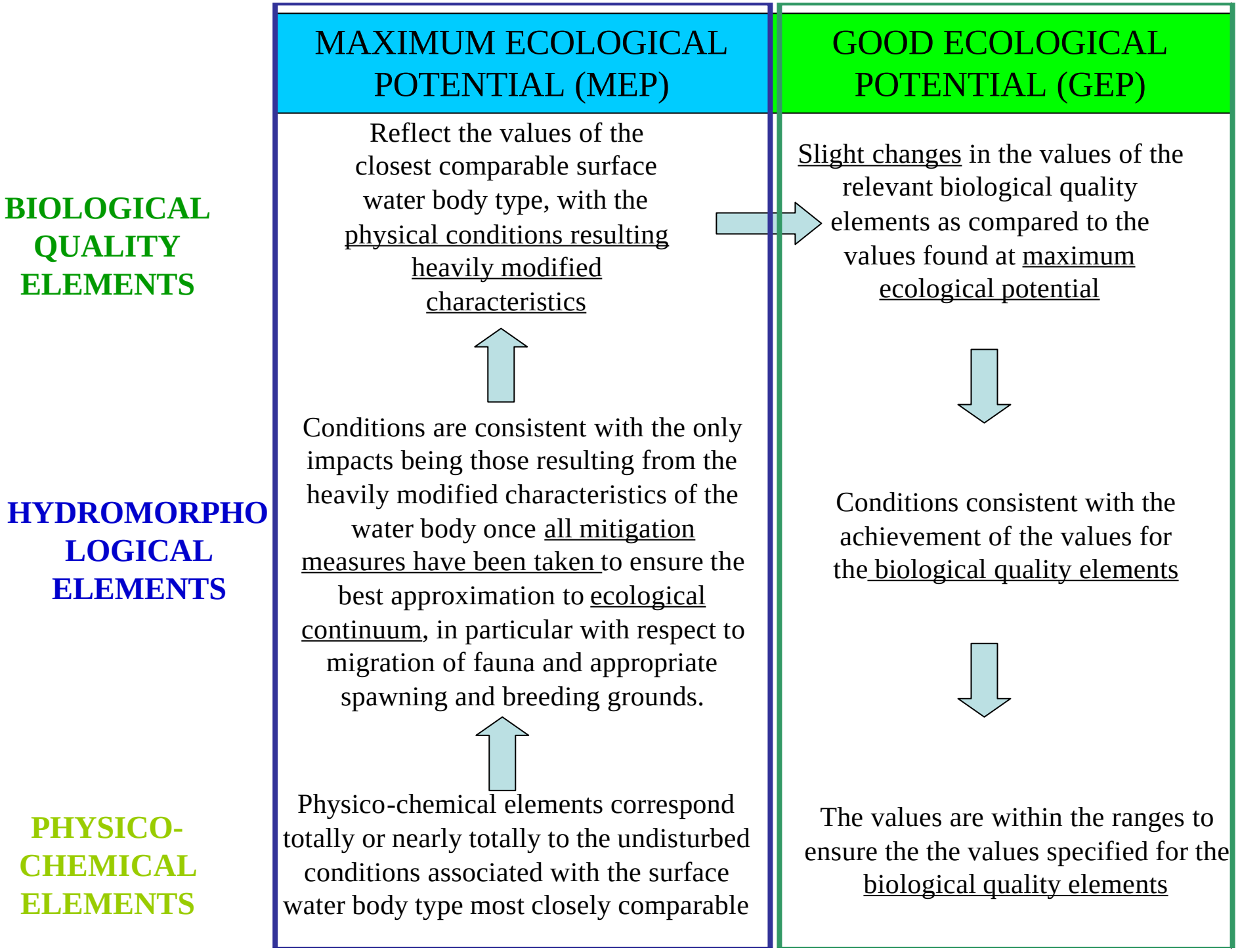
Seppo Hellsten
Jukka Muotka

Other team members:
Aroviita, J., Marttunen, M., Savolainen, M., Sutela, T. & A. Tarvainen

SYKE

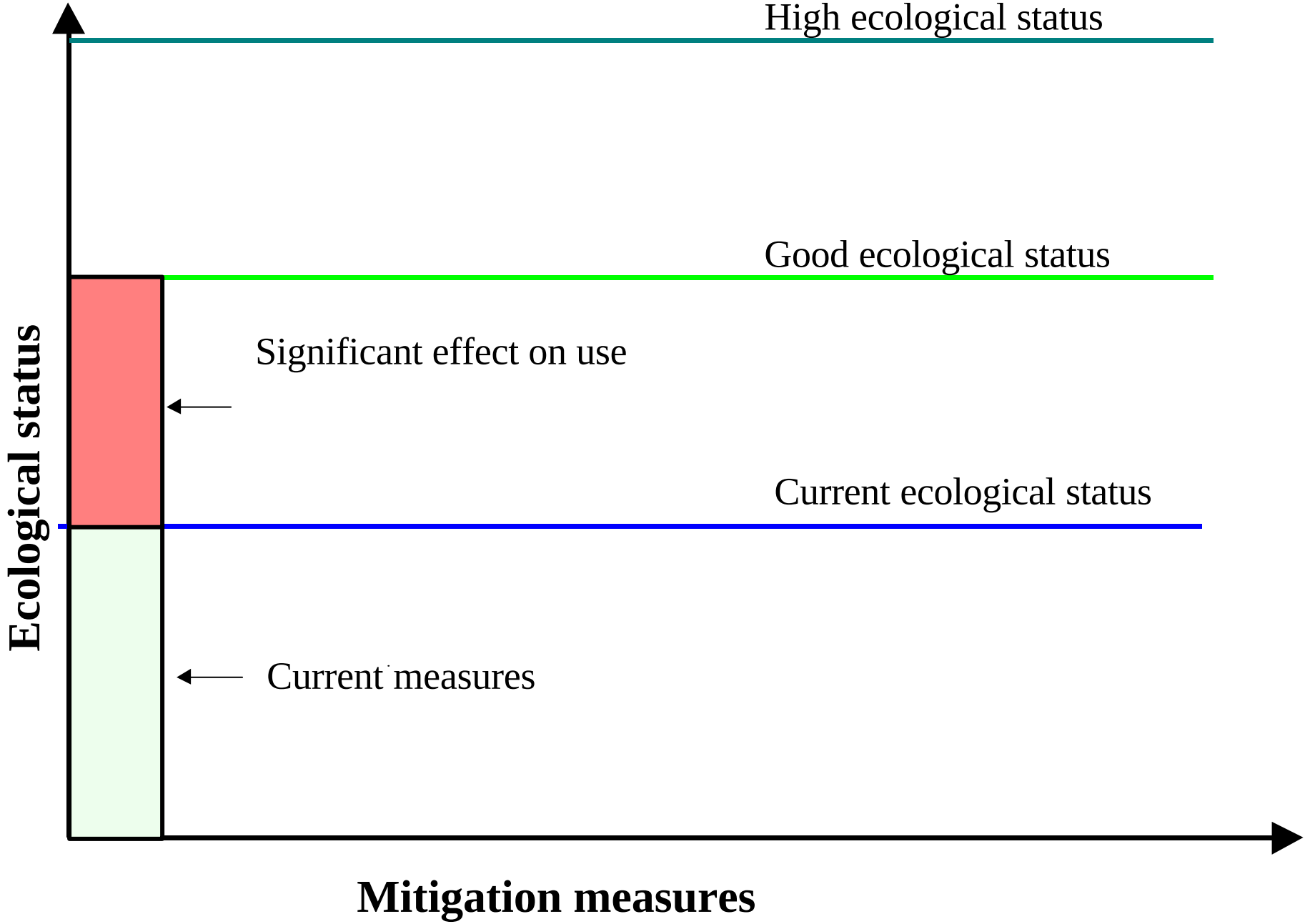
Content

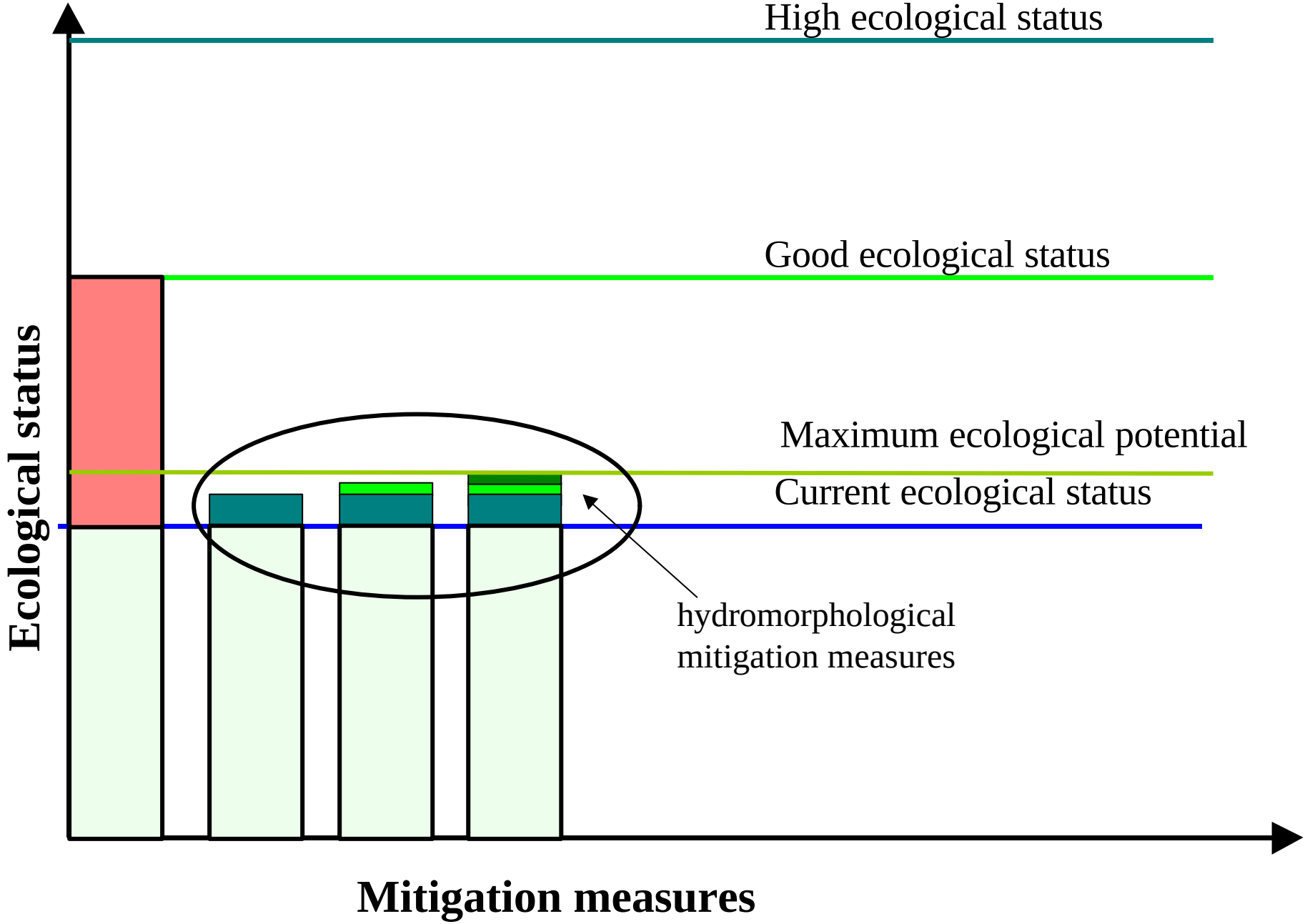
- Some basic principles in defining reference conditions and environmental objectives
- Finnish case studies:
  - River Oulujoki
  - Lake Kemijärvi
- Principles, approach and major outcome of Lake Kemijärvi case

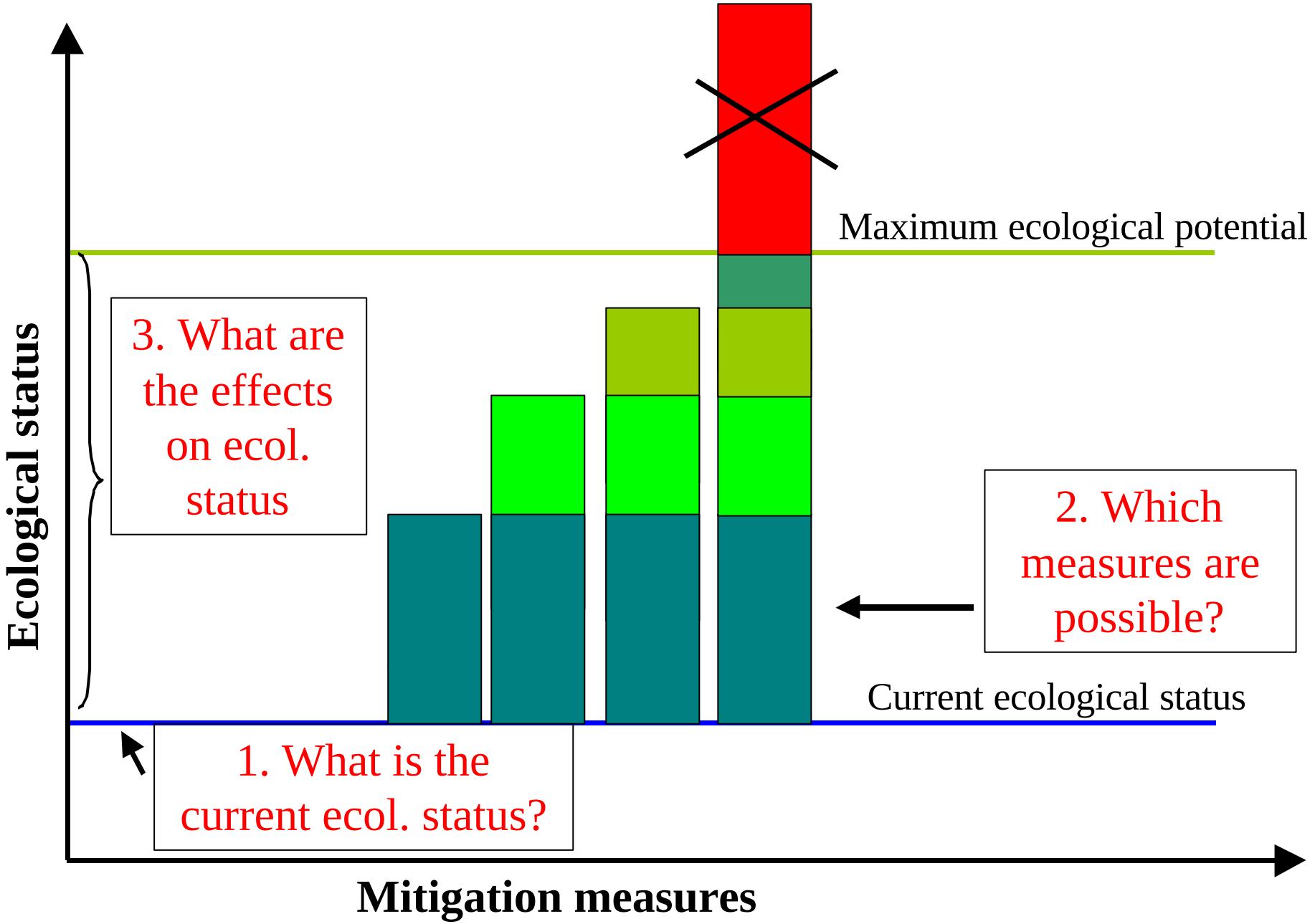

MAXIMUM ECOLOGICAL POTENTIAL (MEP)
GOOD ECOLOGICAL POTENTIAL (GEP)
BIOLOGICAL QUALITY ELEMENTS
Reflect the values of the closest comparable surface water body type, with the physical conditions resulting heavily modified characteristics
Slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential
HYDROMORPHOLOGICAL ELEMENTS
Conditions are consistent with the only impacts being those resulting from the heavily modified characteristics of the water body once all mitigation measures have been taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds.
Conditions consistent with the achievement of the values for the biological quality elements
PHYSICO-CHEMICAL ELEMENTS
Physico-chemical elements correspond totally or nearly totally to the undisturbed conditions associated with the surface water body type most closely comparable
The values are within the ranges to ensure the the values specified for the biological quality elements

Reference conditions for HMWB

- Two options
  - 1) Similar waterbody type with changed hydromorphological properties excluding other pressures like acidification and eutrophication
  - 2) Same waterbody including all mitigation measures
- First option is difficult to imagine
  - same water level fluctuation regime, final succession stage of biota, no nutrient loading
- Second option is much easier to understand
  - all practical mitigation measures
  - qualitative and quantitative approach


High ecological status
Good ecological status
Significant effect on use
Current ecological status
Current measures
Ecological status
Mitigation measures


High ecological status
Good ecological status
Maximum ecological potential
Current ecological status
hydromorphological
mitigation measures
Ecological status
Mitigation measures


Maximum ecological potential
3. What are the effects on ecol. status
2. Which measures are possible?
Current ecological status
1. What is the current ecol. status?
Ecological status
Mitigation measures

Work flow

- Determination of ecological quality ratios for all relevant biological quality elements (macrophytes, zoobenthos, fishes)
  - Taxonomic composition, abundance, sensitive species
  - One or several variables per quality element
- Focus on quantitative change
- Main duties
  - 1) Decision of mitigation measures
  - 2) Decision of variables
  - 3) Estimation of effects of mitigation measures on these variables
  - 4) Reference status calculations

NOTE!

Mitigation measures

- Should improve hydromorphological condition !
- Should not have significant adverse effects on the specific use or wider environment !

- Lake Kemijärvi
  - Heavily regulated lake for hydropower and flood defence with regulation amplitude of 7 m
  - Large lake (288 km^2) situated in the middle of water course
  - Fully developed downstream stretch with 8 power plant
  - Total value of produced hydropower app. 10 M€

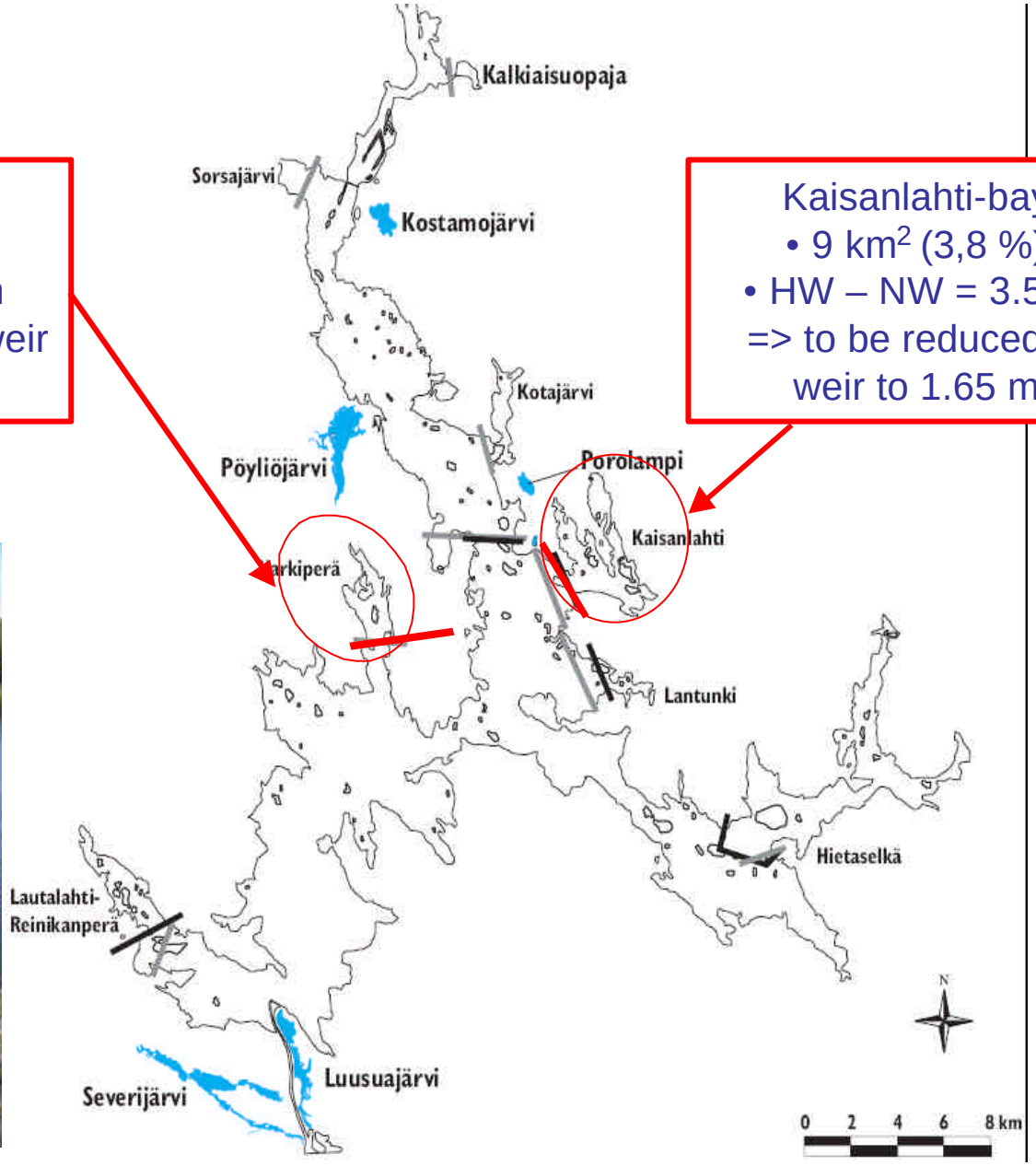
Mitigation measures

A) Changes in regulation practise

B) Construction of bottom weirs

Narkiperä-bay
• 3 km^2 (1,3 %)
• HW - NW = 4.76 m
=> to be reduced by weir to 1.65 m

Kaisanlahti-bay
• 9 km^2 (3,8 %)
• HW – NW = 3.5 m
=> to be reduced by weir to 1.65 m



C) Other mitigation measures

Restoration of habitats

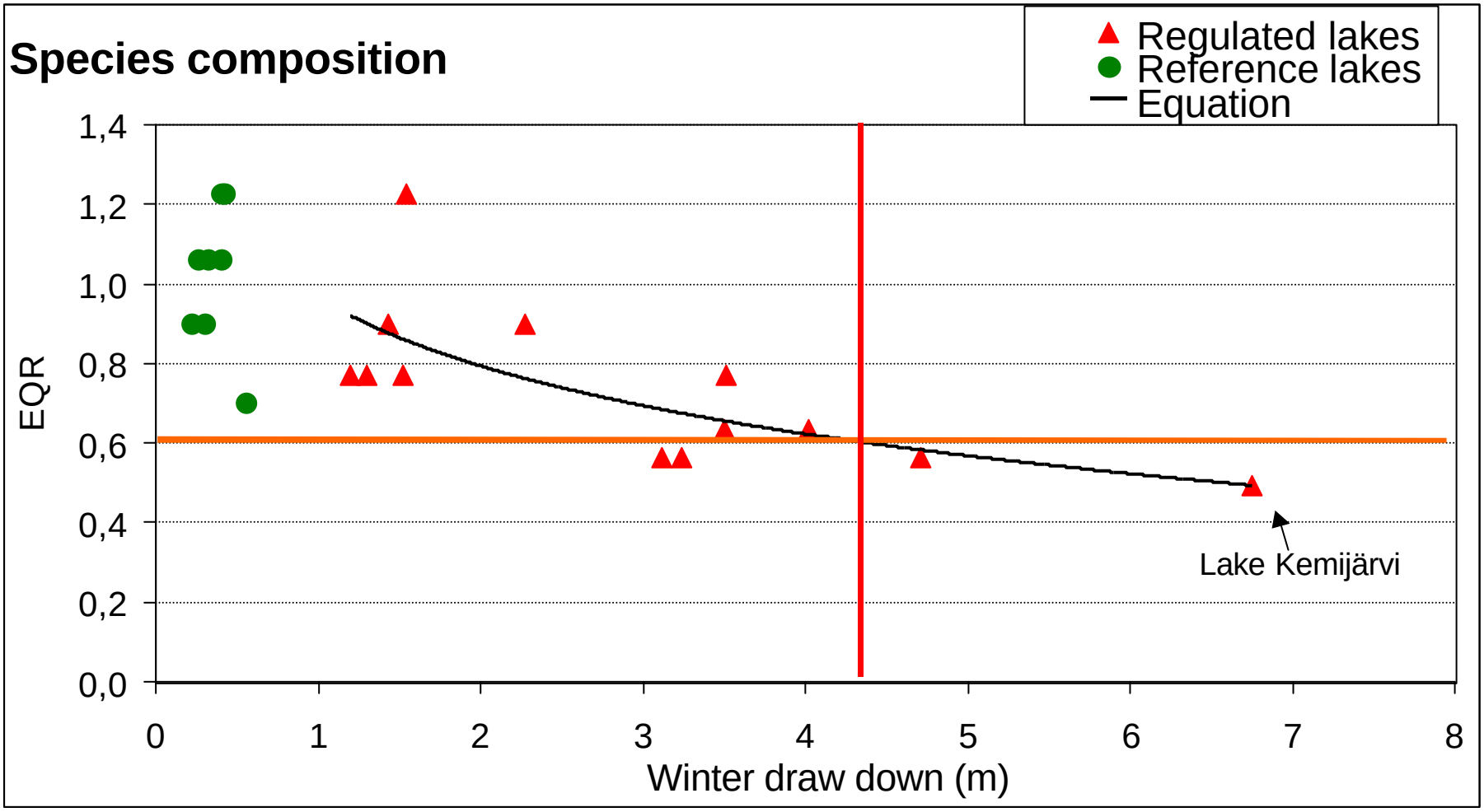
- water phase aeration, sediment aeration
- restoration of tributaries
- re-establishment of wetlands and flood meadows

Shore protection practises

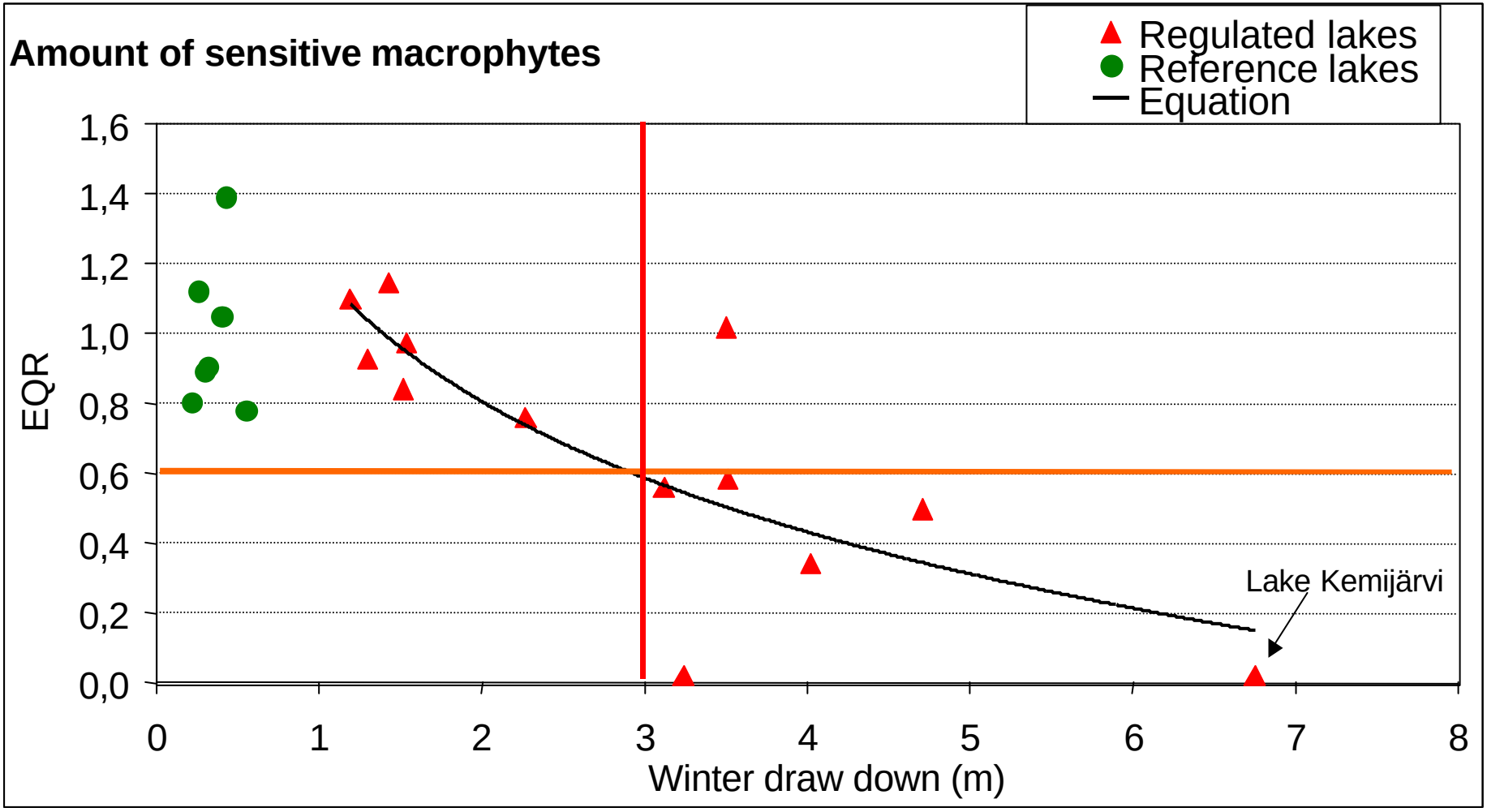
- ecoengineering methods (planting of willows etc.)
- other methods

Ecological quality ratios (EQR)

Aquatic macrophytes

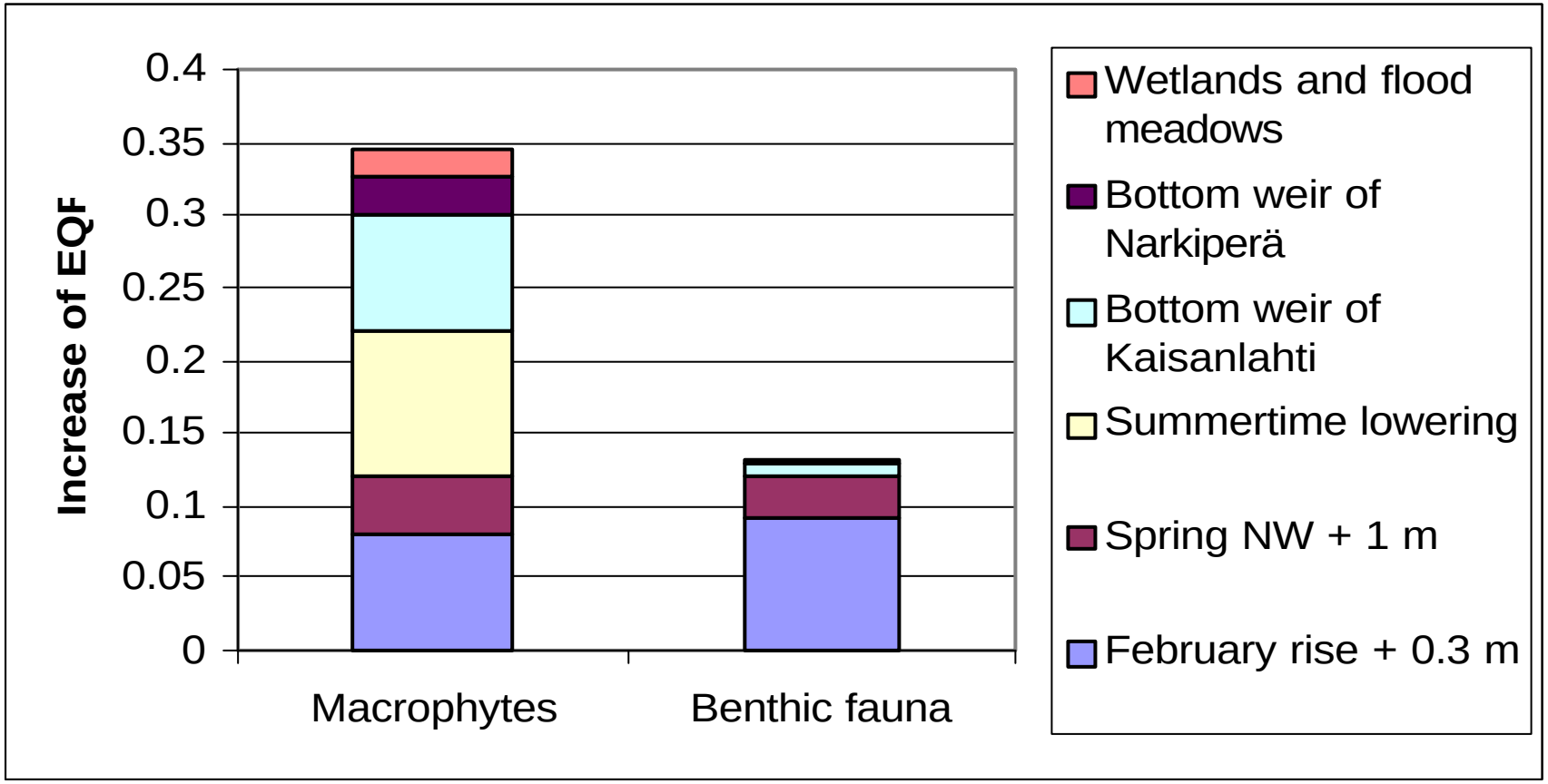


Aquatic macrophytes



EFFECTS OF MEASURES ON EQR

”CURRENT STATUS = 0”



AQUATIC MACROPHYTES

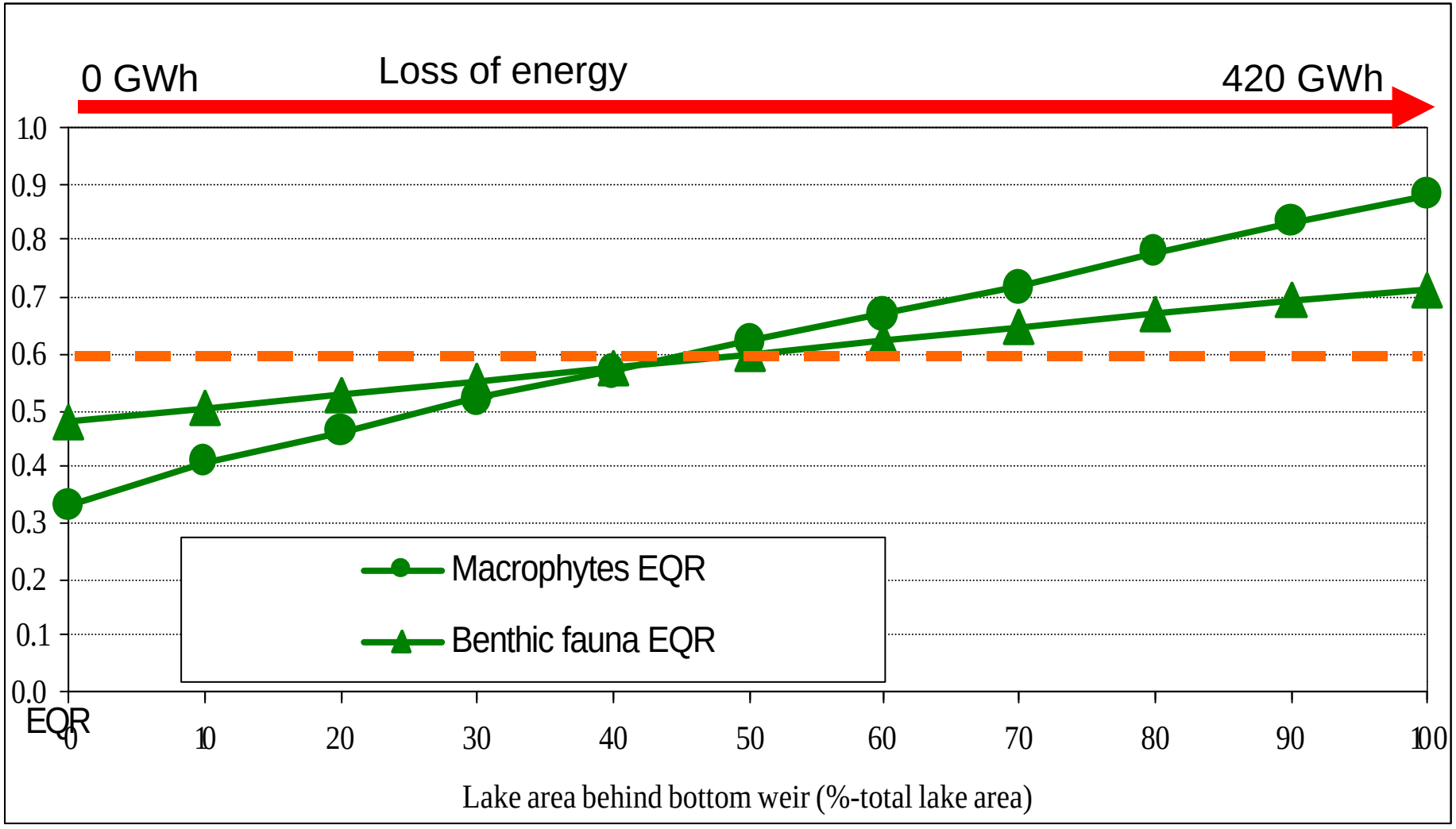
	Species composition	Abundance	Total
CURRENT STATUS (EQR compared to ref.lakes)	**0.49**	**0.02**	**0.29**
Changes in regulation practise			
• 1.2. **waterlevel rise 0.3 m**	0.57	0.32	0.36
• **Spring water level rise 1 m**	0.53	0.24	0.34
• **Summer decrease 0.5 m**	+	+	+
Bottom weirs			
• **Kaisanlahti ecol. status EQR**	0.66? 0.84	0.50? 0.91	0.56? 0.88
• **Whole Lake Kemijärvi**			**0.31**
• **Narkiperä ecol. status EQR**	0.55? 0.84	0.34? 0.91	0.42? 0.88
• **Whole Lake Kemijärvi**			**0.30**
Wetlands and flood meadows	+	+	+
Other measures		No effect	
EQR AFTER ALL MEASURES	**0.58**	**0.35**	**0.46**

BENTHIC FAUNA (LITTORAL)	Stony littoral	Soft bottoms
CURRENT STATUS (EQR compared to ref.lakes)	**0.48**	**0.50**
Changes in regulation practise		
• **1.2.** waterlevel rise **0.3 m**	0.57	0.53
• **Spring water level rise 1 m**	0.51	0.50
Bottom weirs		
• **Kaisanlahti ecol. status** EQR	0.61? 0.72	0.60 ? 0.67
• **Whole Lake Kemijärvi**	0.49	0.51
• **Narkiperä ecol. status EQR**	0.61? 0.72	0.60 ? 0.67
• **Whole Lake Kemijärvi**	0.48	0.50
Other measures	No effect	
EQR AFTER ALL MEASURES	**0.58**	**0.53**

FISHES

	Species composition	Abundance	Age structure
CURRENT STATUS (EQR compared to ref.lakes)	**18**	**sensitive spec. 28%**	**salmon, trout is missing,**
Changes in regulation practise			
•1.2. waterlevel rise 0.3 m	no effect	+ vendace	
Bottom weirs			
• Kaisanlahti ecol. status EQR	no effect	+ lake spawning whitefish	
• Whole Lake Kemijärvi	no effect	slightly positive	
• Narkiperä ecol. status EQR	no effect	+ lake spawning whitefish & vendace	
• Whole Lake Kemijärvi	no effect	local positive effect	
Restoration of tributaries	no effect	+ lake trout	
Other restoration measures		no effect	
ECOLOGICAL STATUS AFTER ALL MEASURES	**18**	**Positive effects for lake spawning white fish, vendace, pike, lake trout**	

Effects of bottom weir areas on ecological status and loss of produced hydropower

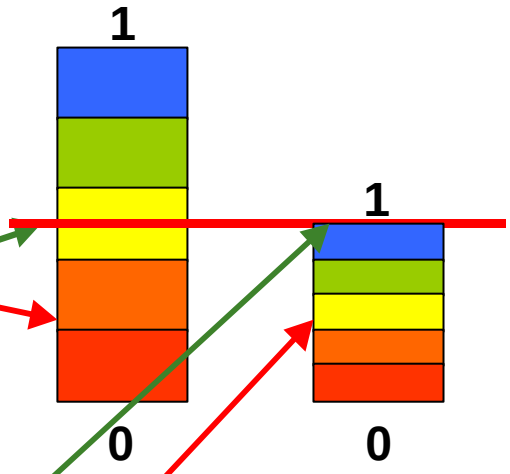


Maximum ecological potential?

How to calculate maximum ecological potential - macrophytes?

- Assumption: eutrophication is not having significant effect on ecological status

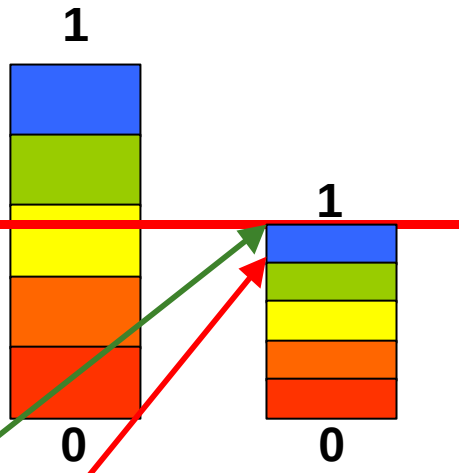
- Macrophytes EQR
  - Present 0.29
  - after measures 0.46 (MEP)



  - Transformation for scale 0-1
    - ⇒ reference status 1
    - ⇒ present status 0.63 (=**good ecological potential**)

How to calculate maximum ecological potential – benthic fauna?

- Benthic fauna EQR (stony littoral)
  - Present 0.48
  - after measures 0.56 (MEP)



- Transformation for scale 0-1

  ⇒ reference status 1

  ⇒ present status 0.83 (=**maximum ecological potential**)

Conclusions (1)

- Significant differences on availability of biological data:
  - No possibilities to calculate EQR for fishes
  - Littoral benthic fauna data moderate
  - Macrophyte data relatively good
- Moderate background data enables quantitative analysis
- It is difficult to raise ecological status without changing regulation practise
  - only local changes are possible e.g. by constructing bottom weirs

Conclusions (2)

- **How to estimate significant effect on use?**
- **Annual benefit of Lake Kemijärvi regulation for hydropower production is app. 10 mill. €**
- **Significant effect 2 %? => 200 000 €**
- **Significant effect 5 % ? => 500 000 €**
- **Estimated effects of MEP**
  - **0,3 m rise in February > 0,5 mill. €/ year**
  - **1 m rise in April 0,5 mill. €/year**
  - **Summer time lowering 0,5 m > 0,1 mill. €/year**
  - **Bottom weirs (Kaisanlahti & Narkiperä) 0,15 mill €/year**
  - **Total losses > 1,2 mill. €/year > SIGNIFICANT (12 %) LOSS**
- **Finally the costs of MEP were too high!!!**

Effects on use/
Costs

NON ACCEPTABLE MEASURES

MEP

Regulation practice

Bottom weirs

Restoration of tributaries etc.

GEP

Ecological significance