Retention of sediments and nutrients in buffer zones with different riparian vegetation

D.Krzeminska, A-G. B. Blankenberg, A. Nemes, F. Bøe, E. Skarbøvik

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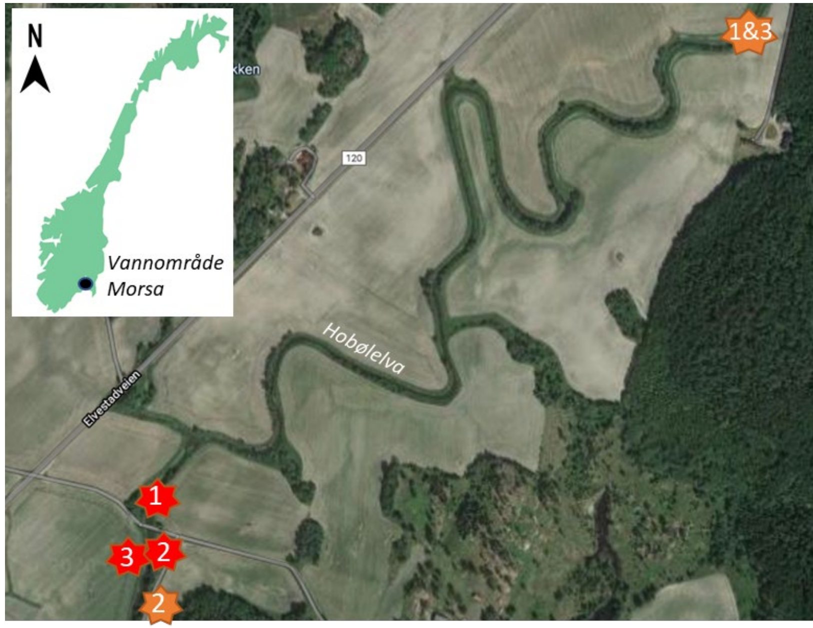
NORSK INSTITUTT FOR BIOØKONOMI

The aim: to show how buffer zones with different vegetation cover may influence the water, sediment and nutrient transport within the catchment.

We present field based research focusing at **the effectiveness of buffer zones for**:

- **the retention of nutrients and particles**
- **the protection against bank erosion**

Buffer zones with: (a) grass, (b) trees; (c) berry bushes



Location of:

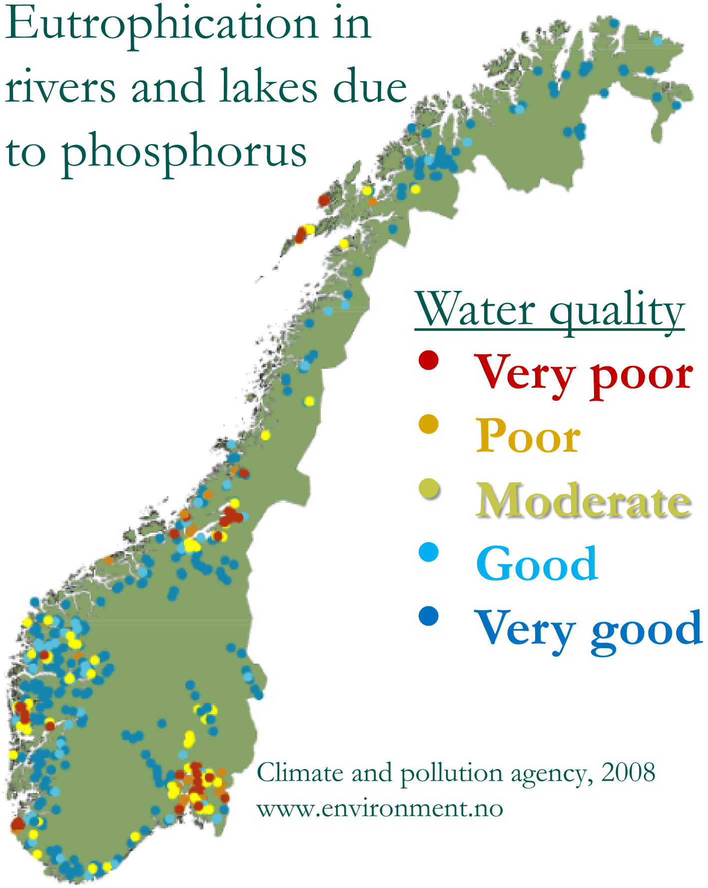
- *field observation*
- *experimental plots along Hobøl River*

(source: Google Maps)

- **Eutrophication** is a major problem for freshwater quality, due to excess phosphorus inputs from agriculture area.

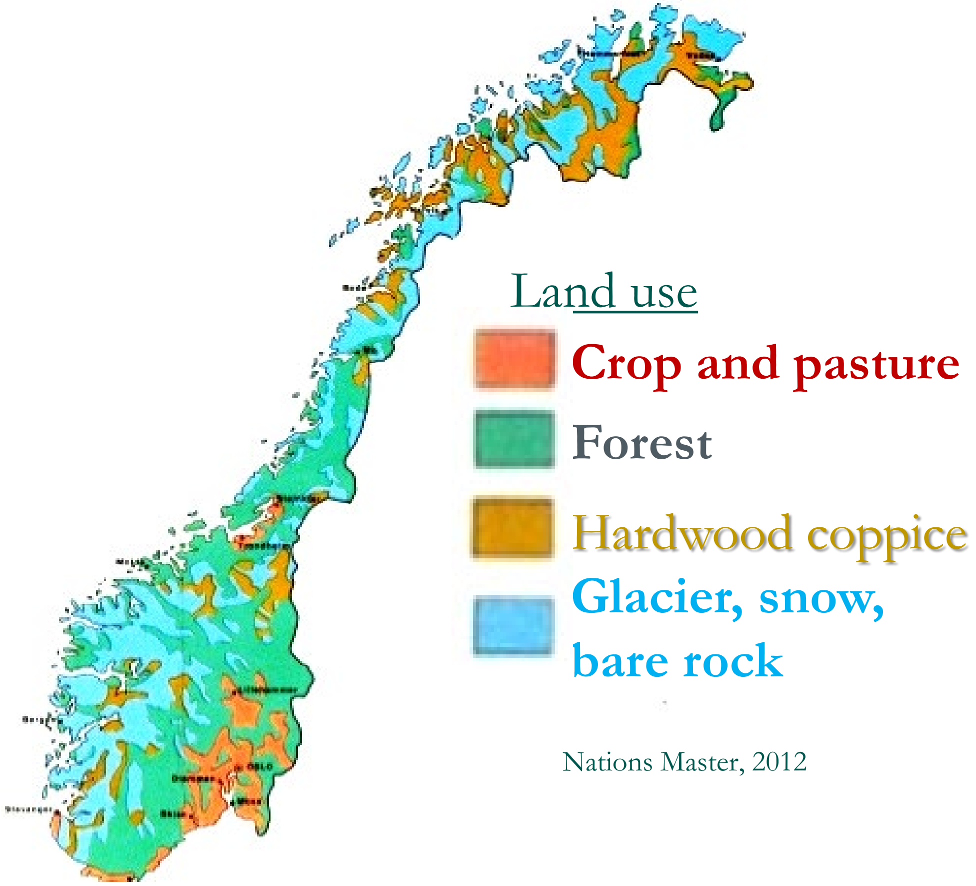
- **3 % of Norway's total area is arable land**, and 30 % of this can be used for cereal production and vegetables.

Eutrophication in rivers and lakes due to phosphorus



Climate and pollution agency, 2008
www.environment.no

VS.



Nations Master, 2012

- There is a system of **subsidies** for environmental measures in agriculture to encourage farmers to take steps **to reduce erosion and runoff**, among others **to establish buffer grassedzones along rivers and streams**.

VS.

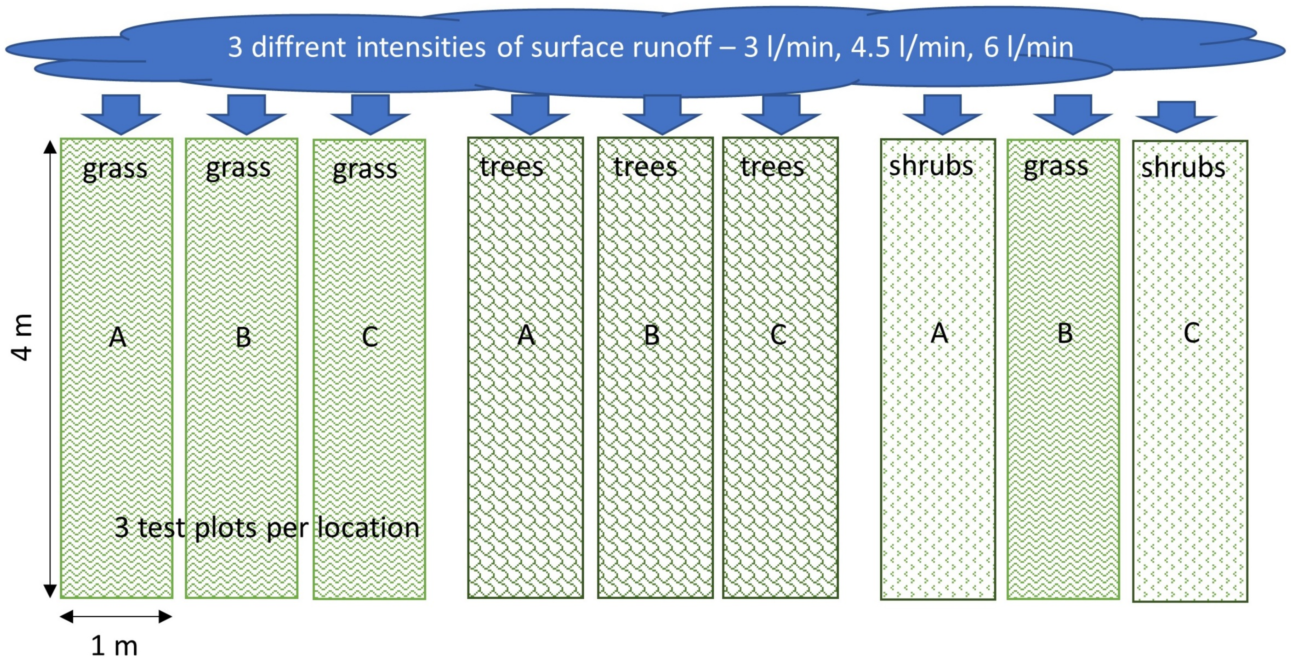
- **The acreage and cultural landscape scheme** (direct payments from the government) is the most important program for crops including fodder and grassland.

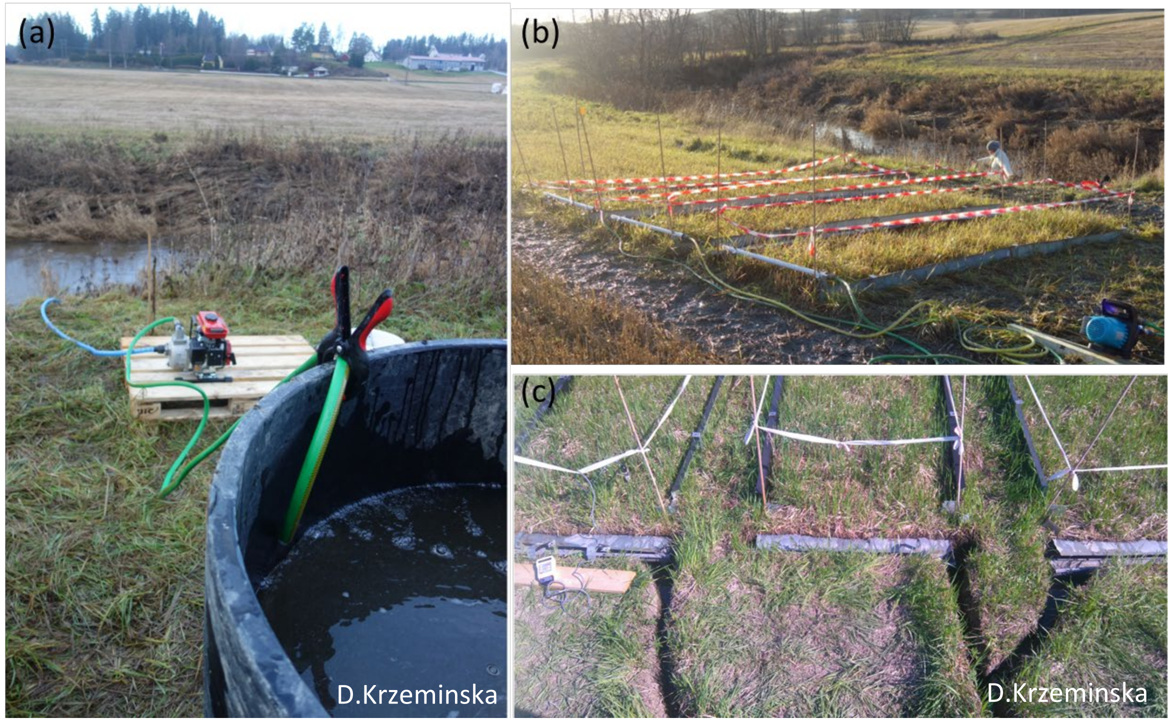
METHODOLOGY

Runoff simulation experiments:

- Mimicking surface runoff from the agricultural land that enters and flow through the buffer zone to the stream.

Experimental setup:





***Runoff simulation setup**: (a) water from the stream was pumped to a tank and mixed with slurry to a known suspended sediment concentration; (b) the mix was distributed upslope of the experimental plots by line irrigation; (c) surface runoff was collected downslope and laboratory analyzed for: **suspended sediment, total phosphorus, total nitrogen, organic matter** and **clay content**.*

For more details see: Krzeminska et al. 2020, NIBIO Report 6(30)

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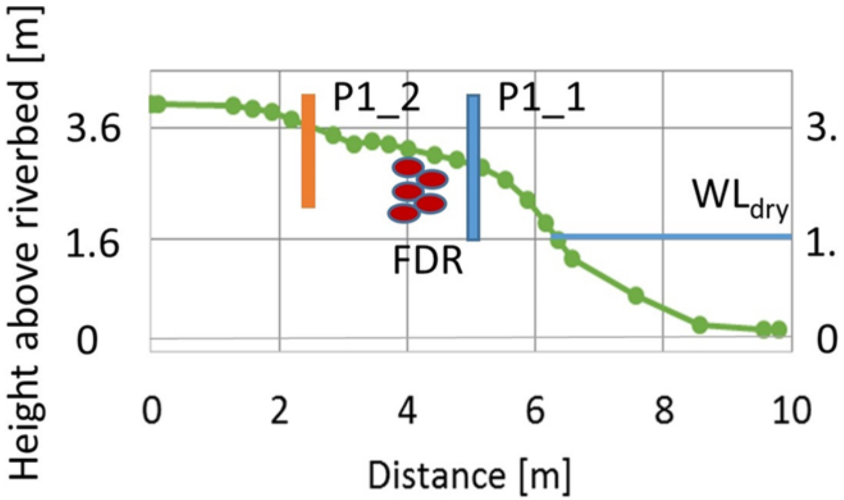
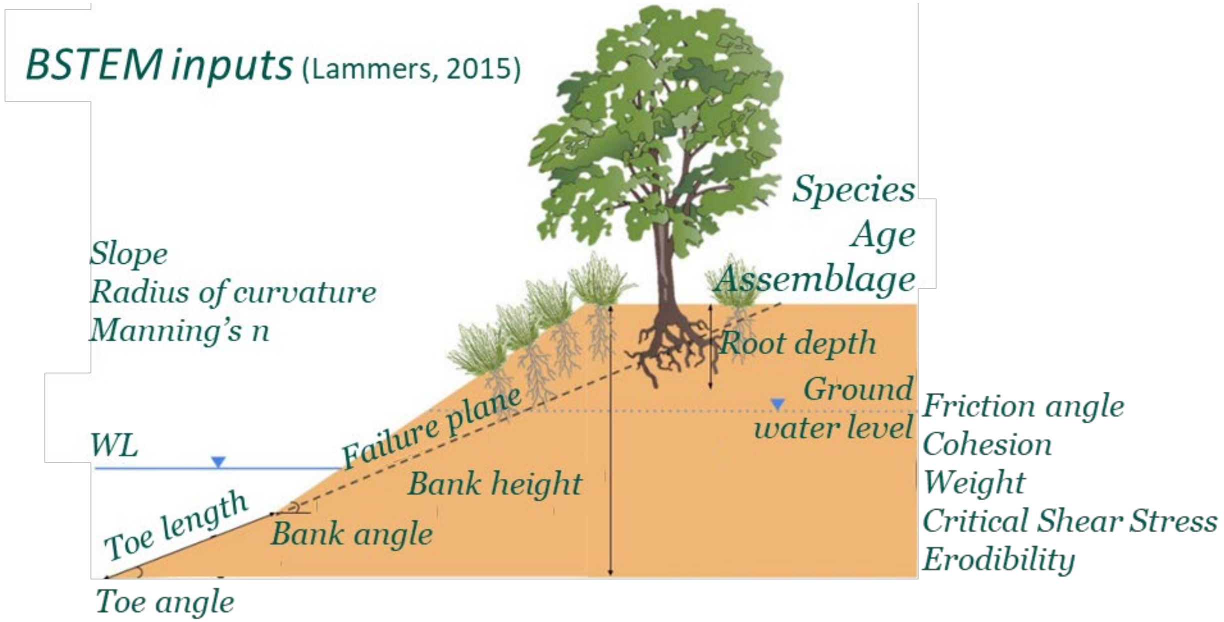
Stream bank hydrogeological monitoring and slope stability estimation

- **Long-term hydrogeological monitoring** of stream banks. The monitoring involves:
  - spatial and temporal monitoring of soil moisture conditions - θ (FDR)
  - ground WL (DIVER) and WL in the stream (ULTRASONIC)
  - soil shear strength - τ (FIELD INSPECTION VANE TESTER)
- **Stream bank stability modeling** (BSTEM)

Monitoring setup:





For more details see: *Krzeminska et al. 2020, NIBIO Report 6(30)*
Krzeminska et al. 2019, CATENA 172: 97-96

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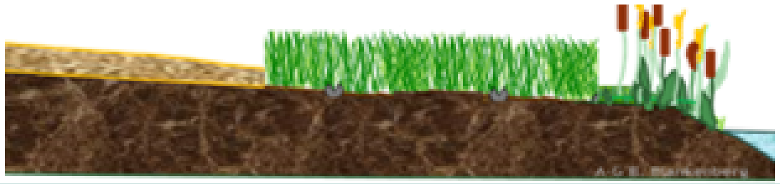
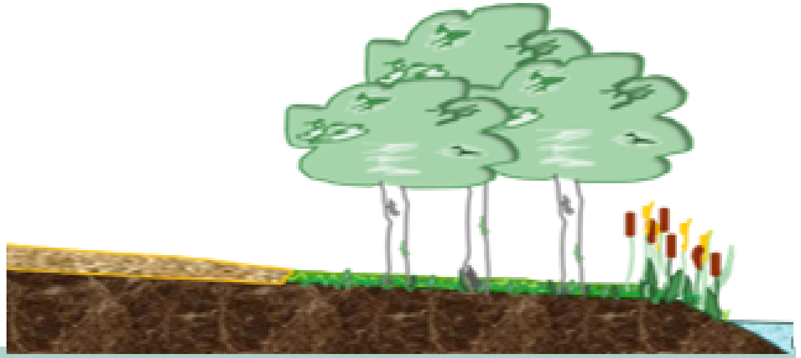
RESULTS

Infiltration capacity/ reduction of surface runoff:



GRASS and SHRUBS	Depth	Crop field	Upper part of the buffer zone	Lower part of the buffer zone
Infiltration capacity [cm/min]	surface	0,15-0,22	<0,01	<0,01
Saturated hydraulic conductivity - K_{sat} [cm/min]	0-10 cm	0,24-0,46	0-0,01	0,01-0,25
	20-30 cm	<0,01	<0,01	<0,01
Unsaturated hydraulic conductivity – $K_{near\ sat}$ [cm/min]	0-10 cm	0,02-0,03	0,02-0,05	0,02-0,05
	20-30cm	0,02	<0,01	<0,01

Methods:
- double/single ring for infiltration capacity
- constant head method for K_{sat}
- mini-disk infiltrometer for $K_{near\ sat}$



TREES	Depth	Crop field	Upper part of the buffer zone	Lower part of the buffer zone
Infiltration capacity [cm/min]	surface	0,15-0,22	1,56-1,65	0,55-1,38
Saturated hydraulic conductivity - K_{sat} [cm/min]	0-10 cm	0,24-0,46	0,42-1,33	0,88-3,61
	20-30 cm	<0,01	0,15-2,18	0,47-2,15
Unsaturated hydraulic conductivity – $K_{near\ sat}$ [cm/min]	0-10 cm	0,02-0,03	0,26-0,76	1,63 – 1,87
	20-30cm	0,02	1,01 – 1,46	1,26 – 3,16

RESULTS

Retention effect (R_{sim}):

$$R_{sim} = \frac{m_{in} - m_{out}}{m} \cdot 100\%$$

m_{in} and m_{out} - masses entering and leaving the test plots.

Effectiveness of buffer zone with GRASS		GRASS	TREES	SHRUBS
Infiltration/runoff reduction	%	60 – 82	100	51-80
Suspended sediment	%	86 – 94	-	84-93
Total phosphorus	%	76 - 89	-	74-85
Total nitrogen	%	78 – 89	-	68-84
Total organic carbon	%	72 – 80	-	78-85

For more details see: Krzeminska et al. 2020, NIBIO Report 6(30)

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RESULTS

Stream bank stability:

modeling scenarios:

- *(existing)* – slope angle as observed in the field
- *slope 24.7°* - assuming the minimal slope angle (observed in the field)
- *slope 54.0°* - assuming the maximal slope angle (observed in the field)

Histograms of calculated safety factors for all simulated scenarios. Shadowed areas indicate stability classes according to the BSTEM model: red – unstable slope; yellow – conditional stability; green – stable slope.

For more details see: *Krzeminska et al. 2020, NIBIO Report 6(30)*
Krzeminska et al. 2019, CATENA 172: 97-96

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CONCLUSIONS

Buffer zones with	Runoff infiltration	Influence on transport of			Reduction of slope erosion (=material loads to the streams)	
		Sediment	Phosphorus	Nitrogen	Hydrological effect	Mechanical effect
Grass	*					
Shrubs	*					
Trees	100%	No surface runoff observed				

**Based on saturated and unsaturated infiltration tests no there is no significant difference in infiltration capacity between buffer zone and crop field.*

Colour scale

- Strong positive effect
- Moderate positive effect
- Small or none positive effect

For more details see: Krzeminska et al. 2020, NIBIO Report 6(30)

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Thank you for your attention

Dominika.Krzeminska@nibio.no
Anne-Grete.Blankenberg@nibio.no
Attila.Nemes@nibio.no
Frederik.Boe@nibio.no
Eva.Skarbovik@nibio.no