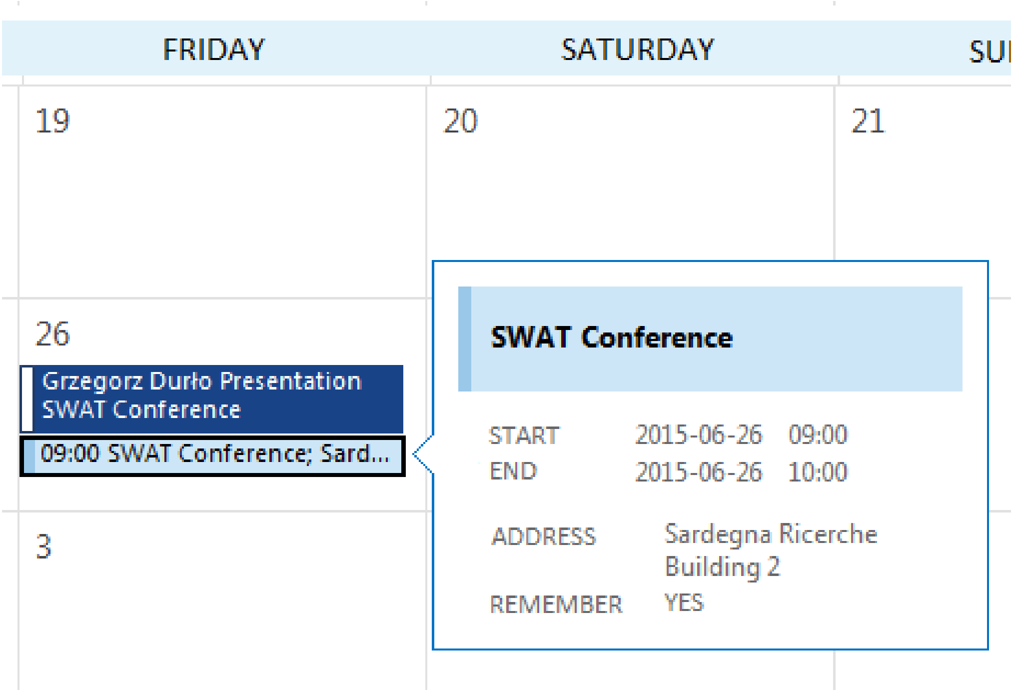
Impacts of deforestation on water balance components of a watershed on the Silesian Beskid

Grzegorz Durło, Małek S., J agiełło-Leńczuk K., Kormanek M., Banach J., Dudek K., Barszcz J.

Agricultural University in Cracow, Poland

Schedule of presentation

- Study area
- Deforestation process
- Land cover changes and their consequences
- Climate models and scenarios
- Water balance past and present
- Plans for the future
- References
- Summary

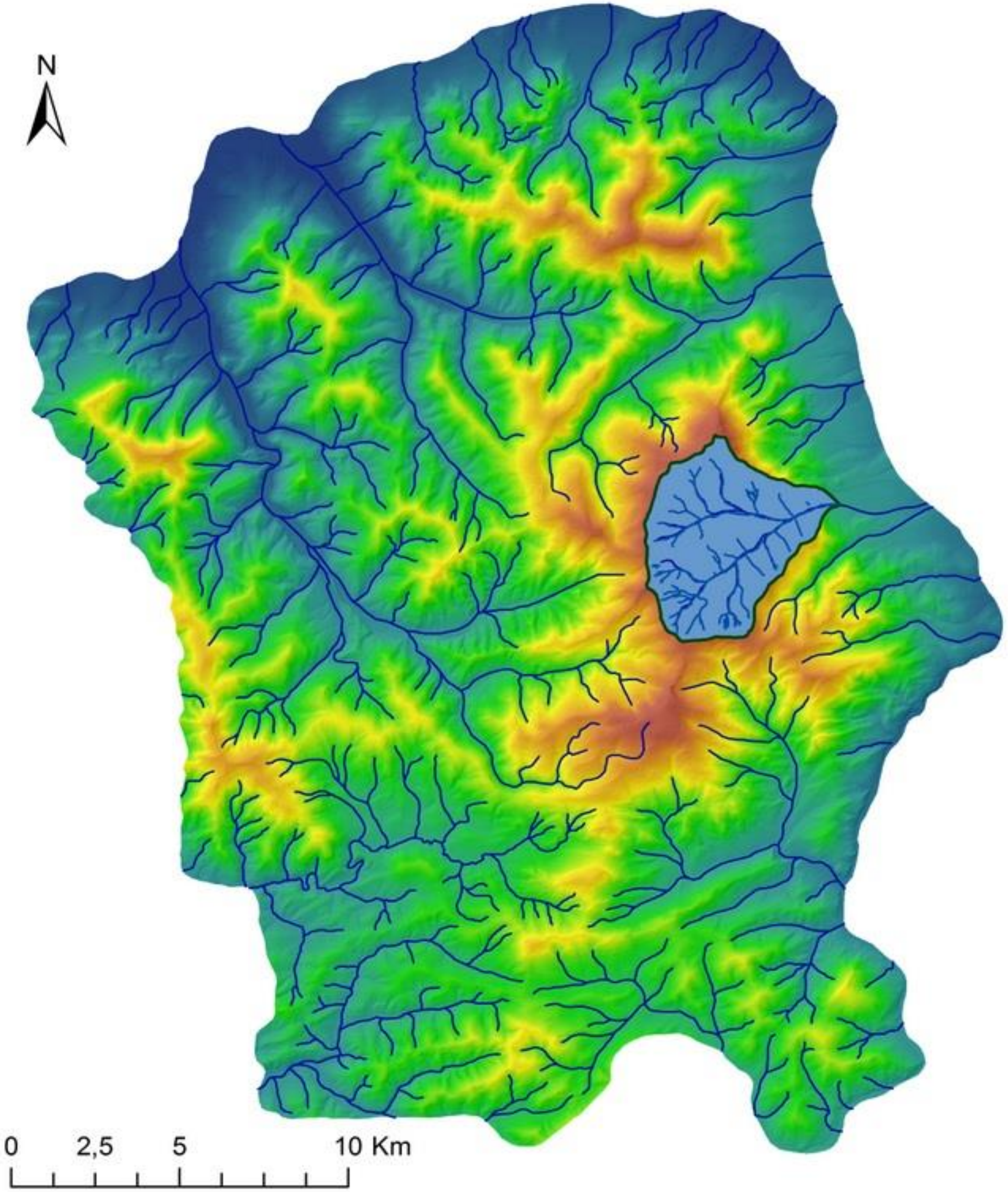


Study area

Central Europe – Western Carpathians – Poland – Western Beskids – Silesian Beskid – 720 km^2 – Altitude from 270 to 1257 m a.s.l.

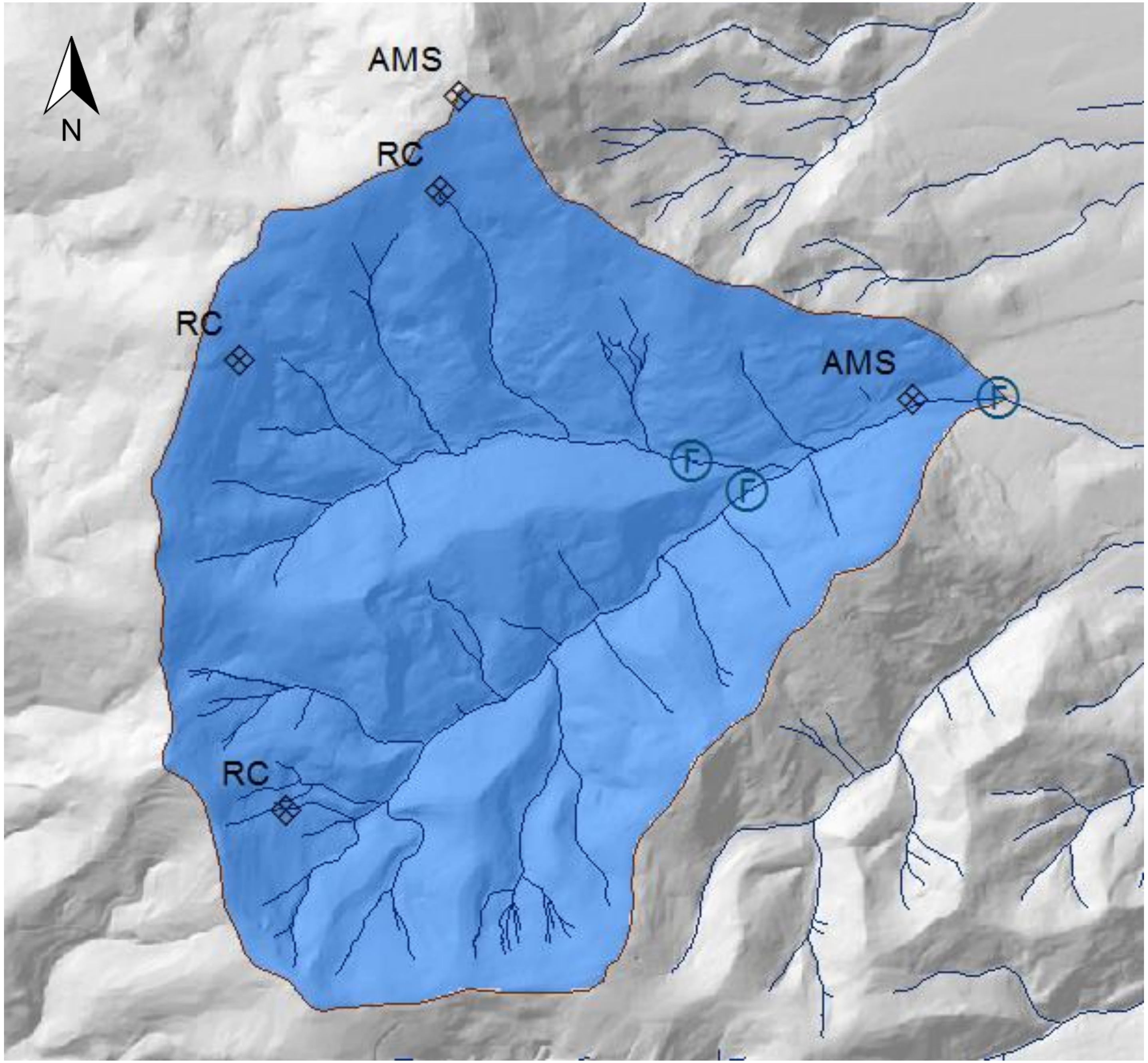
Study area - global

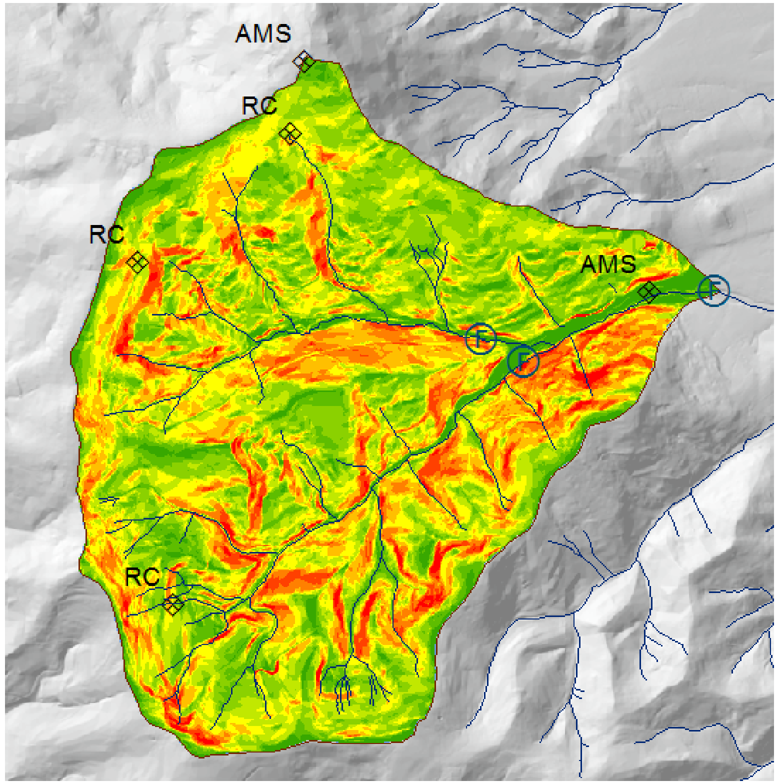
Continent: Europe
Region: Central
Country: Poland
Subregion: Western Carpathians
Mesoregion: Silesian Beskid
Basin: Vistula
Sub basin:Soła
Catchment: Forest Creek



Study area - local

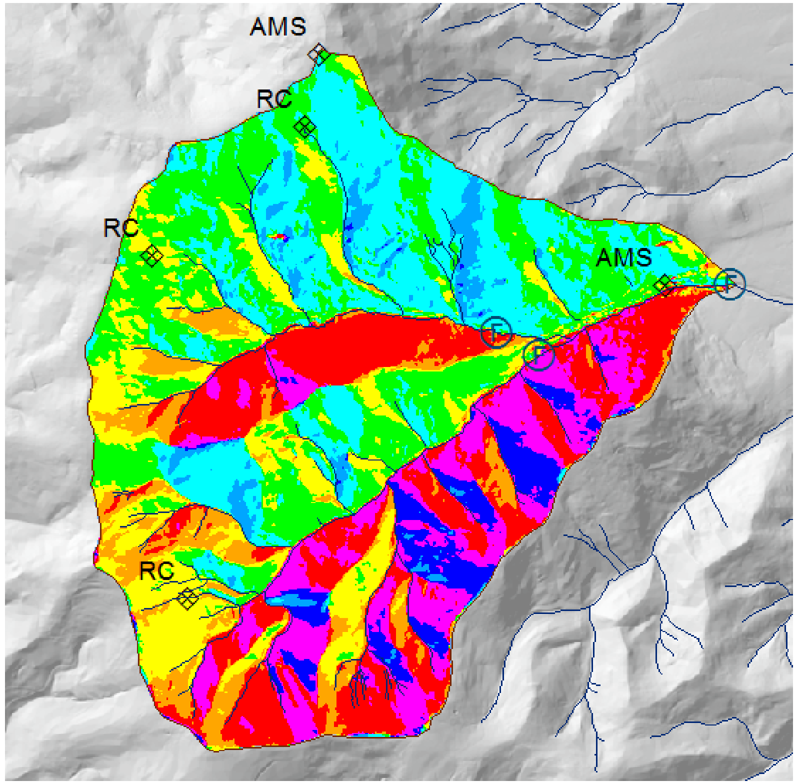
Catchment: Forest Creek
Area of cathchment: 22.1 km²
Number of subcatchment: 2
Catchment_1: 11.9 km²
Catchment_2: 10.2 km²
Lenght of stream: 43.01 km
Potential forest area: 19.4 km²
Meteorological station: 2
Rainfall collector: 3
Flow meter station: 3
Altitude: 550 to 1257 m a.s.l
Average slope: 19.0°
Modal aspect: 174°





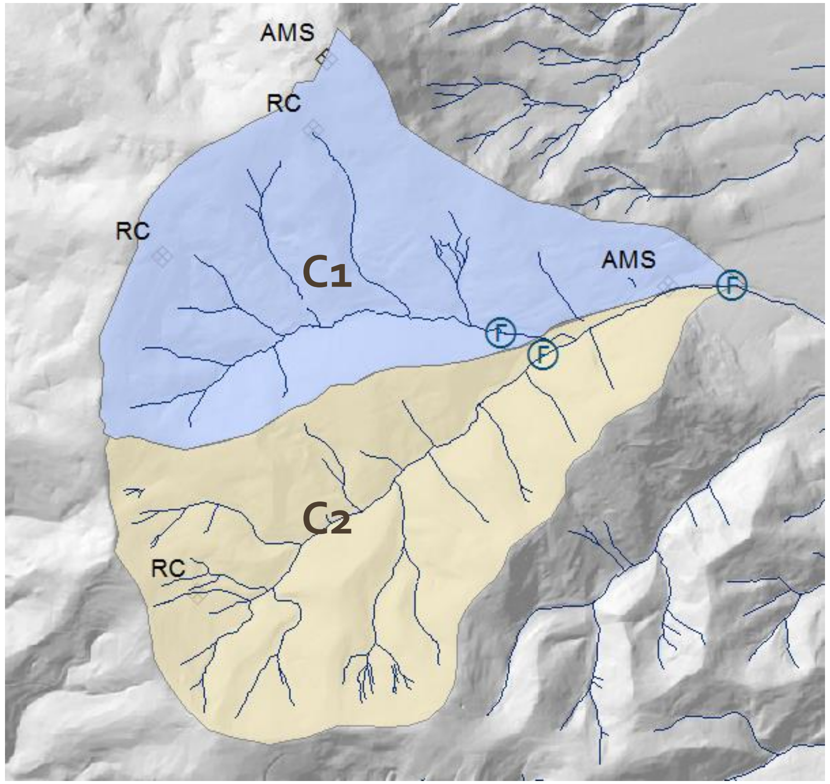
Slope

- 0,0254 - 7,6
- 7,61 - 12,4
- 12,5 - 16
- 16,1 - 19,4
- 19,5 - 22,8
- 22,9 - 26,2
- 26,3 - 29,9
- 30 - 35,1
- 35,2 - 50,9



Aspect

- Flat (-1)
- North (0-22.5)
- Northeast (22.5-67.5)
- East (67.5-112.5)
- Southeast (112.5-157.5)
- South (157.5-202.5)
- Southwest (202.5-247.5)
- West (247.5-292.5)
- Northwest (292.5-337.5)
- North (337.5-360)



Catchments

Statistics of ciek_lin_Clip

Field

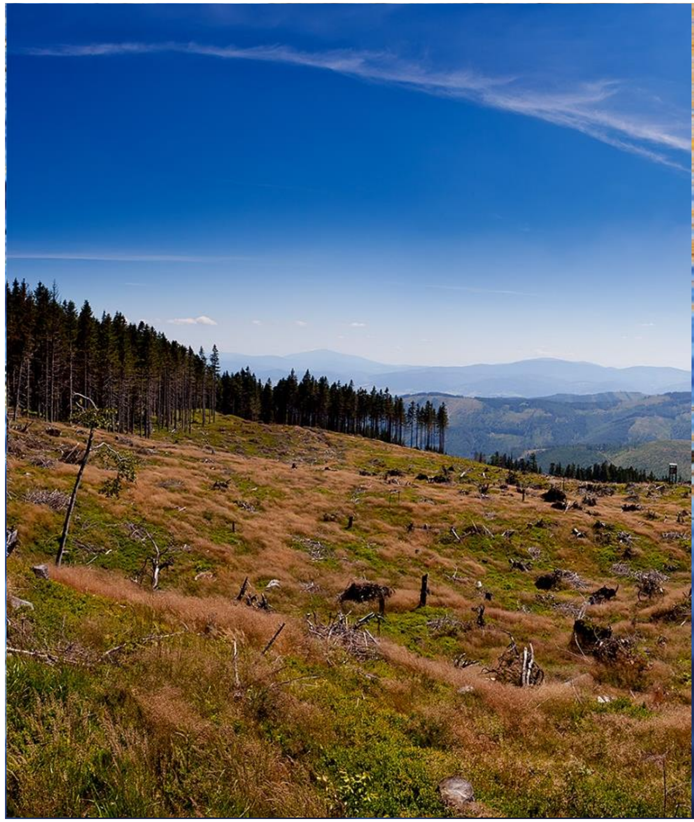
Shape_Length

Statistics:

Count: 123
Minimum: 16,08439
Maximum: 1551,433619
Sum: 43004,99063
Mean: 349,63407
Standard Deviation: 266,508626
Nulls: 0
Catchment_1: 11.9 km2
Catchment_2: 10.2 km2

Deforestation process

Changes in the annual rainfall distribution – drought air temperature increase – reducing the number of days with snow cover – insects - fungi



Deforestation process



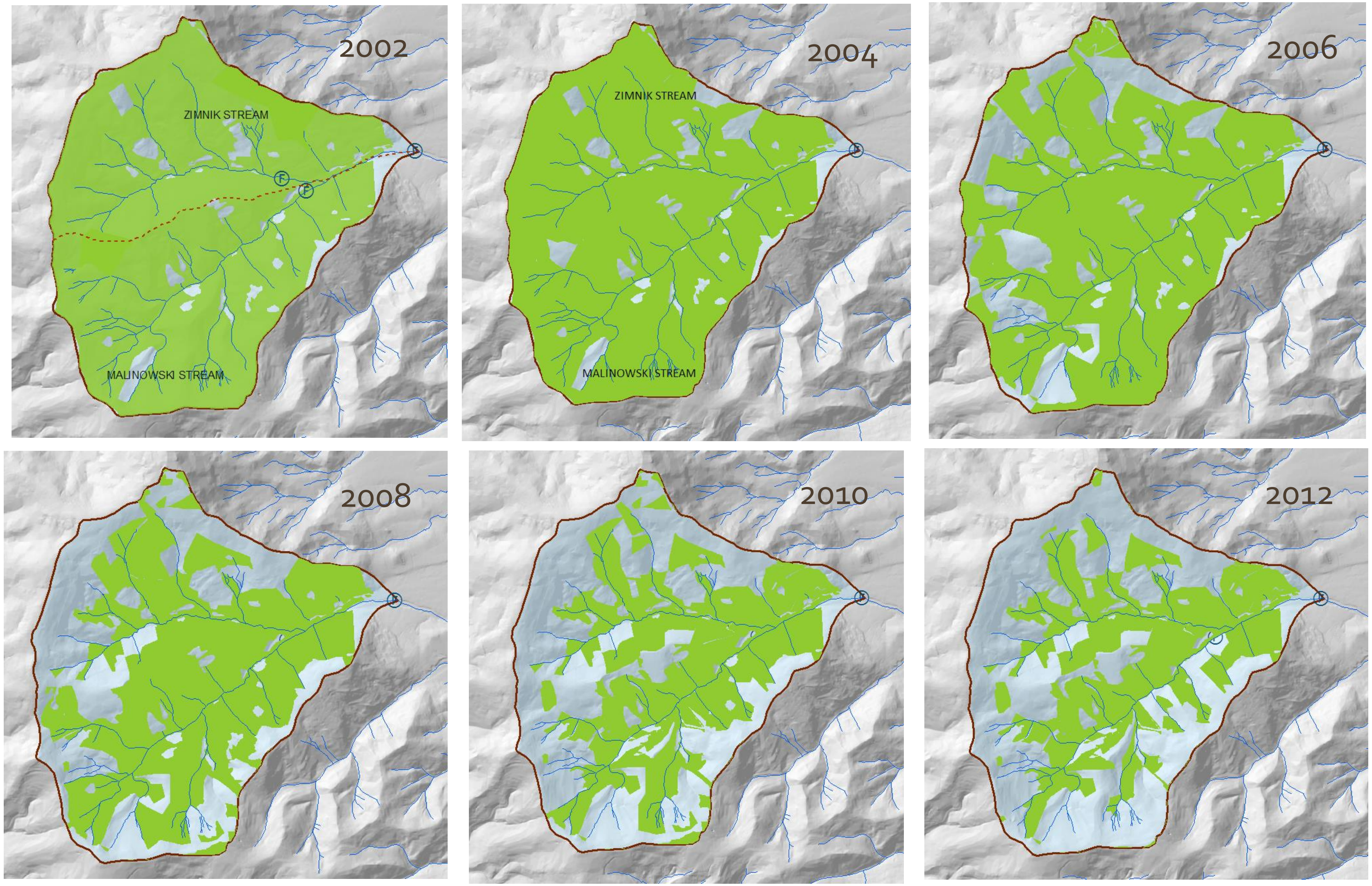



Photo. Marcin Rejment

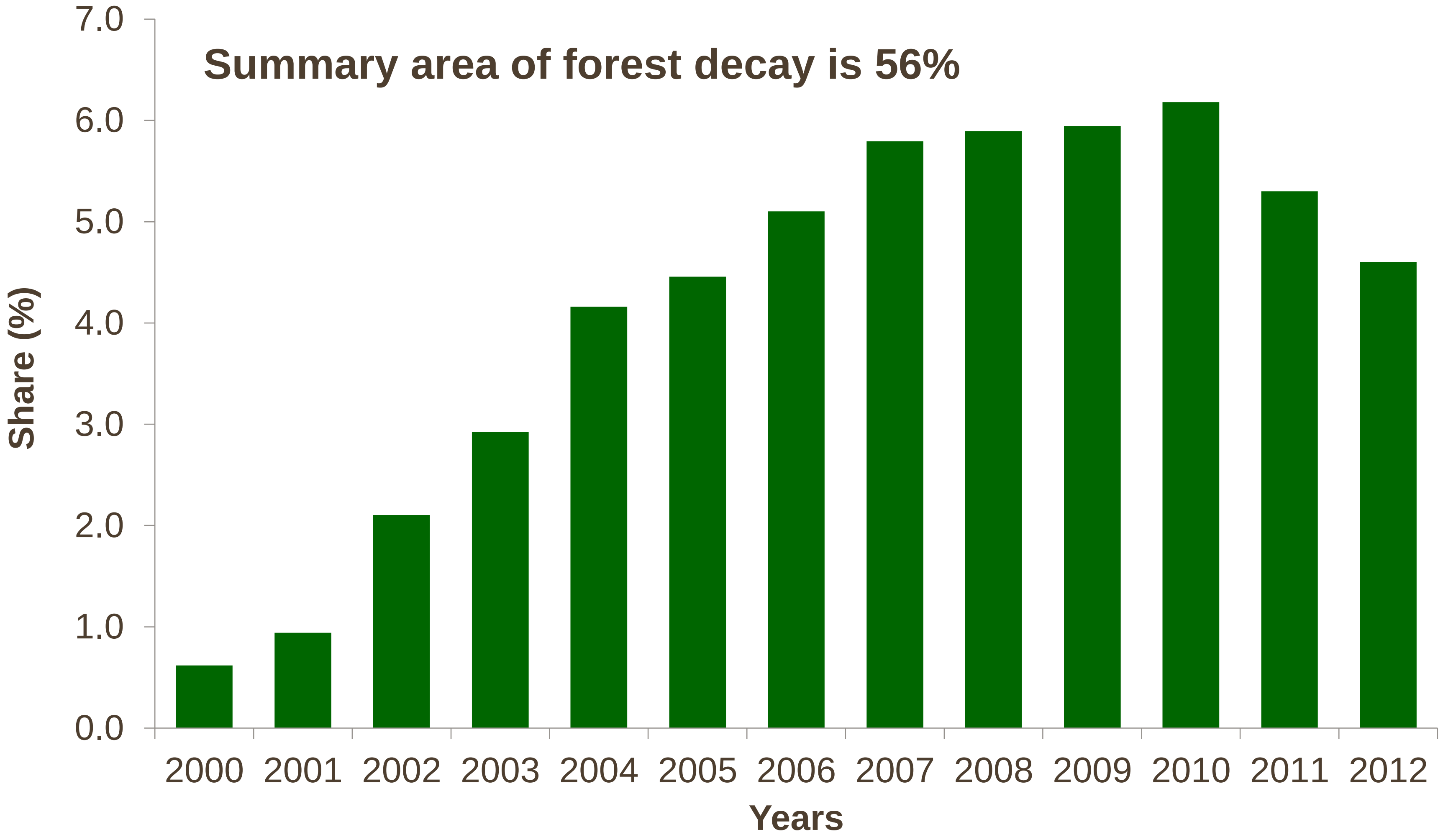
Deforestation proces – situation in 2010 year.

Photo. Marcin Rejment

Forest stands decomposition process



The rate of forest degradation



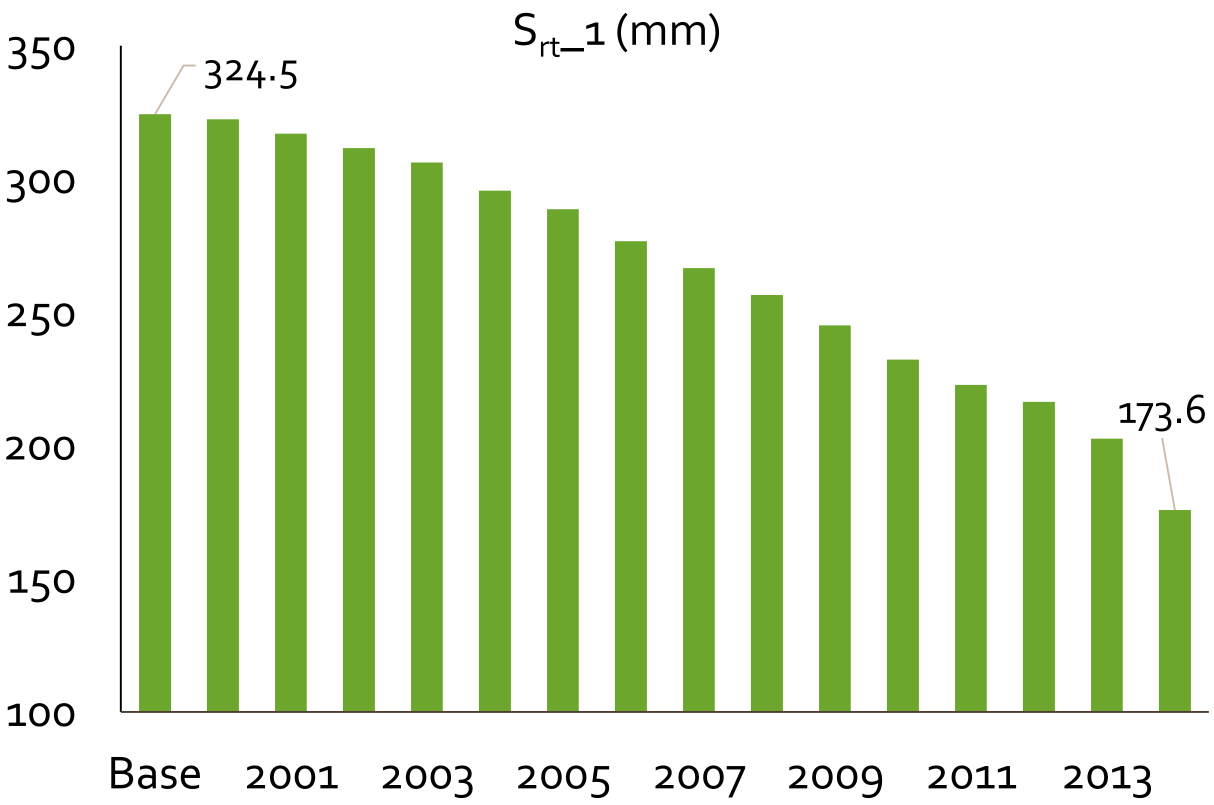
Hypothesis

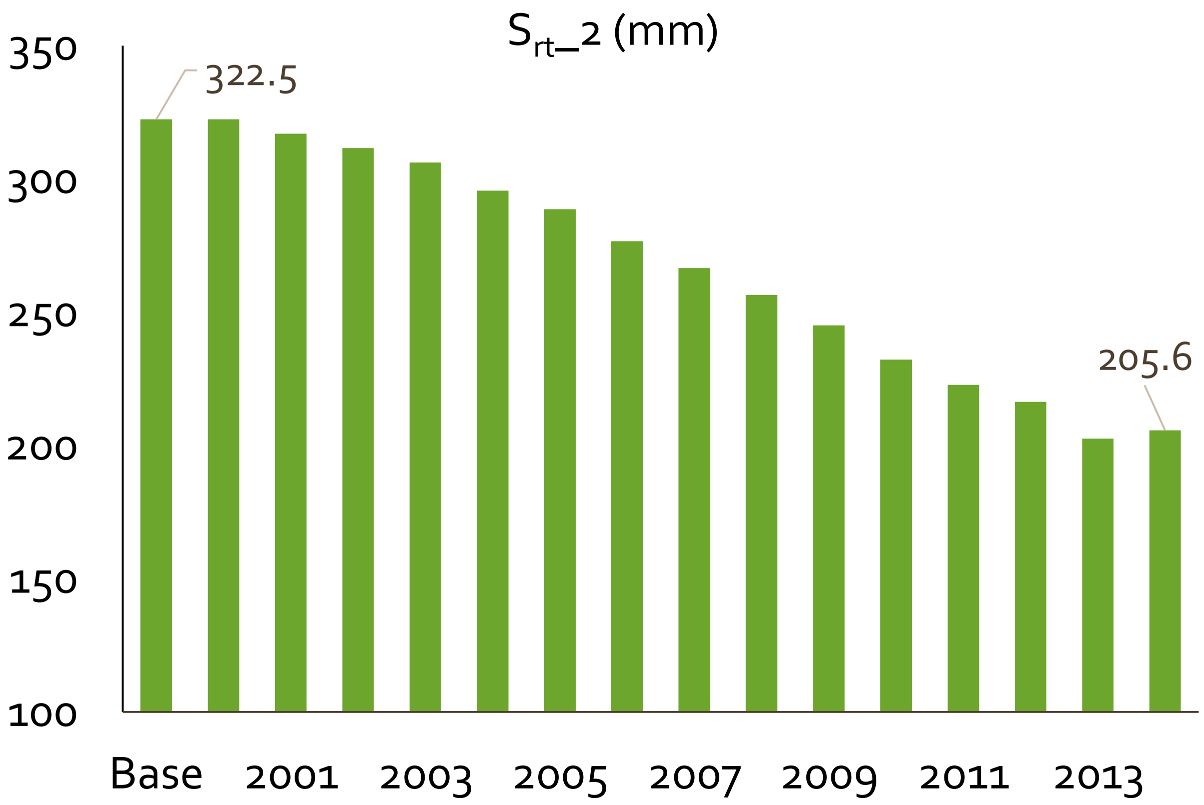
- Loss of stability by forest stands has a significant impact on the mountain catchment water balance and can have dangerous consequences for the environment
- The floods in the lowlands are closely dependent on the forest retention in the mountain catchment area

Land cover changes and their conseqences

Changing in water retention – runoff speed – flood - erosion

Changing the water retention at the catchment

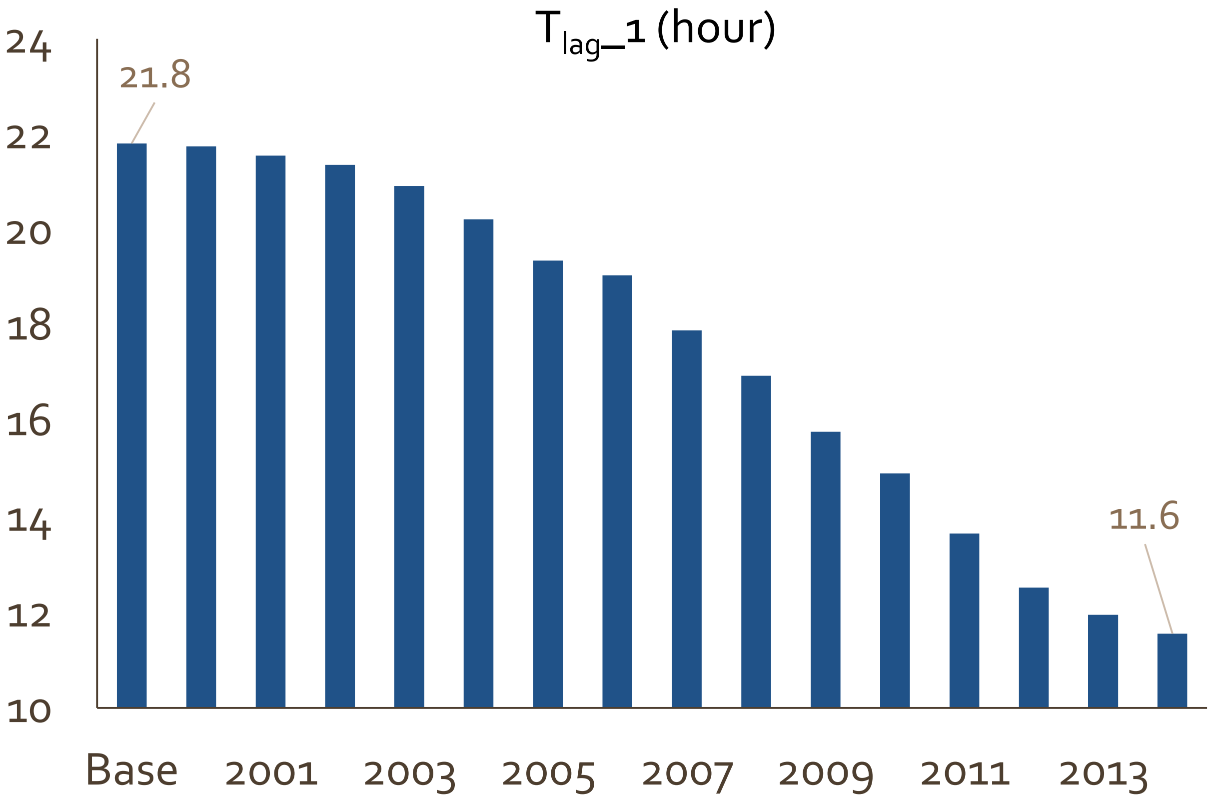


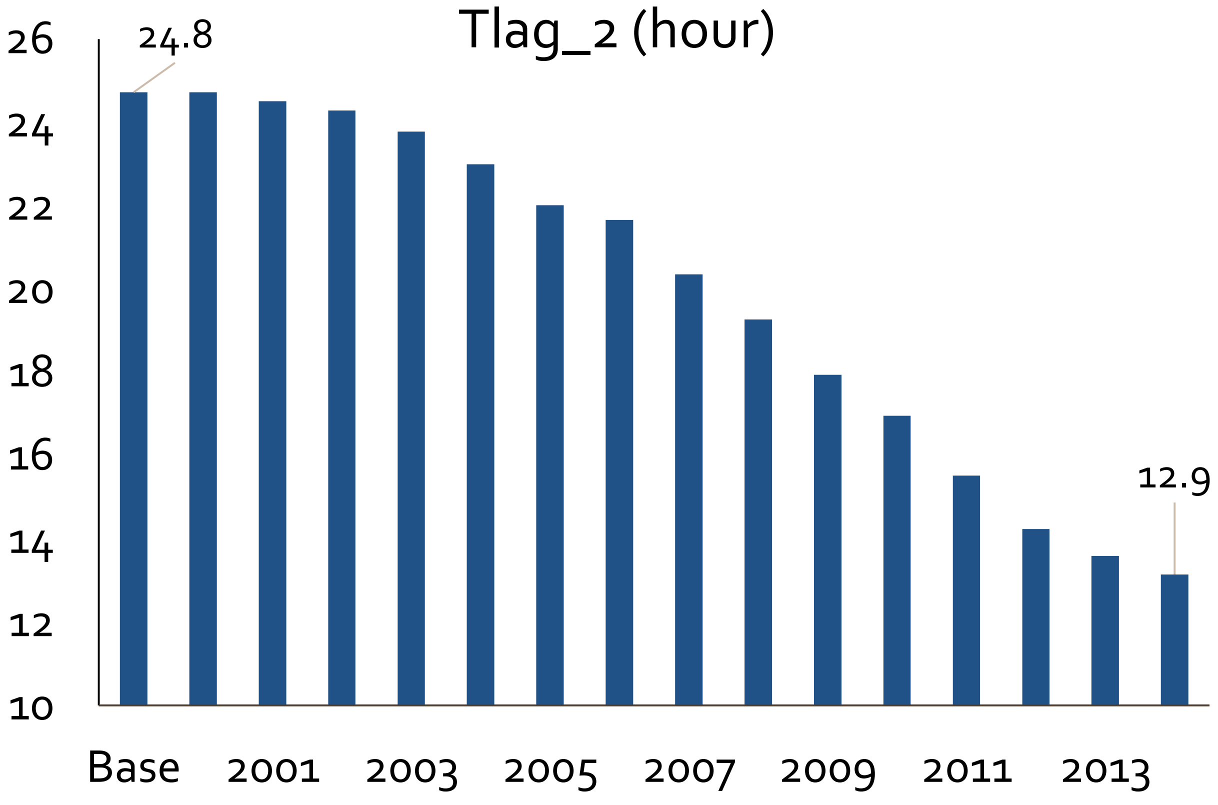


Catchment_1
Change of retention: 45.0%

Catchment_2
Change of retention 42.6%

Changing the speed of water runoff from the catchment





Catchment_1
Change of outflow delay: 47.0%

Catchment_2
Change of outflow delay: 48.0%

Climate models and scenarios

GISS_E Model – GISS_WC Model – RTP Model – RWB Model - WGN_K data generator

Climate models

Climate norm	**Air temperature** Parametrer and time period	
1961-2010 (50 years)	Average - year - winter - summer Standard dev. - year	 +6.0 °C -1.9 °C +15.0 °C +0.8 °C

Circulation model	**Air temperature** Parameter/Time/Change	
GISS Model E	Average - year - winter - summer Standard dev. - year	 +2.8 °C +3.2 °C +2.0 °C +12 %

Circulation model	**Air temperature** Parameter/Time/Change	
GISS Model E Var. WC	Average - year - winter - summer Standard dev. - year	 +0.9 °C +1.1 °C +0.7 °C +4,0 %

Climate norm	**Rainfall** Parametrer and time period	
1961-2010 (50 years)	Average - year - winter - summer Standard dev. - year	 1210 mm 256 mm 435 mm 178 mm

Circulation model	**Rainfall** Parameter/Time/Change	
GISS Model E	Average - year - winter - summer Standard dev. - year	 +10 % +15 % 0 % +15 %

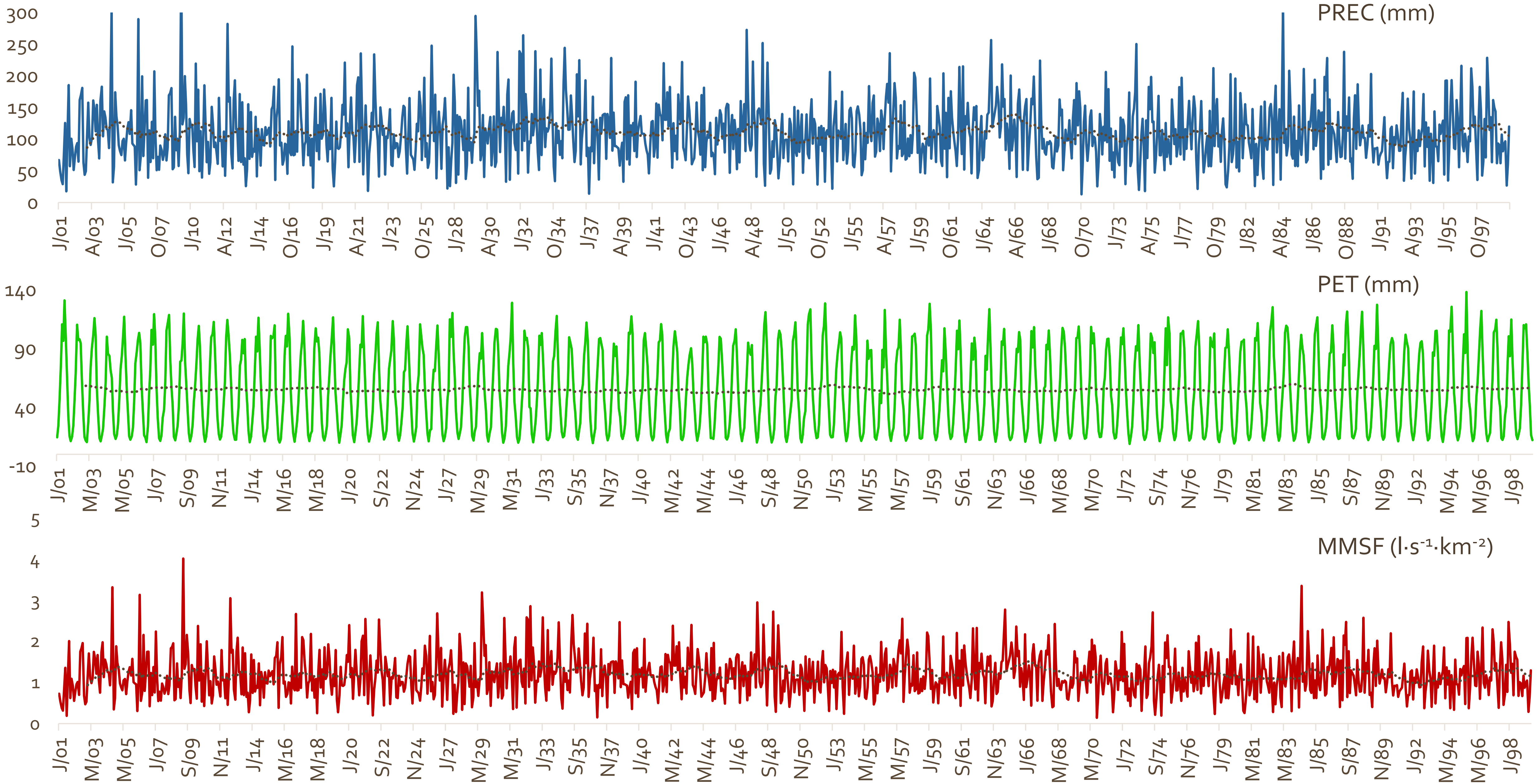
Circulation model	**Rainfall** Parameter/Time/Change	
GISS Model E Var. WC	Average - year - winter - summer Standard dev. - year	 +3,0 % +5,0 % 0 % +5,0 %

Climate change based on two models calculation – example of results

Climate indicators	Time period 1961-1990	Time period 1991-2010	GISS_E 2081-2100	GISS_E_WC 2081-2100
Yearly average **air temperature**	5.6	6.3	8.8	6.8
Average of vegetation season **air temperature**	10.5	11.2	13.9	12.2
Average of yearly maximum **air temperature**	8.9	9,3	12.2	10.3
Average of yearly minimum **air temperature**	2.2	2,5	5.0	3.4
Vegetation period duration (days)	185	192	222	202

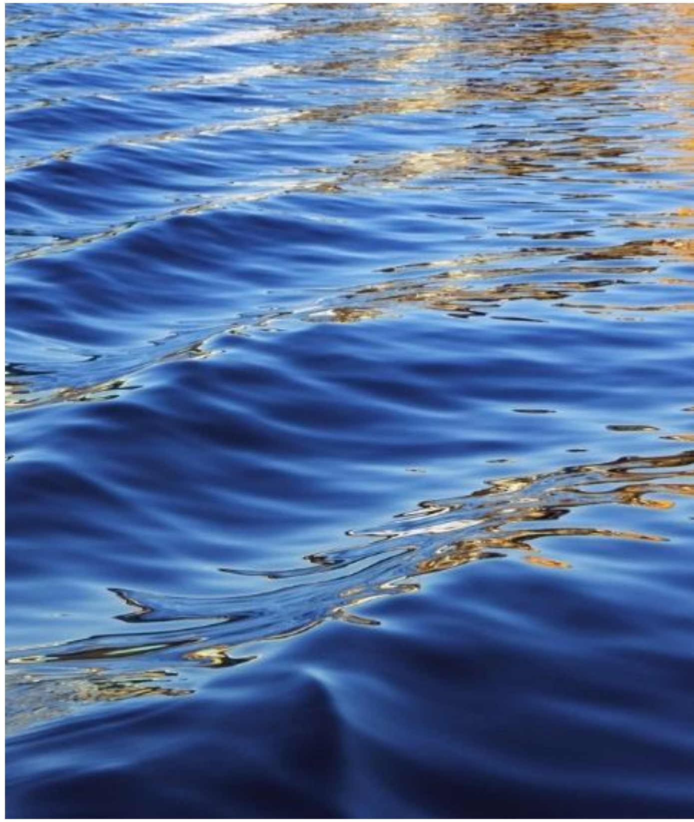
Climate indicators	Time period 1961-1990	Time period 1991-2010	GISS_E 2081-2100	GISS_E_WC 2081-2100
Yearly **sum of rainfall** (mm)	1270.5	1223.5	1299.2	1302.4
Sum of rainfall in vegetation season	825.4	746.7	771.5	783.4
Number of **days with rainfall** (year)	196	189	195	199
Number of **days with rainfall** (IV-X)	113	109	108	109
Winter to Summer **rainfall ratio** (%)	59.9	62.5	76.5	70.7

Based on GISS_E_WC model meteorological and hydrological data were generated (WGENK)



Water balance

Reducing of rainfall interception – reducing of water retention – reducing of transpiration – faster outflow – rapid runoff



Input data

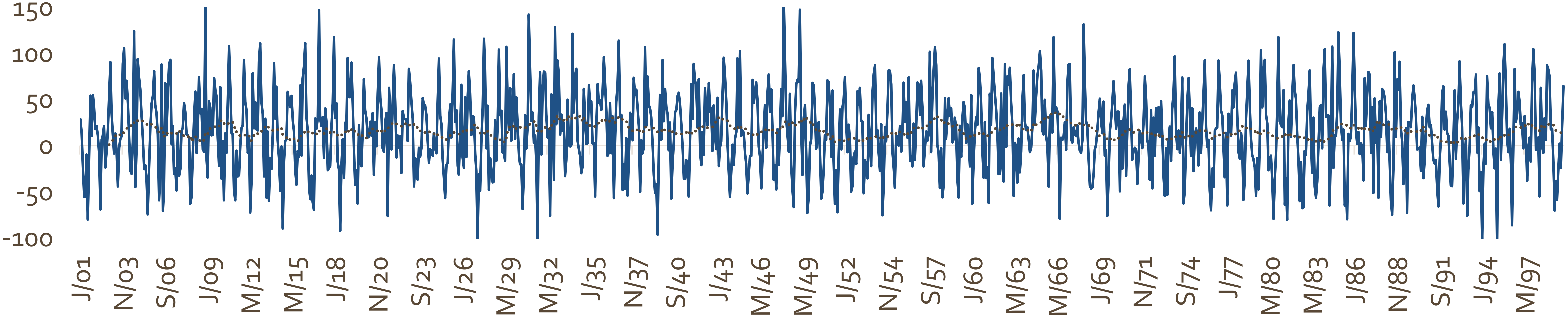
- Catchment area
- Lenght of cathment
- Slope of cathcment
- Sum of precipitation
- Sum of evaporation
- Average sreamflow
- Summarize outflow
- Retention
- Type of soil
- Soil permeability index
- Type of forest
- Kind of tree species
- Forest density
- Forest area

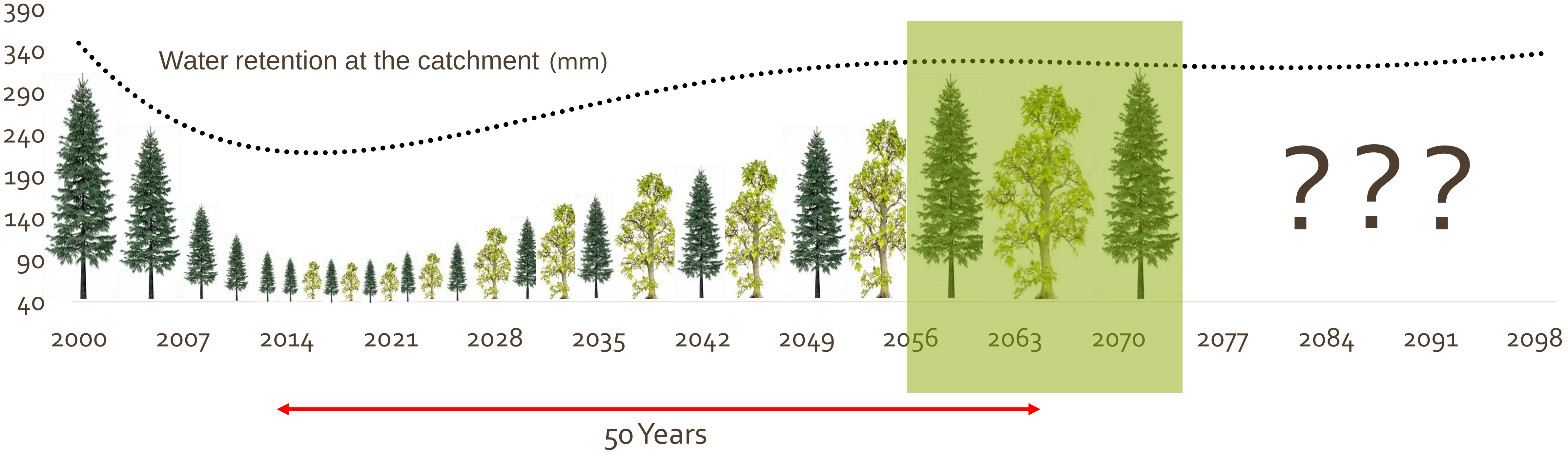
Water balance components (XI-X) – preliminary results

SubCatchment_1 (northern part)	Time period 1961-1990	Time period 1991-2010	GISS_E 2081-2100	GISS_E_WC 2081-2100
Yearly average sum of **precipitation** (mm)	1268.6	1223.5	1289.2	1297.1
Yearly average sum of **evapotranspiration** (mm)	694.5	671.6	692.7	670.4
Yearly average **streamflow** ($dm^3 \cdot s^{-1} \cdot km^{-2}$)	16.24	15.21	14.78	15.29
Yearly average **retention change** (mm)	+214.1	+195.0	+176.2	+188.7

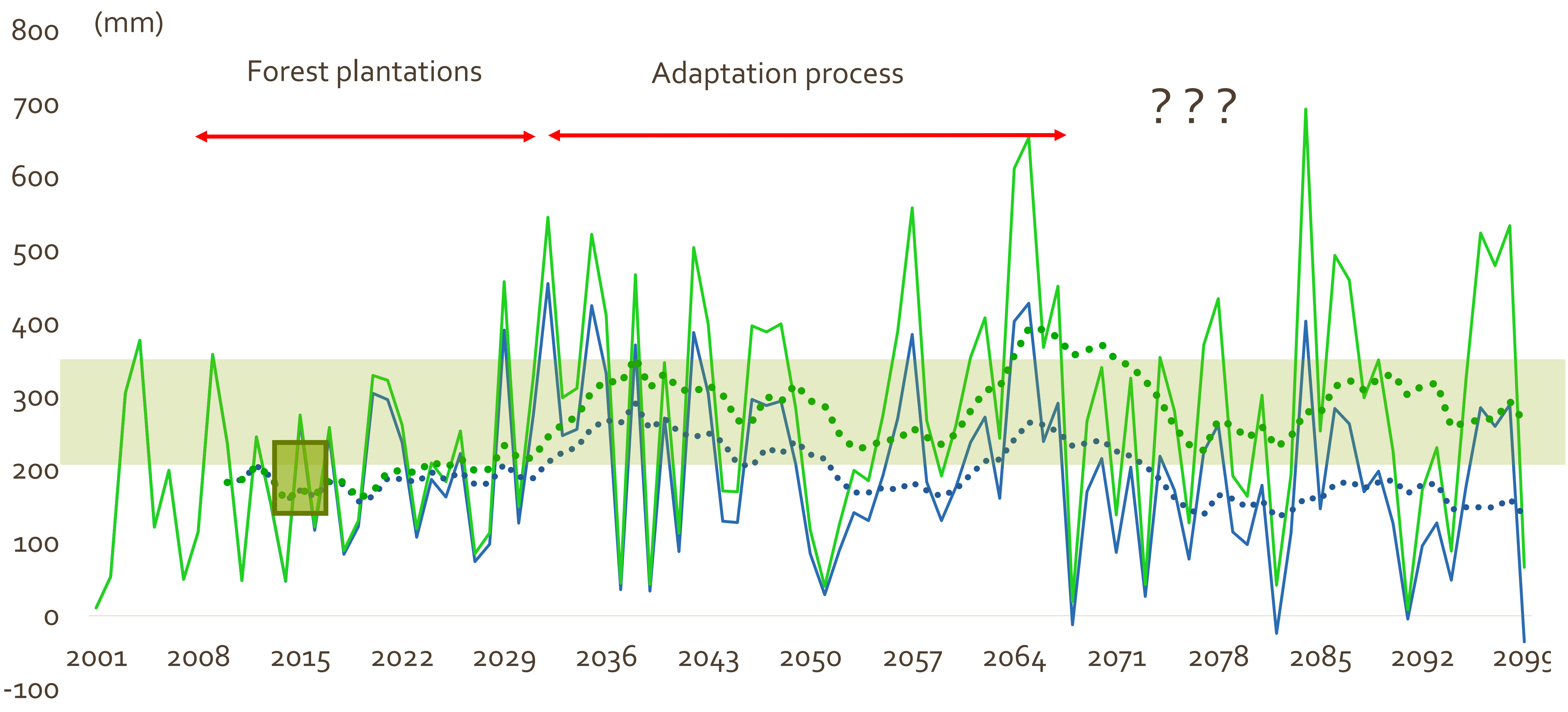
SubCatchment_2 (southern part)	Time period 1961-1990	Time period 1991-2010	GISS_E 2081-2100	GISS_E_WC 2081-2100
Yearly average sum of **precipitation** (mm)	1214.0	1189.1	1265.3	1277.5
Yearly average sum of **evapotranspiration** (mm)	688.3	663.9	689.3	698.5
Yearly average **streamflow** ($dm^3 \cdot s^{-1} \cdot km^{-2}$)	16.78	15.66	14.69	15.43
Yearly average **retention change** (mm)	+223.2	+199.0	+178.5	+195.8

Water retention change now and in the future



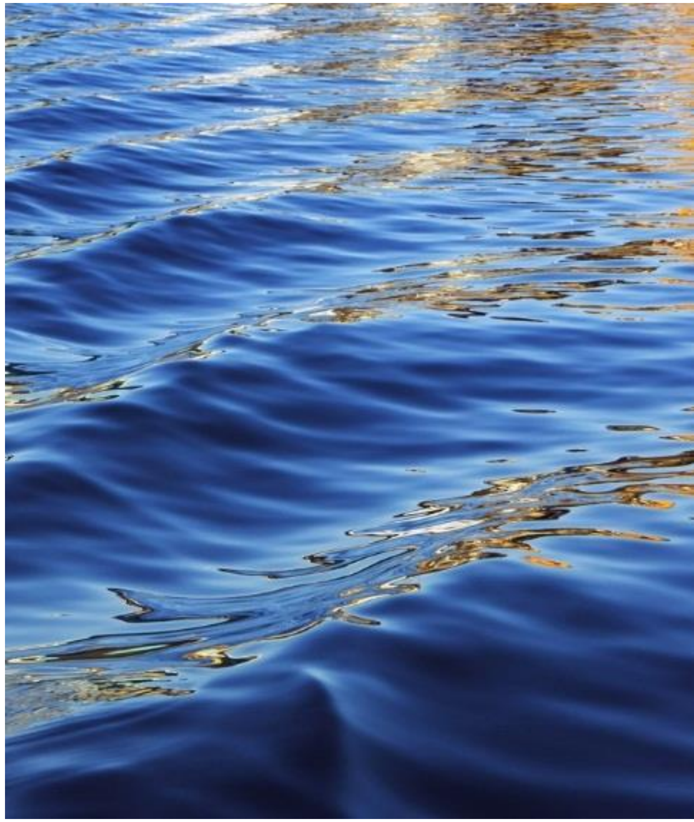


Water retention in the future taking into account changes in land cover by forest



Plans for the future

Fast afforestation - development of slopes – small retention - biodiversity



Revitalization of forest stands at Silesian Beskid

2000

Species	Catchment_1	Catchment_2
Spruce	**78.7**	**78.2**
Beech	14.6	14.1
Fir	5.1	5.3
Larch	1.3	2.1
Birch	0.2	0.23
Sycamore	0.1	0.1
Other	0.002	0.001

Decidous/Coniferous = 0.17

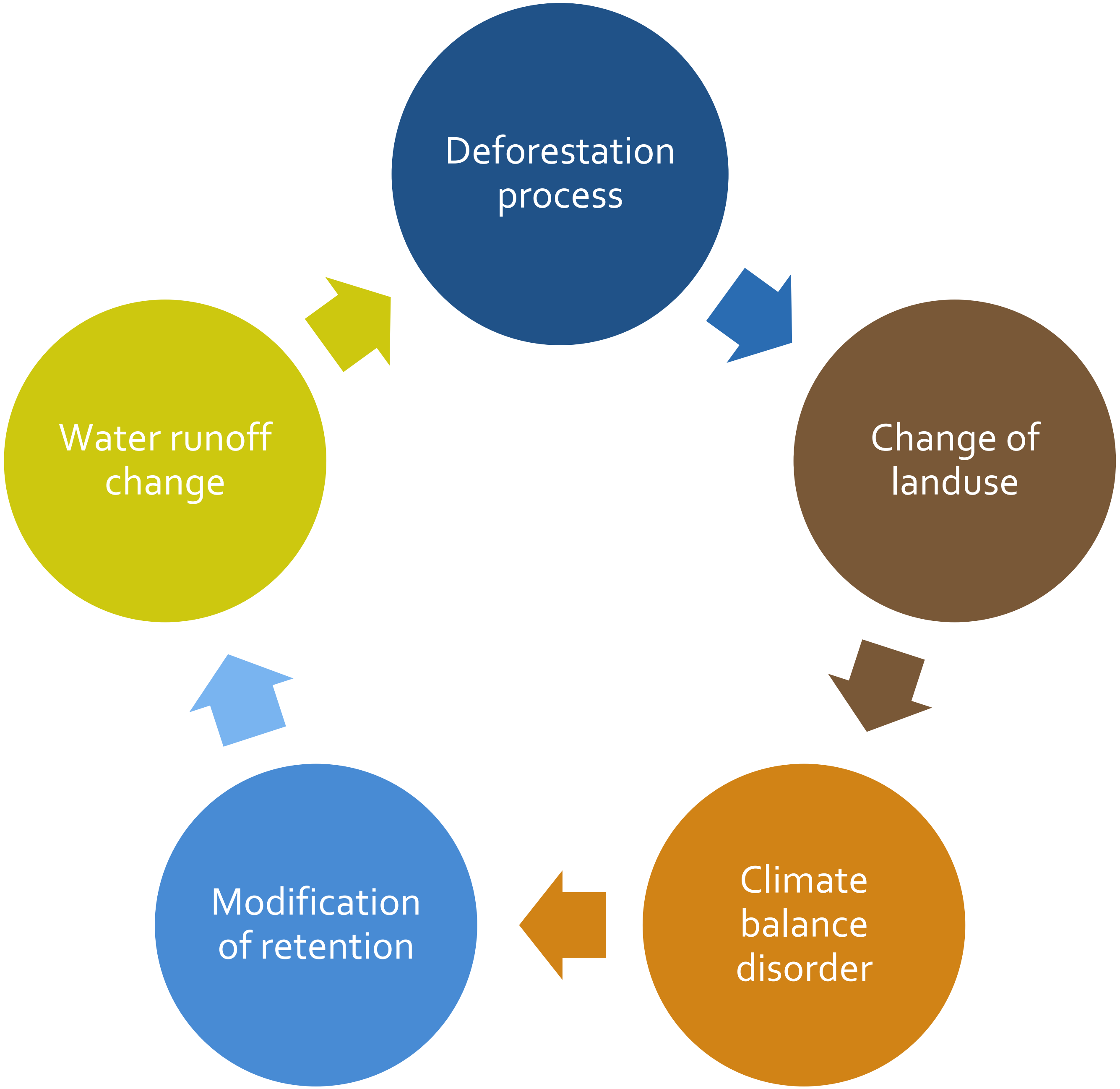
2014

Species	Catchment_1	Catchment_2
Spruce	**43.2**	**42.7**
Beech	39.1	38.7
Fir	12.9	13.7
Larch	2.6	2.8
Birch	1.5	1.4
Sycamore	0.7	0.6
Sorb, Elm, Oak	0.5	0.6

Decidous/Coniferous = 0.72

Cause - effect

1. Adverse changes in water retention occured in just 10 years
2. For the reconstruction of retention need about 40-50 years
3. Some changes may be irreversible eg erosion and movement of soils
4. Increasing the risk of floods
5. Restoring balance in the environment even at such a small scale is a very expensive proces



Summary

- The analysis confirmed that the rate of changes of forest cover played a dominant role in watershed water balance
- The effects of deforestation on the hydrological processes have been strengthened by changes in weather and climate
- It is possible to improve the water balance conditions after ca. 50 years, when seedlings and young forest will reach density parameters to increasing retention
- Changing the ratio between winter and summer rainfall may slow down this process. Restoration of water balance stability will be delayed.

But – only one extreme weather event
and everything goes back to the beginning

After windstorm 2013/2014

2013-12-25
and
2014-01-06

Max wind speed
37.0 m/s

Exposure time
11 hours

Woods losses
(3 Forest Inspectorate)

~70 000 m^3

References

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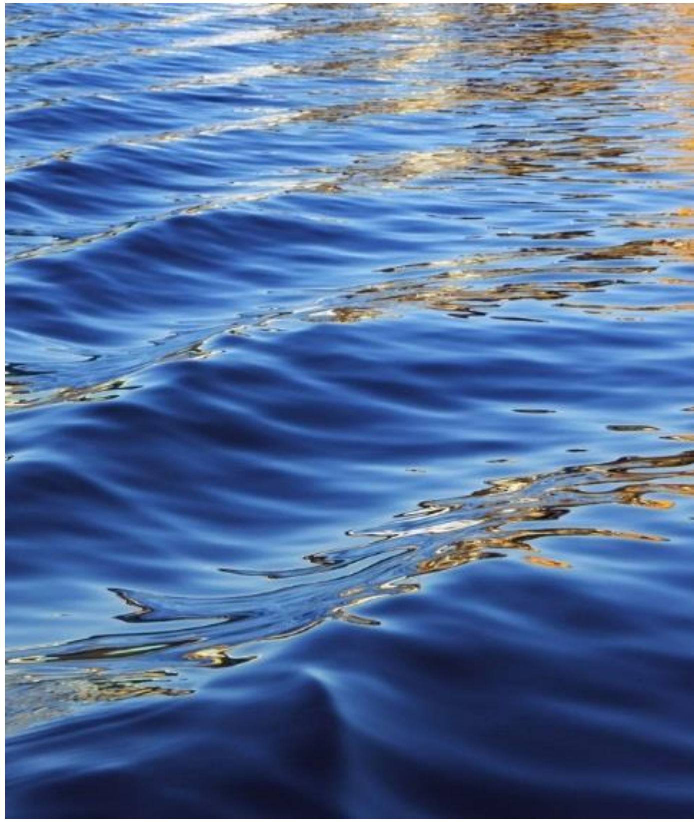

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Thank you

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