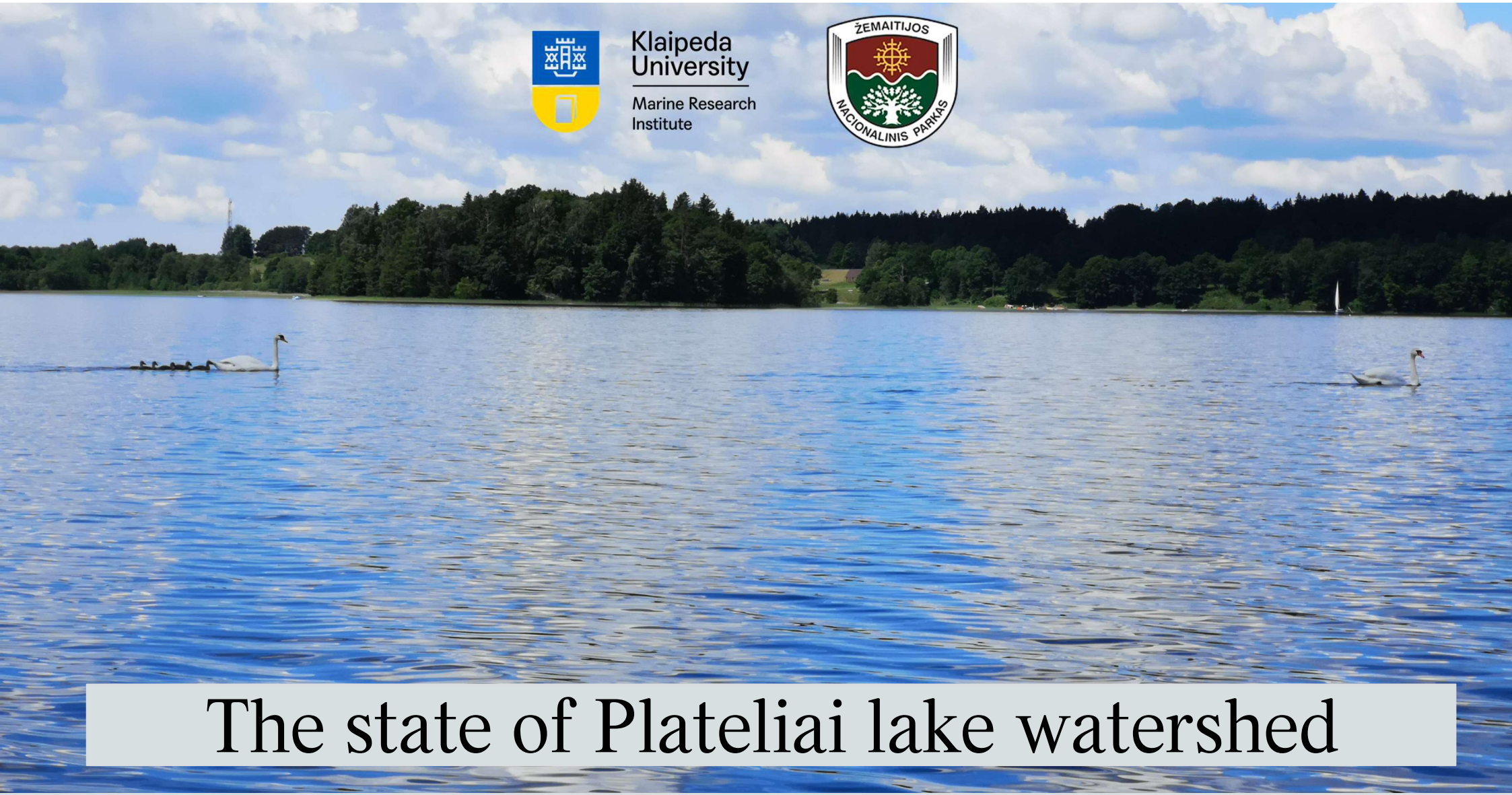


Klaipeda University
Marine Research Institute

ŽEMAITIJOS NACIONALINIS PARKAS

The state of Plateliai lake watershed

Implementers: Dr. Martynas Bučas, Dr. Jolita Petkuvienė, Dr. Diana Vaičiūtė, dokt. Jonas Gintauskas, dokt. Edvinas Tiškus, Dr. Mindaugas Žilius, Greta Kilmonaitė, Andrius Skersonas, Dr. Irma Vybernaitė-Lubienė, Nijolė Domarkienė, Dr. Donata Overlingė, Dr. Tobia Piloti.

Plateliai lake

Mesotrophic lake

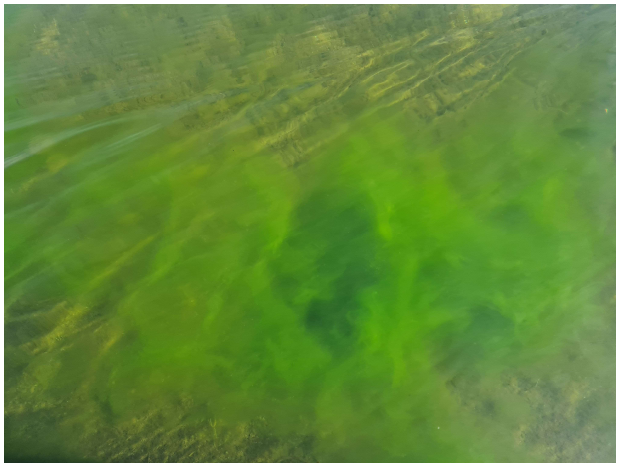
Largest in Samogitia and 9th biggest in Lithuania.
12 km^2, average depth 10.5 m, deepest place 48.5 m
7 islands
1 river outflow

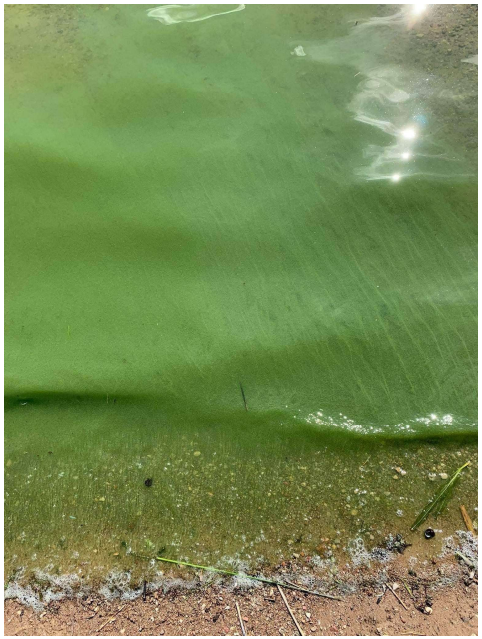
Žemaitija national park administration picture

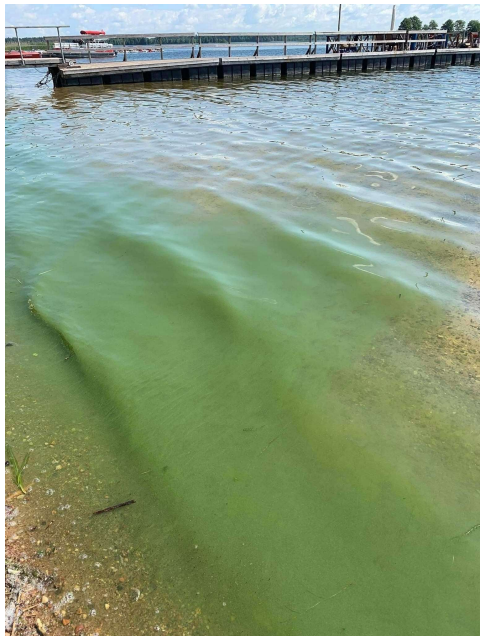
<u>Heavy recreational use:</u>
nature trails
bicycle path around the lake
diving and yacht club
swimming and camping places
traditional events

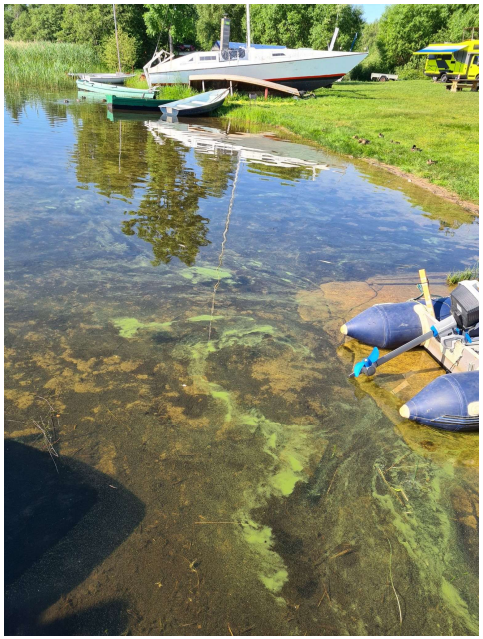
Marija Jankauskienė pictures

Need of research









Outlines

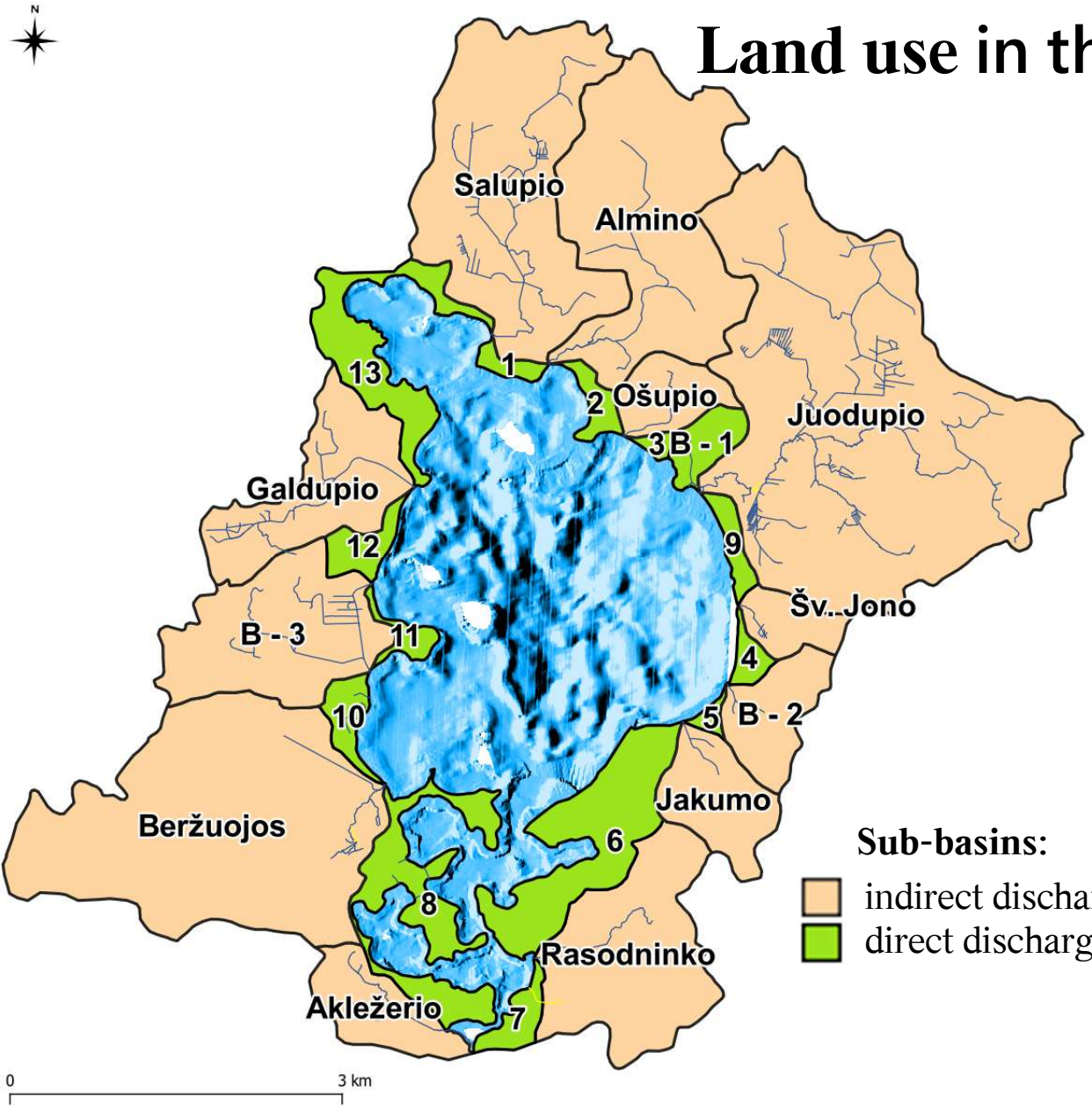
I task. LAND USE IN THE WATERSHED AND RETROSPECTIVE ANALYSIS OF PRIMARY PRODUCERS

II task. STATE-OF-ART ECOLOGICAL STATUS OF THE LAKE INCLUDING INFLOWS

III task. PRELIMINARY MEASURES FOR WATER QUALITY IMPROVEMENT

I task. LAND USE IN THE WATERSHED AND RETROSPECTIVE ANALYSIS OF PRIMARY PRODUCERS

Land use in the watershed

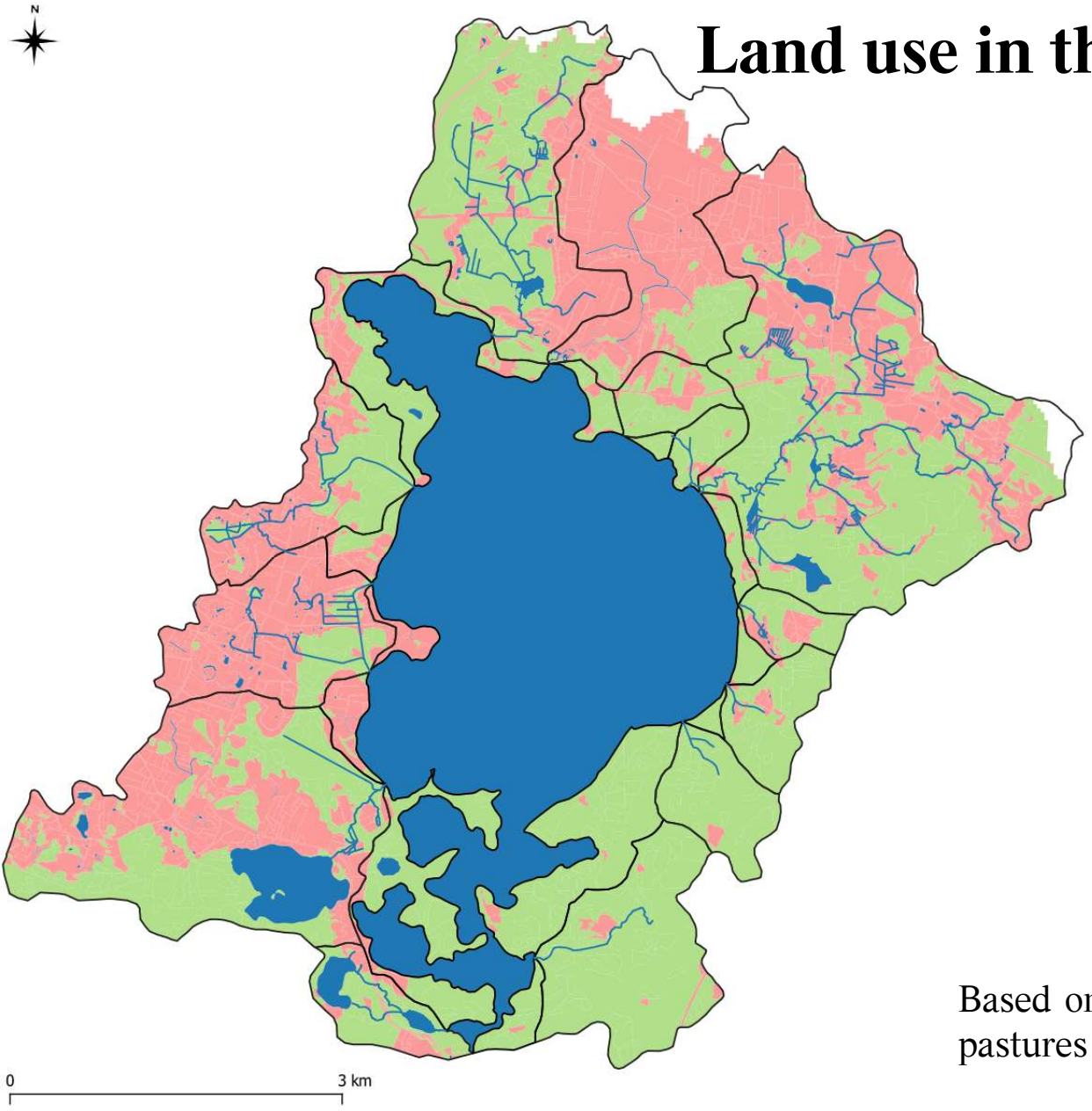


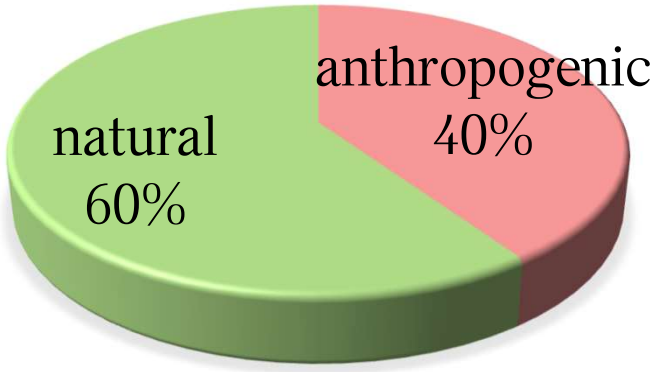
Watershed area: 35 km²
Sub-basins: 26
Residence time: 12 % year^{-1}

Sub-basins:

- indirect discharge (14)
- direct discharge (12)

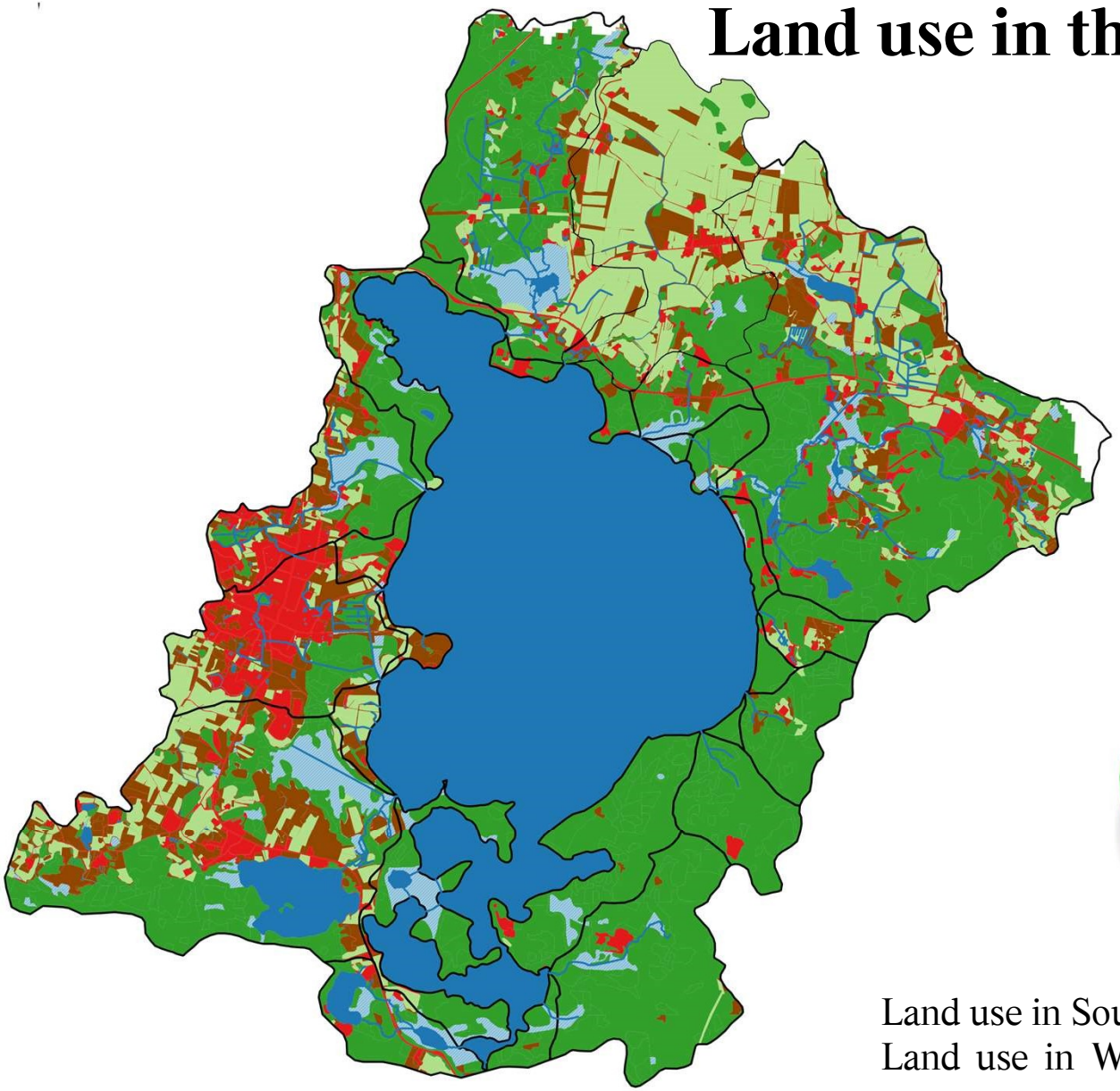
Land use in the watershed

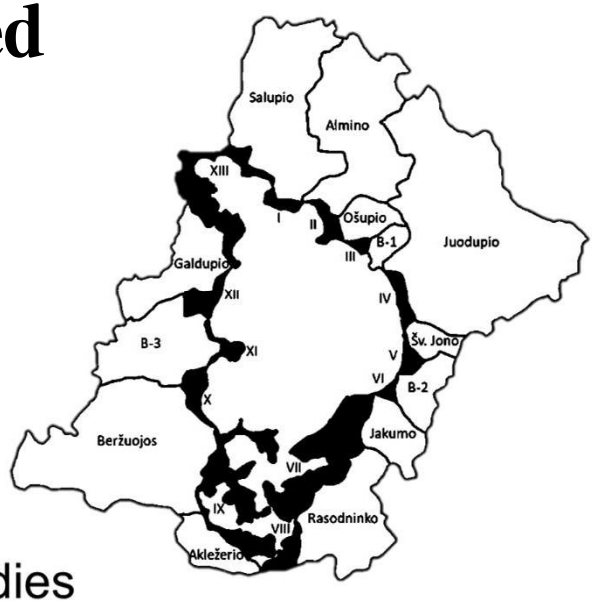


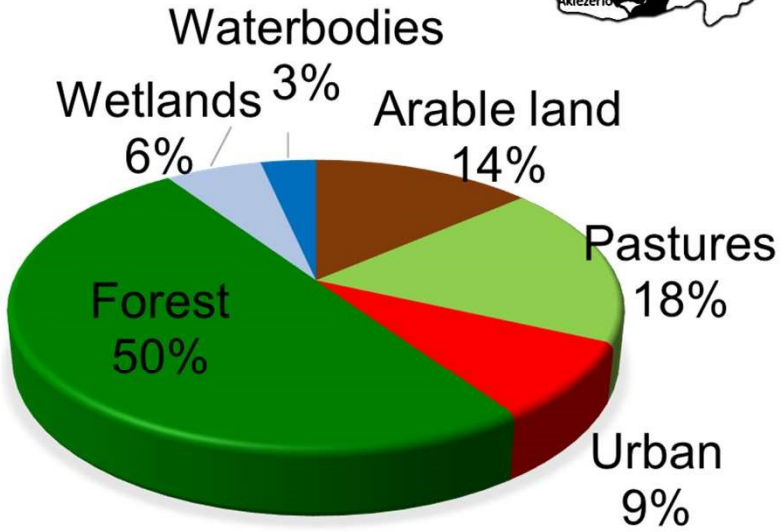


Based on CORINE landcover data over 1990-2020, < 2 ha of pastures have been replaced by cultivated fields

Land use in the watershed

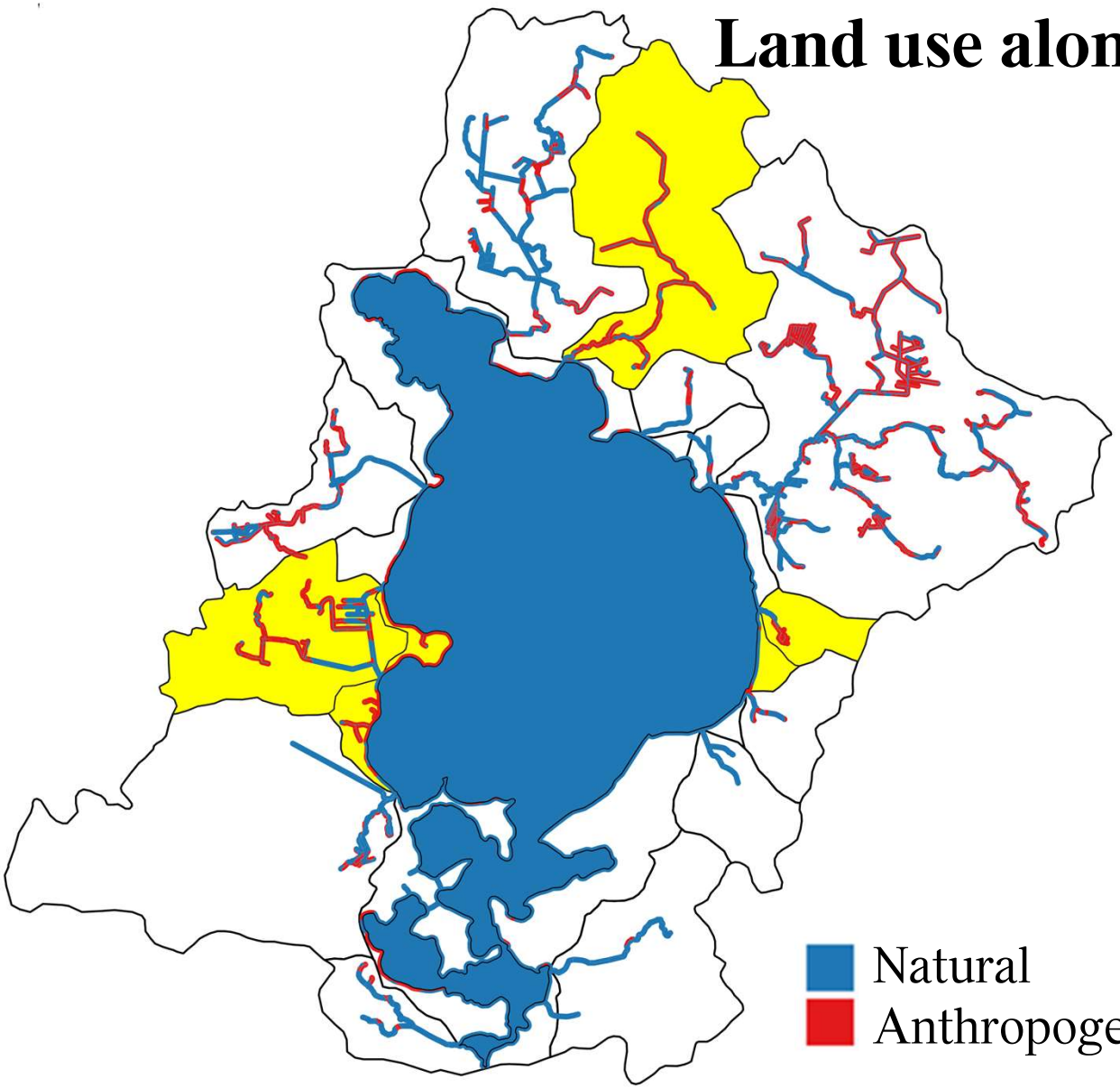






Land use in Southern, Eastern & Northern parts is mainly natural
Land use in Western and NE parts consists of farmlands and urban areas

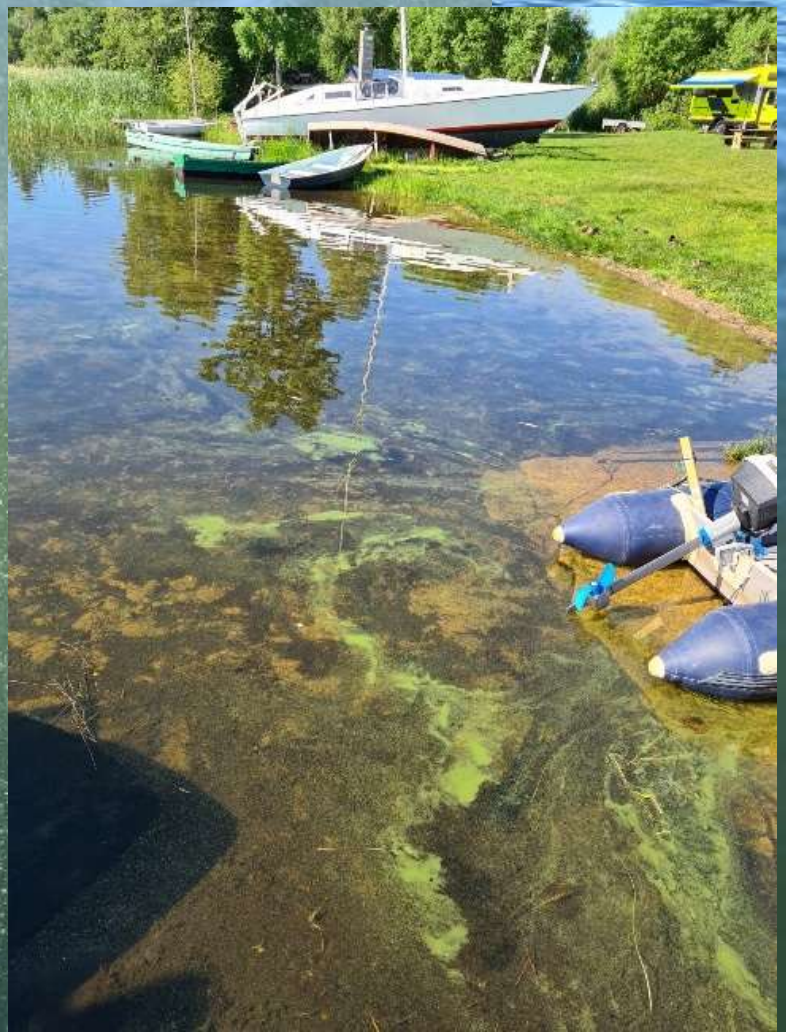
Land use along the rivers



6 sub-basins with anthropogenic land use of > 50 %

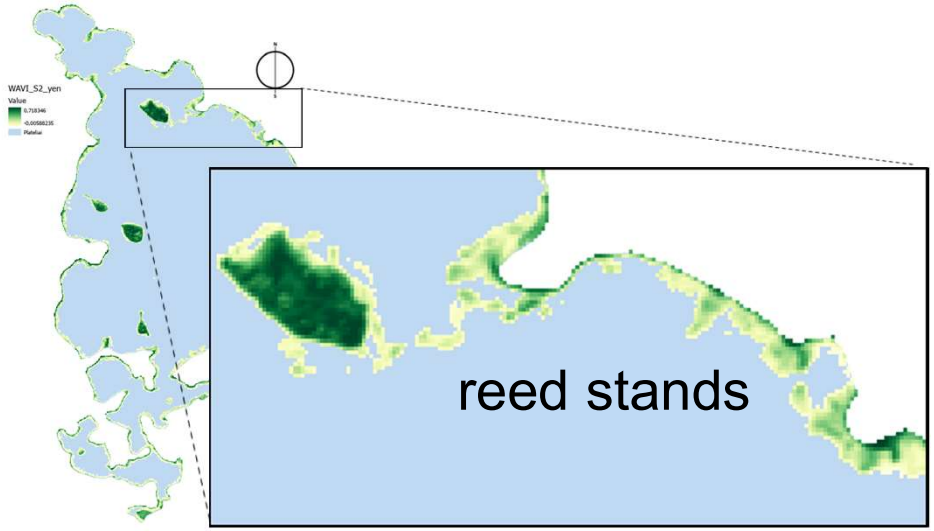
2 of them with direct anthropogenic land use within 25 m from the shoreline in the Western part

2022.06.26



2022.08.11

Retrospective analysis of primary producers



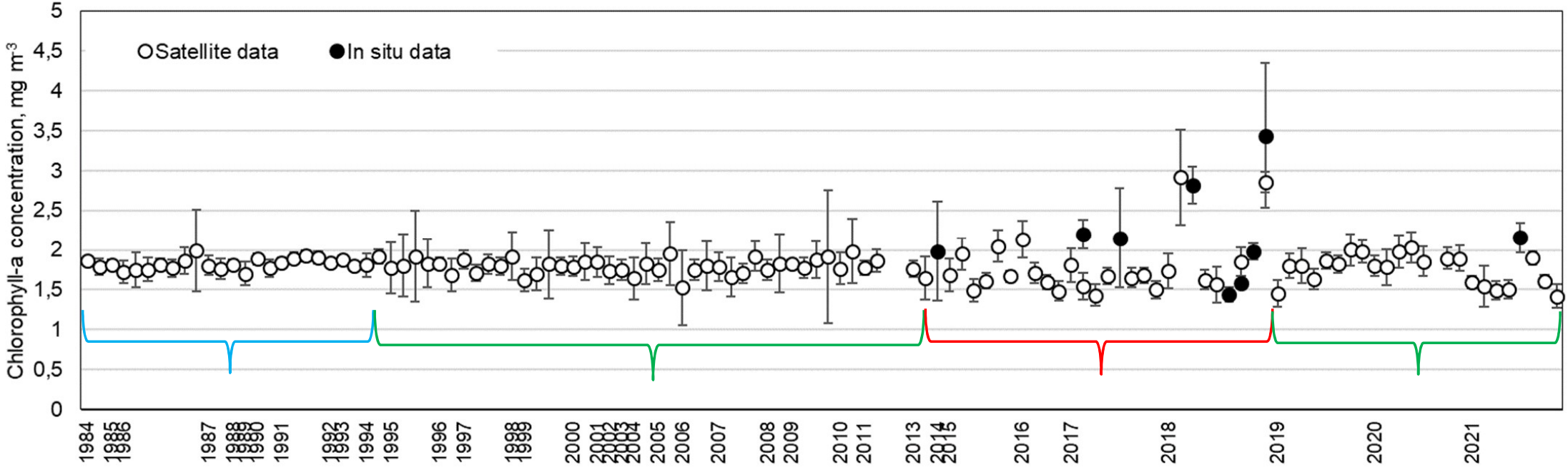
1984 1999 2011 2013 2015 2021

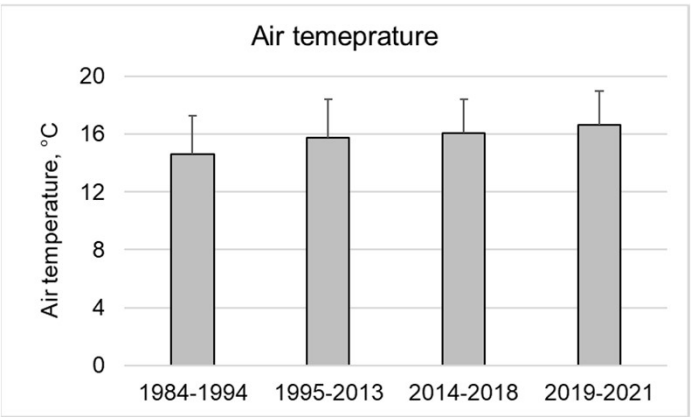
HISTORY NOW

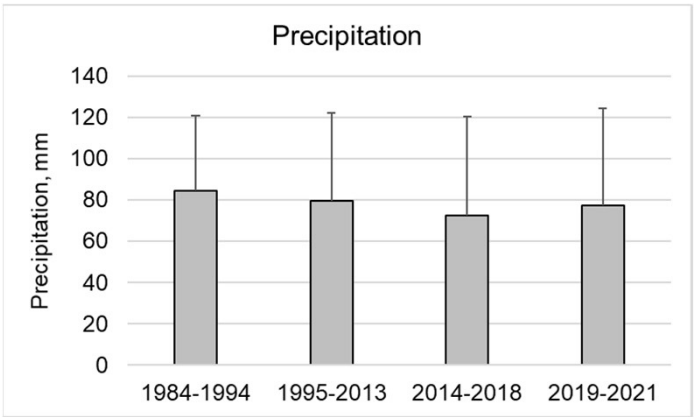
Landsat-5 Landsat-5, 7 Landsat-7 Landsat-7, 8 Landsat-7, 8 Sentinel's

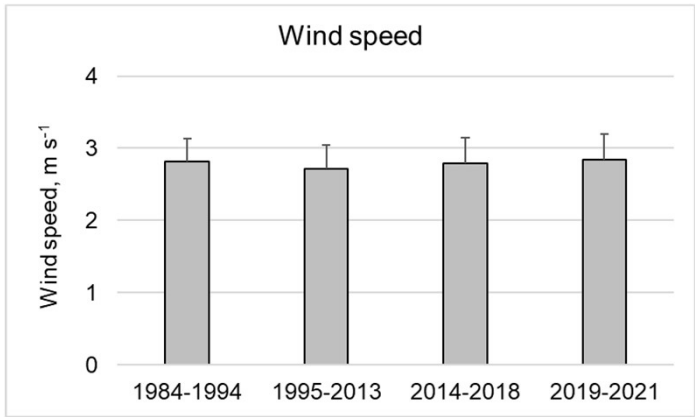
Spatial resolution: 30 m 10 m

Retrospective analysis of chloropyll-a

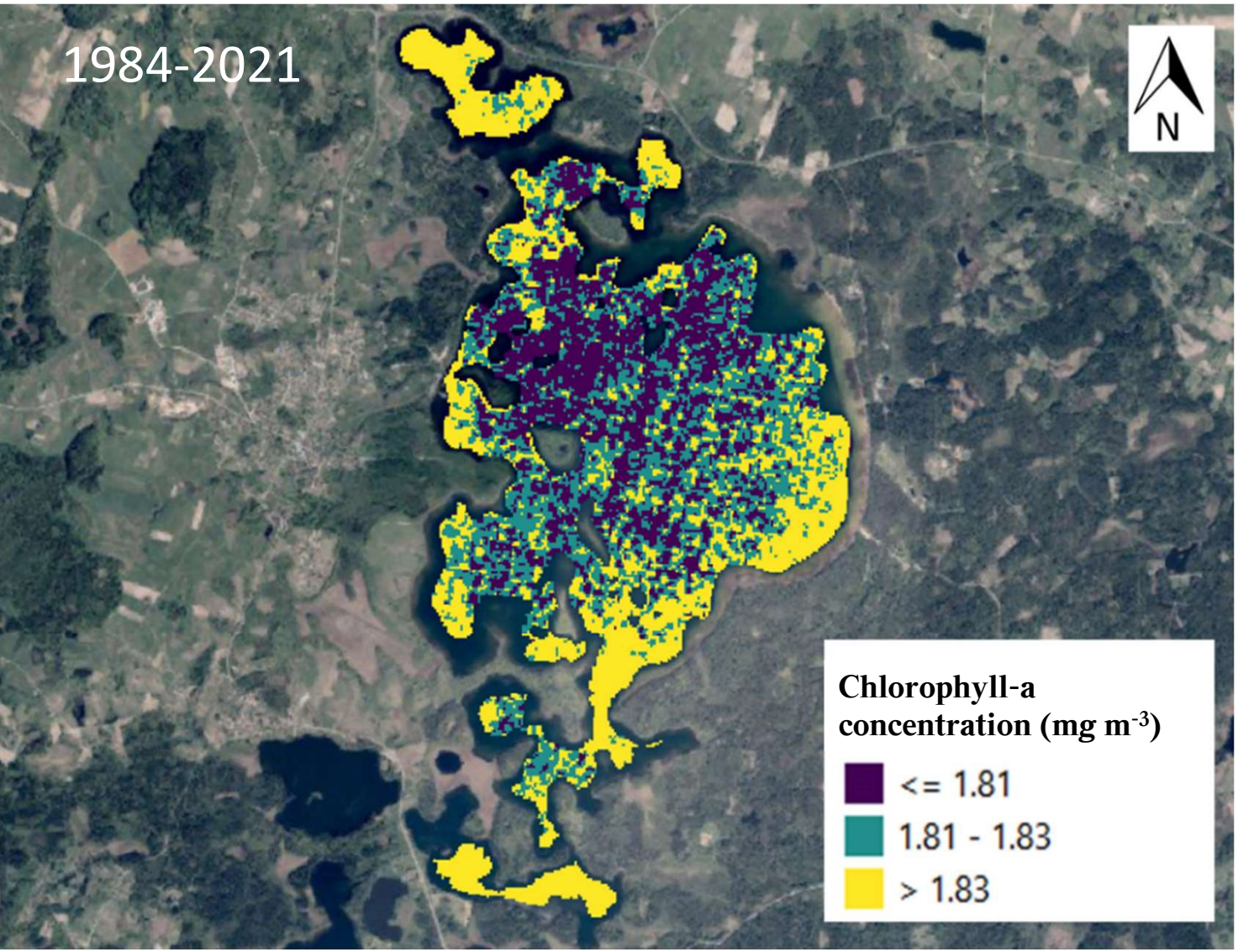


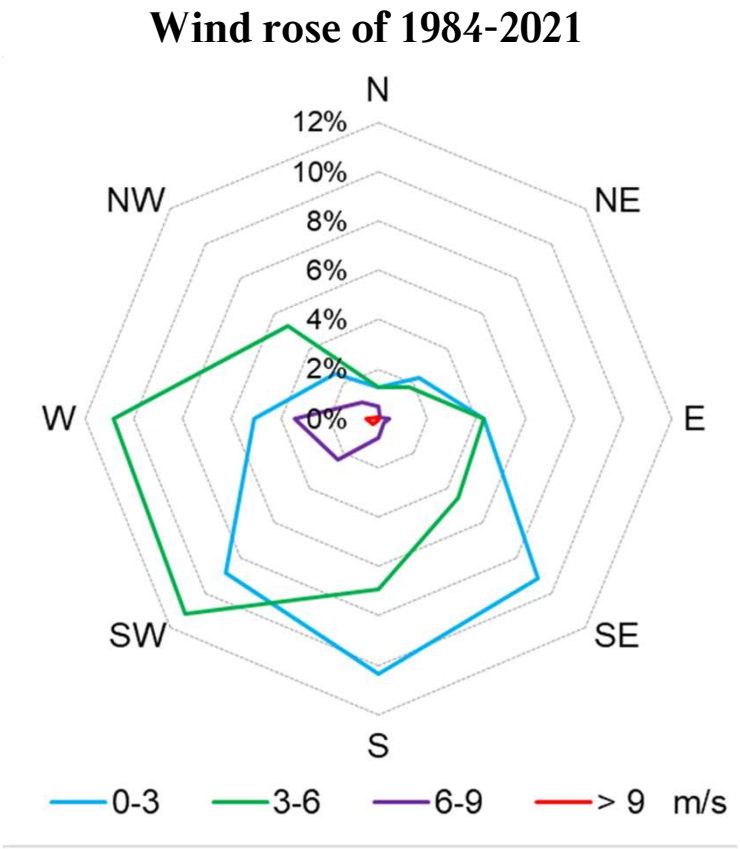




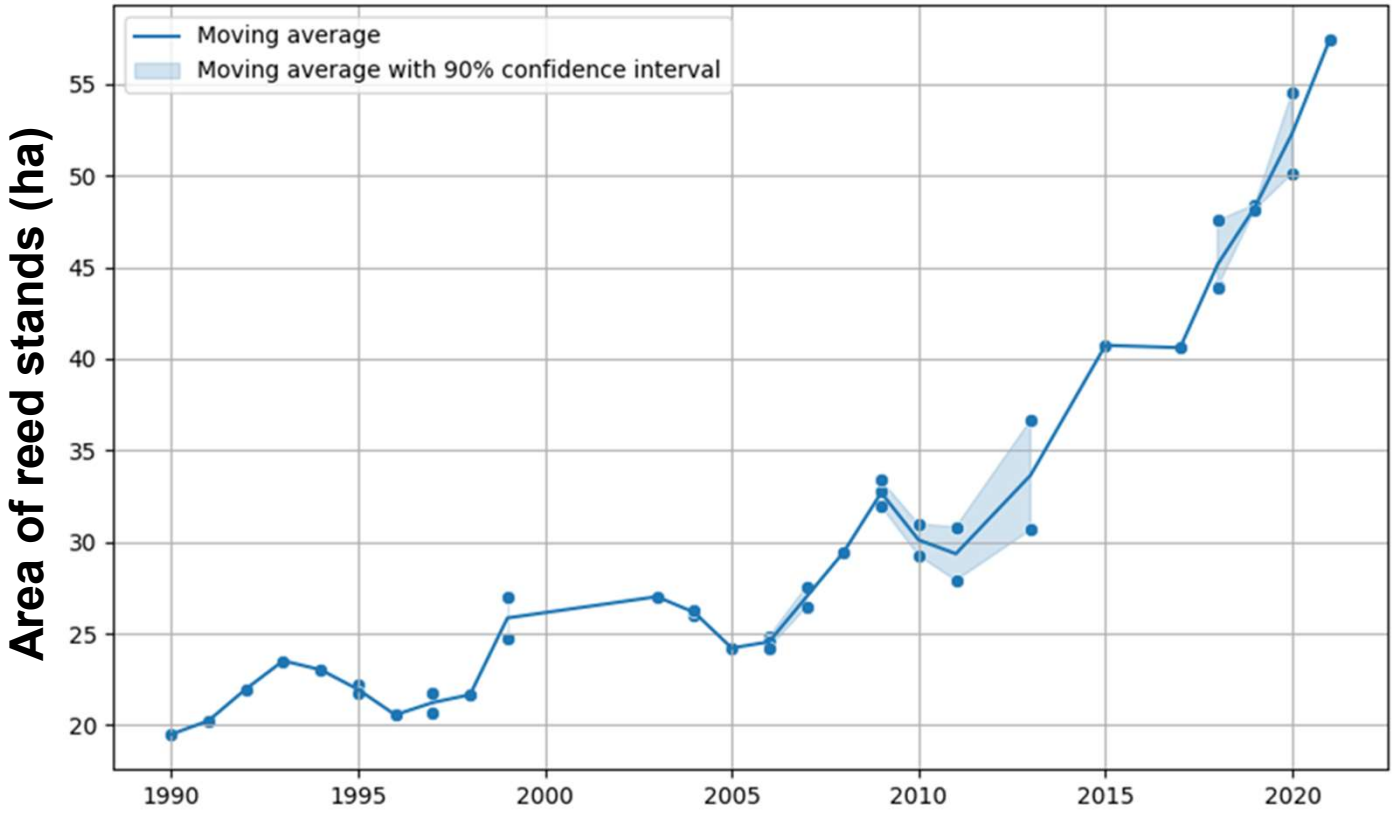


Retrospective analysis of chloropyll-a



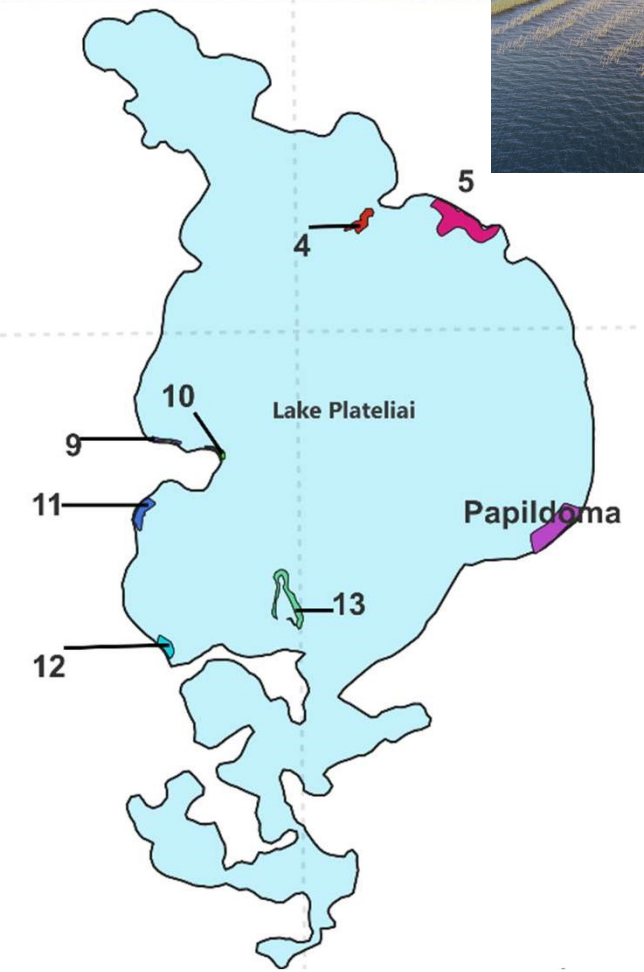


Retrospective analysis of reeds



The area occupied by reed stands tripled since 1990's, mainly in the Eastern part of the lake

Retrospective analysis of reeds



Reduced area of reed stands (ha)

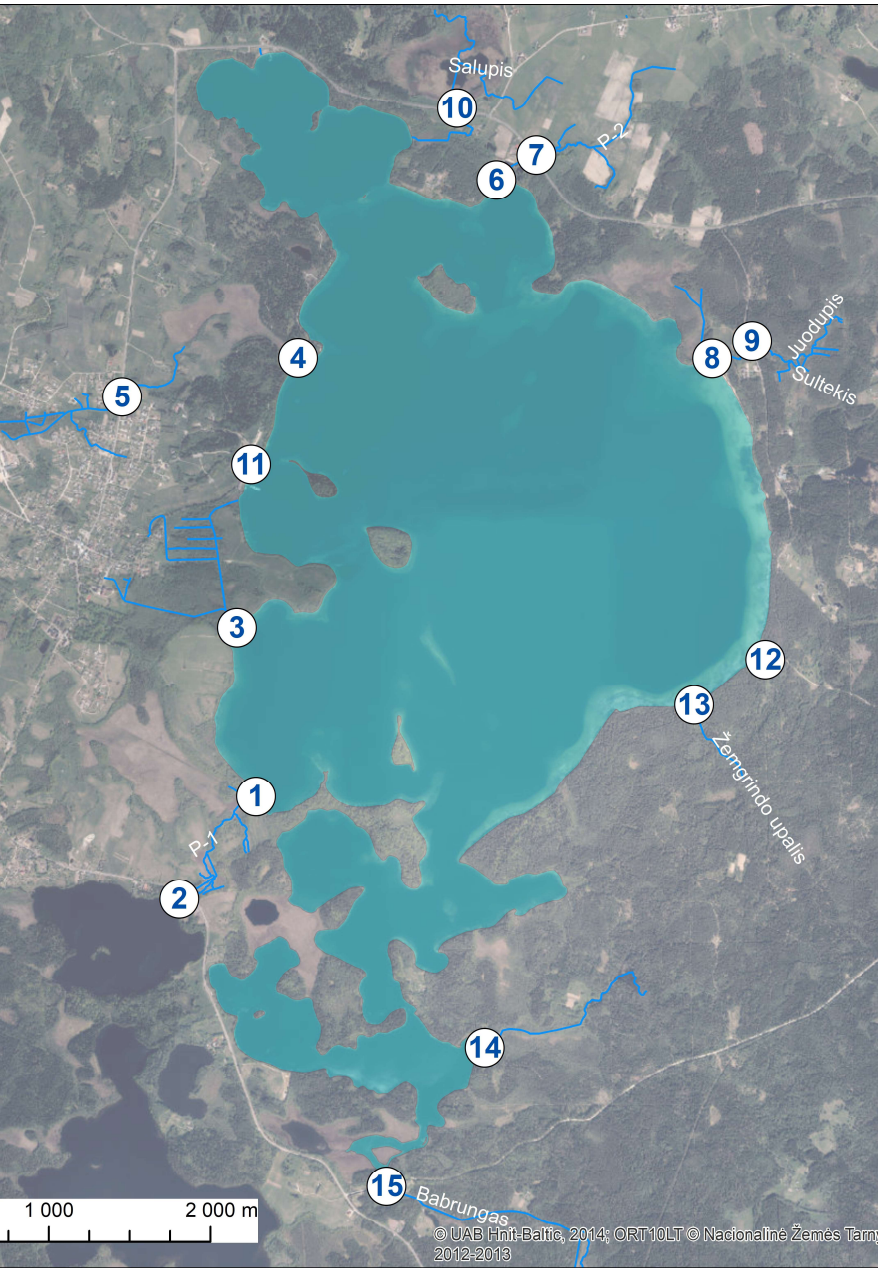
	2016	2017	2018	2019	2020
Reference area	0.16	0.15	0	0	0
Mowed area 5	0.18	0.08	0.41	0.81	0.03

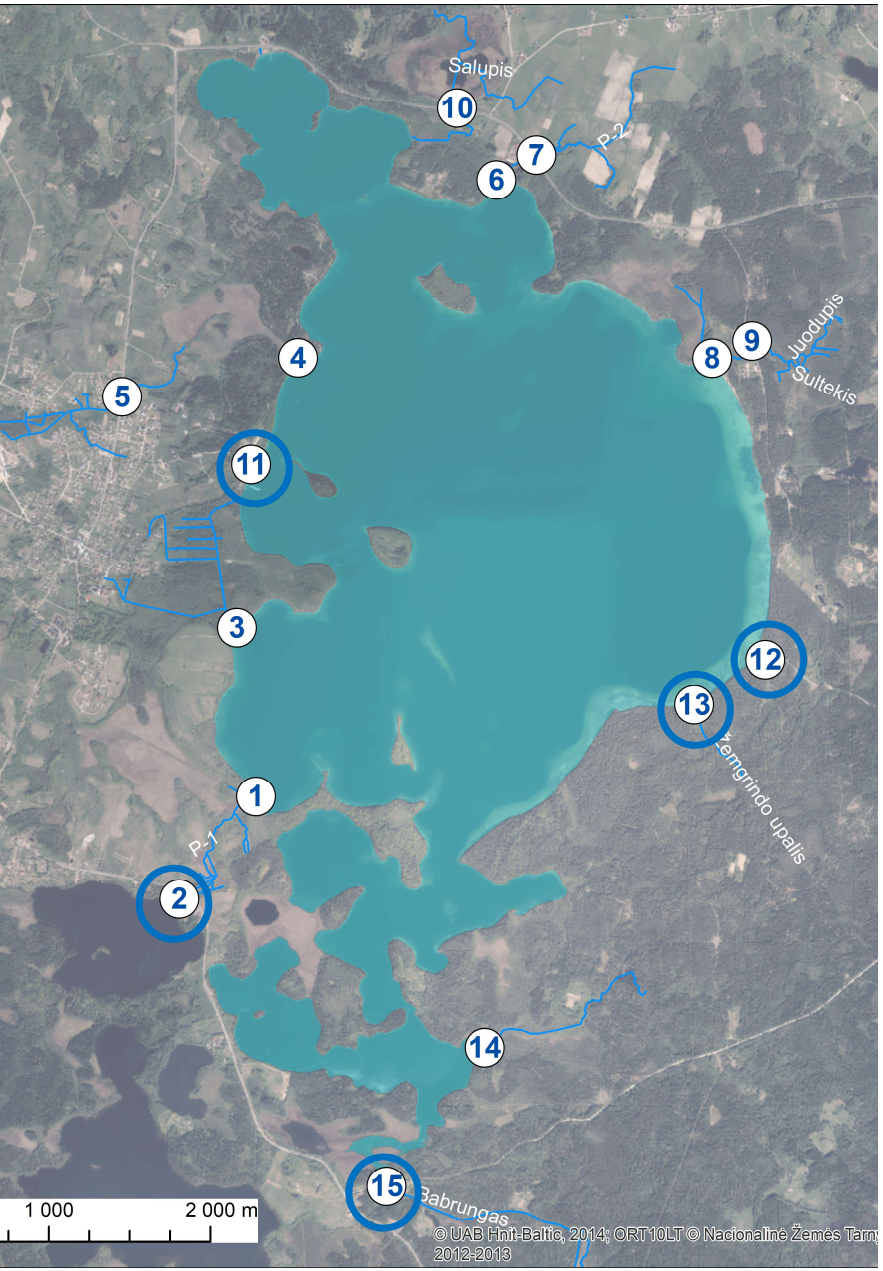
mowing of reeds

II task. STATE-OF-ART ECOLOGICAL STATUS OF THE LAKE INCLUDING INFLOWS

M&M: Lake tributaries and outflow

- Monthly sampling from January to December 2022
- 15 study sites:
  - 10 creeks inflowing into Plateliai Lake
  - 1 creeks outflowing from Plateliai Lake
  - 4 study sites in creeks upstream
- Analysis:
  - Basic water quality indicators (T, O_2, pH, conductivityBOD_7)
  - Nitrogen and phosphorus forms (TN, TP, DIN=NH_4^+ + NO_x, PO_4^{3-})
- Debit


Salupis
10
7
6
P-2
4
8
9
Juodupis
Sultekis
5
11
3
12
13
Žemgrindo upalis
1
P-1
2
14
15
Babrungas
1 000
2 000 m
© UAB Hnit-Baltic, 2014; ORT10LT © Nacionalinė Žemės Tarn
2012-2013

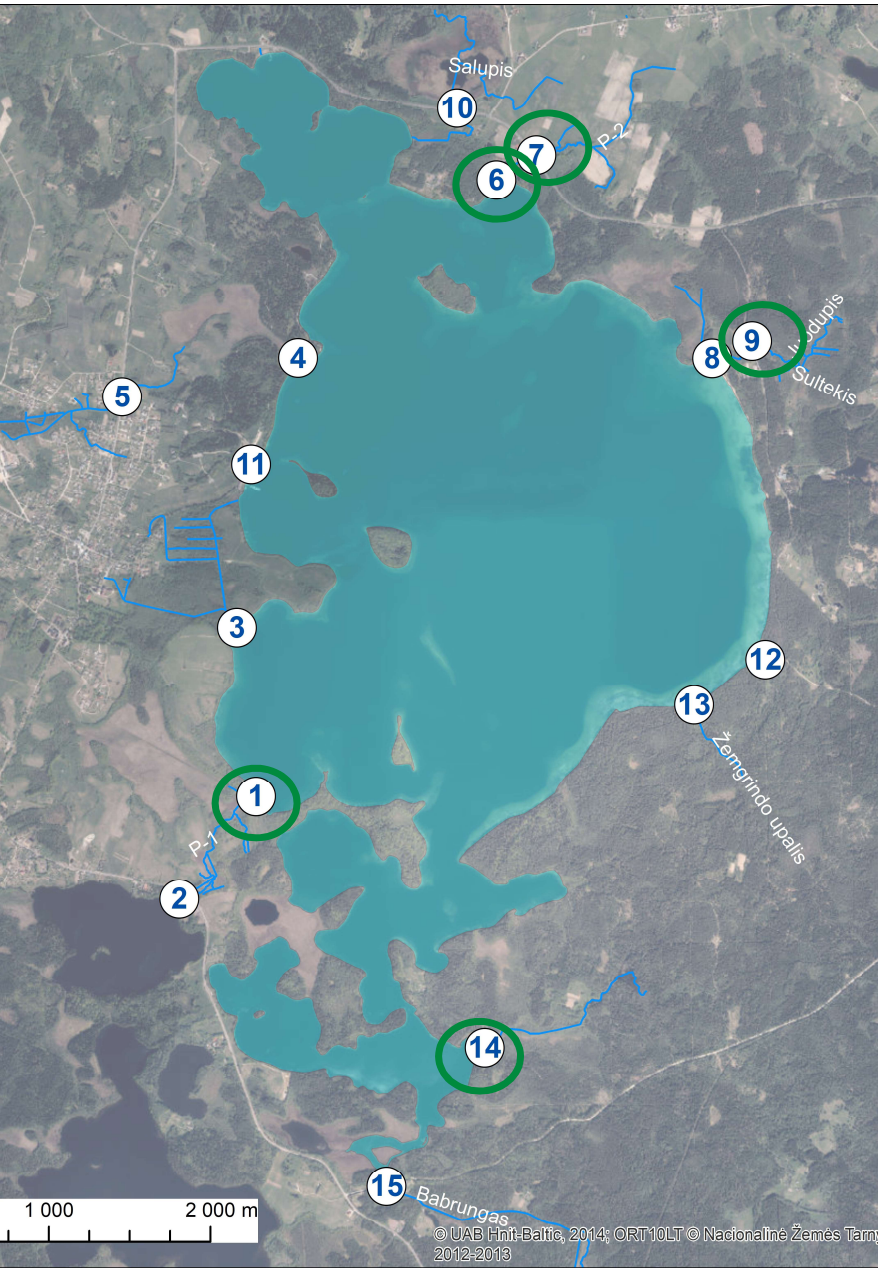


Water ecological status in creeks

Study sites No.	NH_4^+	NO_3^-	TN	PO_4^{3-}	TP	BOD_7	O_2
ST-1	0.02	0.01	0.47	0.008	0.028	1.54	8.37
ST-2	0.02	0.06	0.47	0.003	0.022	1.82	10.88
ST-3	0.34	0.12	1.53	0.045	0.115	3.09	5.13
ST-4	0.06	0.02	0.69	0.008	0.031	1.80	7.05
ST-5	0.07	0.41	1.28	0.051	0.192	4.10	6.98
ST-6	0.04	0.24	0.79	0.010	0.035	2.60	9.42
ST-7	0.04	1.00	1.48	0.010	0.050	2.37	10.71
ST-8	0.15	0.14	0.90	0.019	0.066	2.21	6.98
ST-9	0.04	0.15	0.71	0.008	0.035	2.06	8.19
ST-10	0.04	0.10	0.76	0.005	0.028	2.22	5.38
ST-11	0.02	0.23	0.56	0.012	0.039	2.17	12.33
ST-12	0.06	0.20	0.57	0.013	0.035	1.79	10.74
ST-13	0.02	0.11	0.62	0.009	0.027	2.01	11.07
ST-14	0.04	0.06	0.54	0.008	0.026	2.11	7.96
ST-15	0.02	0.03	0.43	0.0052	0.017	2.07	11.76

- High ecological status of all indicators assessed in 5 creeks: St-2, St-11, St-12 St-13 and St-15.

High	Good	Moderate	Poor	Bad



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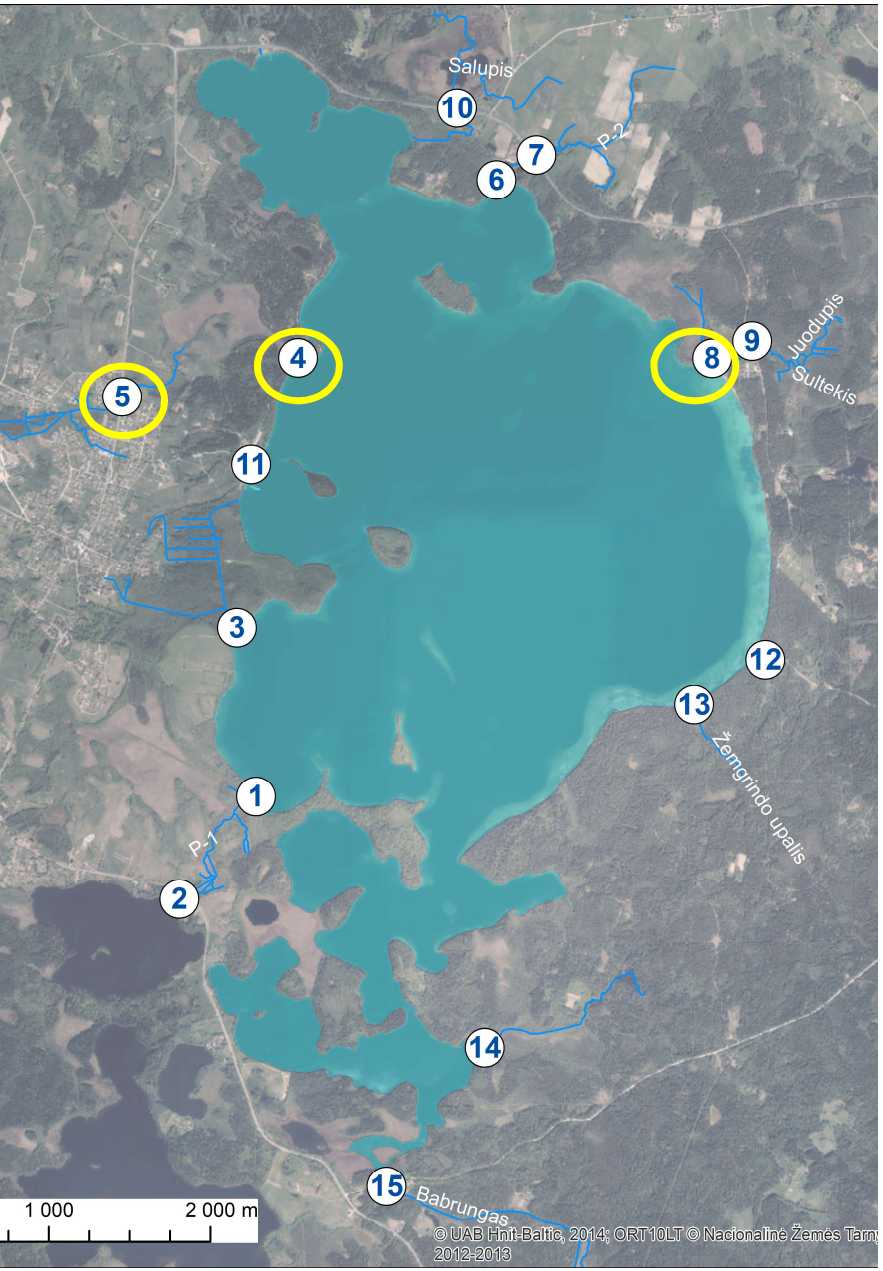
ST-15	0.02	0.03	0.43	0.0052	0.017	2.07	11.76

- High ecological status of all indicators assessed in 5 study sites: St-2, St-11, St-12 St-13 and St-15.
- Good ecological status assessed in 5 study sites: St-1, St-6, St-7, St-9 and St-14 due to O_2 and BOD_7.

High | Good | Moderate | Poor | Bad



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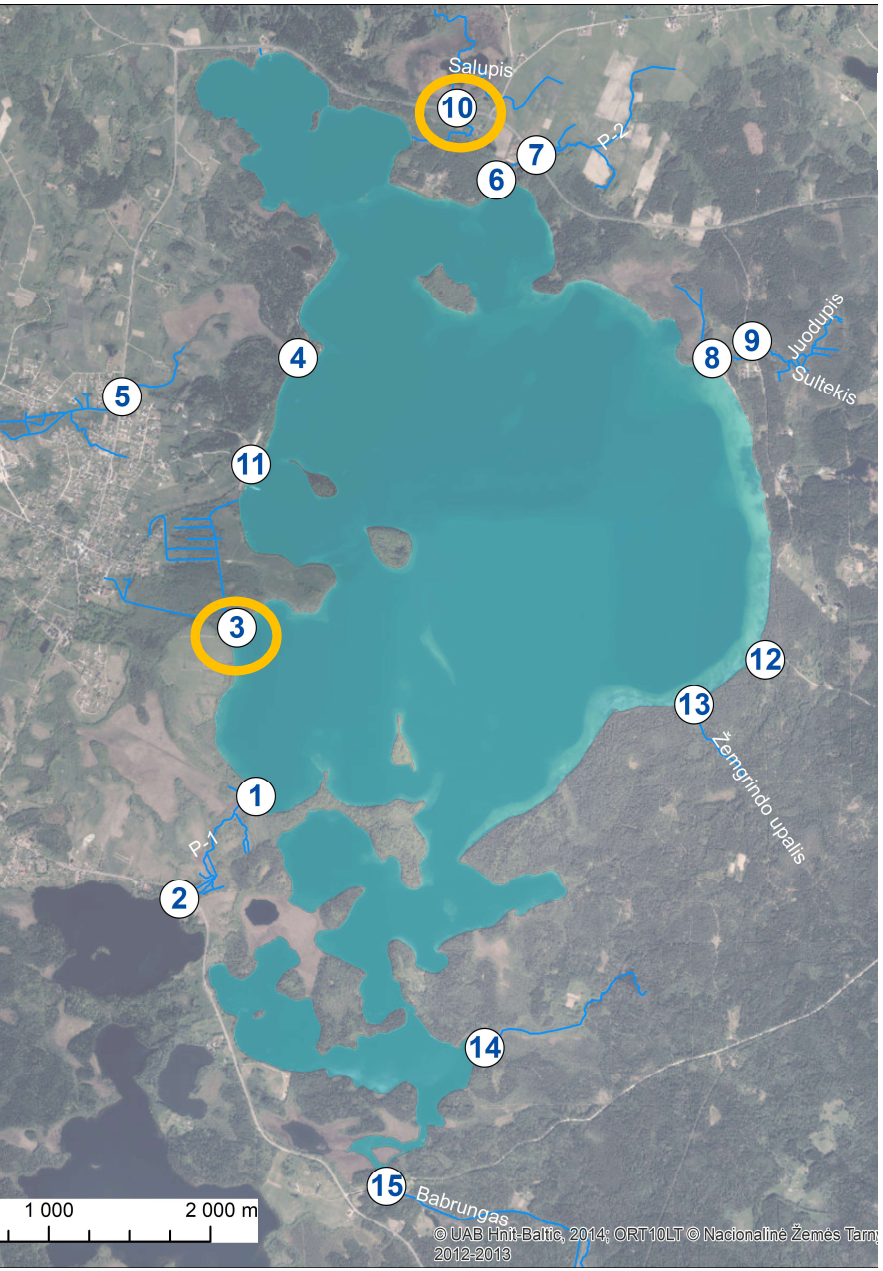
- Good ecological status assessed in 5 study sites: St-1, St-6, St-7, St-9 and St-14 due to O_2 and BOD_7.
- Moderate ecological status assessed in 3 study sites: St-4, St-5, St-8 due to O_2, TP, BOD_7 indicators.

High | Good | Moderate | Poor | Bad



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ST-15	0.02	0.03	0.43	0.0052	0.017	2.07	11.76

- High ecological status of all indicators assessed in 5 study sites: St-2, St-11, St-12 St-13 and St-15.
- Good ecological status assessed in 5 study sites: St-1, St-6, St-7, St-9 and St-14 due to O_2 and BOD_7.
- Moderate ecological status assessed in 3 study sites: St-4, St-5, St-8 due to O_2, TP, BOD_7 indicators.
- Poor ecological status assessed in 2 study sites: St-3 and St-10, where O_2 was <5.99 mg l^{-1}.

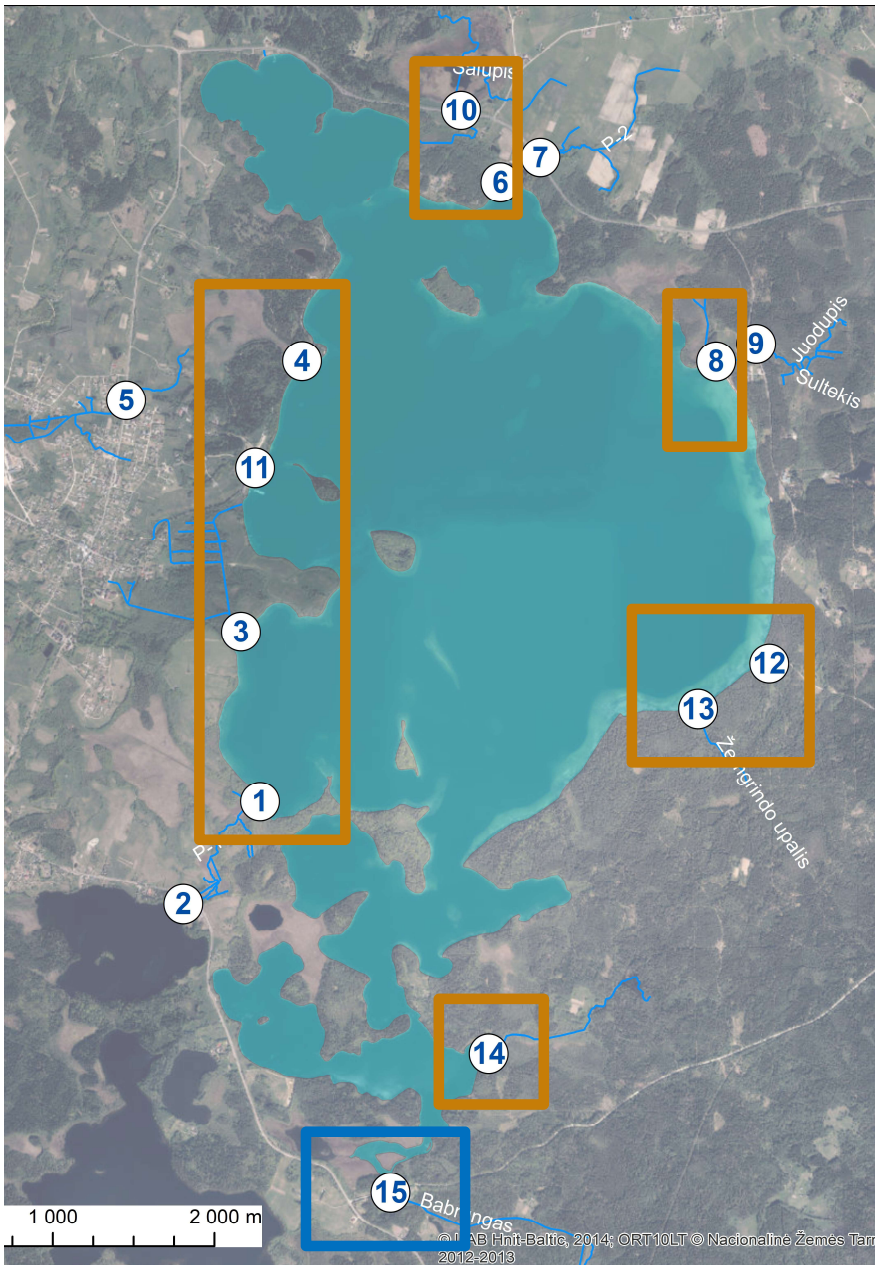
High | Good | Moderate | Poor | Bad

How much of nutrients are delivered to Plateliai Lake?

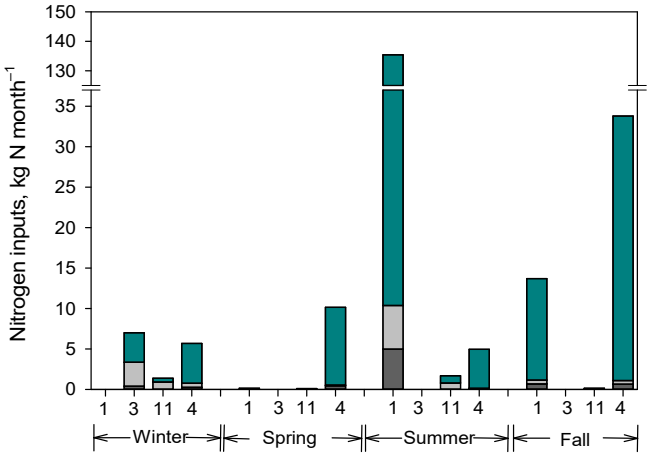
Input = concentration × creek debit

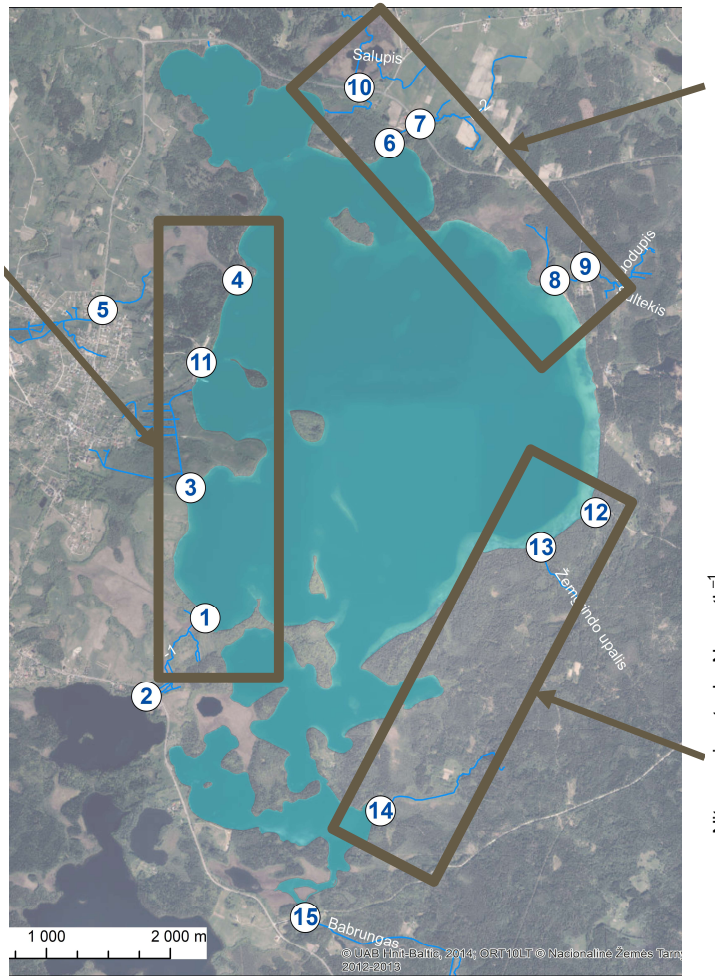
Input measured at study sites: St-1, St-3, St-11, St-4, St-10, St-6, St-8, St-12, St-13, St-14.

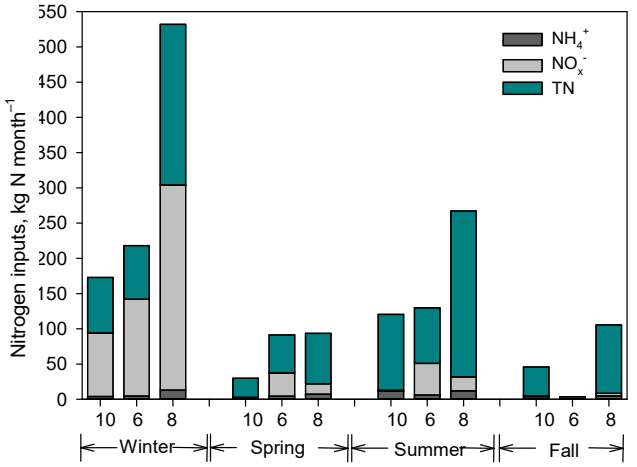
Output measured at St-15 study site.

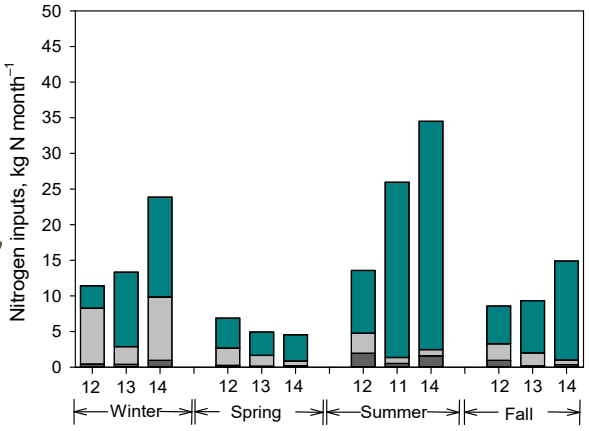


Nitrogen inputs to lake



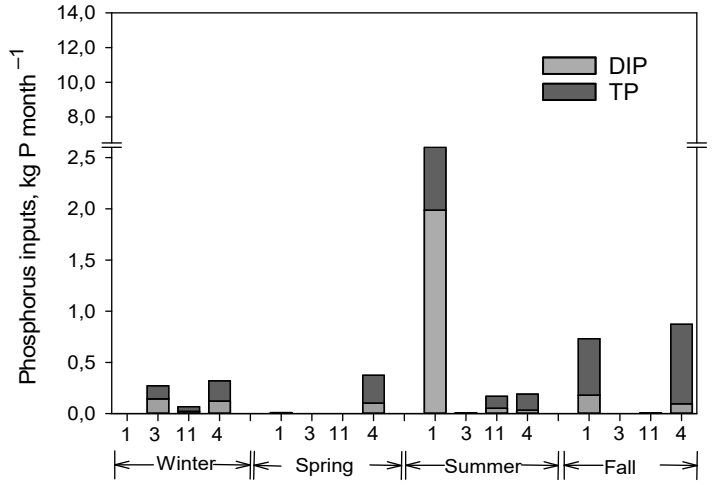




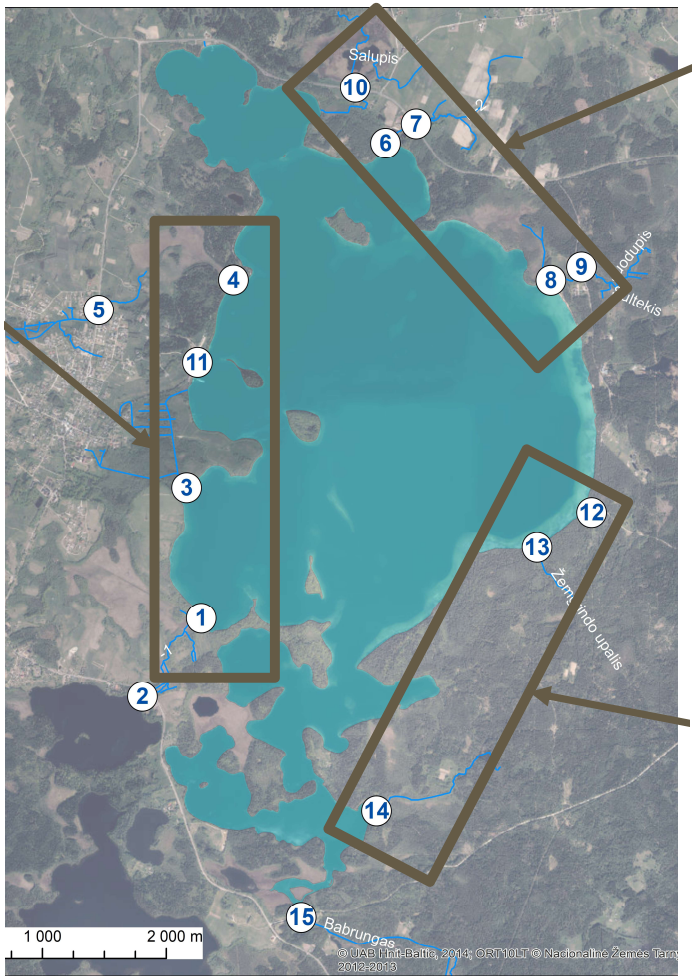


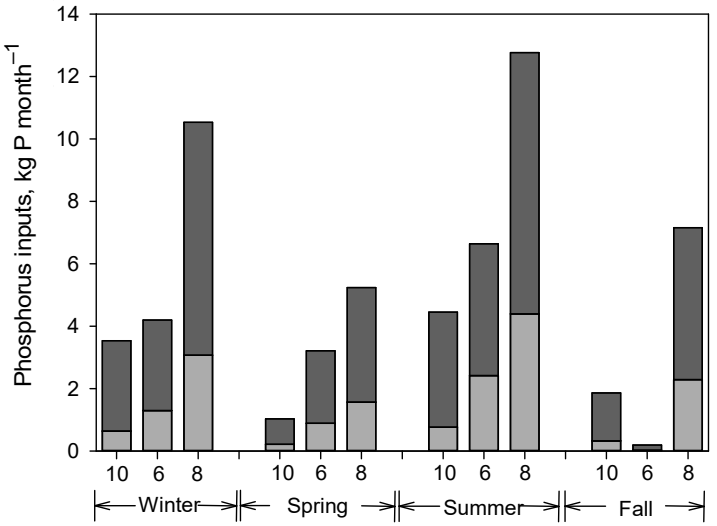
- Nitrogen inputs to the lake varied seasonally and depended on the site;
- The highest input was during winter and summer periods, lowest – fall;
- The nitrogen was primarily delivered in dissolved organic and particulate forms.

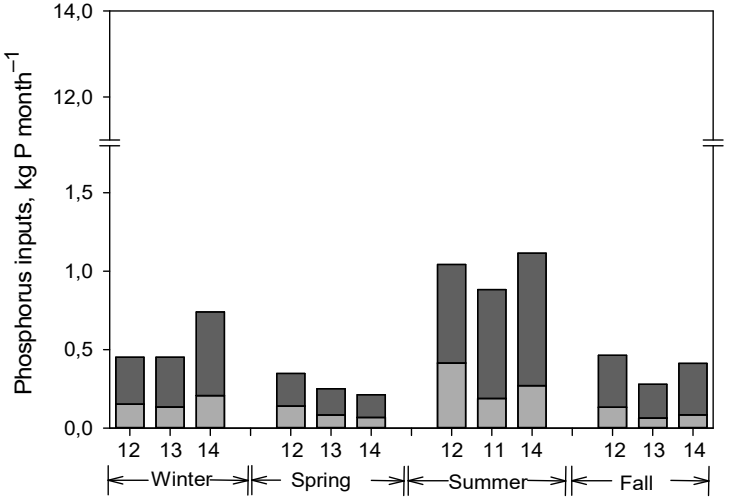
Phosphorus input to lake



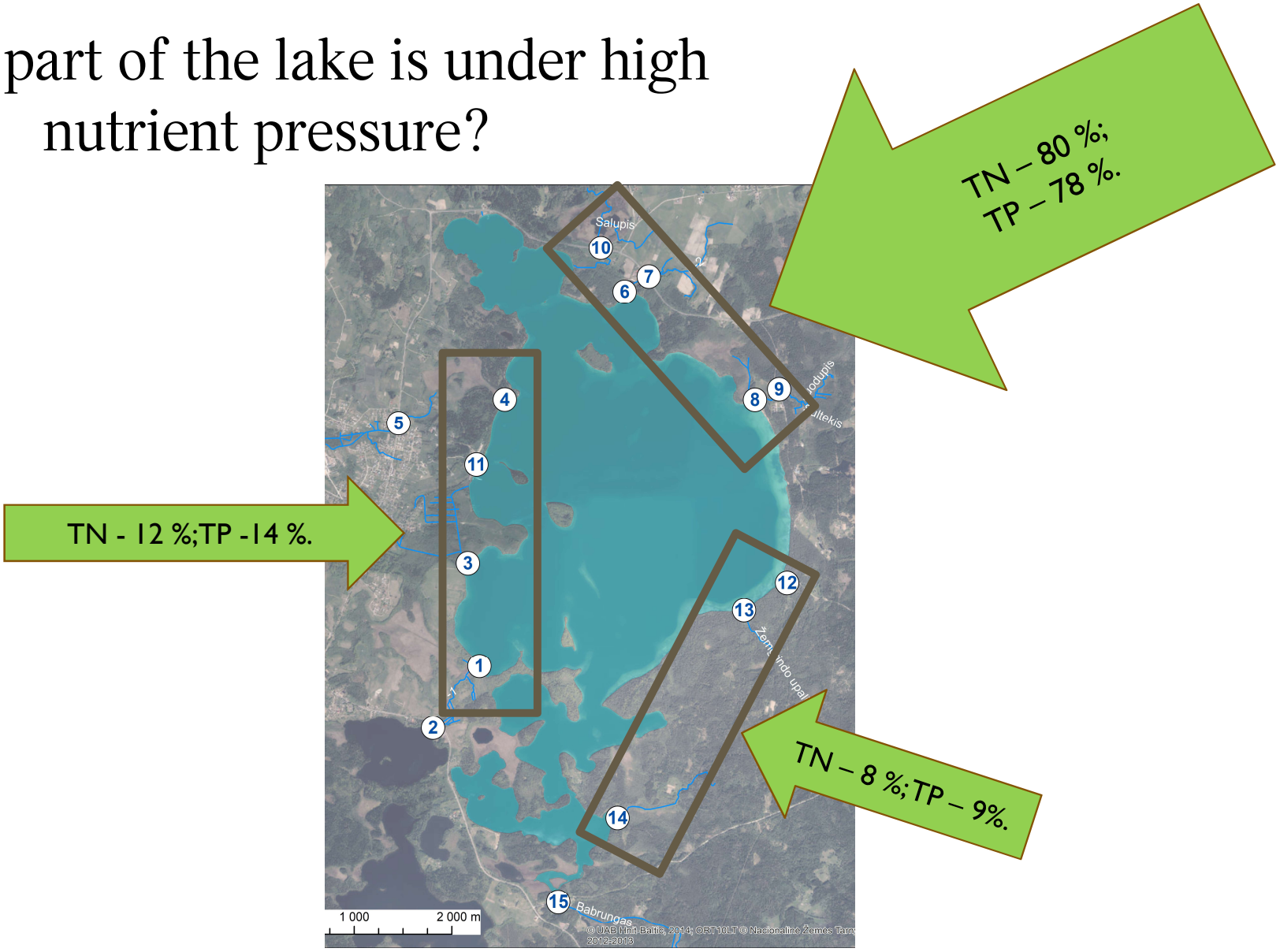
- Phosphorus inputs to the lake varied seasonally and depended on the site;
- DIP fraction in total phosphorus input contributed relatively low part.





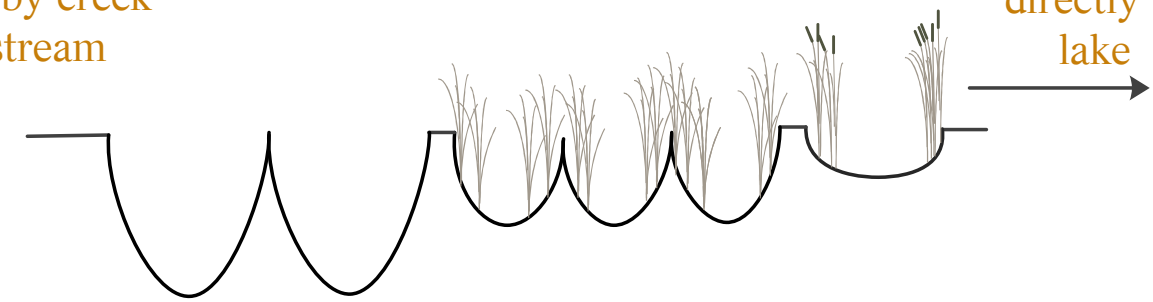


Which part of the lake is under high nutrient pressure?



Can natural or human-made stretches reduce nutrient inputs to the lake?

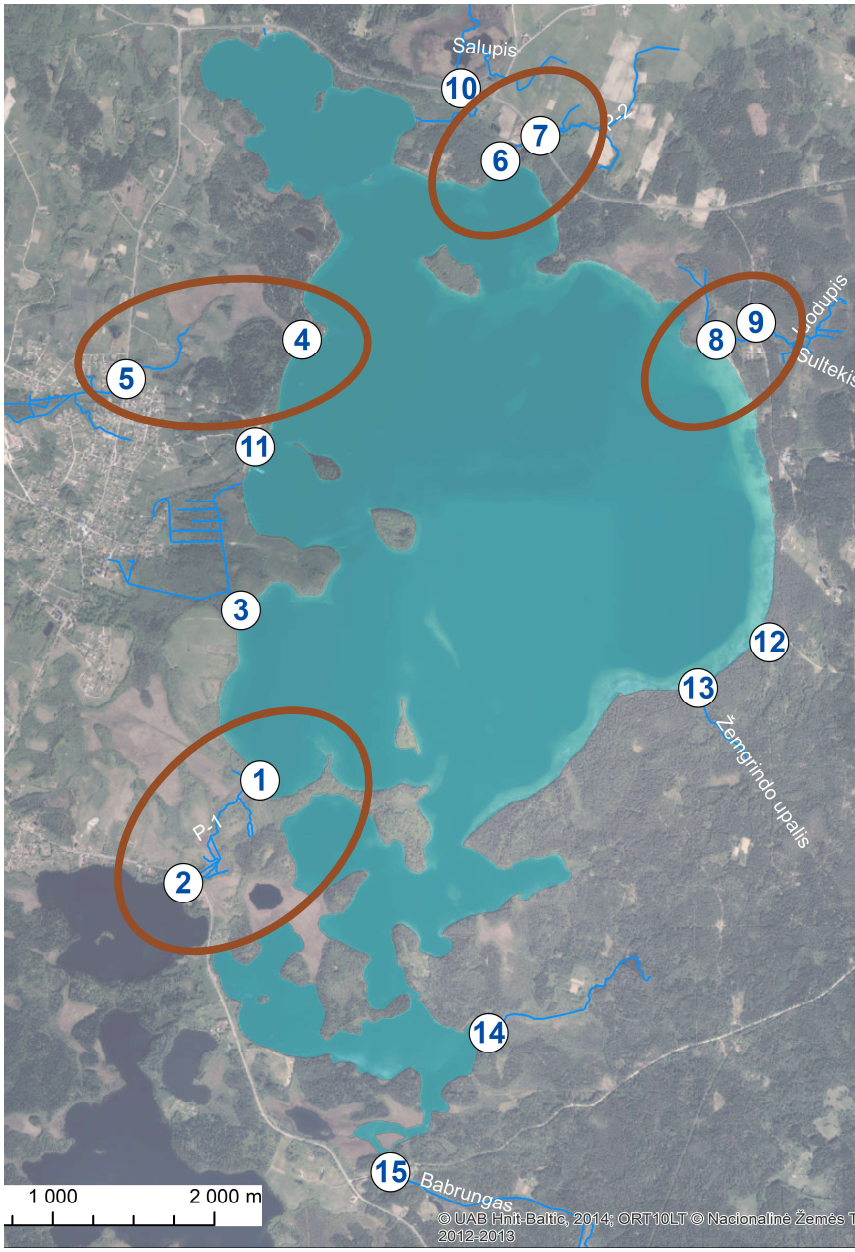
Input by creek upstream

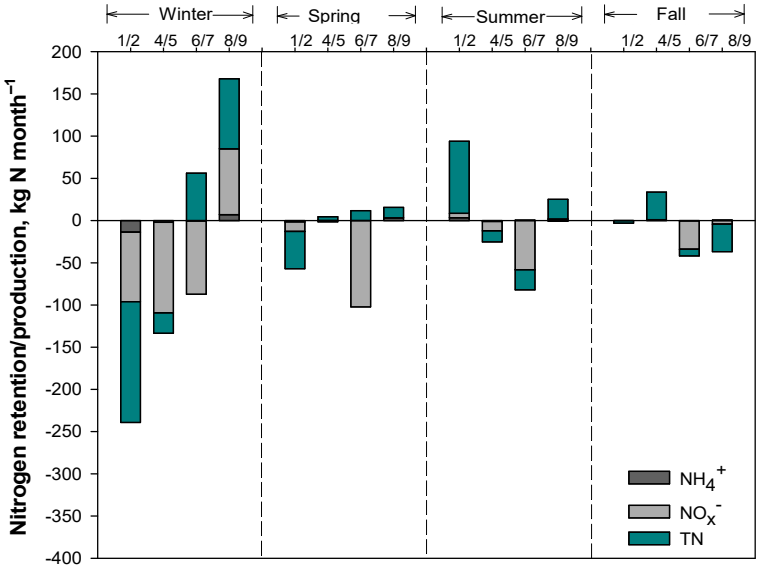


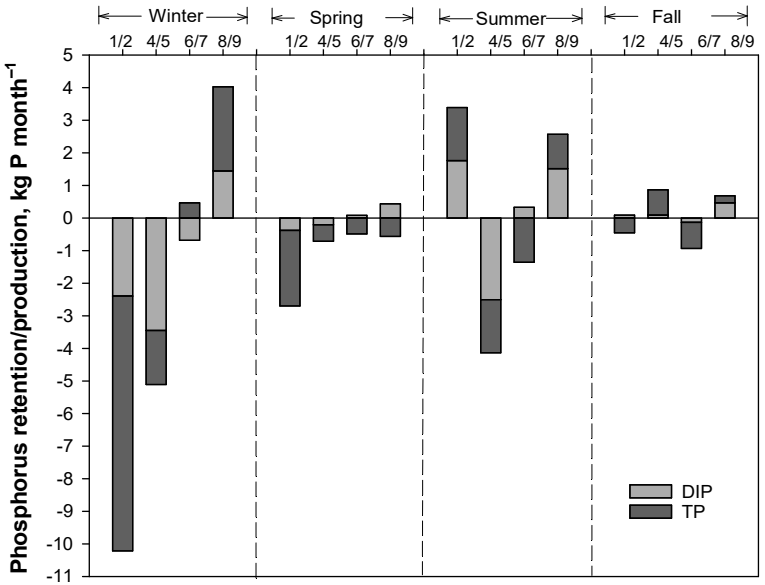
Input by creek directly to lake

Positive value indicate production

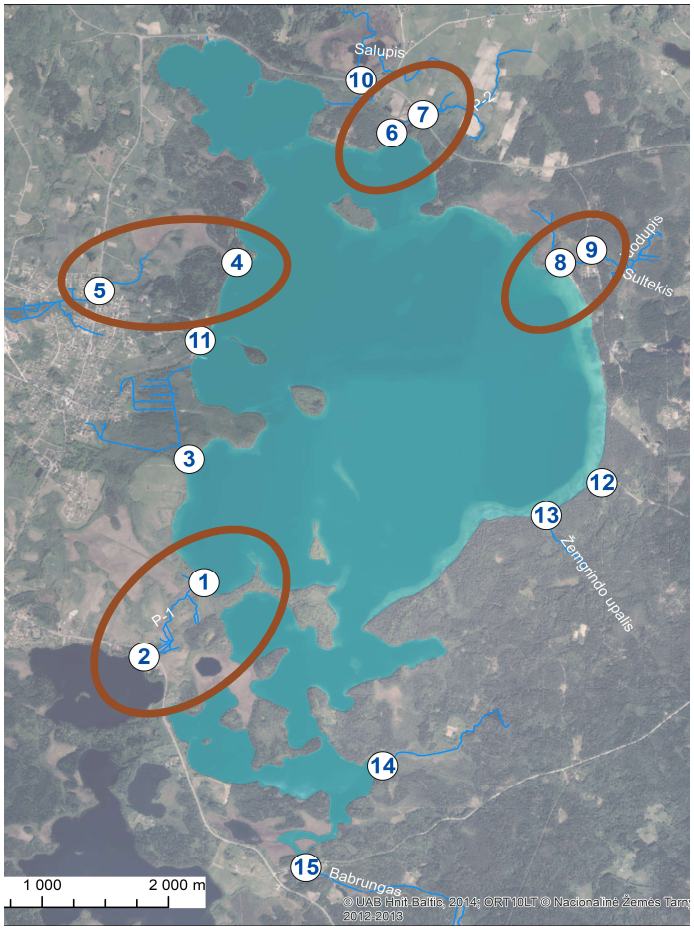
Negative value – uptake.







The role of buffering streches

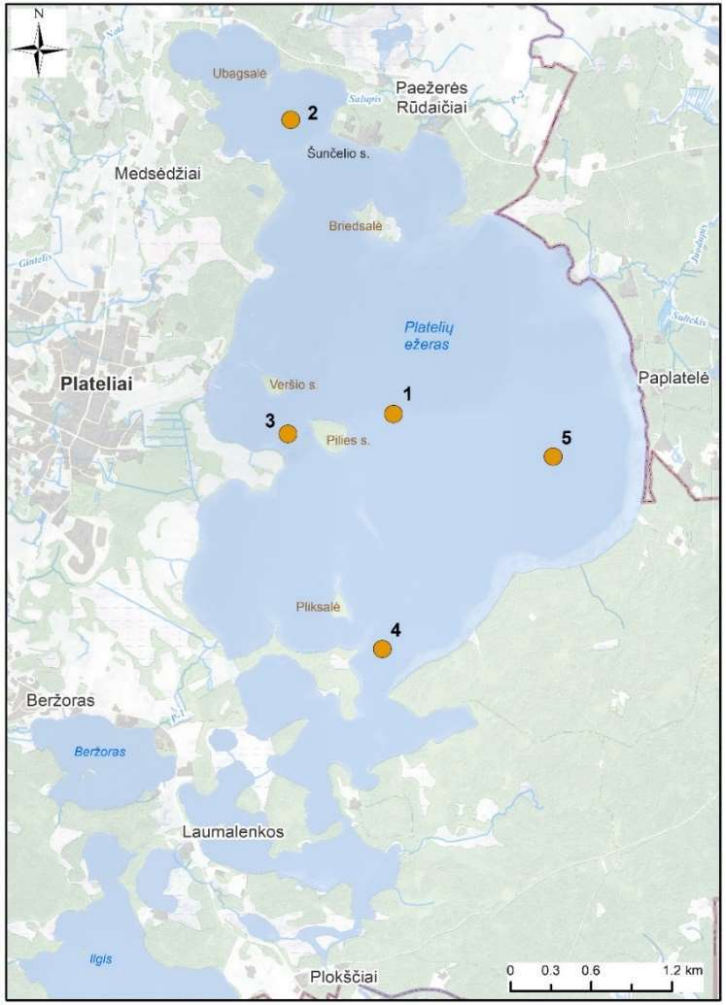


Positive value indicate production whereas negative value – uptake.

Simple balance of TN and TP in Plateliai Lake

Season	Input to lake	Output	Difference (output – input)
		TN balance (kg month^{-1})	
Žiema	986	1732	746
Pavasaris	241	987	746
Vasara	734	1004	270
Ruduo	235	239	4
		TP balance (kg month^{-1})	
Žiema	21	73	52
Pavasaris	11	40	29
Vasara	33	39	6
Ruduo	12	8	-4

Survey in Plateliai Lake



Research was done from April to October 2022.

At 5 study sites:

1 – central deep (depth - 43 m)
2 – northern (depth - 7 m)
3 – western (depth - 9 m)
4 – southern (depth - 11 m)
5 – eastern (depth - 25 m)

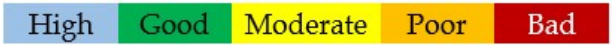
Analysis:

- Water column profiles (T, O_2, pH, conductivity)
- Nutrient forms (TN, TP, DIN=NH_4^+ + NO_x, PO_4^{3-})
- Biological parameters (Chl-a, Phytoplankton)
- BOD_7

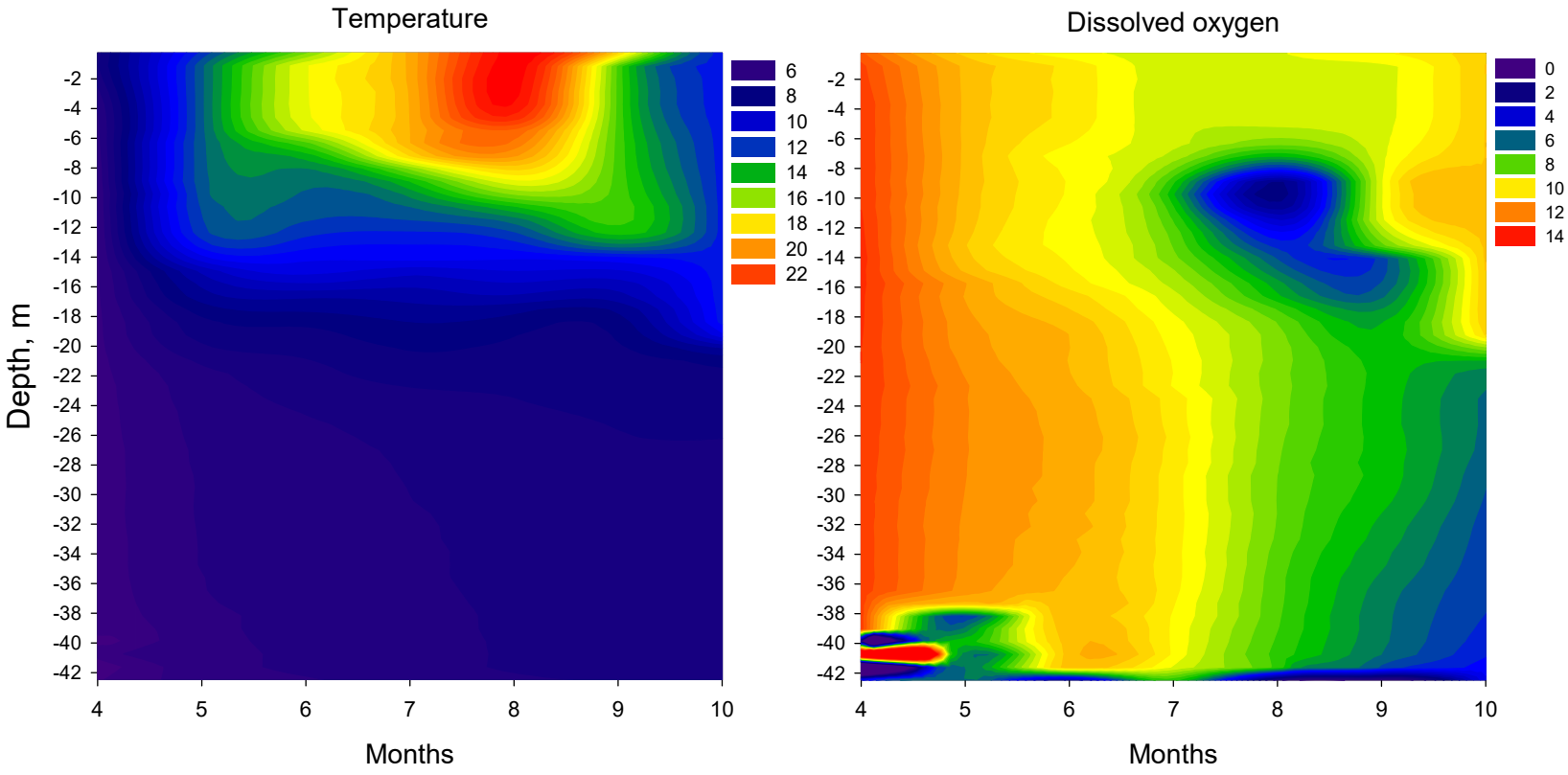
Past and present ecological status of Plateliai Lake

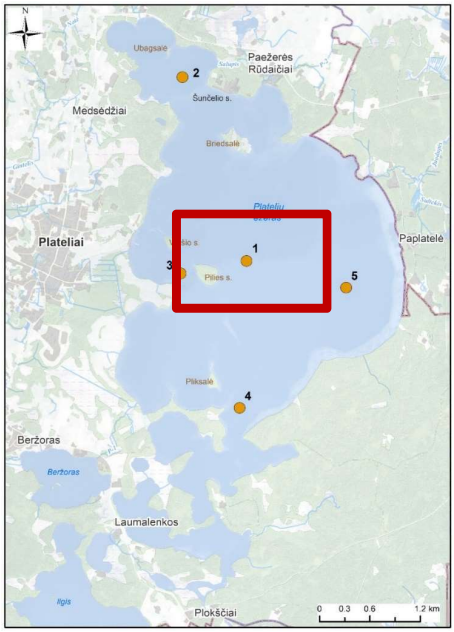
Years	EQR	TN	TP	BOD_7	Class/Status
2001	1.35	0.44	0.009	1.05	High
2002	0.83	0.54	0.012	1.42	High
2003	1.31	0.43	0.011	1.06	High
2004	1.33	0.40	0.000	1.28	High
2005	1.54	0.57	0.018		High
2006	1.52	0.34	0.011	1.43	High
2007	1.07	0.69	0.014	2.28	High
2010	0.96	0.53	0.029	1.82	High
2011	0.36	0.52	0.024	1.34	Good
2012	0.72	0.46	0.054	1.89	Good
2013	1.12	0.50	0.046	1.22	Good
2014	1.19	0.43	0.039	1.57	High
2015	1.29	0.48	0.037	1.36	High
2016	0.92	0.43	0.011	1.53	High
2017	0.93	0.42	0.012	2.29	High
2018	0.68	0.48	0.014	2.19	High
2019	0.73	0.66	0.015	2.01	High
2020	0.76	0.59	0.013	1.26	High
2022 N	0.92	0.40	0.015	1.69	High
2022 W	0.91	0.44	0.015	1.58	High
2022 D	0.92	0.38	0.014	1.4	High
2022 E	0.92	0.38	0.014	1.38	High
2022 S	0.94	0.40	0.015	1.38	High

- In 2022, water quality met high ecological status.
- Slightly higher mean values of TN and TP were measured in northern, western and southern part of the lake whereas BOD_7 in northern and western part;
- In the last 20 years, Plateliai Lake remains in high ecological status except 2011-2013, when it decreased to good in terms of EQR and TP.

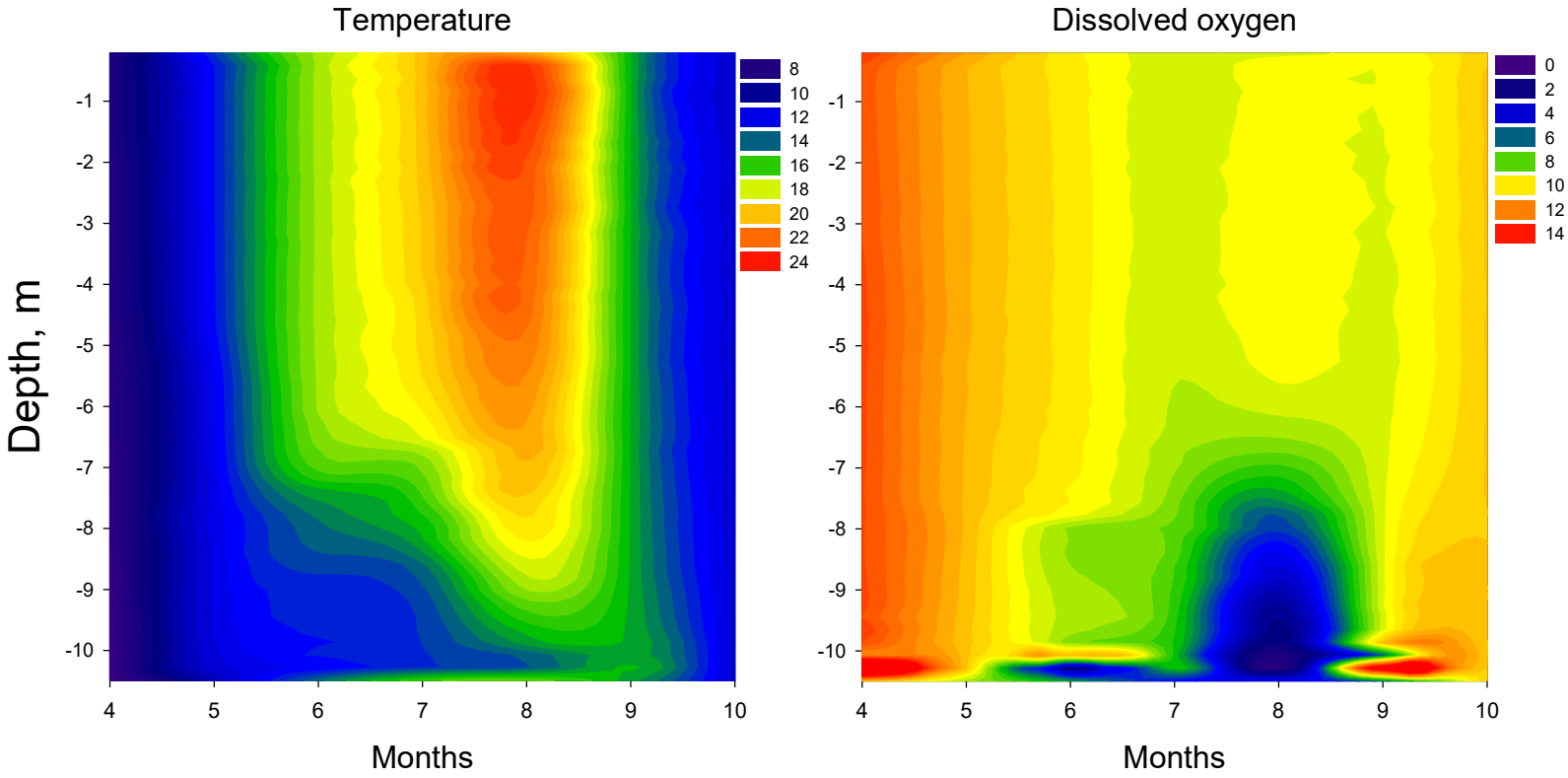


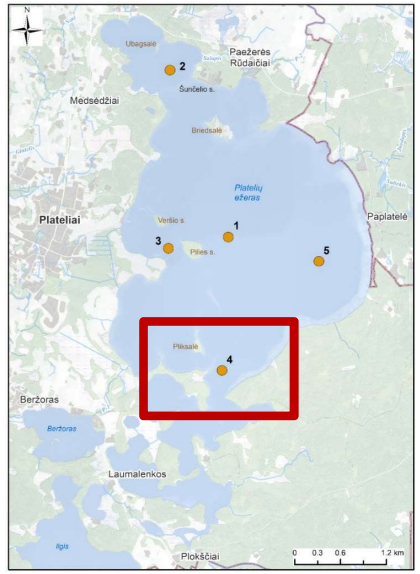
Vertical profiles of temperature and oxygen: deepest site





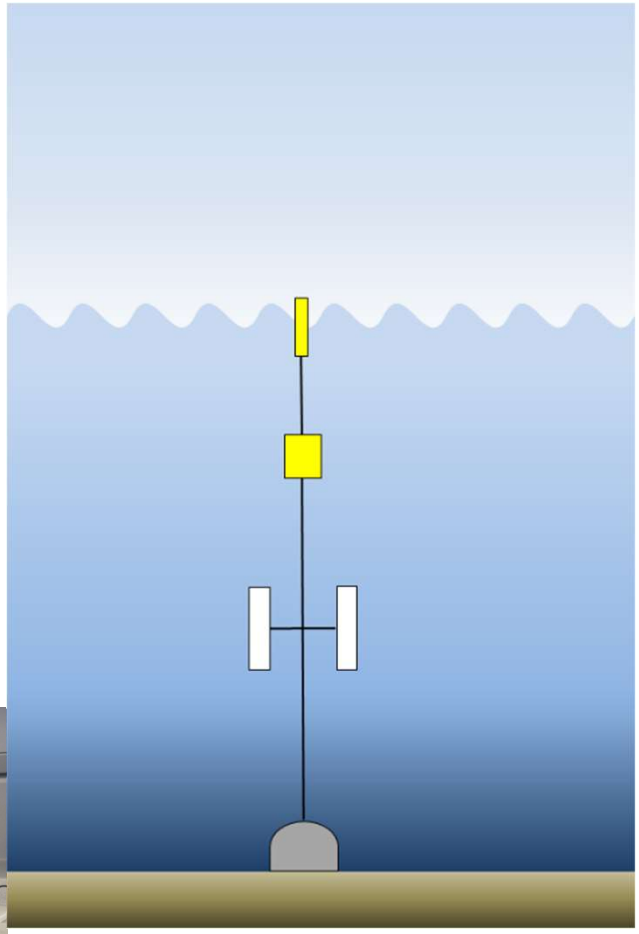
Vertical profiles of temperature and oxygen: southern lake part

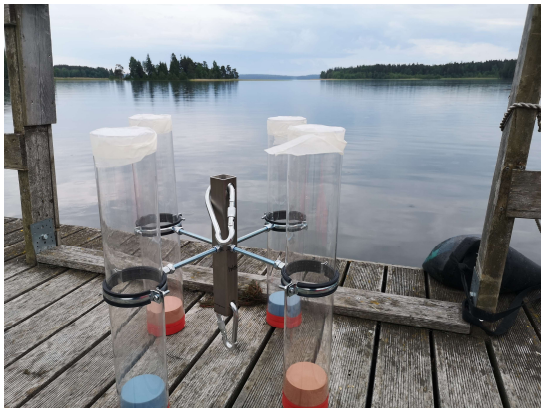




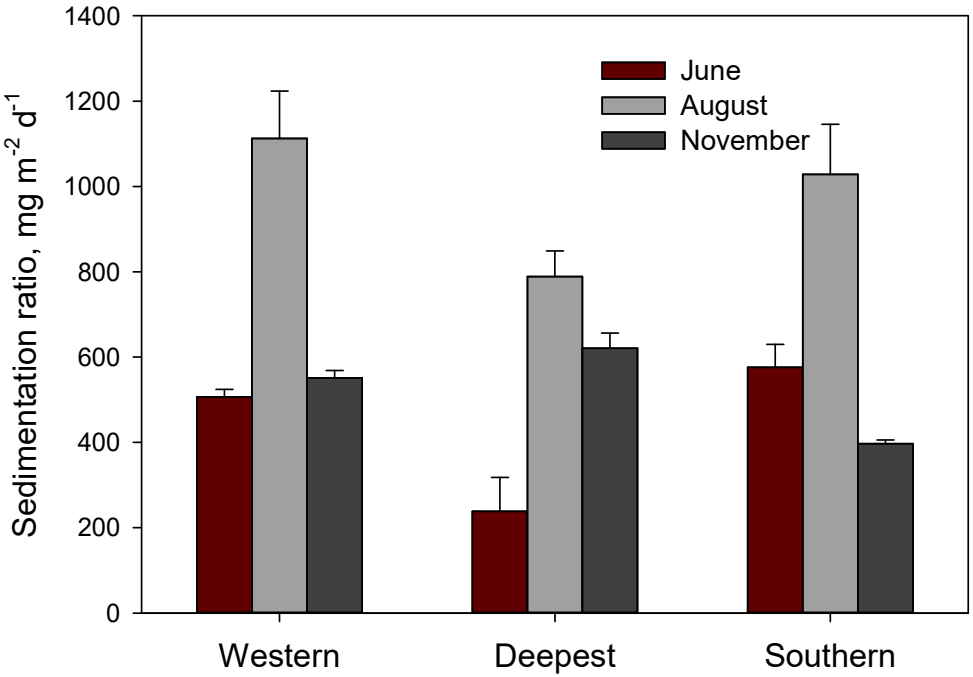
How much of suspended matter does settle down from water column to sediment?

- Suspended matter sedimentation rates measurement was done 3 times per year: June, August and November;
- At 3 study sites: deepest, western and southern parts;
- Sediment trap holding period – 10 days.





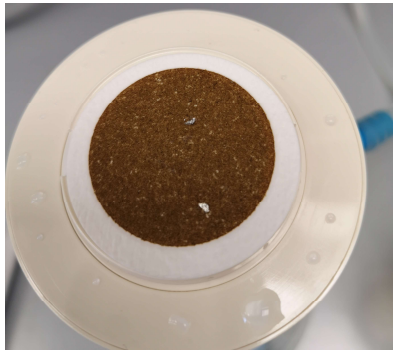
Sedimentation rates of the suspended matter (SM)

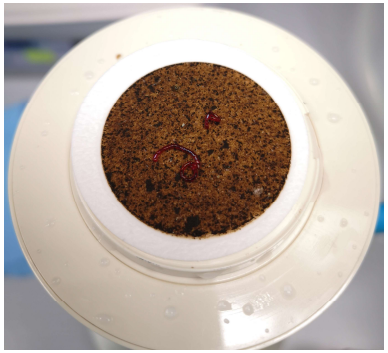


Sedimentation rates were 2 times higher in August comparing with other periods;

Higher mean sedimentation rates were estimated in western and southern parts of the lake.

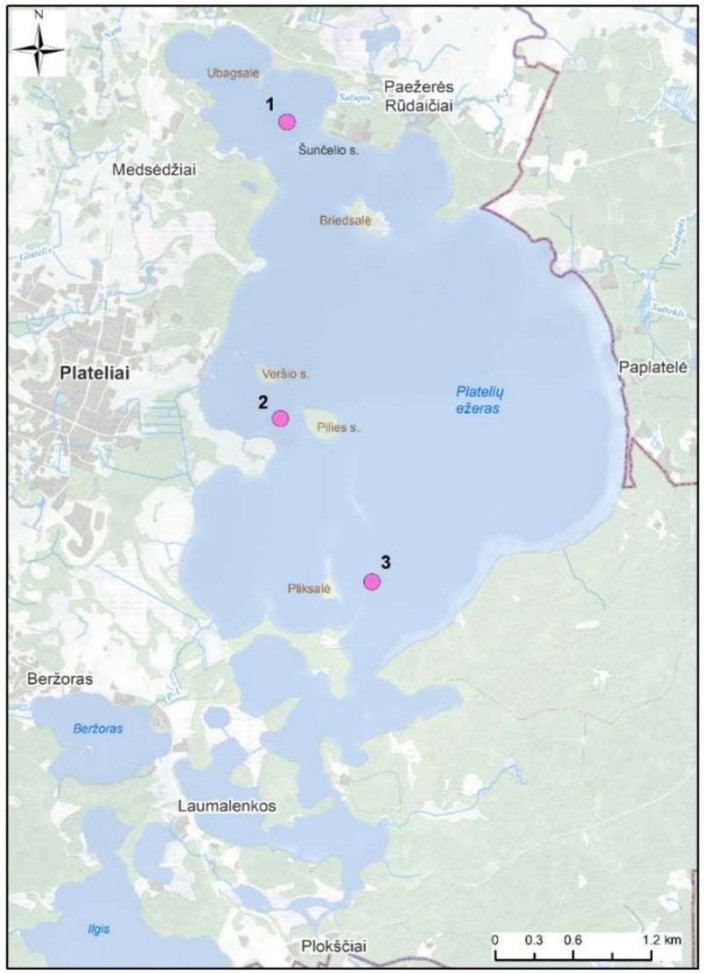
Less than 10% of SM in water column were settled to surface sediment.



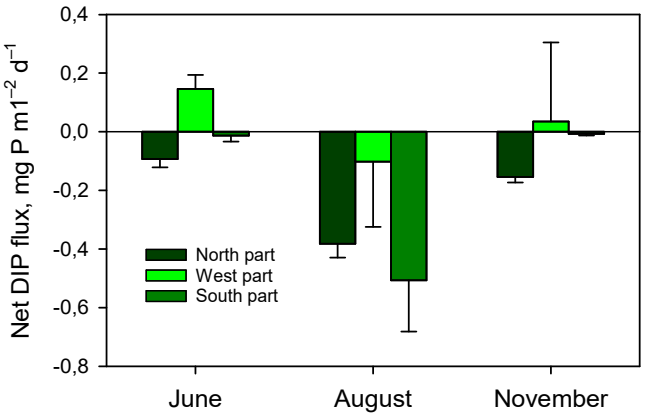


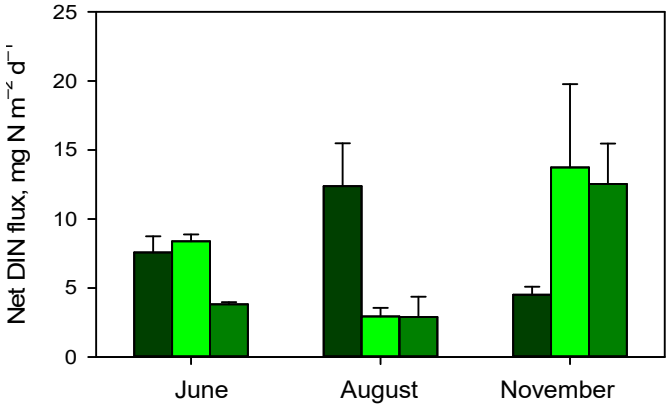
Can lake sediment act as a source of nutrients?

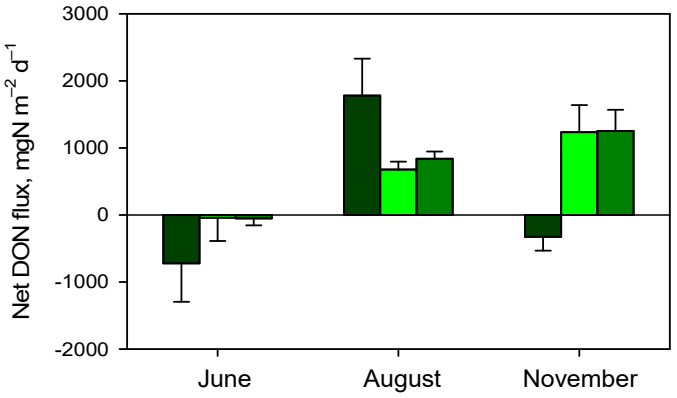
- Sediment cores were done 3 times per year: June, August and November;
- At 3 study sites: northern, western and southern parts;
- Intact cores were collected by scuba divers;
- 5 large (i.d. 8 cm, 30 cm length) intact sediment cores were collected for nutrient fluxes across water-sediment interface measurement;



Nutrients exchange across sediment-water interface

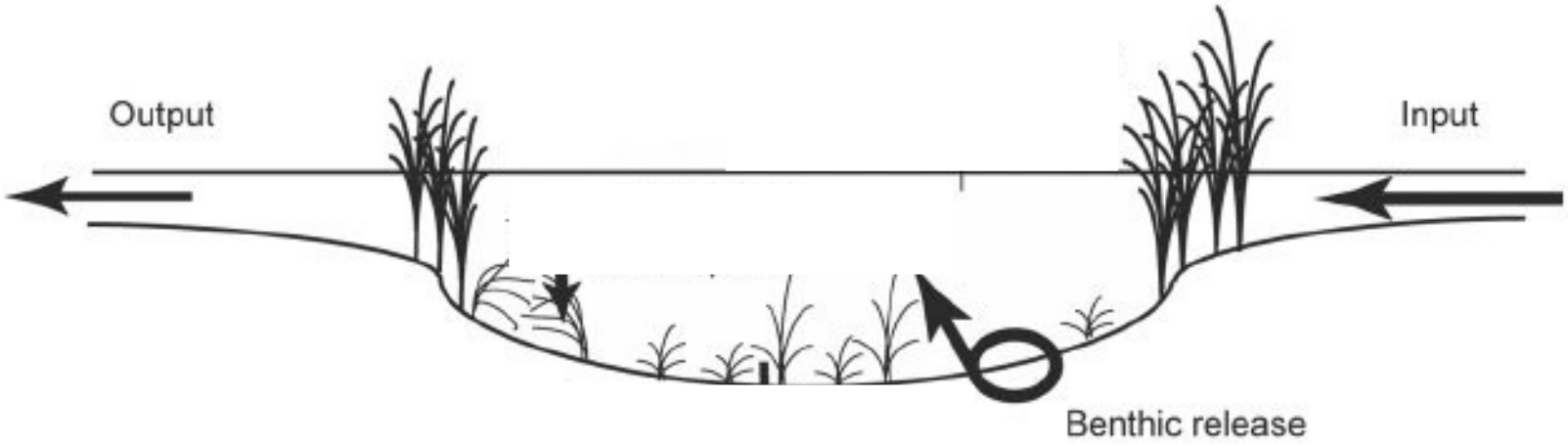






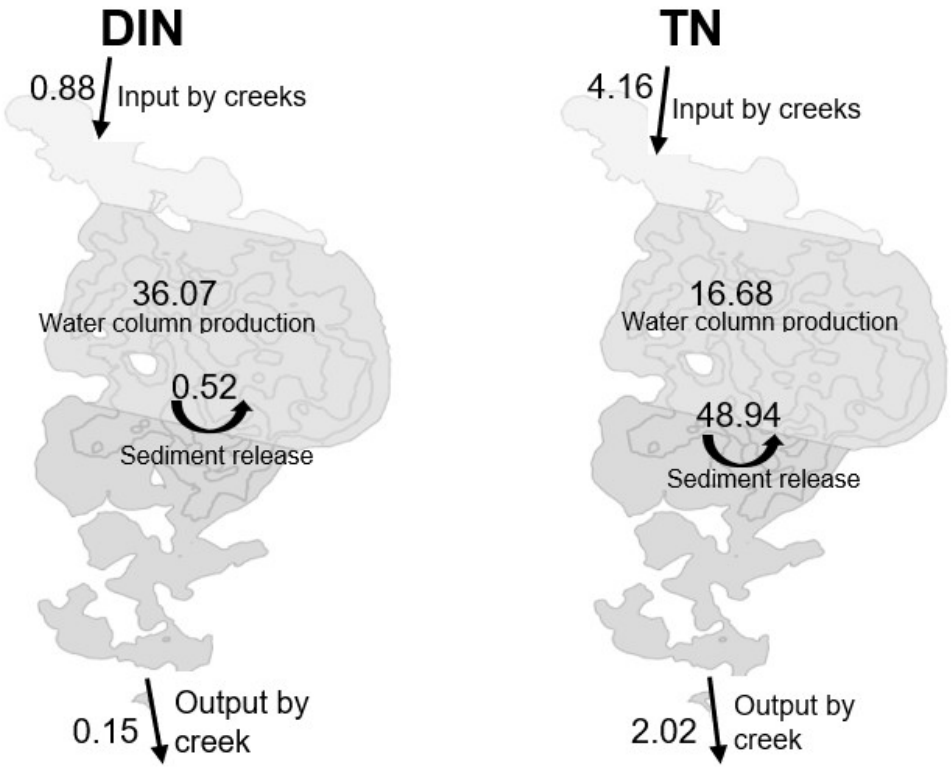
- Lake sediments were a sink for phosphorus most of the time.
- Sediments all time released DIN water column.
- Sediments also released DON, which flux was by two orders of magnitude higher than DIN.

Does nutrient are delivered by creeks or recycled within the lake ecosystem?



- Balance calculated according “black box” principle;
- All inputs of nutrients by creeks were summed;
- Nutrient concentrations of water column at different lake zones were averaged by area proportion and time;
- Loads divided by corresponding lake area.

Annual DIN and TN balance in the Plateliai lake



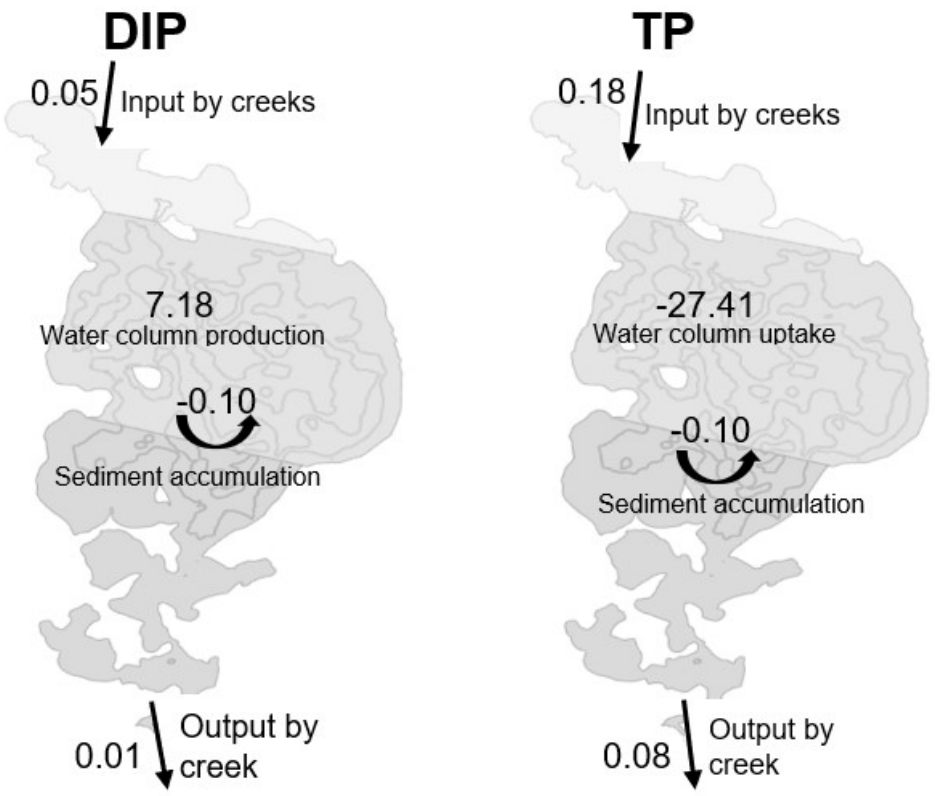
Input of DIN and TN by creeks is important but water column may produce significant amount of N via recycling;

DON and PN forms are delivered by creeks while in water column DIN;

DON release from sediments is largest and significant in the ecosystem N support.

Units: mg m^{-2} day^{-1}

Annual DIP and TP balance in the Plateliai lake



Input of DIP by creeks is important but water column may produce significant amount of DIP via recycling;

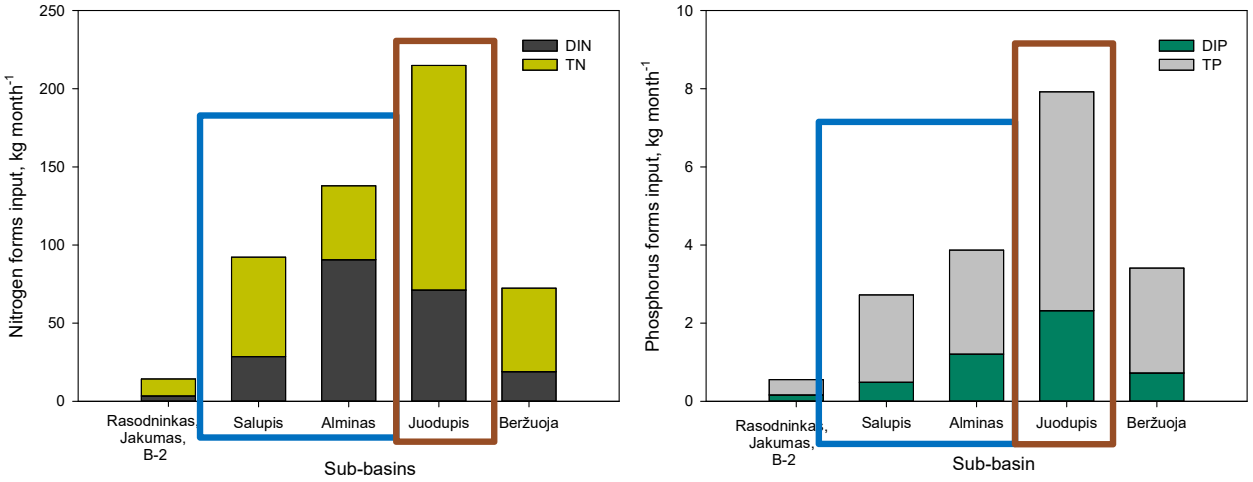
Meanwhile TP has significant input by creeks and high uptake in water column;

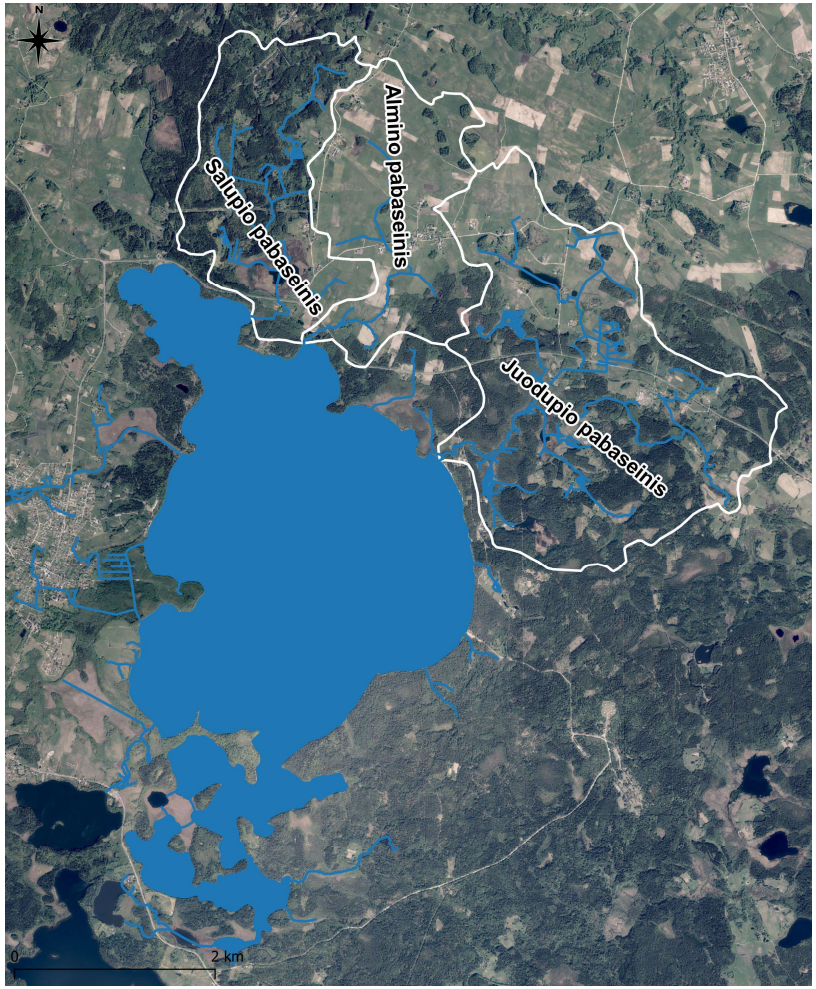
In the sediment DIP is accumulated.

Units: mg m^{-2} day^{-1}

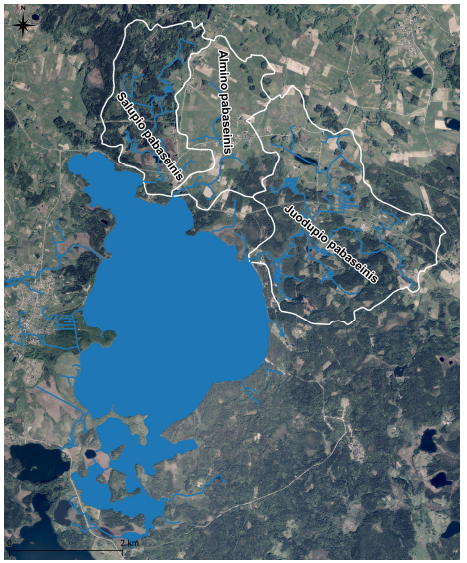
III task. PRELIMINARY MEASURES FOR WATER QUALITY IMPROVEMENT

Summarizing I and II tasks:



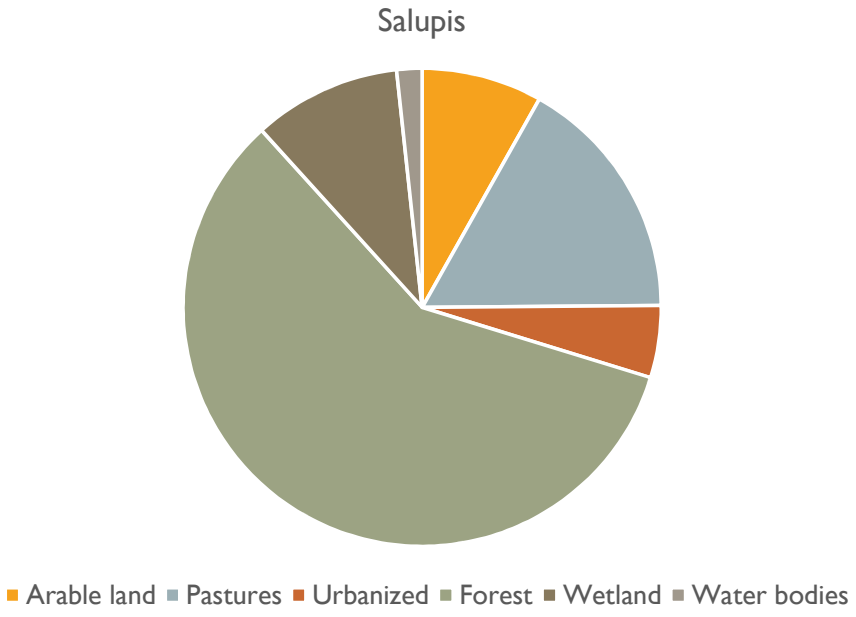


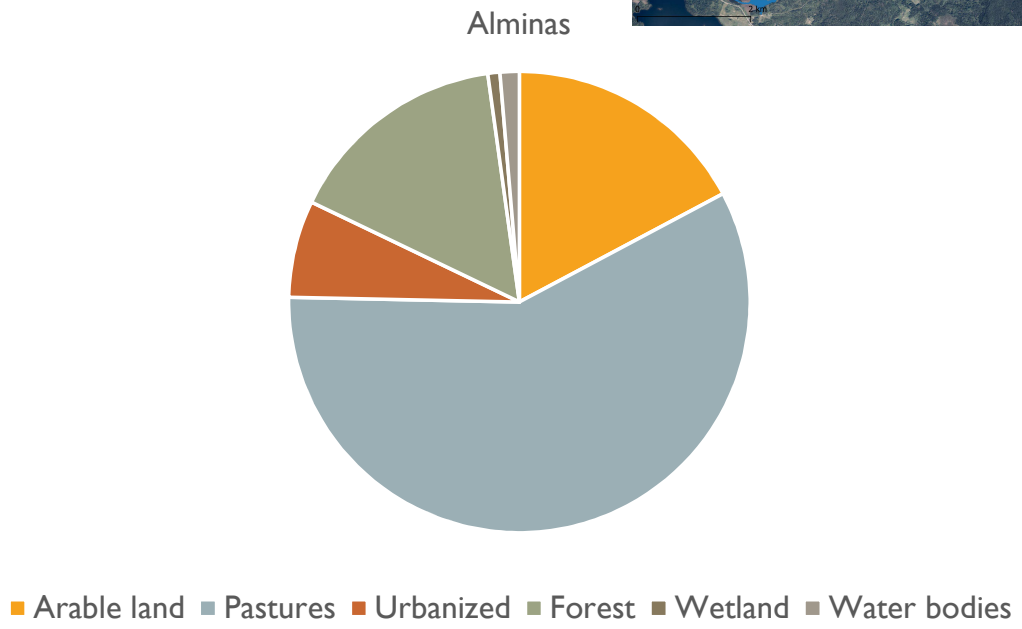
Actions related to pollution at Salupis and Alminas sub-basins



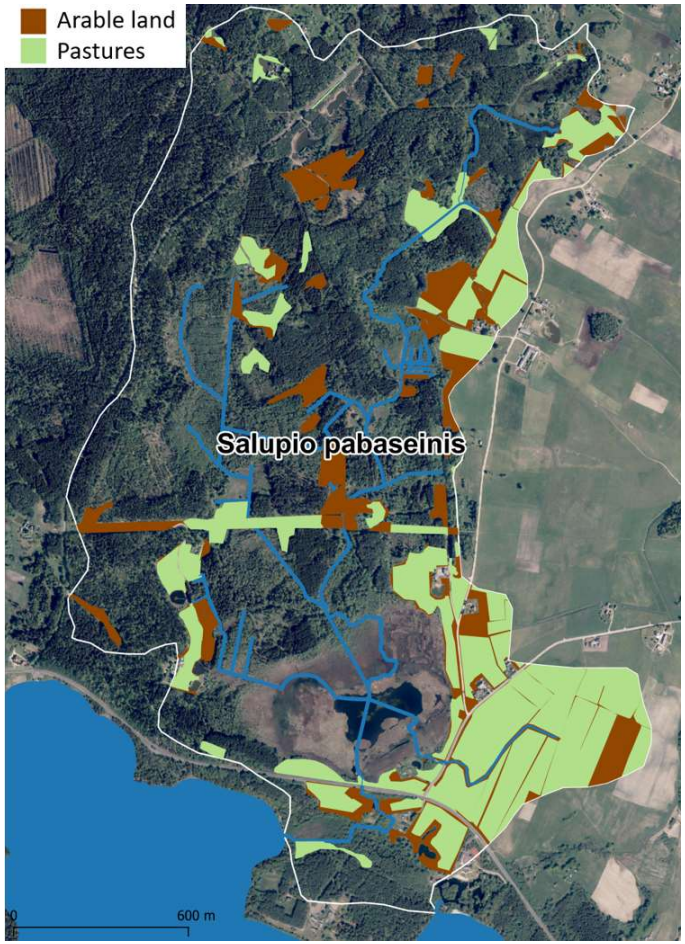
Salupis sub-basin: the dominating land use – forest;

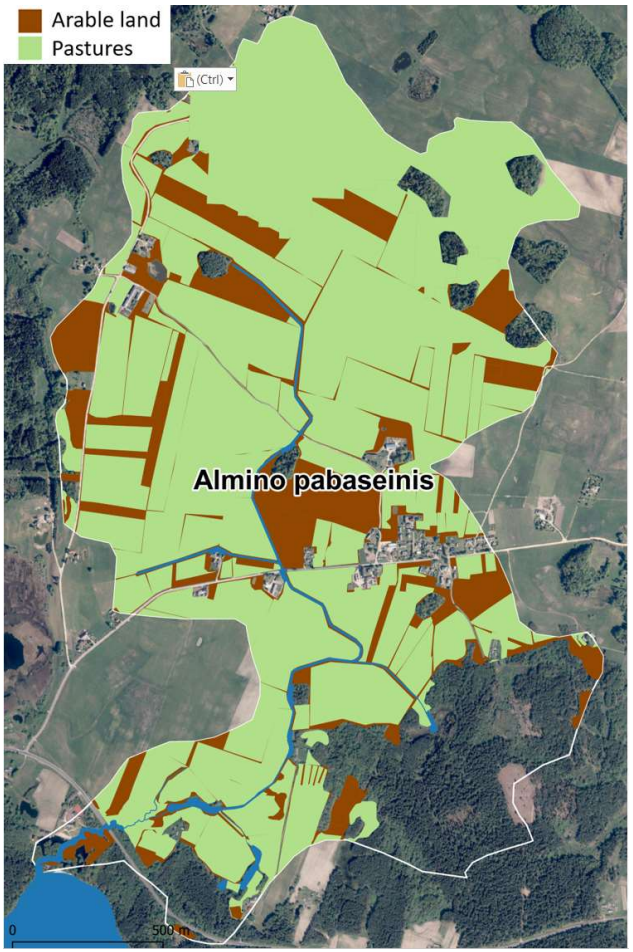
Alminas sub-basin: the dominating land use – pasture and arable land



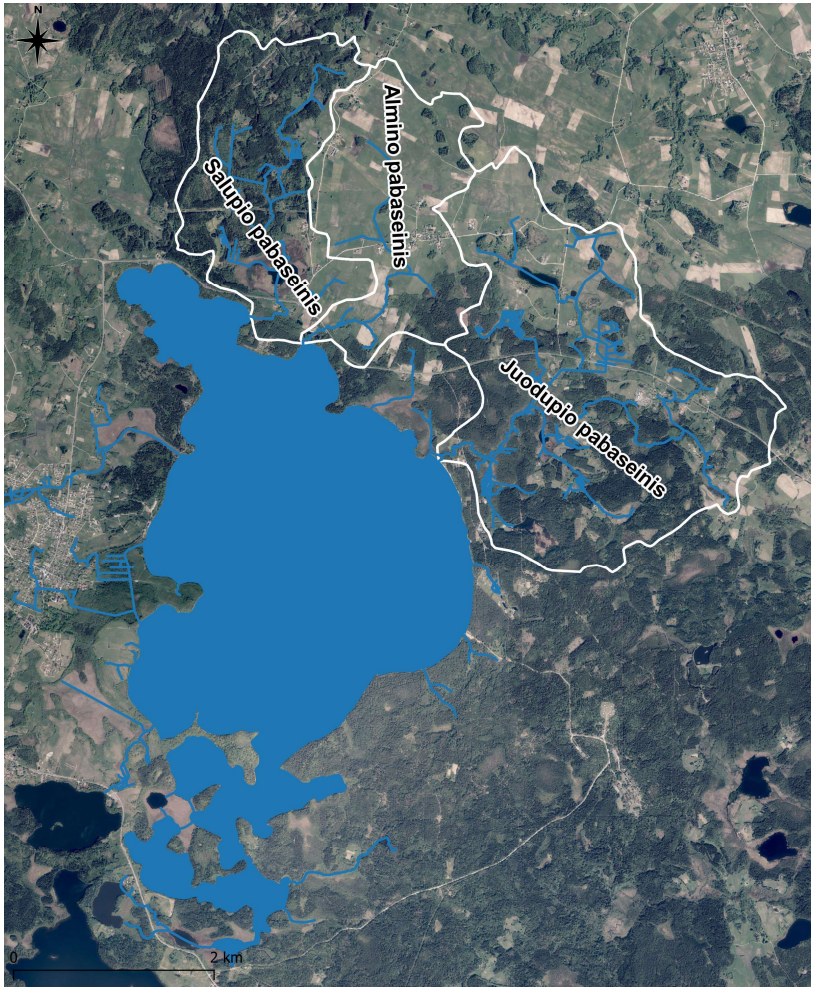


Actions related to pollution at Salupis and Alminas sub-basins



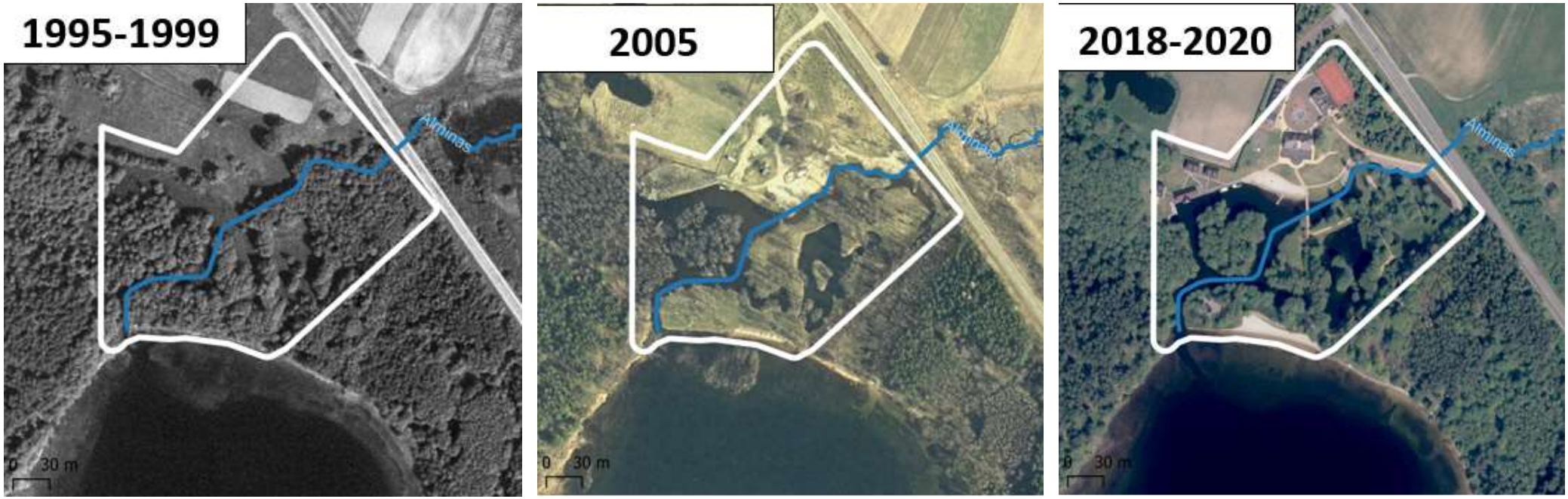


Alminas sub-basin

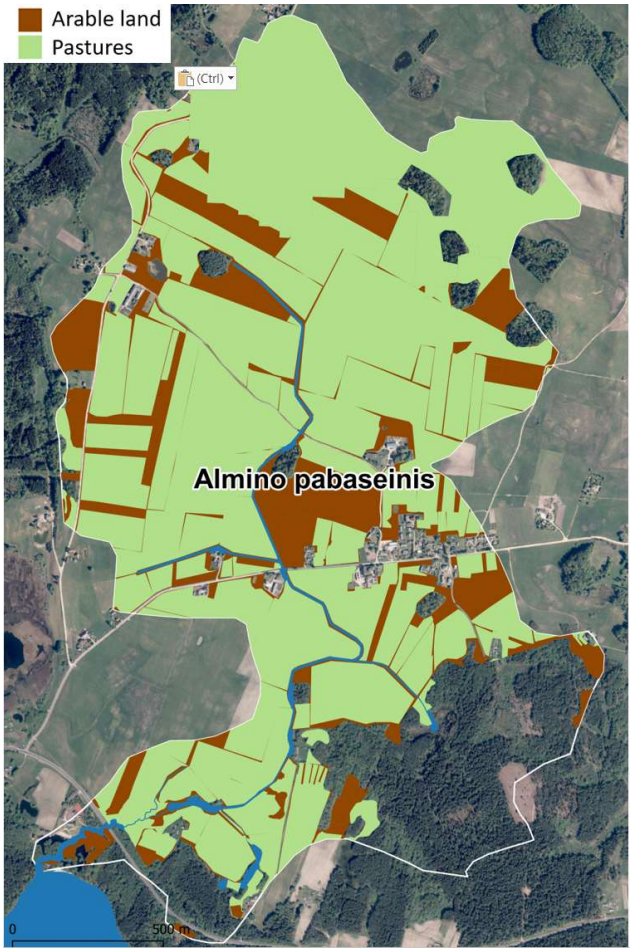


Sampling sites	DIN	TN	DIP	TP
	kg month^{-1}			
ST-6	50.03	100.90	1.15	3.50
ST-7	127.91	171.85	1.26	4.21

Actions related to pollution at Salupis and Alminas sub-basins



Actions related to pollution at Salupis and Alminas sub-basins



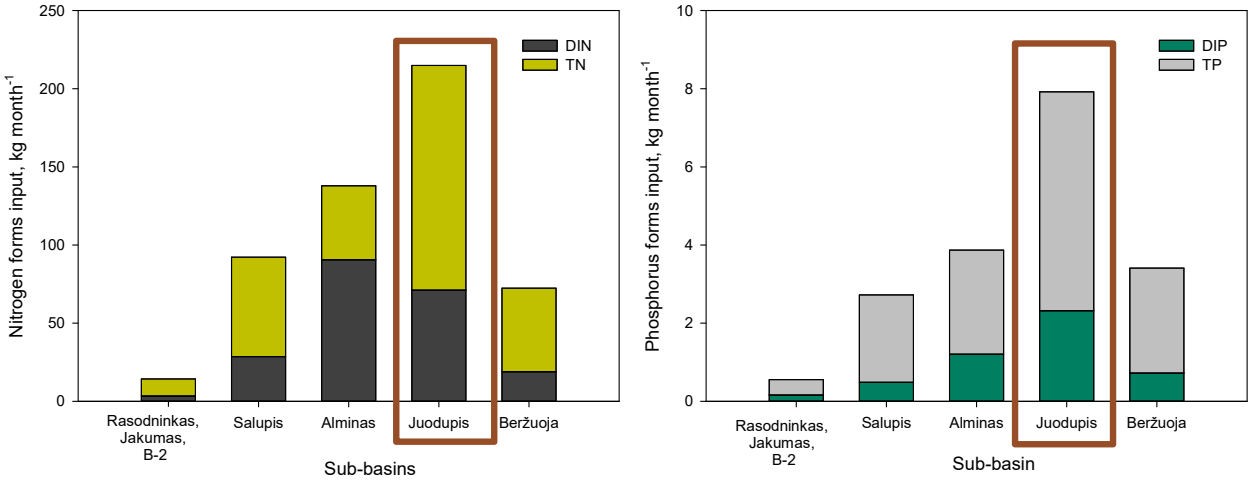
The potential measures:

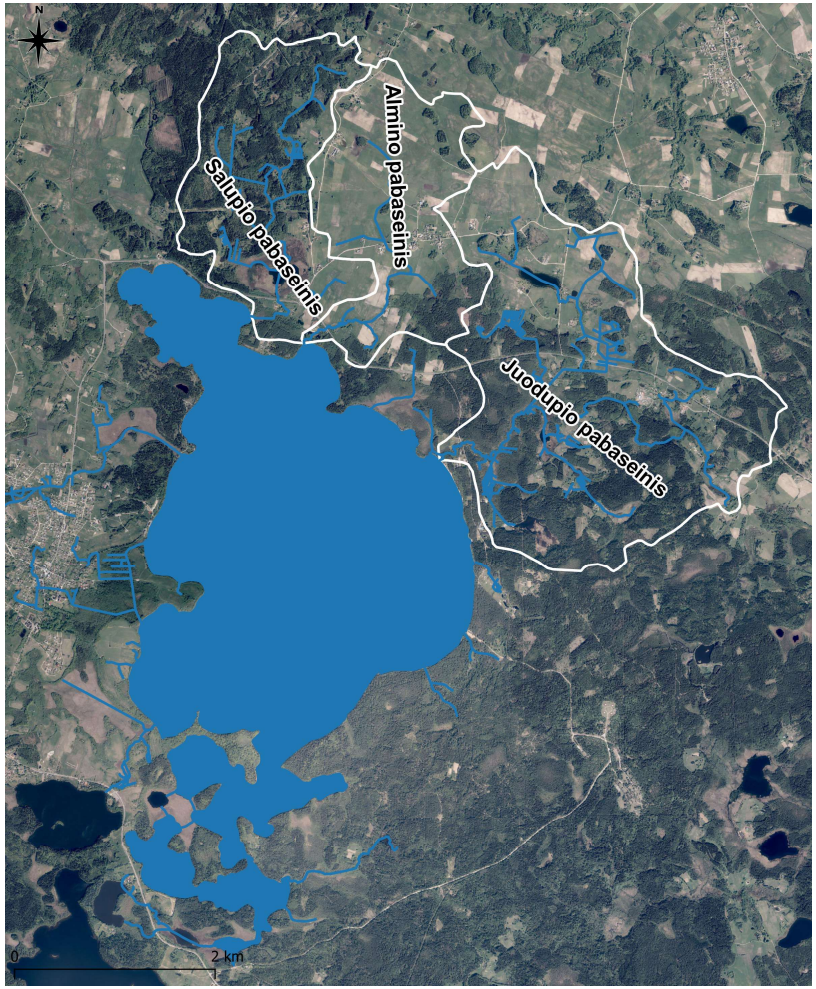
I. In order to prevent the over-fertilization of soils and leaching of nutrients **to strengthen the control of the use of fertilizing products** in the basin of this stream

II. **Promote the change of land use** from arable to grassland *(modelled that input of N may decrease ~49 %)*

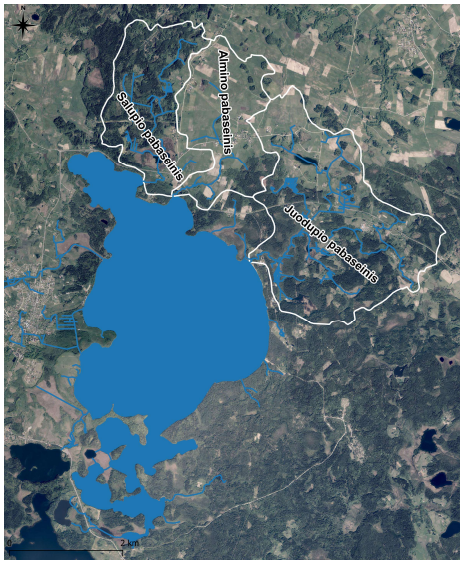
III. Restoration of damaged wetland habitats or creation of new wetland/barrier *(modelled that 6 % of N and 29 % of P may be assimilated by wetlands)*

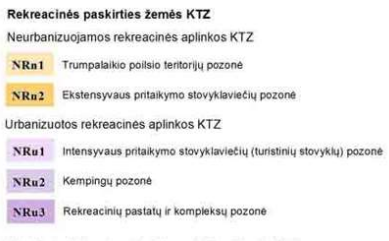
Summarizing I and II tasks:



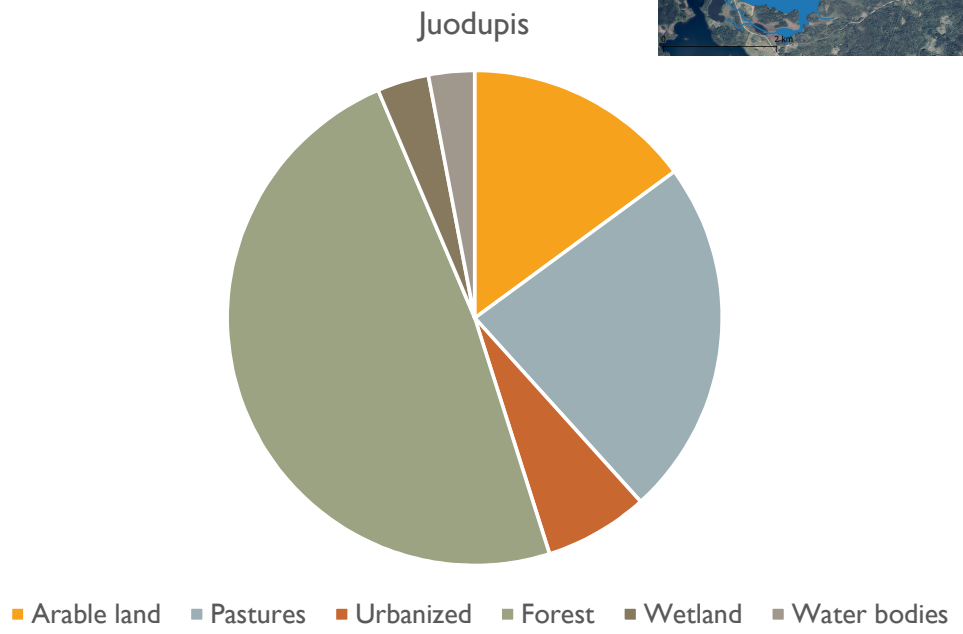


Actions related to pollution at Juodupis sub-basins





The area according Žemaitija National Park management plan



Actions related to pollution at Juodupis sub-basins

Actual sampling sites (yellow) and the potential input places (blue)

Sampling sites	DIN	TN	DIP	TP
	kg month^{-1}			
ST-8	72.27	223.91	2.81	8.78
ST-9	70.13	206.63	1.87	7.13

Actions related to pollution at Juodupis sub-basins

The potential measures:

1. Inventory of the sewage outlets
2. Monitoring in different places of the stream to assess the exact sources of pollution
3. Maximize the treatment of sewage discharge or move the discharges further away from the stream

Other measures at lake scale

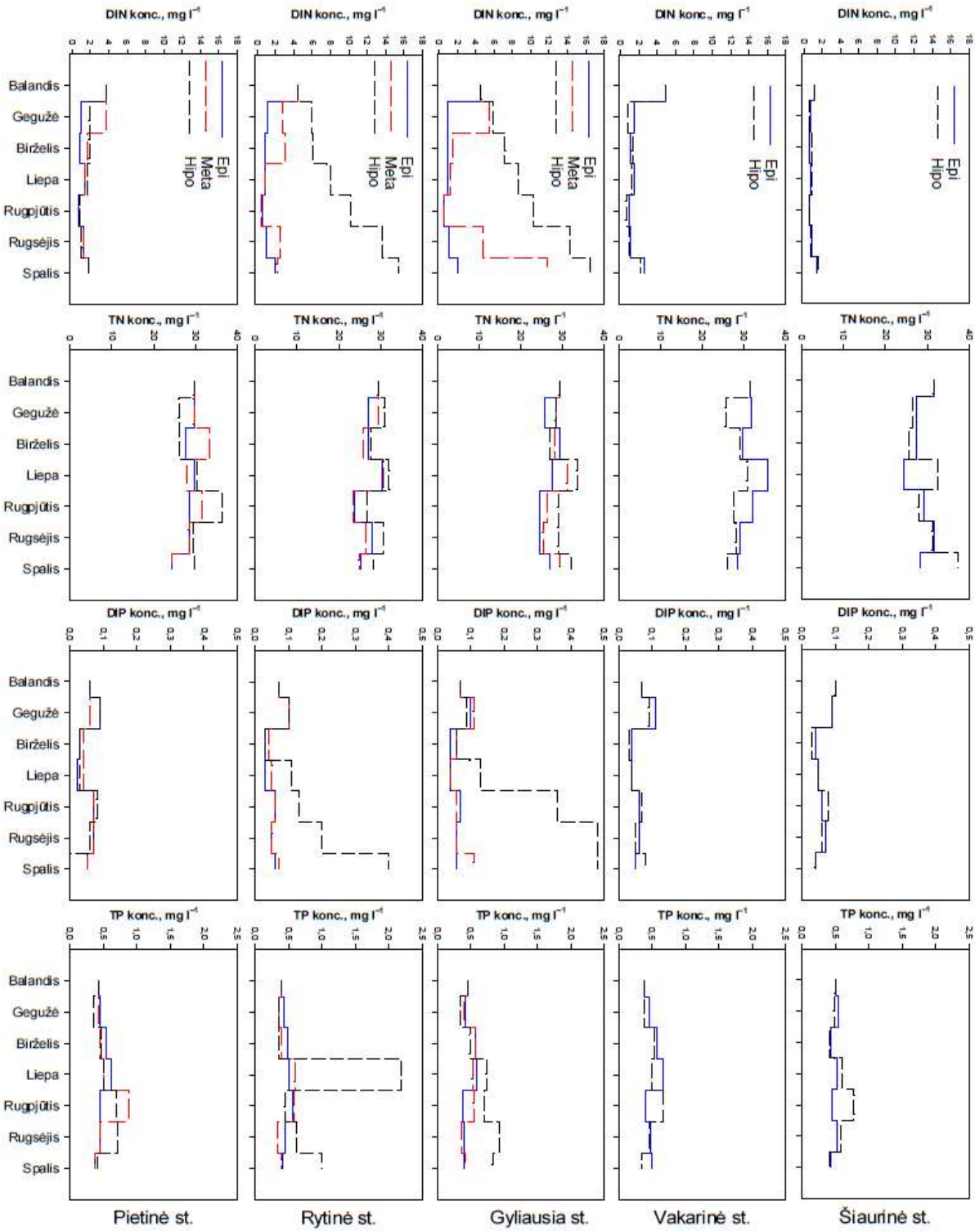
- Analysis of other lake components as Dreissena polymoprha, fish trophic state, to assess the impact on nutrient recycling and availability;
- Recreation affect to littoral lake zone as shoreline erosion;
- Study on diffusive pollution effect on littoral zone of lake;
- Thermocline observation in lake.

Other measures

1. The optimise already used measure (biogen removal by mowing macrophytes) by changing the places;

2. Carry out active dissemination about the concentrated and diffuse pollution that determines the state of the Plateliai lake, its causes, the possibilities of reducing pollution from households and sustainable agriculture, and the mutual economic and environmental benefits that this brings, as well as the possibility of receiving EU support for this.

THANK YOU FOR YOU ATTENTION!


DIN konc., mg l⁻¹
TN konc., mg l⁻¹
DIP konc., mg l⁻¹
TP konc., mg l⁻¹
Epi
Meta
Hipo
Balandis
Gegužė
Birželis
Liepa
Rugpjūtis
Rugsėjis
Spalis
Pietinė st.
Rytinė st.
Gyliausia st.
Vakarinė st.
Šiaurinė st.