The Krycklan Catchment Study

A unique infrastructure for field based research on hydrology, ecology and biogeochemistry

A Hitcher's Guide 3.1

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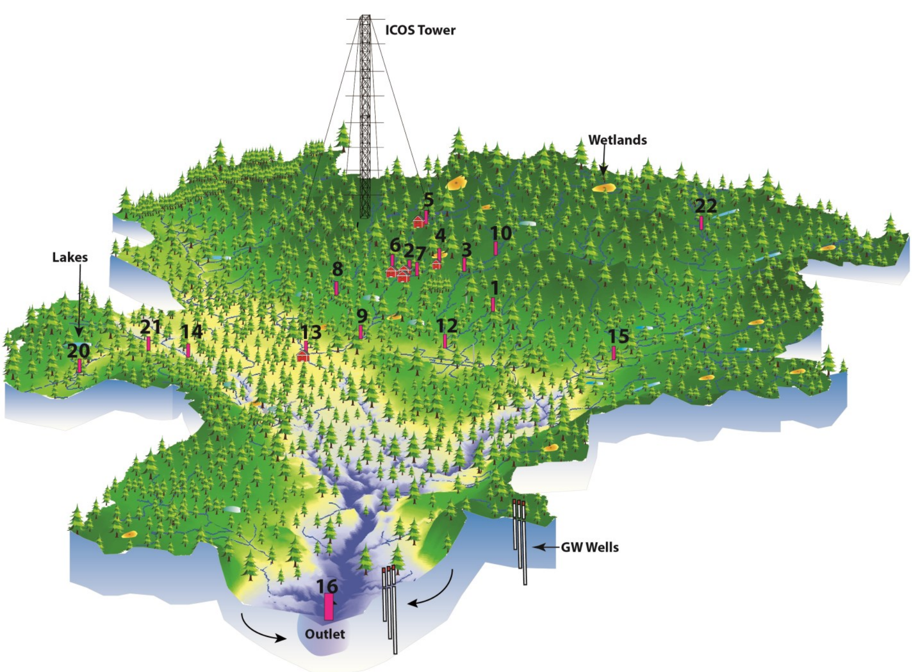
Krycklan in a nutshell...

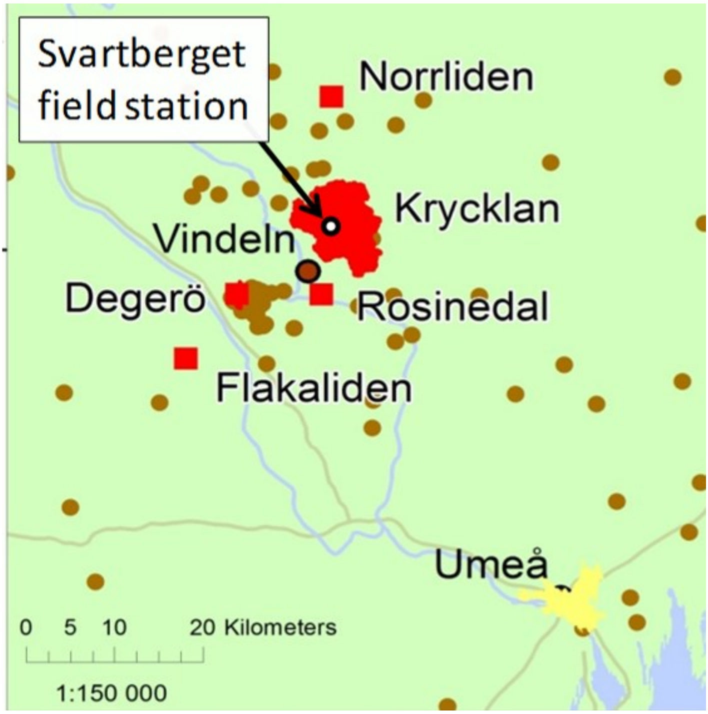
The 68 km^2 Krycklan catchment encompasses the natural mosaic of boreal landscapes consisting of forests, mires, streams and lakes that make up 70% of the area in Sweden, and which is representative of 30% of the world's forest cover.

Krycklan is an integral part of the Svartberget field research infrastructure, which belongs to the Swedish University of Agricultural Sciences (SLU). The Svartberget field station is also responsible for Degerö stormyr, Rosinedal, Flakaliden and Norrliden.

The ongoing field activities include over 50 research projects, involving several hundred scientists from all major universities in Sweden and 30 countries. In total ~ 50 PhD students conduct research at the site. Over 1000 scientific publication are based on results from Svartberget since the beginning in 1910. There is also 110 PhD-thesis (the first published in 1923) where approximately half are based directly on the Krycklan catchment.

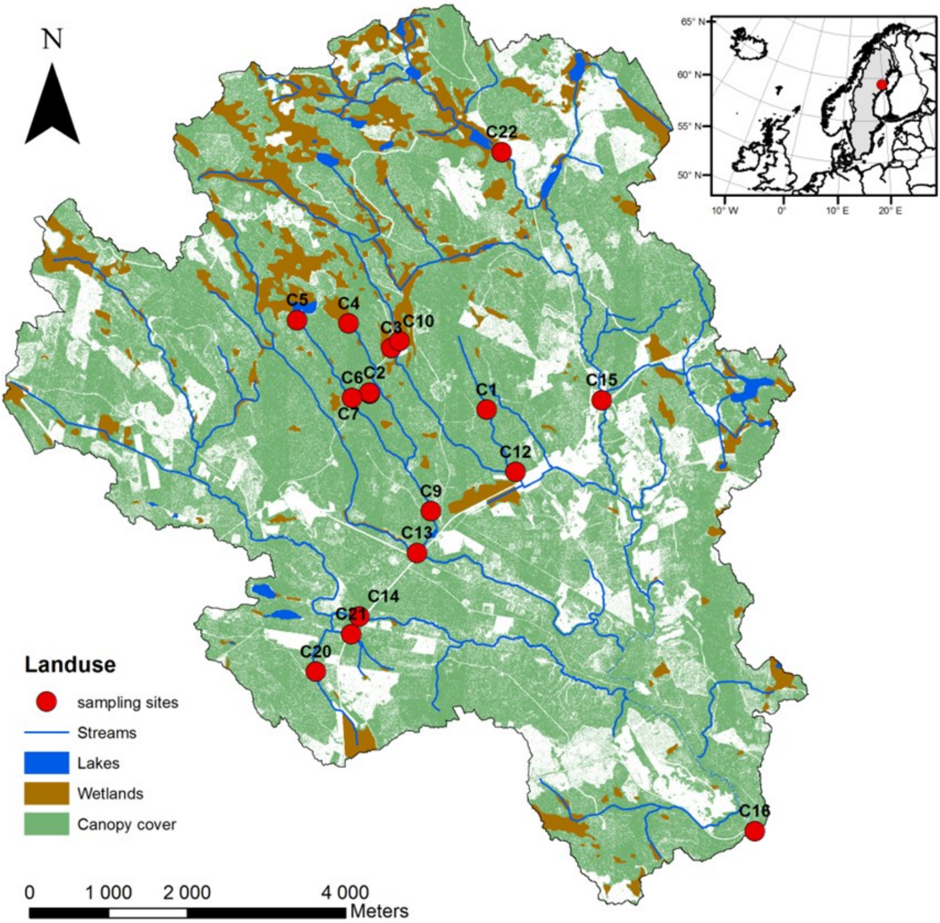


Above: An overview of the Krycklan catchment and basic monitoring stations.



Left: Location of the Krycklan catchment and other related study areas. The smaller dots are part of the national forest production research network consisting of 1400 sites across Sweden.

SiteNo	FullName	Area (km^2)	Wetland (%)	Forest (%)	Lake (%)
3	Lillmyrbäcken	0.04	53	47	0
2	Västrabäcken	0.12	0	100	0
4	Kallkällsmyren	0.18	51	49	0
21	Lillsed	0.26	0	100	0
7	Kallkällsbäcken	0.47	19	81	0
1	Risbäcken	0.48	0	100	0
5	Stortjärnen Outlet	0.65	48	46	6
6	Stortjärnbäcken	1.10	29	65	4
20	Mulltjärnsbäcken	1.45	12	87	0
8	Fulbäcken	2.30	17	81	0
9	Nyängesbäcken	2.88	15	80	1
10	Stormyrbäcken	3.36	29	71	0
22	Bergmyrbäcken	4.91	29	68	3
12	Nymyrbäcken	5.44	19	81	0
13	Långbäcken	7.00	12	86	1
14	Åhedbäcken	14.10	7	91	1
15	Övre Krycklan	20.13	15	82	2
16	Krycklan	68.91	9	88	1



Key references

Laudon, H and Sponseller, RA (2017). How landscape organization and scale shape catchment hydrology and biogeochemistry: Insights from a long-term catch ment study, WIRE Water (In press).

Laudon, H., et al. (2013), The Krycklan Catchment Study—A flagship infrastructure for hydrology, biogeochemistry, and climate research in the boreal landscape, *Water Resour. Res.*, 49, doi:10.1002/wrcr.20520.

Laudon, H. and Taberman, I. (2016). Data rules: from personal belonging to community goods. Hydrol. Process. doi: 10.1002/hyp.10811

Swedish Infrastructure for Ecosystem Science

SITES is a national coordinated infrastructure for terrestrial and limnological field research. SITES consists of nine research stations, including Svartberget/Krycklan. The stations are distributed all over Sweden covering the different landscapes and climatic regions, including agricultural land, forests, mountains areas, wetlands, several type of inland waters, boreal catchments, tundra ecosystems etc.

SITES is available for all researchers on equal terms, regardless of affiliation. SITES offers facilities, sampling equipment and use of data generated from installations and/or observations in the field.

The SITES initiative is funded by the Swedish Research Council and the five partner organisations, i.e. the University of Gothenburg, the Swedish Polar Research Institute, Stockholm University, Uppsala University and Swedish University of Agricultural Sciences. The latter also hosts and coordinator SITES.

Much of the structures described in this guide can also be found on other SITES stations as part of the SITES Water programme. Read more at www.fieldsites.se

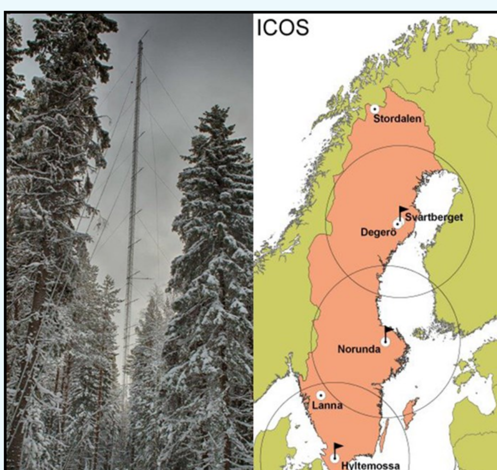
Above: Location of research stations within SITES

ICOS – Integrated Carbon Observatory System

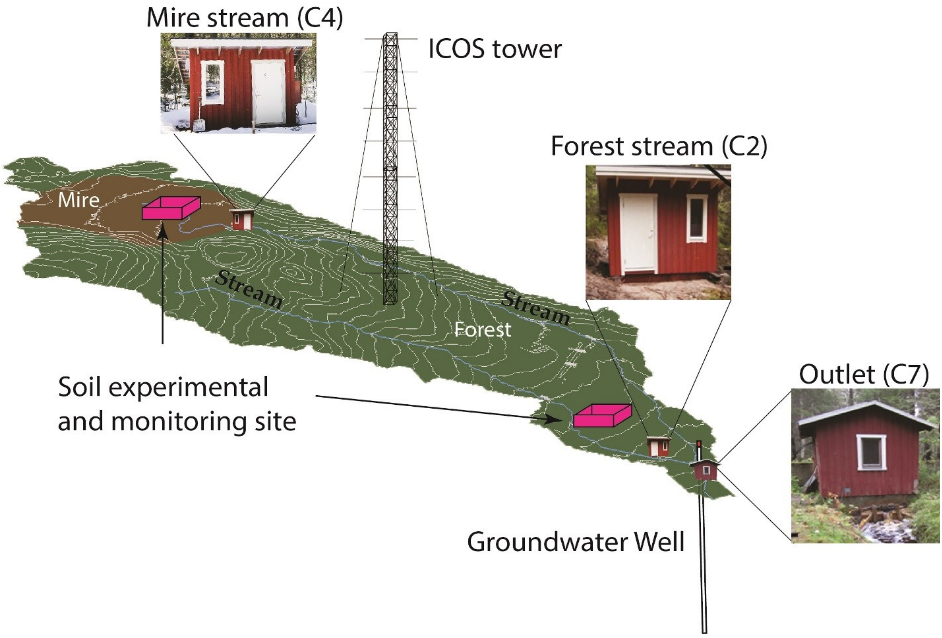
ICOS is a European research infrastructure for quantifying and understanding the greenhouse gas balance of the European continent and of adjacent regions. ICOS collaborates with nationally operated measurement stations in 17 European countries. ICOS Sweden (http://www.icos-sweden.se) consist of three atmospheric, six ecosystems and one ocean station.

ICOS in Vindeln combines atmospheric and forest ecosystem site at Svartberget and one mire ecosystem site at Degerö stormyr.

At Svartberget, the tower is 150m high where CO_2, H_2O, air temperature, incoming and outgoing radiation, soil moisture, soil heat flux, temperature, canopy radiation and tree temperature are measured.www.icos-sweden.se

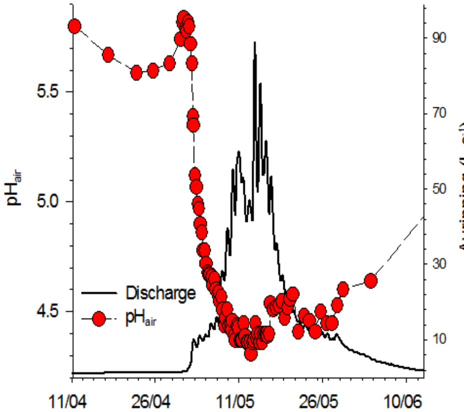


The Svartberget Catchment



Above: The Svartberget catchment (C7) is the centre of Krycklan

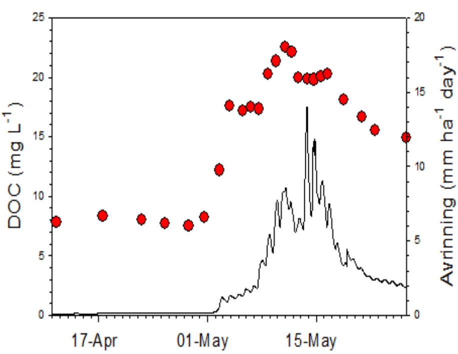
The catchment with many names (Svartberget, Nyänget, SVW, C7) is where it all began in 1979. It is also the heart of much of the current research on the contrasting hydrological and biogeochemical behavior of forested and mire catchments in Krycklan. The Svartberget catchment also hosts the first soil experimental and monitoring sites that begun in 1997, including the S-transect and the “Russian wells”.



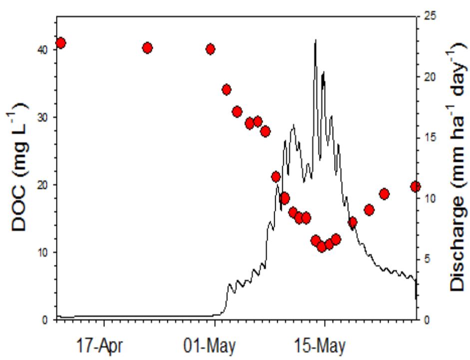
Left: Decline of pH during the spring flood at C7. This decline is mainly driven by natural processes caused by increases in the concentration of DOC (Dissolved Organic Carbon).

Below: The contrasting behavior of DOC between the forested catchments and wetland dominated catchments.

Forest Catchment (C2)



Wetland Catchment (C4)



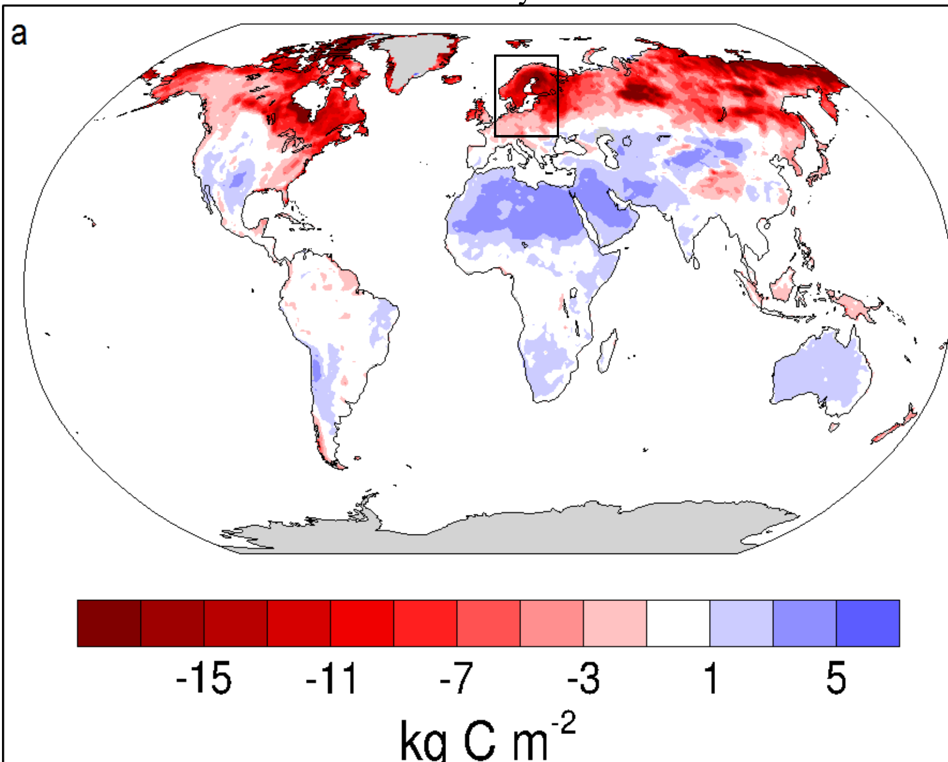
Key references

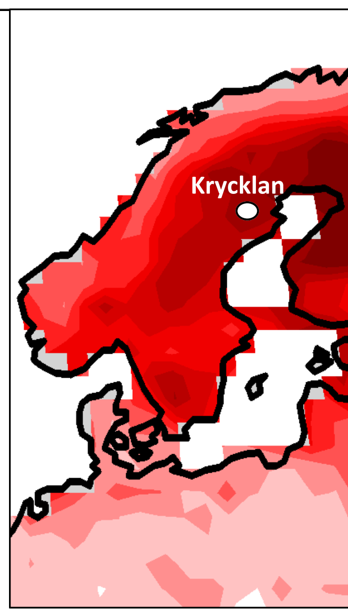
Peralta-Tapia A., et al. (2016). Hydroclimatic influences on non-stationary transit time distributions in a boreal headwater catchment. Journal of Hydrology http://dx.doi.org/10.1016/j.jhydrol.2016.01.079

Öquist, M. G. et al. (2014). The full annual carbon balance of boreal forests is highly sensitive to precipitation. Environ. Sci. Technol. Letters., 2014, 1 (7), 315–319

Sundman, A., et al. (2014). XAS study of iron speciation in waters and soils from a boreal catchment. Chemical Geology, 364, 93-102.

Oni, S. K et al. (2013). Long-term patterns in dissolved organic carbon, major elements and trace metals in boreal headwater catchments: trends, mechanisms and heterogeneity, Biogeosci, 10, 2315-2330.

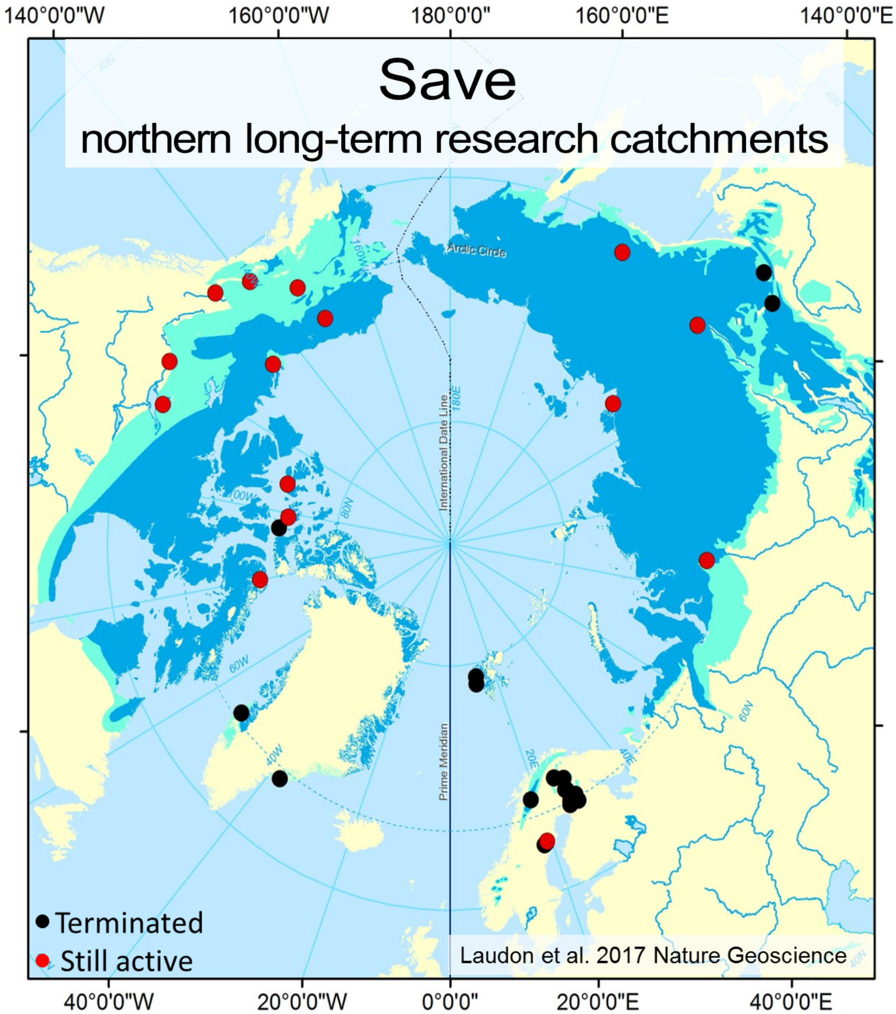




Regions in red indicate the sensitivity of the soil C stocks. In a global perspective northern boreal soils are among the most sensitive in the near future to climate warming because soils with large carbon stocks are not permanently frozen, and rapid increases in temperature are already observed.

Key reference

Crowther TW et al. (2016). Quantifying global soil carbon losses in response to warming; Nature, 540, 104–108. doi:10.1038/nature20150

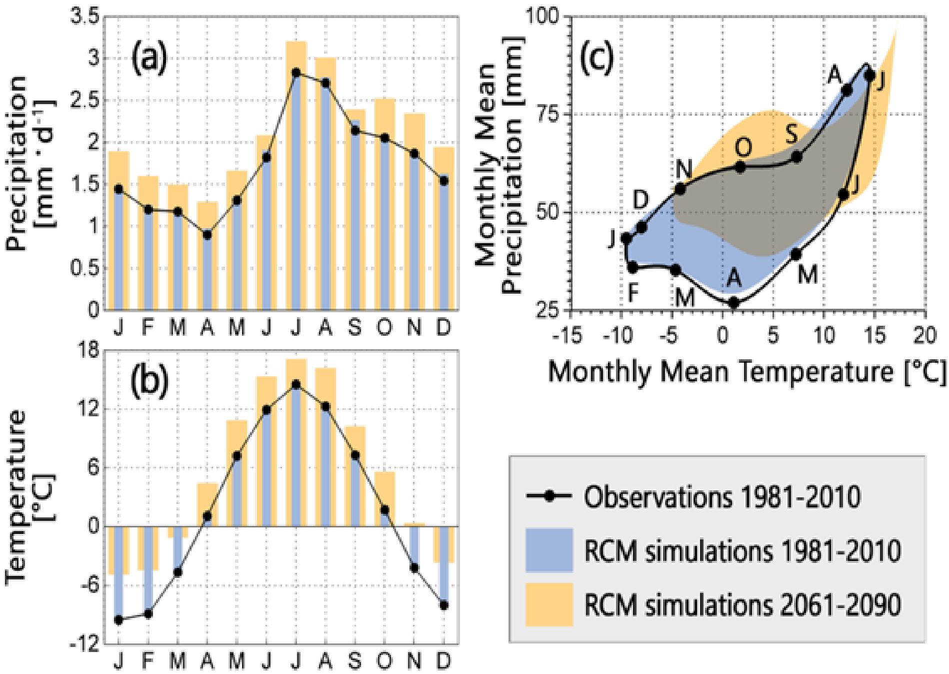


Northern freshwaters are changing rapidly in response to global warming and human perturbation. Despite this there is an ongoing downsizing of small research catchments in the north. This is problematic as such research infrastructures are needed to understand and predict sustainable ecosystem services and social prosperity in this rapidly changing region.

Key reference

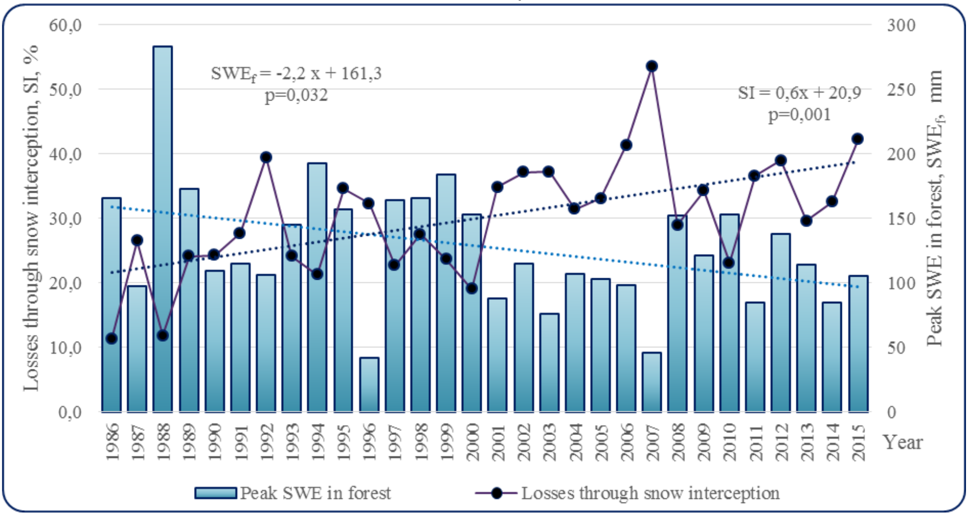
Laudon et al. (2017). Save northern high-latitude catchments, Nature Geoscience, 10, 324–325, doi:10.1038/ngeo2947

Krycklan and Climate



Above: Seasonal Regional Climate Model (RCM) simulations in Krycklan of monthly (a) P and (b) T for reference period (blue) and future climate (orange) as well as (c) monthly P-T for reference (blue) and future (orange). Black dots connected with a continuous line are observations (Teutschbein et al. 2016).

Right: One of 5 climate stations in the catchment, where the longest one has been running since 1981.



Above: Development of snow water equivalents (SWE, bars and right axis) in spruce forest and changes in losses of water through forest canopy interception (connected points, left axis). (From Kozii et al. in prep.).

Key references

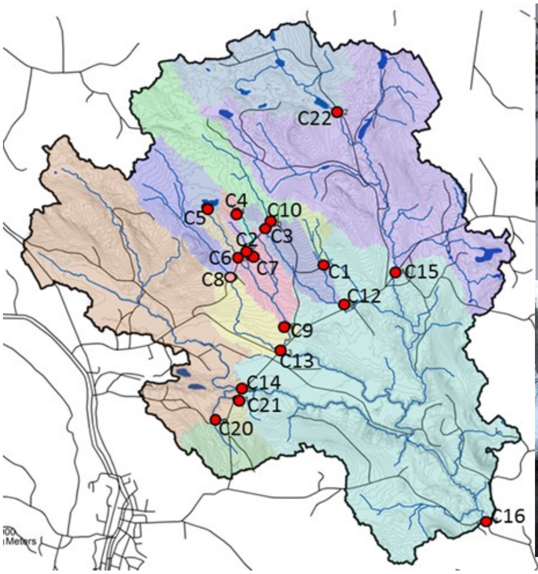
Kozii, N et al. (2017). Increasing water losses from snow captured in the canopy of boreal forests: A case study using a 30 year data set, Hydrological Processes, In press

Laudon, H. and Ottosson Löfvenius, M. (2016). Adding snow to the picture – providing complementary winter precipitation data to the Krycklan catchment study database, DOI: 10.1002/hyp.1075.

Teutschbein, C., Grabs, T., Karlsen, R.H., Laudon, H., Bishop, K., (2016). Hydrological response to changing climate conditions: Spatial streamflow variability in the boreal region. Water Resources Research, 10.1002/2015WR017337.

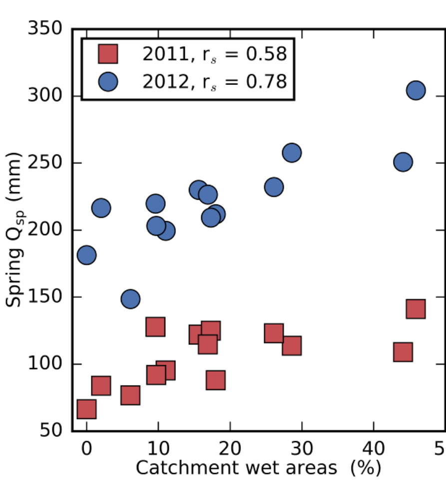
Laudon, H., et al. (2013), The Krycklan Catchment Study—A flagship infrastructure for hydrology, biogeochemistry, and climate research in the boreal landscape, Water Resour. Res., 49, doi:10.1002/wrcr.20520.

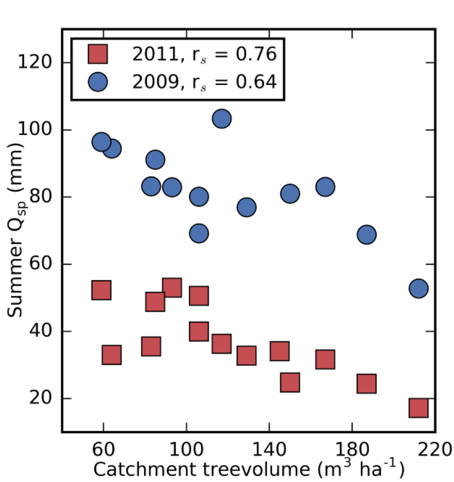
Krycklan and Hydrology

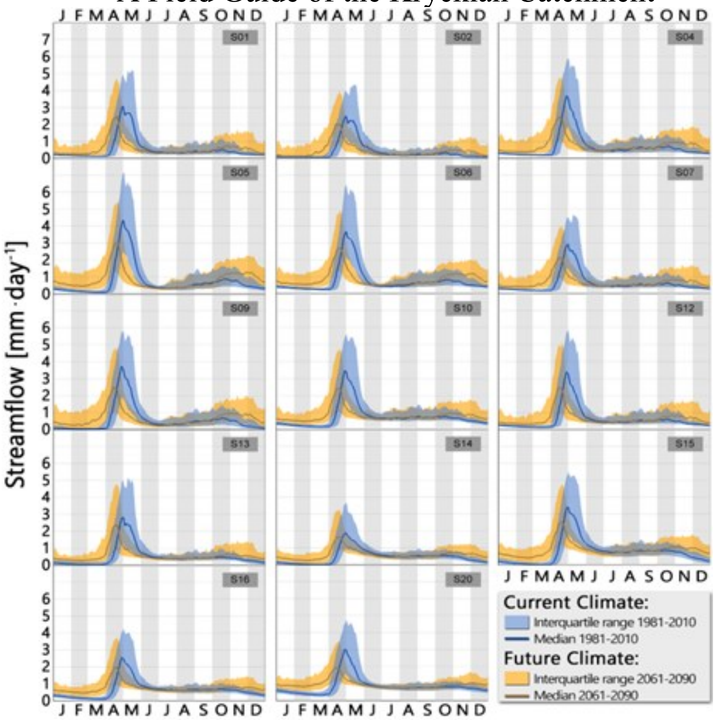


In C7 discharge has been measured since 1980 (above right), C2 and C4 from 1994 and the remaining stations from 2004. The are 18 regularly monitored water quality monitoring *stations* (above left). Six of the stations are in heated houses for year around measurements (left).

Below: Discharge in the different sub-catchments as determined by different catchment characteristics (Karlsen et al. 2016).







Above: Simulated future streamflow in 14 sub-catchments. The reference period (blue) and future (orange) climate conditions are shown. The dark curve presents the median of all simulations (Teutschbein et al. 2016).

Key references

Karlsen, R. H. et al. (2016), Landscape controls on spatiotemporal discharge variability in a boreal catchment, Water Resour. Res., 52, 6541–6556, doi:10.1002/2016WR019186.

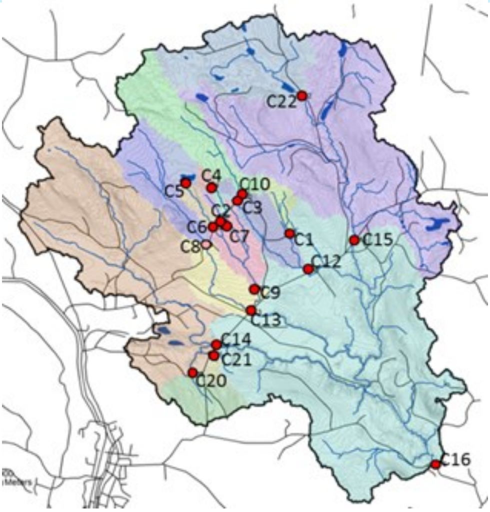
Oni, S., et al. (2016). Using dry and wet year hydroclimatic extremes to guide future hydrologic projections. Hydrology and Earth System Sciences, 20, 2811-2825.

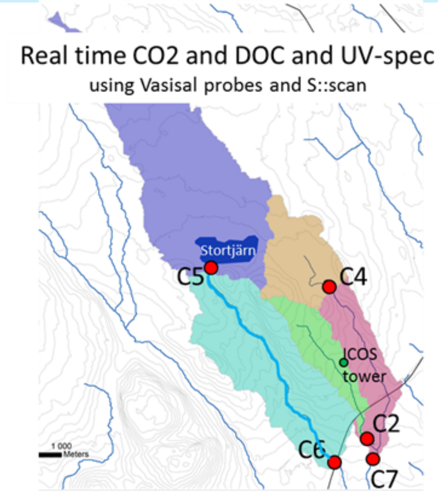
Lidman, F., et al. (2016). 234U/238U in a boreal stream network — Relationship to hydrological events, groundwater and scale. Chemical Geology, 420, 240–250.

Teutschbein, C., et al. (2016). Hydrological response to changing climate conditions:Spatial streamflow variability in the boreal region. Water Resources Research, 10.1002/2015WR017337.

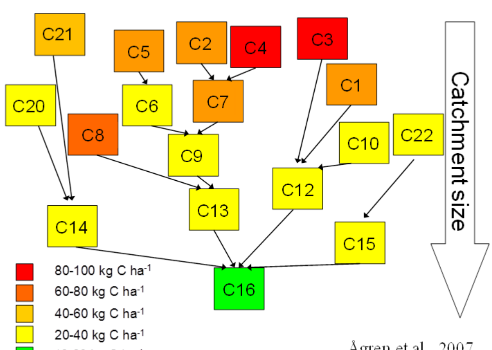
Karlsen, R.H.et al. (2016). The Assumption of Uniform Specific Discharge: Unsafe at Any Time? Hydrological Processes, doi: 10.1002/hyp.10877.

Krycklan and Stream Carbon



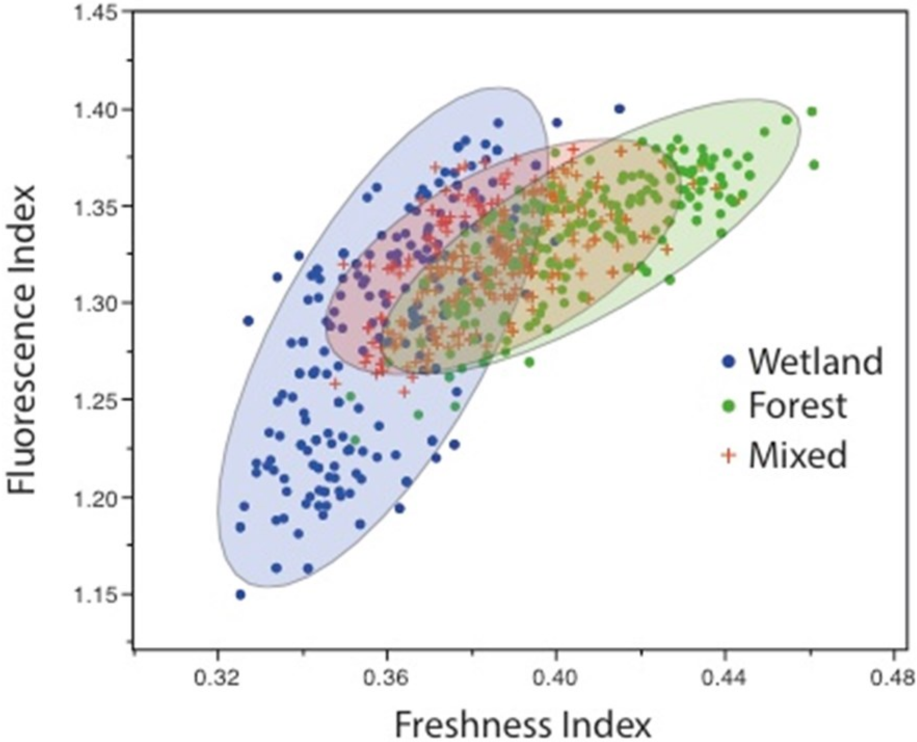


Above: Krycklan and the stream carbon monitoring program. The grab sampling program begun 2002 and includes ~30 samples of DOC, CO_2, CH_4 and UV spec per year. The sensor network is continuously being expanded but focus on the central parts of the catchment.



Left: Annual export of DOC from the different sub-catchments in Krycklan. Note that the export of DIC can be as large, or even larger.

Here you can also see how the streams are connected.



Above: Grouping of common optical DOC indexes by land cover (Kothawala et al. 2015).

Key references

Kasurinen, V., et al. (2016). Modeling nonlinear responses of DOC transport in boreal catchments in Sweden. Water Resources Research. 10.1002/2015WR018343

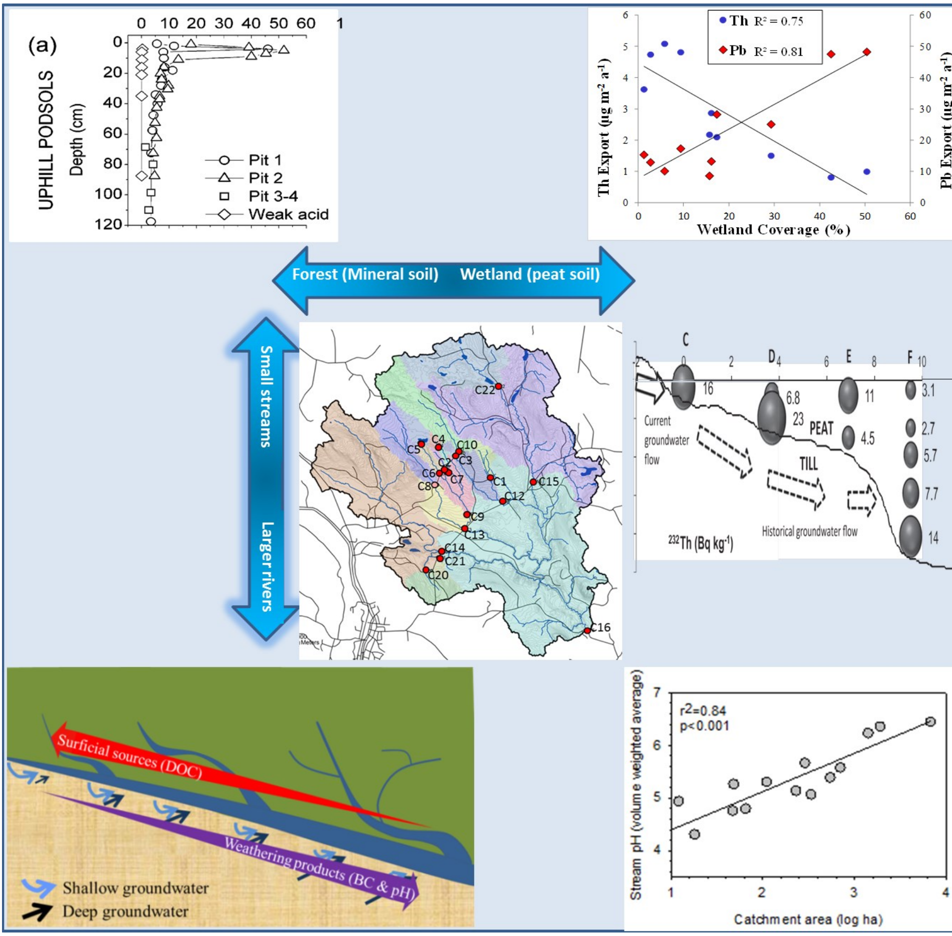
Oni, S. K., et al. (2015), Local- and landscape-scale impacts of clear-cuts and climate change on surface water dissolved organic carbon in boreal forests, J. Geophys. Res. Bio, 120, 2402–2426

Kothawala, D. N., et al. (2015), The relative influence of land cover, hydrology, and in-stream processing on the composition of dissolved organic matter in boreal streams, J. Geophys. Res. Biogeosci., 120.

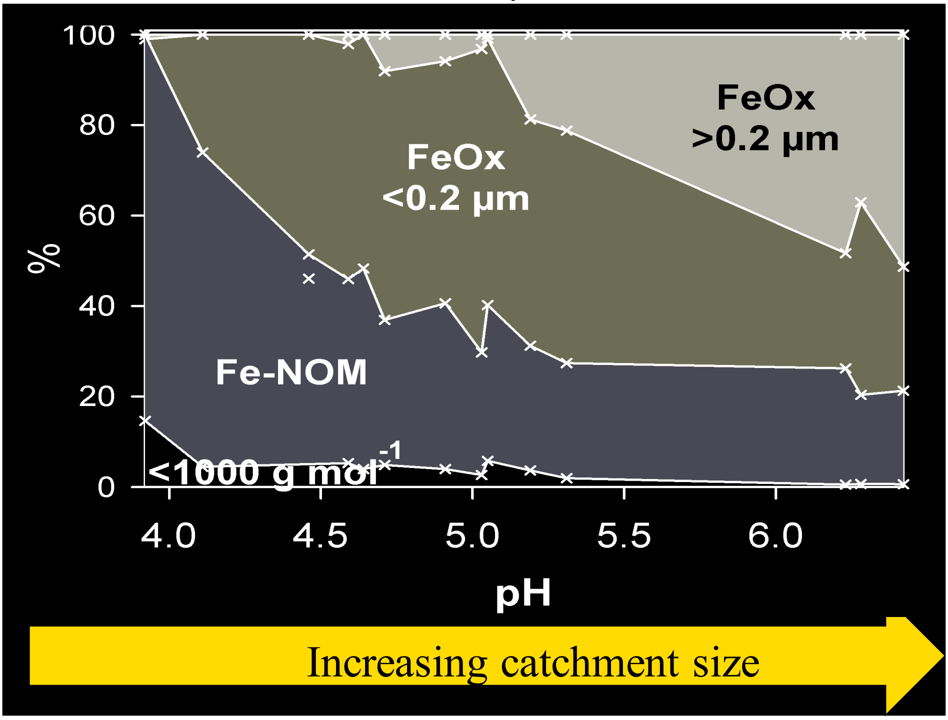
Ågren, A., et al. (2014). Can the heterogeneity in stream dissolved organic carbon be explained by contributing landscape elements? *Biogeosciences*, 11, 1199-1213.

Wallin, et al. (2013). Evasion of CO2 from streams – The dominant component of the carbon export through the aquatic conduit in a boreal landscape. *Global Change Biology*, 785-797.

Krycklan and Biogeochemistry



The contrasting behavior of different elements in the landscape depends on 1) its affinity to organic matter and 2) the primary source of the element. For the examples above, thorium (Th) and lead (Pb) affinity to organic matter are similar but Th is a weathering product while Pb originates mainly from deposition. Similarly, another relationship can be seen with pH which increases as the catchment size increase.



Above: Iron speciation changes from the upstream low pH streams to the downstream increase in pH (Neubauer et al. 2013).

Key references

Tiwari, T.et al. (2017), GISbased prediction of stream chemistry using landscape composition, wet areas, and hydrological flow pathways, J. Geophys. Res. Biogeosci., 122, 65–79, doi:10.1002/2016JG003399.

Josefsson, S. et al. (2016). Persistent Organic Pollutants in Streamwater: Influence of Hydrological Conditions and Landscape Type. Environmental Science & Technology, 50 (14), 7416–7424, DOI: 10.1021/acs.est.6b00475

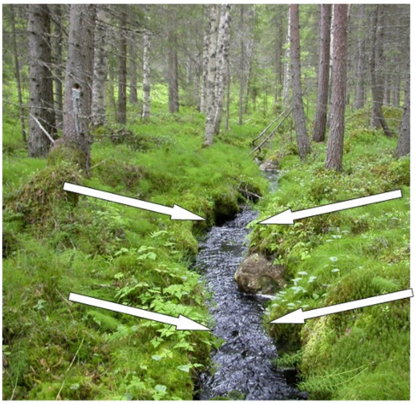
Filipovic, M., et al. (2015). Mass Balance of Perfluorinated Alkyl Acids in a Pristine Boreal Catchment. Environmental Science and Technology, 10.1021/ acs.est.5b03403

Köhler, SJ. et al. (2014). Landscape types and pH control organic matter mediated mobilization of Al, Fe, U and La in boreal catchments. Geochimica et Cosmochimica Acta, 135, 190-202.

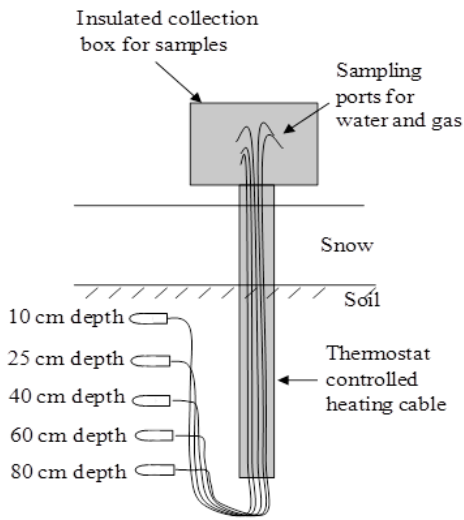
Lidman, F. (2014). Metal transport in the boreal landscape - the role of wetlands and the affinity for organic matter. Environmental Science & Technology. 48, 3783-3790.

The Riparian Zone and the S-transect

The riparian zone has a disproportional large impact on the stream

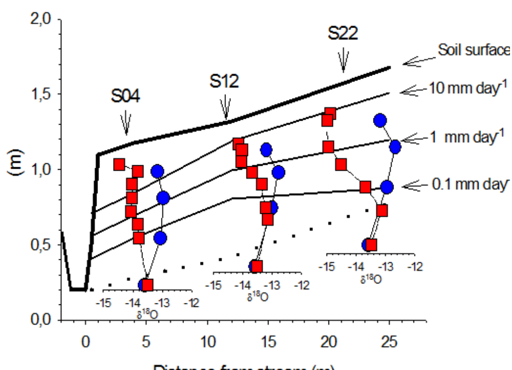


biogeochemistry. Partly this is because it is the large last environment the soil water meets before becoming surface water. But this large influence also has to do with the fact that the riparian soil in the boreal region is highly organic rich, and therefore very different compared to most other soils in the catchment. The S-transect was installed 1997 and has been sampled monthly since.

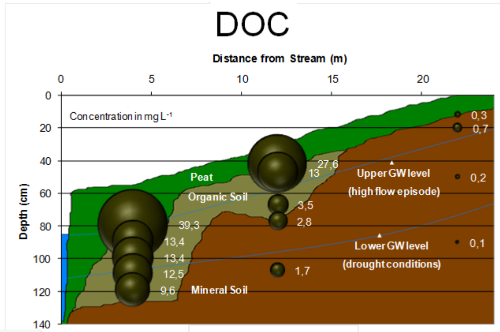


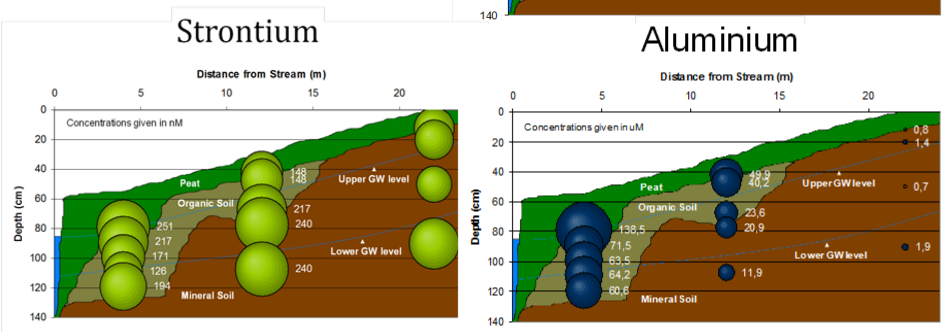
The transect consists of ceramic suction lysimeters at 5-7 depths in three plots (below): in the riparian zone 4 m from the stream (S04), 12 m from the stream (S12) and in the upslope mineral soil 22 m from the stream (S22).

The installations are made so that samples can be collected all year by using a heating cable where the water passes through the frozen soil. The hydrology (above) is focused in the upper horizons due to the hydrological conductivity which increases exponentially towards the soil surface.



Right: Pattern of DOC in the S-transect. Note the very high concentration in the riparian zone and the much lower concentration uphill.





Above: Contrasting patterns of strontium, which has low affinity to DOC and aluminium, which has a very high affinity to DOC. Most other elements in the periodic table behave similarly depending on their DOC affinity.

Key references

Lidman, F (2017). From soil water to surface water – how the riparian zone controls element transport from a boreal forest to a stream, Biogeosciences, 14, 3001- 3014, https://doi.org/10.5194/bg-14-3001-2017

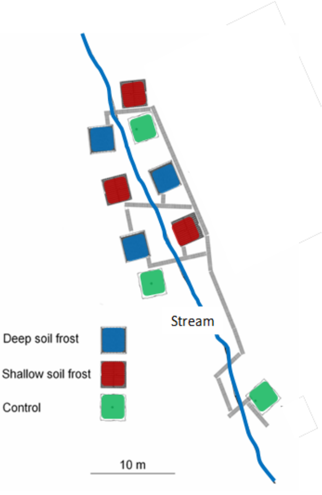
Blackburn, M et al. (2017). Evaluating hillslope and riparian contributions to dissolved nitrogen (N) export from a boreal forest catchment, Journal of Geophy sical Research: Biogeosciences, DOI: 10.1002/2016JG003535

Ledesma, LJ et al. (2017). Towards an Improved Conceptualization of Riparian Zones in Boreal Forest Headwaters, Ecosystems DOI: 10.1007/s10021-017-0149-5

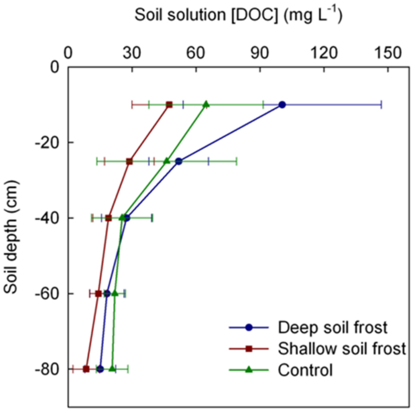
Amelia, A.A. et al. (2016). Hillslope permeability architecture controls on subsurface transit time distribution and flow paths. Journal of Hydrology, Doi.org/10.1016/ j.jhydrol.2016.04.071

Ledesma, L.J.L., et al (2016). Boreal forest riparian zones regulate stream sulfate and dissolved organic carbon, Science of the Total Environment, 561, 110–122.

The Soil Frost Experiment

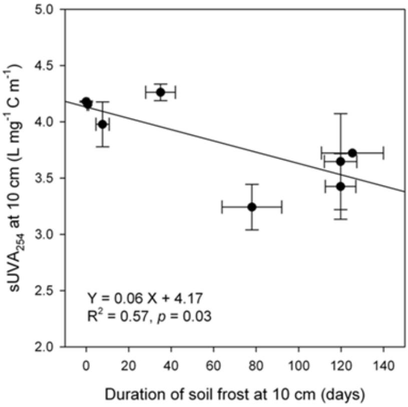


The soil frost experiment begun 2002 which makes it the longest ongoing experiment of its kind in the world. Winter conditions in the soil are strongly dependent on the timing and amount of snow. Little snow gives very cold soils, whereas early and large amounts of snow will result in "warm" soils.



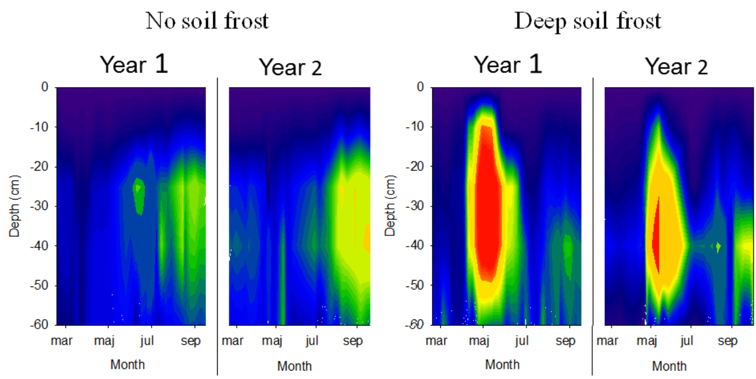
Colder soils and deeper soil frost gives higher DOC concentrations in the upper soil layers

Colder soils also gives rise to higher DOC concentration in the streams during the spring flood. (From Haei et al. 2010).



Left: The DOC quality is affected negatively by the length of winter. Here it is measured as SUVA. (From Haei et al. 2011).

Below: CO_2 concentrations at different depths in the soil over two years without soil frost (left) and with extensive soil frost (right). (From Öquist and Laudon, 2008)



Key references

Blume-Werry, G. et al. (2016). Short-term climate change manipulation effects do not scale up to long-term legacies: Effects of an absent snow cover on boreal forest plants. Journal of Ecology, 104: 1638–1648. doi:10.1111/1365-2745.12636.

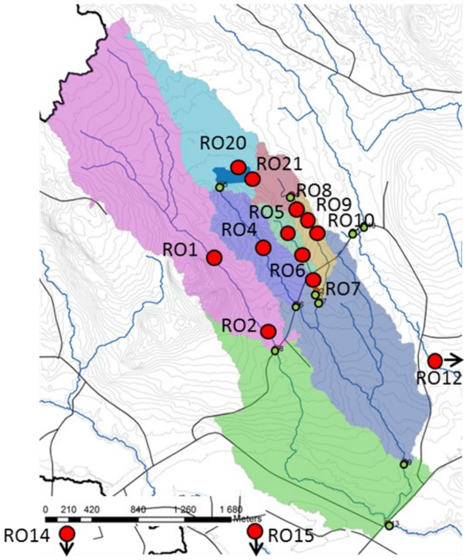
Panneer Selvam, B. (2016), Influence of soil frost on the character and degradability of dissolved organic carbon in boreal forest soils, J. Geophys. Res. Biogeosci., 121, doi:10.1002/2015JG003228.

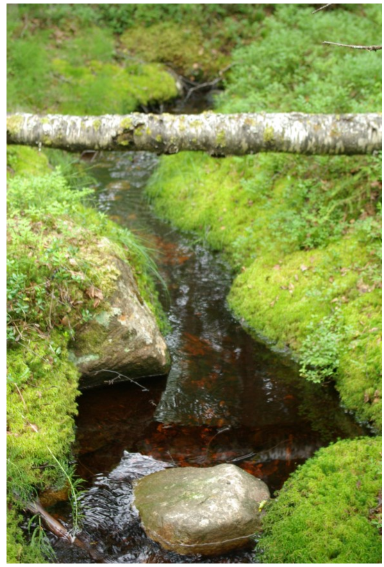
Haei, M. et al. (2013). Winter climate controls soil carbon dynamics during summer in boreal forests. Environmental Research Letters 8, 024017. doi:10.1088/1748-9326/8/2/0240.

Kreyling, J., et al. (2012). Absence of snow-cover reduces understory plant cover and alters plant community composition in boreal forests. Oecologia, 168, 577-587.

Haei, M., et al (2010). Cold winter soils enhance dissolved organic carbon concentrations in soil and stream water. Geophysical Research Letters, 37, L08501, doi: 10.1029/2010GL042821.

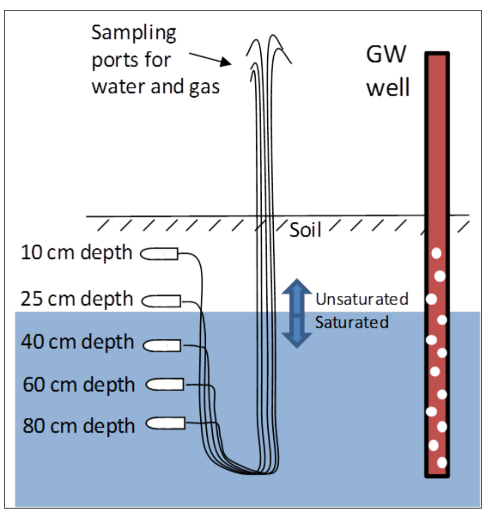
The Riparian Observatory

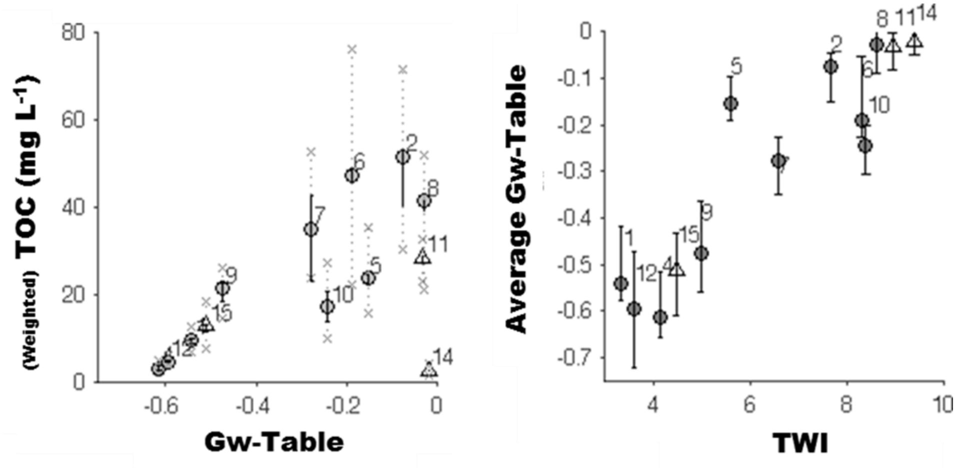




The riparian observatory is distributed at 20 locations in Krycklan and is designed to investigate the soil-surface water interaction in terms of hydrology and biogeochemistry. It is similar to the S-transect in design at 7 locations with transects from uphill to riparian zone.

Each of the RO sites has installations for soil water, soil gas sampling and ground-water (GW) monitoring. Seven of the sites have installations both in the riparian zone and uphill, 20 -30 m away from the RO site to study the chemical evolution of water along the flow pathway.





The TOC concentration (mean weighted) is well correlated with the average groundwater table in each location (left), with the exception of RO14 which is located on sediment soils. The average groundwater table (right) is in turn strongly correlated with the TWI (topographic wetness index). As TWI can be calculated using topographic maps this is a way forward to predict TOC in the riparian soils (From Grabs et al. 2012).

Key references

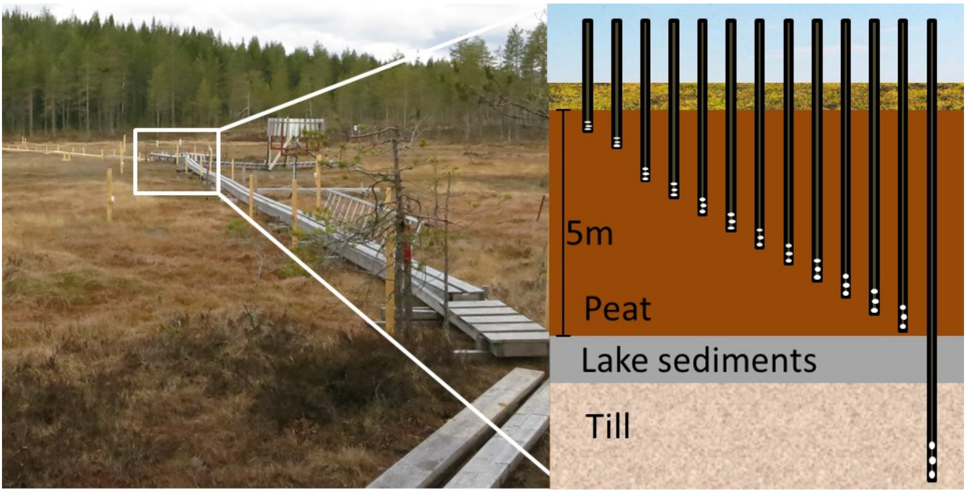
Ledesma, J.L.J et al. (2014). Potential for long-term transfer of dissolved organic carbon from riparian zones to streams in boreal catchments. Global Change Biology, DOI: 10.1111/gcb.12872 .

Ledesma, J. L. J. et al. (2013). Riparian zone controls on base cation concentrations in boreal streams. *Biogeosci.* 10, 3849-3868.

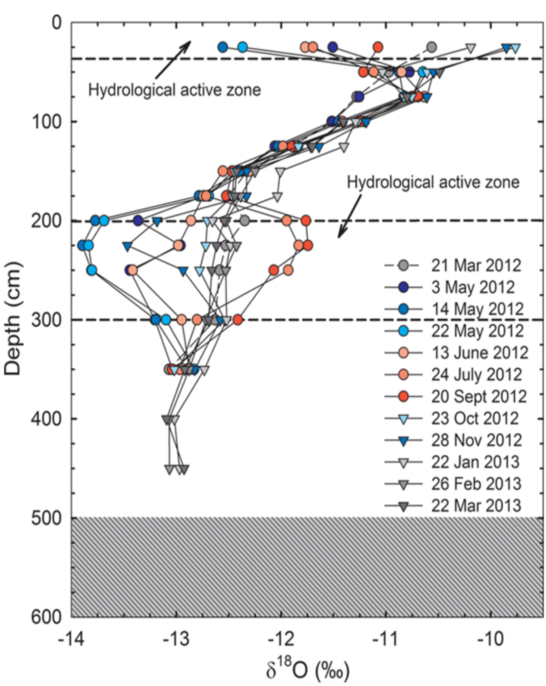
Grabs, T. et al. (2012). Riparian zone hydrology and soil water total organic carbon (TOC): implications for spatial variability and upscaling of lateral riparian TOC exports. *Biogeosci.*, 9, 3901-3916.

Lyon, S.W. et al. (2011). Variability of groundwater levels and total organic carbon (TOC) in the riparian zone of a boreal catchment, *J. Geophys. Res.-Biogeo.*, 116, G01020, doi:10.1029/2010JG001452.

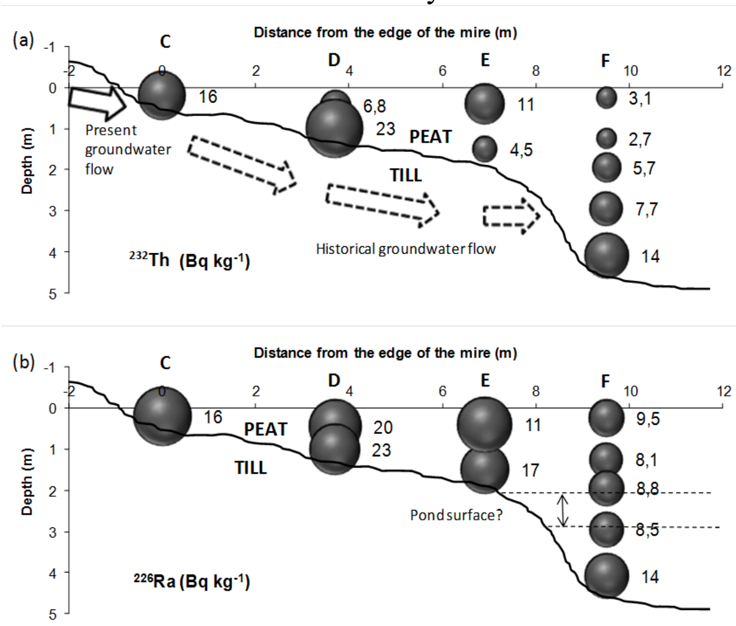
The Kallkäls Mire



The Kallkäls mire is the source area for stream C4, and the location of the “Russians wells”. The “Russian wells” are a set of piezometers allowing sampling at different depth in, and below the mire.



Left: Flow pathways through the mire during spring, summer and autumn using stable isotope oxygen -18 ($\delta^{18}O$) as tracers. Note the two dominating path-ways, 1. As overland flow and 2. Through the mire at 200 to 300 cm depth at some preferential pathway (From Peralta-Tapia et al. 2015).



Profile of chemical analyses following the pathway of water as it flows from the mineral soil into the mire. Here we show the activity (concentration) of thorium (Th) (above a) which is an element with a high affinity to DOC and radium (Ra) (below b) with low affinity to DOC (From Lidman et al. 2012).

References

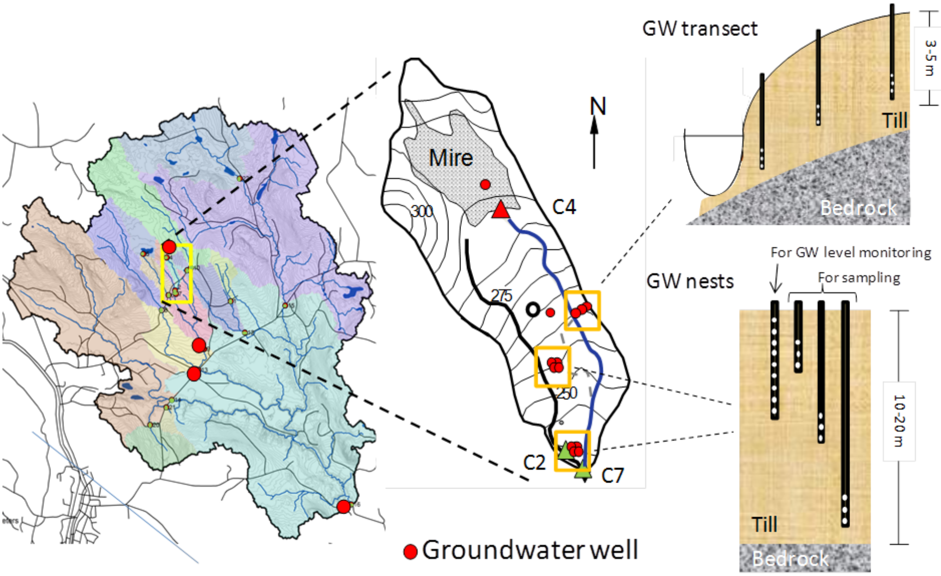
Sponseller, R.A., et al. (2017). Headwater mires constitute a major source of nitro gen (N) to surface waters in the boreal landscape, Ecosystems, In press

Peralta-Tapia, A. et al. (2015). Connecting precipitation inputs and soil flow pathways to stream water in contrasting boreal catchments, Hydrological Processes, In press

Lidman, F., et al. (2012). Distribution and transport of radionuclides in a boreal mire - assessing past, present and future accumulation of uranium, thorium and radium. Journal of Environmental Radioactivity, DOI: 10.1016/ j.jenvrad.2012.06.010.

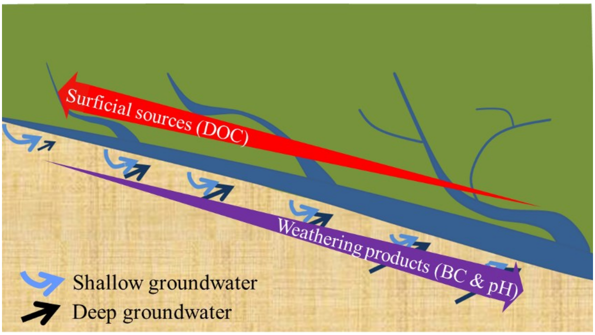
Grabs, T., et al. (2009). Modeling spatial patterns of saturated areas: A comparison of the topographic wetness index and a dynamic distributed model. Journal of Hydrology, 373, 15-23.

Groundwater Observatory (GO)

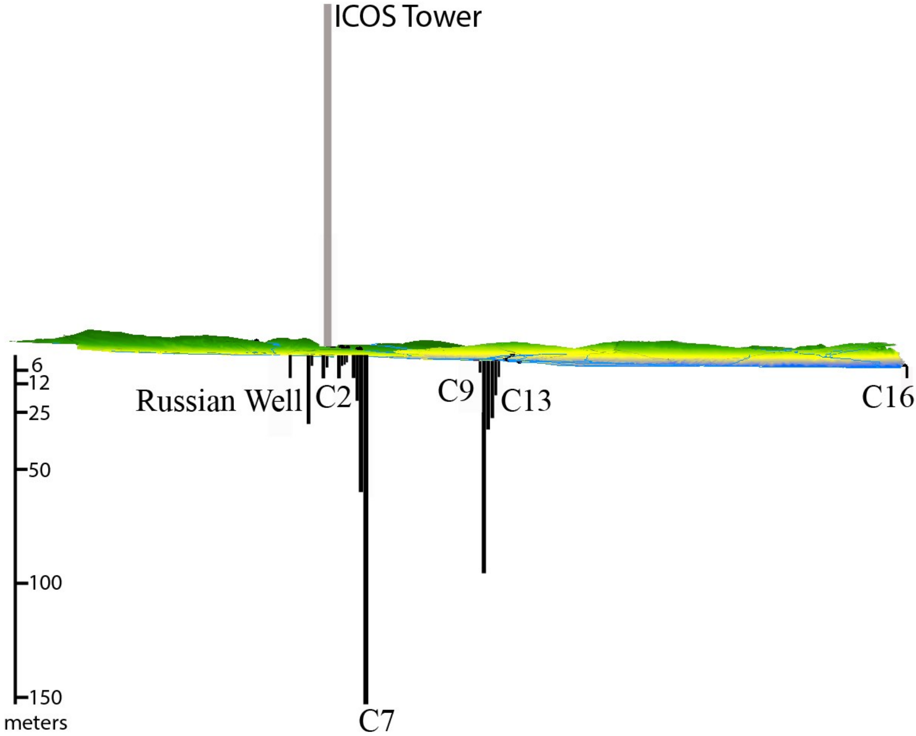


Above: Groundwater wells in Krycklan.

In total, close to 20 wells are installed spanning from 5 m to over 150 m depth. The installations were made to cover the entire catchment to investigate regional groundwater as well as allow more local studies of water pathways. The first wells were installed by the Swedish Geological Survey (SGU) in the 1980s and have been monitored since, whereas the majority was installed in 2012.



Left: Schematic figure of water flow pathway in Krycklan (Peralta-Tapia et al. 2015) showing the long travel distance for water surfacing downstream in the larger rivers.



The profile view shows the 150 m ICOS tower and major groundwater wells ranging between 5 and 153m.

Key references

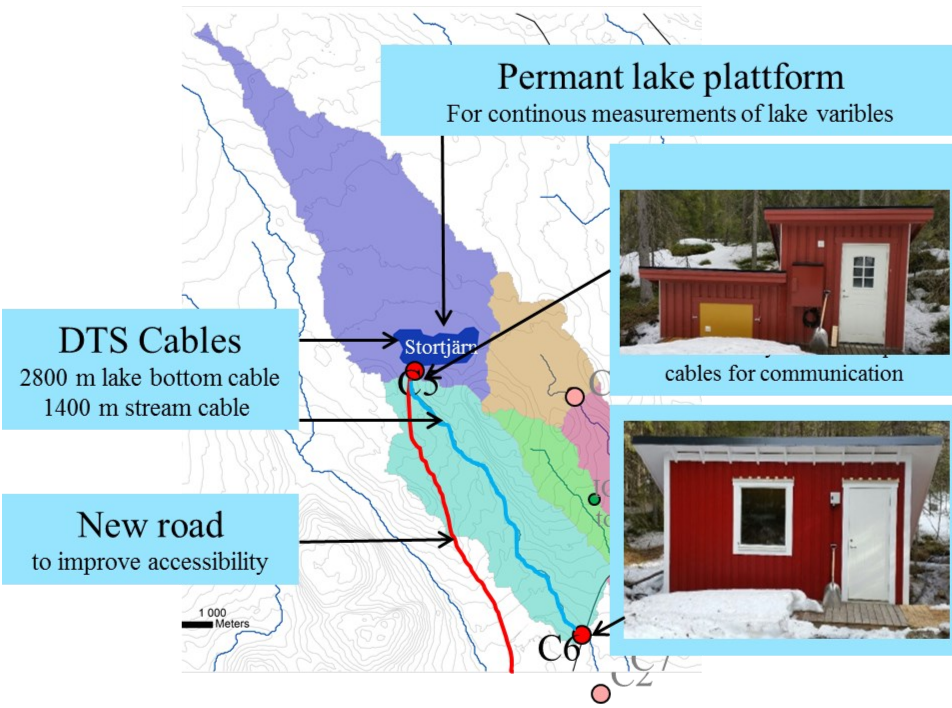
Tiwari, T. et al. (2017). Inferring scale-dependent processes influencing stream water chemistry from headwater to Sea, Limnology and Oceanography, in press.

Lidman, F., et al. (2016). 234U/238U in a boreal stream network — Relationship to hydrological events, groundwater and scale. Chemical Geology, 420, 240–250.

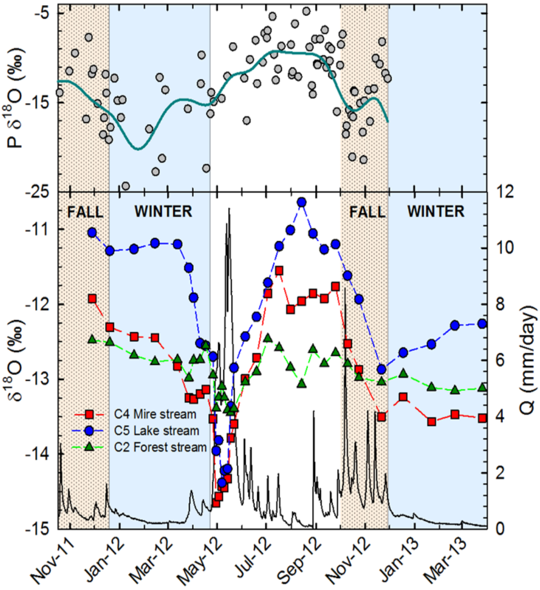
Peralta-Tapia, A., et al. (2015). Scale-dependent groundwater contributions influence patterns of winter baseflow stream chemistry in boreal catchments, J. Geophys. Res. Biogeosci., 120, doi:10.1002/2014JG002878.

Tiwari, T. et al. (2014). Downstream changes in DOC: Inferring contributions in the face of model uncertainties. Water Resources Research, DOI: 10.1002/2013WR014275.

Lake studies and Stortjärn infrastructure



Lake Stortjärn is one of the most expansive research sites in Krycklan both in terms of new projects and infrastructure development.



The contrasting behavior between the lake outlet (blue C5), mire outlet (green C4) and forested stream (red C2) under a full year.

Note the much larger response to snow melt and rain episodes in the lake (blue) compared to both the mire, (red) but especially the forested stream (green) (from Peralta-Tapia et al. 2015).

Key references

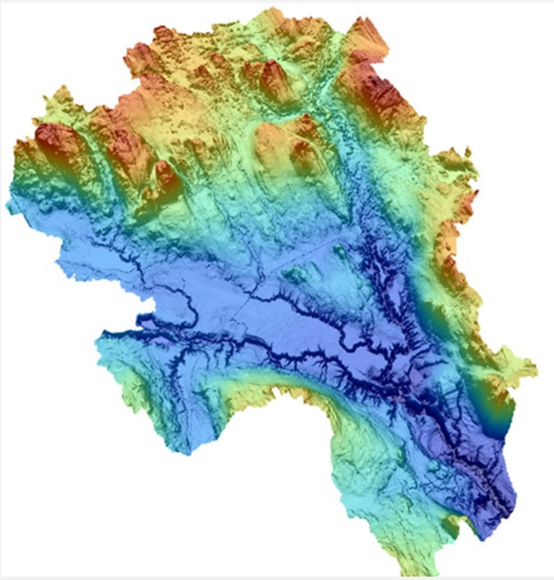
Leach et al. (2017). Evaluating topography-based predictions of shallow lateral ground water discharge zones for a boreal lake--stream system, Water Re sources Research, 53, Pages: 5420–5437DOI: 10.1002/2016WR019804

Peralta-Tapia, A. et al. (2015). Connecting precipitation inputs and soil flow pathways to stream water in contrasting boreal catchments, *Hydrological Processes*, In press

Karlsson, J. et al. (2012). Terrestrial organic matter support of lake food webs: Evidence from lake metabolism and stable hydrogen isotopes of consumers. *Limnology and Oceanography*, 57, 1042-1048, DOI: 10.4319/lo.2012.57.4.1042.

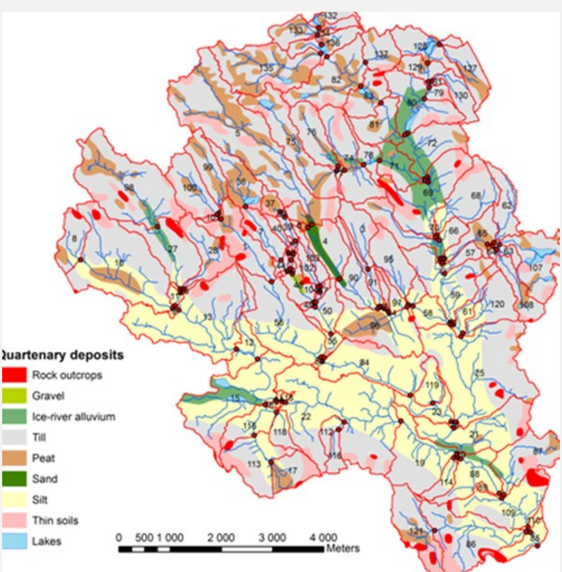
Berggren M. et al. (2010). Lake secondary production fueled by rapid transfer of low molecular weight organic carbon from terrestrial sources to aquatic consumers. *Ecology Letters*, 13, 870-880, DOI: 10.1111/j.1461-0248.2010.01483.x

Topography, Soils and Vegetation in Krycklan



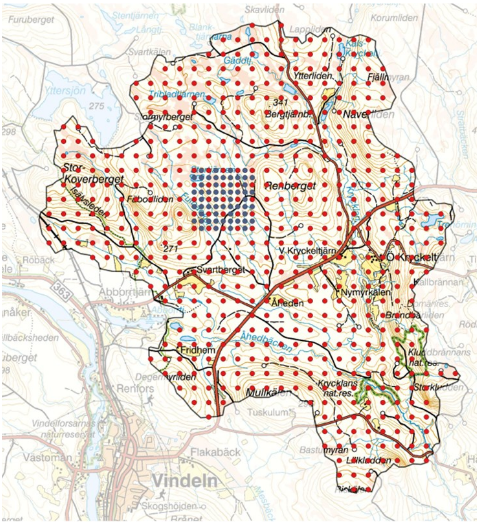
Lidar based topography in Krycklan.

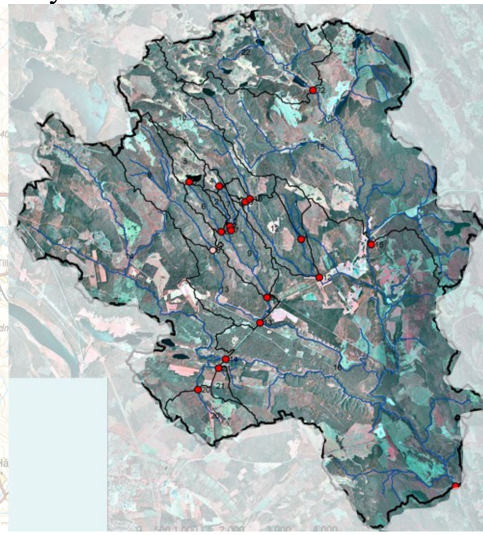
Based on the high resolution lidar 10, 5 and 0.5 m Digital Elevation Models (DEM) are available for the entire 68 km^2 catchcment.



Left: Quarternary deposits map with the 100 ”Survey locations” superimposed.

The survey catchments are sampled less often compared to the regular sites.





Above left: Vegetation survey (marked with black circles) carried out using the National Forest Inventory protocol with more dense survey around the ICOS tower in the center of the catchment

Above right: IR-ortophoto of the Krycklan catchment with the regular sites in red.

Key references

Roberge, J-M., et al. (2016). Socio-ecological implications of modifying rotation lengths in forestry. Ambio, 45, 109–123,DOI 10.1007/s13280-015-0747-4.

Logue, J.B., et al. (2016). Experimental insights into the importance of aquatic bacterial community composition to the degradation of dissolved organic matter. The ISME Journal, 1–13.

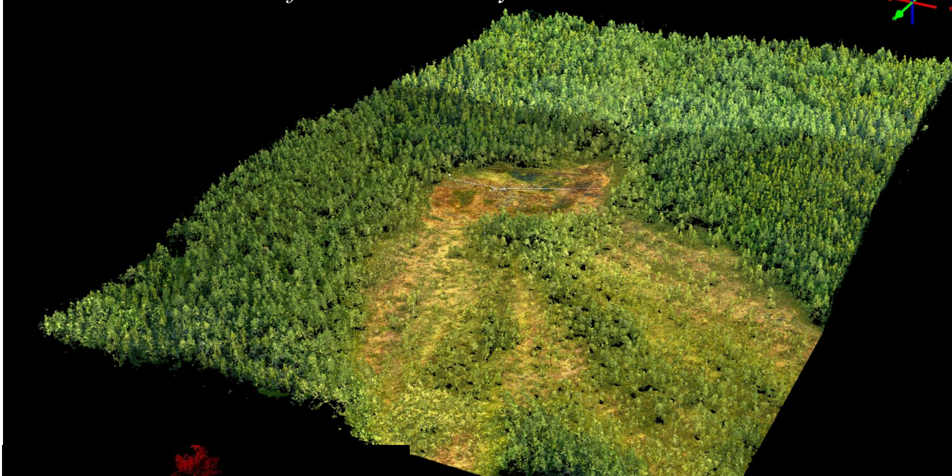
Tiwari, T., (2016). Cost of riparian buffer zones: A comparison of hydrologically adapted site specific riparian buffers with traditional fixed widths, Water Resources Research, doi: 10.1002/2015WR018014

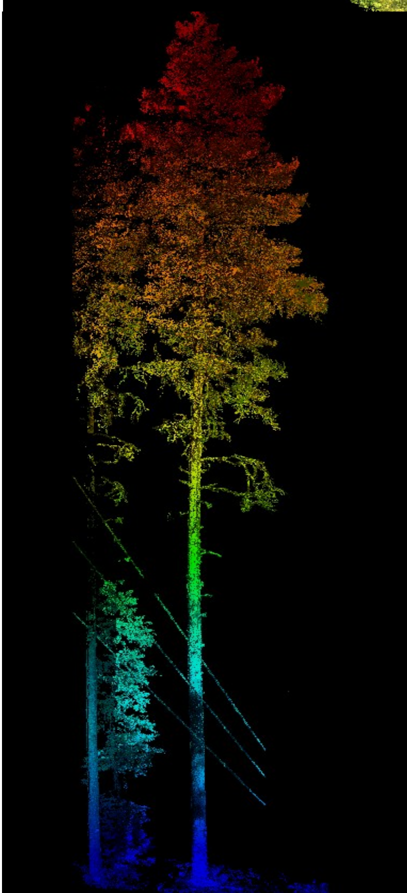
Kuglerová, L., et al. (2015). Local and regional processes determine plant species richness in a river-network metacommunity. Ecology, 96, 381-391.

Ågren, A. (2015). Mapping Temporal Dynamics in a Forest Stream Network- Implications for Riparian Forest Management. Forests, 6, 2982-3001.

Remote Sensing in Krycklan

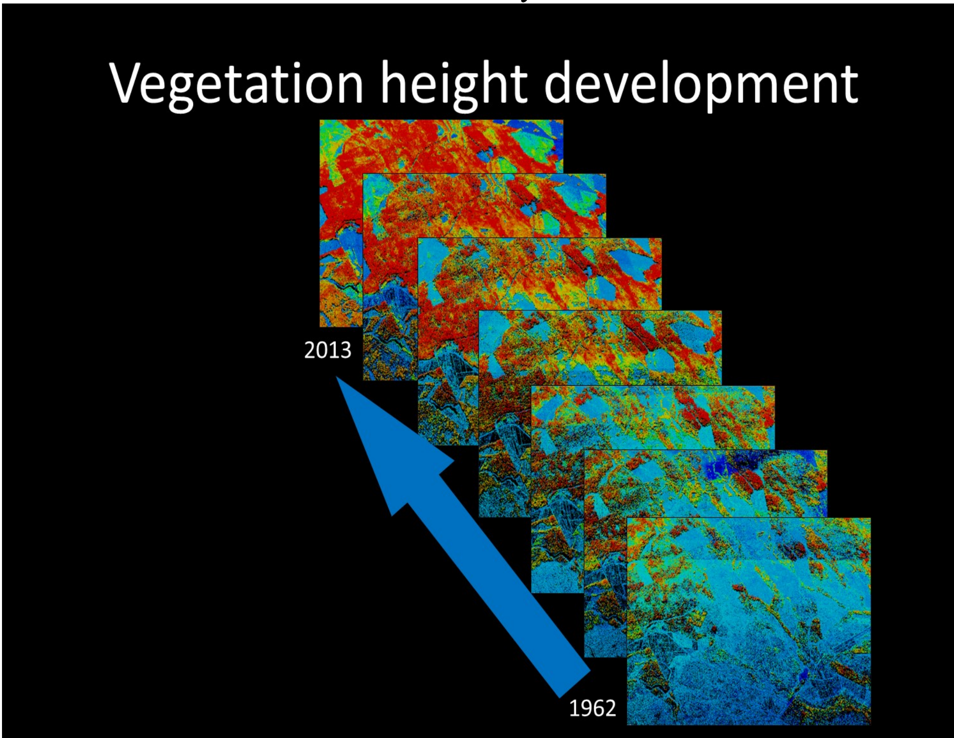
Remote sensing is currently one of the most rapidly evolving research field with the Krycklan catchment.





Above: 3D point cloud derived using stereo photogrammetry of very high resolution aerial images. This example is from the Kallkälsmyren.

Left: Example of data collected using terrestrial laser scanning using the Trimble TX8 scanner. The picture is a side-view of the three dimensional point measurements of a pine tree at the ICOS tower (note the supporting wires in the picture). Each point is color coded by the height above ground level.



Above: Aerial images of Krycklan from 1962 to 2013.

Left: Northern Lights

Key references

Laudon, H., et al. (2016). The role of biogeochemical hotspots, landscape heterogeneity and hydrological connectivity for minimizing forestry effects on water quality, Ambio, 45, 152–162.

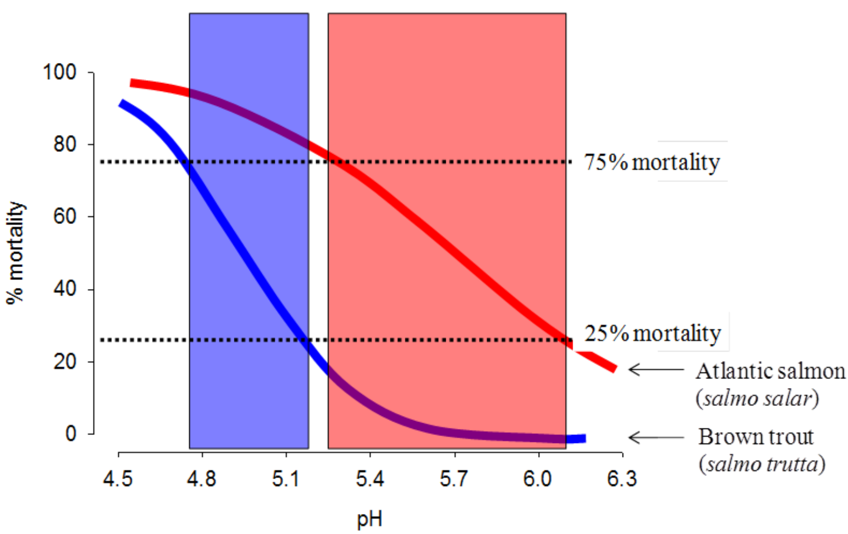
Lyon, S.W., et al. (2015) Can Low-Resolution Airborne Laser Scanning Data Be Used to Model Stream Rating Curves? Water 7, 1324-1339.

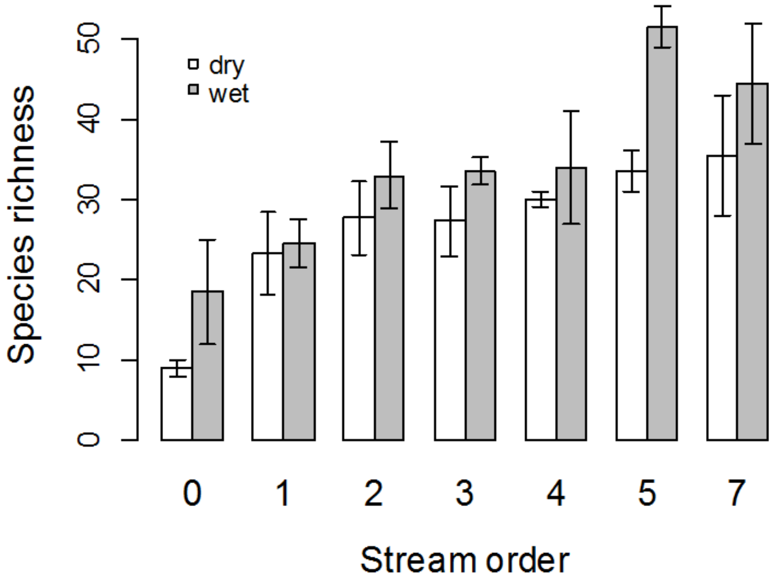
Ågren. A. et al. (2014). Evaluating digital terrain indices for soil wetness mapping - a Swedish case study. Hydrol Earth Syst Sciences, 18, 3623-3634

Krycklan Stream and Plant Ecology

Right: A number of stream and riparian ecology studies have been conducted related to plants, fish and invertebrates in aquatic, terrestrial riparian ecosystems.

Below: Acidity thresholds for young (1+) fish measured in the Krycklan. These results are now a basis for the new SEPA guidelines for liming .





Above: Plant species diversity in the riparian zone in dry versus wet locations along streams ranging from hollows (zero order streams) across all stream sizes in Krycklan all the way up to the Vindeln River (7 order stream) (From Kuglerová et al. 2014).

Key references

Tiwari, T., et al (2016). Cost of riparian buffer zones: A comparison of hydrologically adapted site-specific riparian buffers with traditional fixed widths, Water Resources Research, doi: 10.1002/2015WR018014

Burrows, R et al.(2015). Nitrogen limitation of heterotrophic biofilms in boreal streams. Freshwater Biology, 60, 1237–1251.

Kuglerová, L., Jansson, R., Sponseller, R.A., Laudon, H., Malm-Renofalt, B. (2015). Local and regional processes determine plant species richness in a river-network metacommunity. Ecology, 96, 381-391.

Kuglerová, L. et al. (2014) Groundwater discharge creates hotspots of riparian plant species richness in a boreal forest stream network, Ecology, 95, 715-725.

Serrano, I, et al. (2008). Thresholds for survival of brown trout (Salmo trutta) embryos and juveniles during the spring flood acid pulse in DOC-rich streams. Transactions of the American Fisheries Society, 137, 1363-1377.

Krycklan - A brief history

Research in Krycklan started over 100 years ago with the study of paludification effects on forest growth. In the 1970's, the Svartberget field station was established. Research then was focused more on forest hydrology and biogeochemical cycling. During the 1990's, a decade of more intensive work on the role of acid deposition on stream water chemistry contributed to new views of anthropogenic acidification and natural acidity in organic carbon-rich boreal waters. In recent years, the research scope expanded substantially to include more work on biogeochemistry, carbon cycling, hydrology and ecology. More intensive research also began on the connections between soils and surface waters, leading to a process-based understanding of the regulation of stream water chemistry.

Recognition of the need to work at the landscape scale when addressing climatic influences on aquatic ecology led to the expansion of the Svartberget catchment from 50 ha to the 6800 ha Krycklan catchment in 2002. This has further increased the research scope to include both fundamental research questions as well as management issues that are currently addressed.

In recent years, Krycklan has transformed into a unique experimental platform for testing pure and applied research questions in a natural environment. The platform continuously attracts new scientific projects as well as directly collaborates with the Swedish Nuclear Waste Program, Swedish EPA, Sveaskog and others.

Krycklan would not be possible without the excellent support from the field and laboratory crew.
Read more and access data at www.slu.se/Krycklan.
Photos by Peder Blomkvist, Ishi Buffam and Tobias Lindborg.
Layout by Tejshree Tiwari.
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