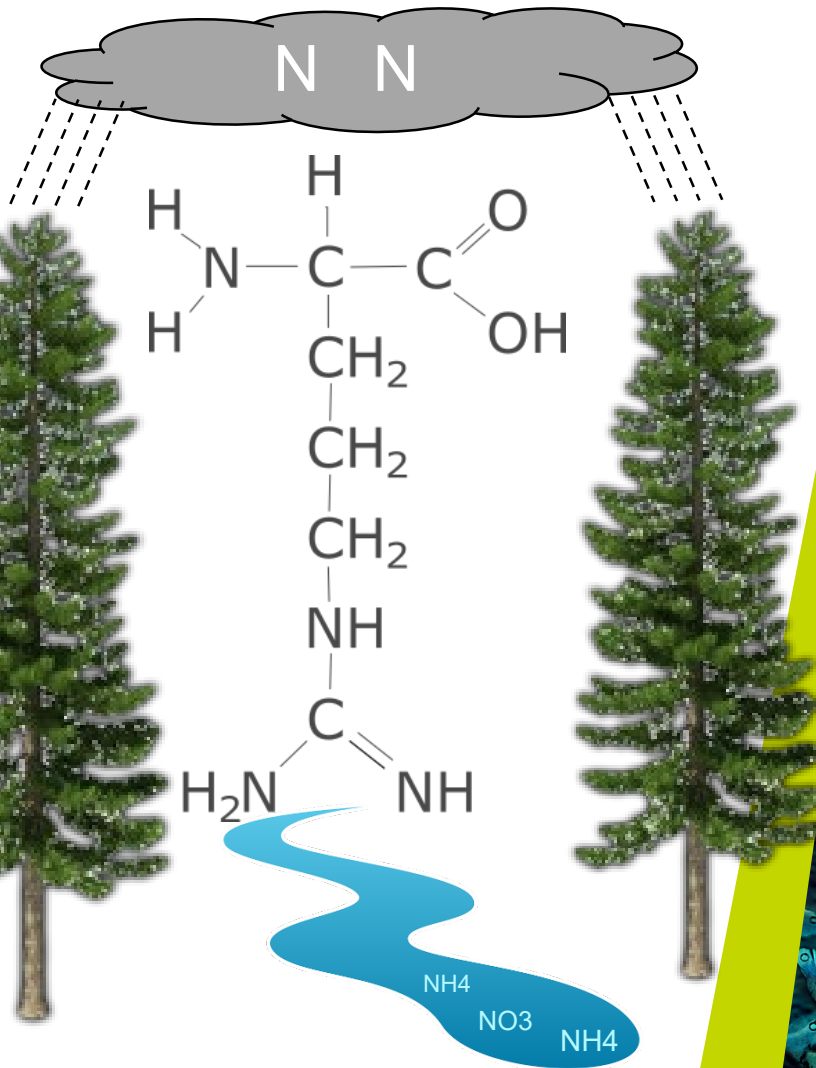


# Arginine in spruces at Swedish IM sites

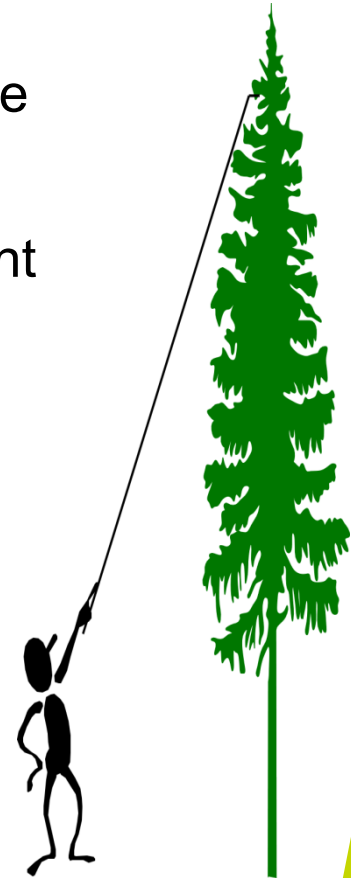


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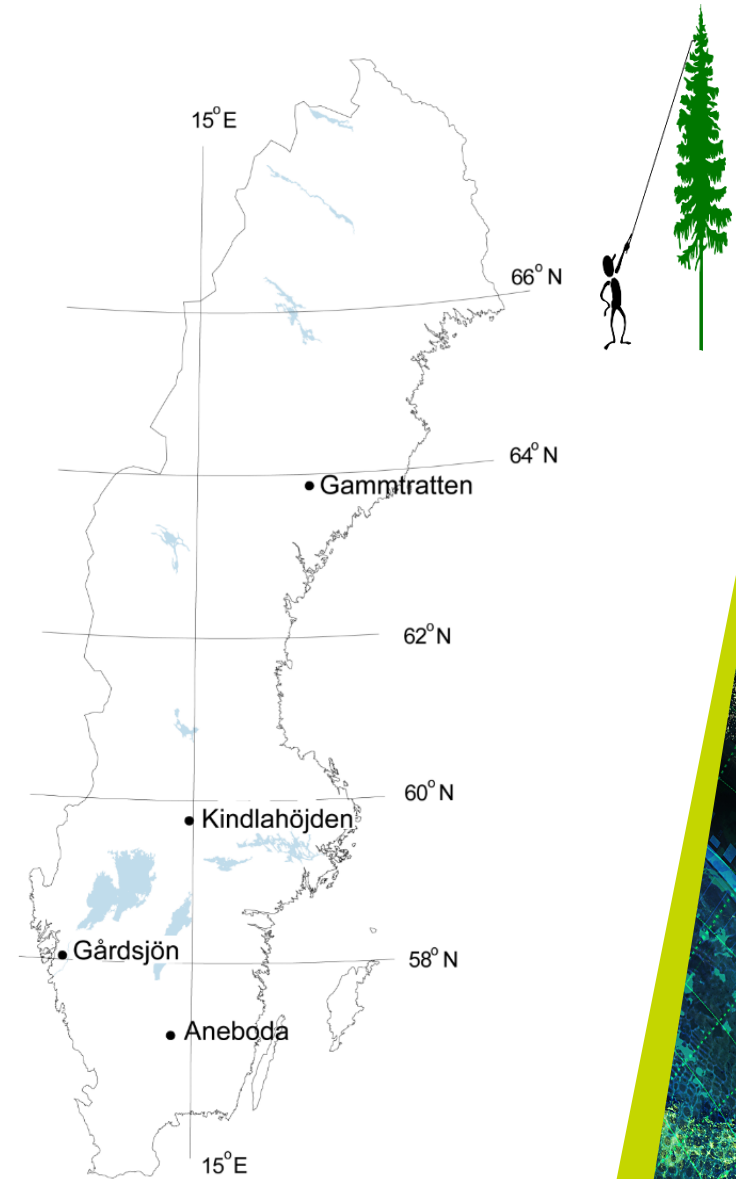
## Arginine monitoring

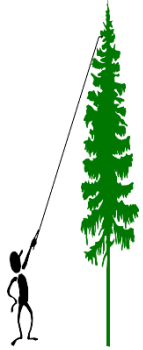
- Arginine in spruce needles is an optional IM variable
- An indicator of risk for N leakage from the catchment
- Swedish IM has a > 20 yr time series of annual measurements
- Sampling in winter from top of high solitude trees



## Background

- 4 Swedish IM sites – along climatic and depositional gradient
- A spruce will take up as much N as it can from the soil solution ➡  
High soil N = high uptake
- N not fixed in the metabolism is mainly stored as arginine
- Arginine concentration below  $5 \mu\text{mol g}^{-1}$  indicates very low risk for N leakage from the catchment





## Questions

- Does the arginine levels indicate risk of N leakage?
- Temporal variation and trends in arginine over the > 20 years?
- Can the arginine variation be explained by N deposition?
- Has the vegetation period gotten longer and can that explain trends in arginine levels?\*

\*) Craine et al. (2018). Nature Ecology & Evolution doi:10.1038/s41559-018-0694-0

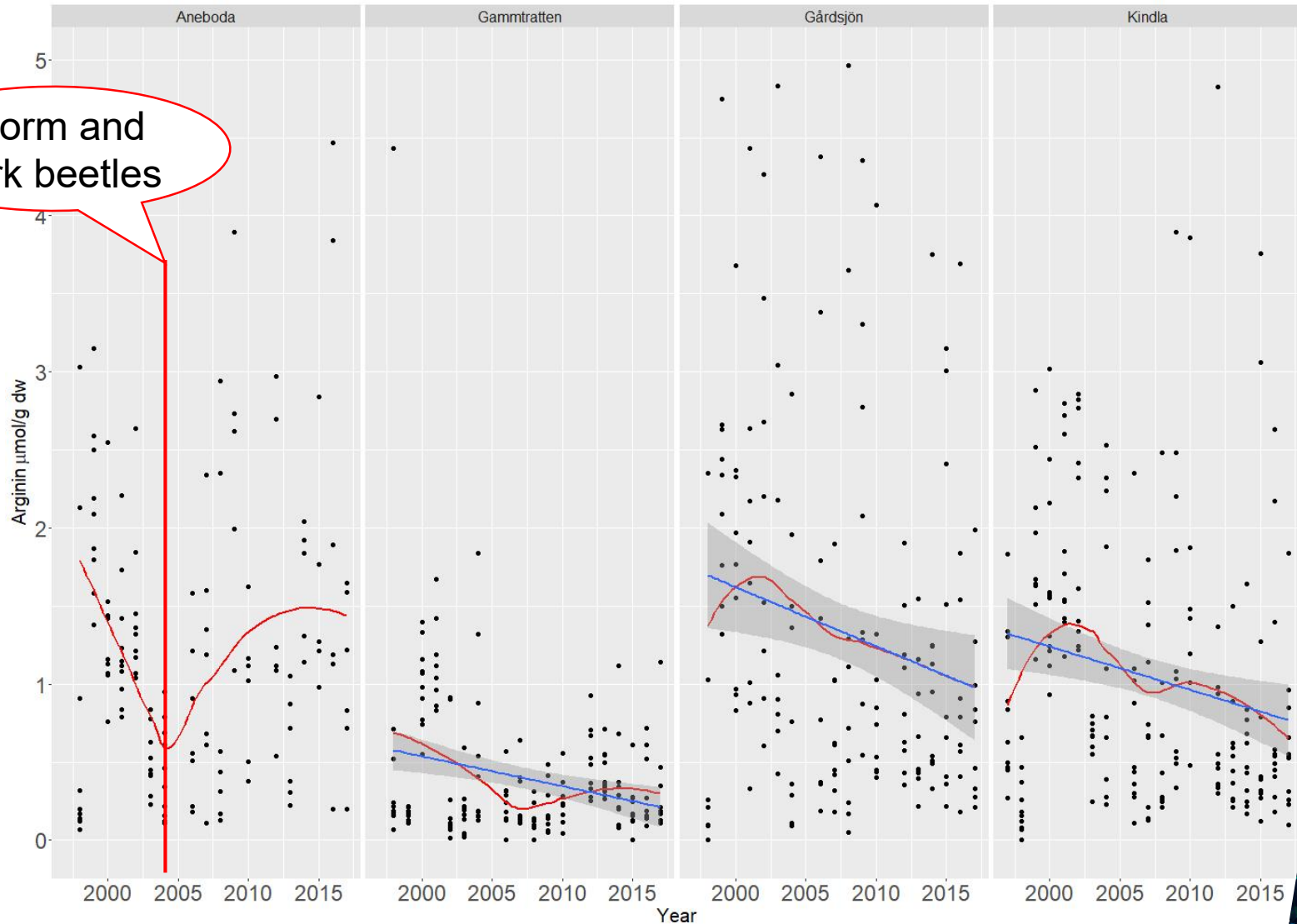
Longer vegetation period leads to decline in available N.



# Arginine in spruce needles from the Swedish IM sites, for 20 years

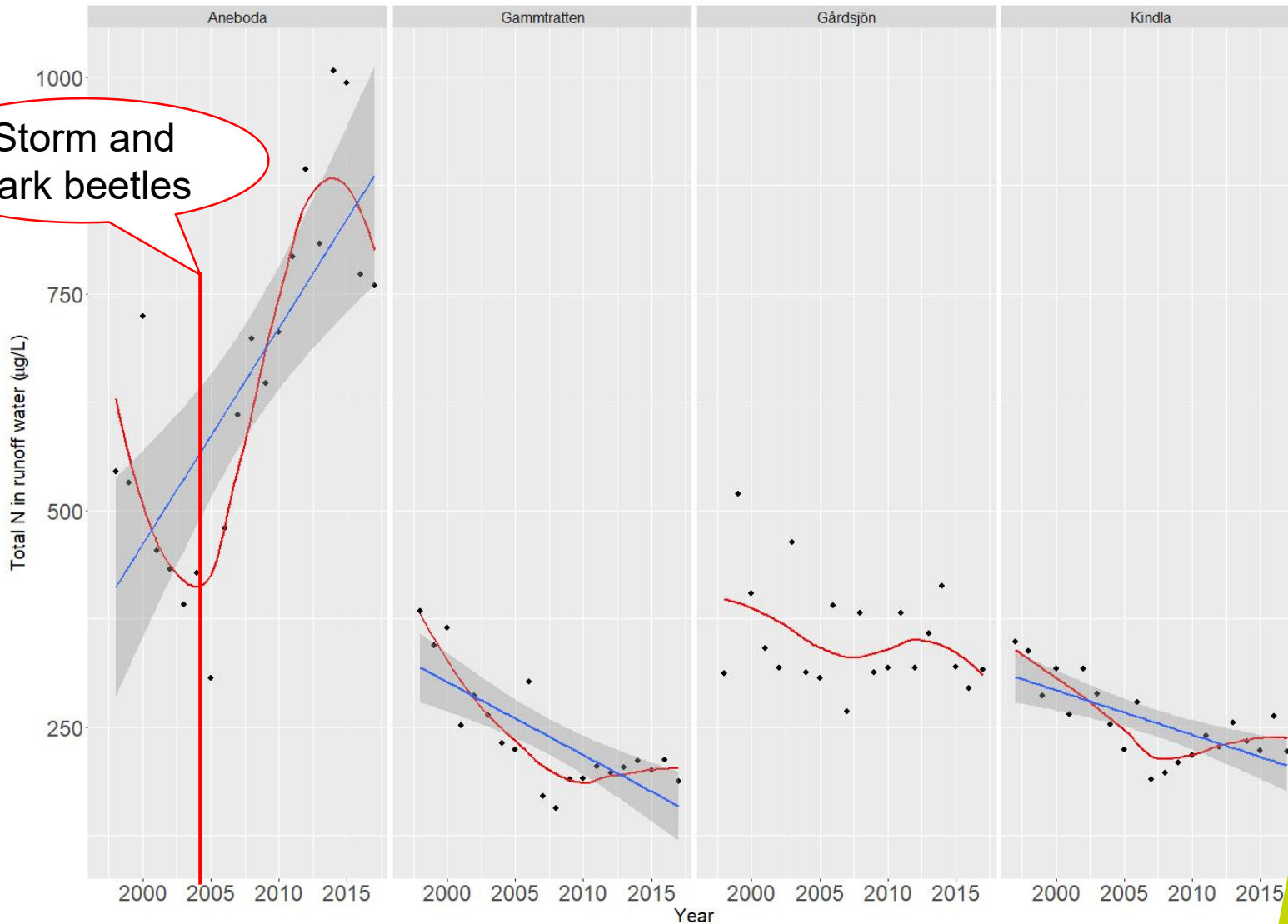
Significant ( $p < 0.014$ ) decrease at 3 sites (mixed linear model, plot as random factor).

A few outliers above  $5 \mu\text{mol g}^{-1}$  not shown (no effect on the trends).



# Total N in runoff water, at the Swedish IM sites

Significant ( $p < 0.001$ ) trend at 3 sites (linear model).



## Relationship ( $r^2$ ) between N species in different medium and arginin in spruce needles

Annual mean the year before needle sampling vs. needle arginine concentration

Medium	Species	Coef. of determination			
		Aneboda	Gammtratten	Gårdsjön	Kindla
Runoff water	NO <sub>2</sub> +NO <sub>3</sub>	-	0,42**	n/a	-
Runoff water	NH <sub>4</sub>	-	-	-	-
Runoff water	TotN	-	-	-	-
Through fall	NO <sub>3</sub>	-	-	0,30*	0,22*
Through fall	NH <sub>4</sub>	-	0,29*	-	-
Soil water, B-horizon	NH <sub>4</sub>	-	-	-	-
Soil water, E-horizon	NH <sub>4</sub>	-	0,61***	-	-
Soil water, peat	NH <sub>4</sub>	0,23*	-	-	0,26*
Soil water, B-horizon	NO <sub>3</sub>	-	0,45**	-	-
Soil water, E-horizon	NO <sub>3</sub>	-	0,31*	0,34*	-
Soil water, peat	NO <sub>3</sub>	-	-	-	-

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## Other explanations?

- High variation in arginine?
- Too low levels of arginine?
- Climatic effects, lower relative N due to higher CO<sub>2</sub>?
- Other?





# Within year variation in arginine

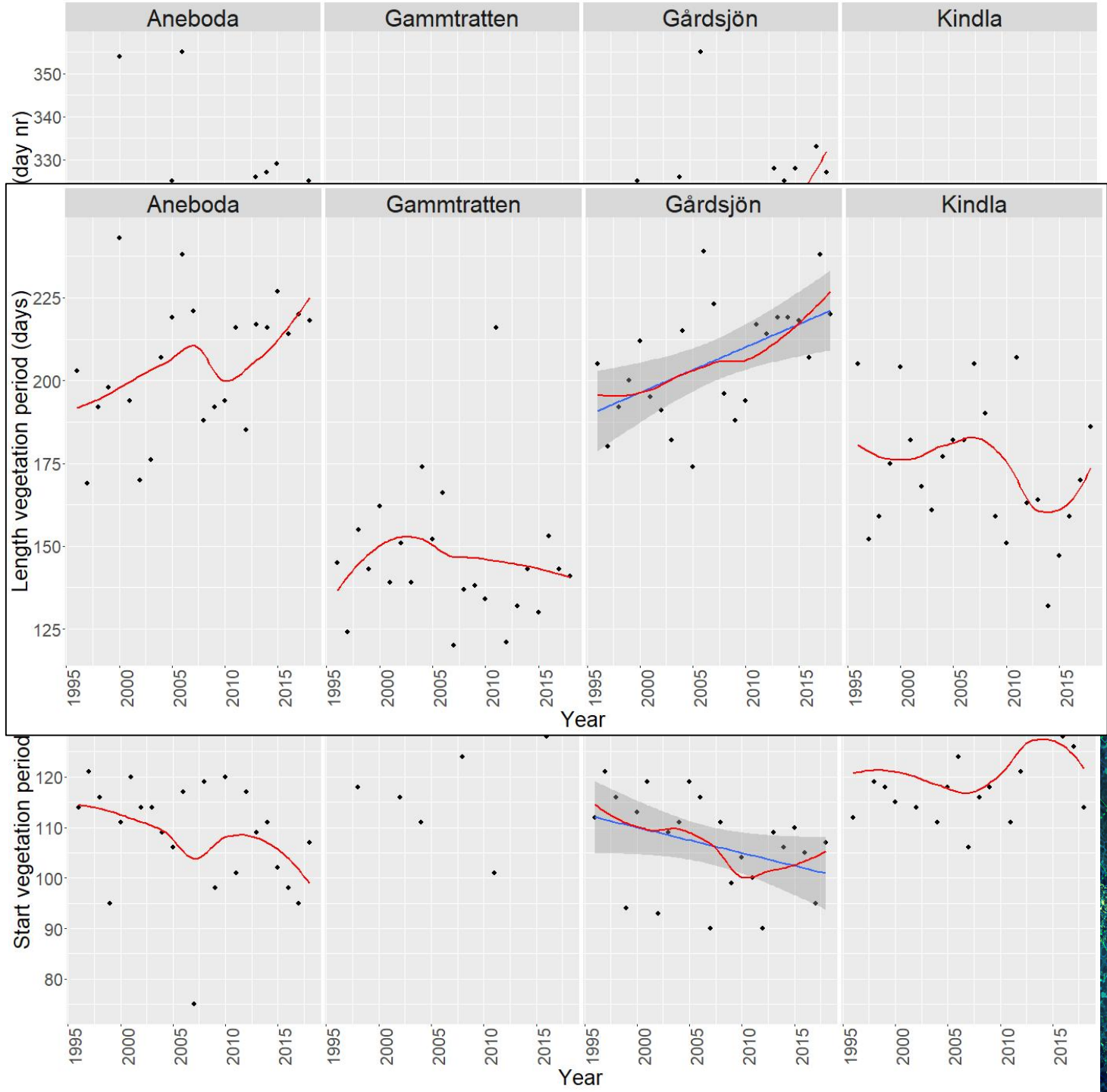
Increased variation at Kindla ( $p < 0.01$ , linear model)

From  $CV < 50\%$  to  $CV > 100\%$





- Regional Kendall test
- $p < 0.05$  at Gårdsjön
- $\approx 1$  month longer vegetation period from 1995 to 2018



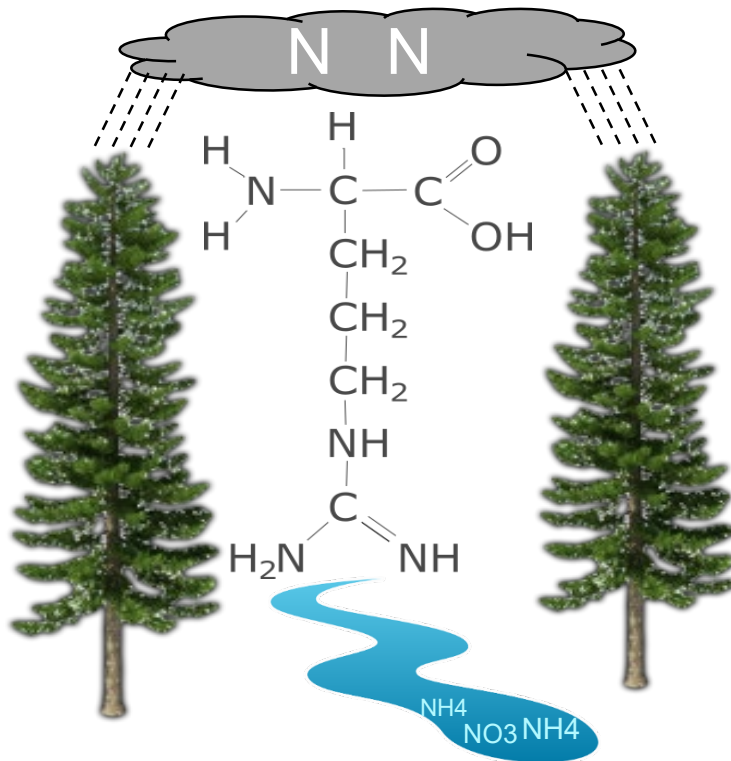
## Results

- Arginine in needles is below the 5  $\mu\text{mol g}^{-1}$  limit
- Decreasing arginine levels
- Decreasing tot-N in runoff water
- Few correlations between arginine in needles and any measured N species in any medium
- Few significant trends in length of vegetation period, hence no climate effect in the arginine levels



# Conclusions

- No indication of N leakage from the catchments
- Cannot (yet) explain the observed decreasing levels in arginine





**Thanks for your attention!**  
**Any questions?**



Gammtratten, ICP IM SE16, Photo Ulf Grandin

