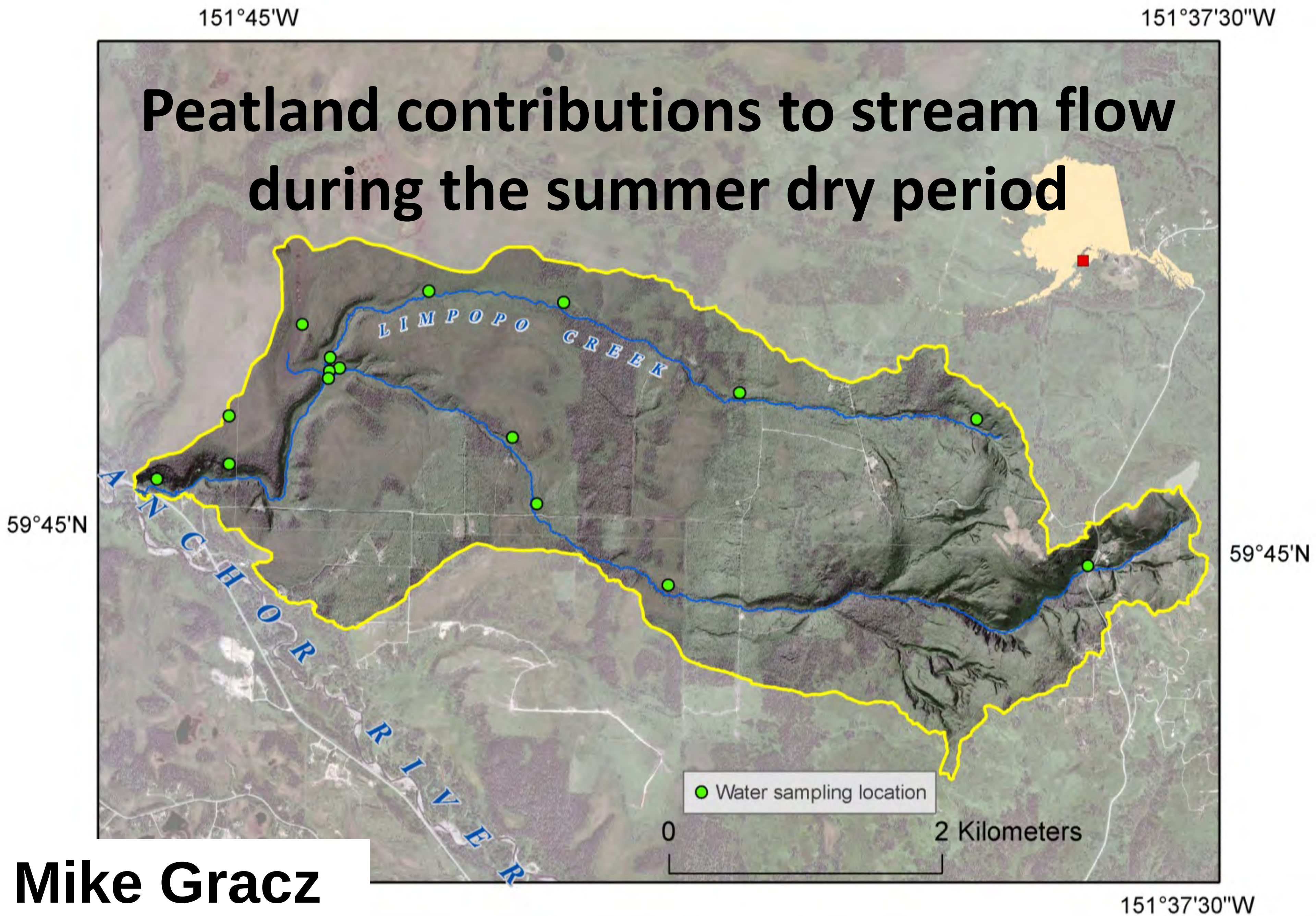
Peatland contributions to stream flow during the summer dry period



Mike Gracz
907-299-6122

Temperatures in exceedance for returning adult salmon

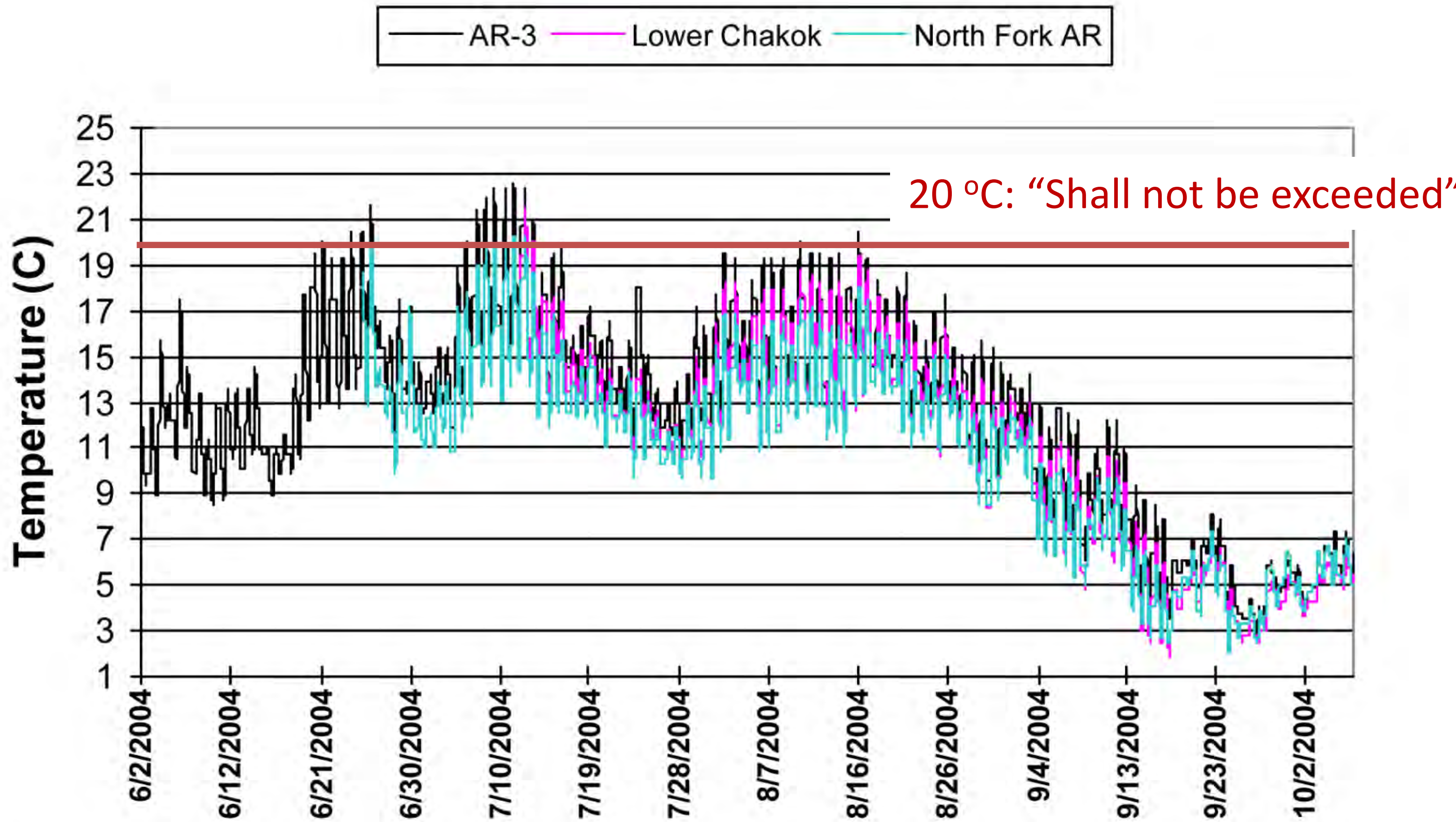
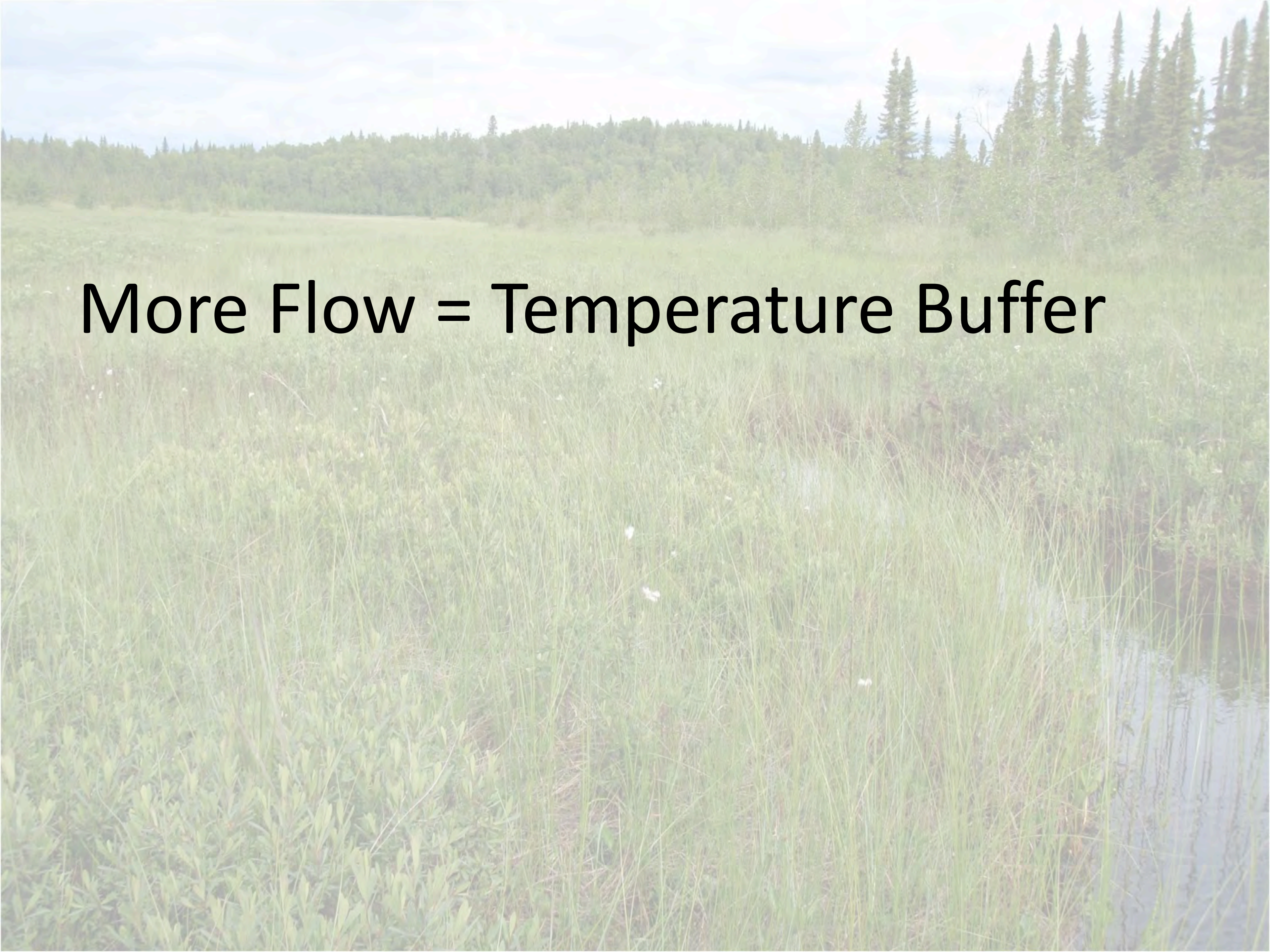


Figure 20. Temperature profiles of sites in the northern portion of the Anchor River watershed.

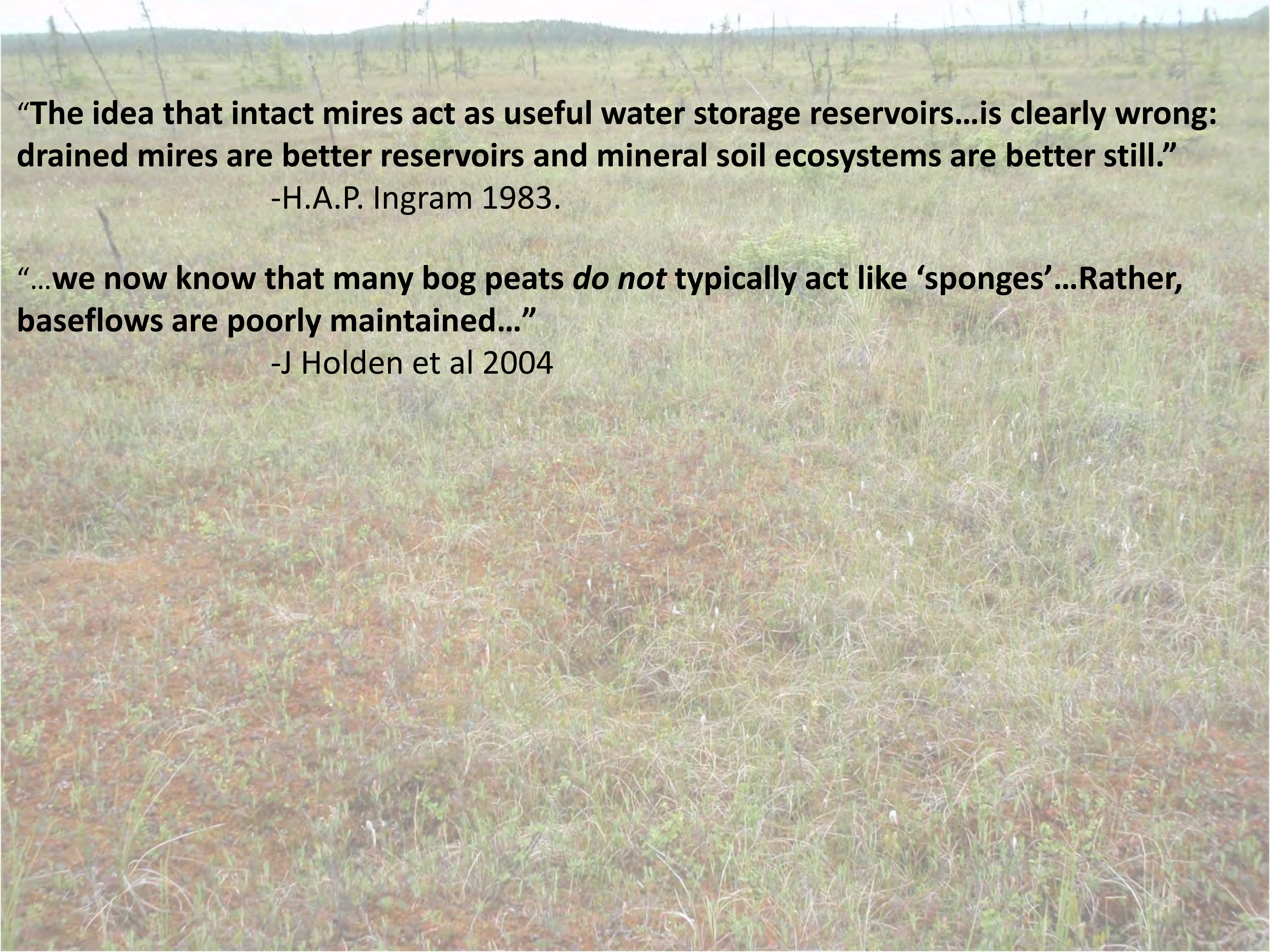
From Mauger, 2005

More Flow = Temperature Buffer



More Flow = Temperature Buffer

Peatlands important for dry-season flow?



"**The idea that intact mires act as useful water storage reservoirs…is clearly wrong: drained mires are better reservoirs and mineral soil ecosystems are better still.**"

-H.A.P. Ingram 1983.

"…**we now know that many bog peats *do not* typically act like 'sponges'…Rather, baseflows are poorly maintained…**"

-J Holden et al 2004

“The idea that intact mires act as useful water storage reservoirs…is clearly wrong: drained mires are better reservoirs and mineral soil ecosystems are better still.”

-H.A.P. Ingram 1983.

“…**we now know that many bog peats *do not* typically act like ‘sponges’…Rather, baseflows are poorly maintained…”**

-J Holden et al 2004

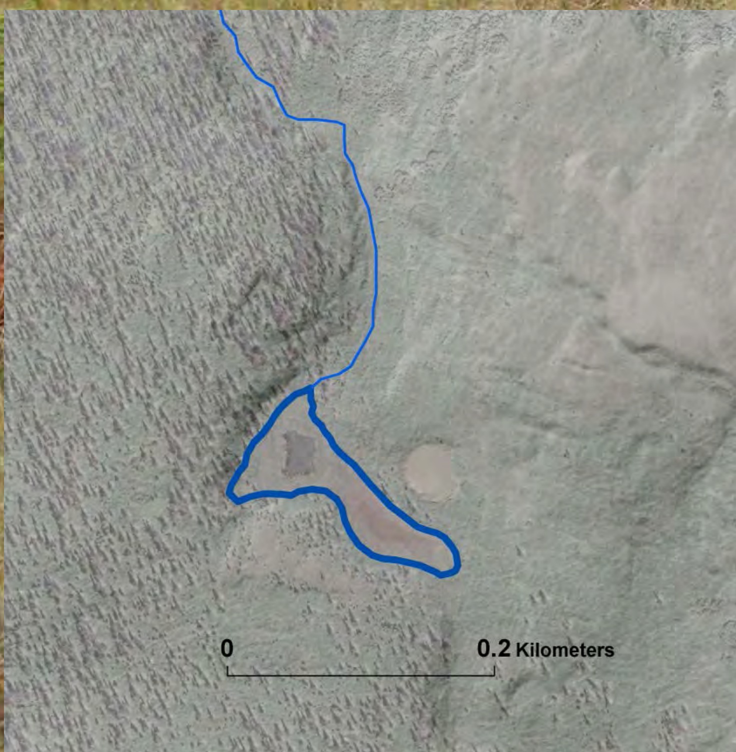
“During the drought, streams draining blanket peat on Plynlimon and elsewhere In mid-Wales sustained higher minimum flows than those draining podzol or brown-earth soils.”

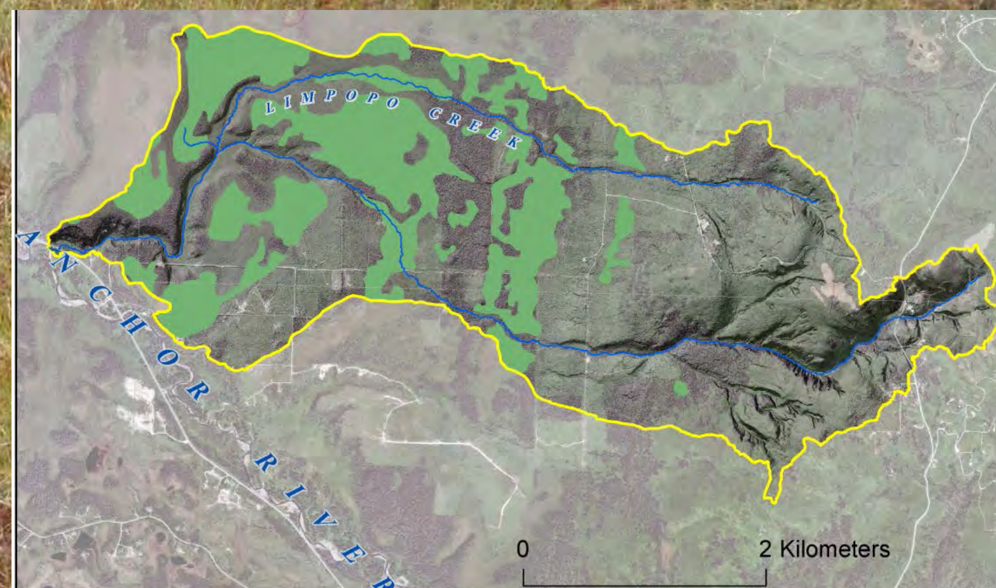
-M.D. Newson 1980

“Thus, more than half of the...runoff… during years of near and below normal precipitation… is water slowly released from storage within lakes and wetlands.”

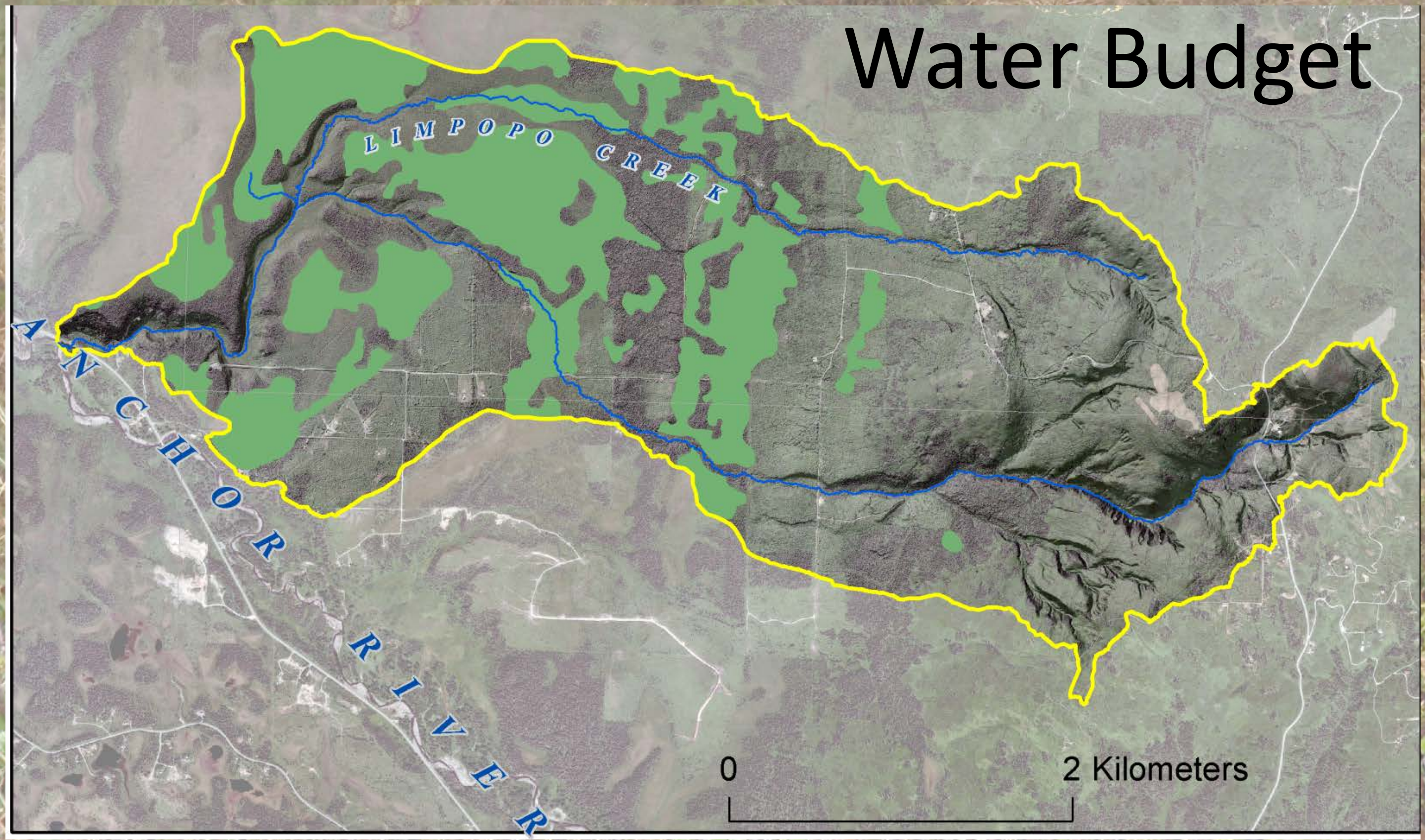
-E.A. Ackroyd et al. 1967

Hydrogeologic setting is important

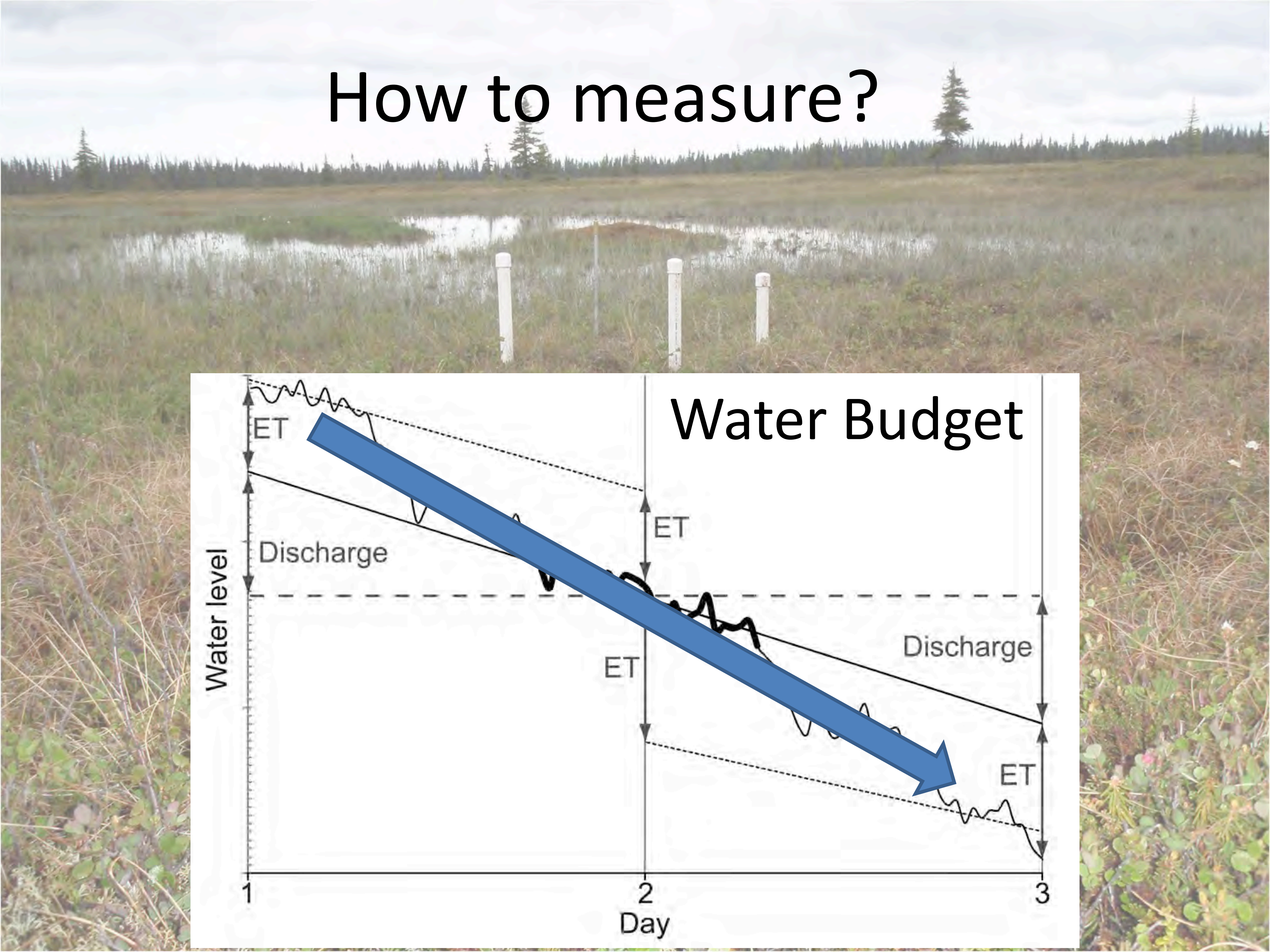




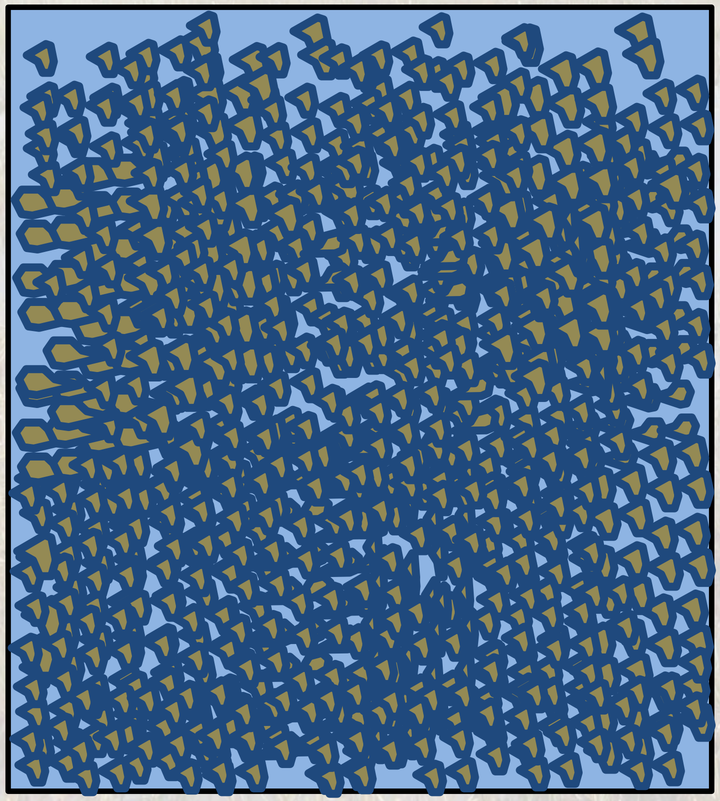
How to measure?



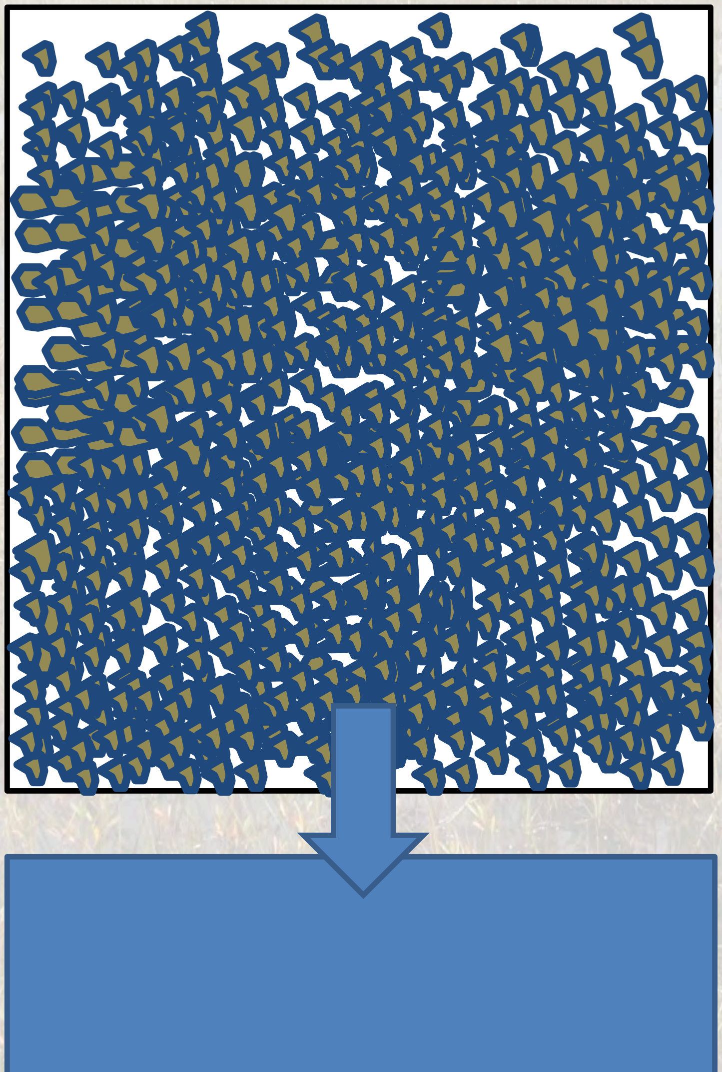
How to measure?



Water produced during drawdown?



Water Produced during drawdown?



= Specific Yield (S_y)

Potential Evapotranspiration (ET):

Thornthwaite method

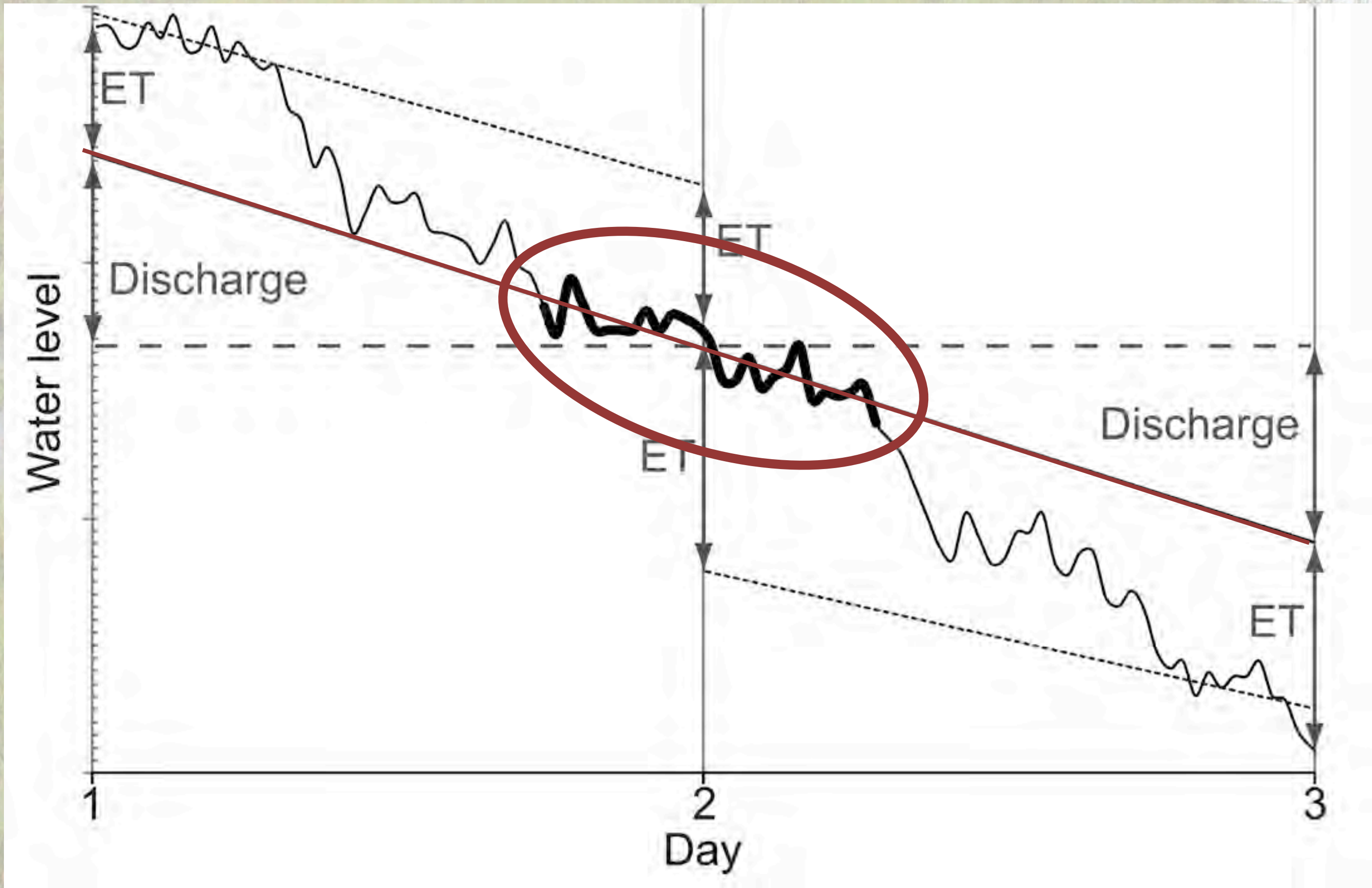
Temperature

Latitude

How to measure?

Diurnal Method

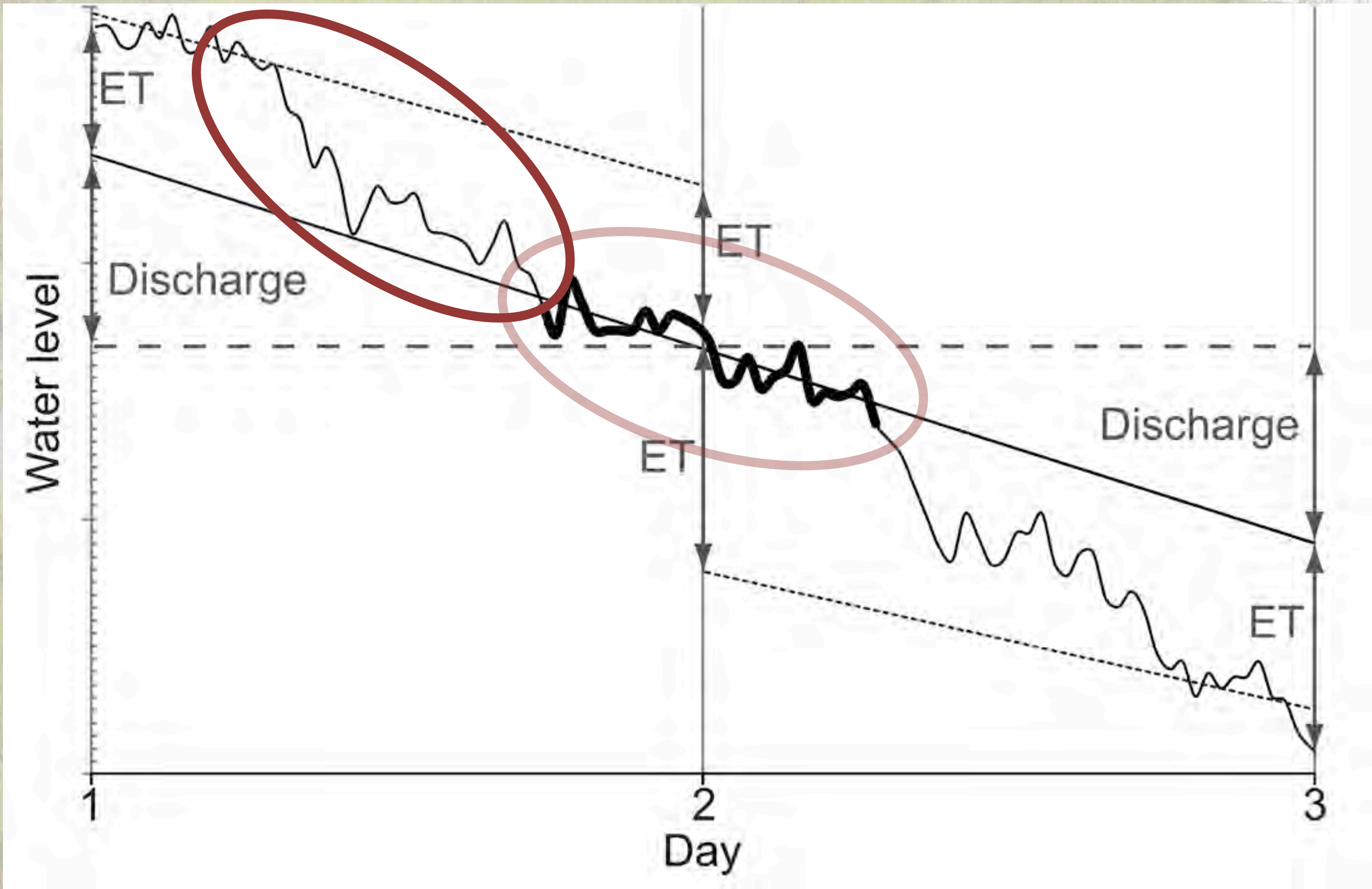
Night-time rate of decline



How to measure?

Diurnal Method

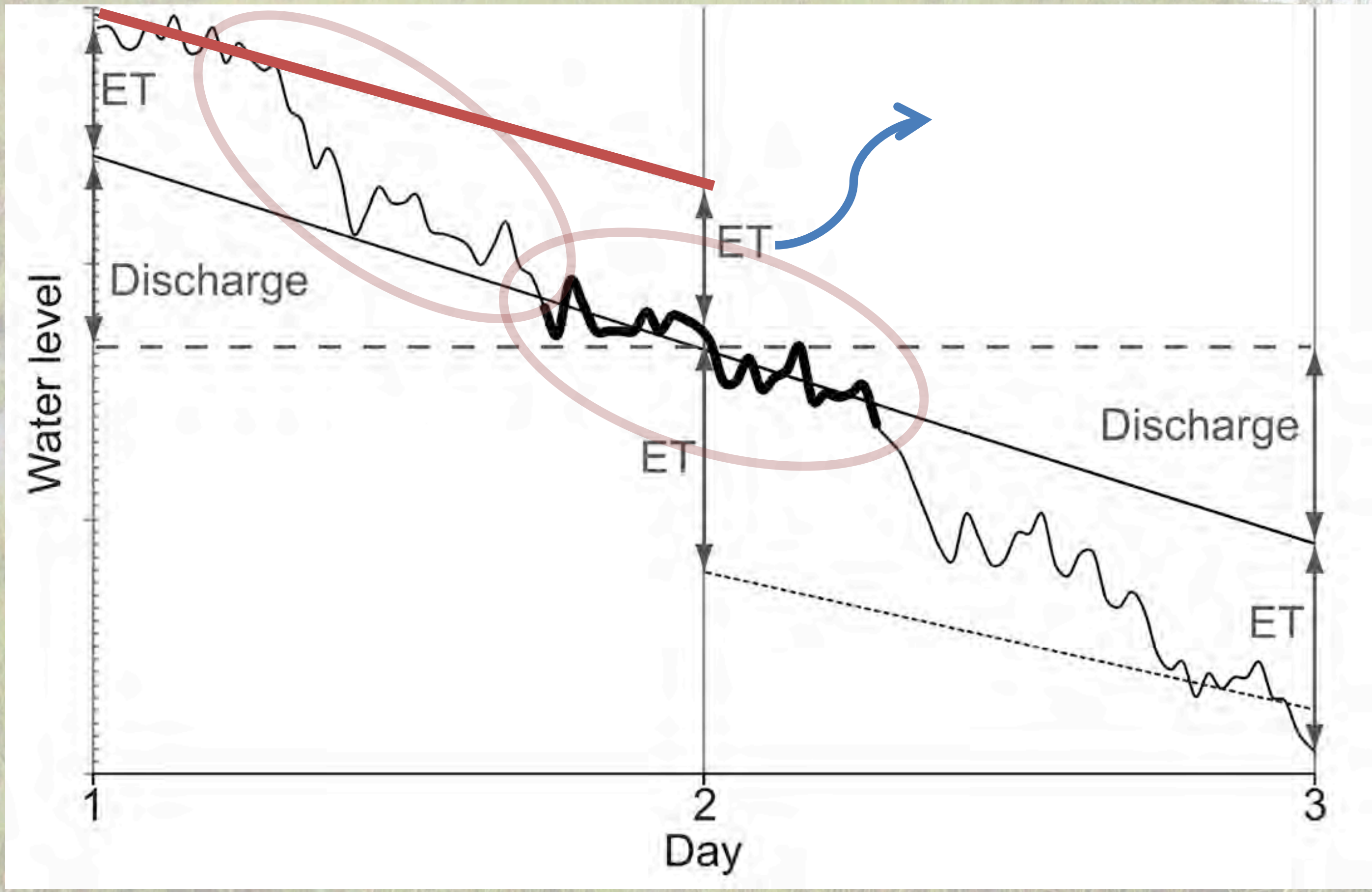
Day-time rate of decline



How to measure?

Diurnal Method

Difference = ET



Surplus Remaining For Stream Flow
Limpopo Creek

Actual water level decline (228mm/8d)
Area of similar peatlands in watershed

Actual dry-period flow **(0.06 m^3s^{-1})**

Amount Remaining For Stream Flow

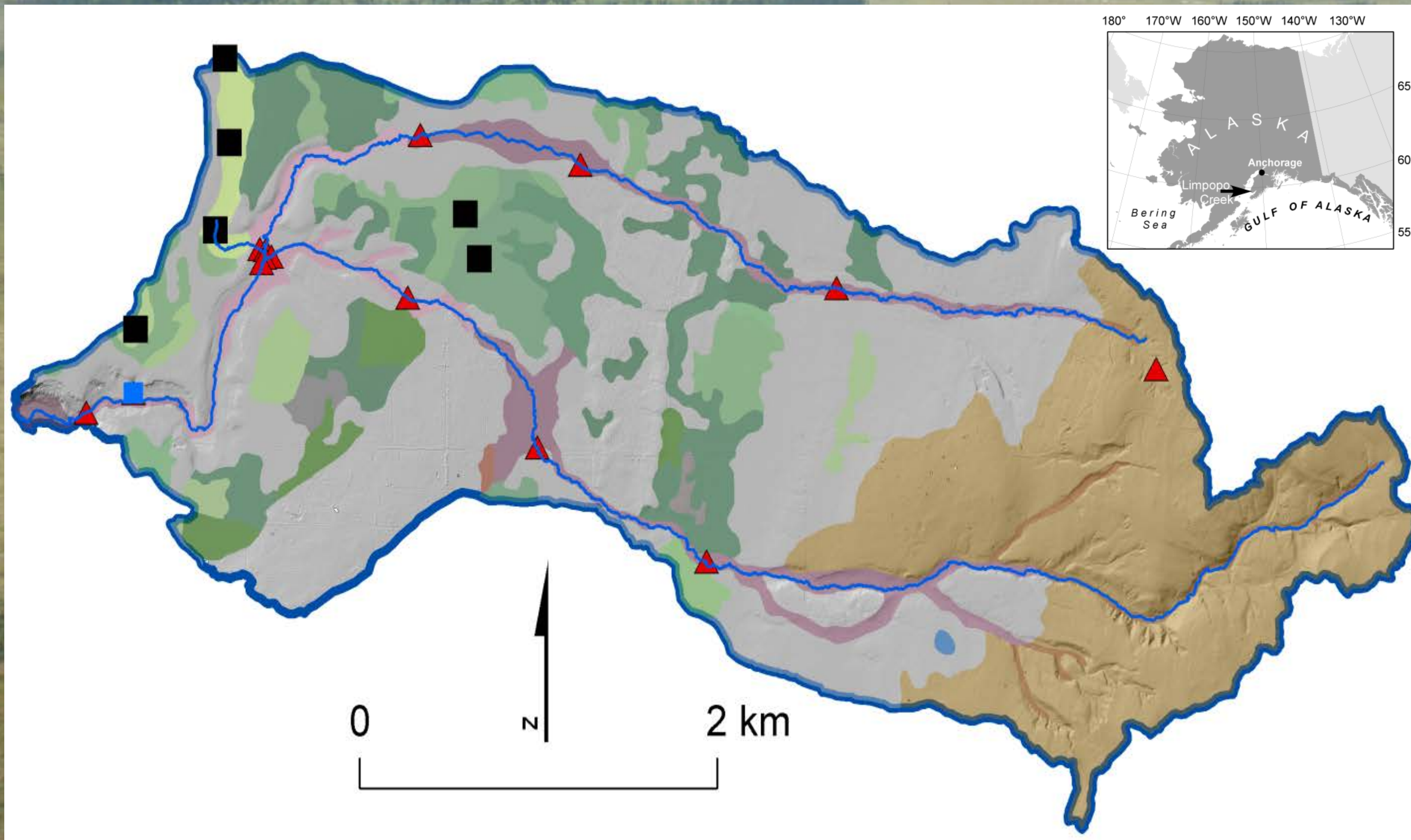
(Actual dry-period flow = 0.06 m^3s^{-1})

	Specific Yield			
ϕ	**0.45**	**.14**	**.10**	**0.05**
0.8	0.259	0.080	0.060	0.029
0.9	0.297	0.092	0.066	0.033
0.131	0	0	0	0
Diurnal ET	0.108	0.033	0.024	0.012

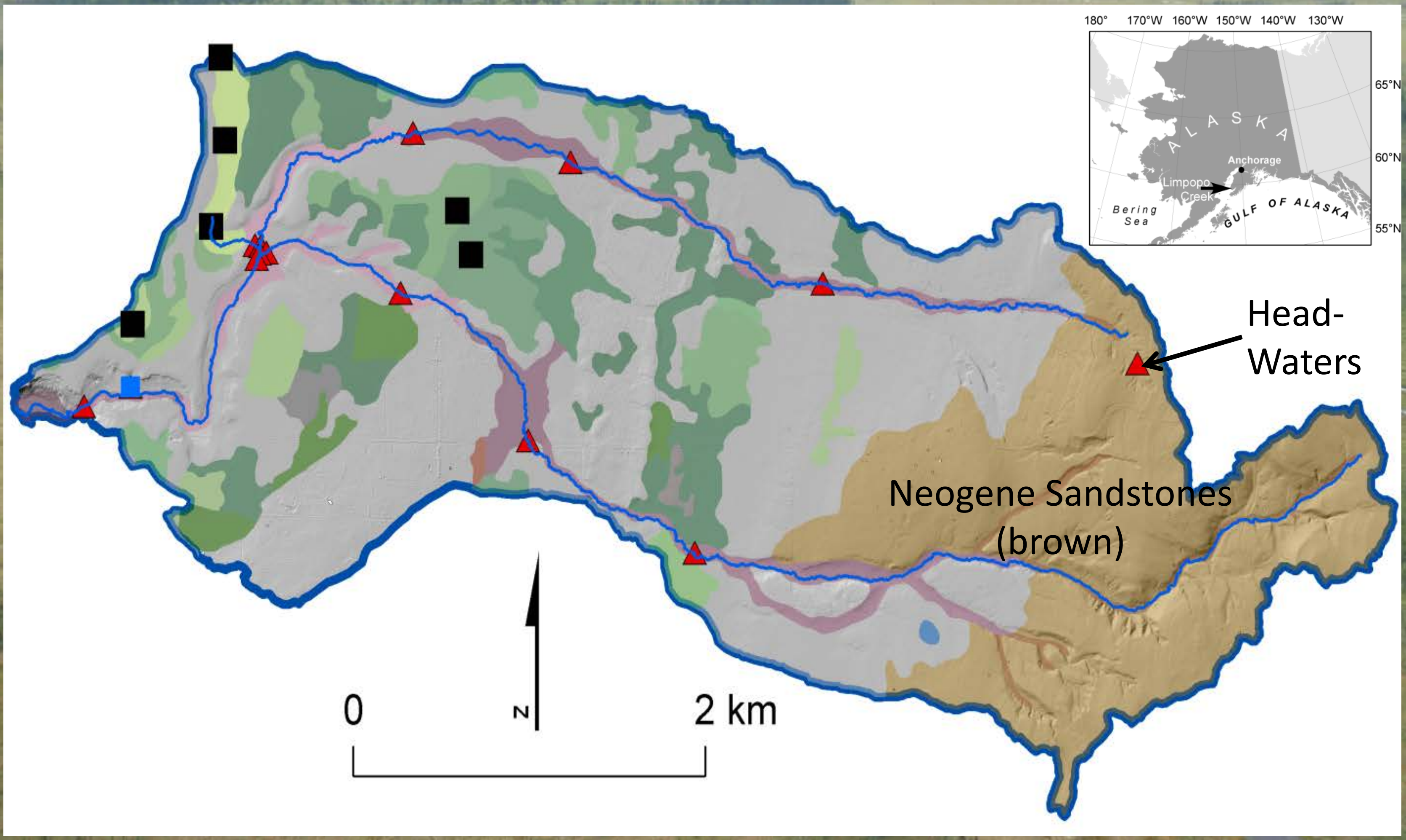
Possible that peatlands support flow during dry periods

Mixing Model

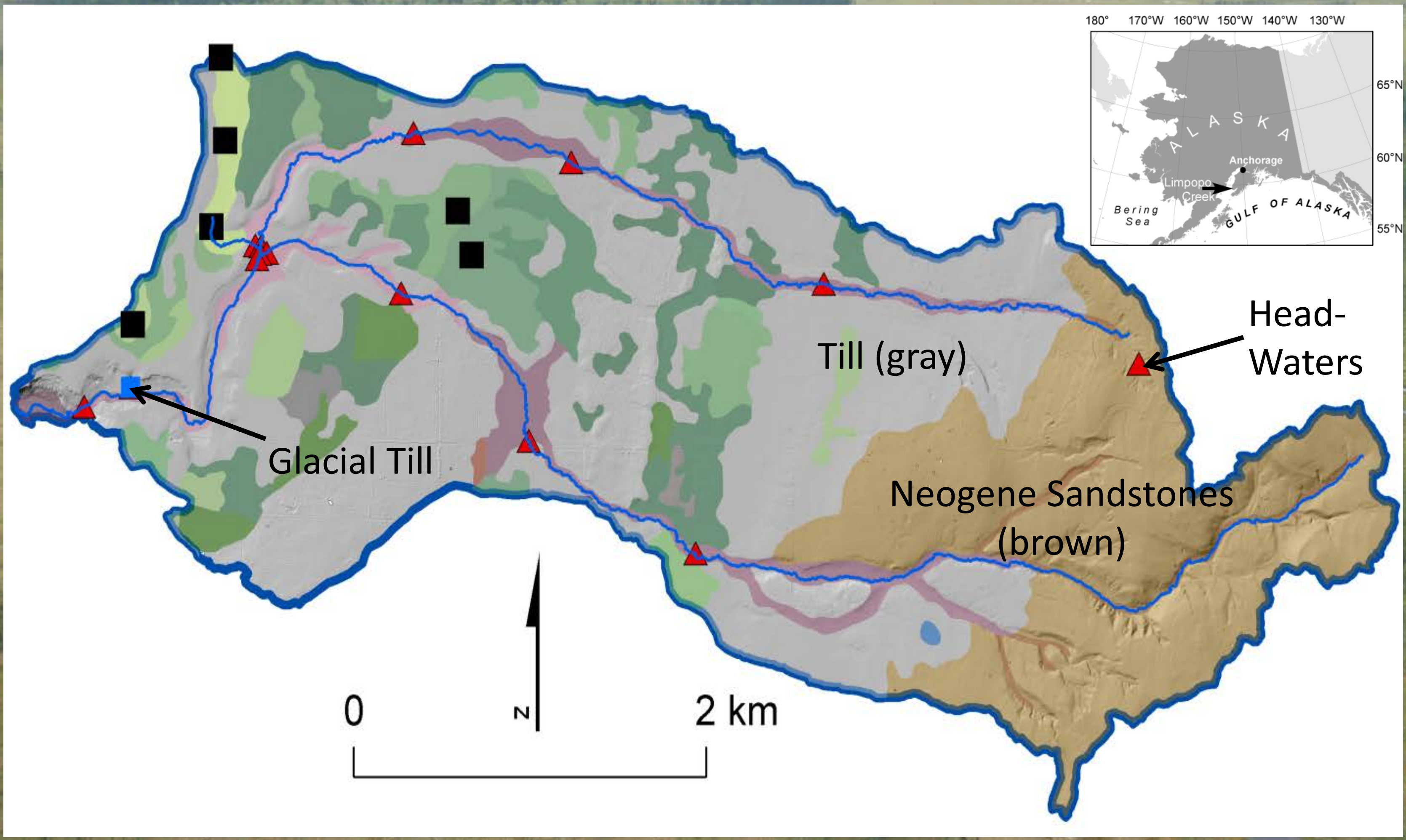
% contribution of end-members to stream flow



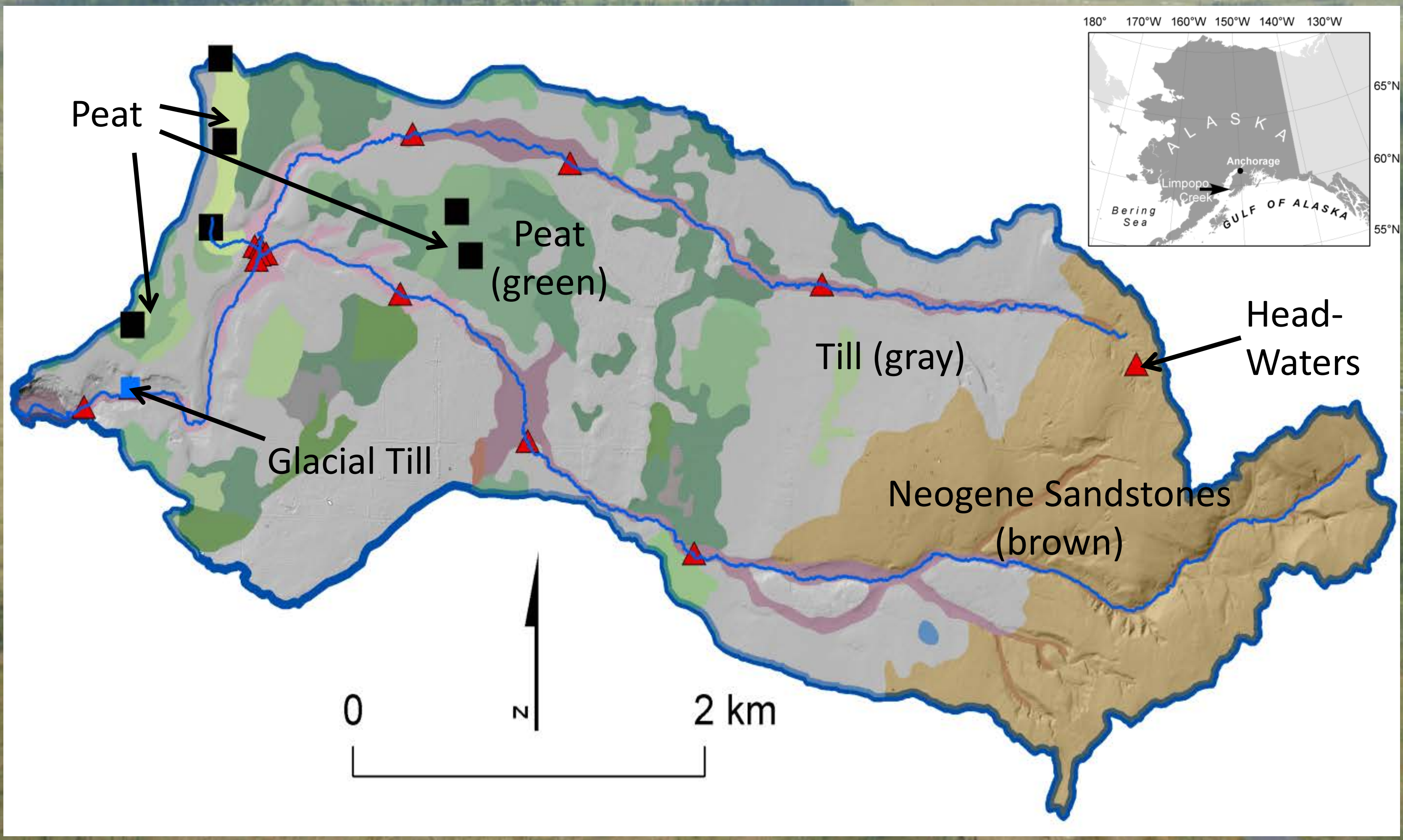
Mixing Model



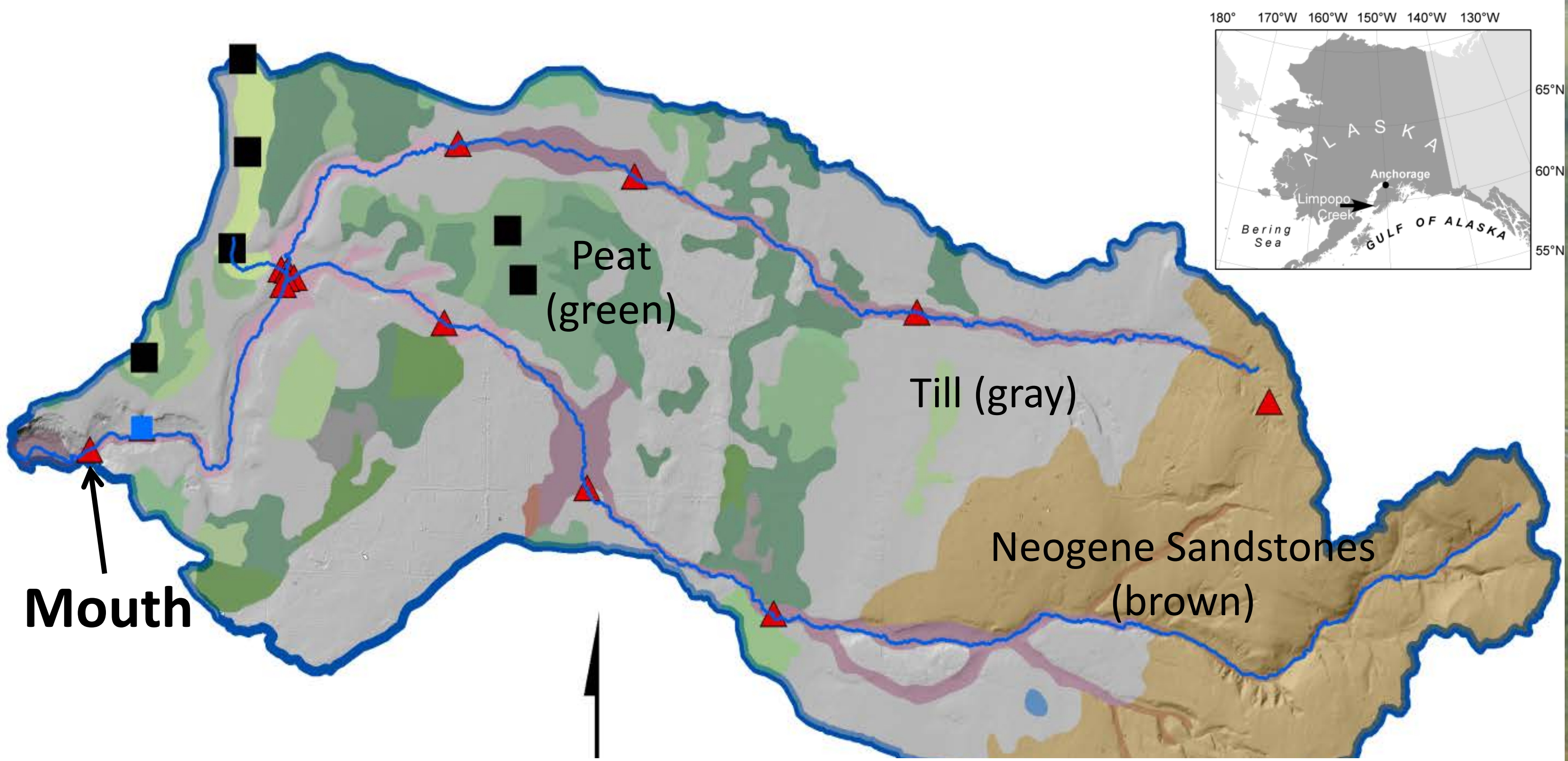
Mixing Model



Mixing Model



Mixing Model



Stream Water at Mouth = % each end-member

Mixing Analysis

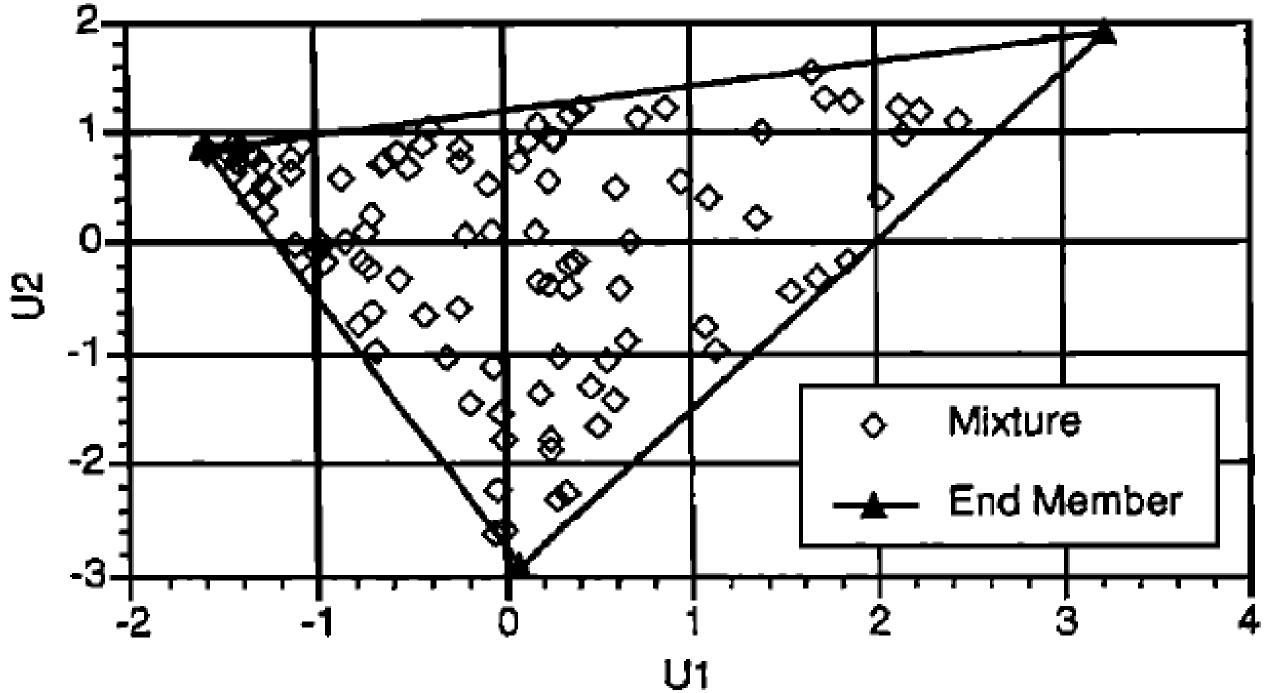
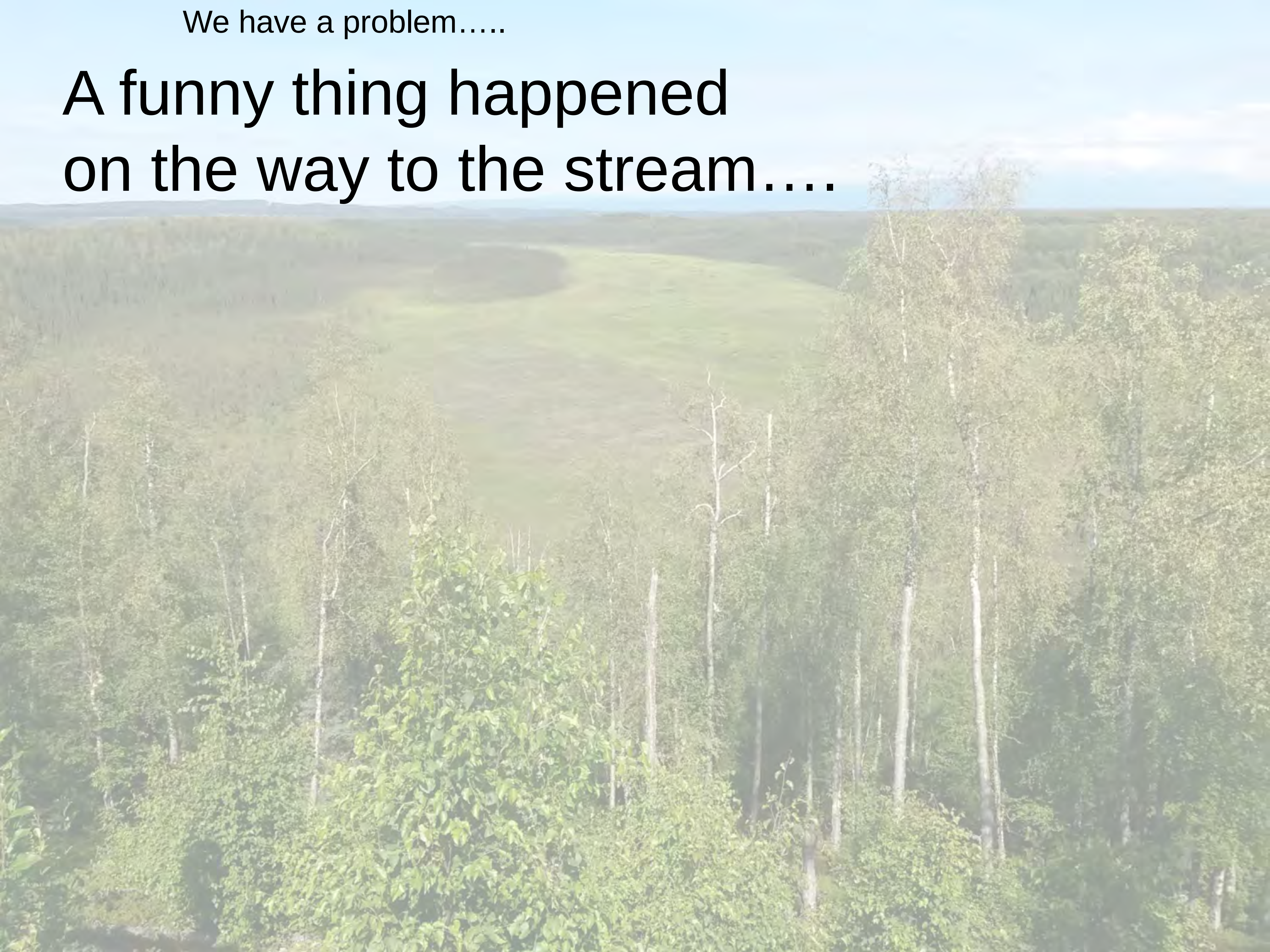


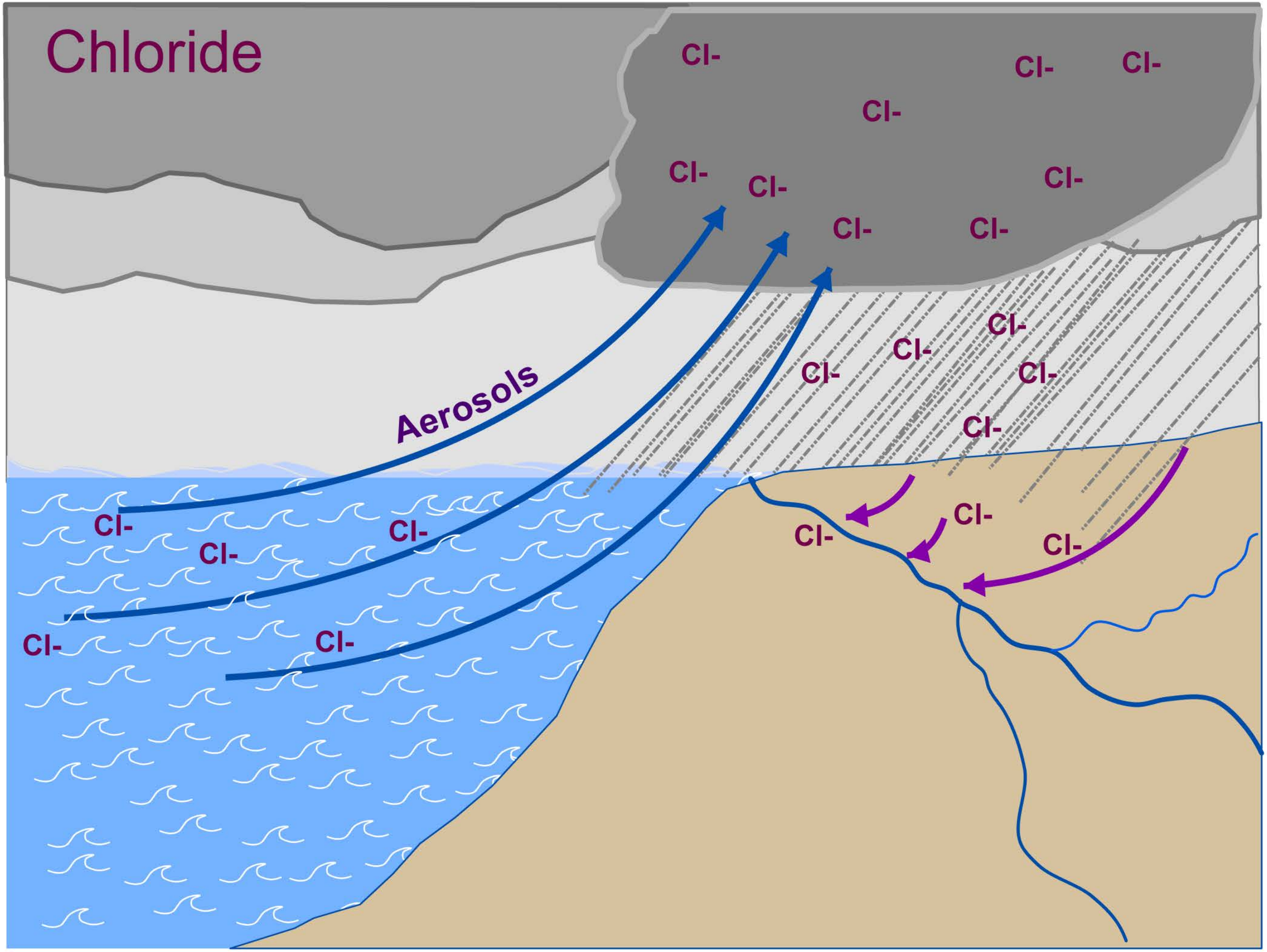
Fig. 3. Artificial data with pure end-members in *U* space defined by the correlation matrix.

FROM:
Christophersen N, Hooper RP 1992. Multivariate analysis of stream water chemical data: The use of principal components analysis for the end-member mixing problem. *Water Resources Research* 28, 99-107. DOI: 10.1029/91wr02518.

We have a problem…..

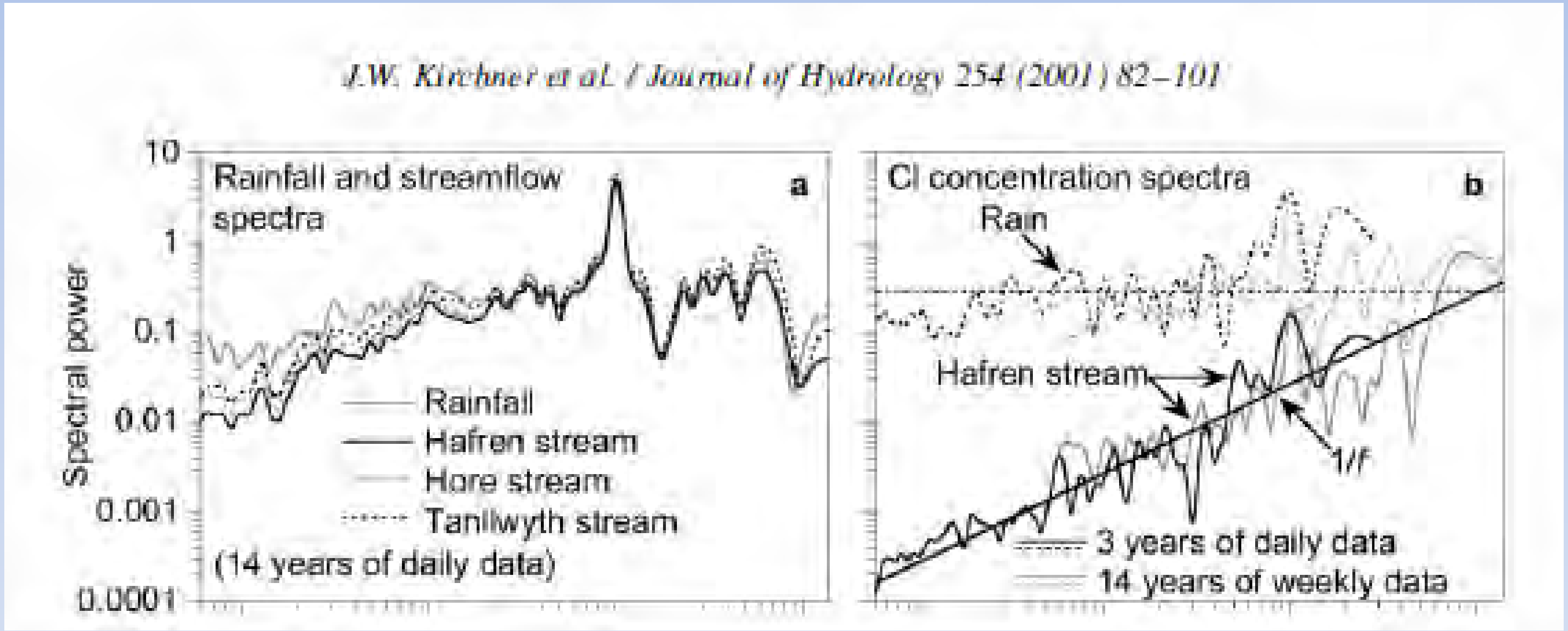
A funny thing happened on the way to the stream….





Chloride
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Aerosols
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-
Cl-

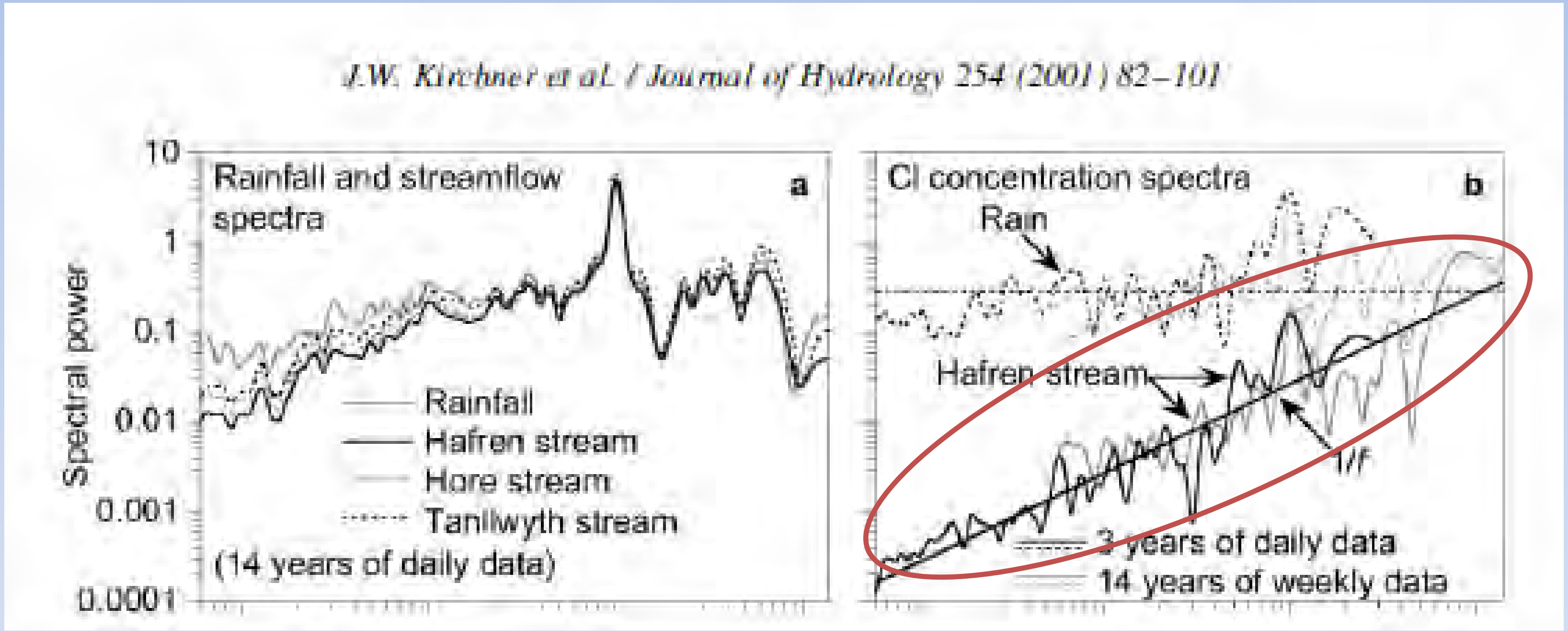
Flow & Rainfall average over time
Chloride in rain averages over time



Amount of rainfall or streamflow

Chloride in rainfall or stream water

Flow averages over time
Chloride in rain averages over time
Chloride in stream water does not average



Amount of rainfall
or streamflow

Chloride in rainfall
or stream water

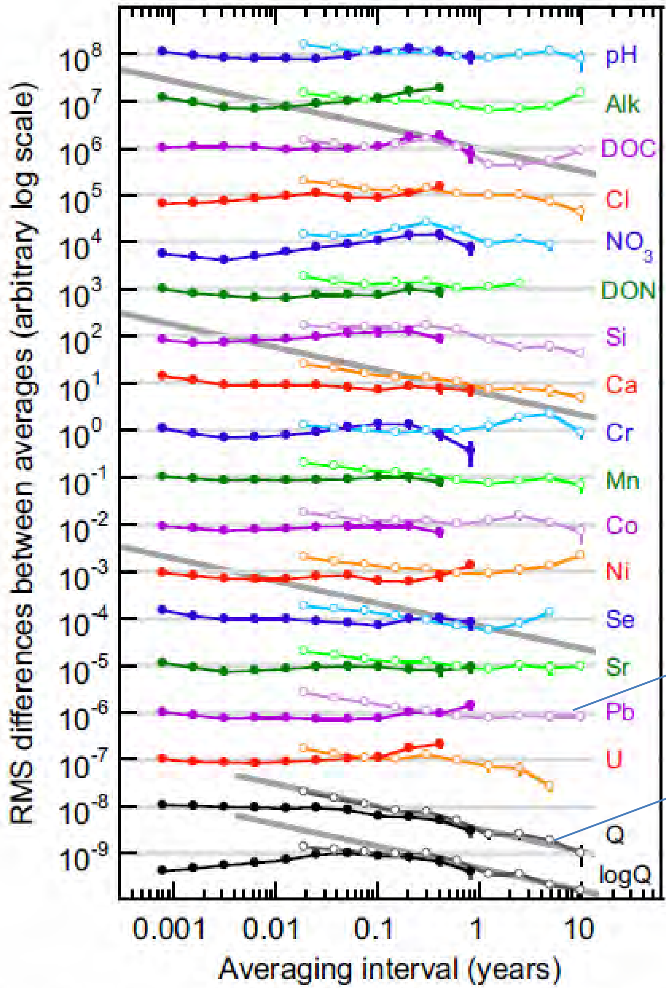


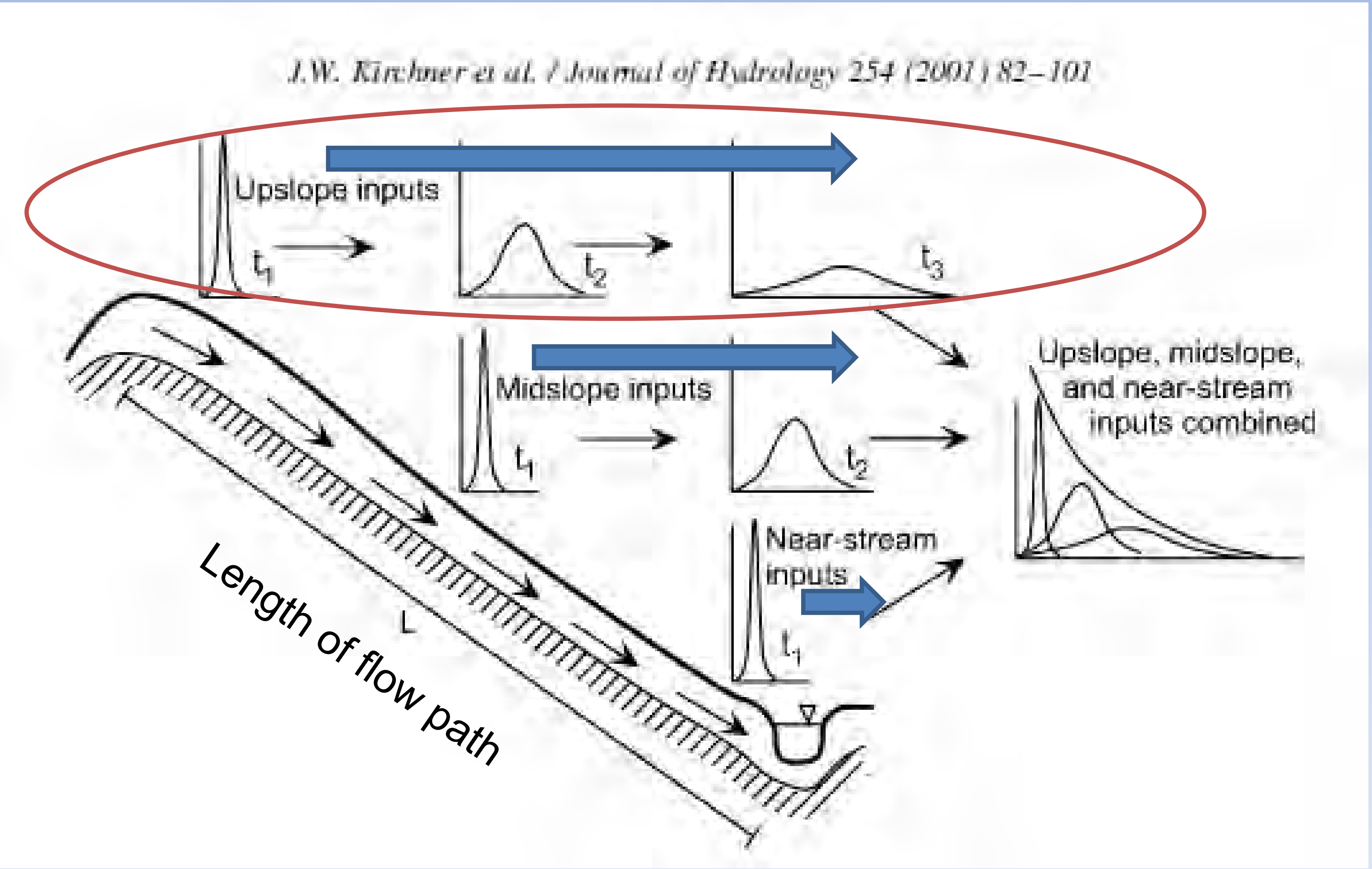
Fig. 4. Non–self-averaging behavior in water quality time series, illustrated by rms differences between successive mean concentrations of selected solutes in 7-h and weekly samples of Upper Hafren streamwater (solid and open symbols, respectively) averaged over intervals ranging from 7 h to 5–10 y. Error bars show SEs. Thin gray reference lines show trends for non–self-averaging behavior, in which averages over longer and longer time scales do not converge. Heavy gray lines show the slope of −0.5 predicted by the central limit theorem for self-averaging time series. The solutes generally plot as horizontal lines, indicating non–self-averaging behavior. In contrast, stream discharge and its logarithmic transform both follow the self-averaging behavior indicated by the heavy gray lines, for time scales longer than ~0.1 y. Individual solutes are shifted by arbitrary factors so they can be plotted together. Plots for all 45 solutes and both sampling sites are shown in *SI Appendix*, Fig. S10.

NOT Self-averaging over time: Lead
(or almost everything but streamflow)

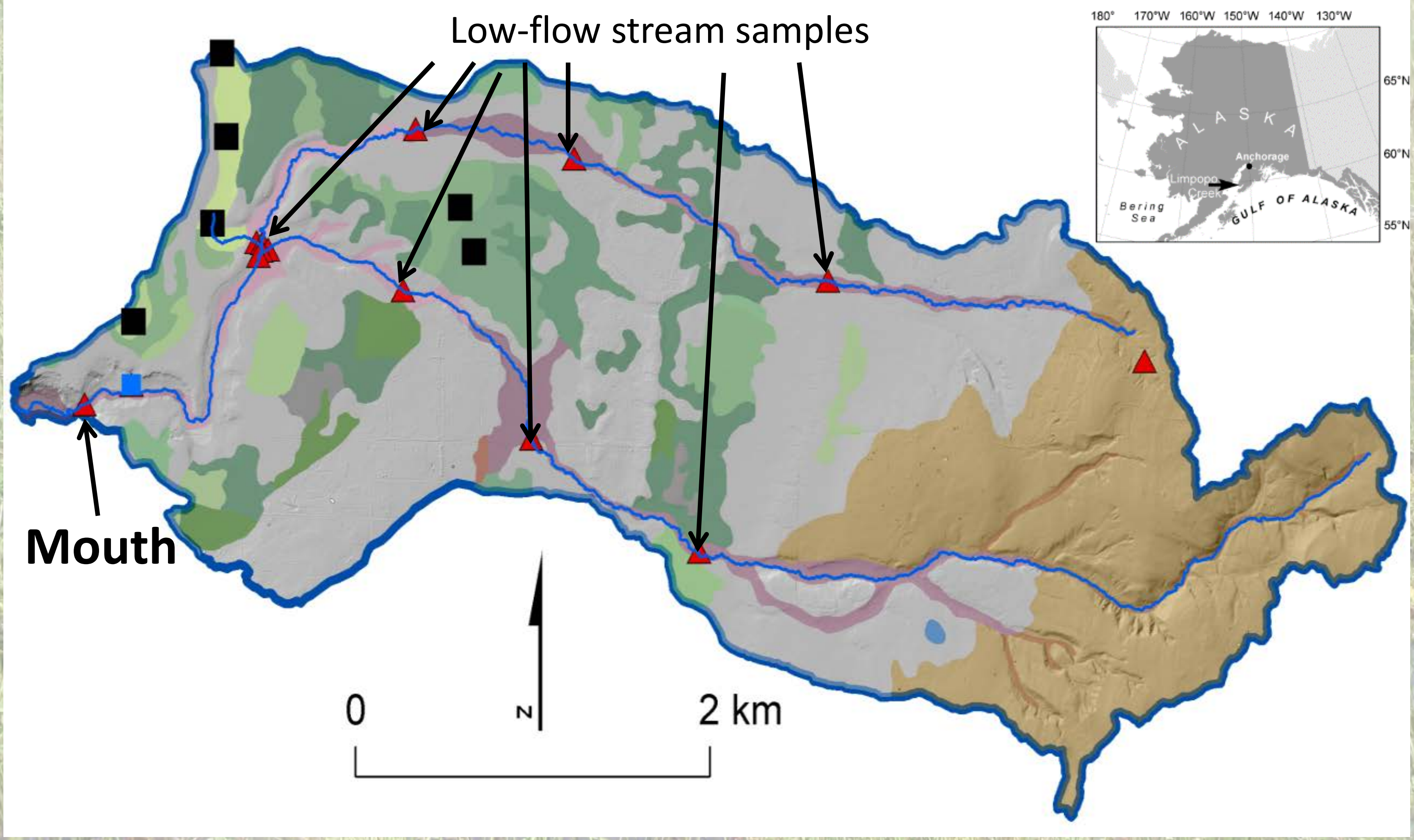
Self-averaging over time: streamflow

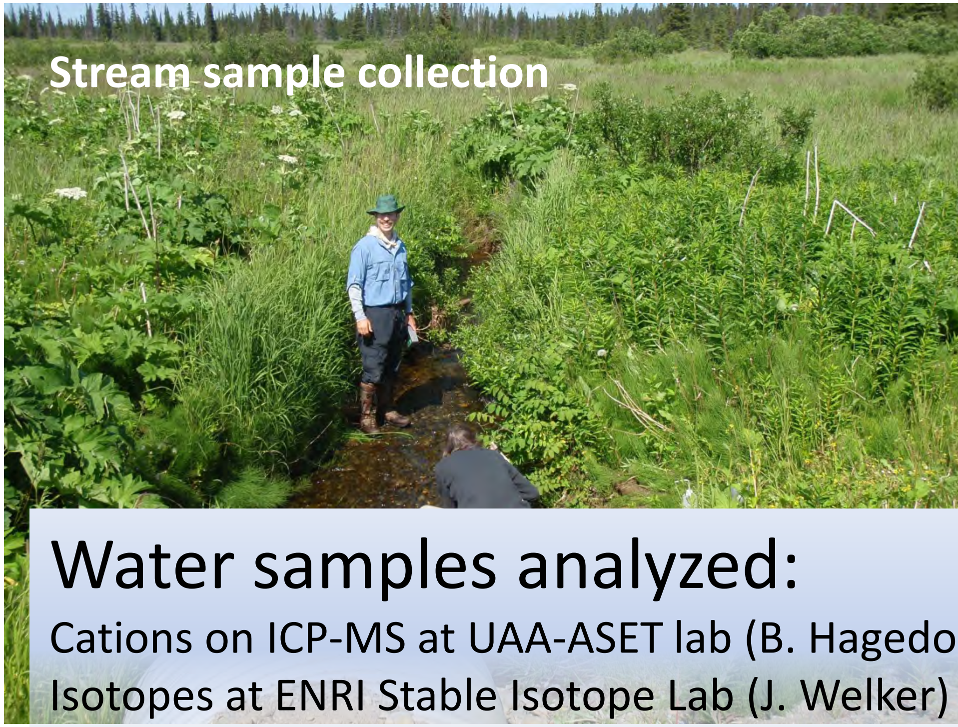
From: Kirchner, J.W., and Neal, C., 2013. Universal fractal scaling in stream chemistry and its implications for solute transport and water quality trend detection. Proceedings of the National Academy of Sciences 110, 122213-122218

Watershed acts as a "fractal filter"



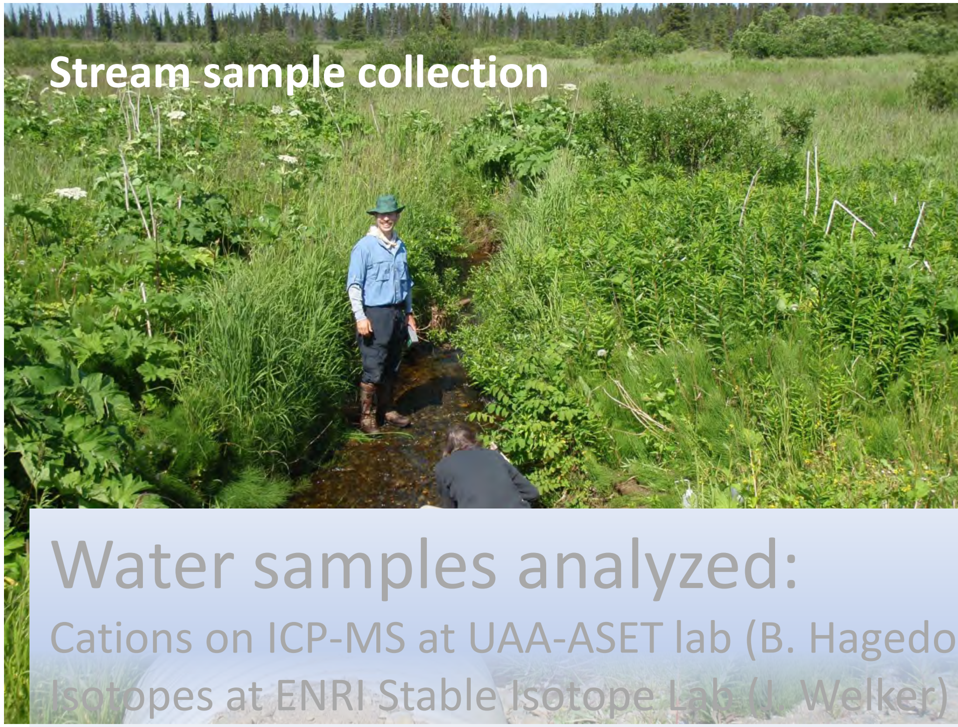
Mixing Analysis





Water samples analyzed:

Cations on ICP-MS at UAA-ASET lab (B. Hagedorn)
Isotopes at ENRI Stable Isotope Lab (J. Welker)
Anions at EPA MED lab, Duluth, MN (M. Moffett, L. Anderson)



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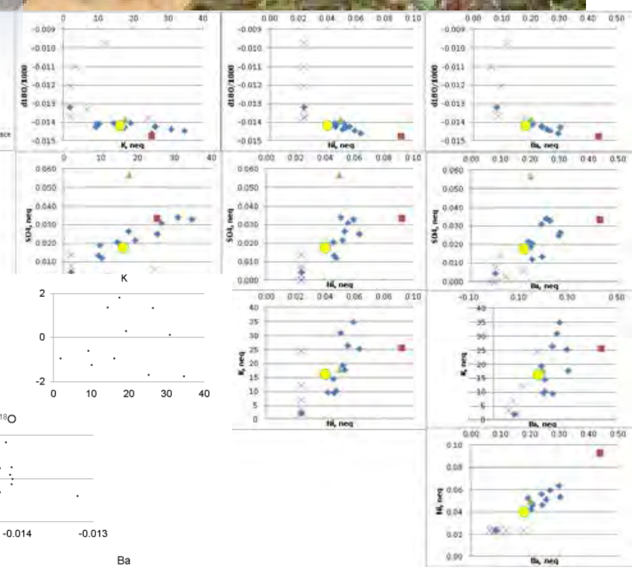
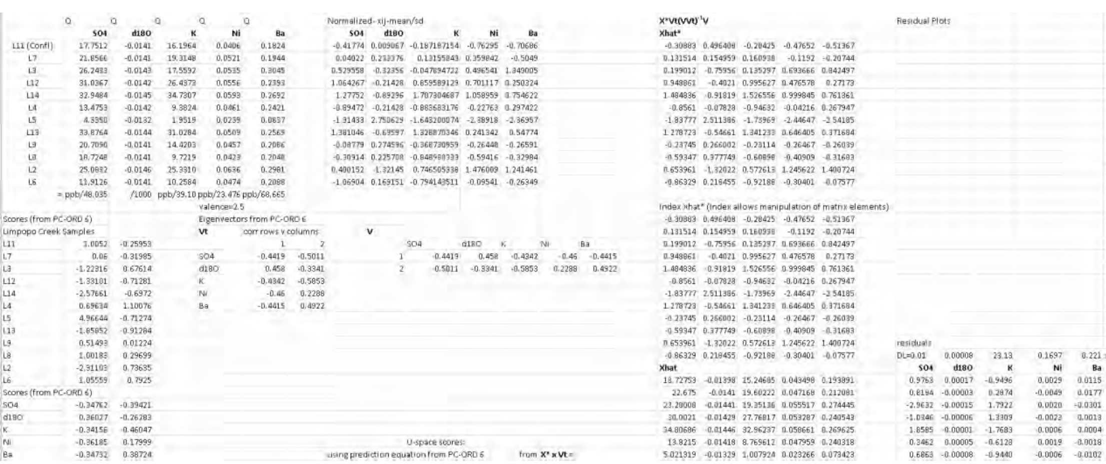
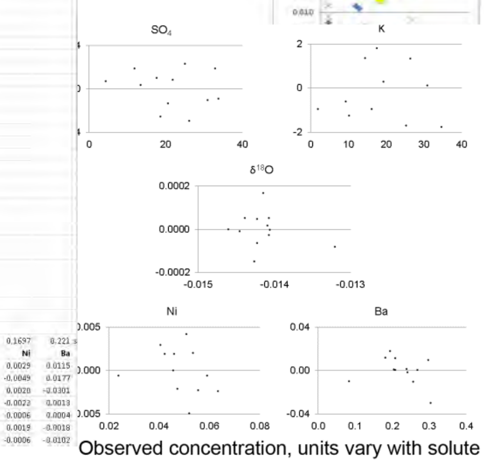
PCA: EMMA procedures

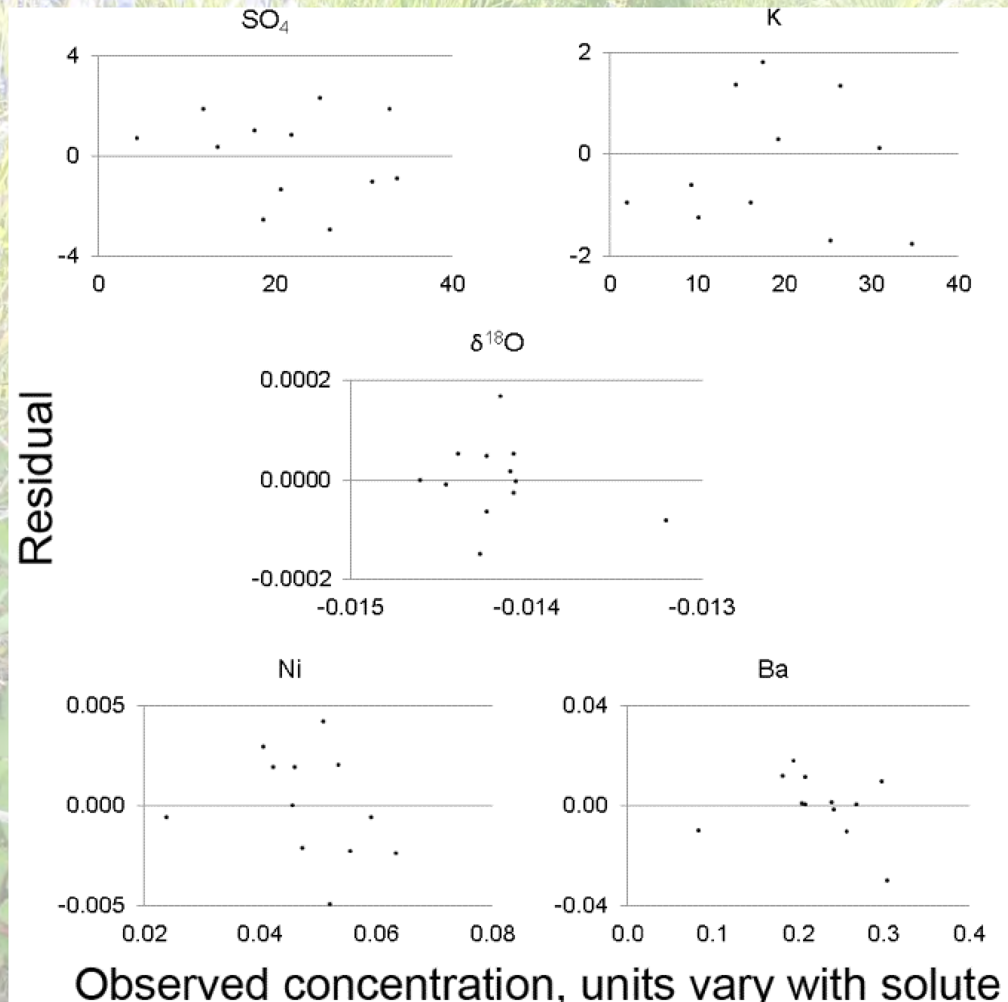
-Hooper 2003



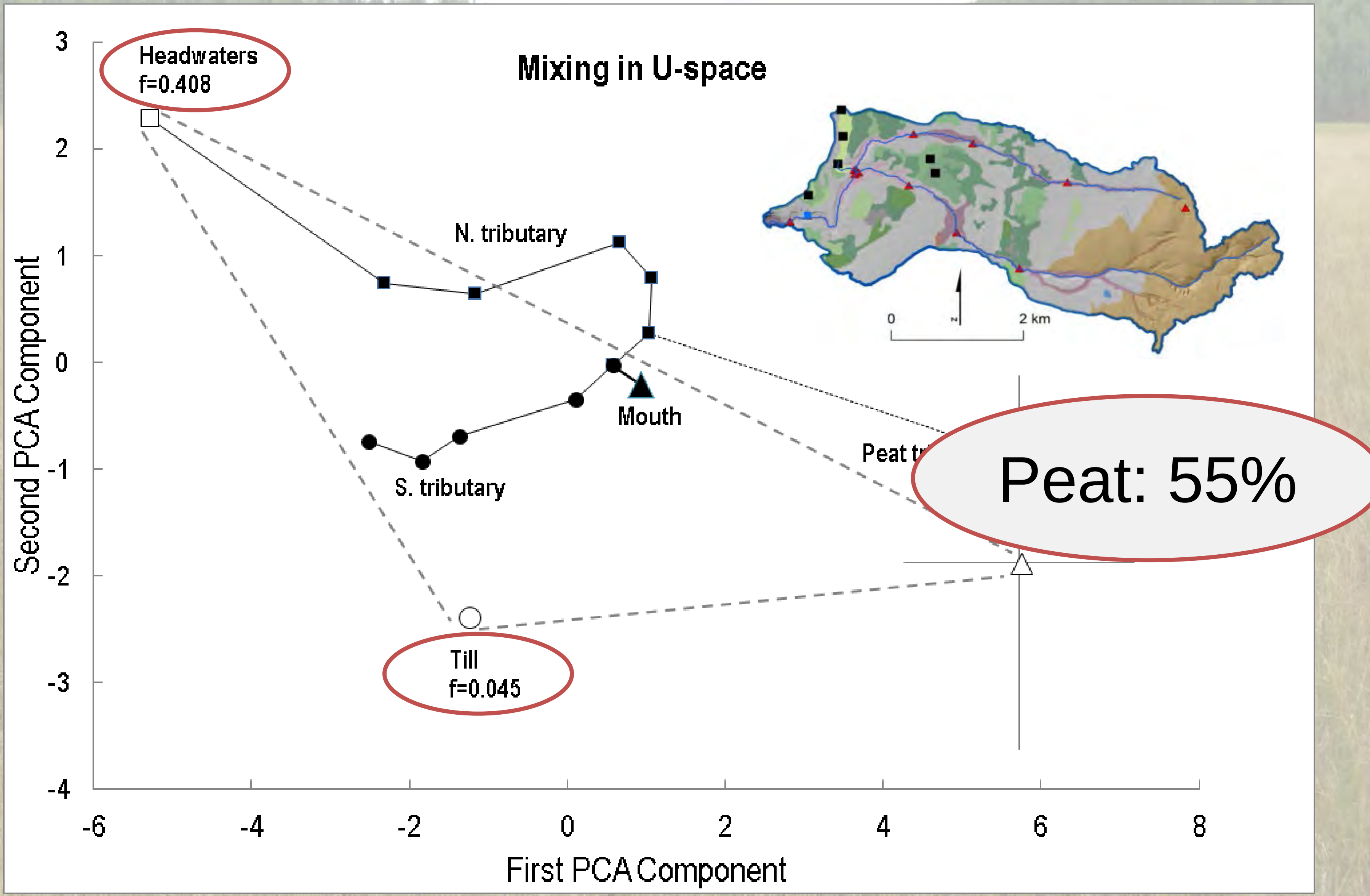




5 tracers: SO_4, K, $\delta^{18}O$, Ni, Ba



3 End-member model



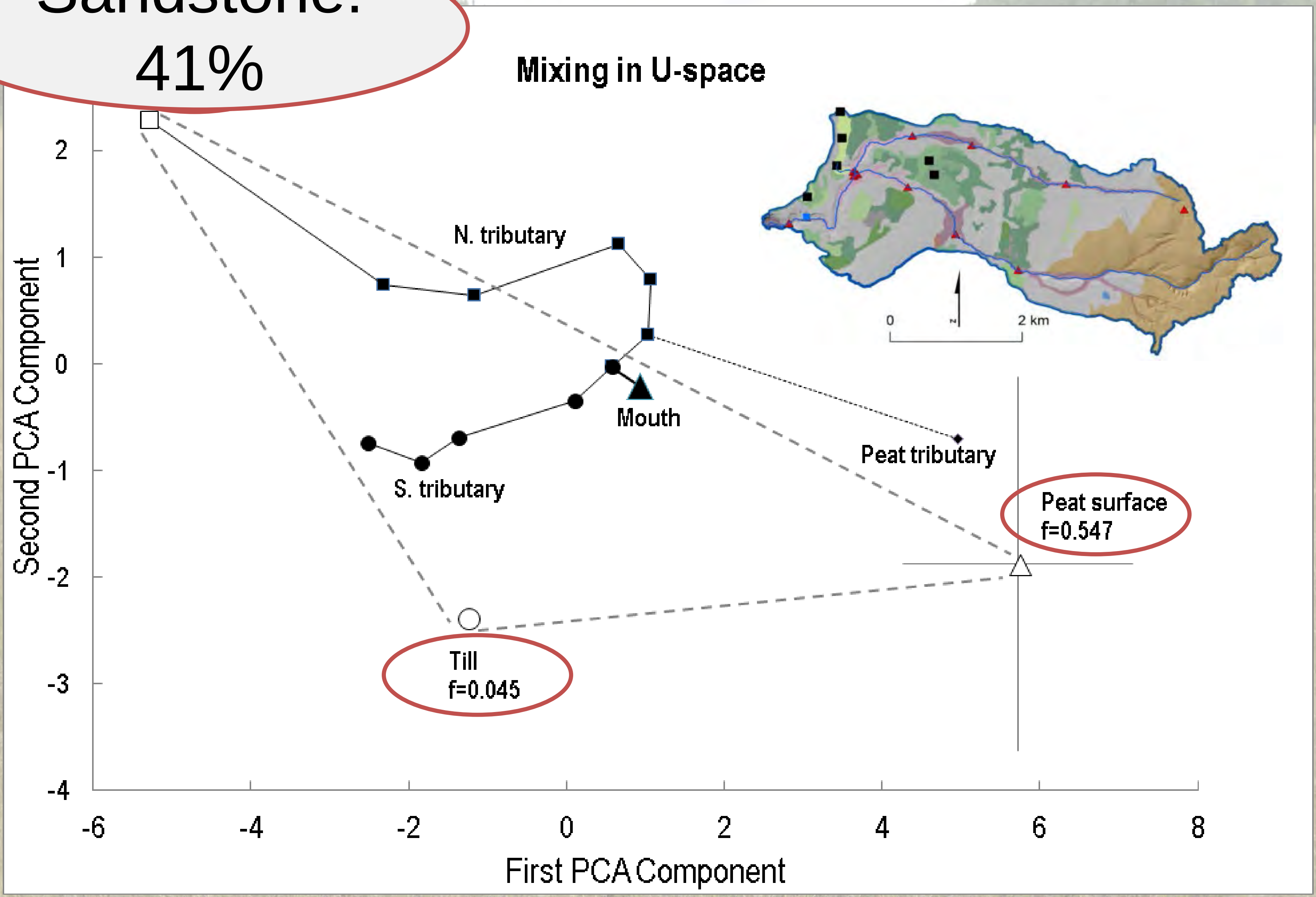
55% Matches peatland flow in water budget

		Specific Yield			
	ϕ	**0.45**	**.14**	**0.10**	**0.05**
Thornthwaite	0.8	0.259	0.080	0.060	0.029
	0.9	0.297	0.092	0.066	0.033
	0.131	0	0	0	0
Diurnal ET		0.108	0.033	0.024	0.012

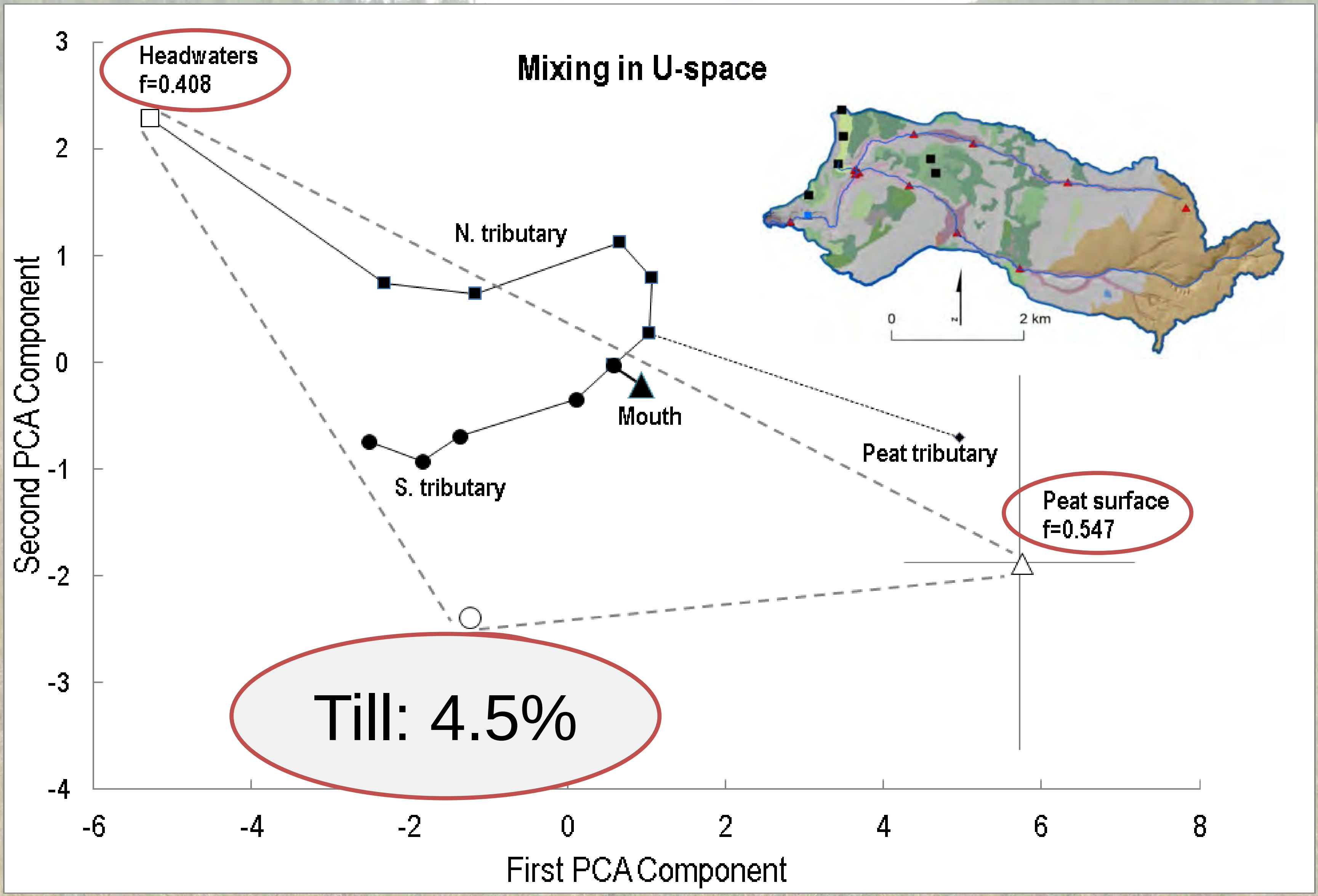
(Actual streamflow = 0.06 m^3s^{-1})

3 End-member model

Sandstone: 41%



3 End-member model



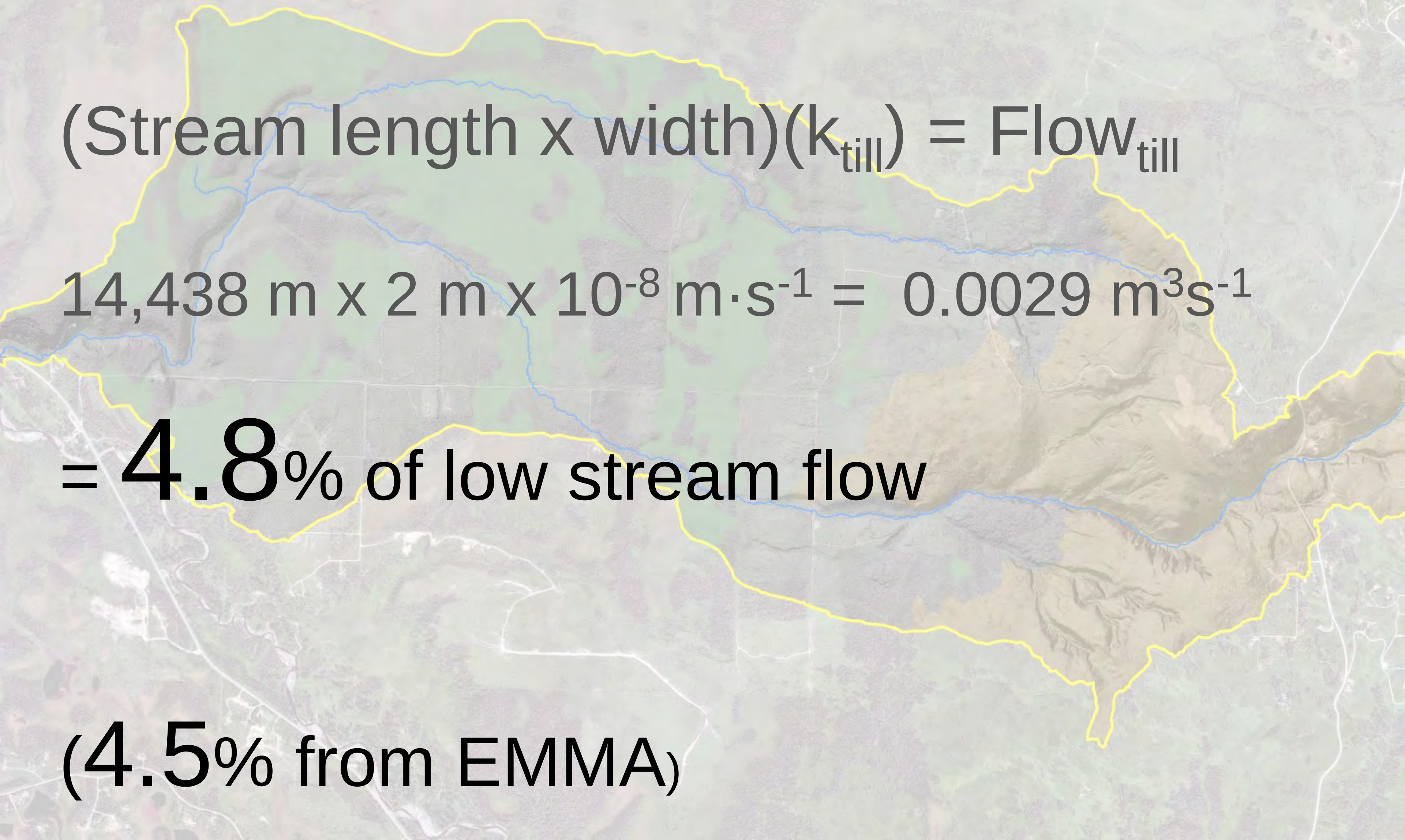
Low conductivity of Glacial Till

$(\text{Stream length x width})(k_{till}) = \text{Flow}_{till}$

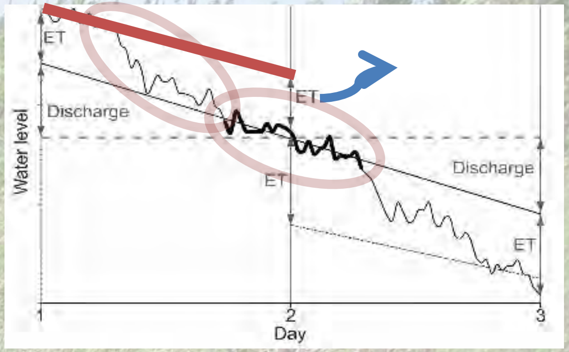
$14{,}438 \text{ m} \times 2 \text{ m} \times 10^{-8} \text{ m}\cdot\text{s}^{-1} = 0.0029 \text{ m}^3\text{s}^{-1}$

= **4.8**% of low stream flow

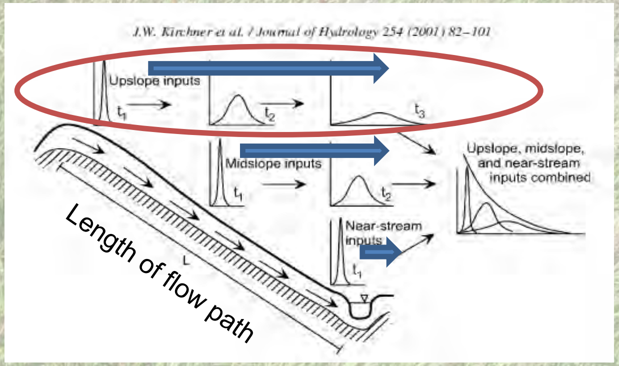
(4.5% from EMMA)



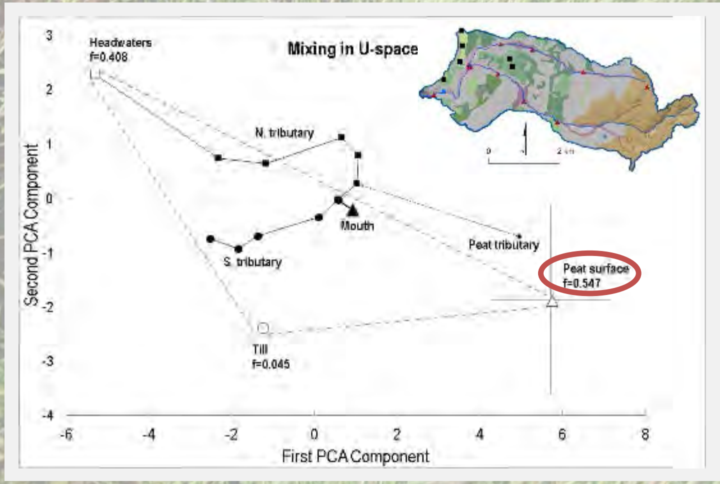
1. **ET estimated using a diurnal method without recharge**



2. **Space-for-Time sampling in EMMA can avoid fractal filtering problems**



3. **Peat contributed ~55% of dry-season stream flow**



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Richard Reger
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Mary Moffet
Nigel Roulet

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Don Siegel
Leroy Anderson
Collen Elonen
Jeffery Welker
Matt Rogers
Birgit Hagedorn

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Phil North
Mary Moffet
Sue Mauger
Marcella Dent
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US Fish and Wildlife Service
University of Minnesota

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