Modelling the effects of changing retention time on phytoplankton

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Why is retention time important?

Retention time is the length of time it takes for a particle to pass through a lake system

Directly related to discharge (climate) and lake volume

For phytoplankton, changes can affect abundance, species composition and timing of blooms

Retention time and lake biology

Can be very important in short retention time lakes -

- **Loss process – flushing out algae**
- **Controlling the availability of nutrients**

Phosphorus (P) and phytoplankton biomass

- **Vollenweider model – chlorophyll related to P**
- **Assumes P is a controlling factor**

A simple model

Related to Vollenweider's model, it allows for the delivery, loss and sedimentation of phosphorus (*P*)

$$P = \frac{M}{(Q + \sqrt{QV})}$$

***M* = Annual P load**
***Q* = Lake discharge**
***V* = Lake volume**

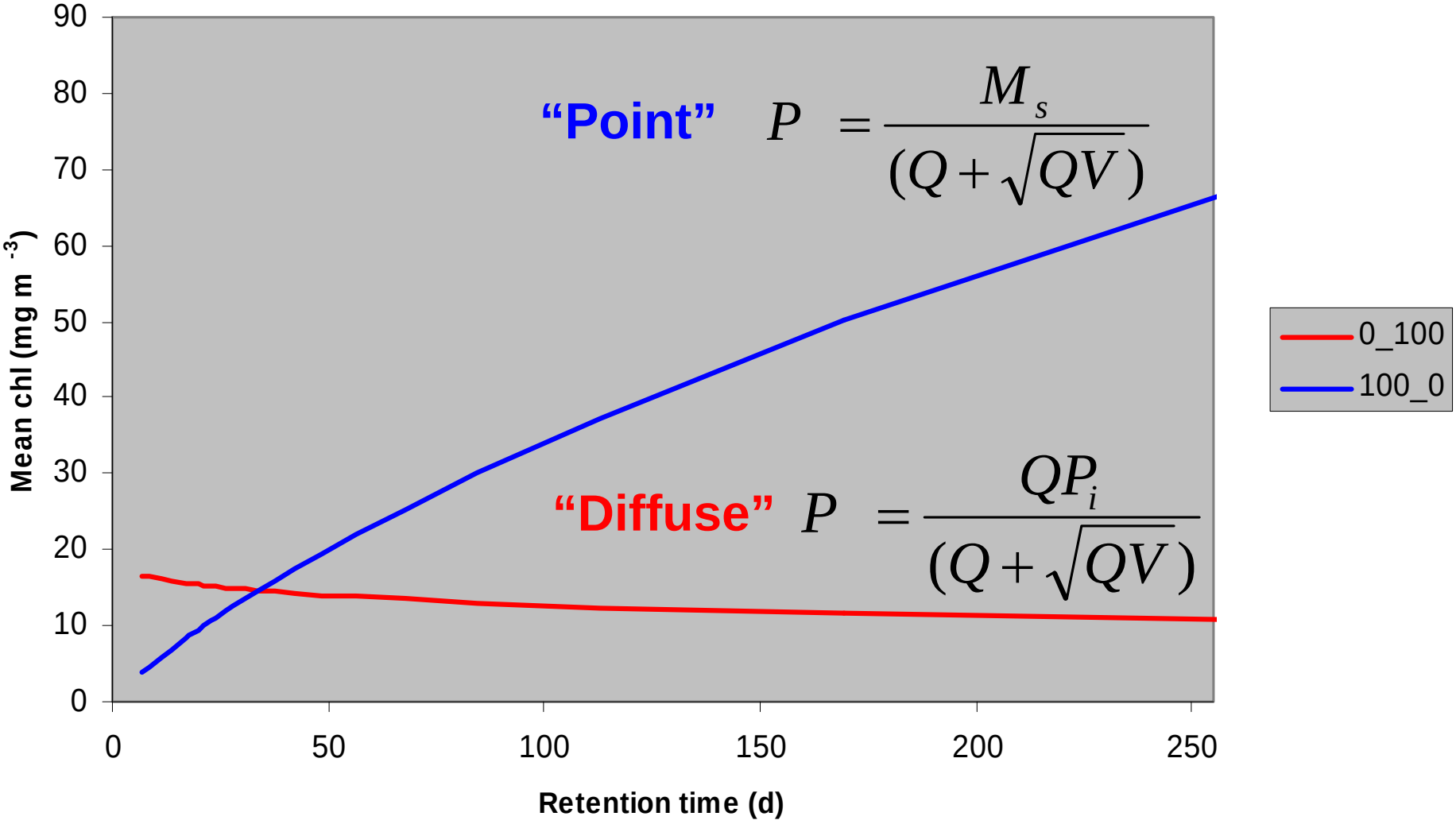
$$M = QP_i + M_s$$

P_i = inflow P concentration
M_s = point source/internal P

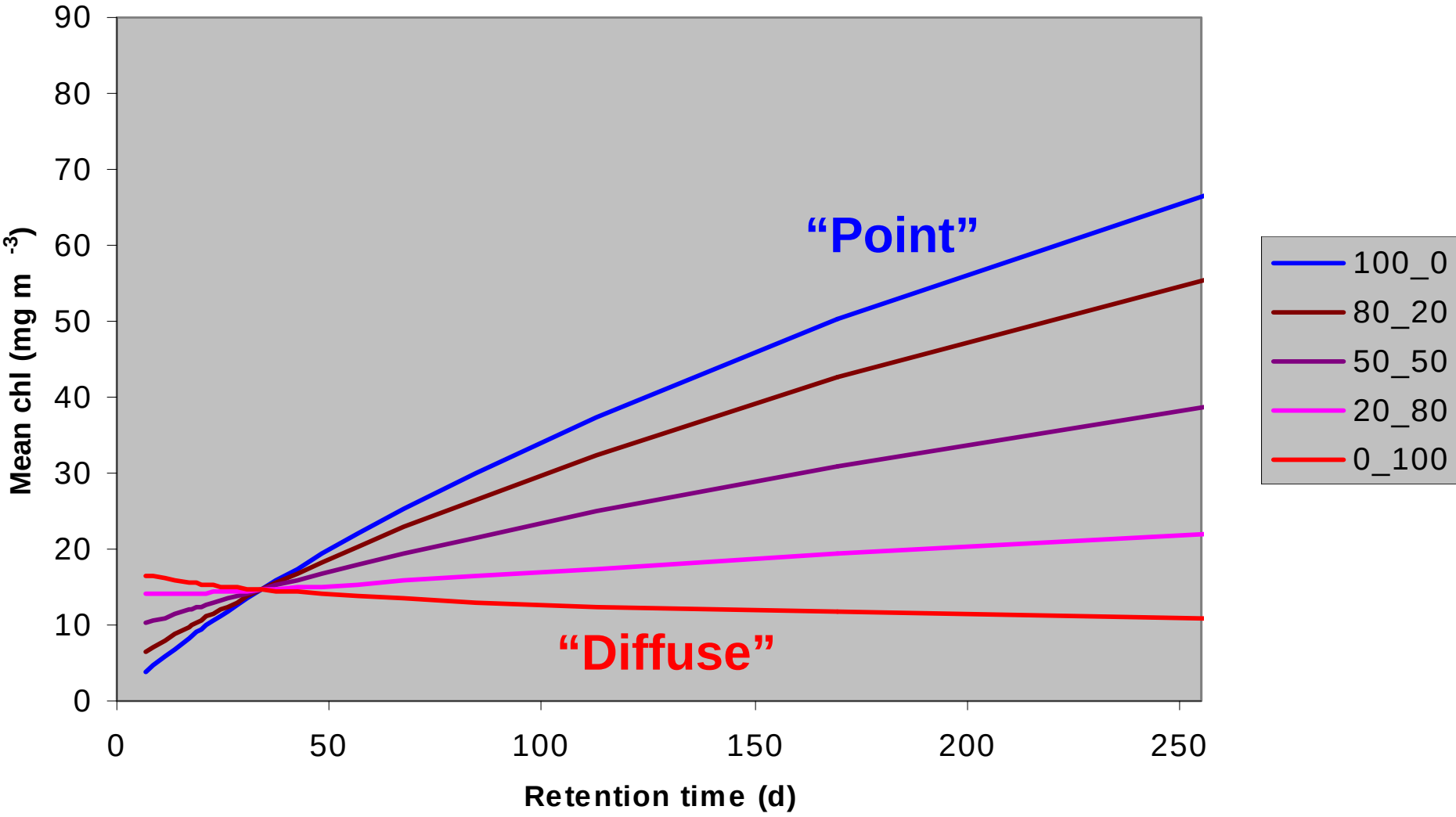
"Diffuse" **"Point"**

$$P = \frac{QP_i}{(Q + \sqrt{QV})} + \frac{M_s}{(Q + \sqrt{QV})}$$

Theoretical effect



Theoretical effect



Testing the theory

Test the theoretical response by process-based modelling of a real lake

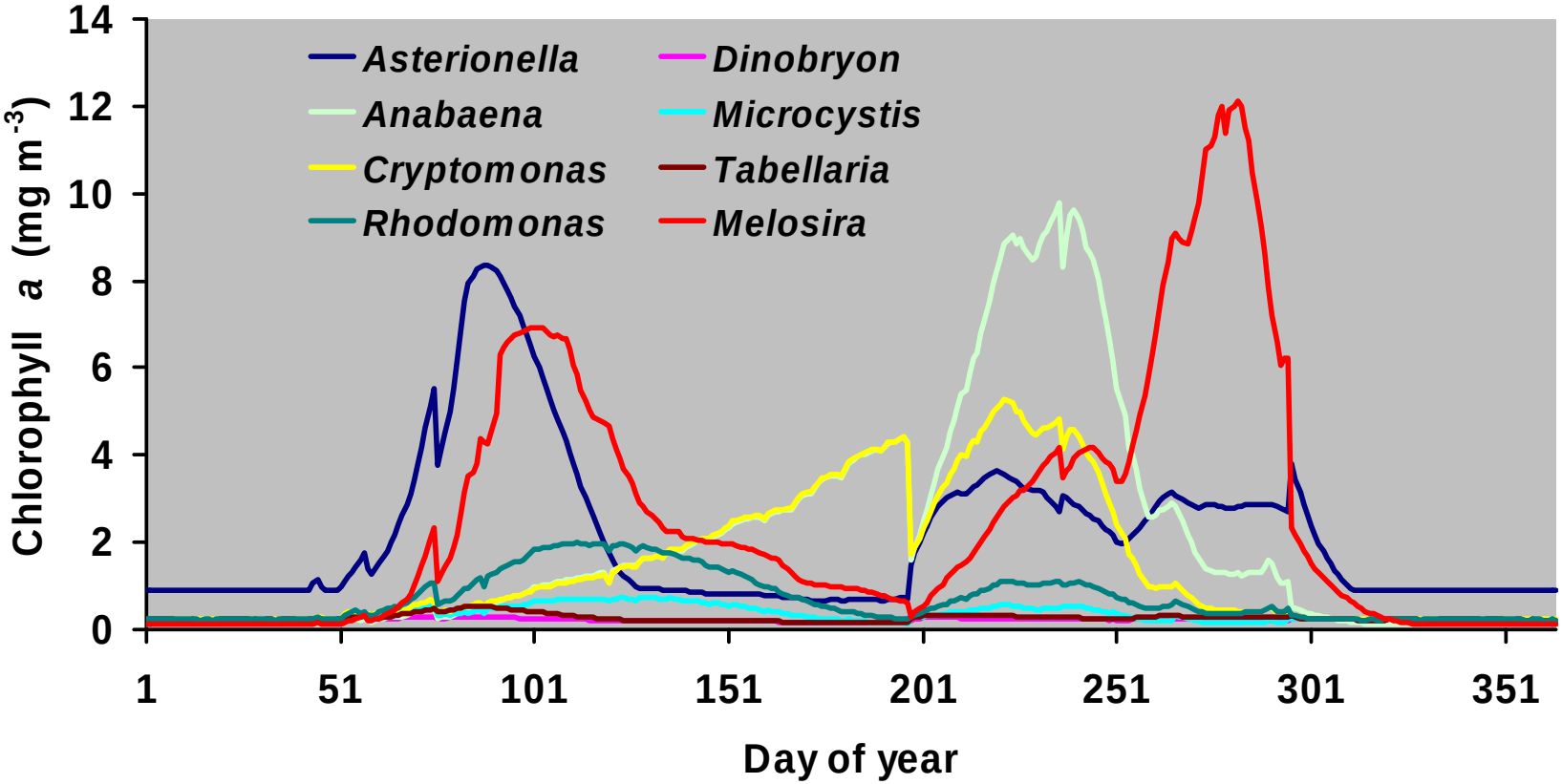
Run 100s of simulations over a range of retention times

Use a range of nutrient sources: from 100% “diffuse” to 100% “point”

Bassenthwaite Lake

A process-based model

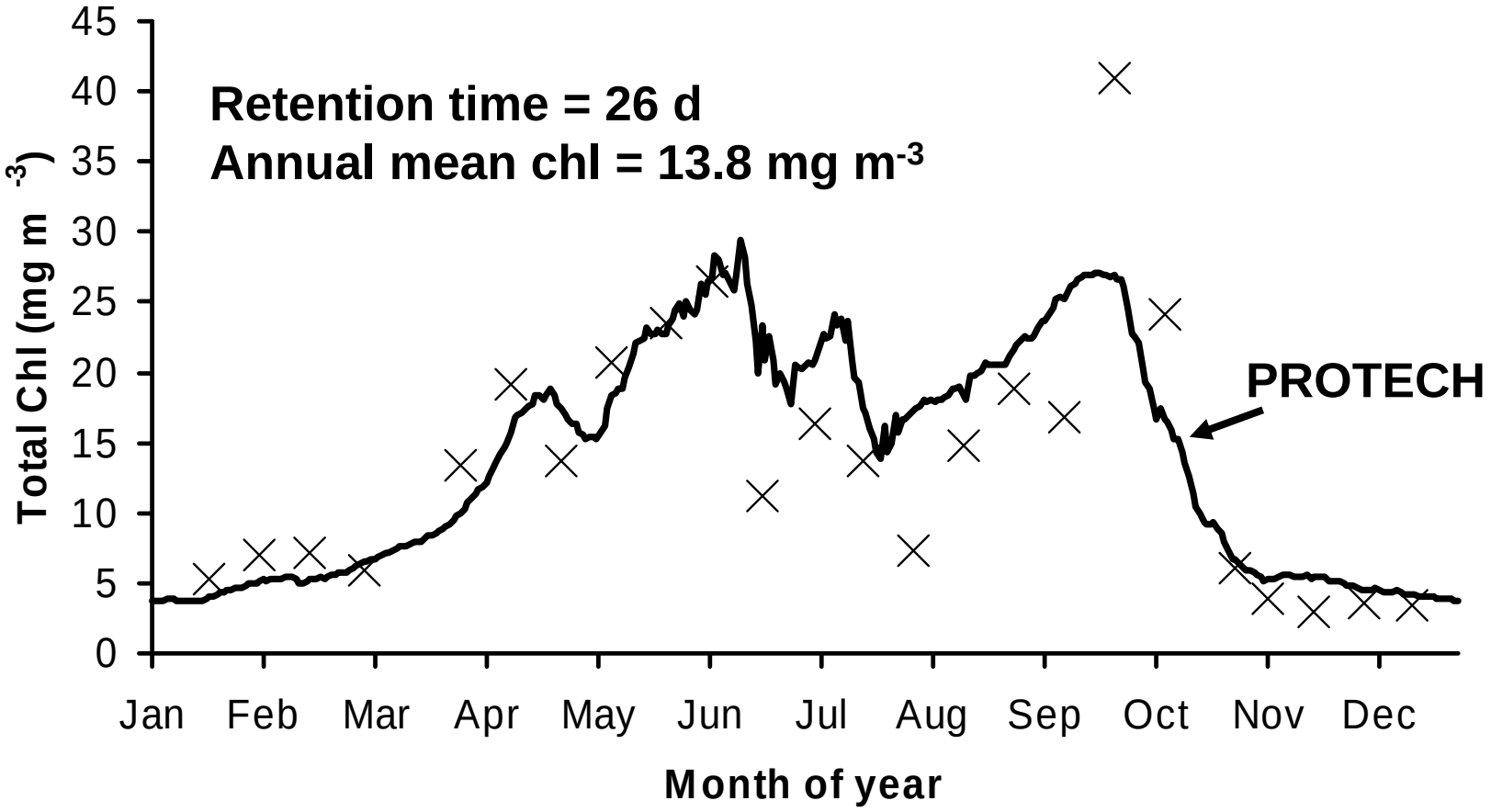
PROTECH (Phytoplankton RespOnses To Environmental CHange)



PROTECH predicts the biomass and species composition of the algal community giving it a unique world status

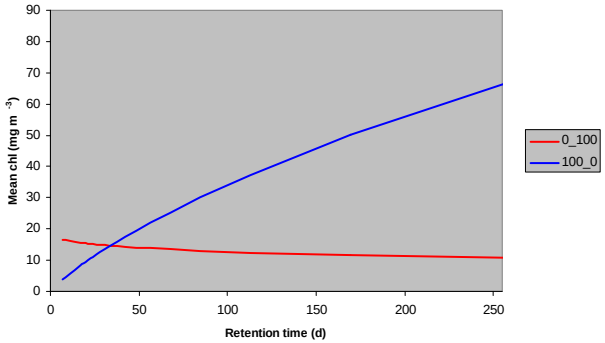
Model vs Observed

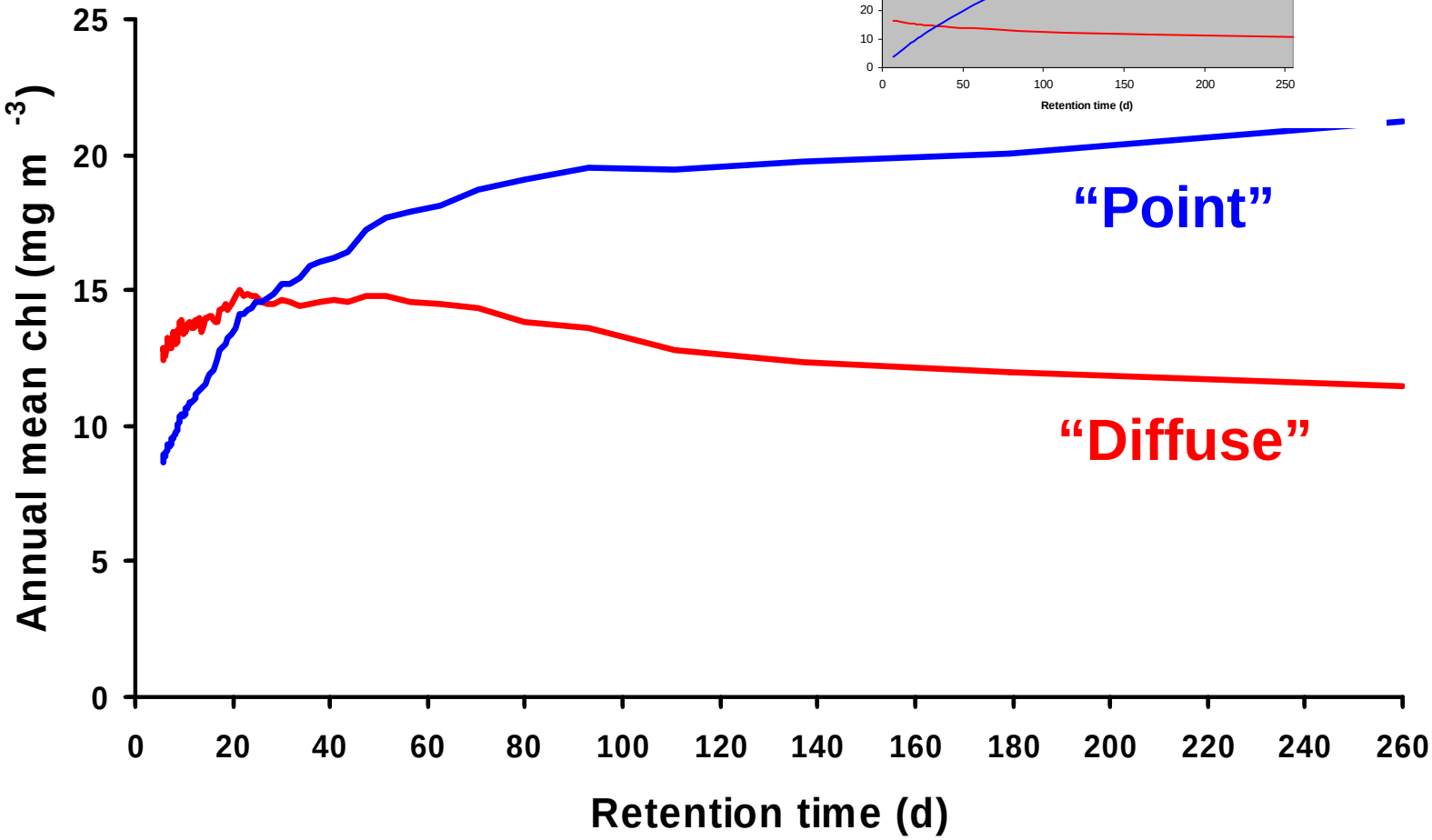
Total chlorophyll *a* (1996)



Change in annual mean chlorophyll

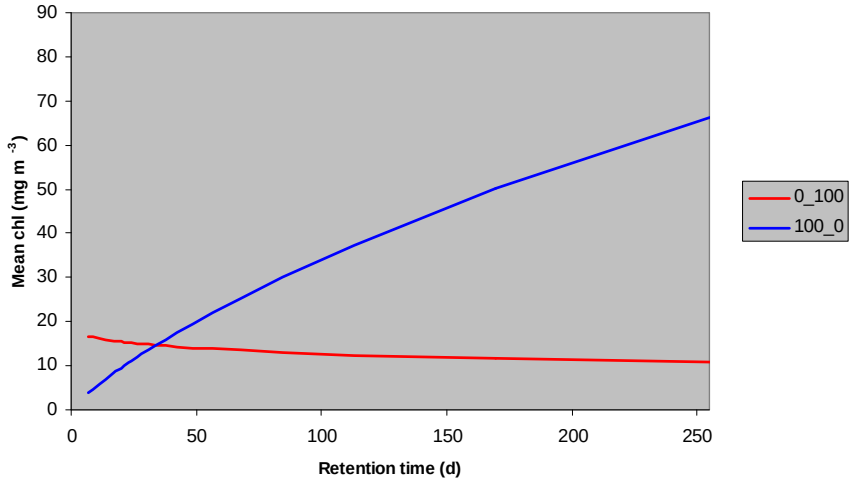
Comparison between the two nutrient scenarios

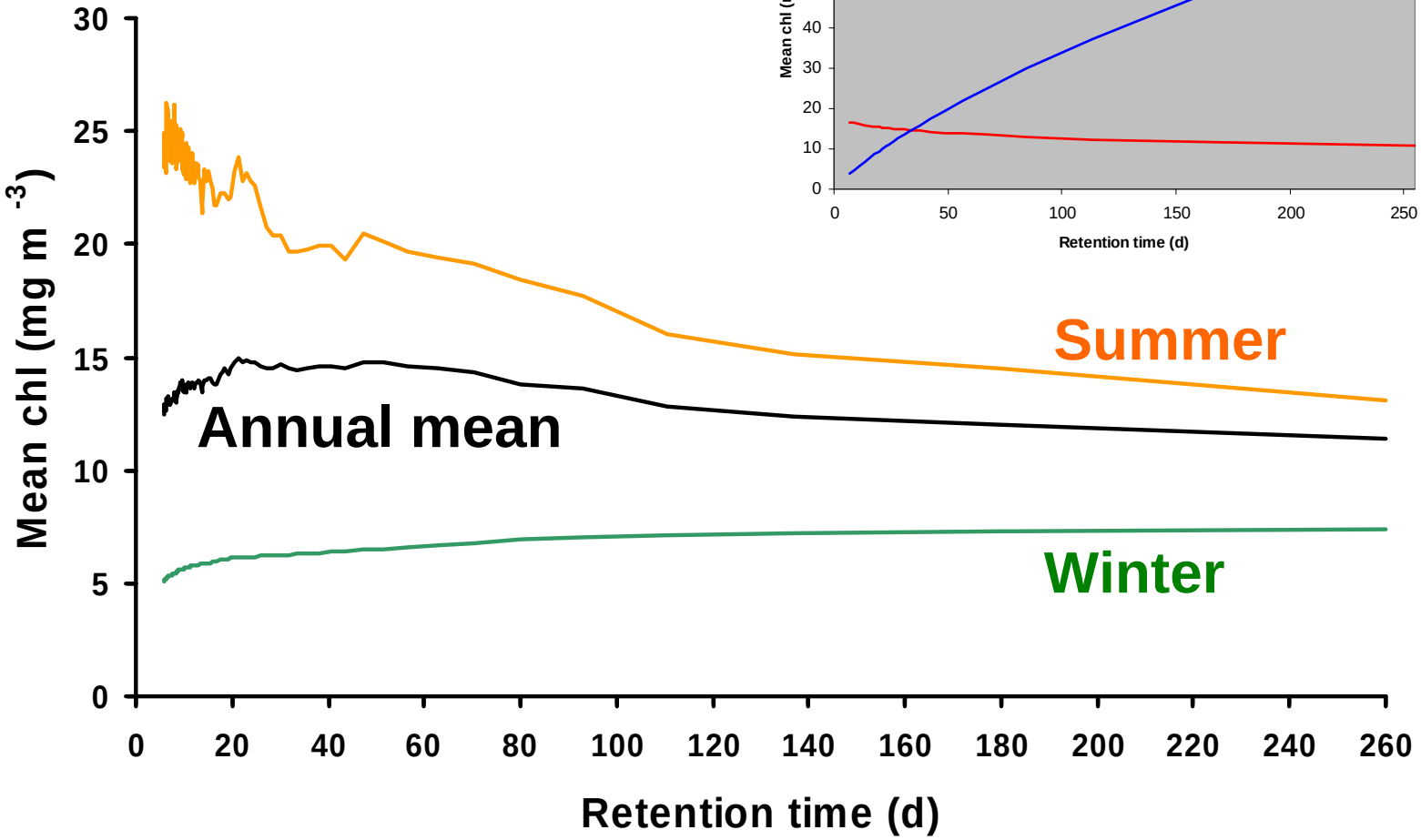




Seasonal changes

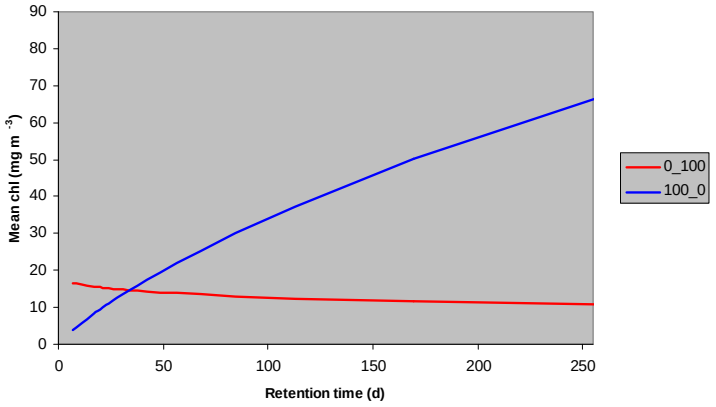
"Diffuse" nutrient source

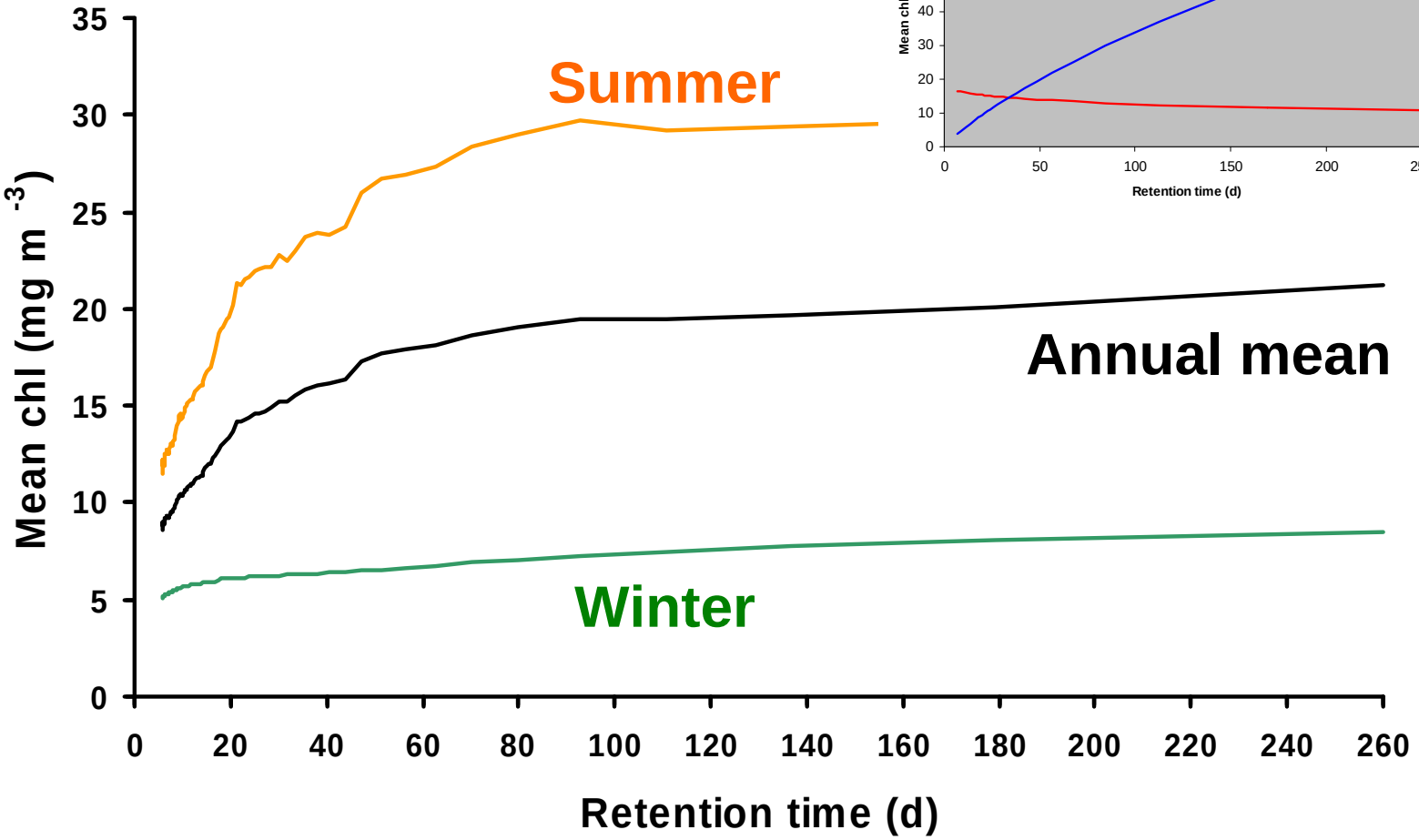




Seasonal changes

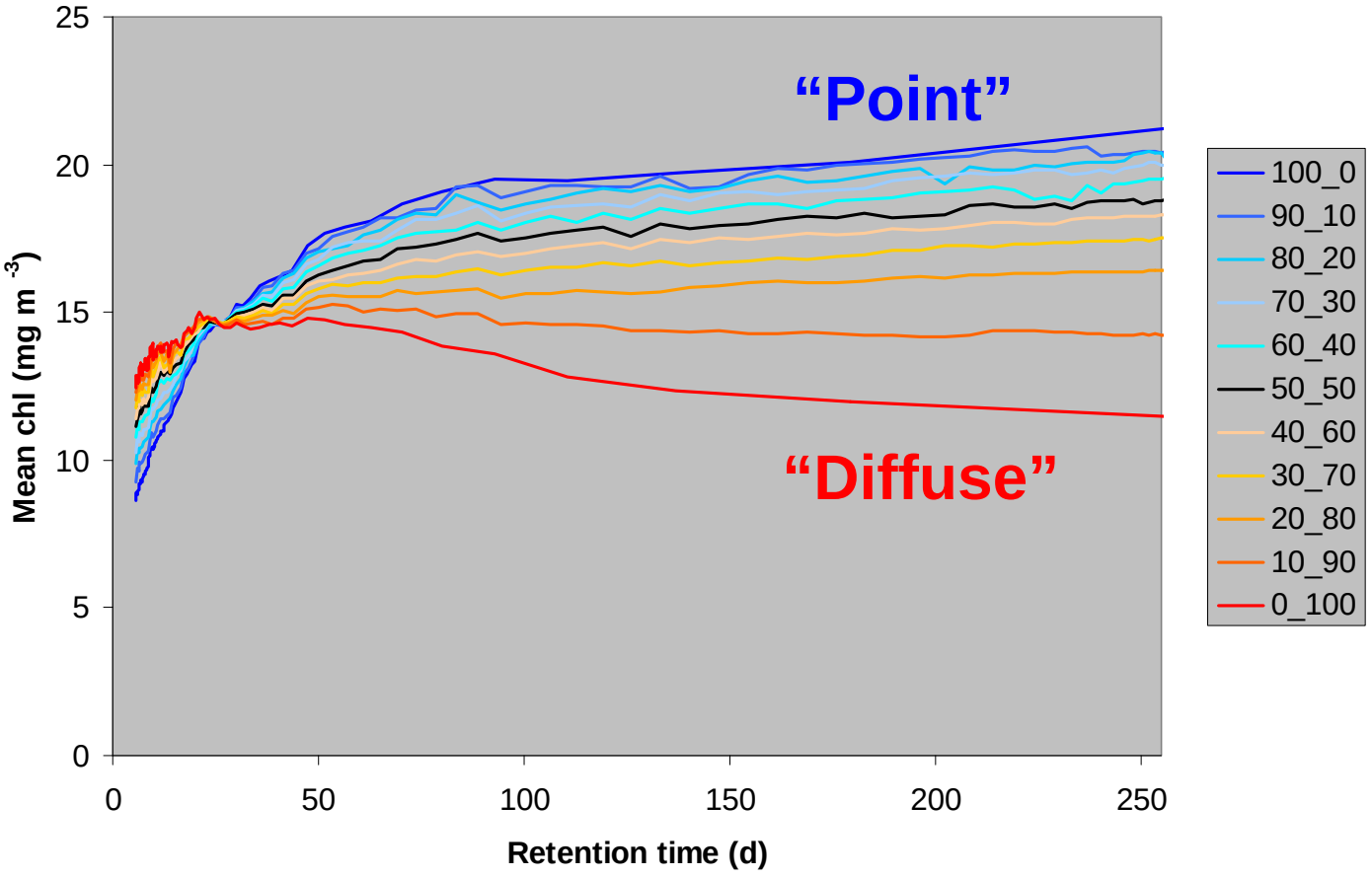
"Point" nutrient source





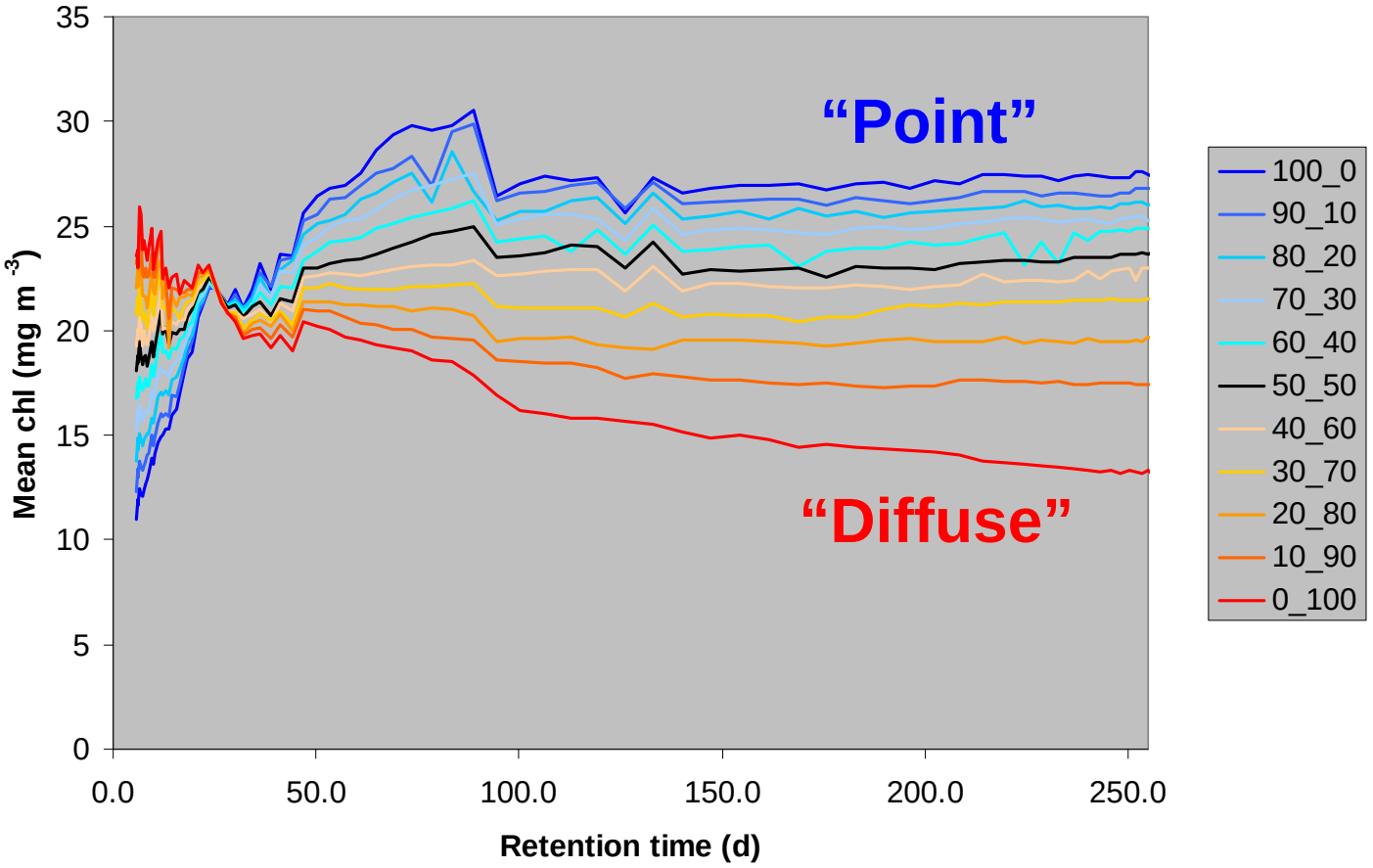
Diffuse-point balance effect

Annual mean



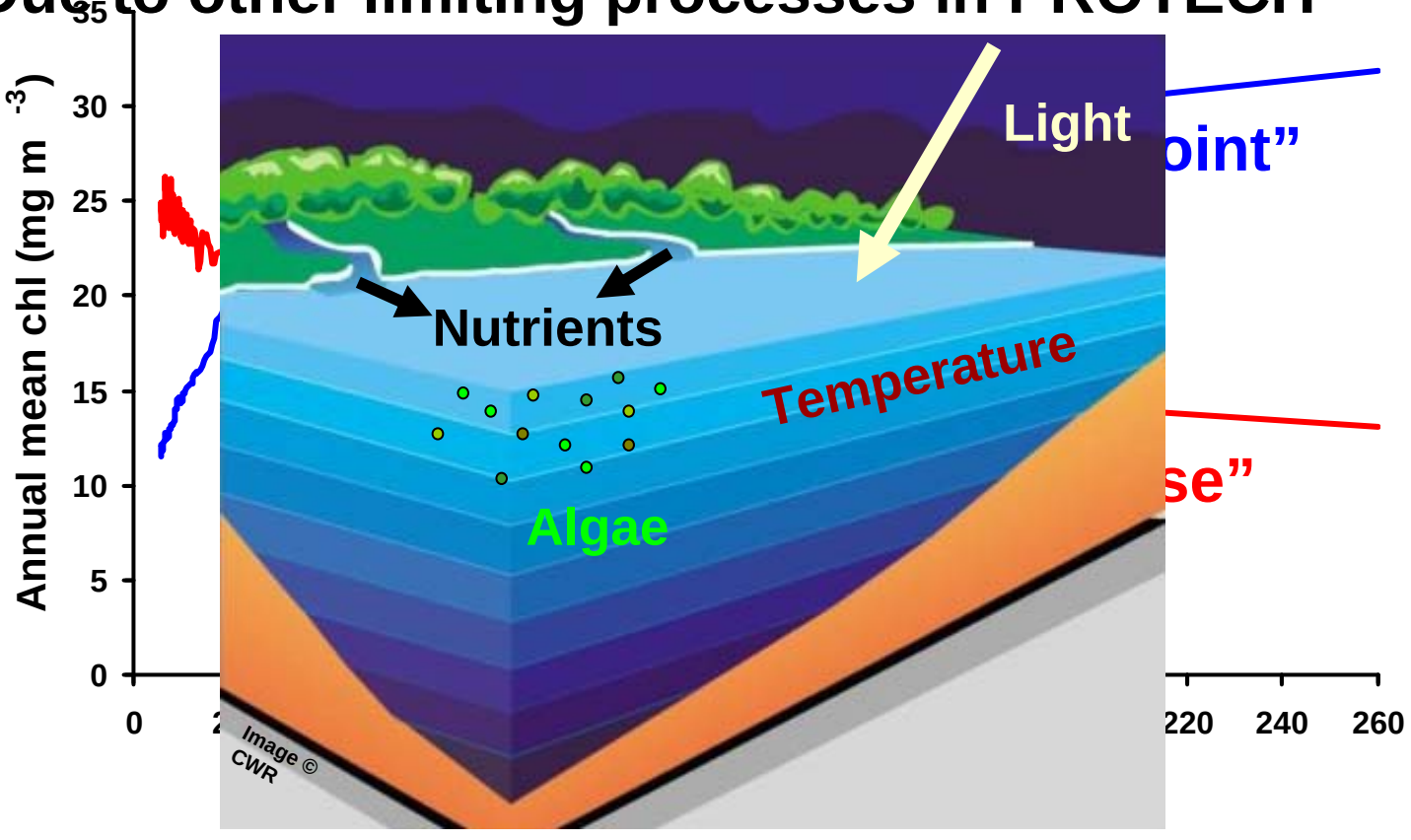
Diffuse-point balance effect

Summer mean chlorophyll



What do the results tell us?

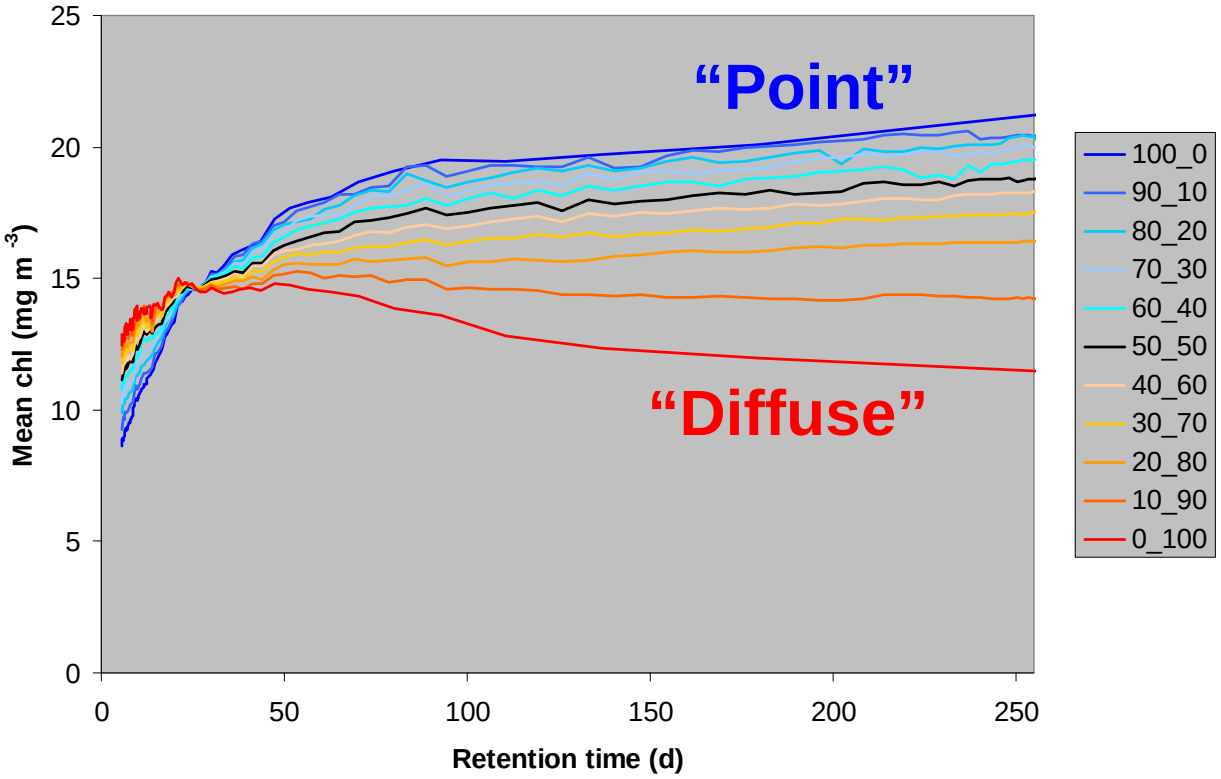
- The simple model's assumptions were only valid in the summer when nutrient limitation occurred
- Above 60-100 d retention time, the effect reduced Due to other limiting processes in PROTECH



What do the results tell us?

- **The source of the nutrients greatly determined the effect -**

  100% Diffuse was less sensitive to retention time change (by < 80% Diffuse, sensitivity increased)



General implications

- **Lakes with retention times < c.100 d will be sensitive to discharge changes (e.g. climate effects)**
- **Nutrient source matters**
- **Summer is the most sensitive period, due to nutrient limitation**