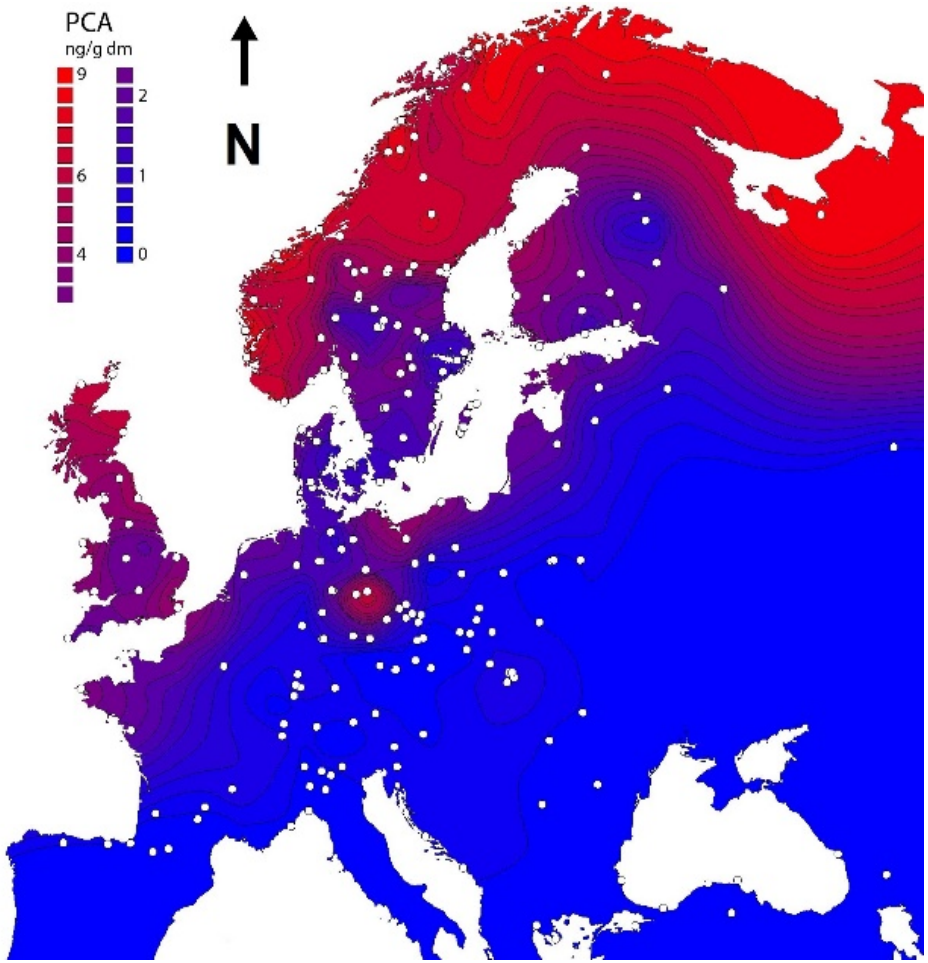
Biological factors regulate the uptake of airborne POPs into “plants” and the deposition of POPs to remote terrestrial ecosystems

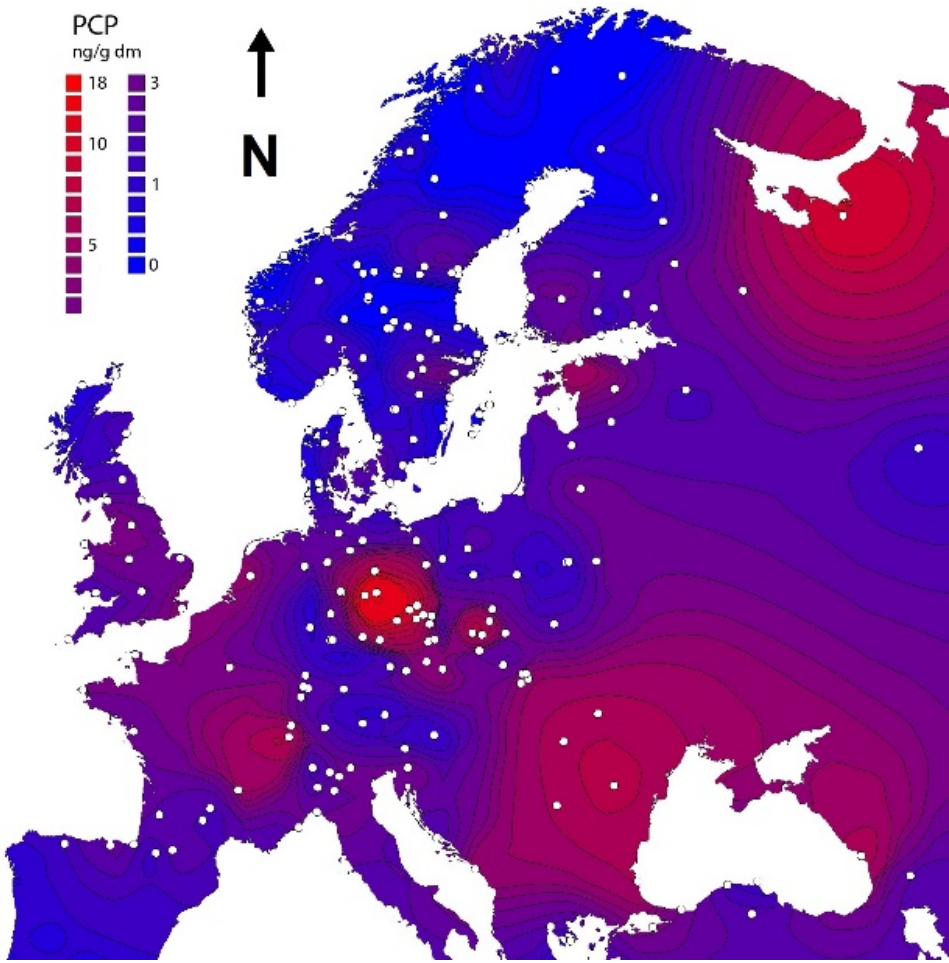
Henrik Kylin[a,b] , Henk Bouwman[b]

[a]Dept. Thematic Stud. – Environ. Change, Linköping Univ., Sweden
[b]Environ. Sci. & Develop., North-West Univ., Potchefstroom, South Africa

LINKÖPING UNIVERSITY

PCA is **NOT** a good proxy for PCP






Sören Jensen – Analysis of pine needles (1967) instrumental to show that PCB pollutants were industrial

“Plants” useful to map the distribution of POPs in remote areas

- But how do we interpret the data?

- Measurement ↔ model differences most obvious for gas phase POPs

What's a "Plant" anyway?

- The "Plant Kingdom" as defined by Linnaeus 1735 vs. modern classification?
- Phylogenetic proximity vs. physiological adaptations?
  - Mosses and vascular plants are plants, lichens are not
  - Homeohydric physiology, **hydrophobic surface** – most vascular plants
    Poikilohydric physiology, **hydrophilic surface** – mosses and lichens
- We ***SHOULD NOT*** use data from vascular plants, mosses, and lichens interchangeably!
- Using different species of vascular plants ***must be done with caution***!

Example of misinterpretation due to ignorance of plant ecophysiology

- Simonich & Hites 1995. Global Distribution of Persistent Organochlorine Compounds. Science, vol. 269, 1851-1854

  Using “tree bark” ***without specifying species***

- The data presented reflects the biogeography of Gymnosperms (conifers) vs. Angiosperms (flowering plants)

  Conifers dominating high latitudes are “more lipophilic” than angiosperms

α-HCH concentration in the moss *Hylocomium splendens* at constant air concentration

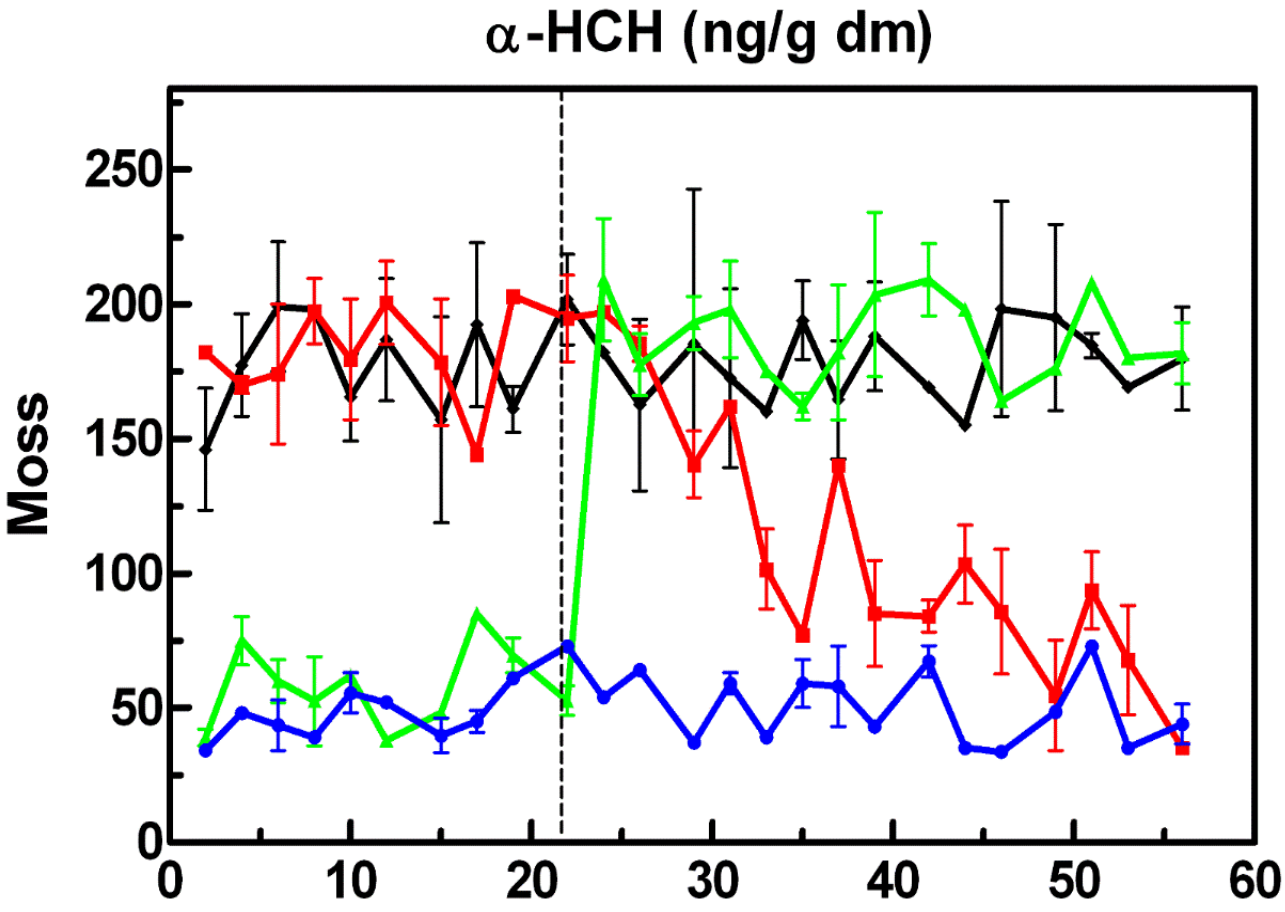
1) Hydrated
2) Hydrated at start,
3) Desiccated at start,
4) Desiccated

Hydration state governs the uptake of airborne HCHs

Lipid content DOES NOT explain the difference!

Volume and sorp-tion site exposure?

Lichens behave similarly – both are poikilohydric



Kylin & Bouwman (2012) ES&T **46**:10982-10989

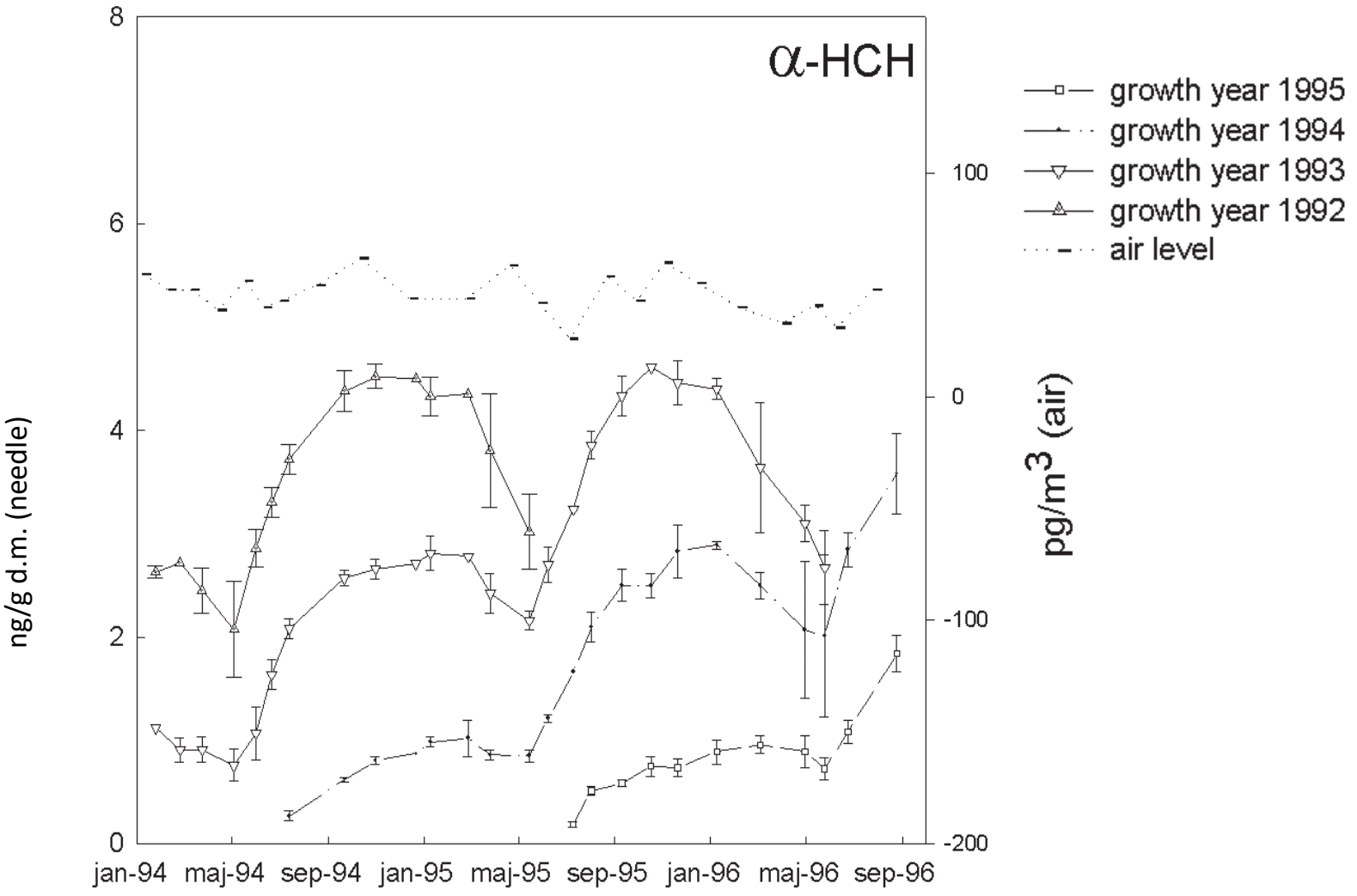
“Lipid content” – a meaningless entity in plants

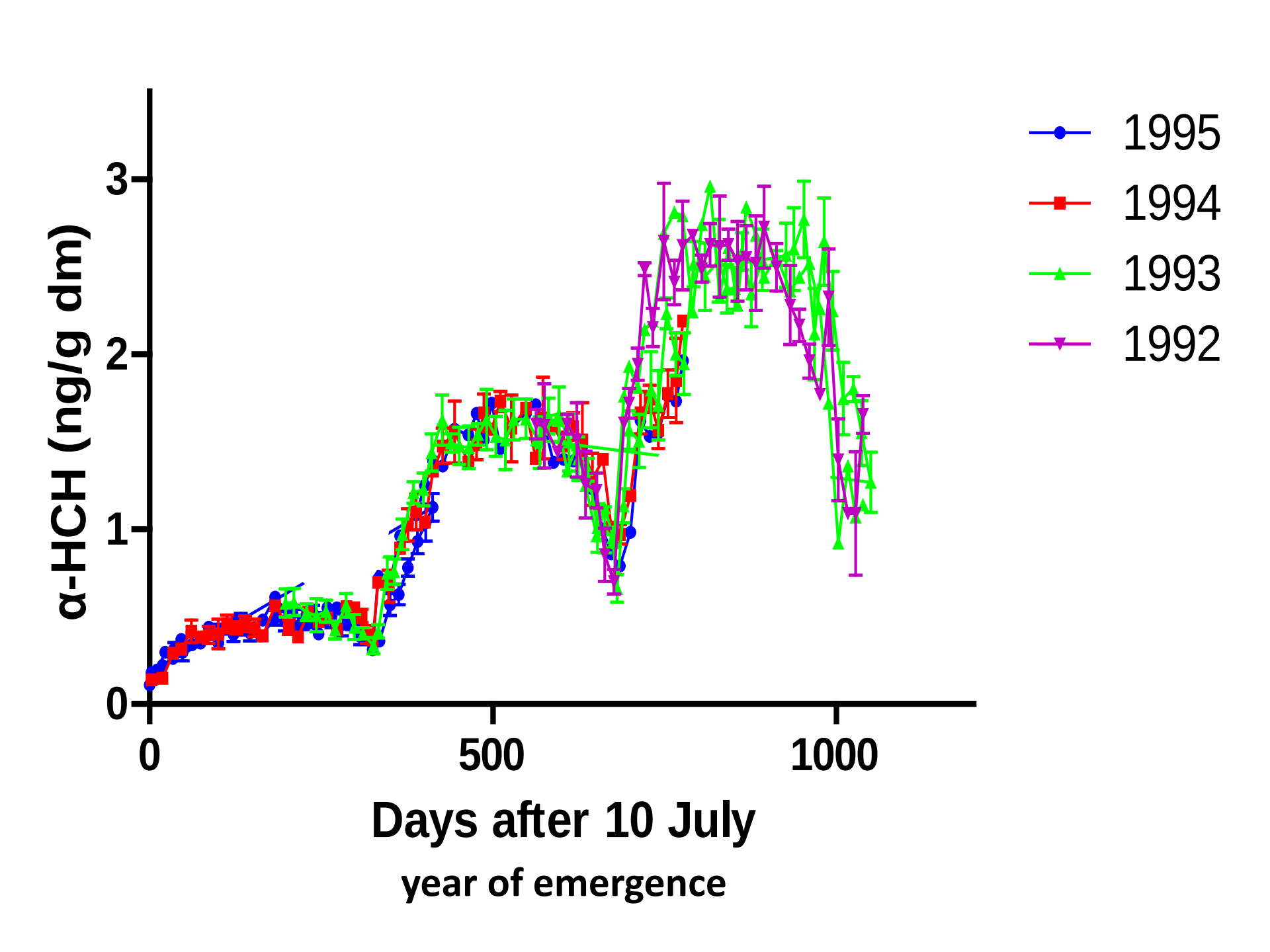
- Determination of lipid content usually done as for animal samples

HOWEVER

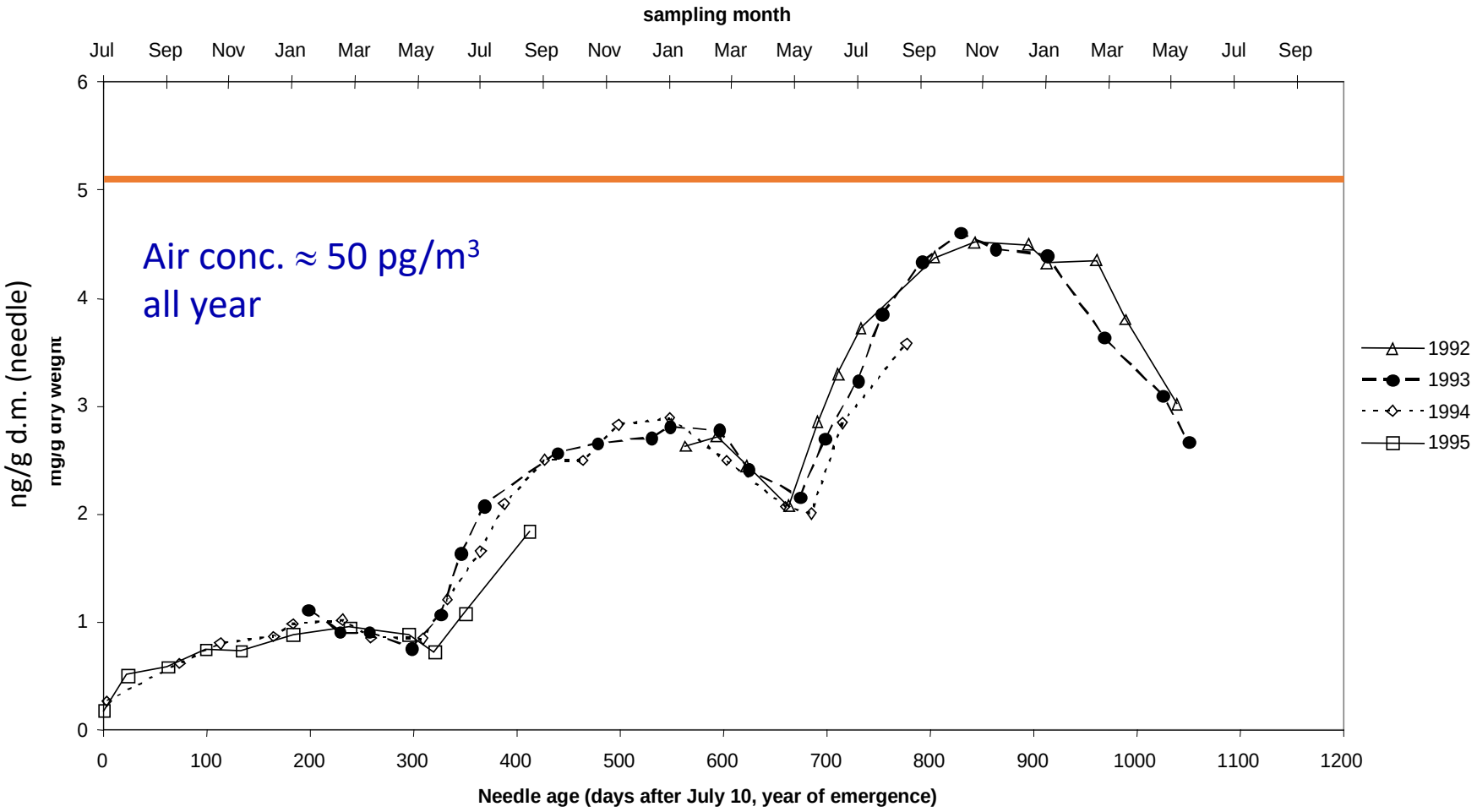
- Both foliage and bark contains “polymeric lipids” (10-80% of “total lipids”) that will not be extracted
- VOCs will be lost during “lipid determination”
- The VOCs affect the properties of both wax and “polymeric lipids” making them “stickier” and increasing diffusion

α-HCH in air and Scots pine needles during 33-months

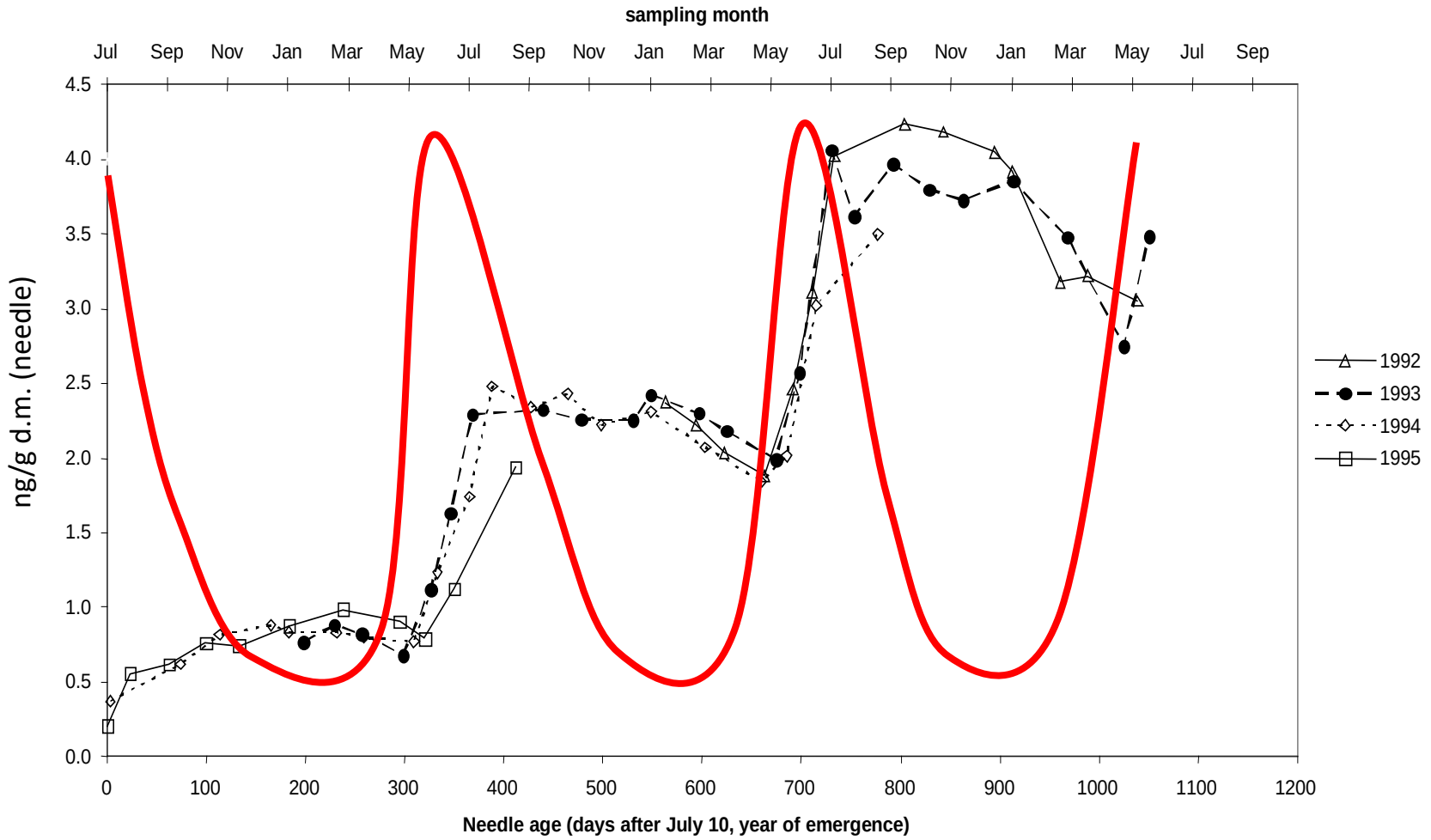



α-HCH (ng/g dm)
0
1
2
3
0
500
1000
Days after 10 July
year of emergence
1995
1994
1993
1992

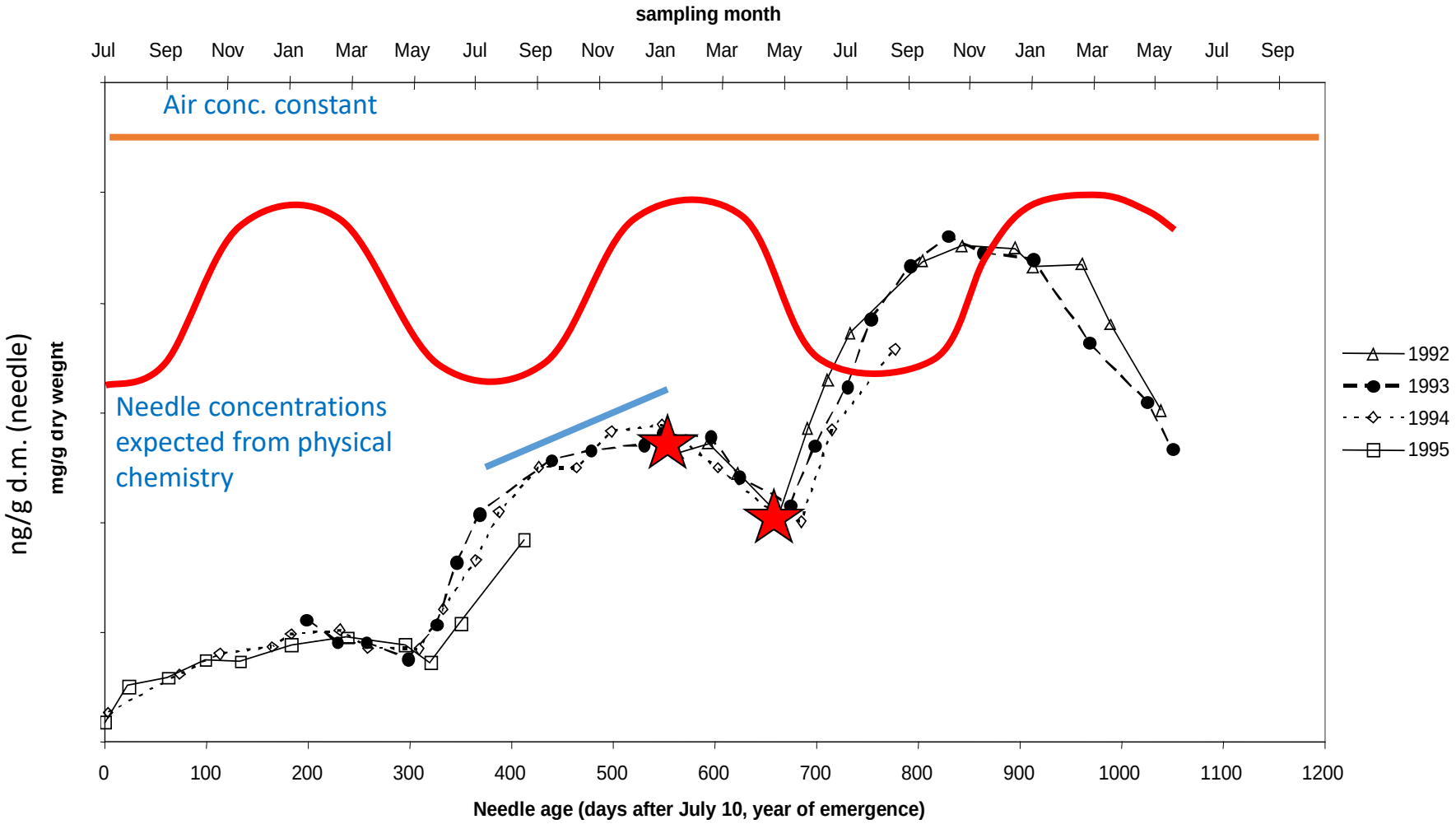
α-HCH in air and Scots pine needles



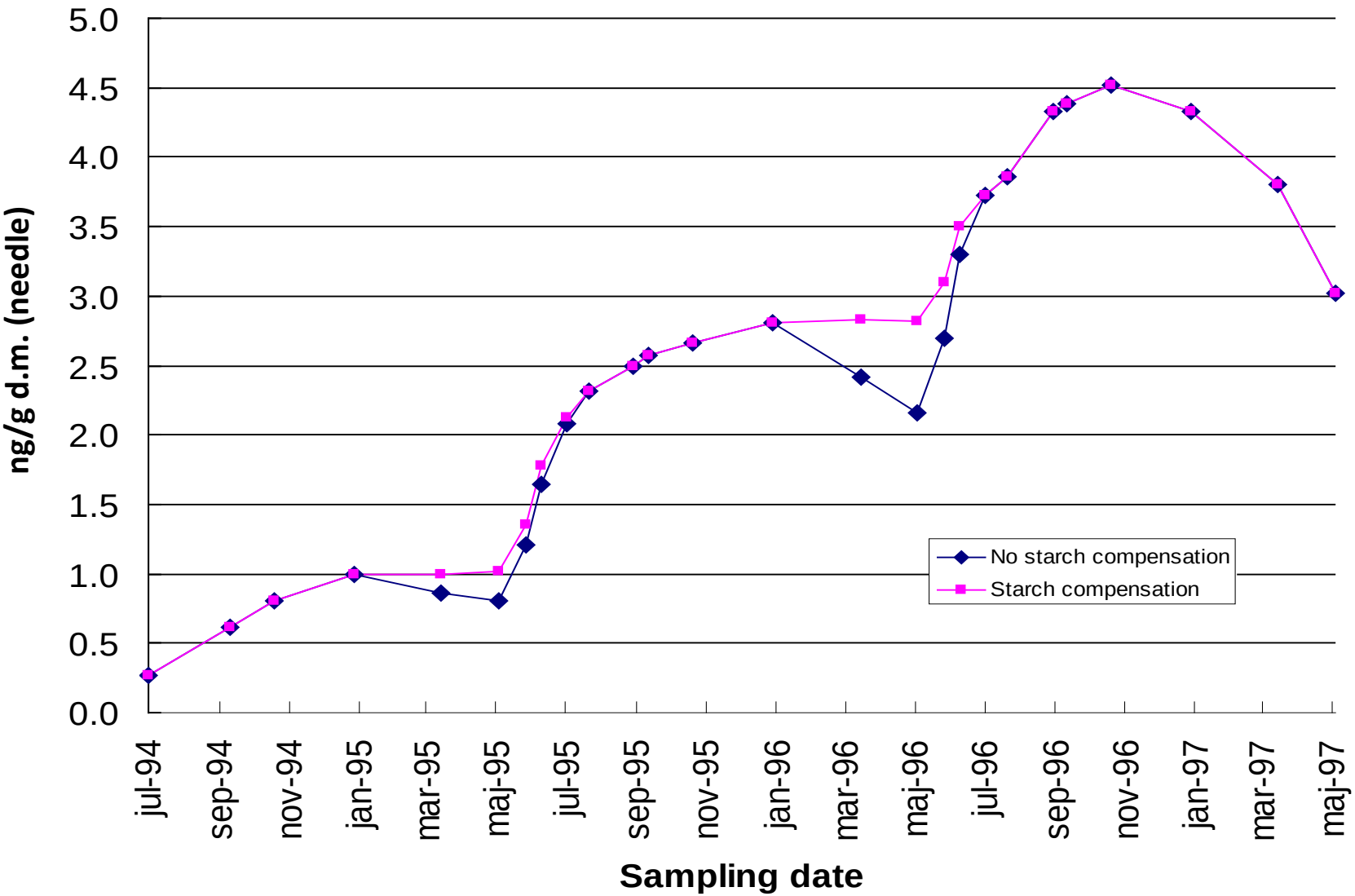
γ-HCH in air and Scots pine needles



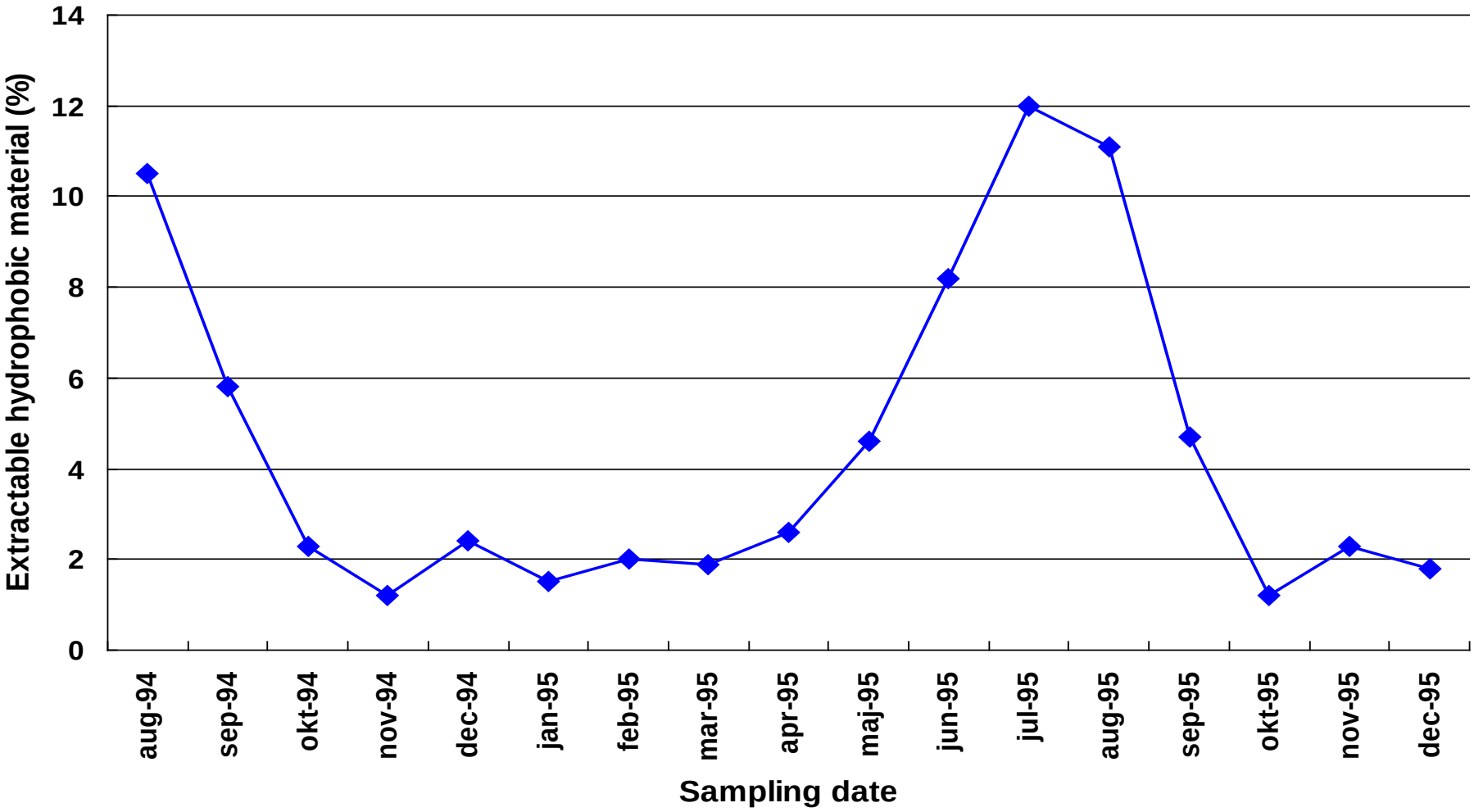
Models vs. Reality: The importance of long time-series



The Spring Dip – α-HCH in pine needles, starch compensated

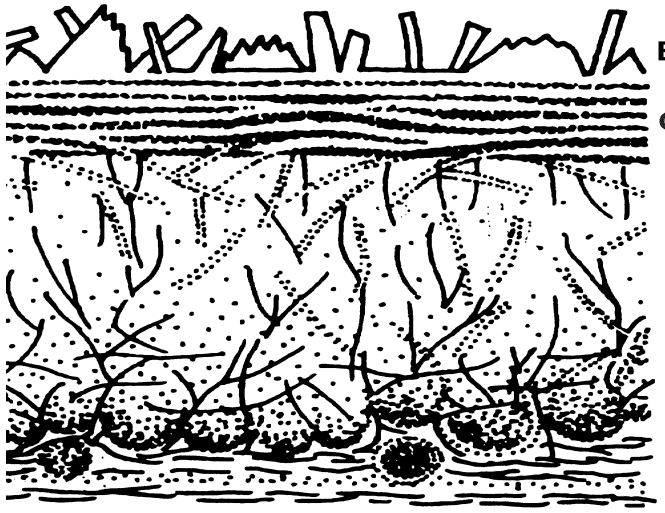


Annual variation of endogenous VOCs in Scots pine needles



Kylin et al. (2002) Bull. Environ. Toxicol. Contam. 68:155-160

Cuticle structure and POP accumulation

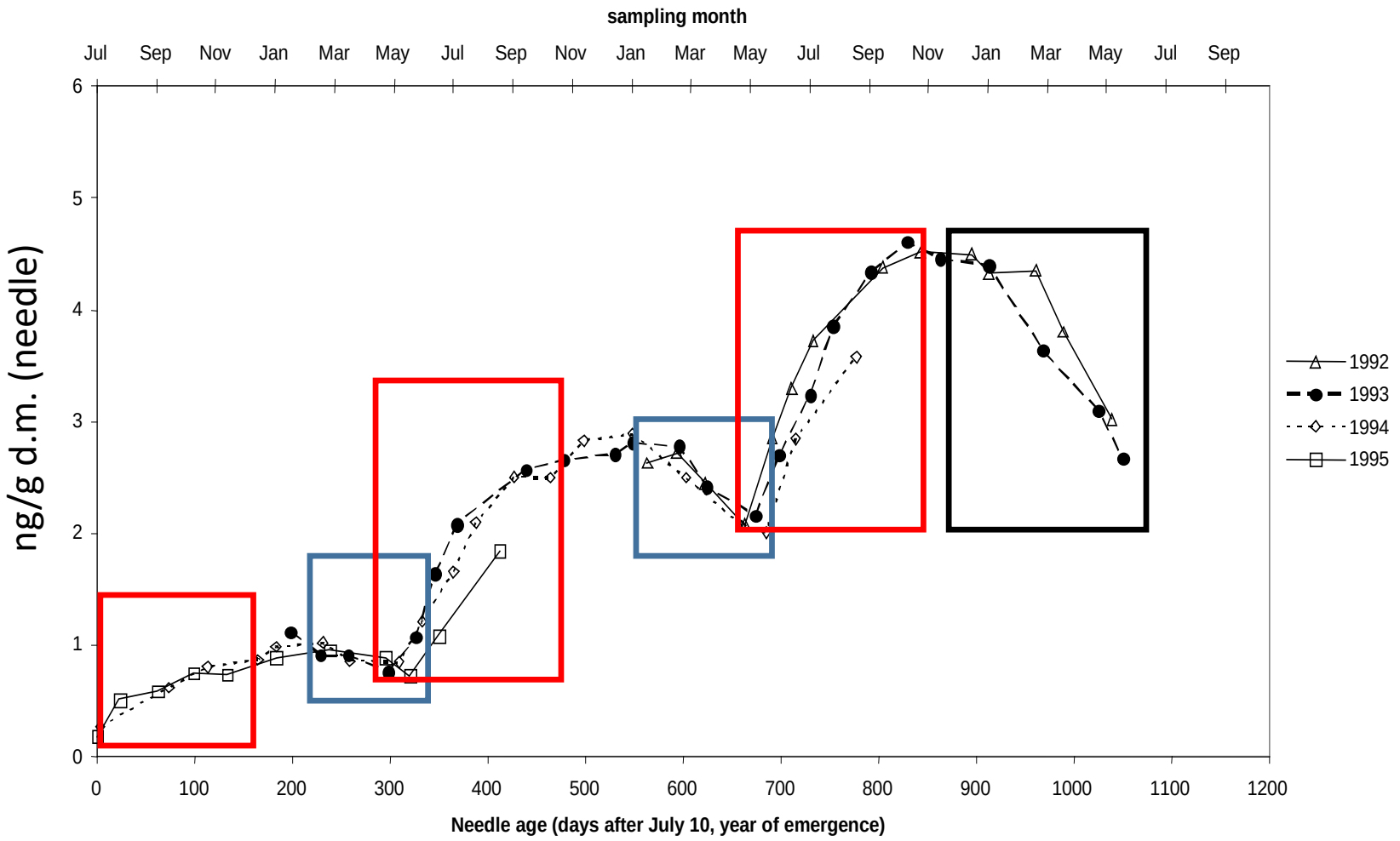


- High VOC concentrations in summer will cause swelling of wax and cutin

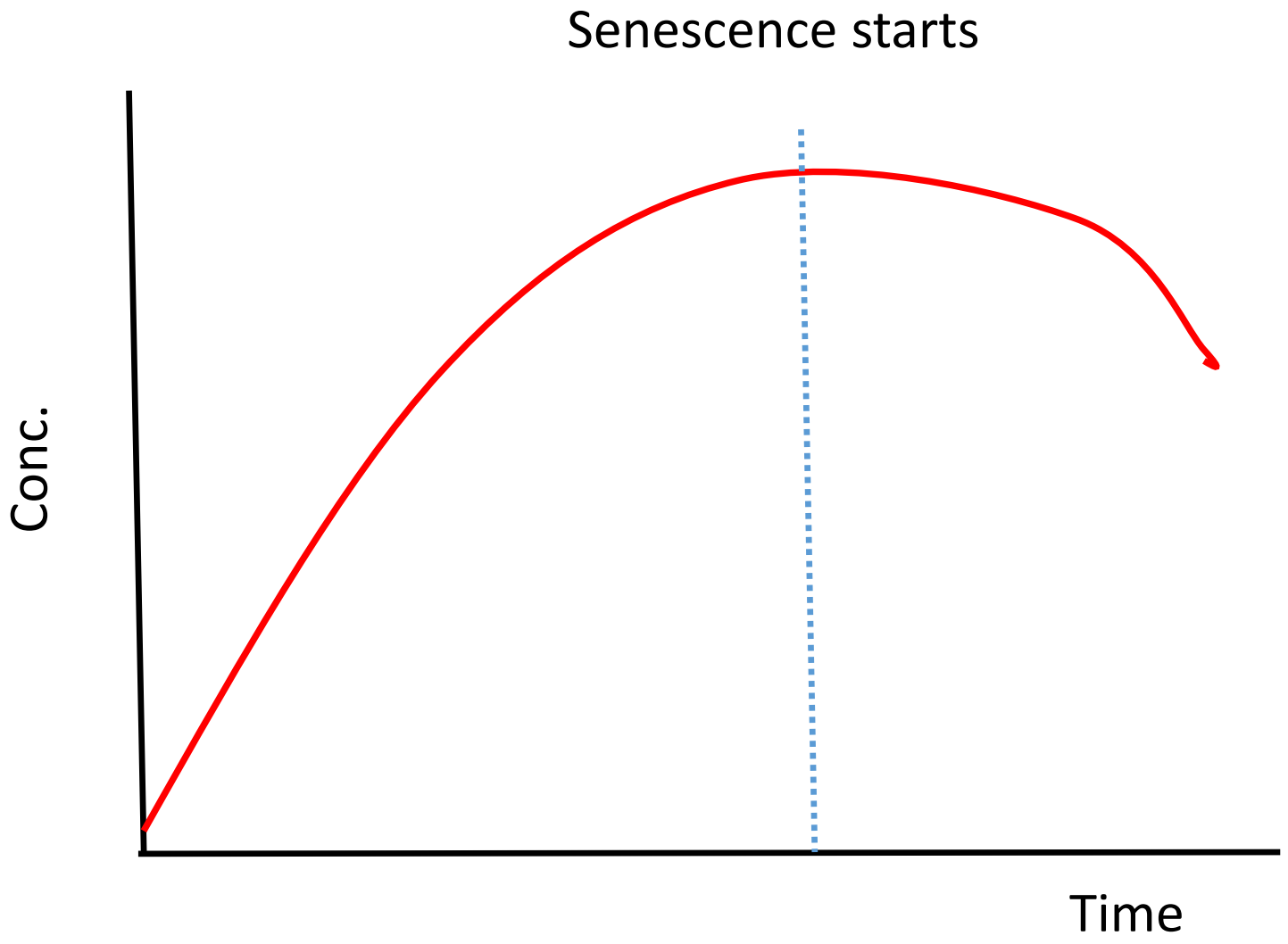
→ POPs will diffuse rapidly deep into the three-dimensional structure of the "leaf" during summer and then be "trapped" due to lower diffusion during winter

→→Net annual accumulation

High VOC content
High starch content
Senescence

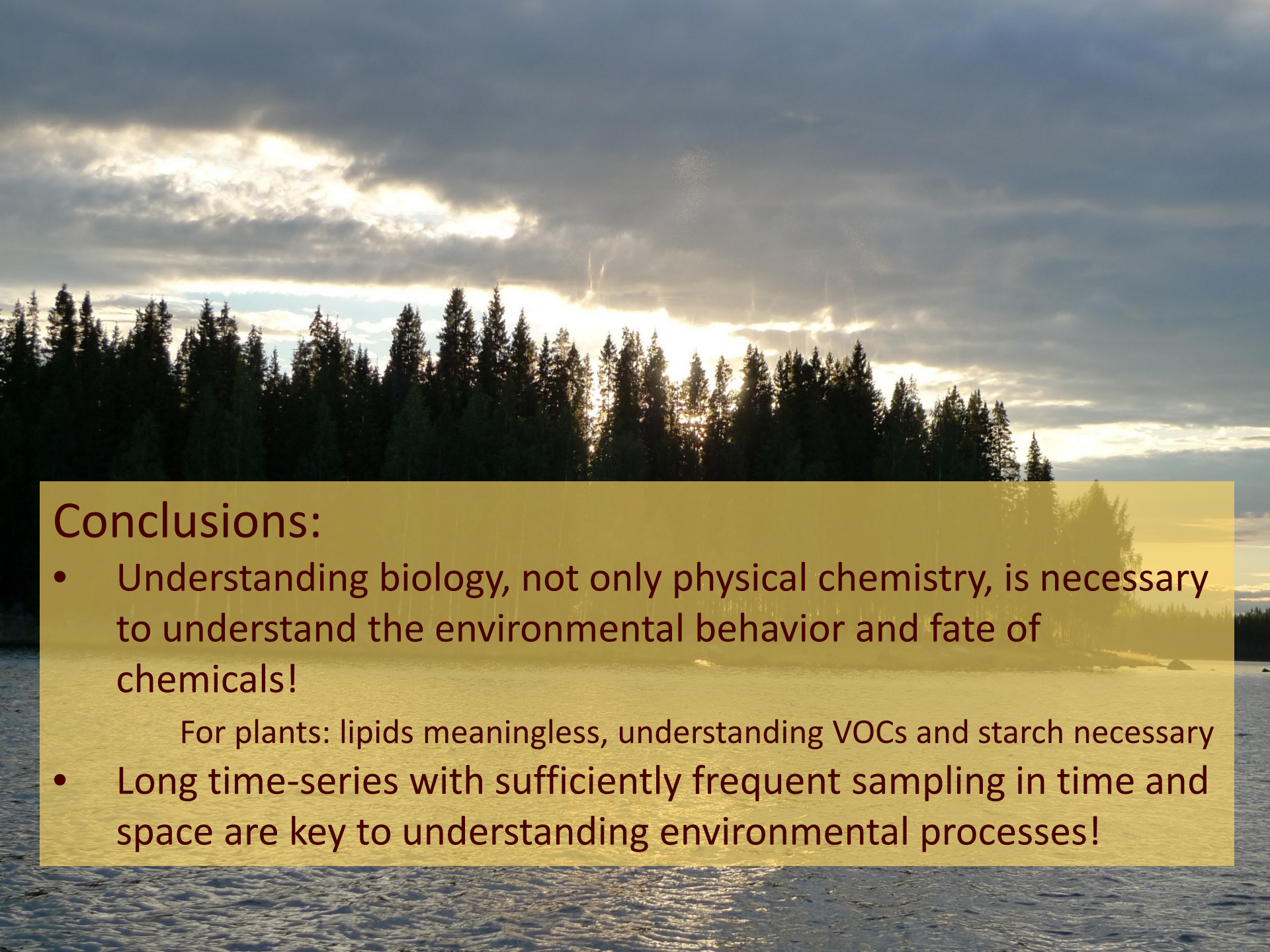


Accumulation: a general process in vascular plants



Accumulation: a general process in vascular plants

- No evidence of saturation
- Accumulation occurs in all year-classes until senescence
  - In >12 year-classes in angiosperms (*Cassiope quandrangulata*)
    in >20 year-classes in conifers (*Pinus aristata*, *P. balfouriana*)
- Differences between year-classes may be more than one order of magnitude
  - Which year-class should be sampled for environmental monitoring or as basis for determining the air-plant partitioning coefficient?
- No evidence of "grass-hopping" in boreal areas – overall flux from air to plant
- **100 Lakes Project**: The length of the vegetation season determines POP deposition to both terrestrial and limnic ecosystems in boreal and probably in nemoral regions



Conclusions:

- Understanding biology, not only physical chemistry, is necessary to understand the environmental behavior and fate of chemicals!

  For plants: lipids meaningless, understanding VOCs and starch necessary

- Long time-series with sufficiently frequent sampling in time and space are key to understanding environmental processes!