

Determining the controls on faecal stanol concentrations and ratios in tropical lake sediments

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Abstract

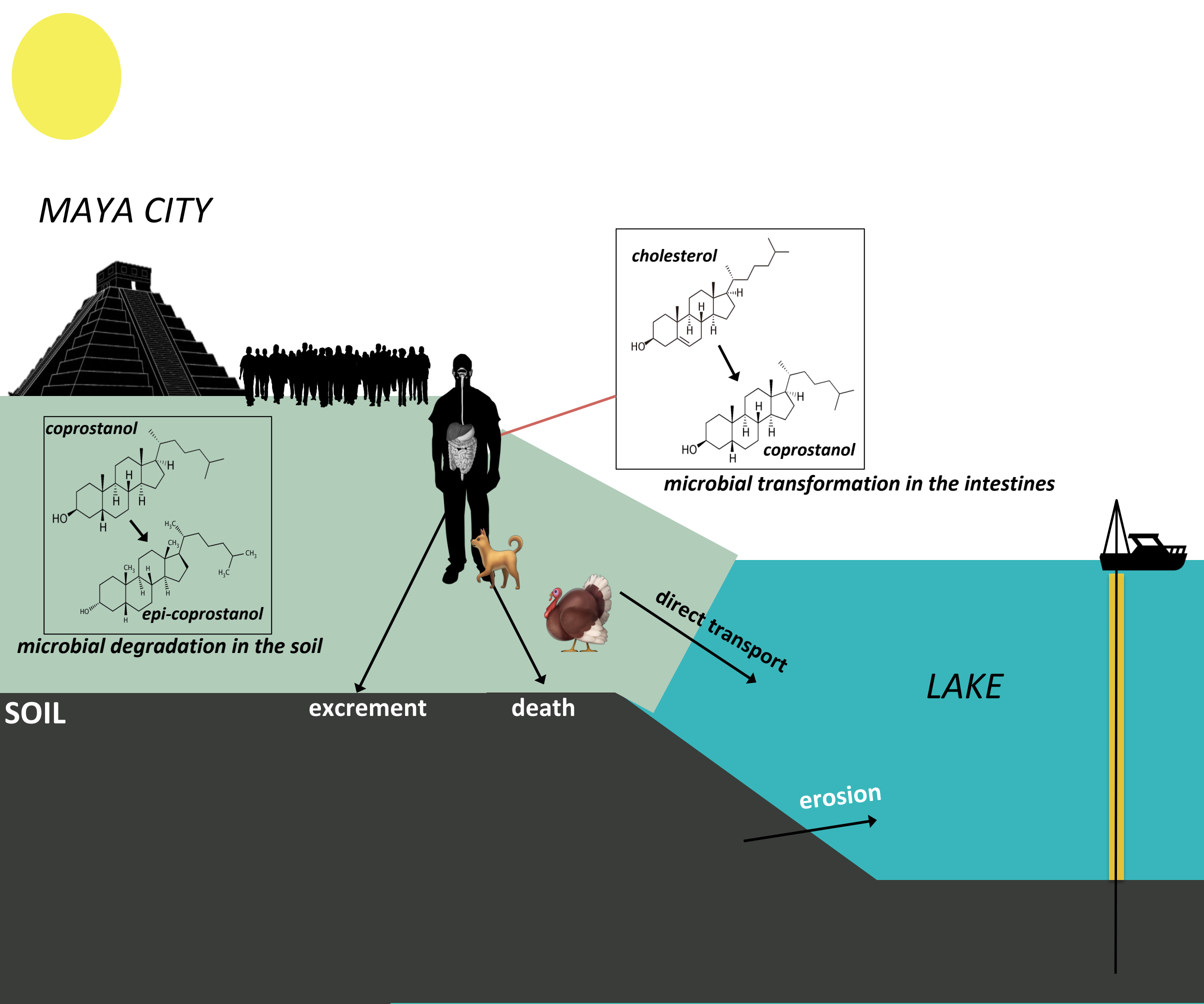
Faecal stanols offer an exciting opportunity to determine population change in the past but the controls of their concentrations and ratios within lake sediments are not well understood. We present the variability in stanol concentrations and ratios from lakes across environmental gradients, both between and in lakes across climatic and land-use gradients in Mexico, Guatemala, and Belize in order to determine the factors controlling preservation and degradation in lacustrine sediments. We also measured physical properties of lakes such as dissolved oxygen, pH, and water column temperature and estimated the approximate human population in each catchment, with the goal of producing a semi-quantitative calibration of human population to coprostanol+epi-coprostanol as a ratio to cholestanol, a more widely produced bacterial stanol. In particular we explore the hypothesis that a dominant control on concentrations and ratios is proximity to a human settlement. We evaluate this hypothesis in two lakes (L. Peten-Itza and L. Izabal) where we collected samples at varying distances from major population centres. This will have implications for the targeting of lake cores in studies where determining population change is the goal. In addition to this work we will share three intriguing preliminary palaeo-records of stanol concentrations from Guatemala (Laguna Itzan, Laguna Peten-Itza, and Lago Izabal). These records imply highly dynamic millennial scale changes in human populations, and we apply the modern sediment data to better constrain the interpretation of these data. Our work shows that faecal stanols have a strong potential as proxies for changes in human population and land-use change through time, and can be used to complement archaeological datasets to link human populations with palaeoenvironmental change.

DETERMINING THE CONTROLS ON FAECAL STANOL CONCENTRATIONS AND RATIOS IN TROPICAL LAKE SEDIMENTS

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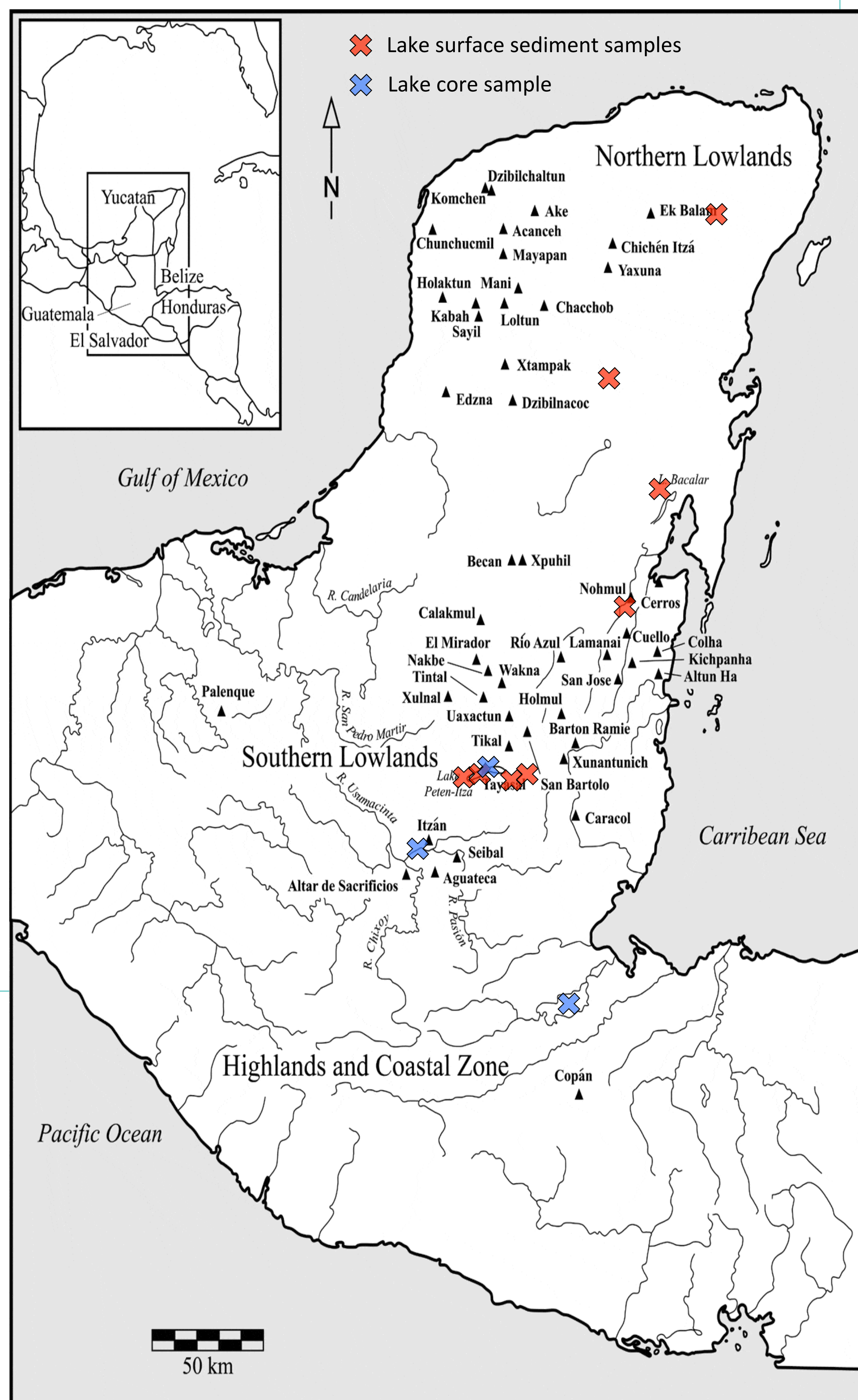
ANCIENT APPLICATION



- Coprostanol enters the environment as a component of faeces
- Quantifying changes in concentrations or ratios through time could tell us about changing population through time

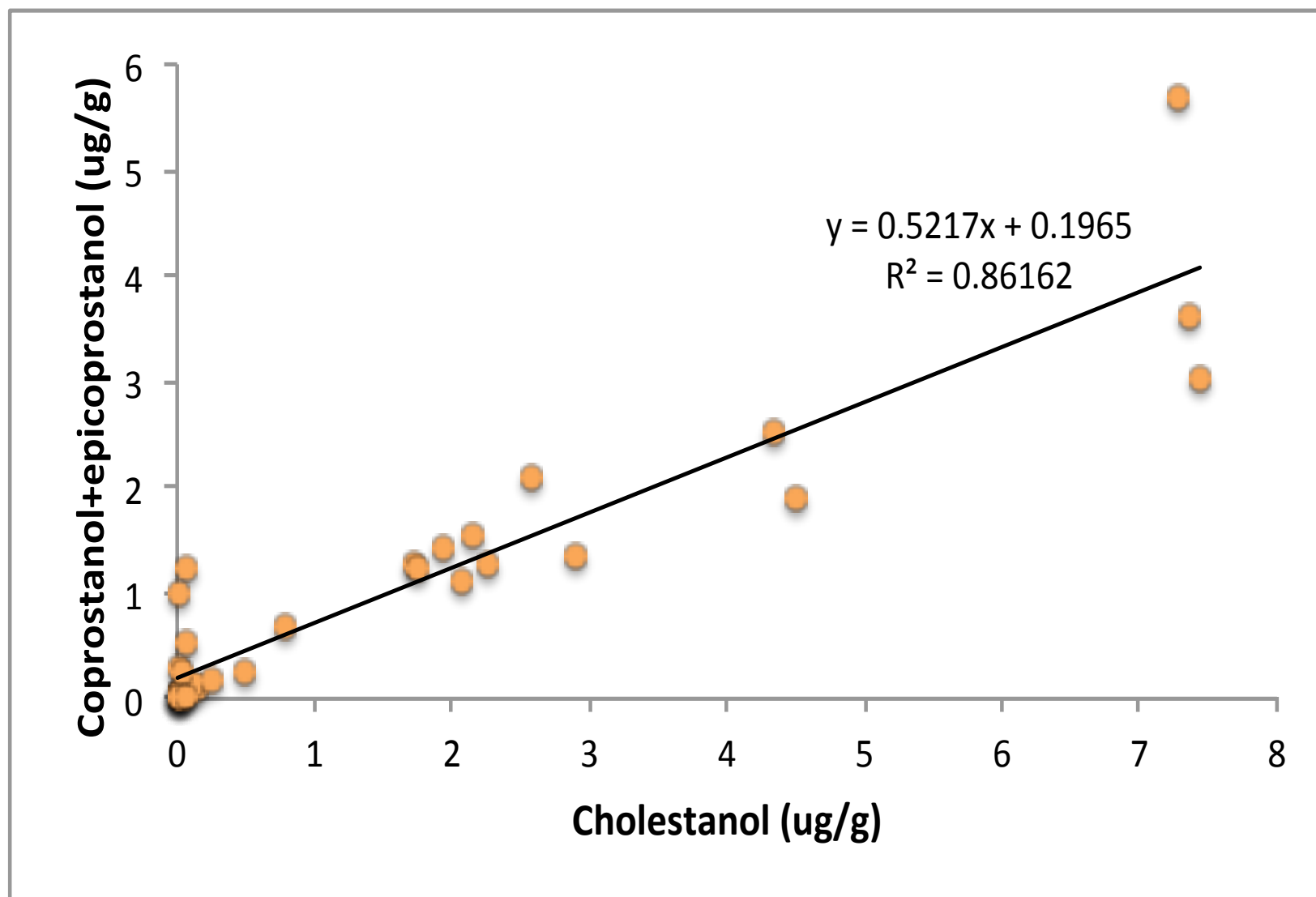
What affects concentrations and ratios in modern lake sediments?

- We extracted lipids from sediments from 10 modern lakes and quantified the faecal stanols present
- We also quantified faecal stanols from three lake cores to infer population change through time, with the ultimate goal of relating population change to climate change

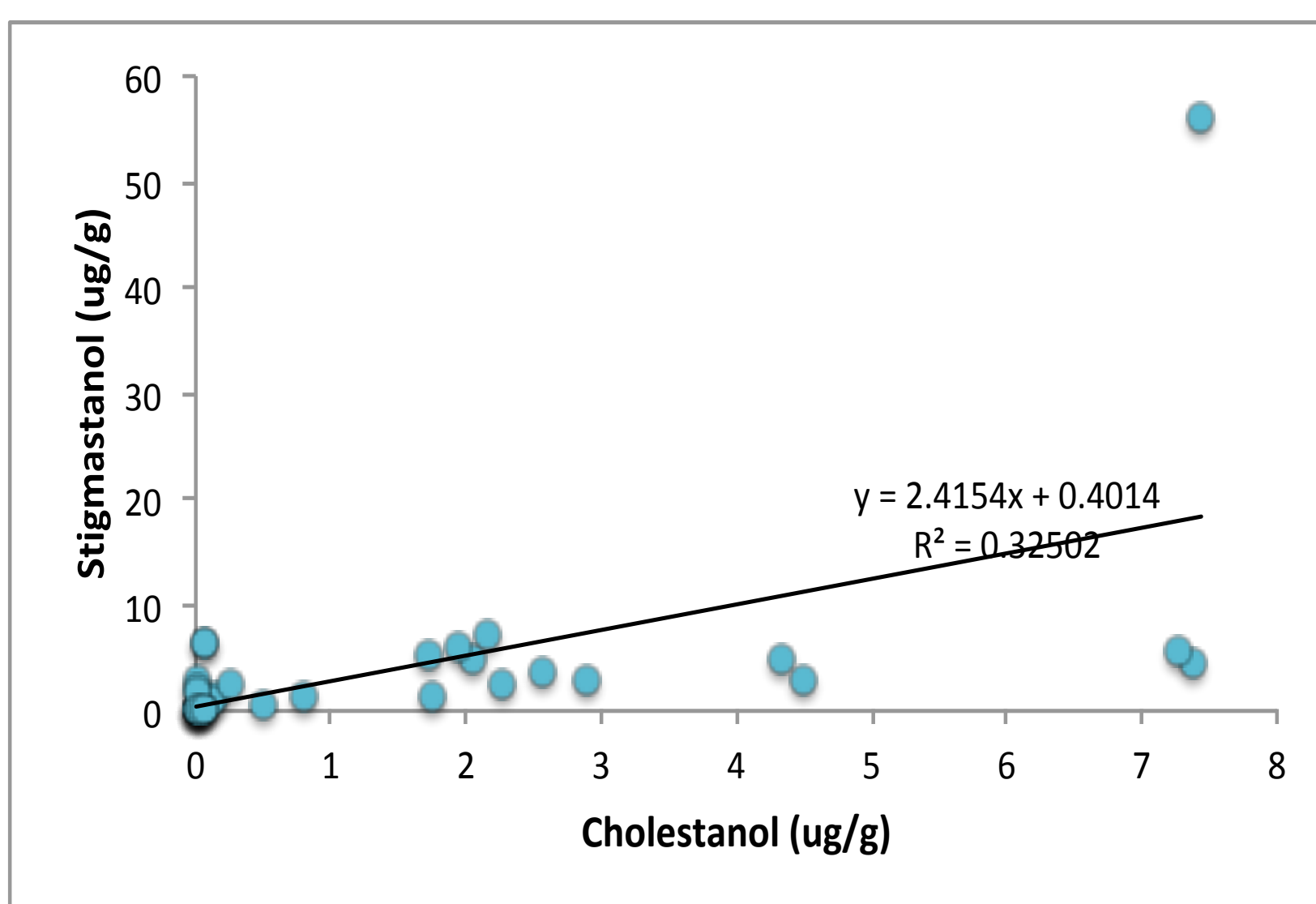


IS USING RATIOS APPROPRIATE?

Concentrations of coprostanol+epicoprostanol and cholesterol in lake sediments



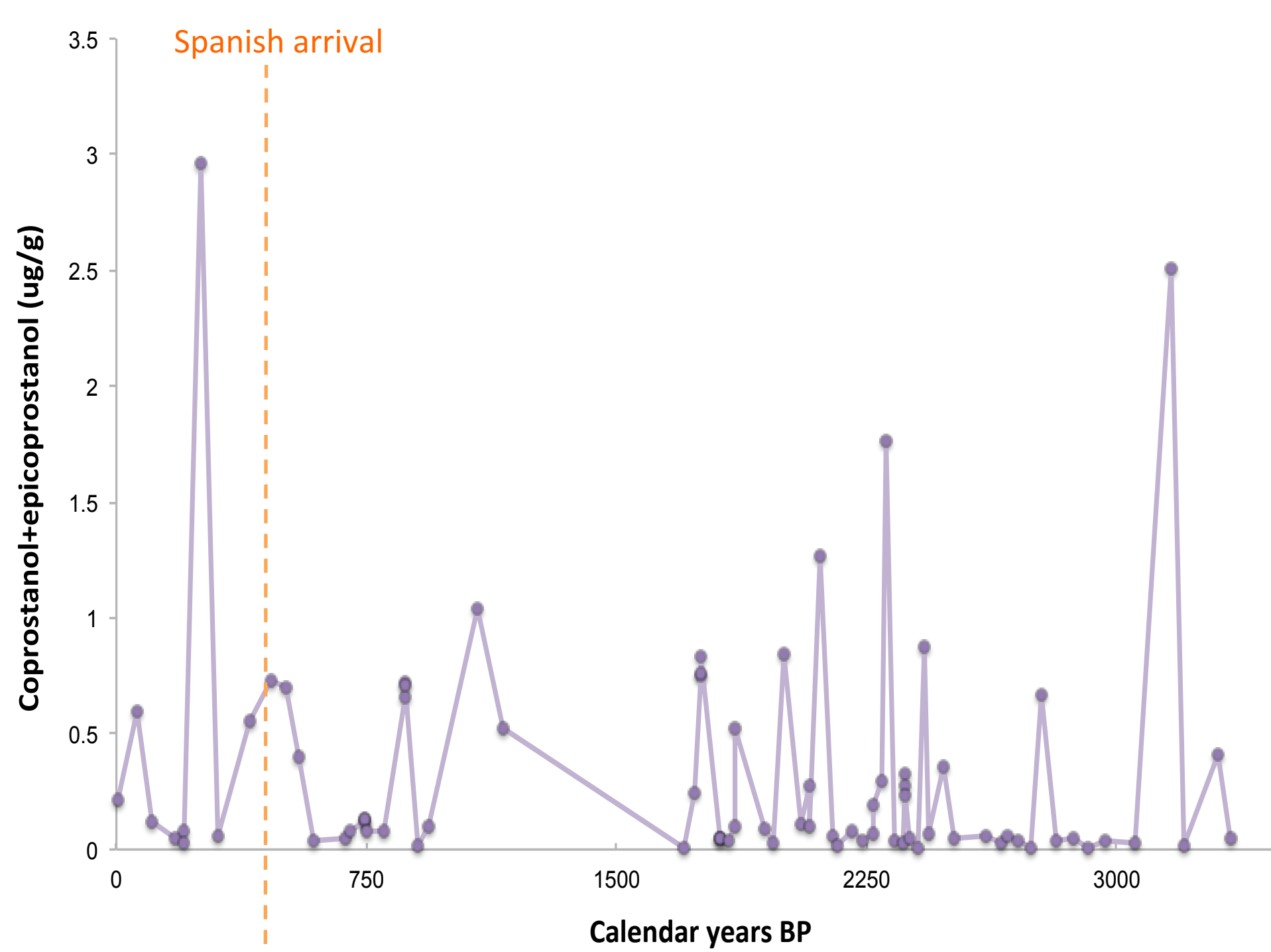
Concentrations of stigmasterol and cholesterol in lake sediments



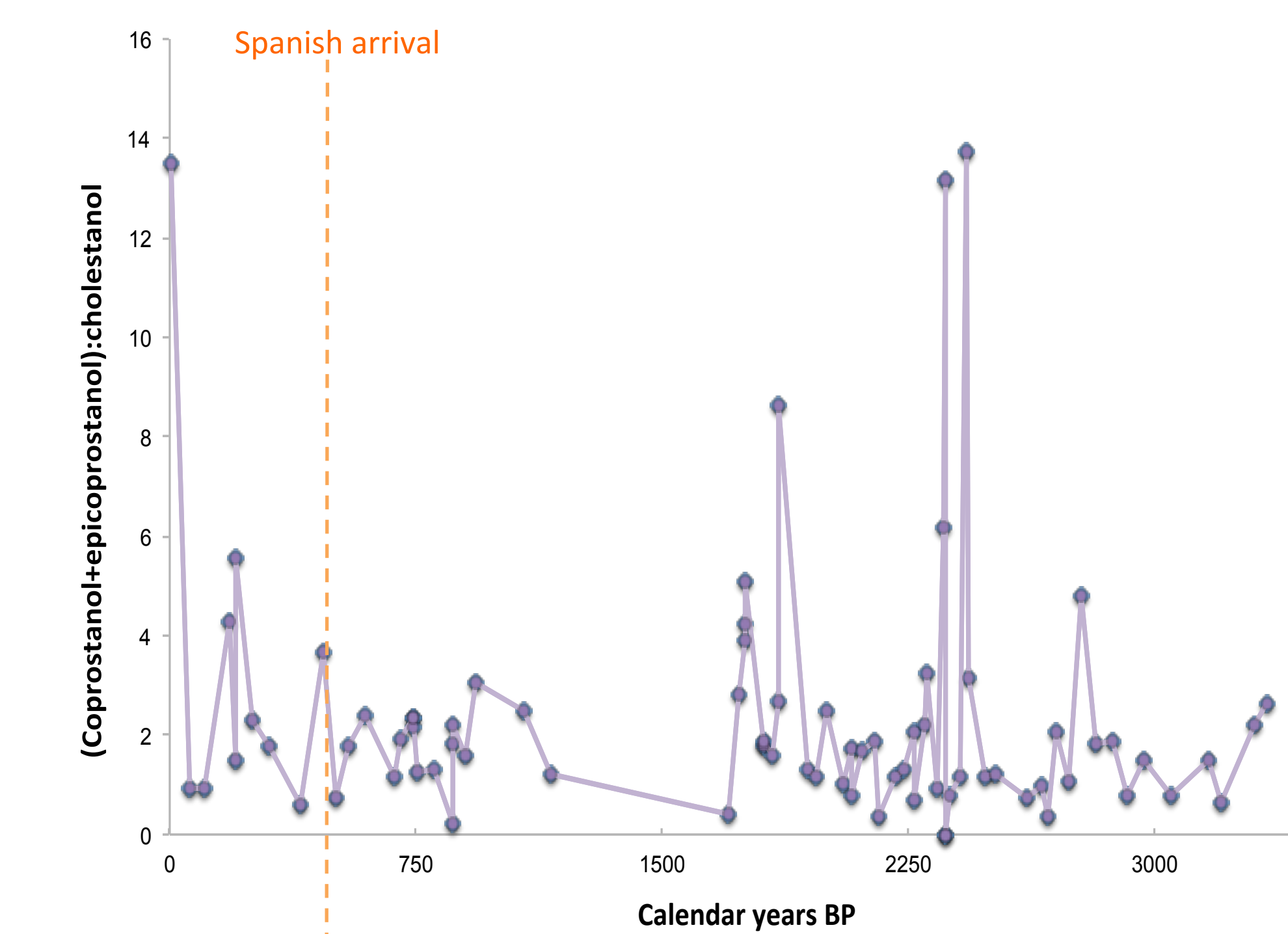
Coprostanol and cholesterol correlation suggests that the processes controlling the deposition/preservation are similar

The correlation between stigmasterol and cholesterol is less certain

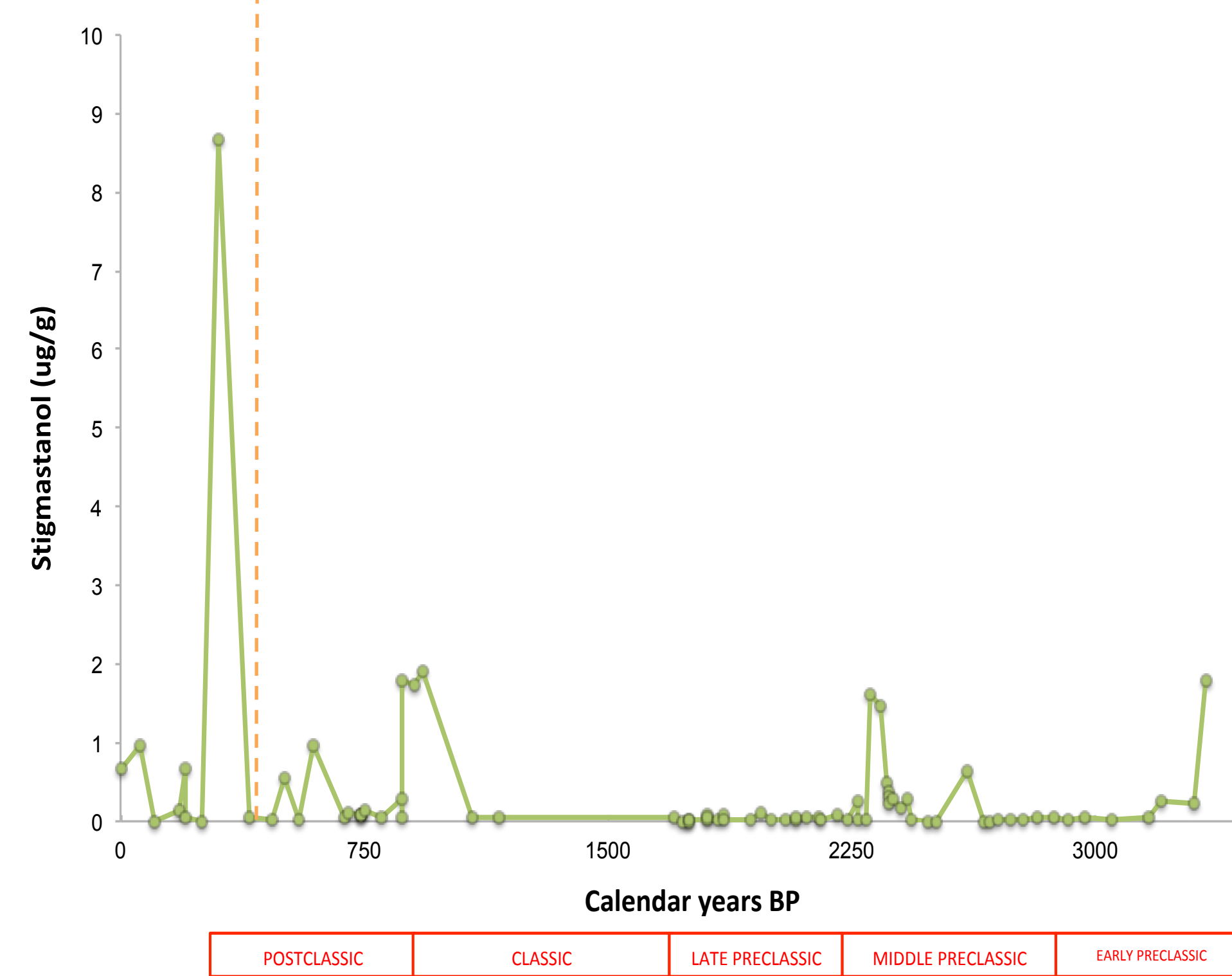
Changes in the concentration of coprostanol+epicoprostanol over time



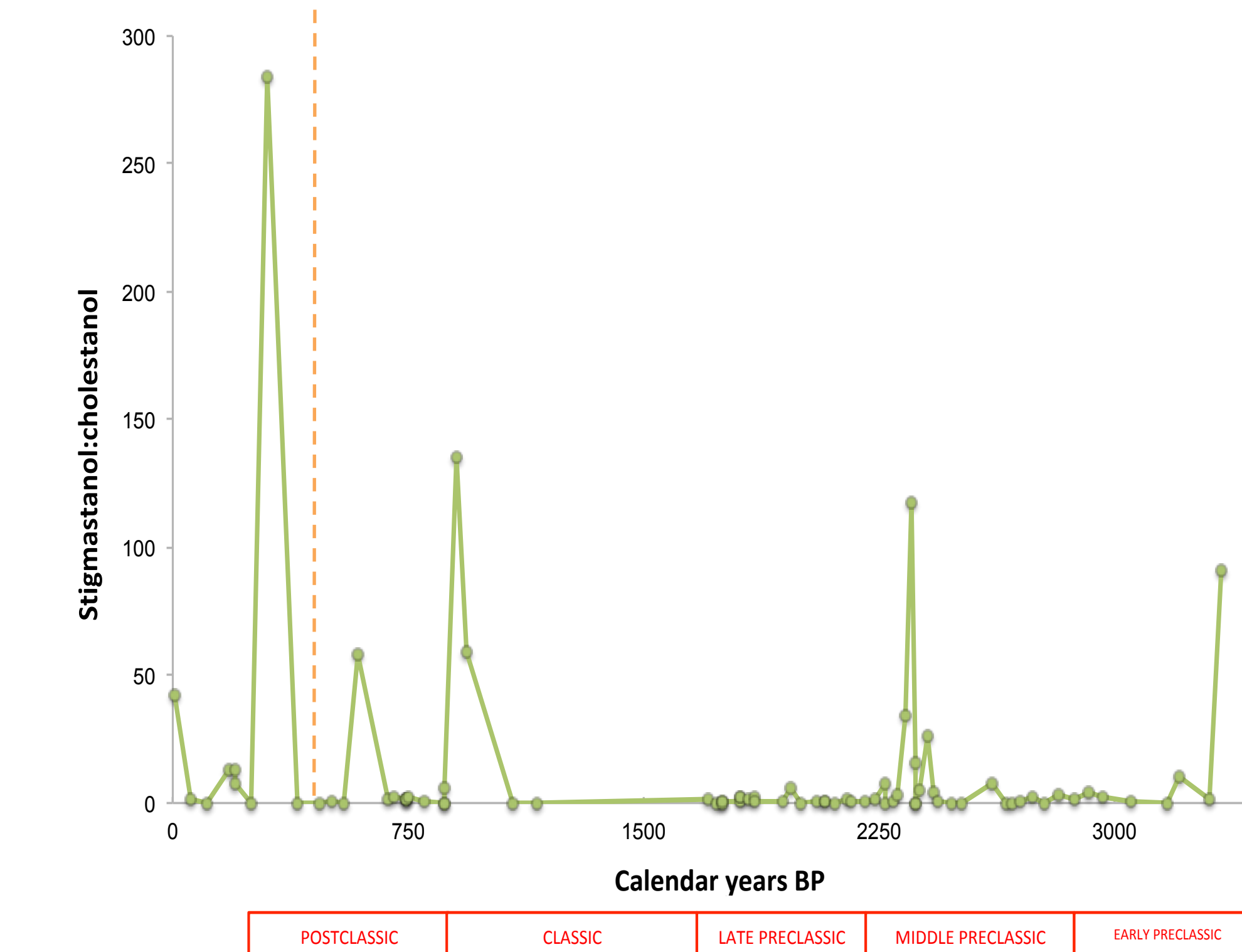
Changes in the ratio of coprostanol and epicoprostanol to cholesterol over time



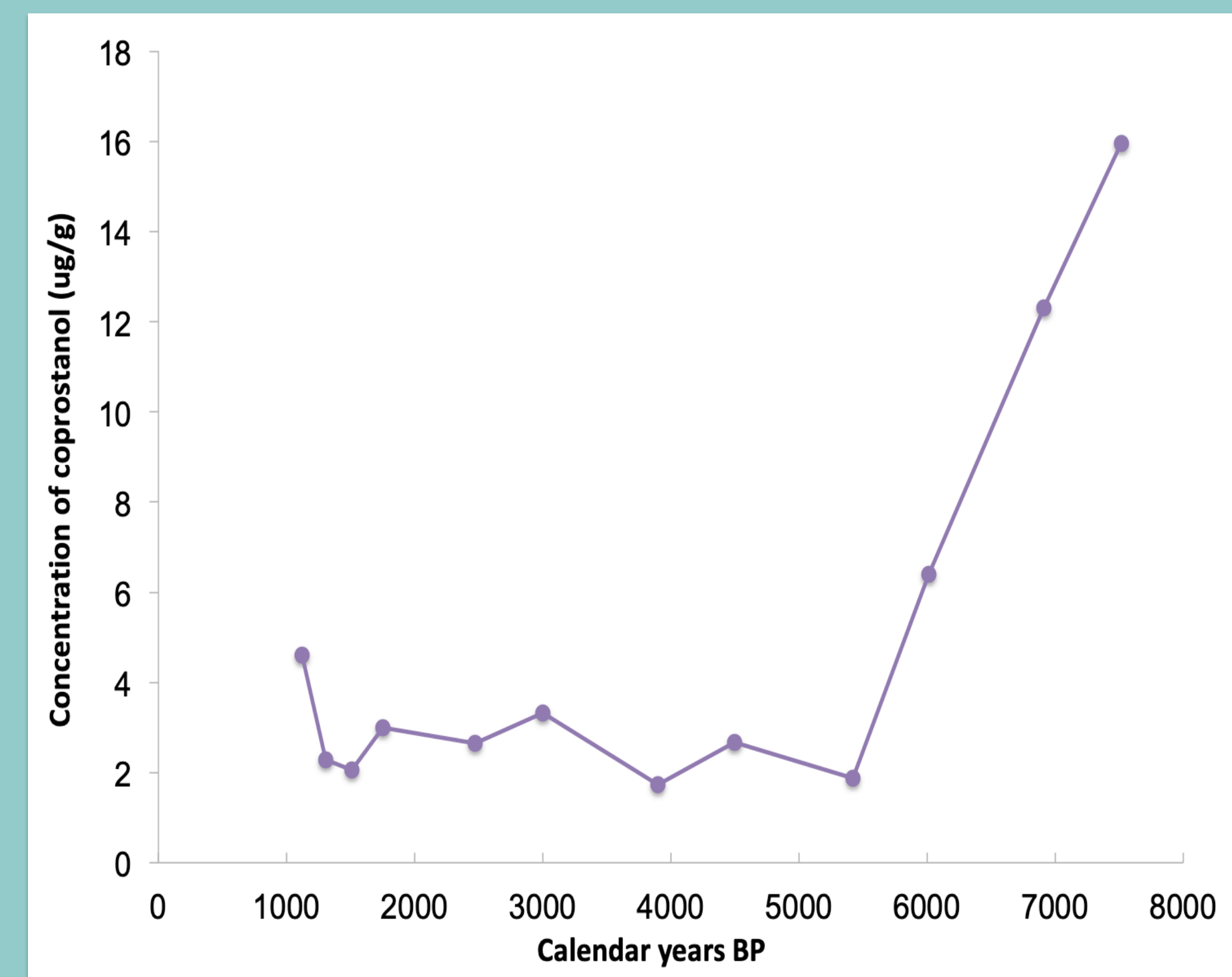
Changes in the concentration of stigmasterol over time



Changes in the ratio of stigmasterol to cholesterol over time



Changes in the absolute concentration (ug/g) in coprostanol over time in sediment cores from Izabal, top, and Peten-Itza, bottom (analyses by Emma Fabre)



- For coprostanol, changes in the ratio show possible cycles of boom and bust during the Preclassic
- Absolute concentration in coprostanol and epicoprostanol changes might reflect migration in and out of the area, and the low modern value reflects the fact that the area is not occupied by humans in the modern day
- High coprostanol/cholesterol ratio in the present day may be a result of livestock such as pigs and sheep
- The average values for coprostanol and epicoprostanol in the modern day are likely related to modern waste disposal and management
- Stigmasterol peaks less variable
- Large peaks from 1500 AD onwards could reflect introduction and breeding of livestock by the Spanish (smaller peaks prior to this may be coming from herbivores living around the lake)

WORKING CONCLUSIONS

- There is a question of whether proximity to population centre is the dominant control on concentration?
- Significant spatial heterogeneity exists in modern lake sediments
- The contribution of livestock farming is very large
- Using coprostanol:cholesterol appropriate for ancient lake core records but this is uncertain for stigmasterol:cholesterol

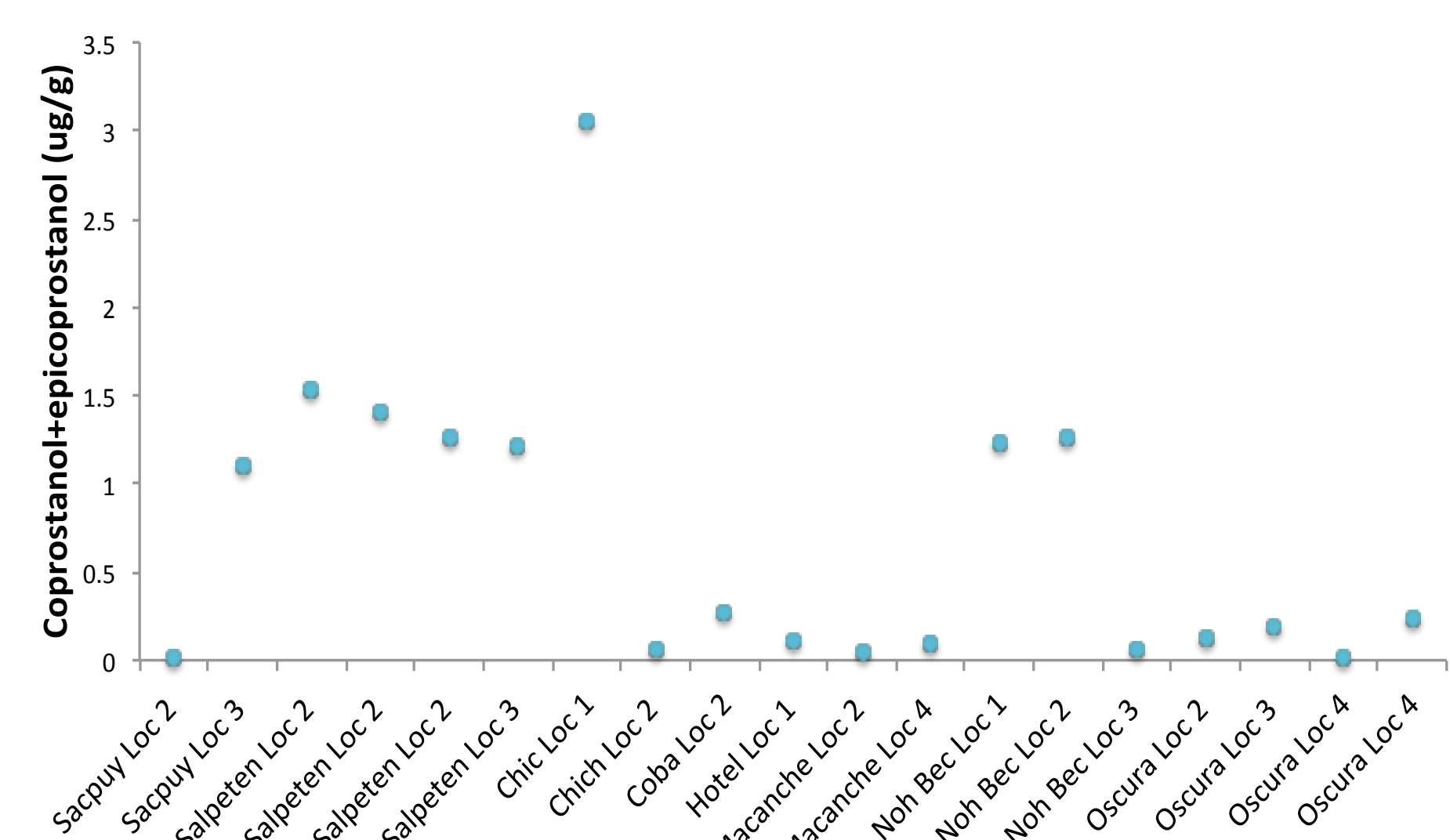
Thanks to Yves Gélinas, Anic Imfeld, Thi Hao Bui, Bjorn Sundby, Claire Guimond, Yasmine Flynn-Arajdal, Sakshi Dev, and funding from the Eric Mountjoy Fellowship and NSERC. Map provided by Kevin Johnston.



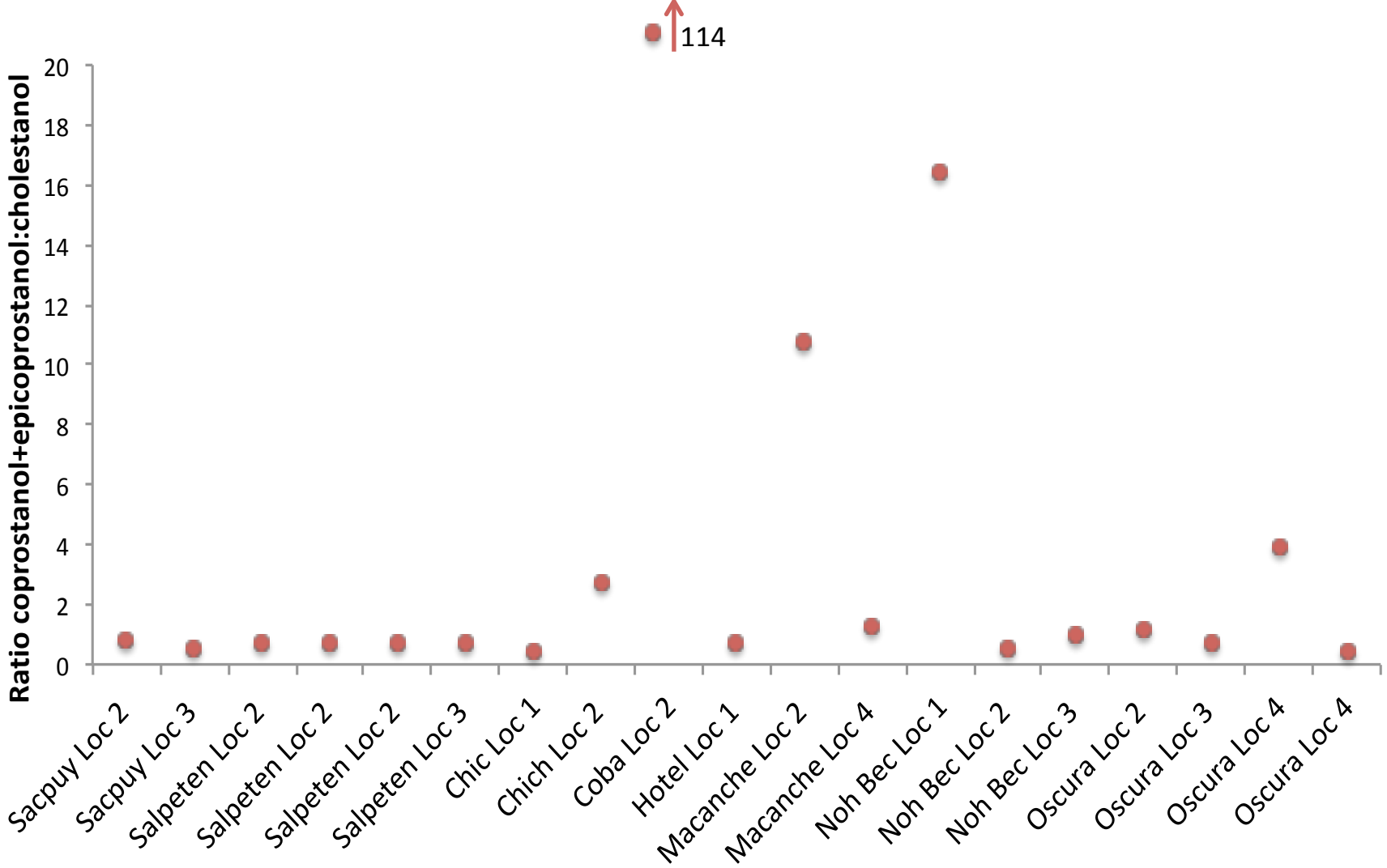
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MODERN CALIBRATION

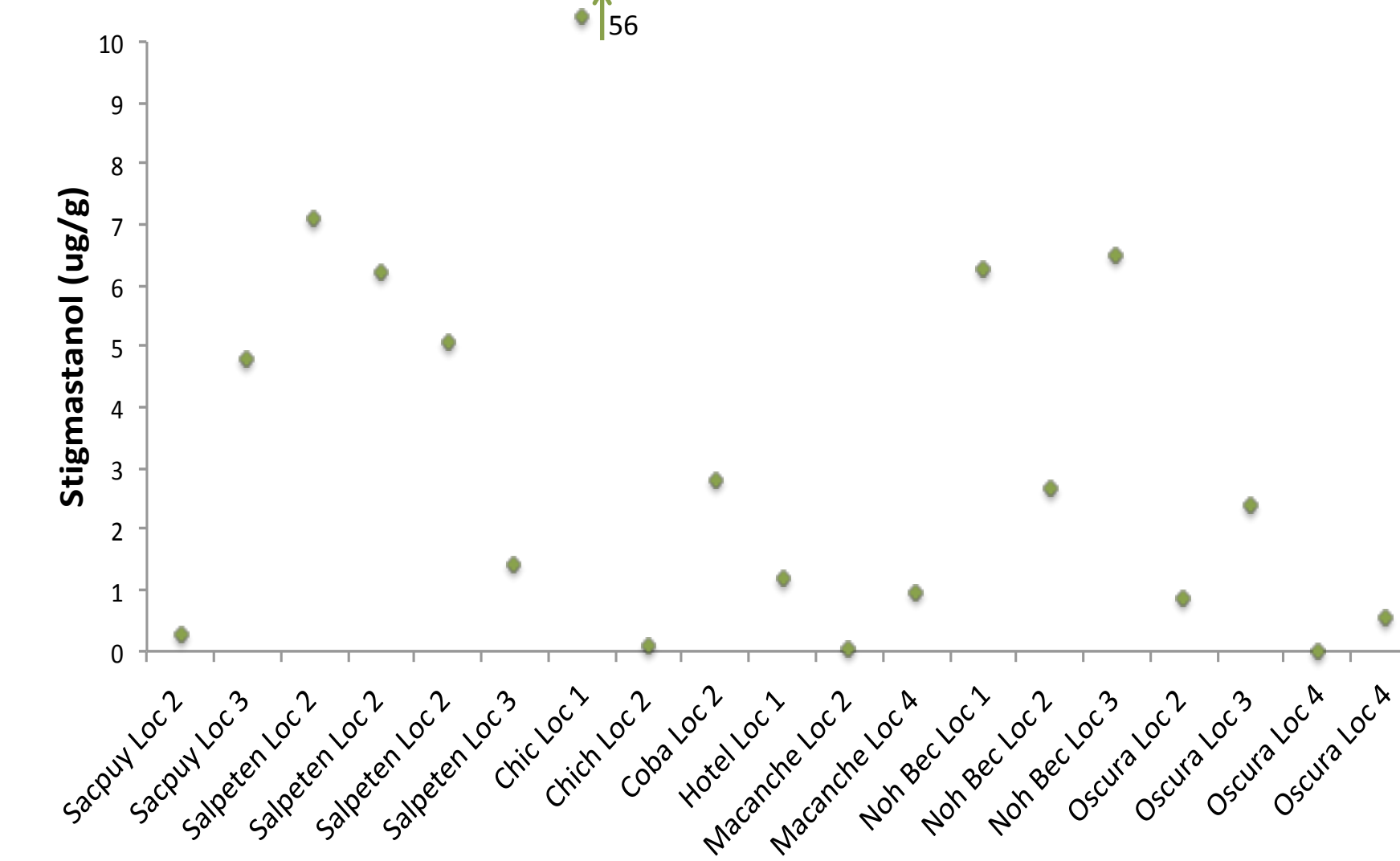
Concentration of coprostanol and epicoprostanol in lake sediments



Ratios of coprostanol and epicoprostanol to cholesterol in lake sediments



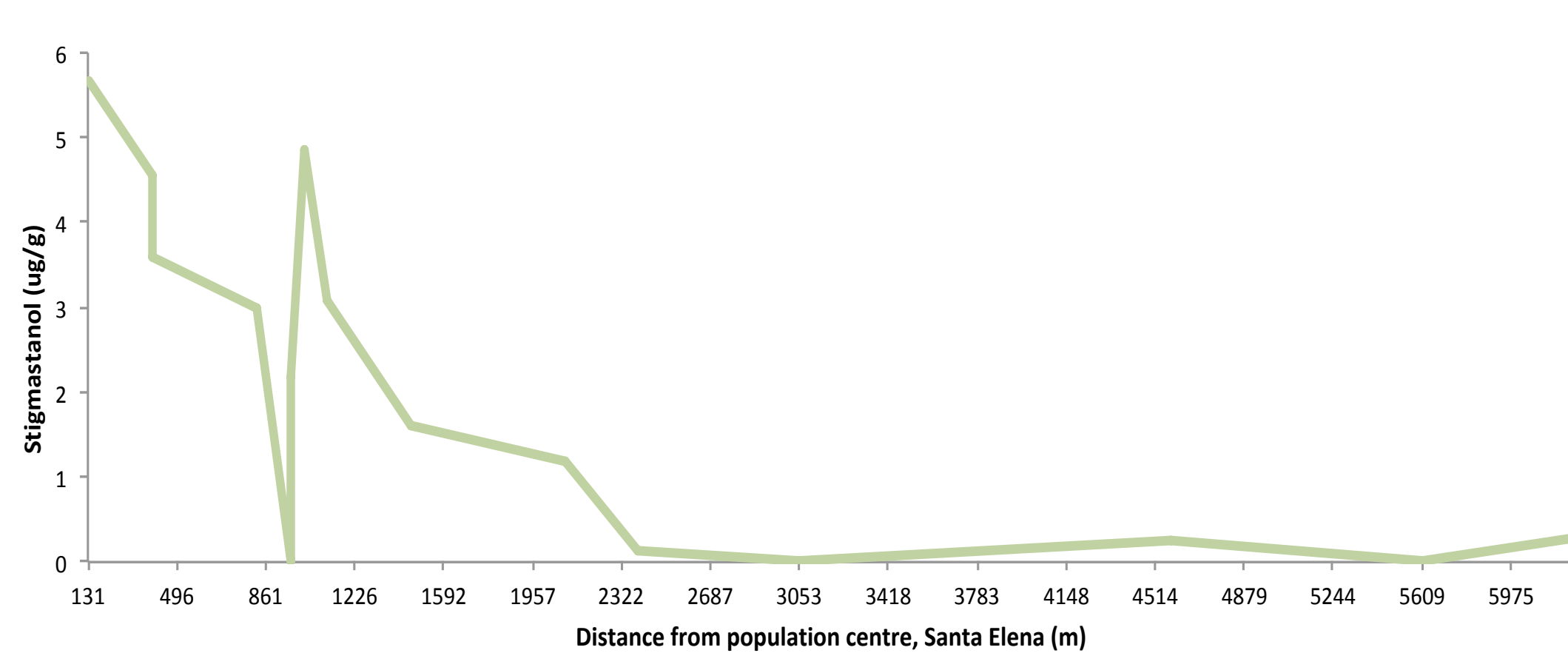
Concentration of stigmasterol in lake sediments



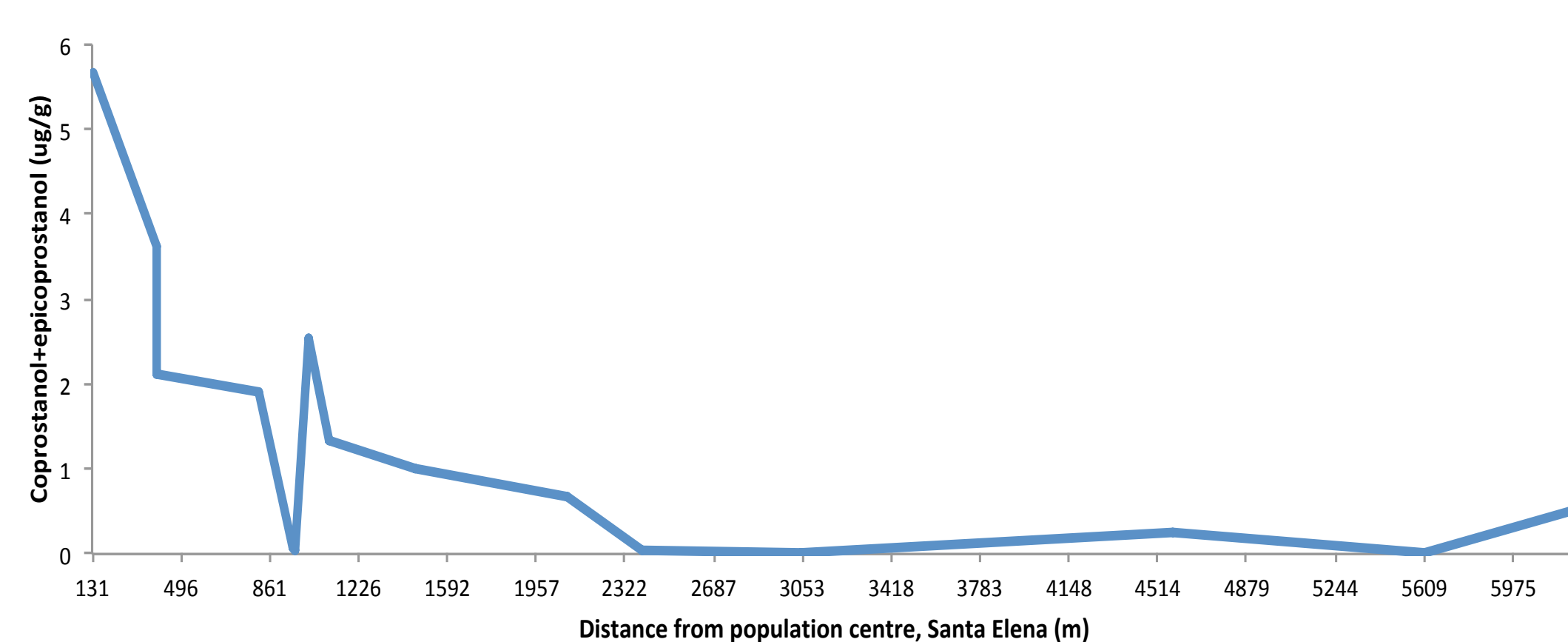
- Lot of variability that does not seem to be related to proximity to human settlements
- Some sampling sites located close to towns (Coba) but low concentrations
- Coba is close to a town and has a very high ratio, L. Chichancanab further from town but have very high concentrations
- Unknown effects of sewage management/treatment- different levels of infrastructure across the peninsula
- Significant spatial variability in concentrations within the same lake (Chichancanab, Noh Bec, Sacpuy)
- Chichancanab extremely high values for coprostanol and stigmasterol. High values do not translate to high ratios: this is likely a function of transport/preservation as opposed to source
- Stigmasterol is the dominant faecal stanol in modern lake sediments

LAGO PETEN-ITZA

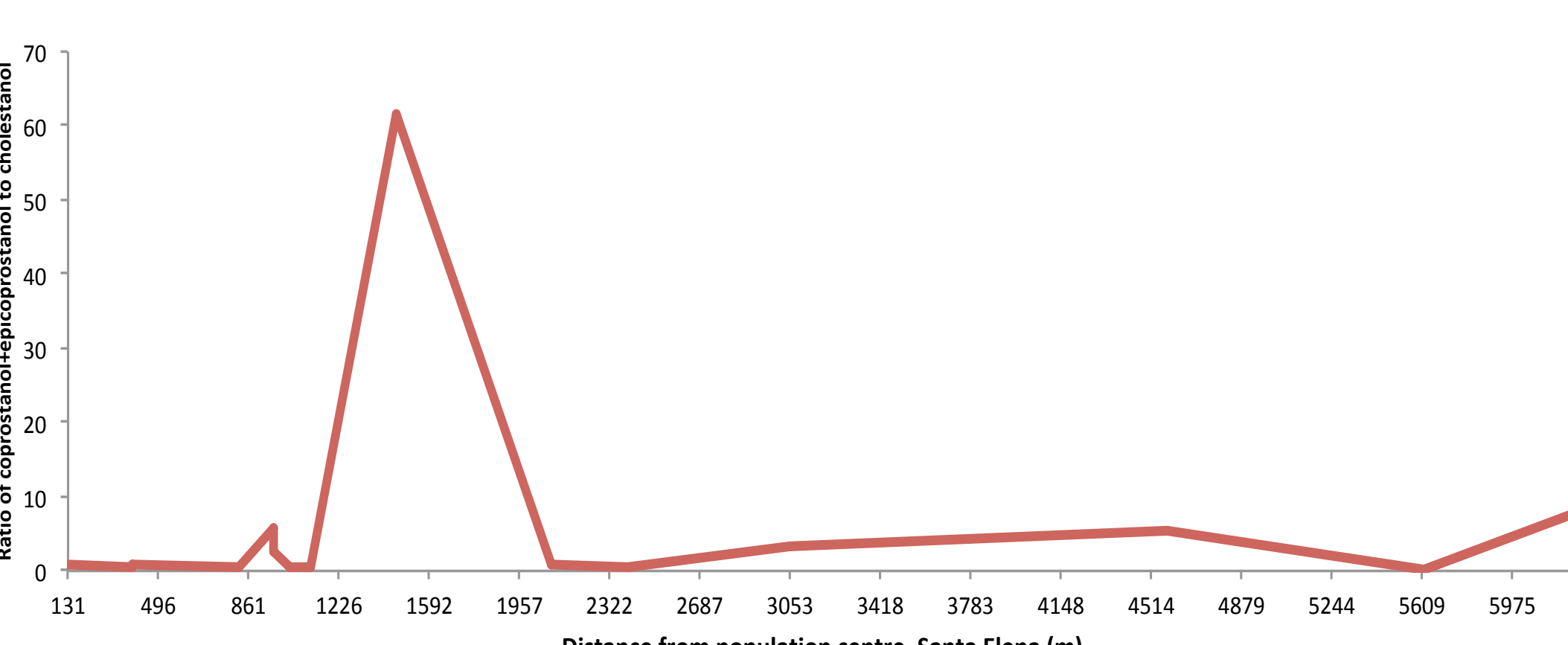
Changes in the concentration of stigmasterol with distance from Santa Elena, Guatemala



Changes in the concentration of coprostanol and epicoprostanol with distance from Santa Elena, Guatemala



Changes in the ratio of coprostanol and epicoprostanol to cholesterol with distance from Santa Elena, Guatemala



- As expected, concentrations of coprostanol decrease away from Santa Elena but do not increase with proximity to population centres on the northern side of the lake
- Stigmasterol concentrations have a similar pattern and could reflect livestock populations
- Low faecal stanol concentrations close to Santa Elena (861 m from population centre) show that other variables influence either the deposition or preservation of faecal stanols