The Neolithic transition in Europe: Archaeology versus Genetics

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Models of Neolithic transitions

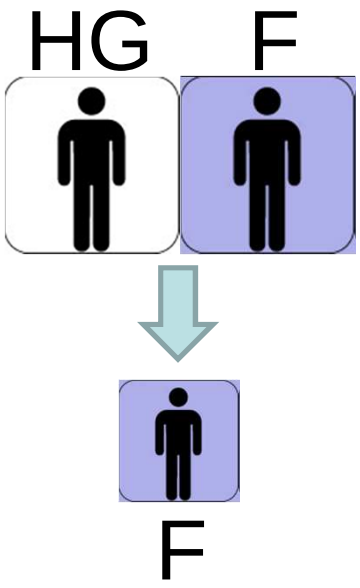
- **Demic diffusion** = spread of farming populations = dispersal + net reproduction

- **Cultural diffusion** = spread of ideas = transmission of plants, animals and knowledge from farmers to hunter-gatherers (acculturation).

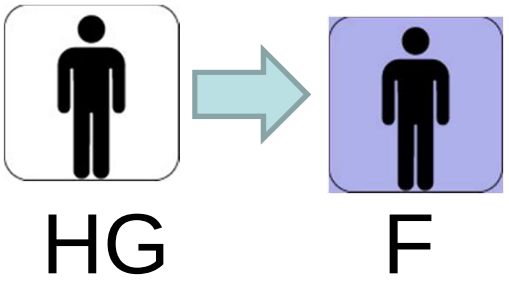
- **Demic-cultural models**

Cultural diffusion

It takes 2 forms:



1) **Vertical** = due to interbreeding between hunter-gatherers (HG) and farmers (F)



2) **Horizontal/oblique** = due to acculturation (copying)

Horizontal/oblique transmission

Population numbers after *(P')* and before *(P)* cultural transmission (during 1 generation):

$$\begin{cases} \text{farmers } (F): \quad P'_F = P_F + f\dfrac{P_F P_H}{P_F + \gamma P_H} \\ \text{hunter} - \text{gatherers } (H): \quad P'_H = P_H - f\dfrac{P_F P_H}{P_F + \gamma P_H} \end{cases}$$

γ = preference of *H*s to copy *F*s rather than *H*s (if $\gamma < 1$)

If $\gamma \approx 1$ (random copying)$\rightarrow$ eqs. of vertical transmission

Cavalli-Sforza & Feldman (*book* 1979)
Boyd & Richerson (*book* 1985)
Fort (*PNAS* 2012, Phys Rev E 2011)

$$\begin{cases} P_F' = P_F + f\dfrac{P_F P_H}{P_F + \gamma P_H} \approx P_F + C\,P_F \\ P_H' = P_H - f\dfrac{P_F P_H}{P_F + \gamma P_H} \approx P_H - C\,P_F \end{cases}$$

$C = \frac{f}{\gamma}$

when the first farmers arrive $(P_F \approx 0)$

$C = \frac{P_H' - P_H}{P_F}$ = number of HGs converted per farmer per generation (in horizontal/oblique transm.)

or

$C = \frac{P_F' - P_F}{P_F}$ = fraction of Fs that mate HGs per generation (in vertical trans.)

Fort (*PNAS* 2012)

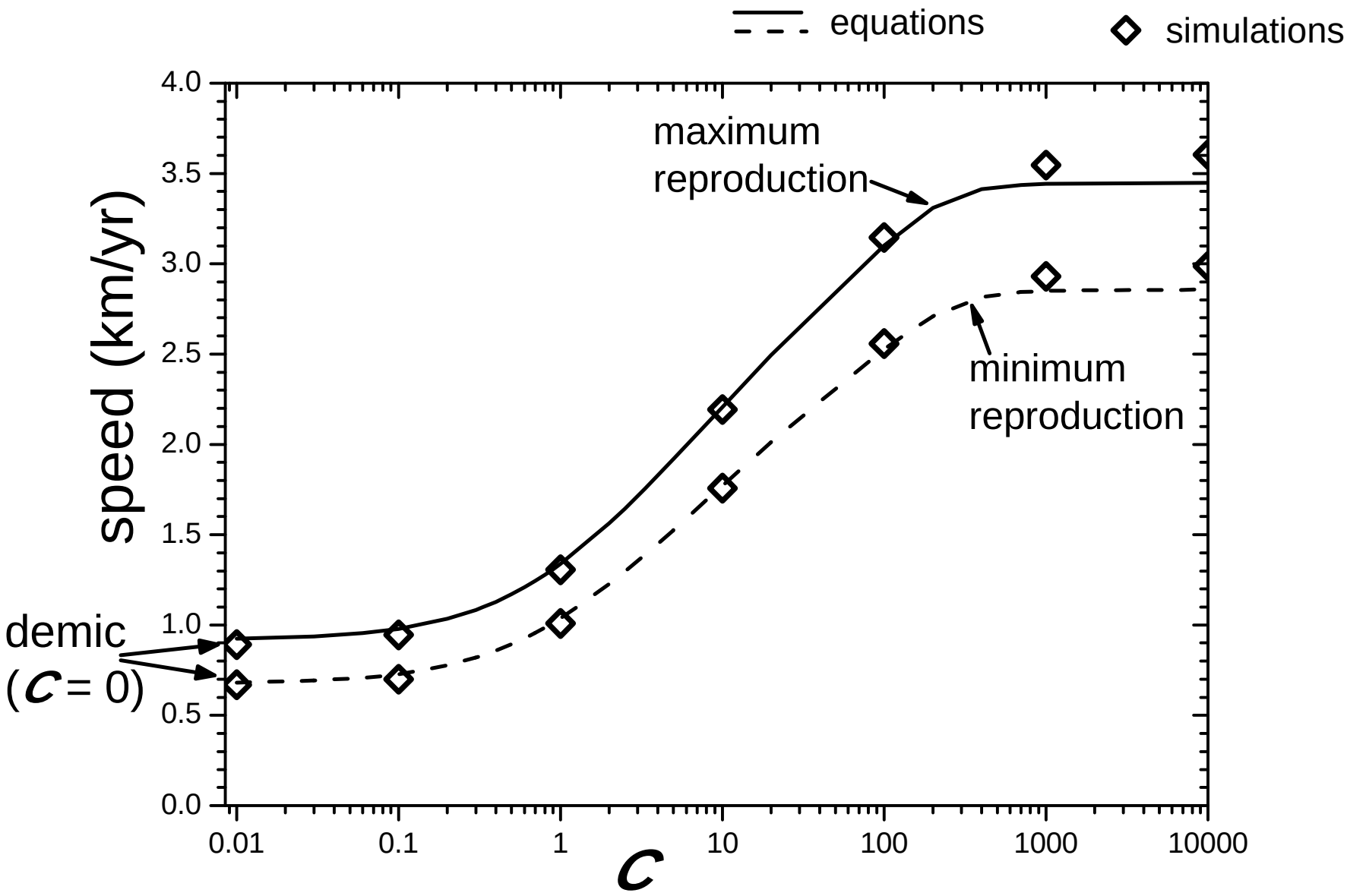
Demic-cultural models

Steps:

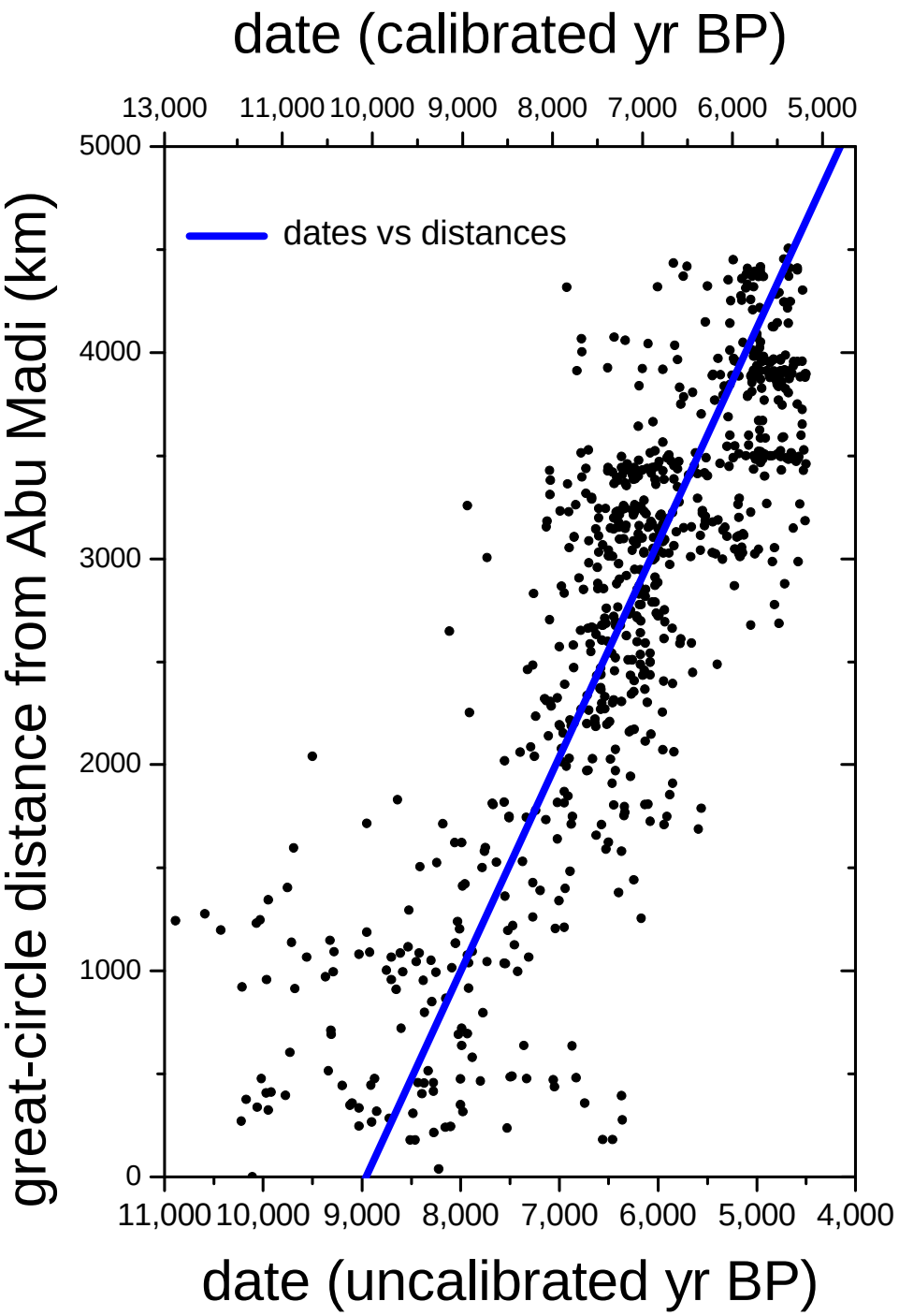
1. reproduction (logistic)
2. cultural transmission (vertical/horizontal)
3. dispersal (distance kernel)

The order of steps does not change the speed

This cycle is repeated many times (once per generation)



Fort, *PNAS* (2012)



What is the observed speed?

0.9-1.3 km/yr

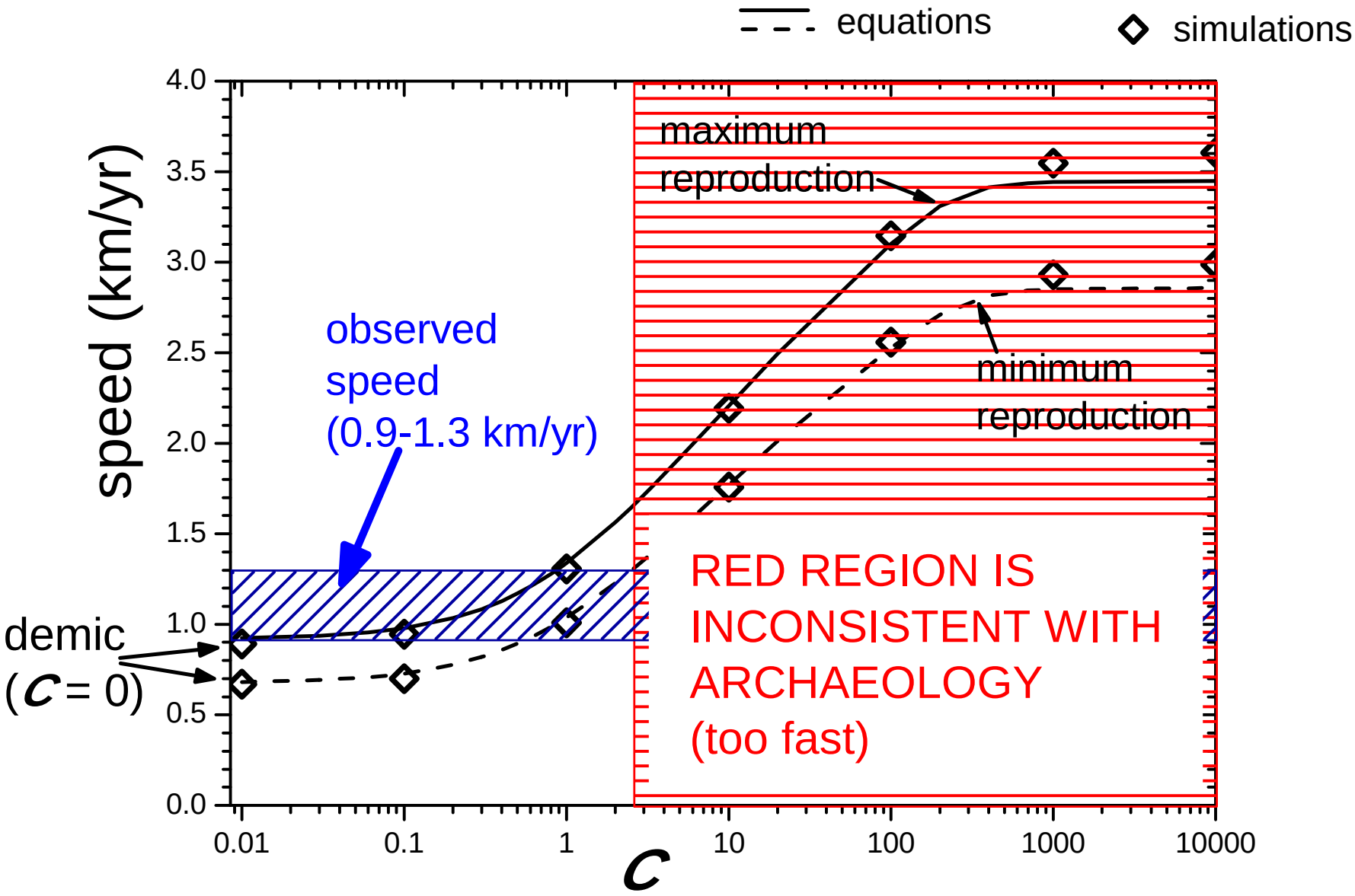
735 sites in Europe & Near East

$r = 0.83$

highest-*r* origins

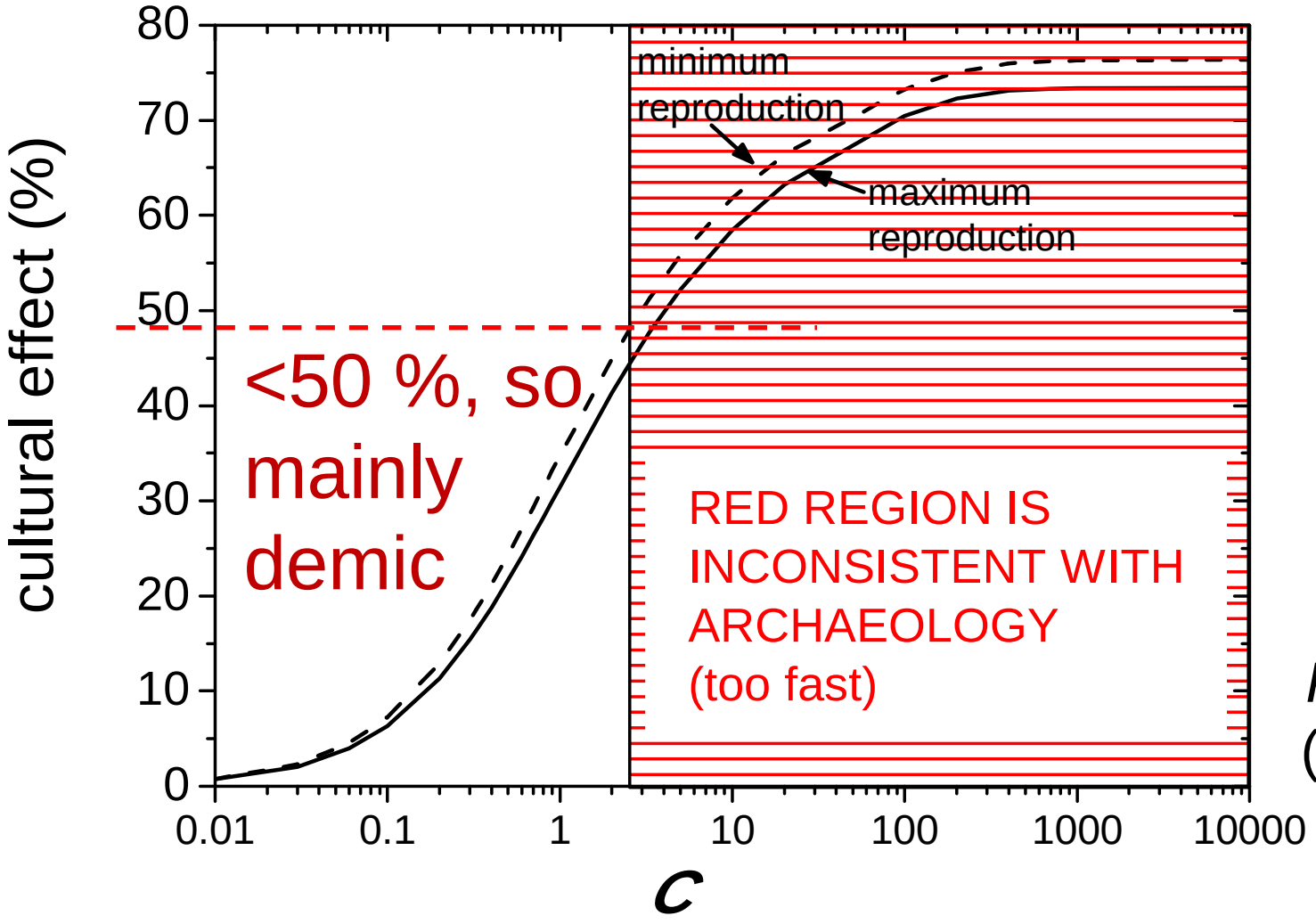
great circles & shortest paths

Pinhasi, Fort & Ammerman, *PLoS Biol.* (2005)



Fort, *PNAS* (2012)

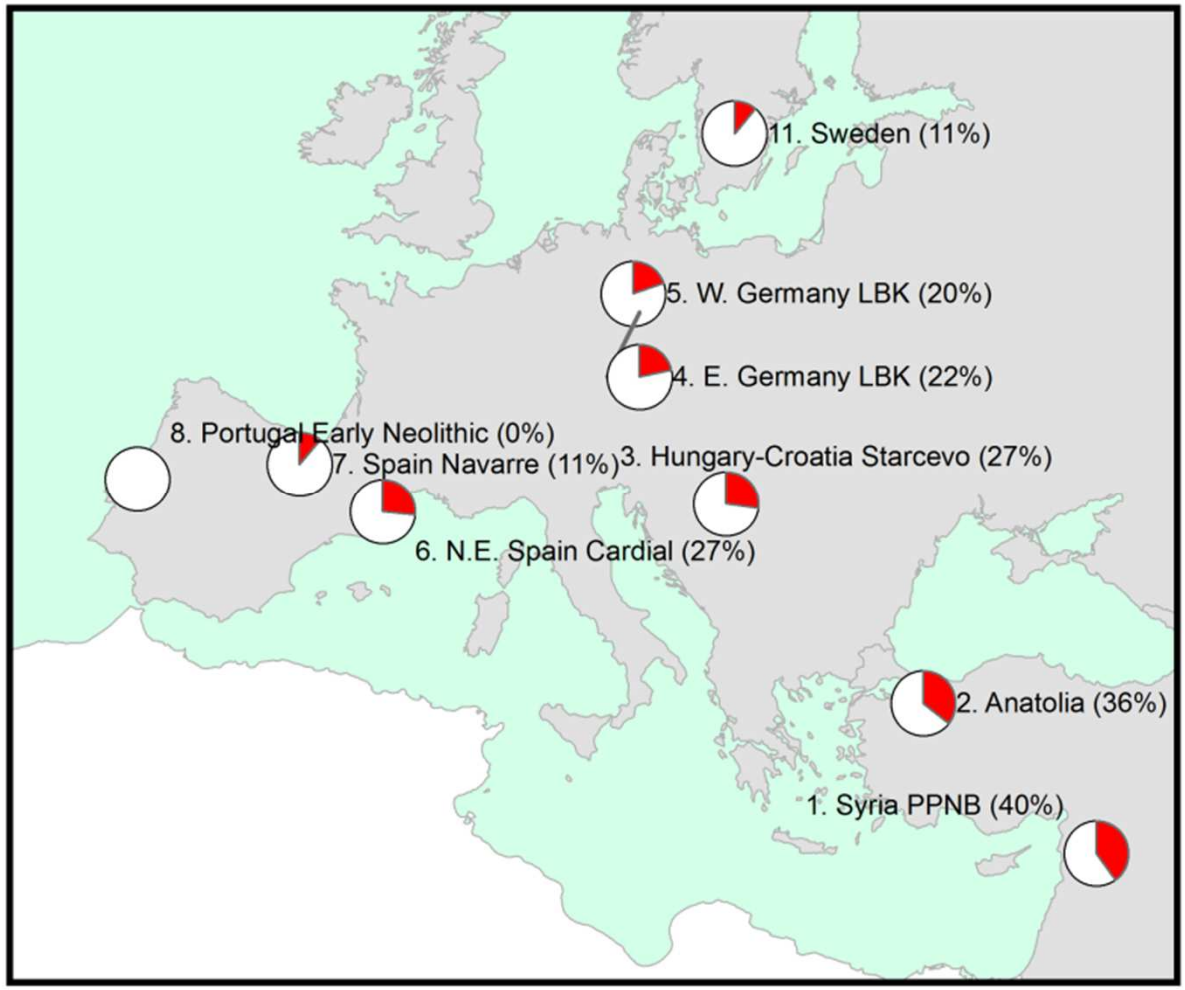
Cultural effect (%) = (speed – demic speed) /speed · 100



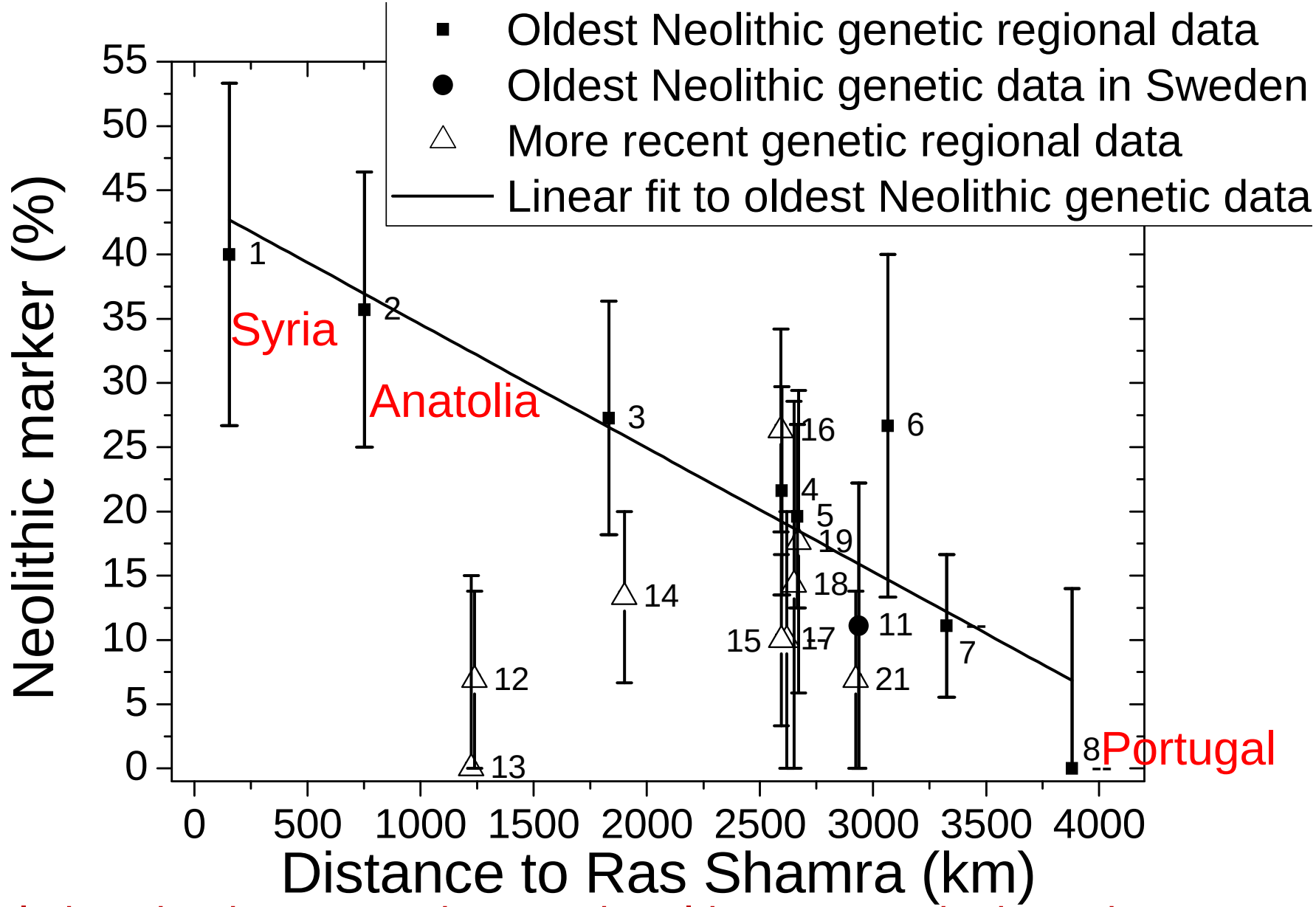
Fort, *PNAS* (2012)

Ancient genetics

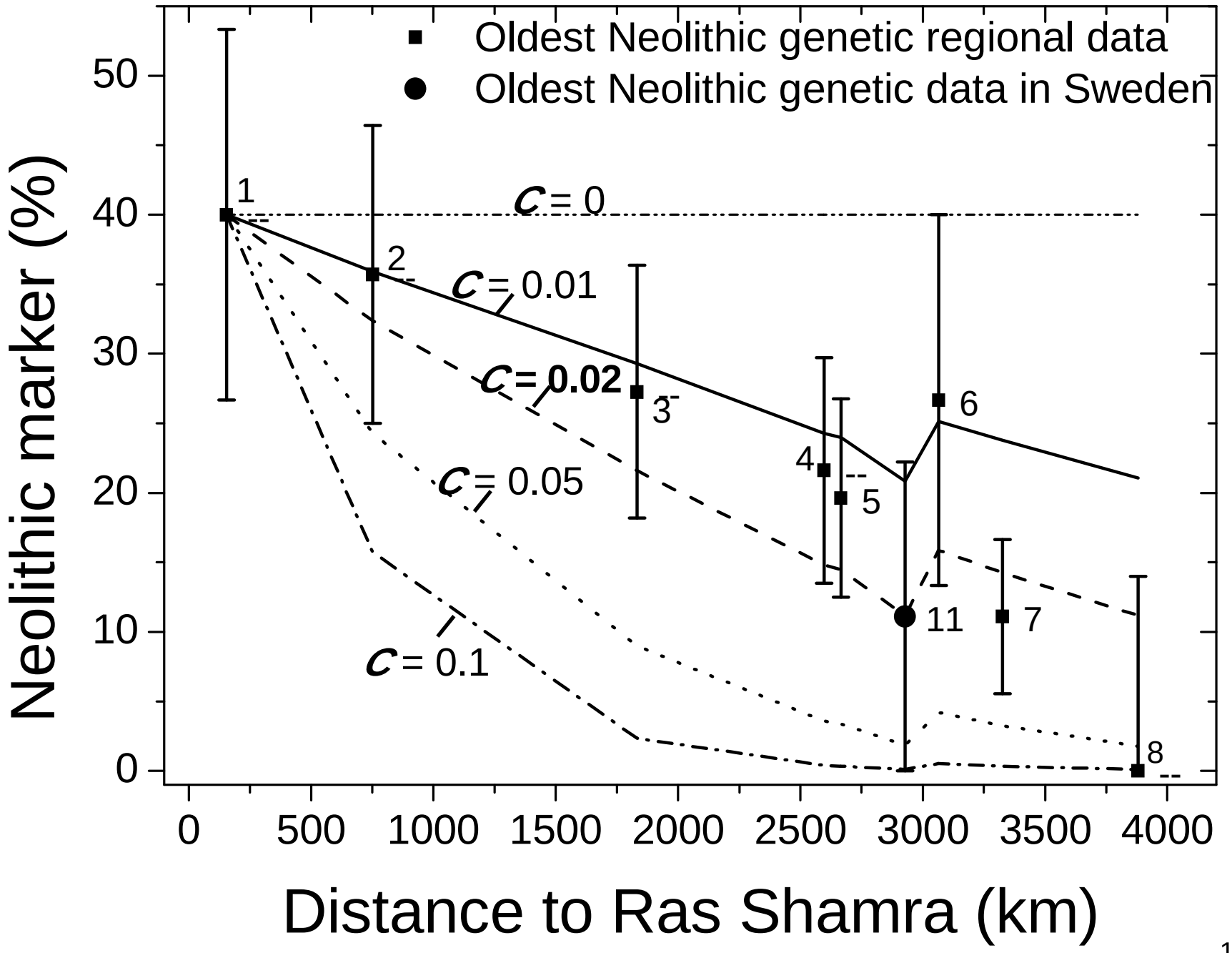
We have gathered a database of all Neolithic individuals (514) whose mtDNA has been determined



We analyze a marker such that its frequency (red) decreases Westwards and Nothwards

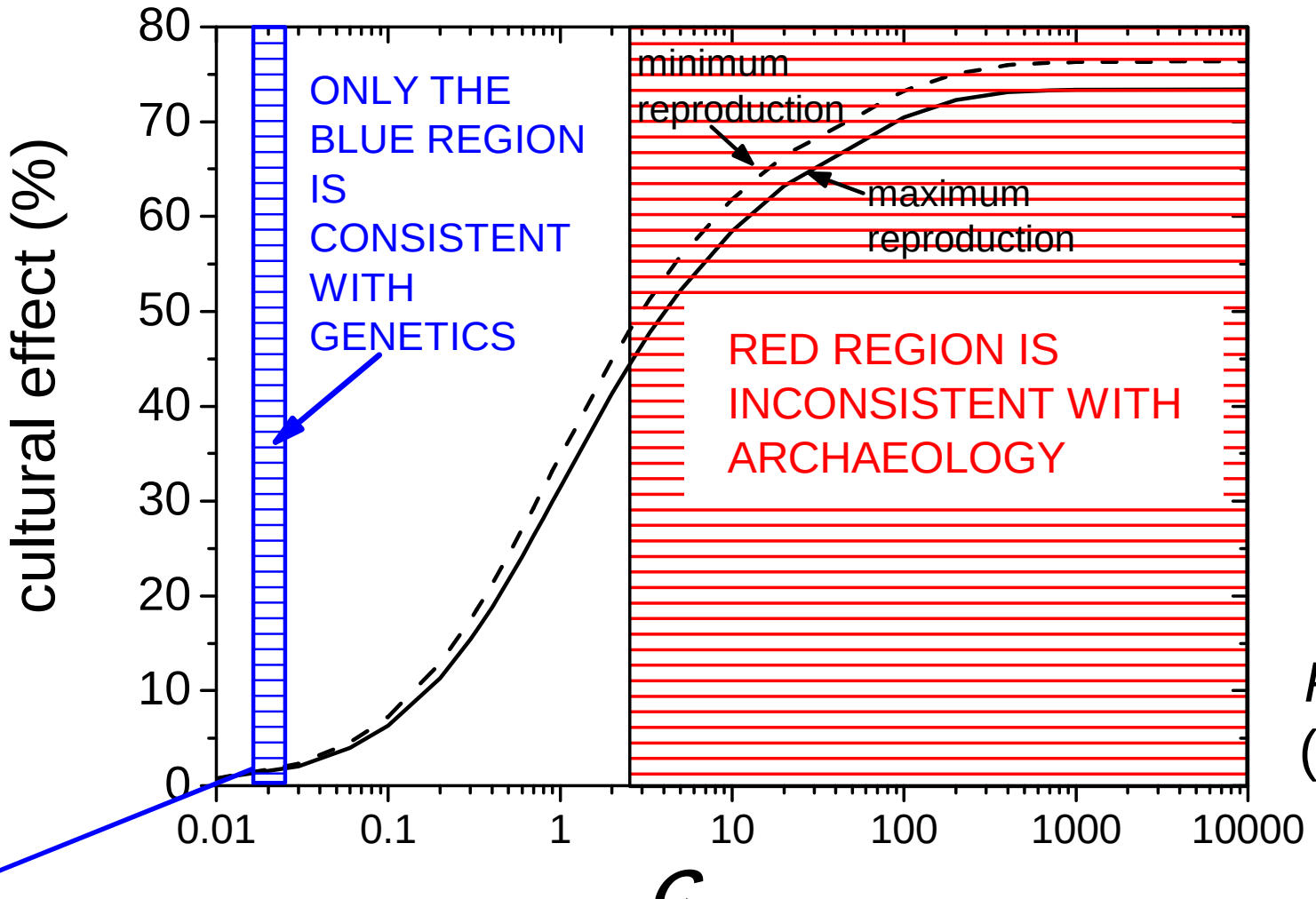


Simulations begin at Ras Shamra, the oldest PPNB site in Syria from Pinhasi et al (2005). They begin at the oldest date from Archaeology and with the observed % of the marker from Genetics



Fort, Isern & de Rioja, Sci. Rep. (subm.)

Effect (%) = (speed – demic speed) /speed · 100



Fort, *PNAS* (2012)

2%, so demic>>cultural

Conclusions

- Archaeology suggests cultural effect <50%→mainly demic
- Genetics suggests cultural effect ≈2%→demic>>cultural

Open problem

Are the parameter values used realistic?

It would help a lot to measure prehistoric dispersal kernels, if possible:

- Strontium isotope: not accurate distances
- Genetics: identification of parent-child pairs?

Until we have accurate parameter values, the models can be useful but the conclusions are preliminary.