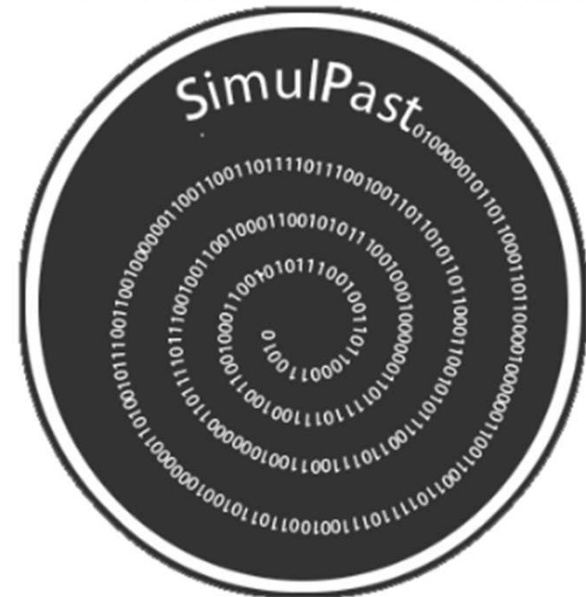# Neolithic transitions: demic or cultural?

Joaquim Fort
Universitat de Girona
(Catalonia, Spain)

SimulPast session
SAA annual meeting
San Francisco
April 16th, 2015

Models of Neolithic transitions

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

- Cultural diffusion = spread of ideas

  = acculturation of hunter-gatherers

- Demic-cultural models

  = reproduction + dispersal + acculturation

Acculturation

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

$$\text{farmers } (F): \quad P_F' = P_F + f\,\frac{P_F P_H}{P_F + \gamma P_H}$$

$$\text{hunter} - \text{gatherers } (H): \quad P_H' = P_H - f\,\frac{P_F P_H}{P_F + \gamma P_H}$$
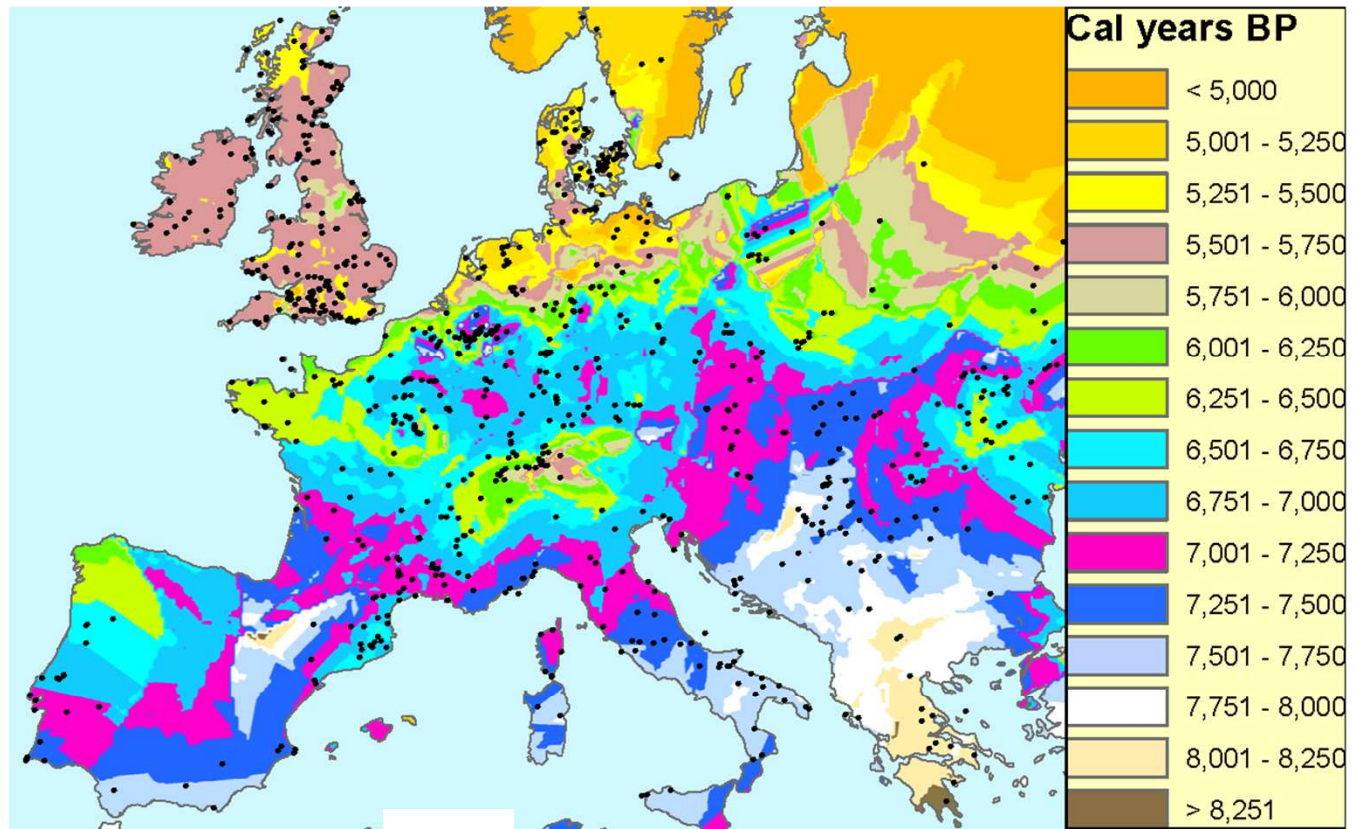
f = intensity of cultural transmission

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

$$\text{if } P_H \gg P_F: \quad \begin{cases} P_F' \approx P_F + C\,P_F \\ P_H' \approx P_H - C\,P_F \end{cases} \quad \boxed{C = \frac{f}{\gamma}}$$

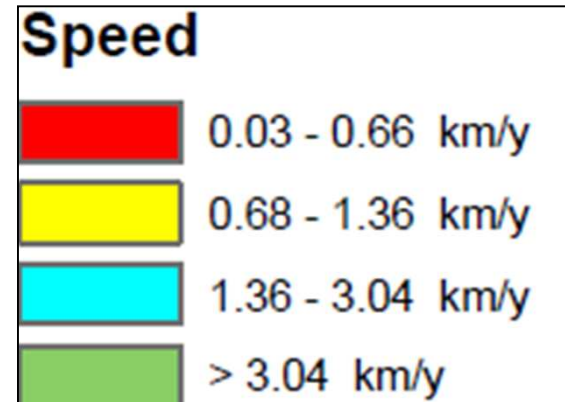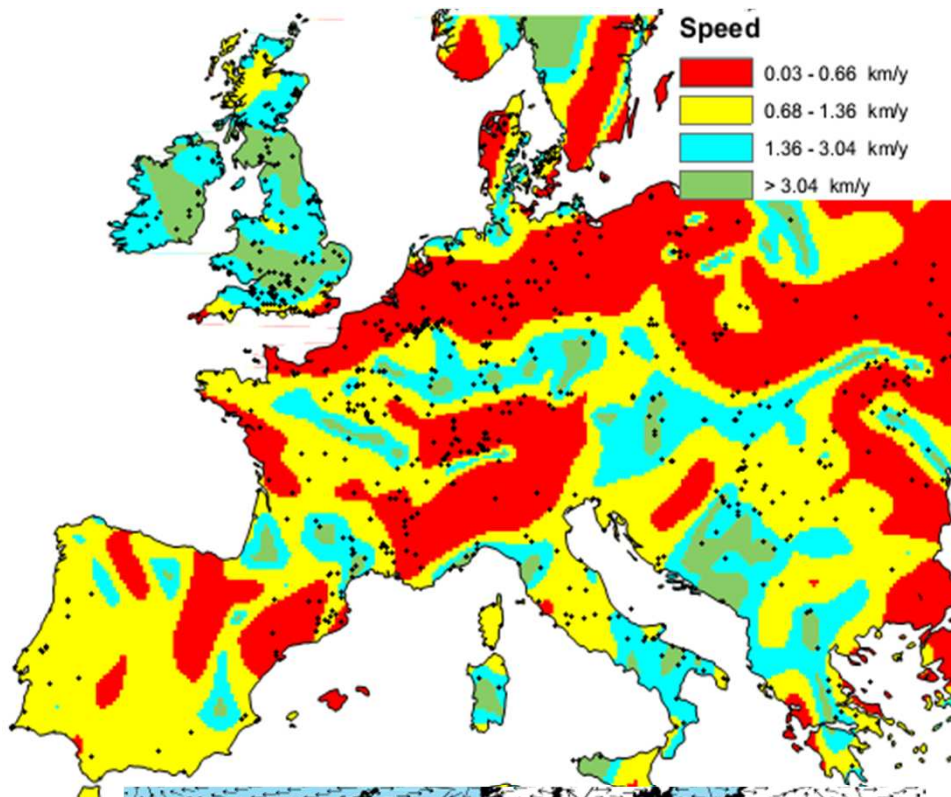$\dfrac{P_F' - P_F}{P_F} = C$ is the number of *H*s converted by farmer

The front speed depends on *C* (*not on* f and γ separately)   3

Interpolation of 918 sites

Fort,
J. R. Soc. Interface
(2015)

Speed

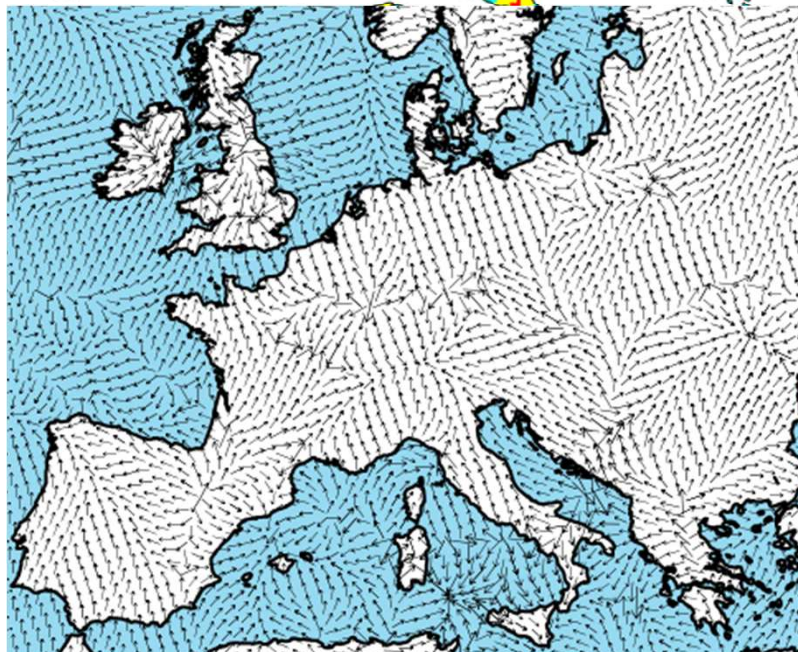|	
🟥	0.03 - 0.66 km/y
🟨	0.68 - 1.36 km/y
🟦	1.36 - 3.04 km/y
🟩	> 3.04 km/y

after smoothing

Fort,
J. R. Soc. Interface
(2015)

The previous maps show <u>observed</u> speeds.
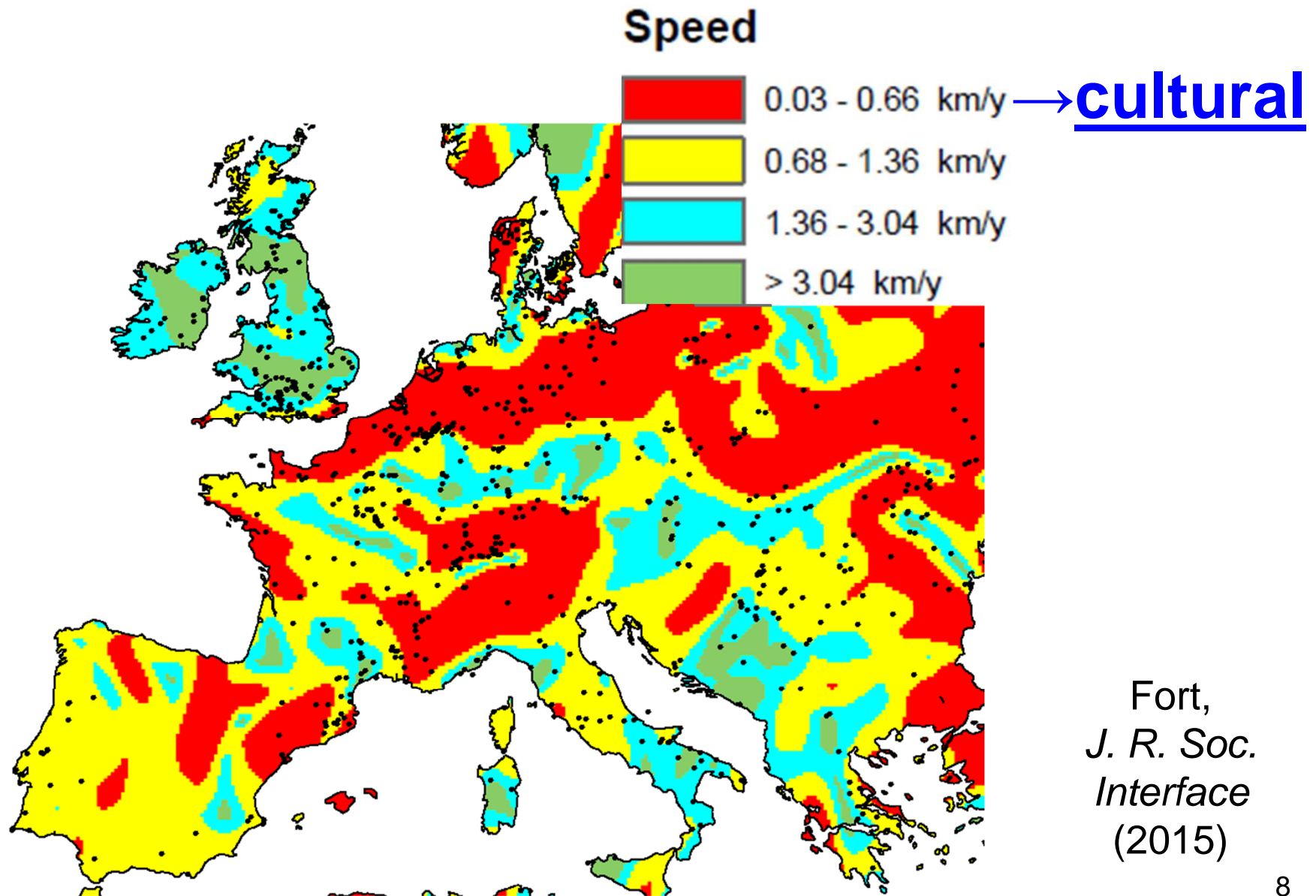
What are the speeds from the models?

1. Purely cultural model

2. Purely demic model

3. Demic-cultural model

Purely cultural model

· Population 1 (Mbuti, band I): $\{P_k\}$={0.59, 0.37, 0.04}, $\{R_k\}$={2.5, 7.5, 12.5}km → 0.17-0.36 km/y.

· Population 2 (Mbuti, band II): $\{P_k\}$={0.12, 0.30, 0.43, 0.15}, $\{R_k\}$={2.5, 7.5, 12.5, 17.5}km → 0.30-0.57 km/y.

· Population 3 (Mbuti, band III): $\{P_k\}$={0.20, 0.41, 0.26, 0.08, 0.05}, $\{R_k\}$={2.5, 7.5, 12.5, 17.5, 22.5}km → 0.32-**0.66 km/y**. **MAX**

· Population 4 (Aka): $\{P_k\}$={0.12, 0.25, 0.11, 0.04, 0.03, 0.16, 0.05, 0.05, 0.05, 0.14}, $\{R_k\}$={0.05, 0.1, 0.2, 0.25, 0.3, 0.4, 2, 3, 5, 6}km → 0.09-0.19 km/y.

· Population 5 (Baka): $\{P_k\}$={0.48, 0.04, 0.13, 0.14, 0.18, 0.03}, $\{R_k\}$={0, 0.5, 0.8, 1.5, 1.7, 2.7}km → **0.03**-0.07 **km/y**. **MIN**

Overall range: **0.03-0.66 km/y** (cultural model)

Interpretation of the observed speeds

Speed

- 0.03 - 0.66 km/y →**cultural**
- 0.68 - 1.36 km/y
- 1.36 - 3.04 km/y
- > 3.04 km/y

Fort,
J. R. Soc.
Interface
(2015)

8

Purely demic model

·<u>Population A </u>(Gilishi 15): $\{p_j\}$={0.54, 0.17, 0.04, 0.25}, $\{r_j\}$={2.4; 14.5, 36.3, 60.4}km → 0.87-1.15 km/y.

·<u>Population B </u>(Gilishi 25): $\{p_j\}$={0.40, 0.17, 0.17, 0.26}, $\{r_j\}$={2.4; 14.5, 36.3, 60.4}km → 0.92-1.21 km/y.

·<u>Population C </u>(Shiri 15): $\{p_j\}$={0.19, 0.07, 0.22, 0.52}, $\{r_j\}$={2.4; 14.5, 36.2, 60.4}km → 1.14-**1.48 km/y**. **MAX**

·<u>Population D </u>(Yanomano): $\{p_j\}$={0.19, 0.54, 0.17, 0.04, 0.04, 0.02}, $\{r_j\}$={5, 30, 50, 70, 90, 110}km → 1.12-1.48 km/y.

·<u>Population E </u>(Issongos): $\{p_j\}$={0.42; 0.23; 0.16; 0.08; 0.07; 0.02; 0.01; 0.01}, $\{r_j\}$={2.3, 7.3, 15, 25, 35, 45, 55, 100}km → **0.68**-0.92 **km/y. MIN**

Overall range: **0.68 -1.48 km/y** (purely demic model) 9

s_{obs} = observed speed

s_D = speed predicted by the purely demic model

Cultural effect (in %) = $E = \frac{s_{obs} - s_D}{s_{obs}} 100$

$s_{D\,min} = 0.68$ km/y $\rightarrow E_{max} = (1 - \frac{0.68}{s_{obs}}) 100 \rightarrow$

$E_{max} < 50\%$ if $s_{obs} \leq 1.36$ km/y:
mainly demic regions (yellow)

Interpretation of the observed speeds

Speed

- 0.03 - 0.66 km/y → cultural
- 0.68 - 1.36 km/y → **mainly demic**
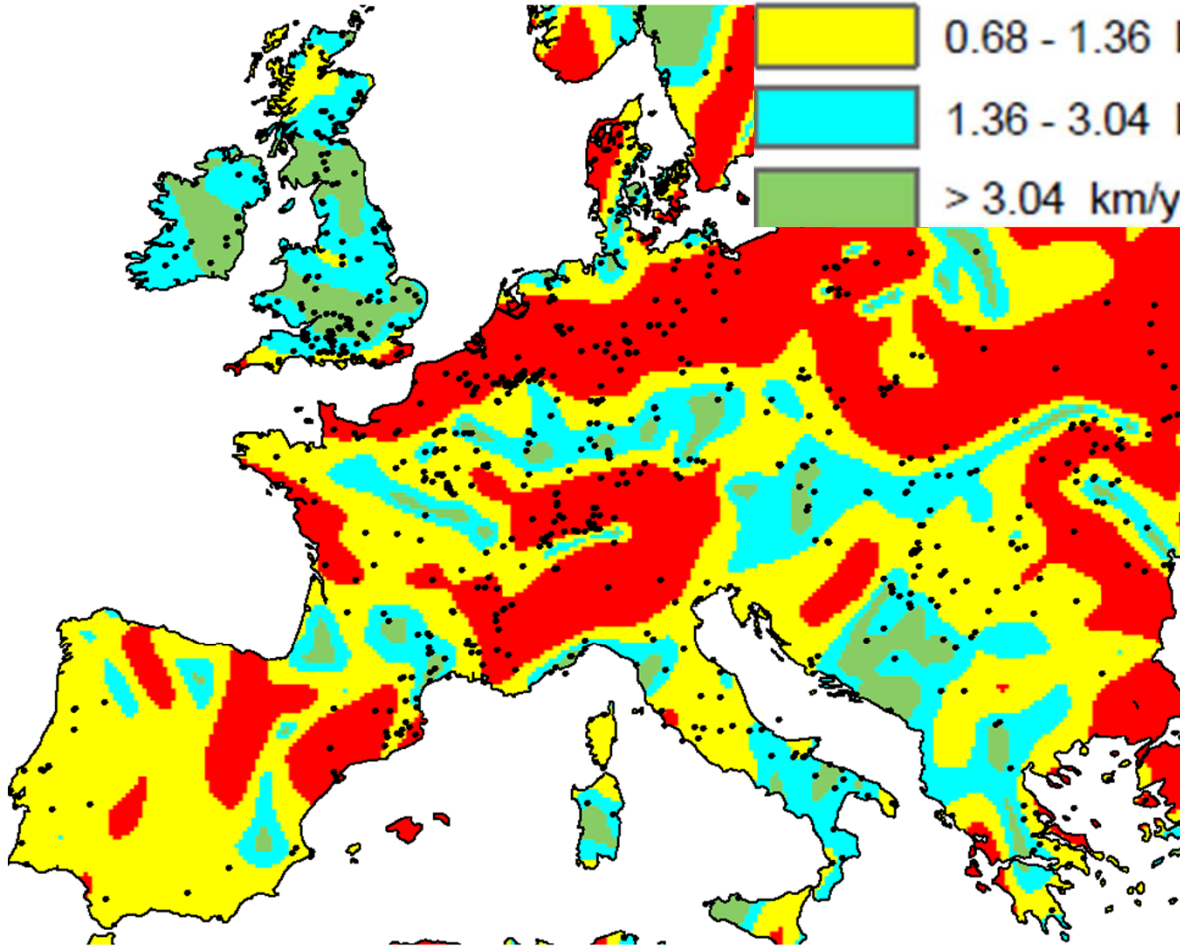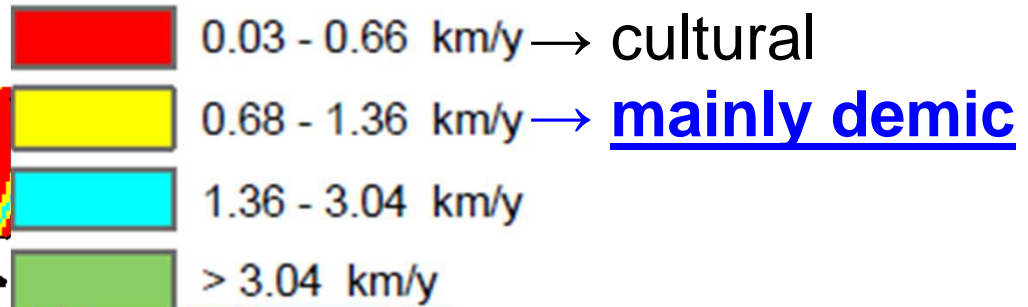- 1.36 - 3.04 km/y
- > 3.04 km/y

Fort,
*J. R. Soc.
Interface*
(2015)

Fig. 3

11

Demic-cultural model

Its **fastest speed** is obtained for:
· The strongest observed intensity of cultural transmission ($C = 10.9$),
· The fastest cultural kernel (population 3),
· The fastest demic kernel (population C or D),
· The highest observed value of the reproduction rate a_N ($0.033\ y^{-1}$), and
· The lowest observed value of the generation time T ($29\ y$).

Using these data we find **3.04 km/y.**

Interpretation of the observed speeds

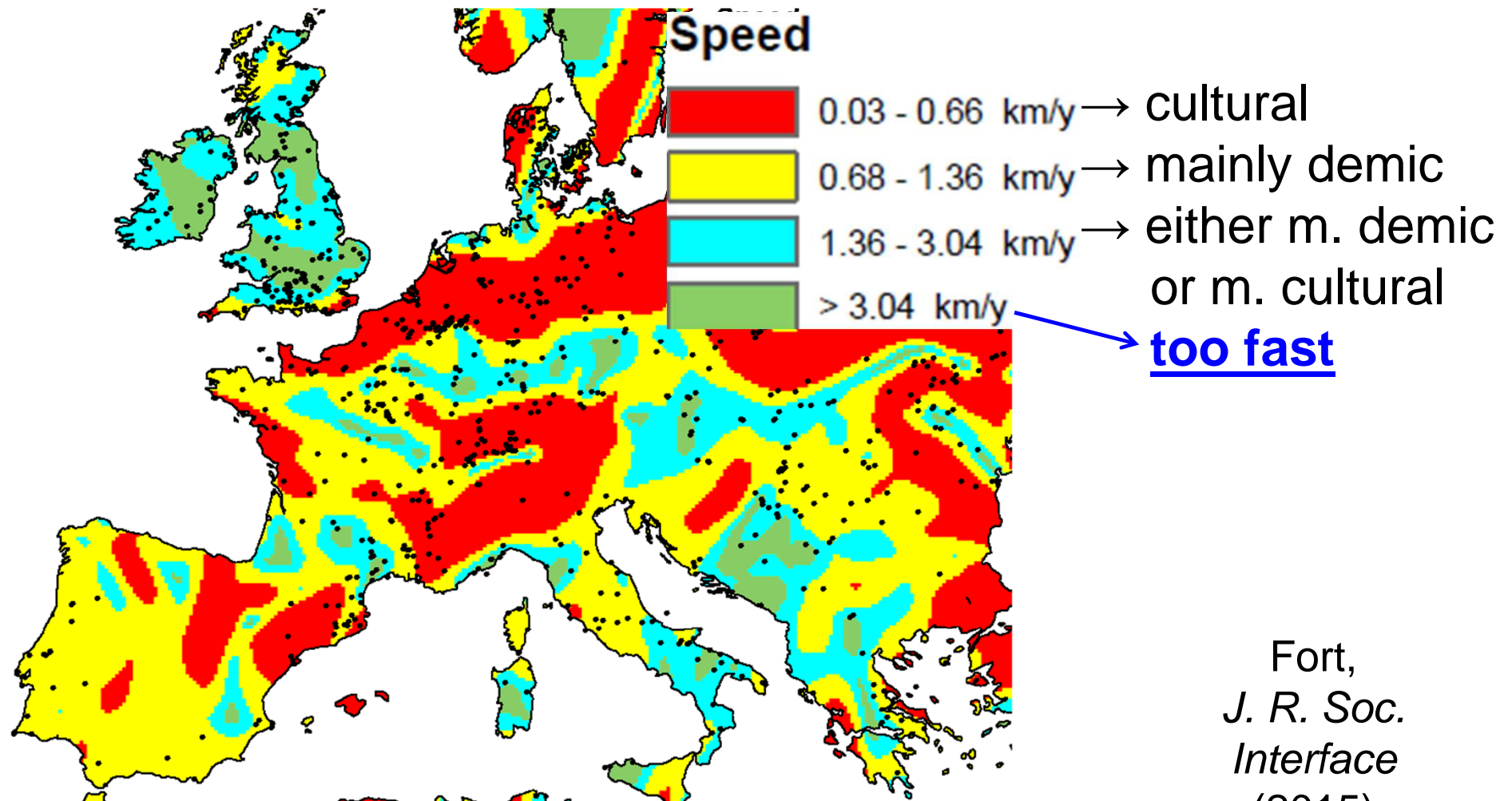
Fig. 3

Speed

🟥	0.03 - 0.66 km/y → cultural
🟨	0.68 - 1.36 km/y → mainly demic
🟦	1.36 - 3.04 km/y → either m. demic or m. cultural
🟩	> 3.04 km/y → **too fast**

Fort,
*J. R. Soc.
Interface*
(2015)

Conclusions

· Mainly demic diffusion (yellow) was fast (speeds above 0.68 km/y). Areas: Greece, Italy, the Balkans, Hungary, Slovakia, Czechia and central Germany.
This includes a substantial part of the Linearbandkermic (LBK) culture in Central Europe*.
It agrees with Bogucki (2003) and Shennan & Edinborough (2007).

·Cultural diffusion (red) was slow (speeds below 0.66 km/y). Areas: Northern Europe, the Alps and West of the Black Sea (red color). This agrees, respectively, with Bogucki (1996), Clark (1990) and Anthony (2007).

*Kaczanowska M, Kozlowski JK, 2003, Fig. 12.7   14

Other Neolithic transitions

- Southern Africa (Khoikhoi):

  $2.4{\pm}1.0$ km/yr $\rightarrow$ 57 ± 7 % cultural

  Jerardino, Fort, Isern & Rondelli, Plos One 2014

- Southwest Asia:

  $0.7{\pm}0.1$ km/yr* $\rightarrow$?? % cultural (B. Comas)

  *Gangal, Sarson & Shukurov, Plos One 2014

- Africa (Bantu): ?? km/yr

  data: Russell, Silva & Steele, Plos One 2014

- Other ??