



# Reply to 'Reduction in grain pollen indicates population decline, but not necessarily Black Death mortality'

A. Izdebski<sup>1,2</sup>, M. Bauch<sup>3</sup>, P. Guzowski<sup>4</sup>, S. Mensing<sup>5</sup>, A. M. Mercuri<sup>6</sup>, T. Newfield<sup>7</sup>, G. Piovesan<sup>8</sup>, L. Sadori<sup>9</sup>, C. Vignola<sup>1,9</sup> and A. Masi<sup>1,9</sup>✉

REPLYING TO: Daniel R. Curtis et al. *Nature Ecology & Evolution* <https://doi.org/10.1038/s41559-022-01862-4> (2022)

In his thoughtful reply to our paper<sup>1</sup>, Daniel Curtis raises concerns not about the results of our analysis of pollen data from 261 sites from 19 modern-day European countries, but about how we interpreted our results. Following the principle of parsimony, our large-scale palaeoecological approach allowed us to roughly measure an otherwise obscure phenomenon, a historical mortality event. We empirically demonstrated that landscape change during the Black Death era was highly variable and that the Black Death did not uniformly, or widely, lead to arable contraction and landscape rewilding. Spatial heterogeneity in mortality, as opposed to universal mass mortality, is one of the explanations of this unexpected pattern. We posited that this revealed 'the significance of cultural, ecological, economic, societal and climatic factors that mediated the dissemination and impact of the disease'. We established these inter-regional differences for 16 of our study regions (including Italy) for intervals of 100, 50 and 25 years, meaning that the trajectories in land use we discerned were visible in the short and longer term, and we used our results not to make a regionally specific argument but rather to support the opinion that the Black Death's demographic impact was irregular and not, as commonly supposed, unfailingly catastrophic. A European mortality of approximately 50 or 65%<sup>2</sup> is incommensurate with our findings.

While we very much appreciate that regional contexts matter, our interpretation cannot for most regions be empirically demonstrated due to a sheer dearth of adequate written source material. However, we conducted validity tests (for southern Sweden and the area comprising the medieval Kingdom of Poland), which Curtis does not mention, to show that our interpretation holds where there are written and palynological data to test it.

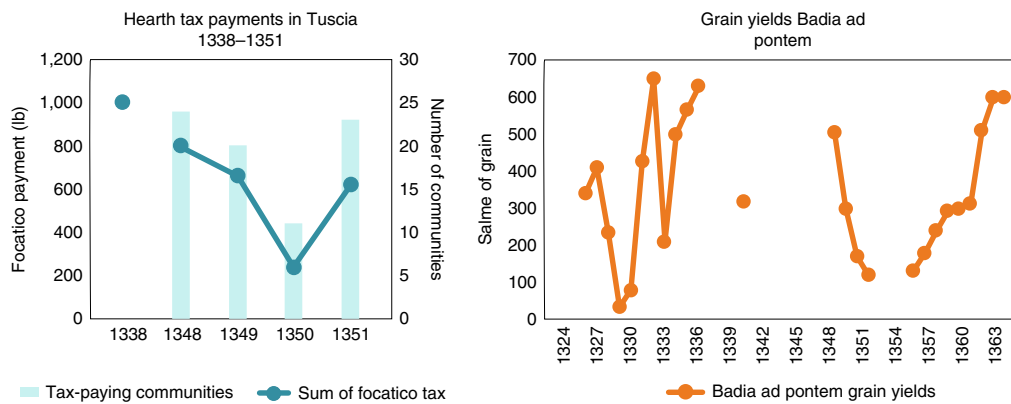
As alternative, 'potentially confounding' explanations for changing arable trajectories, instead of epidemic excess mortality, Curtis proposes out-migration and structural-spatial reorganization of agriculture. To support these alternative proposals, Curtis focuses on central Italy, for which we analysed pollen samples from four coring sites. He draws on generalist historical literature, including work on England, and specific research focused on Tuscany. Importantly, whether the late medieval developments Curtis raises as possibly explaining the arable decline we discerned for central Italy date to within all three of our study intervals is unclear, as is

their relevance for the specific central Italian region we addressed in our study. We argued against using data from one region as a proxy for another but Curtis draws not on research from Lazio, the region for which we presented pollen data, and research available for Lazio supports our interpretation.

Northern Lazio (Maremma Laziale) was a major cereal-producing area for the city of Rome in the fourteenth century<sup>3,4</sup>. While written sources are scarce, data are available for the aggregate quantity of cereals collected annually from the region in a granary under papal control, castle Badia ad pontem (Castello dell'Abbadia; Fig. 1), 40 km from Lago di Vico and 20 km from Lago di Mezzano, from which we presented palaeoecological evidence. These written data, while discontinuous, reveal clearly the supraregional Italian harvest failure and famine of 1328–1330 (ref. <sup>5</sup>) and an 80% decline in cereals collected from 1348 (starting before the Black Death's arrival in Lazio in August 1348) to 1351, confirming that these data comprise a reliable record of variations in cereal production. From 1355 to 1360, the cereals collected slowly recovered to approximately 60% of pre-Black Death levels. The sharp rise in cereals apparent after 1360 might reflect migratory movements from plague-stricken villages to this productive and important (for feeding Rome) cereal-producing area, of the sort Curtis suggests (migration towards developed arable lands is also proposed for other regions, for example<sup>6–8</sup>). Had such migration taken place, we would expect the upward trend in cereals collected to be at least temporarily sustained; however, the data stop after 1363. However, pollen data, including that from nearby Mezzano, supports the idea that cereal contraction was experienced in the region<sup>9</sup>.

Meanwhile, regional demographic decline post 1348 is confirmed by short-running serial evidence for hearth tax (focatico) payments (Fig. 1), which show a nearly 70% reduction of paid taxes from 1348 to 1350. A comparable decline in tax-paying communities in the *Patrimonium Petri* is likewise apparent, with the number of small to mid-size towns paying the focatico falling approximately 50% between 1348 and 1350 (ref. <sup>3</sup>). Combined, these datasets indicate, in line with our interpretation and validity tests, that dramatic population loss negatively affected cereal production in the region. At the same time, the quick partial recovery in tax payments and community number would seem to also suggest rural-urban migration, in line with Curtis' proposal. However, despite this, regional

<sup>1</sup>Max Planck Institute for the Science of Human History, Jena, Germany. <sup>2</sup>Jagiellonian University in Krakow, Krakow, Poland. <sup>3</sup>Leibniz Institute for the History and Culture of Eastern Europe, Leipzig, Germany. <sup>4</sup>University of Bialystok, Bialystok, Poland. <sup>5</sup>University of Nevada, Reno, NV, USA. <sup>6</sup>University of Modena and Reggio Emilia, Modena, Italy. <sup>7</sup>Georgetown University, Washington, DC, USA. <sup>8</sup>University of Tuscia, Viterbo, Italy. <sup>9</sup>Sapienza University of Rome, Rome, Italy. ✉e-mail: [lessia.masi@uniroma1.it](mailto:lessia.masi@uniroma1.it)



**Fig. 1 | Hearth tax payments and cereals collected in northern Lazio during the time of the Black Death.** Based on Palermo<sup>3</sup> pp. 87–88 (hearth tax payments to the Apostolic Chamber) and pp. 323–324, Table 50 (Badia ad pontem grain yields).

arable did not rebound to pre-Black Death levels, almost certainly as the region helped feed the (plague-struck) city of Rome.

Curtis also suggests that structural changes in agriculture, including a movement towards sharecropping (mezzadria) could explain the significant central Italian decline in cereal pollen we evidenced. To support this proposal, Curtis again draws on generalist literature and research pertaining to Tuscany. However, specific studies using historical data from northern Lazio underline consistently that the Black Death had a sizeable demographic impact that caused a contraction of cereal cultivation, a turn towards pastoralism and, particularly after 1400, the cultivation of sharecropped olive trees<sup>10,11</sup>. Support for these developments comes both from written sources and the pollen evidence presented in our paper. Palaeoecological data from the Rieti Basin (Lago Lungo) in northern Lazio, for example, allow for a comparatively high-resolution reconstruction of landscape dynamics that reveals a sudden interruption of intensive cereal cultivation after the Black Death leading to a widespread and persistent phase of woodland expansion and restoration<sup>12</sup>. Potential pollen evidence for expansion of mezzadria, a phenomenon that itself is poorly dated on the basis of written sources, is seen specifically in a sharp increase in cultivated trees (particularly olive) and a decline in deciduous oaks after 1400, approximately 50 years post-Black Death (and subsequent to other second-pandemic plague epidemics). This agrees with the historical documentation for northern Lazio, which records a spread of mezzadria from the beginning of the fifteenth century<sup>13</sup>. There is no doubt that rewilding started in the second half of the fourteenth century, eventually restoring pre-Roman woodland ecosystems.

Curtis' proposals that out-migration and the structural-spatial reorientation of agriculture could account for the cereal trajectories and related changes in population we discerned need to be taken seriously. As we emphasized in our paper, discernible changes in land use after the Black Death would have been mediated by a number of factors, including migration. However, the focus of our original study was not a particular regional trajectory, even if combining palaeoecological and historical evidence nearly always has the potential of offering new insights for almost every European region, as we demonstrated for the case of Lazio, Italy. Rather, our aim was to evaluate the validity of the overarching European narrative of the Black Death, which posited exceptionally high excess mortality across the continent. Our large-scale analysis of the palaeoecological data demonstrated that the situation on the ground was in fact much more variable.

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## Author contributions

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## Competing interests

The authors declare no competing interests.

## Additional information

**Correspondence and requests for materials** should be addressed to A. Masi.

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