

# Did rain bring down the ROMAN EMPIRE?

Analysis of the most complete tree-ring database for Central Europe provides a record of climate change over the past 2500 years. It also reveals synchronies with important historical events, reports Naomi Lubick.

In 1789, English historian Edward Gibbon published the final volume of his life's work, *The History of the Decline and Fall of the Roman Empire*. The opus became an instant classic, setting new standards in objectivity for historians. In six volumes, Gibbon painstakingly charted the Empire's final demise, using original reference material where possible. Gibbon blamed the fall on several factors: a loss of civic virtue, the use of barbarians as mercenaries rather than Roman soldiers, and the rise of Christianity, which led to increased pacifism and widespread beliefs that a better life awaited Roman citizens after death.

Unprecedented tree-ring data now provide historians with a new set of original reference materials to add to the arguments over what exactly led to the Roman Empire's demise. Their findings may have led Gibbon to different conclusions.

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## Unravelling the rings

Tree-ring data provide a summer-season climate record with the kind of yearly accuracy that could be useful for historical studies. Dendrochronologists in Europe have been diligently collecting data on oak and pine for decades, in an attempt to fill in the annual temperature and climate records.

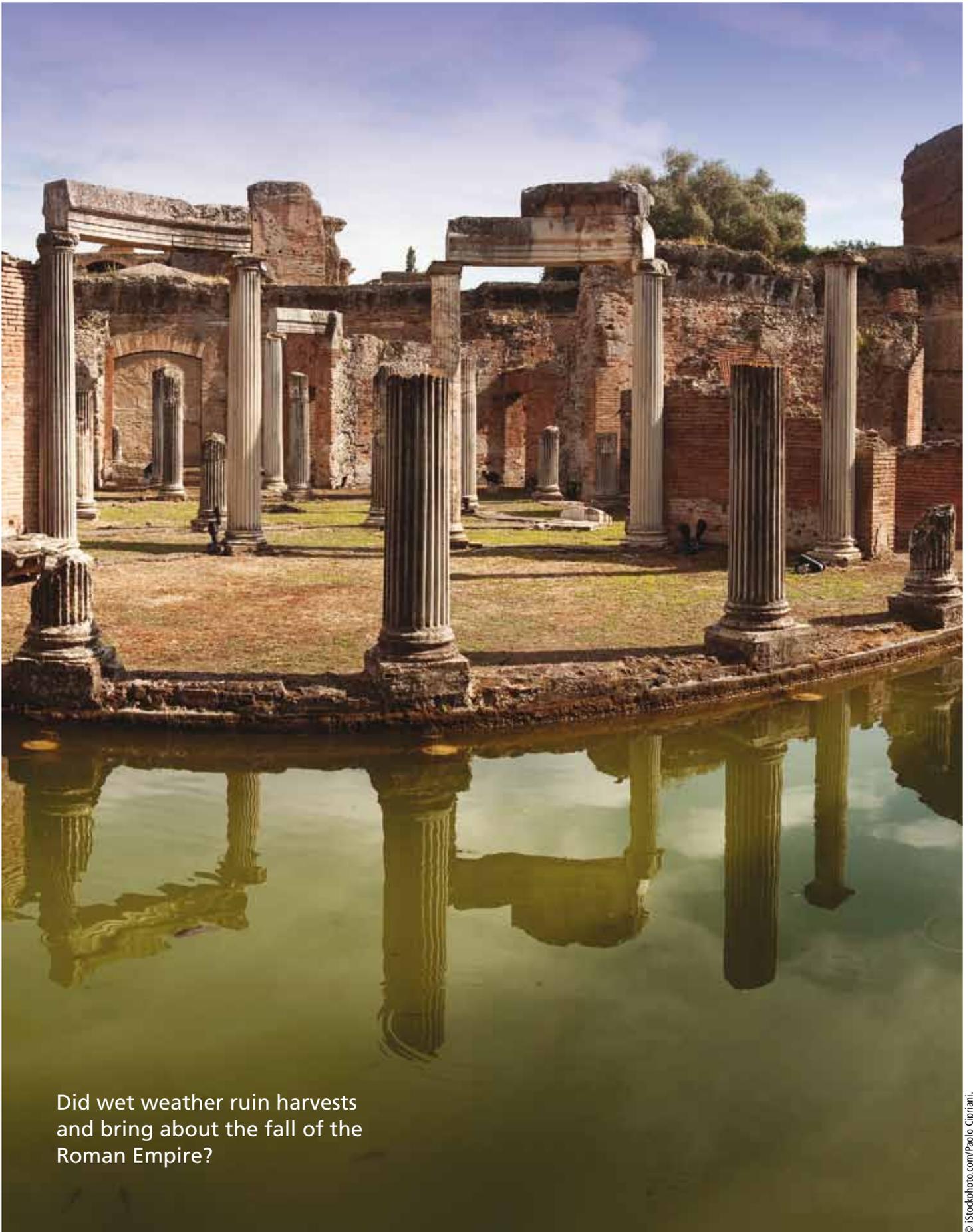
Thick rings imply good years, with warmth and sufficient water to keep a tree growing comfortably in the summer season. Thin rings might indicate meagre water and cooler conditions. But the growth of individual trees is influenced by local climatic conditions. Different conditions within a forest or field might allow one tree at the water's edge to have a great summer, while another – only some distance away – suffers from what looks like mild drought conditions. Tree-ring data thus need to be interpreted carefully before reaching conclusions about regional climate.

The newest and most complete dataset of temperature and precipitation records for Central Europe based on tree rings and extending back 2500 years (Büntgen *et al.* 2011) has now allowed a multidisciplinary team of researchers to carefully reconstruct the climate of the times – and to cautiously link historic events to temperature and precipitation variability.

The research that created this database rests on both scientific and historic data. Led by Ulf Büntgen, a geographer and tree-ring climate specialist at the Swiss Federal Research Institute for Forest, Snow and Landscape (WSL), the research team started with existing tree-ring data that roughly cover the entire Holocene (the past 10,000 years or so). To this the team added samples of wood taken from, for example, stumps drowned in mountain lakes or logs buried in sediments.

The team first compared modern tree-ring data with instrumental climate records to quantify the relationship between tree-ring growth and climate (precipitation and temperature). They used this relationship to glean climate information from the ancient tree rings for which no instrumental records were available. To avoid getting strong local signals from one or a handful of trees in a particular forest or mountain site, the team used data for thousands of pieces of oak wood across Central Europe. Precipitation was reconstructed by using over 7000 oak trees across France and Germany. And 1500 or so stone pine trees from the Austrian Alps region provided information about temperature.

The database included wood samples from historic buildings, where human records told the researchers when the structure was built or the origins of the wood purchased. Found in church beams or in pieces down a well, each piece of wood also added information to the economic and



Did wet weather ruin harvests and bring about the fall of the Roman Empire?

historical context of the time. In good times, people cleared more land and felled more trees in Central Europe, including regions of France, Germany, Switzerland and Austria, the researchers concluded (Figure 1 A). During periods from which fewer wood samples survived, they surmise periods of trouble or poverty.

Other kinds of historic records proved useful for verification: “We have Roman protocols showing repairs of streets,” for example, in Switzerland, says co-author Heinz Wanner of the Oeschger Centre for Climate Change Research in Bern, who was co-chair of IGBP’s PAGES project. Fewer repairs provide evidence of very little flooding, matching periods of low precipitation.

“The [new] dendroclimato-logical database is extensive compared with other climate reconstructions,” says Eduardo Zorita, a specialist in climate of the past millennia at the Institute for Coastal Research (Helmholtz-Zentrum Geesthacht in Germany). He acknowledges the care the team took in collecting signals from old wood – from semi-fossilised trees to construction beams – and the validation processes they used, for example comparing the data to 20th-century observations of modern tree-ring growth.

## The tale in the trees

When all the data are pooled together, some interesting trends emerge (Figure 1 B). From the beginning of the Roman Empire to its peak (c. 50 BC to AD 250), the climate was relatively stable, with warm and wet summers. During the two-and-half centuries or so that followed, though, Europe had “the most unfavourable conditions for agriculture that you can imagine”, says Fredrik Charpentier Ljungqvist, a history graduate student at Stockholm University. This interval corresponds to

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what is known as the Migration Period – a 250-year-period of turmoil and waves of migration.

Wet weather that can ruin harvests marked the end of the Roman Empire in the fifth century, and then transitioned to an extremely dry and cold period around AD 550. Better conditions returned again around AD 700, and the reduced climate variability from AD 1000 to 1200 was coincident with prosperity and a growing population. The onset of the Little Ice Age around AD 1300 – marked by higher precipitation and a dip in temperature – seems to coincide with the Great Famine and the Black Death plague pandemic.

The coincidence between changes in climate and important historical events begs the question: how much can climate

influence history? Jonathan Overpeck of the University of Arizona is fascinated by the team’s conclusions about the links between climate and past societies. The researchers “have managed to put together an amazing picture of human-environment interactions over a couple of thousand years [that is] more comprehensive and convincing than any other job that’s been done [before]. I’m pretty amazed at how well their connections make some sense.”

Carole Crumley, an anthropologist at the University of North Carolina at Chapel Hill and the Stockholm Resilience Centre, agrees, “I think they are trying to do something that’s been missing from most scholarly work in history and archaeology for a very long time. It’s rather bizarre that there is a disconnect

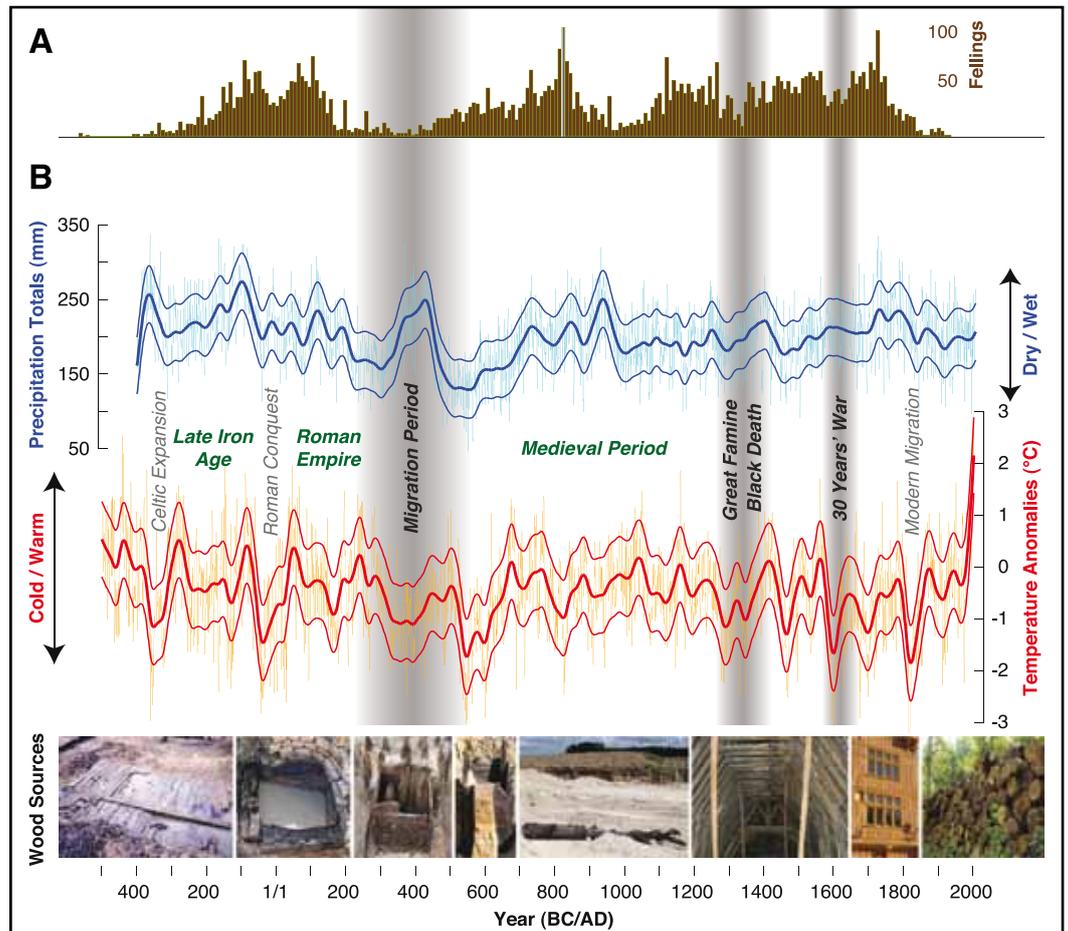


Figure 1. Deciphering the rings. A) Tree felling over the past 2500 years. B) Reconstructed precipitation (April-June) and temperature (June-August) of the last 2500 years. The grey vertical bars indicate key events in European history. Modified after figures 2 and 4 from Büntgen *et al.* (2011) 2500 Years of European Climate Variability and Human Susceptibility. *Science* 331: 578-582. Reprinted with permission from AAAS.

between how humans behave in their surroundings and how that gets communicated in historical documents.”

Crumley and colleagues at the Resilience Centre are working to determine different societies’ “coping mechanisms” in the face of variability and shifts in climate. For the Romans, for example, being wedded to wheat may have been a problem: over-reliance on a grain that is susceptible to cold and wet weather – prevalent conditions at the end of the empire, according to the new tree-ring data and climate reconstruction. This could have led to shortages of a key commodity. Wheat may well have been the perfect crop during the first three centuries or so of the empire, when it was generally warmer and not as wet according to the database. But during those cold, wet times, history shows multiple revolts because of food shortages. And perhaps people at that time could not shift gears to adjust quickly enough.

“If the Romans had been using rye, they wouldn’t have gotten into all that trouble,” Crumley comments. On the other hand, she continues, “they may have gotten into trouble in any event,” owing to other drivers, such as politics or the “far-flung” nature of the vast empire they were attempting to govern in a uniform fashion. “Some would argue that they were overstretched,” she says.

Zorita and others are intrigued by evidence for the rate of deforestation and tree felling, which hints at economic and social conditions. But Zorita cautions against overinterpreting the correlations with historic events. While “human populations had a stronger influence ... to shape the landscape and immediate environment earlier than previously thought,” Zorita says, “the influence of climate change and variability on the fate of past societies, for instance the Roman Empire, but also in more recent

times ... is debatable, although certainly worth considering in view of the results presented in the paper.” More work is necessary to ensure that the confluence of climate and human events is not just coincidence, he says.

Co-author Wanner also remains personally very cautious when it comes to interpreting human activities with regard to climate change. Specifically, tree-ring data represent summers only, and the need to use models to fill in the winter blanks, so to speak, can lead to uncertainties. More broadly, he says, “it would be too easy to tell the story that climate was driving human development,” but correlation does not mean causation. “I think [climate] was one of many different factors.”

Büntgen points out that the research team brought together historians, climate modellers, archaeologists and geographers, all of whom “don’t necessarily speak the same language”, and who have different experiences with statistically relevant data and lines of evidence. “We are not making a causal link,” he explains, in comparing climate records with historical events. Climate instead “is an added element – you cannot ignore climate as a driving component” in human activities, particularly for agrarian societies or those otherwise reliant on weather patterns such as seasonal rains.

### **Past foretells future?**

Büntgen and his colleagues conclude that climate and variability in weather patterns ought to be considered for current-day decision-making, something that Overpeck finds entirely reasonable. The researchers “highlight two things climatically: mean trends and variability”, he says. “Too often people think [only] of slow increases in mean temperatures” when they think

of climate change, Overpeck says, something that “could in itself cause problems. But it’s also the extremes superimposed on that long trend: hotter drier conditions such as in 2003 and 2010 in Europe and Russia.” In Russia last year in particular, three- to four-degree shifts in temperatures over the course of one week led to deaths, forest fires, crop losses and other problems. Of course, climate researchers are still trying to dissect whether those extremes are related to anthropogenic warming or are part of natural climate variability.

Ljungqvist comments that applying this kind of climate data has inspired “surprisingly little interest among historians” or others working with ancient cultures, “probably because most of this research is published in natural science journals”, rather than history or archaeology journals. However, new ideas and culture are not “the only things that change society”. Climate is at least one driver in human history and human adaptations to its variability, he says. But most of today’s society is not agrarian-based, he argues. Modern responses will be different than those of the Middle Ages, for example.

Still, in periods of steady change, variability such as a sudden drought or massive storms may be the straw that broke the camel’s back, Overpeck says – and not just for ancient societies. Büntgen and his colleagues “are actually playing down that likely future extremes will be harder to deal with than these past ones with gradual climate changes”. ■

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### **REFERENCES**

Büntgen U *et al.* (2011) *Science* 331 (6017): 578-582, doi: 10.1126/science.1197175.

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