Californian sudden oak death epidemic 'unstoppable,' new epidemics must be managed earlier

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Large-scale tree mortality in northern Sonoma County, California. Credit: David Rizzo

New research shows the sudden oak death epidemic in California cannot now be stopped, but that its tremendous ecological and economic impacts could have been greatly reduced if control had been started earlier. The research also identifies new strategies to enhance control of future epidemics, including identifying where and how to fell trees, as "there will be a next time".

Sudden oak death - caused by *Phytophthora ramorum*, a fungus-like pathogen related to potato blight - has killed millions of trees over hundreds of square kilometres of forest in California. First detected near San Francisco in 1995, it spread north through coastal California, devastating the region's iconic oak and tanoak forests. In 2002 a strain of the pathogen appeared in the south west of England, affecting shrubs but not oaks, since English species of oak are not susceptible. In 2009 the UK strain started killing larch - an important tree crop - and has since spread widely across the UK.

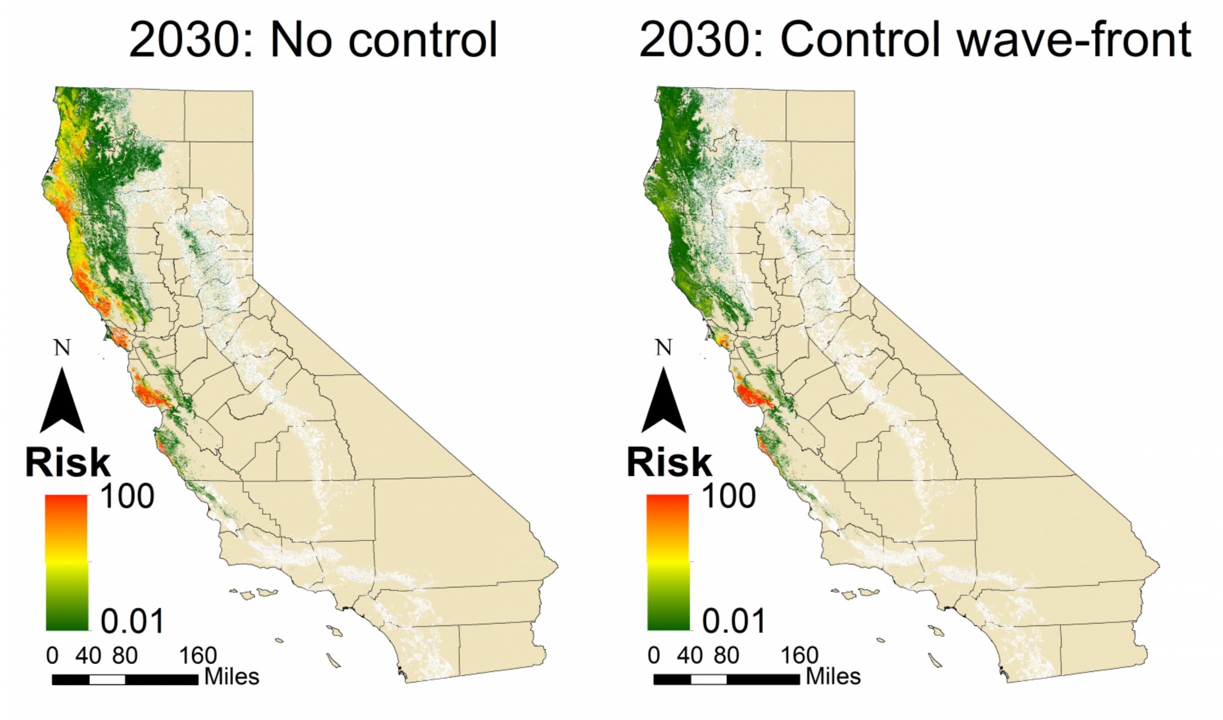
In a study published today in *PNAS*, researchers from the University of Cambridge have used mathematical modelling to show that stopping or even slowing the spread of *Phytophthora ramorum* in California is now not possible, and indeed has been impossible for a number of years.

Treating trees with chemicals is not practical or cost-effective on the scales that would be necessary for an established forest epidemic. Currently the only option for controlling the disease is to cut down infected trees, together with neighbouring trees that are likely to be infected but may not yet show symptoms. "By comparing the performance of a large number of potential strategies, modelling can tell us where and how to start chopping down trees to manage the disease over very large areas," explains Nik Cunniffe, lead author from Cambridge's Department of Plant Sciences.

The authors say that preventing the disease from spreading to large parts of California could have been possible if management had been started in 2002. Before 2002 not enough was known about the pathogen to begin managing the disease. Their modelling also offers new strategies for more effectively controlling inevitable future epidemics.

Models developed in Cambridge are already an integral part of the management programme for the *Phytophthora ramorum* epidemic in the UK. The models are used to predict where the disease is likely to spread, how it can be effectively detected and how control strategies can be optimised, in close liaison with colleagues from DEFRA and the Forestry Commission.

Sudden oak death is known to affect over one hundred species of tree and shrub, presenting a significant risk to the biodiversity of many ecosystems. The death of large numbers of trees also exacerbates the fire risk in California when fallen trees are left to dry out. There is now concern that the disease may spread to the Appalachian Mountains, putting an even larger area of trees at risk.



Map shows risk of infection in 2030 under no control on left; control on and ahead of wave-front on right. Credit: Nik Cunniffe

"Our study is the first major retrospective analysis of how the sudden oak death epidemic in California could have been managed, and also the first to show how to deal with a forest epidemic of this magnitude," explains Cunniffe.

"Even if huge amounts of money were to be invested to stop the epidemic starting today, the results of our model show this cannot lead to successful control for any plausible management budget. We therefore wanted to know whether it could have been contained if a carefully-optimised strategy had been introduced sooner. Our model showed that, with a very high level of investment starting in 2002, the disease could not have been eradicated, but its spread could have been slowed and the area affected greatly reduced."

The model also indicates how policymakers might better plan and deploy control when future epidemics emerge.

"It is a tool by which we can make a better job next time, because it is inevitable that there will be a next time," says Chris Gilligan, senior author also from the Department of Plant Sciences. "With this sort of epidemic there will always be more sites to treat than can be afforded. Our model shows when and where control is most effective at different stages throughout a developing epidemic so that resources can be better targeted."

"It can be tempting for authorities to start cutting down trees at the core of the infected area, but for this epidemic our research shows that this could be the worst thing to do, because susceptible vegetation will simply grow back and become infected again," explains Cunniffe.

Cunniffe, Gilligan and colleagues found that instead treating the 'wave-front' - on and ahead of the epidemic in the direction that disease is spreading - is a more effective method of control. They also found that 'front-loading' the budget to treat very heavily early on in the epidemic would greatly improve the likelihood of success.

"Unlike other epidemic models, ours takes account of the uncertainty in how ecological systems will respond and how the available budget may change, allowing us to investigate the likelihood of success and risks of failure of different strategies at different points after an epidemic emerges," says Gilligan.

"Whenever a new epidemic emerges, controlling it becomes a question of how long it takes for us to have enough information to recognise that there is a problem and then to make decisions about how to deal with it.

In the past we have been starting from scratch with each new pathogen, but the insight generated by this modelling puts us in a better position for dealing with future epidemics," he adds.

The researchers say that the next step in dealing with well-established epidemics such as [sudden oak death](https://phys.org/tags/sudden+oak+death/) is to investigate how to protect particularly valuable areas within an epidemic that - as they have demonstrated - is already too big to be stopped.

The methodology is already being applied to create related models for diseases that threaten food security in Africa, such as pathogens that attack wheat and cassava.

More information: Modeling when, where, and how to manage a forest epidemic, motivated by sudden oak death in California, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1602153113

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