SCIENCE FOR ENVIRONMENT POLICY

A new approach for simulating potential impacts of fungal, insect and mammal pests on European forest ecosystems

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Contact:
Juha Honkaniemi,
juha.honkaniemi@luke.fi

Global forest disturbance patterns — or events which disrupt the structure and composition of forests — are altering as a result of climate change. Changes, such as more severe insect outbreaks, can negatively impact forests and the ecosystem services they provide to society. This study presents a new model that simulates the impacts of forest disturbance from biotic agents such as fungi, insects or large mammals.

The potential impacts of these organisms on forests are currently poorly understood, as a result of a lack of data. Predicting the impacts of emerging pests, over time and space, is therefore important for the creation of effective forest management strategies to ameliorate or prevent such invasions.

Current simulations of vegetation dynamics rarely consider biological disturbance factors, with only a few common agents (such as plant pathogens) being occasionally included. However, as a result of climate change, biotic forest pests may have as much impact as wildfire and floods. As such, a model that can accurately simulate the potential of a non-native species to become invasive, and the level of impacts it might cause at the landscape scale, would be a useful tool for forest managers and policymakers.

The researchers created 'BITE', (the BIotic disTurbance Engine), a model to predict the impacts, and dynamics of pests and pathogens on forest ecosystems — often in data-scarce situations, as with emerging biological pests and pathogens. BITE can be used flexibly, with and without certain data, and coupled with many existing vegetation models. For this study the researchers paired BITE with iLand, an 'individual-based forest landscape and disturbance model'.

BITE produced three patterns to illustrate how the model functions: (1) the impact on host vegetation (mortality or browsing rate (i.e. amount of feeding on leaves of woody plants)); (2) spatial patterns of pest/pathogen spread from a single point of introduction; (3) patterns of pest/pathogen dynamics over time.

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The researchers tailored the model for six very different biological forest disturbance agents: plant pathogens — root rot and ash dieback; insects — gypsy moth and Asian long-horned beetle (ALB); and herbivorous mammals — roe deer and mastodon1 (an extinct mammal, related to the modern elephant, for which no field data were available). They then evaluated the impacts of these pests on forest disturbance individually, using BITE's simulation patterns. The 50-year simulation used a generic landscape, with a temperate biome similar to that of Central Europe.

The BITE model's simulated predictions compared with expected real-world data showed it could handle a wide range of different types of agents. The results demonstrated that the BITE simulations produced realistic patterns of biological disturbance impact.

BITE accurately simulated mortality from root rot and gypsy moth — slightly underestimating the impact of these forest pests. Similarly, roe deer browsing simulation was in line with expectations, whereas the model over-estimated the annual mortality caused by ash dieback. Asian long-horned beetle (ALB) and mastodon were at the extreme ends of the range of impact — however, field data is lacking for these two species. Tree mortality from ash dieback and gypsy moth was higher than background mortality — whilst the opposite was true for tree mortality due to root rot and ALB. Spatial patterns of spread found ash dieback in 100% of the landscape, ALB in 25.6%, gypsy moth in 1.7% and root rot in 0.3%. The spread and patterns of infestation of the pests/pathogens analysed corresponded well with expectations — based on the literature.

BITE simulations provide an accurate prediction of the impacts and population dynamics of novel and well-known invasive forest pathogens/pests over time and space. In addition, the model offers data-poor, realistic simulations to improve scrutiny of potential impacts from emerging novel forest disturbance agents.

1. Mastodons were large mammals distantly related to elephants, living in the forests of North America and Eurasia until their extinction 10–11 000 years ago. The researchers assumed that mastodons were able to browse trees up to 4 m height, with a preference for those between 0–2 m and occasional uprooting of trees, similar to modern elephants.