Modelling disease expression of Phytophthora ramorum to estimate potential economic impacts in European forests

Phytophthora ramorum is an invasive generalist plant pathogen introduced to North America and Europe in the mid-1990s, and is now established in forests and the nursery industry. It causes sudden oak death in the western US and sudden larch death in Western Europe, leading to extensive forest decline and mortality. While well studied in California and Oregon, no quantitative assessment exists for its potential economic impact on European forestry. We assessed the potential direct economic impact of *P. ramorum* on larch and beech in Europe under a "no-control" scenario. Climatically optimal areas for disease expression were derived using the CLIMEX niche model with refined parameter values, updated climate data, and P. ramorum occurrence records from symptomatic forest trees. These areas were overlaid with host distribution data to identify assets at risk. We then applied a radial range expansion model and a partial budgeting method to quantify annualized average damage costs. Our results indicate that 10% of the study area is climatically optimal for disease expression. Within that area, 4 223 km^2 of larch and 2 577 km^2 of beech are at risk. Under worst-case spread and mortality assumptions, annual direct damage costs could exceed €117 million for larch and €130 million for beech. Countries such as the UK, Italy, Austria, and Germany face the highest risks, while potential impacts in Southern Europe are negligible. This study provides an updated risk assessment of the current post-invasion state of *P. ramorum* in Europe, facilitating informed decision-making and the development of appropriate management strategies.