IMPLICATION OF GLOBAL CLIMATE CHANGE ON THE DISTRIBUTION AND ACTIVITY OF *PHYTOPHTHORA RAMORUM*

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ABSTRACT

Global climate change is predicted to alter the distribution and activity of several forest pathogens. Boland et al. (2004) suggested that climate change might affect pathogen establishment, rate of disease progress, and the duration of epidemics, each in a potentially different way. In some cases, climate changes may favor the onset of disease and potentially accelerate the displacement of a tree species from portions of its current geographic range. In other instances, climate changes may be detrimental to the development of disease. Boland et al. (2004) qualitatively predicted that climate change would have a strong positive net effect on four of 18 tree pathogens in Ontario, Canada and would have a negative net effect on another four pathogens.

Phytophthora ramorum is an alien invasive pathogen, likely present in the United States since the mid-1990s. The pathogen is the cause of Sudden Oak Death (SOD) and several other diseases. Infected tanoaks (*Lithocarpus* spp.) and oaks (*Quercus* spp.) are found in 14 western counties of California and one county in Oregon. Previous work has suggested that the distribution of the pathogen is affected by regional climate patterns.

The purpose of the study was to quantify the potential change in occurrence of climatically suitable habitat for *P. ramorum* under future climate scenarios.

All analyses were conducted with the ecological niche model, CLIMEX. Biological parameters describing the response of the pathogen to temperature and moisture were taken from Venette and Cohen (2006). Baseline and future climate projections, downscaled to a 10-minute resolution, were obtained from worldclim.org. Baseline data represented the period from 1961-1990. Climate projections were based on the Canadian General Circulation Model-1 (CGCM1) from the Canadian Centre for Climate Modeling and Analysis under emissions scenario b2 (assumes slowed population growth and reduced greenhouse gas emissions). Climate projections were available for the years 2020, 2050, and 2080. For each year, CLIMEX provided several indices of climatic suitability for the presence of the species. The Ecoclimatic index provides a measure of overall habitat suitability.

The Ecoclimatic Index for the baseline climate data gave a qualitatively satisfactory fit to observed occurrences of the pathogen in California. The pathogen was observed more often in areas that were predicted to be favorable or very favorable than in areas predicted to be marginal or unsuitable. Because the model parameters were not estimated directly or indirectly from field observations, the field observations provide a completely independent validation of the model.

The baseline model predicts that climatically favorable or very favorable habitat in the contiguous US should currently extend along the west coast from approximately Monterey, CA to Puget Sound, WA. Large areas of climatically suitable habitat also occur in the eastern half of the United States. Based on the predictions from CGCM1, we predict that the area that is favorable or very favorable will decrease substantially in the eastern US, but will increase in WA, OR, and CA. By 2050, favorable habitat will extend from Los Angeles, CA to Puget Sound, WA. Inland progression of climatically favorable habitat, even by 2080, is predicted to be modest. In the eastern US, only fragmented pockets of favorable or very favorable habitat are predicted to occur in far western North Carolina, in the northeast quarter of West Virginia, and a small region from northern New Jersey to the southern half of Massachusetts.

This shift in distribution is not likely to be the result of cold stress acting on the pathogen. Cold stress consistently

diminishes from 2020 through 2080. Drought stress also does not seem to be driving the change in distribution. Although drought stress is predicted to increase in the western half of the United States, these changes appear to be occurring in areas that are already largely unsuitable for the pathogen.

The shift in distribution seems likely to be the result of changes in heat stress. Biological heat stress, based on the presumed tolerances of *P. ramorum*, is predicted to increase substantially across much of the contiguous US by 2080, with notable exceptions.

This preliminary model describes the direct effects of changes in temperature and moisture on the suitability of the climate for the pathogen. Climate change may also act indirectly on disease by causing tree stress and altering the susceptibility of trees to infection. More work is needed to relate CLIMEX indices to measures of disease incidence and severity.

Deductive ecological niche models such as CLIMEX are vitally important to integrate biological knowledge about a pathogen and its interaction with the environment. Model outputs provide essential information for quantitative assessments of future risks posed by the pathogen.

Literature Cited

Boland, G.J.; Melzer, M.S.; Hopkin, A.; Higgins, V.; Nassuth, A. 2004. **Climate change and plant diseases in Ontario.** Canadian Journal of Plant Pathology. 26: 335-350.

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