

# Climate-Host Mapping of *Phytophthora ramorum*, Causal Agent of Sudden Oak Death<sup>1</sup>

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## Abstract

*Phytophthora ramorum* infection was modeled using the NAPPFAST system for the conterminous United States. Parameters used to model *P. ramorum* infection were: leaf wetness, minimum temperature, optimum temperature and maximum temperature over a specified number of accumulated days. The model was used to create maps showing the frequency of favorable years for infection and these were compared with historical *P. ramorum* observations from California. The majority of historical observations were located in the greater than 90 percent favorable zone using 10 year climate data. Climate risk areas for *P. ramorum* were then overlaid with hardwood forest density to generate a preliminary composite map that was demarcated based on the degree of climate match and hardwood forest density. These maps are designed to improve the efficacy and economy of survey and detection activities for *P. ramorum* by federal, state and local regulatory agencies. Work is in progress to create international climate risk maps using a daily data set that is temporally and spatially interpolated from the Intergovernmental Panel of Climate Change (IPCC) data set.

**Key words:** climate, hardwood density, historical observations, infection, *Phytophthora ramorum*, survey

## Introduction

In March 2004, considerable quantities of *P. ramorum* infected nursery stock were shipped throughout the United States by retail and wholesale nurseries. This necessitated an emergency response by Plant Protection and Quarantine (PPQ). Federal, state and local regulatory personnel were activated. Their combined efforts have helped mitigate and manage the situation.

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One aspect of the emergency response was GIS mapping of areas with climates conducive to *P. ramorum* infection. These climate maps are designed to increase the efficacy of surveys, provide information to regulatory decision makers and assist decision-making that would mitigate economic and environmental damage associated with the disease.

## Methods

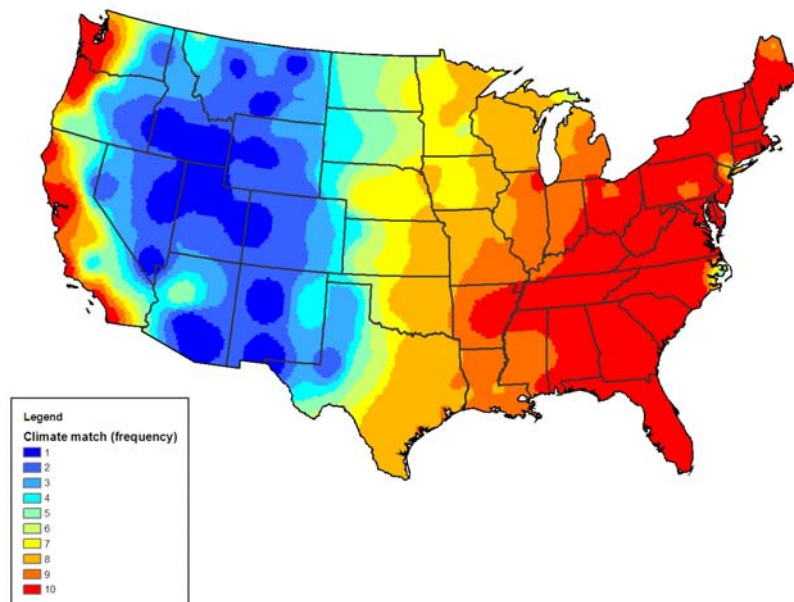
The NCSU/APHIS Plant Pest Forecasting System (NAPPFAS<sup>T</sup>) was used to model *P. ramorum* infection. Historical daily climate data for the 10 year period between 1995 and 2004 was used to construct the model. Temperature was recorded at 1,882 weather stations throughout North America. Leaf wetness was derived for 200 weather stations throughout the conterminous United States. The temperature and leaf wetness data was used to map potential areas of infection with the Barnes interpolation at a 10 km resolution. The parameters used were: Tmin (3 °C); T<sub>opt</sub> (20 °C); Tmax (28 °C) and a minimum accumulated leaf wetness of 12 hours (Huberli and others, 2003; Olikowski and Szukuta, 2002; Werres and others 2001). An area was considered to be at risk if the climate met these infection conditions for 10 or more accumulated days in a month (Jones pers. comm., 2004) or more than 60 days in a year. A probability map was generated using 10 years of climate data. The geotiff images created in NAPPFAS<sup>T</sup> were incorporated into GIS for further analysis.

Model validation points were obtained from locations in California where the presence of *P. ramorum* has been confirmed (UC Berkeley, 2003) and then overlaid with the annual climate match map. The number of confirmations associated with each climate match area was plotted. A distribution for the probability that a confirmation would occur in the 10 year climate match area was determined.

Forest density (1 to 100 percent) was estimated across the conterminous United States at a 1 km resolution using the 1992 National Land Cover Data (USGS, 1992). A hardwood GIS layer was obtained by combining the NLCD deciduous forest and 50 percent of mixed forest density classes. It was assumed that the mixed forest was 50 percent hardwoods. After the climate match layer was converted to a percentage it was summed with the hardwood forest density layer and divided by two to generate a preliminary relative risk map. A mask where no hardwoods occurred was then applied to eliminate areas without suitable hosts.

## Results and Discussion

The climate maps demonstrated a good correlation (greater than 90 percent) with known occurrences of *P. ramorum* in California. This indicates that the model is a good predictor of disease establishment. The climate maps were used in the 2004 *P. ramorum* PPQ National Survey manual and the updated maps will be incorporated into the 2005 version. The preliminary climate match-host density maps indicate that the eastern United States has a high likelihood for *P. ramorum* infection if an inoculum source is available. More sophisticated climate match-host density models and global climate match mapping capabilities are being developed.



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