GIS-Based Epidemiological Modeling of an Emerging Forest Disease: Spread of Sudden Oak Death Across California Landscapes

Rich Hunter and Ross Meentemeyer

Abstract

The number of emerging infectious diseases are thought to be increasing worldwide - many of which are non-native, invasive plant diseases in forest ecosystems. A predictive understanding of invasion processes is necessary to manage and prevent further spread, especially in complex spatially heterogeneous landscapes. Mathematical modeling of susceptible-infectious transitions in plant epidemics often incorporate spatial dynamics, but are rarely applied in a GIS to real-world wildland landscapes. In this paper, we present and evaluate a GIS-based epidemiological model of the spreading forest pathogen *Phytophthora ramorum*, which is causing the devastating forest disease known as Sudden Oak Death. First, we describe a generic mathematical model for a susceptible-infectious epidemic that simulates spatial and temporal patterns of disease spread on a weekly time step for application at large spatial scales. Next, we describe how data from field and lab studies were used to parameterize the driving system variables, including daily rainfall and temperature, host abundance and susceptibility, human density, and dispersal characteristics. The parameterized model was implemented (1990-2005) in a GIS to simulate disease spread across California at a spatial resolution of 250 x 250 meters. We evaluated model performance in the GIS by examining the correspondence between predicted patterns of disease spread and over 1000 geo-located field observations of disease presence. Additionally, we examined the nature of prediction errors by ecoregion, vegetation composition, and climate. The model predicts almost 80% of the spatial variability in current patterns of disease spread and identifies numerous oak woodland systems at high risk of infection. We’ve found the application of epidemiological models to realistic landscapes in a GIS can allow for a rigorous validation of model performance using geo-located field data of disease presence and can be used as an effective management tool to identify actual landscapes at high risk to disease spread.

1 An abbreviated version of this paper was presented at the Sixth California Oak Symposium: Today’s Challenges, Tomorrow’s Opportunities, October 9-12, 2006, Rohnert Park, California.
2 Sonoma State University. e-mail: rich@talonassociates.net.
3 University of North Carolina, Charlotte. e-mail: rkmeente@email.uncc.edu.