Forest Tree Diseases and Climate Change

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Synthesis
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Introduction:

Tree diseases occur everywhere that forest trees grow. Infections diseases caused by biotic pathogens develop over time from interaction of these pathogens with a favorable environment and susceptible host plants [1]. Environmental factors that cause plant stress, especially from moisture deficit caused by drought, contribute to diseases to forest pathogen attack. Some diseases are species-specific, while others affect multiple host species. Pathogens that infect tree diseases include fungi, bacteria, viruses, parasitic plants, nematodes, and other microorganisms. Involved can play a major role in disease development by serving as vectors, providing wounds that allow pathogen ingress, and other factors [2]. Non-infectious forest diseases are caused by abiotic factors that are directly damaging to tree health, such as freezing temperatures and air pollutants [3].

Anticipated changes in climatic conditions may impact the prevalence and severity of these non-infectious diseases. With respect to infectious diseases, altered climatic conditions may dramatically affect the outcome of pathogen-host interactions in forest environments. The cascades of multiple changes will influence a forest’s ability to sustain goods and services at existing levels [4,5]. Direct impact to host tissues occurs in affected trees and can lead to tree mortality.

Understanding the relationship between climate and tree disease is essential for addressing issues associated with changing climate [5] at different spatial scales. Several relationships where greater understanding is required are:

- Effects of biotic and abiotic disease factors on tree survival and growth, forest structure, and species composition [6].
- Effects of pathogens and decay fungi on the forest carbon cycle which impact forest carbon stocks and fluxes [7].
- Development and impact of tree pathogen and associated insect-host interactions under varying temperature and precipitation regimes.
- Incororation of beneficial changes due to changing climate on tree diseases and tree susceptibility in relation to forest species diversity and forest structure [8].

Introduced invasive pathogens, such as the chestnut blight fungus and white pine blister rust, caused extensive damage to U.S. forests in the past century [8]. Thus, studies of both native and exotic invasive pathogens are needed. Understanding how the severity and distribution of tree diseases are affected by seasonal changes in temperature, moisture conditions, precipitation, relative humidity, and soil water availability, tree phenology, and tree physiological stress is also important in forecasting the direction of change expected under predicted climate scenarios.

Likely Changes:

The effects of climate change on forest tree diseases will vary by spatial scale, and will depend on the trajectory of change. Projections and prediction maps of where drier and wetter conditions will be most occur in the U.S. have been and will continue to be published [9].

Projections of changes in impact caused by forest diseases have been made under both “warmer and wetter” and “warmer and drier” scenarios. For diseases where temperature and moisture more directly affect host susceptibility to infection and disease development, “warmer and drier” climate will favor disease increase. In general, root and carrier diseases fall within this category. As a specific example, Ambrosia root disease in the western states is predicted to increase in severity and impact forest productivity [10]. Climate warming accompanied by increasing drought events (warmer/drier) also can lead to increases in “dormant disease” frequency and severity [11]. Such diseases typically involve sequential and additive effects of site conditions, drought, and insect and pathogen build up on stressed hosts [12]. With warming temperatures, some forest tree diseases may be able to occur further north and/or at higher elevations. Opportunistic pathogens may also be favored by such changes.

Diseases where temperature and moisture directly affect the causal organism’s reproduction, spread, infection and survival are predicted to increase under warmer/wetter conditions. In general, foliar and nut diseases fall within this category. Projections based on warmer/wetter
seasonal shifts in precipitation patterns alone can lead to increasingly severe occurrences of tree diseases. For example, documented climate change over one or more decades that affected timing of spring/early-warm associated with outward advances of red maple bud bloom on metasequoia pin in British Columbia [13] and bur oak blooming in Iowa [14].

The complexity of climate effects on community interactions in which diseases occur make it extremely difficult to assign probabilities or predict the trends of climate change impact on forest tree diseases in the future [15]. Changes in precipitation timing, intensity and form within a region or subregion can vary, further contributing to the complexity of disease prediction. Even micrometeorological conditions can profoundly influence disease severity. However, some general principles can be helpful in predicting responses of forest diseases to changing climatic conditions:

- **Prediction of disease outbreaks** will be more difficult in periods of rapidly changing climate and unpredictable weather, because altered reproduction and spread of forest tree pathogens will influence changes in infection, development and severity of diseases.
- **Host resistance to pathogens may be overcome as trees become stressed or as pathogens’ evolution accelerates more quickly than their host defenses.**
- **Warmer winters** will contribute to greater overwintering success of pathogens and associated insects, leading to increasing disease occurrence and severity.

The cycle and pattern of wood decay in forests changes due to influence of changing moisture and temperature regimes on decay fungi. Thus, carbon cycling rates may increase or decrease depending on the direction of future climate change.

### Options for Management:

Forest managers, whether working at the local or the landscape scale, should be aware of current and historic forest health conditions in their jurisdictions, and then integrate that knowledge with climate change projections. Monitoring, forecasting, planning and mitigation strategies are needed to prevent and to adaptively manage tree diseases at various geographic scales [16].

### Forecasting
Climate change scenarios have been used to estimate future risks for several tree diseases [17, 18, 19]. However, uncertainties generated by forecasting must be sufficiently characterized and additional options need to be addressed. Forecasting may be achieved using models, risk analysis and risk rating indices, models with known probability and direction of change. A forecast model for forest health (Hi:W) is currently under development.

### Planning and Mitigation Strategies
Increasing the capacity of an ecosystem to absorb disturbance without shifting to a qualitatively different state (ecosystem resilience) is required to mitigate effects of climate change [20]. Using adaptive options such as:

- **using species with high climate change resistance and resilience** to promote growth and increase the likelihood of survival.
- **using appropriate silvicultural interventions to increase tree vigor and lower pathogen and insect pest impacts under predicted climate scenarios**.
- **Carefully and judiciously using facilitated tree species migration**,
- **and increasing tolerance and resistance to pathogens as part of breeding programs designed to increase species tolerance to environmental stressors**.

### References


20. How to cite this paper: USDA Forest Service, Pacific Southwest Research Station. 2011. The Climate Change and Forest Health: National Assessment. Available online at [http://www.fs.fed.us/forestry/forestry/forestry.htm](http://www.fs.fed.us/forestry/forestry/forestry.htm)