

CLIMATE-BASED SPECIES DISTRIBUTION MODELS FOR *ARMILLARIA SOLIDIPES* IN WYOMING: A PRELIMINARY ASSESSMENT

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ABSTRACT

As part of an ongoing project to predict *Armillaria* root disease in the Rocky Mountain zone, this project predicts suitable climate space (potential distribution) for *A. solidipes* in Wyoming and associated forest areas at risk to disease caused by this pathogen. Two bioclimatic models are being developed. One model is based solely on verified locations of *A. solidipes* in Wyoming and the other is based on verified locations throughout western North America (including Wyoming). Over time, additional surveys/samples from throughout the Rocky Mountain zone will be added to improve predictions and expand model coverage. Cumulative results will be used to develop habitat-specific management strategies to reduce impacts of *Armillaria* root disease. This information will be incorporated with other global data to further develop bioclimatic models for predicting *A. solidipes*-caused disease under various climate-change scenarios.

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INTRODUCTION

Because *Armillaria* species play diverse ecological roles, ranging from beneficial saprobe to aggressive pathogen, it can be difficult for forest managers to assess risk for *Armillaria* root disease unless symptoms are prominent. In North America, *Armillaria solidipes* (= *A. ostoyae*) causes tree mortality and significant growth loss of diverse tree species (e.g., up to 40 percent volume loss over 4 to 8 years in 18-year-old *Pseudotsuga menziesii*) (Cruickshank 2000). In the vegetative state, *A. solidipes* is difficult to distinguish from other less pathogenic *Armillaria* spp. on a site. Furthermore, *A. solidipes* can be present within a site that displays no obvious root-disease symptoms (unpublished data), and forest management activities can exacerbate *Armillaria* root disease in some situations (e.g., McDonald et al. 1987; Rippey et al. 2005). To minimize impact of *Armillaria* root disease, it is important to predict distributions of highly pathogenic *Armillaria* species.

This ongoing project is based on precise location data for *Armillaria* sample collections, DNA-based identification of *Armillaria* spp. (Kim et al. 2006; Ross-Davis et al. 2012), and location-specific climate data. The combined data are used to develop bioclimatic models to predict areas with suitable climate where *A. solidipes* likely occurs and can cause significant disease under some forest management regimes.

OBJECTIVES

The objectives of this study are to 1) determine suitable climate space (potential distribution) for *A. solidipes* in Wyoming, 2) predict which forest areas are at risk to disease caused by *A. solidipes* in Wyoming, 3) develop habitat-specific management strategies to reduce impacts of *Armillaria* root disease, and 4) incorporate information into a bioclimatic model to predict potential future distribution and disease activity of *A. solidipes*.

METHODS

Armillaria isolates were collected in a previous study of the distribution, species, and ecology of *Armillaria* in Wyoming (Blodgett and Lundquist 2011). From that previous study, 122 *Armillaria* isolates were recovered from 82 plots, and 61 isolates from 39 plots were determined to be *A. solidipes* based on pairing tests against known haploid testers. These 61 isolates were then confirmed as *A. solidipes* using DNA-based species identification at the Forestry Science Laboratory, Rocky Mountain Research Station in Moscow, Idaho, USA (Kim et al. 2006; Ross-Davis et al. 2012). The 39 plot locations containing *A. solidipes* were used in two Maximum Entropy (MaxEnt) species distribution models (Phillips et al. 2006). The first model used only the 39 Wyoming locations (Figure 1) and the second model included the 39 Wyoming locations plus all other confirmed locations for *A. solidipes* in western North America (Figure 2). Nineteen bioclimatic variables were used in the models (e.g., annual mean temperature, maximum temperature of warmest month, annual precipitation, precipitation of wettest month, precipitation of coldest quarter, etc.). An interpolation grid of ca. 1-km² resolution

was used, with data derived from 1950-2000 meteorological records (Hijmans et al. 2005).

RESULTS AND FUTURE WORK

Two MaxEnt models provided preliminary predictions of suitable climate space for *A. solidipes* in Wyoming. The first model was based solely on locations of confirmed *A. solidipes* occurrence in Wyoming (Figure 1) and the second model was based on western North America locations, which included Wyoming (Figure 2). Predictions by these two models were generally congruent, but some differences are apparent. Both models predict wide potential distribution (suitable climate space) of *A. solidipes* in Wyoming, especially in coniferous forests. The predictive capacity will be improved by 1) continuing DNA-based identification of *Armillaria* species from samples collected in root-disease surveys, and 2) adding more locations from diverse geographic areas and climates that are confirmed to contain *A. solidipes*. This climate window can also be used to examine how various climate-change scenarios (based on projected greenhouse gas emissions, e.g., RCP 4.5 vs. RCP 8.5) may affect distribution and disease activity of *A. solidipes*. Methods developed from this project can also be used to model other important forest pathogens and examine the potential for invasive species to occupy new areas under climate changes.

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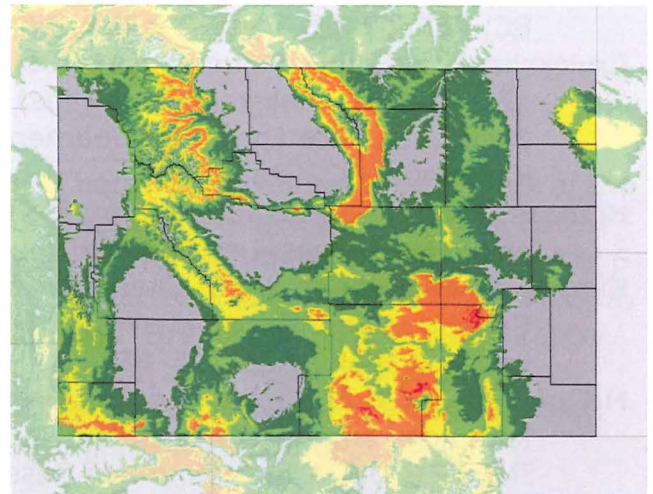
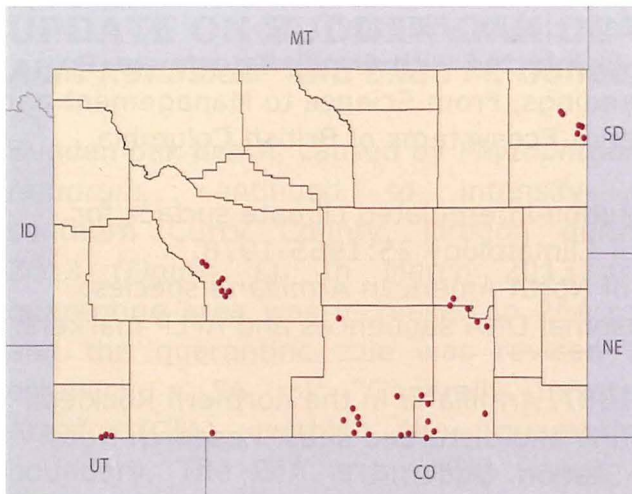


Figure 1. Confirmed occurrence locations of *Armillaria solidipes* (= *A. ostoyae*) in Wyoming, based on surveys of Blodgett and Lundquist (2011) (left). Preliminary Maximum Entropy bioclimatic model of suitable climate space (potential distribution) for *A. solidipes* in Wyoming based on occurrence points for Wyoming only (Blodgett and Lundquist 2011). Dark green represents predicted suitable climate space for *A. solidipes* with light green, yellow, orange, and red indicating increased suitability, respectively (right).

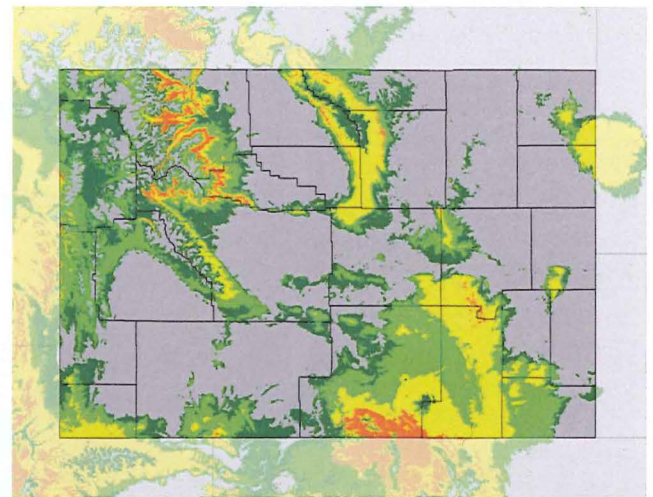
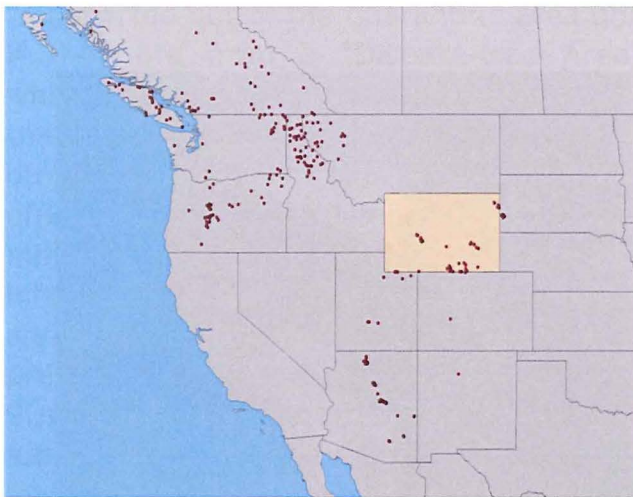


Figure 2. Confirmed occurrence locations of *Armillaria solidipes* (= *A. ostoyae*) in western North America (including Wyoming surveys of Blodgett and Lundquist; 2011) (left). Preliminary Maximum Entropy bioclimatic model of suitable climate space (potential distribution) for *A. solidipes* in Wyoming based on occurrence points in the western North America (including Wyoming surveys of Blodgett and Lundquist 2011). Dark green represents predicted suitable climate space for *A. solidipes* with light green, yellow, orange, and red indicating increased suitability, respectively (right).

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