

# **\*TOWARD A WEST-WIDE MODEL OF ARMILLARIA ROOT DISEASE: NEW SURVEYS NEEDED IN WESTERN OREGON, WESTERN WASHINGTON, AND ALASKA**

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## **INTRODUCTION**

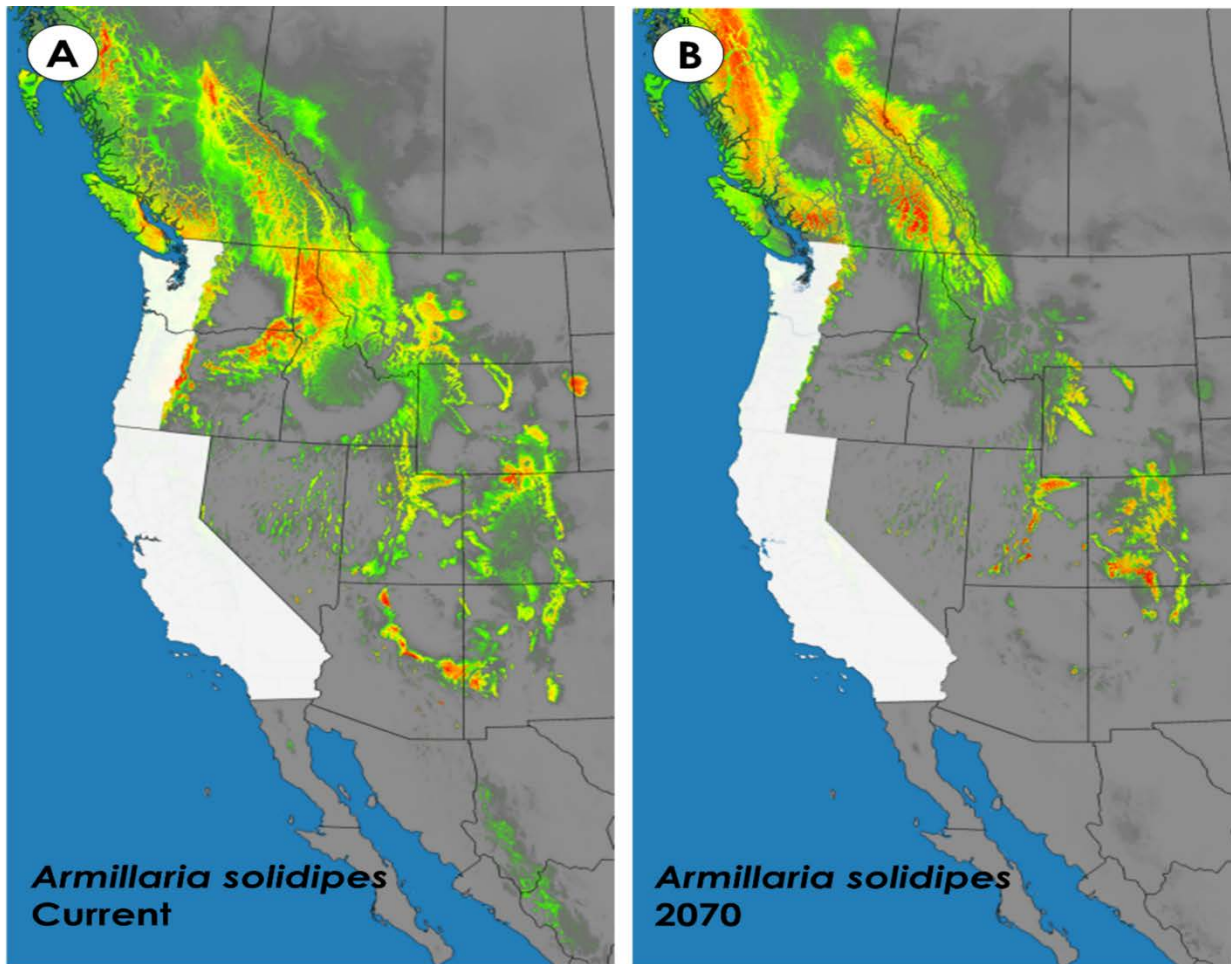
Currently, Armillaria root disease causes large growth/volume losses (e.g., 16-55%) in areas of western North America (Filip and Goheen 1984; Cruickshank 2011; Lockman and Kearns 2016). Armillaria root disease is typically more severe in trees that are maladapted to climate-induced stress (Ayres and Lombardero 2000; Kliejunas et al. 2009; Sturrock 2011). Thus, it is likely that climate change will further exacerbate damage from Armillaria root disease, which can further predispose trees to beetle attack (e.g., Hertert et al. 1975; Tkacz and Schmitz 1986; Goheen and Hansen 1993).

Previously, DNA-based identification methods were used to identify *Armillaria solidipes* and other *Armillaria* species from surveys of the inland northwestern U.S.A., eastern Cascades of Oregon, Arizona, and Rocky Mountain zones (e.g., Blodgett et al. 2015; Burns et al. 2016; Hanna et al. 2007, 2009, 2012, 2014, 2016; Hoffman et al. 2014; Kim et al. 2010; Klopfenstein et al. 2012; McDonald et al. 2011; Nelson et al. 2013). Based on the precise locations of *A. solidipes*, bioclimatic modeling was used to predict the suitable climate space (the geographic area that is climatically suitable for a particular species' survival) or potential distribution of *A. solidipes* under contemporary and changing climates in the interior western U.S.A. (Figure 1). Although Armillaria root disease is commonly found in western Oregon, western Washington, and Alaska, DNA-based identification has been commonly applied to verify *Armillaria* species found in these regions.

Recently, a collaborative project was initiated to precisely identify *Armillaria* species found western Oregon, western Washington, and Alaska. This project will provide new and expanded predictions for potential distribution of *A. solidipes* across northwestern U.S.A. including Alaska, and expand predictions of the potential distribution of *A. solidipes* in the western North America under present and future climate scenarios (Figure 1). Currently, limited studies have identified *Armillaria* in western Washington and western Oregon (e.g., Banik et al. 1996; Volk et al. 1996). Furthermore, only limited information is available on *Armillaria* spp. in Alaska (e.g., Klopfenstein et al. 2009b; Shaw and Loopstra 1988), yet the state is experiencing very strong climate-change influences that could exacerbate Armillaria root disease.

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**Figure 1.** Maximum Entropy bioclimatic model of suitable climate space (potential distribution) for (A) predicted current *Armillaria solidipes* and (B) predicted for the year 2070 *Armillaria solidipes*. Darkest gray represents predicted suitable climate space, with light green, yellow, orange, and red indicating increased suitability, respectively.

## OBJECTIVES

The objectives of this project are to (i) culture and identify *A. solidipes* and other *Armillaria* species from collections/surveys of under-represented areas in western Oregon, western Washington, and Alaska and (ii) integrate survey data from western Oregon, western Washington, and Alaska with previous surveys of *A. solidipes* (ID, MT, WA, OR, UT, CO, WY, AZ, NM, and other states/ provinces). The combined survey data will be used to evaluate and refine existing bioclimatic models for predicting the present and future suitable climate space/potential distribution for *A. solidipes* in western North America. Any new *Armillaria* species/host combinations within OR, WA, and AK will also be documented.



**Figure 2.** *Armillaria* surveys. *Armillaria* root disease center (upper left); Excavating a root collar to survey for *Armillaria* (upper right); *Armillaria* fruiting bodies or basidioma (lower left); *Armillaria* rhizomorphs (lower center); and *Armillaria* mycelial fan (lower right).

#### **New Surveys/Collections Needed in Western Oregon, Western Washington, and Alaska!**

To supplement under-represented areas, additional *Armillaria* surveys/collections are needed in western Oregon, western Washington, and Alaska (Figures. 2, 3, and 4). We ask collaborators to contribute for surveys for *Armillaria* within these areas and send *Armillaria* samples (e.g., mycelial fans on live trees indicating disease activity or rhizomorphs), GPS-based location, and other host information to the USDA Forest Service, RMRS Forest Health Laboratory in Moscow, ID.

## METHODS

- Coordinate and/or collaborate with supplemental surveys/collections of under-represented areas in western Oregon, western Washington, and Alaska.
- Conduct DNA-based diagnostics to identify *A. solidipes* and other *Armillaria* species: We will establish *Armillaria* isolates in culture, and use DNA sequencing (e.g., *tef-1a* gene) to identify isolates of *A. solidipes* and other *Armillaria* species from supplemental regions of OR, WA, and AK (Figure 2).
- Integrate *Armillaria* survey data into bioclimatic models to predict suitable climate space across Region 6 and western North America: A bioclimatic model, such as MaxEnt (Phillips et al. 2006), will be used to determine which climatic factors/predictive variables contribute to the occurrence of *A. solidipes* across the landscape (Klopfenstein et al. 2009a). In general, potential distribution of *Armillaria* root disease will be predicted for areas where the pathogen is climatically well-adapted, with increased risk associated with areas where the host is climatically maladapted.



**Figure 3.** *Armillaria* sample collection. GPS location (left), labeled collection bag for mycelial fans and/or infected wood (center); and labeled tubes for rhizomorphs (right).

## EXPECTED OUTCOMES AND BENEFITS

This project will develop methods to monitor/predict potential disease risks under present and future climate scenarios across the western U.S.A., including Alaska. Predictions of the present and future distribution of *Armillaria* root disease pathogens can help guide forest managers to implement appropriate forest practices to manage *Armillaria* root disease pathogens according to current and future climates. Information from this project will be incorporated into prediction models for the western USA. This approach can also be adapted for other endemic and invasive forest diseases.



**Figure 4.** Map of proposed sample areas.

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