# Root Disease Analyzer – *Armillaria* Response Tool (*A*RT)

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## Introduction

Root rot caused by *Armillaria* fungi warrants special attention before fuels management activities are selected for western forest stands (fig. 1). *Armillaria* species are widely distributed and their effects on disease and mortality can increase greatly after human-caused disturbances (Shaw and Kile 1991). However, not all *Armillaria* species decrease forest productivity. These fungi are diverse in pathogenicity, host-specificity, distribution, and environmental requirements. Some non-pathogenic species of *Armillaria* are efficient decomposers that recycle nutrients on forested sites and may protect susceptible trees from pathogenic species (Bruhn and others 2000). Yet, in many environments, pathogenic *Armillaria* species are a persistent cause of reduced tree growth, increased mortality, and predisposition to bark-beetle attack. In addition, Armillaria root disease can increase wildfire risk by contributing to fuels build up and fuel ladders in affected stands.

Associations of plant species, known as habitat types, are strong indicators of site conditions as influenced by interactions of topography, soil properties, temperature, and precipitation patterns. Data from random *Armillaria* plots throughout the western United States have shown that distribution and activity of *Armillaria* species are strongly correlated with habitat types, which combine overstory series and forest floor vegetation (McDonald 1987, 1999). In conifer forests, the overstory series reflects soil temperature, and the forest floor vegetation reflects soil moisture. Thus, habitat types reflect combined temperature-moisture regimes: habitat types can be grouped together into vegetation subseries (hereafter called subseries) that are used as indicators of *Armillaria* regimes (*Armillaria* distribution and activity), as well as fire severity and fire-return intervals in coniferous forests of the western United States (McDonald and others 2000, see appendix A) (fig. 2).

In this chapter, we will discuss the concept and use of the Root Disease Analyzer - ***A****rmillaria* **R**esponse **T**ool (***A*****RT**) to support fuels management activities at the stand-level basis.

## Description

The *A*RT is an online tool that estimates the risk of Armillaria root disease for individual stands within dry forests of the western United States.

### Mechanics

*A*RT uses habitat types to identify sites with high or low potential risk for developing Armillaria root disease, which can reduce productivity and increase wildfire risk. McDonald and others (2000, 2003) have developed crosswalk tables showing the relationships among habitat types, subseries, fire regimes, and *Armillaria* regimes that are used in *A*RT (appendices A and B). Categories for probability of *Armillaria* presence include (1) “No or Low”, where pathogenic *Armillaria ostoyae* is rare or absent and (2) “High”, where pathogenic *A. ostoyae* is likely to be present with a high potential of causing disease within a second seral overstory (HSERAL *Armillaria* regime) or climax overstory (HCLIMAX *Armillaria* regime) (fig. 3, appendix A). *A*RT indicates how some fire planning (fuels management) activities may exacerbate Armillaria disease within high-risk stands, and helps determine an appropriate fuels management plan for reducing future damage by Armillaria root disease (fig. 4).

*Limit and Scope of ART*
Currently, *A*RT is limited to use for the forests of the Intermountain West. *A*RT can help reveal stands with site conditions that indicate risk for developing Armillaria root disease, if susceptible host trees are present. It is intended to help users (for example, fuels treatment planners, silviculturists, resources managers, and NEPA planners) make predictions and evaluate potential impacts of fuels treatments. Knowledge about the role of fire in western forests and the potential responses of various tree species to natural and prescribed fires are necessary for management considerations. Each fuels-treatment option must be considered in relation to the habitat type, stand composition (tree species present), and other interacting factors.

For effective use of *A*RT, it is essential that habitat types have been correctly identified for a stand. The *Stand-Level version* of *A*RT cannot aid the user in verifying whether habitat type has been correctly assigned, nor can it determine if there are differences in habitat type within a stand. Users of *A*RT assume all responsibility for the accuracy of habitat typing, for assessment of ecological homogeneity of the target stand, and for any management decisions based on the use of the tool. A GIS-based version of *A*RT is being developed for the landscape level. This version will use landscape analysis to identify stands that may have been misclassified and stands with differences in slope and aspect, which may indicate the presence of substands with different habitat types. Historically, habitat types were assigned on the basis of aerial photo interpretation and ground verification. Because most forests were classified prior to the availability of powerful GIS tools and unbiased plant community classification systems, many mapped stands contain significant within-stand heterogeneity. Terrain and climate analysis using GIS has revealed that within-stand variability is prominent (McDonald, unpublished data). To ensure that management decisions are appropriate for substands that may be present, the manager would need to obtain GIS-derived information (for example, digital elevation model data) and sufficient in-house GIS expertise to perform the required analyses for the GIS-based version of *A*RT.

## Inputs
Inputs for the stand-level tool include stand location (region or national forest), habitat type, and fuels treatment (fig. 3).

*Stand location*
Currently, choices of stand location are limited to forested areas in the Intermountain West (Idaho, Oregon, Washington, Montana, Utah, and Wyoming). On the map graphic provided in the tool, the user can click on the general area of the study site or select from

a list at the bottom of the page (fig. 3). Areas are defined by the published habitat type manuals.

*Habitat type*

All valid habitat types for the selected stand location will be displayed on the input screen (fig. 3). Lists of habitat types are taken from the 12 habitat type manuals that cover the Rocky Mountain Montane Conifer Forest biotic communities (Cooper and others 1991, Johnson and Clausnitzer 1991, Johnson and Simon 1987, Lillybridge and others 1995, Mauk and Henderson 1984, Pfister and others 1977, Steele and others 1981, Steele and others 1983, Topik and others 1988, Williams and Lillybridge 1983, Williams and others 1990, Youngblood and Mauk 1985). The 631 habitat types compiled from these 12 habitat type manuals have been classified into 31 subseries representing soil-moisture/soil-temperature regimes (appendix A) (McDonald and others 2000). In *A*RT, habitat types are automatically converted to subseries, and subseries translated into *Armillaria* regimes using the Armillaria Risk crosswalk table developed by McDonald and others (2000) (appendix A).

*Fuels treatment*

To assess the effects of fuels treatments on Armillaria disease, it must first be determined whether *A. ostoyae* is likely to occur on the site. Clearly, fuels treatments will have no effect on Armillaria disease within subseries where Armillaria disease does not occur. Where *A. ostoyae* can occur, the decision process is more complex and depends on stand composition, fire regimes, and fuels treatments.

## Outputs

Outputs of the tool suggest whether a stand has no-to-low or high risk of pathogenic *A. ostoyae* being present and the probable outcomes from different fuels treatment in relation to Armillaria root disease (fig. 3). *A*RT discusses fuels treatments for low and high risk categories (fig. 4). Fuels treatments under consideration in this paper include (1) no treatment, (2) thinning, (3) prescribed burning, (4) thinning and prescribed burning, and (5) wildfire.

*No-to-Low Armillaria root disease risk*

Within subseries where pathogenic *A. ostoyae* does not occur, fuels treatments will not affect Armillaria root disease, regardless of host tree species present (fig. 4).

*High Armillaria root disease risk*

Within subseries where pathogenic *A. ostoyae* does occur, fuels treatments may affect Armillaria root disease (fig. 4). The following fuels treatments and potential outcomes are provided as examples:

**No treatment:** The “no treatment” option avoids creating tree wounds that stress trees and generate root volatiles and nutrient substrates that foster Armillaria disease by either attracting fungal growth or enhancing root colonization. However, if disease mortality is already significant, the “no treatment” option will delay release of resistant species and may promote ladder fuels.

**Thinning:** Thinning treatments that favor climax or late-successional host trees will likely aggravate Armillaria root disease. Thinning treatments that create wounds on host trees will likely worsen Armillaria root rot on all species (Pankuch and others 2003). Thinning treatments that create a nutritional substrate (for example, stumps, dying roots, and woody debris) for *Armillaria* species may worsen Armillaria root rot. However, thinning that favors early seral species may reduce root disease over the long term. Also, greater spacing can improve tree vigor of seral species, which may increase tolerance to Armillaria root disease. In addition, the youngest trees that are most susceptible to *Armillaria* infection (Robinson and Morrison 2001) should be removed.

**Prescribed burning:** Because *Armillaria* species can reside deep in the soil and within large woody roots, superficial slash burning or prescribed fire is unlikely to eliminate the pathogen, although these treatments may reduce infection potential indirectly by removing highly susceptible host species that are readily killed by fire (Hadfield and others 1986) and by favoring other fungi antagonistic to *Armillaria* (Filip and others 2001). Mortality caused by *Armillaria* increases fuel loads. Prescribed fire may be used to reduce fuel loads and inoculum levels above ground by eliminating colonized substrates for growth of *Armillaria*. It also may increase damage to surface roots and create wounds that might facilitate *Armillaria* infection.

**Wildfire:** Wildfire is a natural result of fuels build-up in late successional forests and this process should help restore forest health in Armillaria mortality centers by fostering the regeneration of seral tree species. However, wildfire usually leaves injured roots that are suitable for *Armillaria* colonization. Wildfire impacts on Armillaria disease are likely dependent on the fire type (for example, crown fire or ground fire) and intensity. Thus, it would be advisable to make a post-fire assessment of colonizable substrates generated during wildfire to determine appropriate restoration strategies.

**Acknowledgement**
This paper was supported by the USDA Forest Service - Fuels Planning: Science Synthesis and Integration Project and Rocky Mountain Research Station RWU-4552 (Microbial processes as ecosystem regulators in western forests) and RWU-4702 (Soil and water engineering). The authors thank Drs. Deborah S. Page-Dumroese and Russell T. Graham for their support on this project. The use of trade names does not constitute endorsement by the USDA Forest Service.

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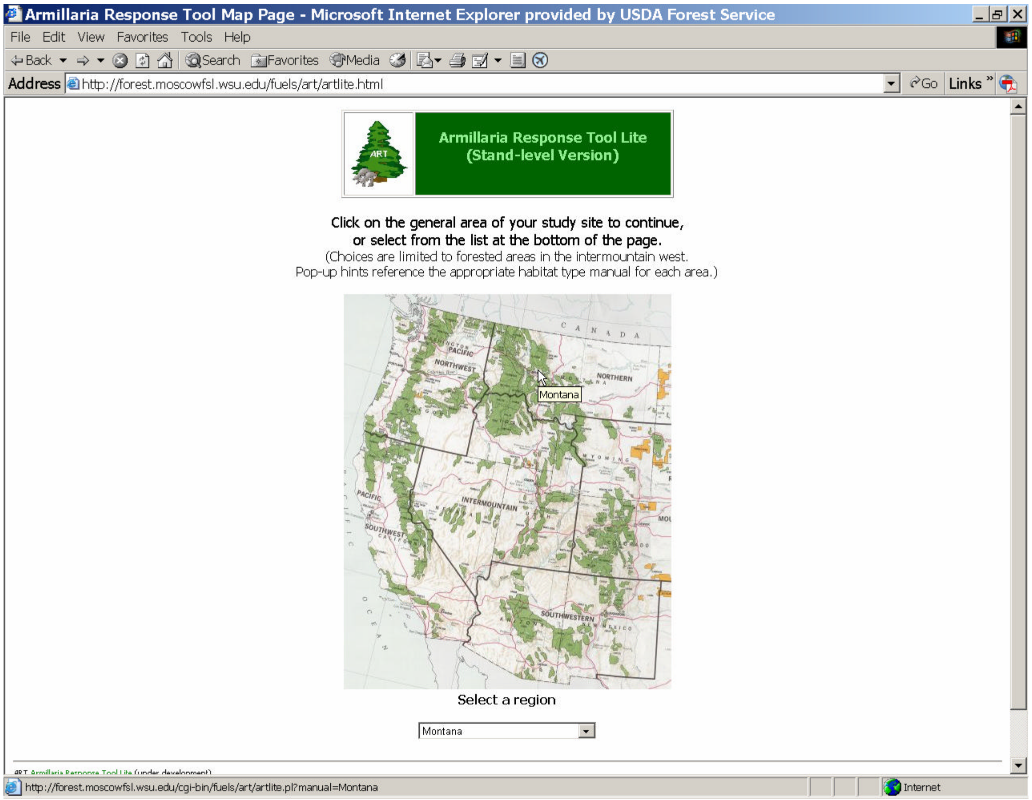
**Fig. 1.** Resinosis (left) is a common symptom on trees infected with Armillaria root disease. Tightly attached mycelial fans (right) are a definitive sign of Armillaria root disease, and can be found beneath the bark on roots and lower boles of infected trees. (Photos by Raini C. Rippy and John W. Hanna)

**Fig. 2.** Huckleberry Site (eastern Washington) - The habitat type-phase for this stand is grand fir/ninebark-ninebark (*Abies grandis*/*Physocarpus malvaceus*-*Physocarpus malvaceus*). The *Armillaria* Response Tool would classify this stand as high risk for the presence of Armillaria root disease. Armillaria root disease causes mortality that can increase fuels build up and risk of wildfire. (Photo by Raini C. Rippy)

**Fig. 3.** *Armillaria* Response Tool - Input and output screens.



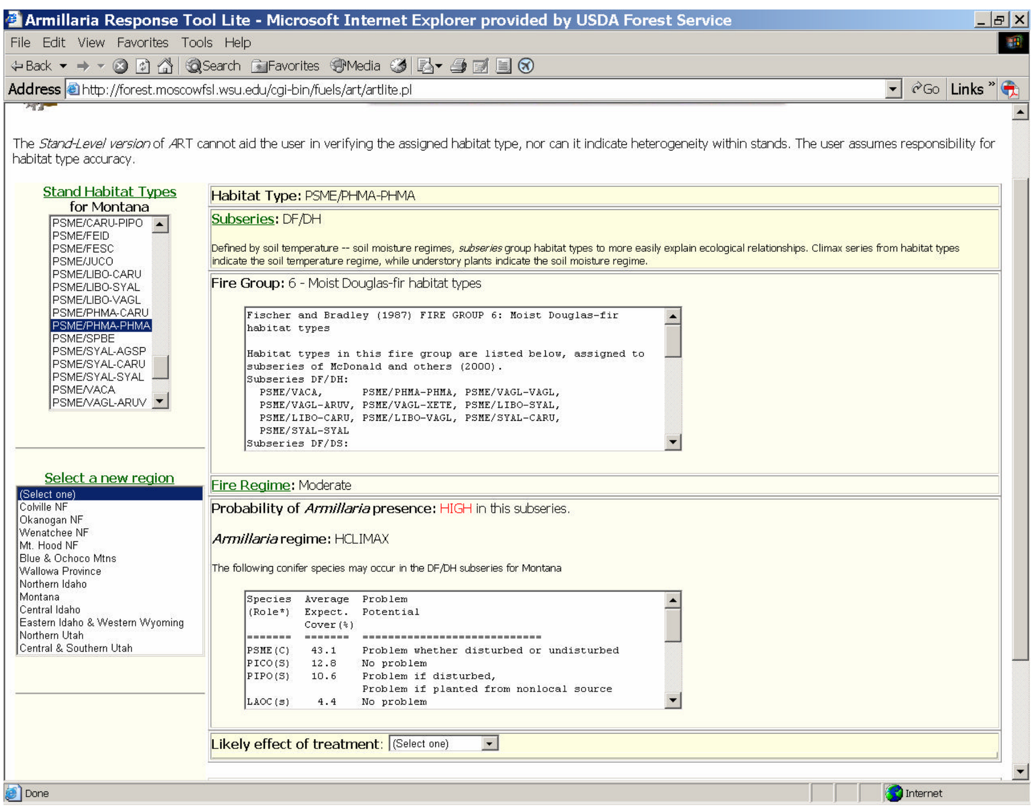
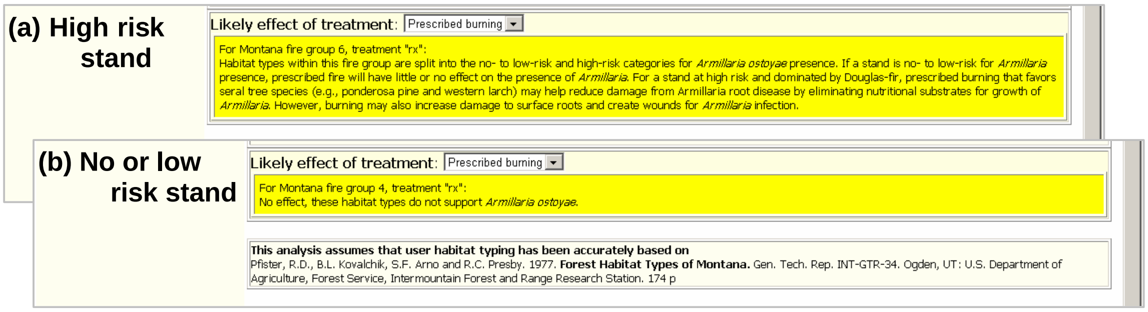



**Fig. 4.** *Armillaria* Response Tool – Likely effects of fuels treatments on Armillaria root disease.



**Appendix A ----** Crosswalk tables showing numbers of habitat types included in each subseries, and relationships between subseries, *Armillaria* regimes, and fire regimes (adapted from McDonald and others 2000).

**I.** Classification of 631 habitat types into 31 subseries (highlighting indicates *Armillaria* regime in appendix A-II).

| **Soil-Temp Class** | **Soil-Moisture Class** | | | | | | |
|---|---|---|---|---|---|---|---|
| | DG | DS | DH | MH | WH | WF | WS |
| PJ | 1 | | | | | | |
| PP | 24 | 29 | 1 | | | | |
| DF | 19 | 101 | ***35**** | 2 | | | |
| CoolP | 13 | 11 | 11 | 1 | | | |
| CH | | | 4 | 24 | 10 | 8 | 5 |
| CoolF | 2 | 18 | 45 | 24 | 6 | 8 | - |
| ColdF | 30 | 43 | 110 | 13 | 5 | 27 | 1 |
| | Water Limited | | Light Limited | | | | |

*35 = number of Douglas-fir/Dry Herb habitat types, compiled from 12 published habitat type manuals for the Rocky Mountain Montane Conifer Forest biotic community

| **Soil-Temperature Regime (Class)** | | **Soil-Moisture Regime (Class)** | |
|---|---|---|---|
| ColdF | Cold Fir | WS | Wet Shrub |
| CoolF | Cool Fir | WH | Wet Herb |
| CH | Cedar-Hemlock | WF | Wet Fern |
| CoolP | Cool Pine | MH | Moist Herb |
| DF | Douglas-fir | DH | Dry Herb |
| PP | Ponderosa Pine | DS | Dry Shrub |
| PJ | Pinyon Juniper | DG | Dry Grass |

**II.** *Armillaria* regimes in the Rocky Mountain Montane Conifer Forest

| ***Armillaria* Regime** | Seral | ***A. ostoyae***<br>2nd Seral | Climax |
|---|---|---|---|
| Low Risk* | Rare | Rare | Rare |
| High Risk on Climax | Tolerant | Tolerant or None | Diseased |
| High Risk on 2nd Seral | Tolerant | Diseased | Tolerant |

*Subseries CoolF/DS and ColdF/DS indicate a High Risk category for Utah and eastern Idaho areas.

**III.** Five fire regimes defined by severity and patch size, for 31 subseries within the Rocky Mountain Montane Conifer Forest

| **Soil-Temp Class** | **Soil-Moisture Class** | | | | | | |
|---|---|---|---|---|---|---|---|
| | DG | DS | DH | MH | WH | WF | WS |
| PJ | 1 | | | | | | |
| PP | 24 | 29 | 1 | | | | |
| DF | 19 | 101 | 35 | 2 | | | |
| CoolP | 13 | 11 | 11 | 1 | | | |
| CH | | | 4 | 24 | 10 | 8 | 5 |
| CoolF | 2 | 18 | 45 | 24 | 6 | 8 | - |
| ColdF | 30 | 43 | 110 | 13 | 5 | 27 | 1 |
| | Low | Moderate | Mixed | | High | | Rare |

| **Fire Regime** | **Underburn** | **Mixed severity** | **Replacement** | **Size** |
|---|---|---|---|---|
| Low | 5-20 yr | rare | rare | 1-2,000 ha |
| Moderate | 25-75 yr | 25-75 yr | 150-300 yr | 20-100 ha |
| Mixed | few | 50-100 yr | 150-300 yr | 200-2,000 ha |
| High | rare | 100+ yr | 300-400 yr | 500-50,000 ha |
| Rare | none | rare | 600+ yr | variable |

McDonald, G.I.; Rice, T.M.; Hall, D.E.; Stewart, J.E.; Tonn, J.R.; Tanimoto, P.D.; Zambino, P.J.; Klopfenstein, N.B.; Kim, M.-S. February 2005 Draft. Root Disease Analyzer – *Armillaria* Response Tool (*A*RT). Moscow, ID: USDA Forest Service, Rocky Mountain Research Station.