United States Department of Agriculture

Forest Service

Pacific Northwest Region

The Malheur National Forest

Location of the World's Largest Living Organism

[The Humongous Fungus]

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2008

Figure 1. Dead and live-symptomatic trees in this *Armillaria* root disease center. Down trees in the foreground died earlier. This root disease center is in Genet E.

The Humongous Fungus on the Malheur National Forest

A group of at least five separate individual *Armillaria ostoyae* genets reside in the mountains east of Prairie City, Oregon (Fig. 3) in the Reynolds Creek and Clear Creek areas in the northeastern portion of the Malheur National Forest (a genet is a genetically unique individual organism). Several of these genets are very large, including the largest known fungus genet in the world, identified with a red outline on the map (Fig. 3)as Genet D; the **Humongous Fungus.**

Figure 2. Vicinity maps showing the location of the Malheur National Forest and the Humongous Fungus on the Prairie City Ranger District.

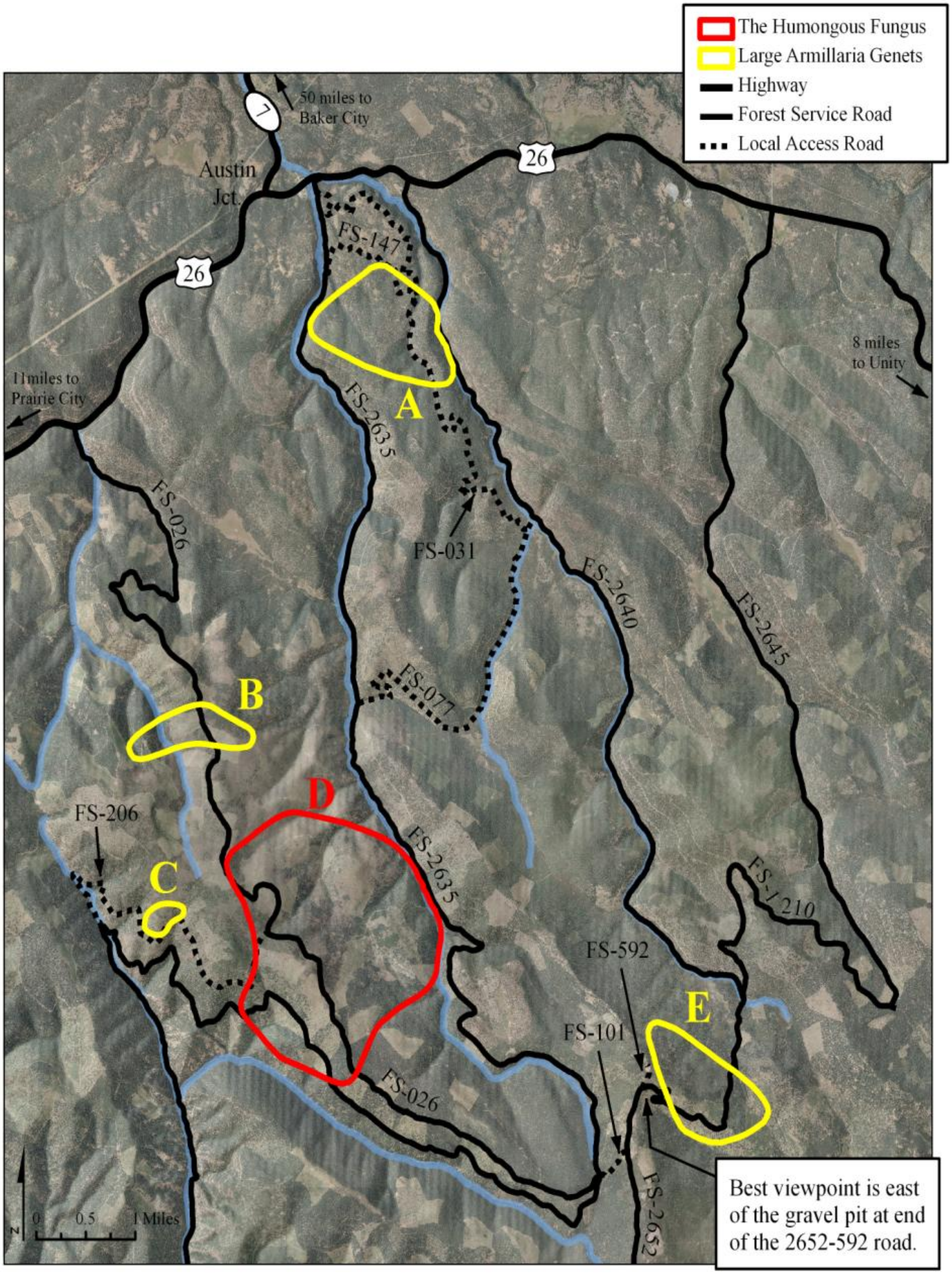

Figure 3. Vicinity map of large *Armillaria ostoyae* genets, including the Humongous Fungus, on the Malheur National Forest, Oregon

Armillaria ostoyae, commonly known as the “shoe-string” fungus, parasitizes, colonizes, kills and decays the root systems of various conifer hosts, resulting in what forest managers know as *Armillaria* root disease. While being a pathogen and tree-killer, *Armillaria ostoyae* can also maintain itself in dead woody material for many years as a saprophyte.

Large root disease centers in the Reynolds Creek and Clear Creek areas were originally recognized by Malheur National Forest personnel. Site evaluations confirmed the prevalence of *Armillaria*, and scientists were invited to conduct research associated with the fungus and their findings have confirmed the species, size, and estimated age of these individuals.

Each *Armillaria ostoyae* genet shown in Figure 3 are separate networks of fungus mycelia tested and determined to be genetically homogeneous, with each genet being a genetically different individual, occupying the soil and tree roots over areas that range in size from 50 to 2,385 acres (Table 1). The largest individual, *A. ostoyae* identified in Fig 3 and Table 1 as Genet D, covers 2,385 acres, and is the largest known root disease center in the world. Using assumptions made for weight estimates of smaller *Armillaria* individuals discovered in Michigan by Smith and others (1992), biomass including fungal mycelia and rhizomorphs of Genet D, is estimated to weigh 7,567 to 35,000 tons, all in the soil and on the roots of diseased trees. So this *Armillaria* individual, located on the Malheur National Forest, is the largest (by biomass) known living organism (fungus, plant, or animal) in the world, and is known as the **Humongous Fungus**.

Table 1. Characteristics and locations of *Armillaria ostoyae* genets in the Reynolds Creek and Clear Creek areas, Malheur National Forest, Oregon (adapted from Ferguson and others 2003).

Genet	**Width** (feet)	**Area** (acres)	**Age estimates** (years)[1]	**GPS coordinates** Lat. / Long. DMS
A	7,054	642	1100, 1250, 4900	44° 33’ 21.24” N 118° 28’ 32.29” W
B	5,643	235	900, 1000, 4000	44° 30’ 4.25” N 118° 30’ 50.88” W
C	--	50	--	44° 28’ 34.21” N 118° 31’ 9.34” W
D	12,500	2,385	1900, 2200, 8650	44° 28’ 34.21” N 118° 29’ 5.17” W
E	6,660	482	1000, 1150, 4600	44° 27’ 16.78” N 118° 24’ 28.83” W

These *Armillaria* genets are not only large, they are also very old, with Genet D estimated to be between 1900 and 8650 years, based on the current size of the genet and estimates of how long it took to expand to its current size at rates ranging from 0.7 to 3.3 feet a year.

[1] Using estimates of spread rates of 0.7 ft/year (van der Kamp 1993), 2.8 ft/year (Shaw and Roth 1976), and 3.3 ft/year (Peet and others 1996).

Scientists are unsure of all the factors that allowed these genets to become as large and as old as they have. *Armillaria* may have effectively spread in historic forests of large trees that were less-densely stocked, and composed of species less susceptible to root disease. Alternatively, forest structure and composition are now possibly more amenable to *Armillaria* spread as current conditions are different from those that developed under the natural fire regimes of the last several hundred years (Ferguson and others - 2003).

Figure 4. *Armillaria ostoyae* mushrooms at the base of a live infected grand fir. Mushrooms are produced following the first rains in the fall of the year. They are commonly called the "honey mushroom".

While these *Armillaria* genets on the Malheur National Forest are huge in size and old in years, they are mostly hidden from sight. Mushrooms are produced for a short period of time in the fall season, usually following the first rains, and will appear at the base of live-infected or recently-killed trees (Figure 4). The *Armillaria* mushroom, commonly called "the honey mushroom", is probably the most visible structure of the fungus seen by the casual observer. They are stalked, 2 to 4 inches tall, 2 to 5 inches across at the cap, and cream to tawny-brown in color. They do not persist for long.

Rhizomorphs are black, shoestring-like, branching structures of *Armillaria* and are characterized as long, slender, and differentiated filamentous fungal tissues that grow in the soil. Rhizomorphs are commonly seen on the exterior of root systems of wind-thrown trees (Fig. 5) and sometimes under the bark. Rhizomorphs are characteristic of the different species of *Armillaria* and serve as a mechanism allowing the fungus to spread through soil. These rhizomorphs find and infest new material, including live hosts. Rhizomorphs can be differentiated from similar-appearing roots by their white interior.

Figure 5. ***Armillaria*** **rhizomorphs, or "shoe-strings" may be observed on the surface of exposed root systems of windthrown diseased trees.**

The other fungal structures that may be seen are latex paint-like mats of mycelial felts that grow under the bark of live-infected trees (Fig. 6). These may be found for several years on infected trees after they have died (Fig. 7). Mycelial felts contribute to killing the host and will grow under the bark of the roots, root collar, and a short distance up the lower bole of trees. Mycelial felts growing under the bark usually result in resin extrusion through the bark and oozing down the bark surface at the root collar and lower bole. Mycelial felts may be found under the loose bark on the roots or root collar of recently windthrown trees. ***Since standing dead trees may fail at any time, avoid walking or standing near, or disturbing standing dead trees.***

While the actual portions of the *Armillaria* fungus are largely hidden and often not always visible, the symptoms expressed by diseased conifers (e.g. dying trees, mortality and large disease centers) are often striking and are the best way to appreciate the size and extent of *Armillaria* on the landscape. Since lateral spread of *Armillaria* occurs through the soil and across root contacts, the resulting expanding pattern in disease centers is a gradient of older dead, to recently-killed, to live-symptomatic, to non-symptomatic trees, moving from the middle to the periphery of disease centers. Older dead trees will be loosing branches and bark will be sloughing off. After dying, trees may soon fail or remain standing for several years before they topple.

On trees that have only been dead for a year or two, red needles will still remain. Live-infected trees may have crown symptoms such as off-color or a chlorotic shade of yellow-green of the live, often sparse, foliage. Live-infected trees may also have rounded tops, abundant cones or other symptoms of infection such as resin exudation at the base. Bark beetles will usually attack dying trees and their presence can be expected.

Conifers vary in susceptibility to *Armillaria*; grand fir are highly susceptible and most likely to be killed, while western larch is fairly resistant to infection and will usually remain alive within disease centers.

Figure 6. *Armillaria* mycelial felts under the bark of a live-infected tree. Note the resin exudate on the lower bole; another symptom of *Armillaria* infection.

Armillaria root disease pockets can be apparent and confirmed by casual observers looking for discrete groups of dead, dying, and symptomatic trees (Figures 1[cover page] and 8) and confirming the presence of the root disease by finding mushrooms, rhizomorphs, or mycelial felts.

Now that you know what to look for, you can visit the world's largest organism, or one of its equally impressive neighbors (Fig. 3). Global Positioning System (GPS) coordinates for centers of each genet are provided in Table 1. Portions of Genet D burned in the Easy Fire of 2002. Genet A, B and C also burned in this fire and some of the now visible mortality is due to that fire. A portion of Genet E is undisturbed and includes forest stands that have never been harvested or salvaged, and is probably has the best examples of root disease center expression described in this pamphlet.

Figure 7. *Armillaria* mycelial felts are white- to cream-colored and can have the texture of latex paint.

Acknowledgements

We would like to thank Bridget Naylor (USFS–PNW) for producing Figure 3, and Patricia Hammett for pamphlet layout and design.

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Figure 8. *Armillaria* disease center with dead and dying trees on the periphery and dead down trees in the center. Note the young trees filling in the disease-created opening. This root disease center is in Genet E.

Standing, dead trees can fall at any time and visitors should avoid walking or standing near, or contacting dead trees.