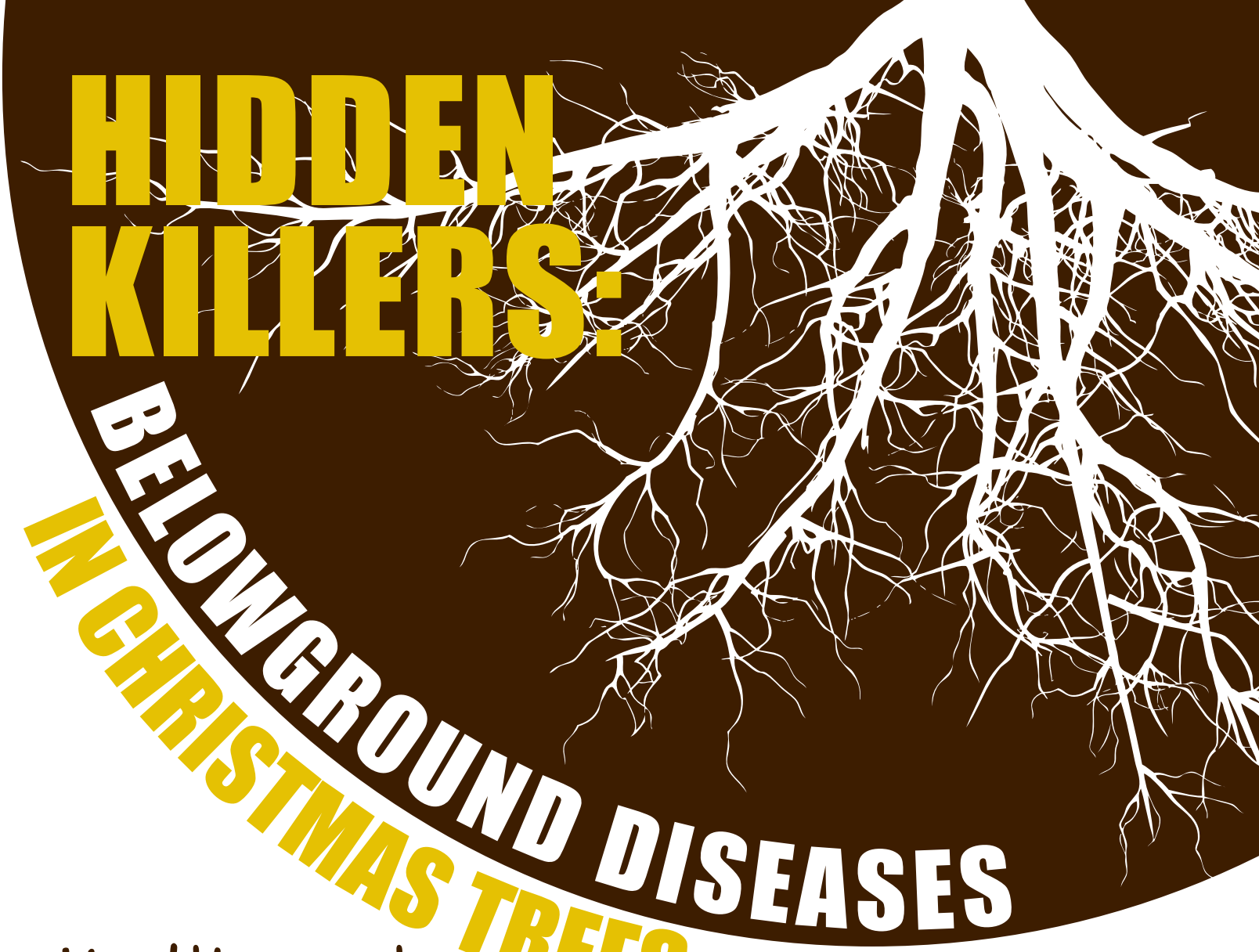


HIDDEN KILLERS: BELOWGROUND DISEASES IN CHRISTMAS TREES

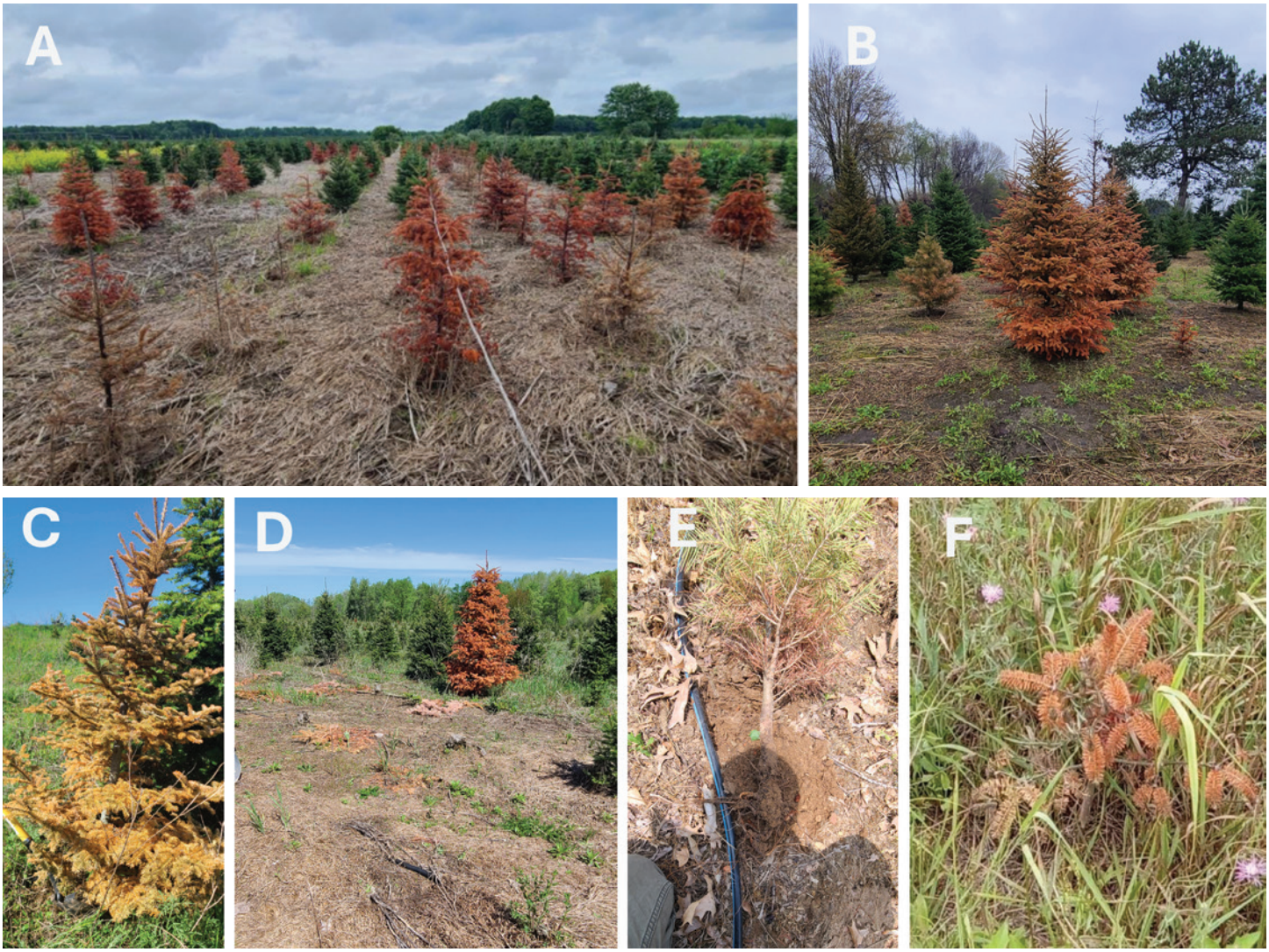
Healthy roots, healthy trees – How to diagnose common root disease problems?

DR. PRATIMA DEVKOTA AND BILL LINDBERG

Introduction:

"What's happening to this tree?" "Why are these trees suddenly dying?"

Unfortunately, these are common questions many Christmas tree growers ask themselves and ones we often hear as well. Determining the root cause of a problem is important because it may change what corrective actions can be taken. Picture 1 (on next page) shows how aboveground tree mortality can appear alike regardless of the cause.



Picture 1 – *Christmas trees are affected by various biotic and abiotic stresses. A & B: Phytophthora Root Rot, C&D: Armillaria Root Rot, E: J-Rooting, F: Drought related mortality. Aboveground symptoms look alike. Picture source (A-E): Pratima Devkota, MSU, Picture F: Bill Lindberg, MSU.*

However, with the use of some field identification knowledge and tips, growers can get a good sense of the underlying issue before sending samples for lab testing. The first step is to determine exactly which tree species you are working with, something most growers know well. Patterns of damage can also provide important clues. If mortality is widespread and uniform across a plantation, the cause is often environmental (non-living). If dead and declining trees are patchy or scattered irregularly, a disease or other biotic factor may be more likely to be at work.

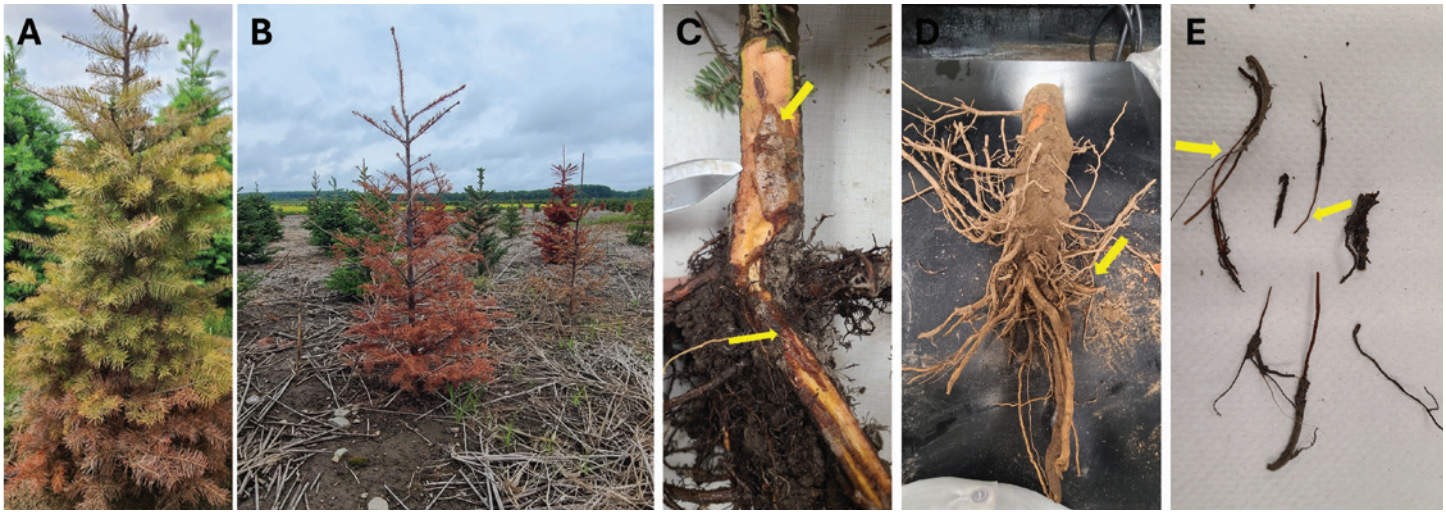
The next step is to understand the difference between **signs** and **symptoms**.

Symptoms are visible changes in a tree's appearance, such as shifts in color or shape. These can be caused by living factors (e.g., fungal pathogens) or non-living factors (e.g., drought, frost, soil compaction). Symptoms are non-specific and if used solely often provide an inaccurate diagnosis.

Signs are direct evidence of the causal agent, such as fungal fruiting bodies, insect galleries, or bacterial ooze. Signs are unique to pests or pathogens and are the most reliable in diagnostic efforts.

Initial steps in narrowing down the cause of the problem:

1. Distribution: Note whether affected trees are clustered, randomly scattered, or concentrated in low-lying/wet areas.
2. Recent environmental stressors: Record any droughts, flooding, or extreme weather events that may have occurred in the past season.
3. Signs and symptoms: Inspect roots, trunk, and foliage for visible abnormalities or direct evidence of pests or pathogens.
4. Tree parts affected: Determine which parts of the tree show damage, when symptoms first appeared, and how quickly they are progressing.
5. Site history: Review the land's previous use. Have Christmas trees been grown here before? Did earlier plantings show similar problems?
6. Soil condition: Assess soil type, drainage and current moisture content.



Picture 2 – *Concolor (A) and Fraser (B) fir trees showing aboveground mortality due to Phytophthora root rot. C: Canker in the lower trunk and root of Fraser fir infected with Phytophthora. D & E: Root ball of fir tree infected with PRR and rotting of roots from infected trees with outer layer easily separating from the core. Photo: Pratima Devkota, MSU*

In this article we describe how to identify some of the common root disease issues in the Christmas tree growing regions in the United States.

Phytophthora Root Rot (PRR)

Phytophthora root rot is caused by multiple *Phytophthora* species and occurs throughout most Christmas tree–producing regions of the United States. Among the predominant species affecting Christmas tree farms are *P. cinnamomi, P. cambivora,* and *P. megasperma* (McKeever and Chastagner, 2016). *Phytophthora* species are often referred to as water molds because they require water to complete their life cycle. These pathogens produce swimming spores that move readily through saturated soils, as well as resting spores capable of surviving for extended periods under unfavorable conditions.

Environmental conditions:

PRR often, but not exclusively, occurs in low-lying or poorly drained soil or in sites with a history of prior PRR problems.

Above-ground symptoms:

Symptoms can vary (Picture 2) depending on the severity of infection, but often include:

a. Branch flagging (dead branches).
b. Needles turning from green → yellow → red.
c. Sudden tree death.

Branch flagging can also result from mechanical damage, such as mowing or other equipment impacts. If flagging is caused by PRR, scraping the bark at the base of affected branches often reveals small cankers. PRR typically progresses very quickly; with healthy trees dying completely within a few weeks after an infection occurs.

Below-ground symptoms:

Excavating soil around the root system often provides more definitive evidence of infection. Key signs include:

a. Root collar discoloration: Scraping away the outer bark near the root collar often reveals large red to cinnamon-brown lesions (Picture 2C).
b. Feeder root decay: Rotten roots are observed when entire tree is uprooted. Outer tissue of feeder roots may slough off easily when gently pulled, another common characteristic of PRR.

Important note: Signs of the pathogen itself are not visible to the naked eye in the field.

Armillaria Root Rot (ARR)

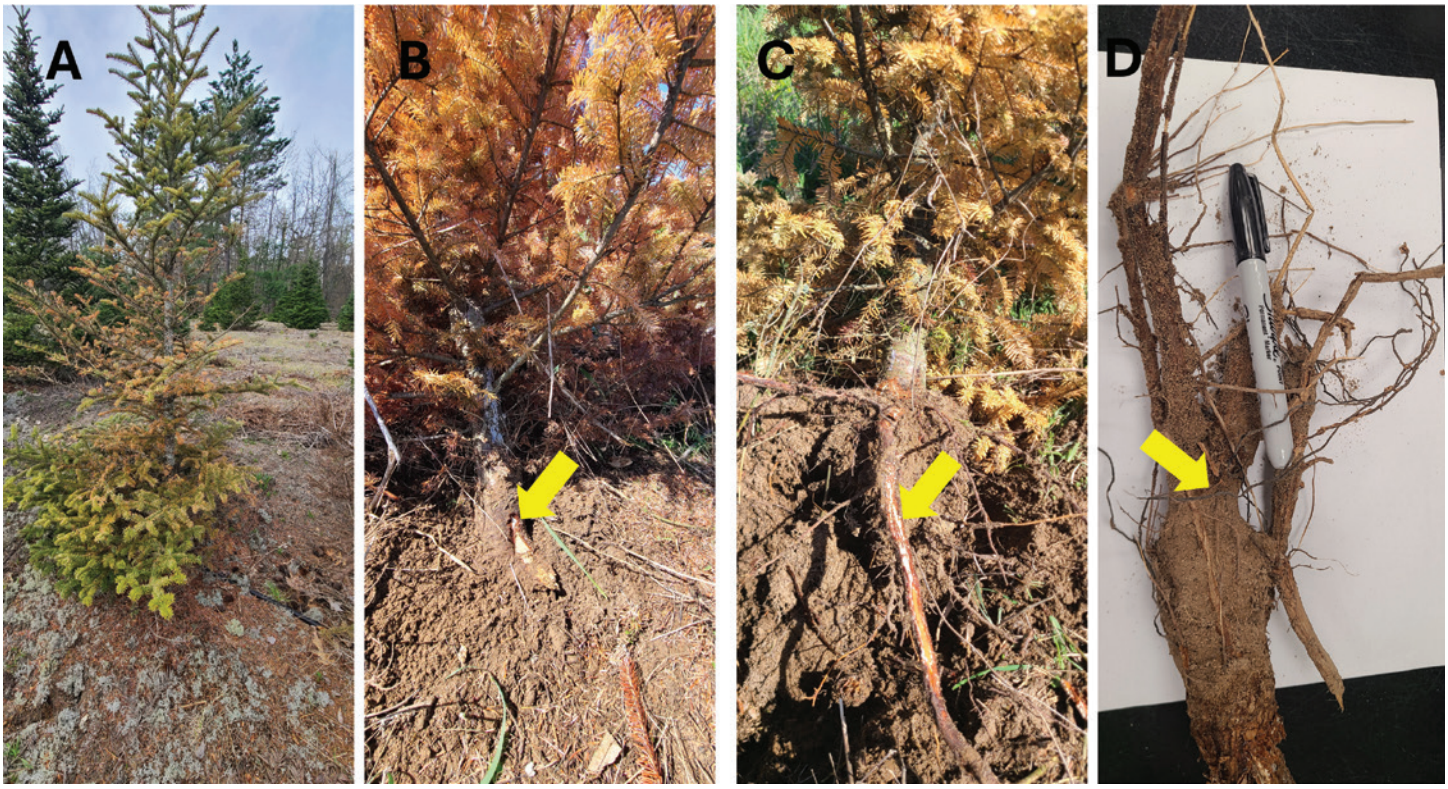
Armillaria root rot is a common soil-borne disease affecting Christmas trees across much of the United States. It is caused by several species of fungal pathogen *Armillaria*, which persist in the soil and colonize the root systems of woody host trees. Once established, the fungus can survive for many years in infected roots or stumps, making eradication difficult (Devkota & Hammerschmidt, 2020).

Disease progression:

The rate of decline can vary widely. In some cases, infected trees die rapidly within weeks, while in others, above-ground symptoms develop slowly over one or more growing seasons. By the time foliar symptoms appear, the root system is typically already extensively colonized.

Above-ground symptoms:

Symptoms are similar to those of Phytophthora root rot in that trees lose the ability to transport water and nutrients from the roots, leading to needle chlorosis (yellowing) and eventual browning (Picture 3A). Branch dieback and general decline are common.



Picture 3 – *A: Tree showing symptoms of ARR -about 70% of the root system was infected. B & C: Dead trees showing signs of Armillaria infection (white mycelial fan underneath the bark), D: Dark thread like fungal structure (rhizomorph) around the root system of tree infected with Armillaria root rot. Photo: Pratima Devkota, MSU*

Below-Ground Signs and Symptoms:

a. Mycelial fans: White to cream-colored sheets of fungal growth found beneath the bark on infected roots and at the base of the trunk. These fans may also spread between trees through natural root grafts (Picture 3B&C).

b. Rhizomorphs: Often called the "shoestrings" of *Armillaria*, these black, cord-like fungal strands grow along or just beneath the soil surface, allowing the pathogen to travel from diseased roots to healthy ones sometimes over many years. They can be mistaken for tree roots, but closer inspection reveals key differences: rhizomorphs are more uniform in thickness than roots, have a black to dark brown exterior with a white interior when cut, and lack the fine branching typical of roots. Occasionally, they hide deeper in the soil and require extra digging to find. In early stages of infection, rhizomorphs may not be detected if the fungus has moved directly between trees through root grafts (Picture 3D).

c. Fruiting bodies (mushrooms): In some cases, clusters of mushrooms emerge at the base of infected trees, usually in late summer or fall. These are the reproductive structures of *Armillaria* and can release spores capable of traveling long distances, potentially starting new infections. However, mushrooms are relatively rare in Christmas tree plantations, and their absence does not mean the fungus and disease is not present underground.

d. Root and lower trunk decay: Infected tissue may be partially to completely rotted, often showing white rot that leaves the wood lighter in color, fibrous, and stringy. In advanced cases, the weakened roots may cause the entire tree to come out of the ground easily.

Recognizing these below-ground features is critical for accurate diagnosis, as above-ground symptoms alone are insufficient to differentiate ARR from other root diseases.

Heterobasidion root disease (HRD)

HRD is one of the most destructive diseases of conifers in the northern hemisphere. It is caused by pathogenic *Heterobasidion* species and has been reported to be highly problematic in Christmas tree plantations in the Pacific Northwest (Dart et al., 2006). Once established, the disease can lead to significant tree losses. HRD symptoms are often confused with those of Phytophthora root rot and Armillaria root rot. However, careful inspection can help distinguish between these different pathogens.

Symptoms of HRD

a. Reduced growth rate, thinning foliage, yellowing of needles and premature mortality.

b. Root and Trunk Decay: Infected trees often show darkly stained wood in the lower trunk and roots when



Picture 4 – *A: Fir tree infected with Heterobasidion root disease. Picture source: Mike Schomaker, Colorado State Forest Service, Bugwood.org. B: Fruiting body of Heterobasidion irregulare, Picture source: Joseph OBrien, USDA Forest Service, Bugwood.org; C: Trunk staining due to Heterobasidion on Douglas fir. Picture source: USDA Forest Service - Northern and Intermountain Region, USDA Forest Service, Bugwood.org*

cut open (Figure 4C). The root and lower trunk become stringy, soft, and rotten.

c. Tree Stability: Diseased trees are easy to push over, similar to Armillaria-infected trees. In contrast, Phytophthora-infected trees may remain firmly anchored even when roots are decayed.

Signs of HRD

a. Conks (fruiting body) appear at the base of the tree or around buried roots (Figure 4A).

b. The underside of conk has tiny round pores that release spores (Figure 4b).

c. White and fluffy mycelium or "popcorn stage" growth inside decayed roots.

Distinguishing Feature

Armillaria produces rhizomorphs (black, shoestring-like threads) which can normally be seen wrapping around root. *Heterobasidion* and *Phytophthora* does not.

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DR. PRATIMA DEVKOTA

