

Madrone Canker

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Introduction:

Madrone canker has brought a lot of confusion to the scientific community, and is harming the madrone trees (*Arbutis menziesii*) that reside on the west coast of North America. It has been misidentified, renamed, and even separated into multiple diseases. Diagnosing it can be difficult, and it offers a multitude of hosts. This paper discusses two main culprits of madrone canker, *Fusicoccum aesculi* and *Neofusicoccum arbuti*. Together these two are contributing to the damage and killing of madrone trees, which are a valuable wildlife, timber, and forest structure component.

Taxonomy:

Madrone canker is confusing because it is not fully understood. It has previously been separated into multiple diseases and misidentified in older scientific articles (Farr, Elliot, Rossman, Edmonds, 2005). In this paper two diseases will be the discussed: The madrone canker which starts in the branch tips (*Fusicoccum aesculi*) and the madrone canker that starts in the trunk and main branches where pathogen was formerly identified as 2007 (M. Elliott, personal communication, 04/06/2017) as *Neofusicoccum arbuti*. *N. arbuti* is a pathogen with earlier names such as *Nattrassia mangiferae*, *Fusicoccum arbuti*, and *Hendersonula toruloidia*. Both *F. aesculi* and *N. arbuti* are considered deuteromycetes, or fungi that do not readily produce sexual fruiting structures or spores.

Disease Cycle:

Madrone canker beginning in the trunk (*N. arbuti*):

N. arbuti is opportunistic and most often forms after an injury to the bark occurs. Once this injury occurs conidia that have come from an infection on the same tree, another madrone, or

another one of the many host species enter this area and penetrate the cambium. In one source the phloem was also mentioned as an area of attack (Elliot, Edmonds, Mayer, 2002). The cambium and phloem are then attacked and asexual conidia spore masses are formed that erupt through the bark (Adams, Kosta, 1993). During this time shoot blight and bark discoloration occur, which are the first symptoms of the disease. The tree then develops two different types of cankers depending on the speed of the disease spread. If the disease spread is slow, the cankers produce raised, knob like, irregular shaped calluses on the tree (Elliot, 1999). If the disease spread is fast then a canker with a smooth region and no callus produces a burnt, sooty appearance (Elliot, 1999). The latter is often associated with damage from sudden sun exposure. These cankers eventually spiral around the trunk and effectively girdle and kill the tree. During this time, longitudinal cracks are formed in the tree, which can also be seen when the bark begins to peel off. The spores are then carried by wind and move on to the next host where the cycle begins again.

Madrone canker beginning in branch tips (*F. aesculi*):

F. aesculi is also opportunistic and primarily affects water stressed madrones that were infected during a prior wet season (M. Elliott, personal communication, 04/06/2017). *F. aesculi* infects madrone trees starting at the branch tips. *Botryosphaeria dothidea* (*B. dothidea*) is the sexual stage of *F. aesculi* and produces ascospores. During periods of wetness, the sexual and asexual forms infect the madrone's branch tips. *B. dothidea* then produces psuedothecia in the cankers that then release ascospores, and *F. aesculi* forms its pinhead-sized pycnidia, which release conidia throughout the growing season (Pitt, Sovacchia, 2017 and Elliot, 1999). Once the tree is under water stress, the symptoms that are used to diagnose the fungus appear. When the fungus moves down the tree, it causes the bark to turn a deep red color. After the bark turns red

and the branch dies, it forms into a burnt look like that of *N. arbuti*. At this stage *F. aesculi* is often confused with *N. arbuti* (Elliot 1999). After infection and the development of cankers *F. aesculi*'s pycnidia overwinter in healthy branch tips and leaves (M. Elliott, personal communication, 04/06/2017), or it can live saprophytically until it finds an opportunity to infect a host (Farr, Elliot, Rossman, Edmonds, 2005). The conidia and ascospores are then dispersed by rain, wind and possibly insects (Oregon State University College of Forestry, 2017). The process repeats once it finds a fresh wound.

Modes of Infection and Spread for Pathogen:

N. arbuti is mainly spread by wind when the spores are exposed from under the bark. *N. arbuti* most commonly infects madrones through mechanical wounds and sun damage, although some sources have noted it is possible for the pathogen to infect healthy appearing madrone on healthy sites (McGregor, Sakaladis, Hamelin 2016). The mechanical wounds are caused from pruning practices, damage from natural occurrences, and heavy traffic in areas near the madrone. Sun damage is often caused by sudden exposure to direct sunlight on areas of the bark that were not previously exposed. This happens because of the madrone's thin bark, and its tendency to be a mid-story tree.

F. aesculi can be spread by wind and rain. Insects have also been noted as a possible mode of transportation. *F. aesculi* infects madrones through branch tips during the wet season, but it primarily shows symptoms when the tree reaches a certain point of drought stress (M. Elliott, personal communication, 04/06/2017). As stated earlier, the pathogen can live saprophytically until conditions are ideal for infection of living tissue. Drought stress has become more common in recent years. The pathogen also tends to infect areas introduced to direct

sunlight in previously shaded areas, but will also attack anywhere photosynthesis is low (Elliot, 1999).

Signs and Symptoms:

N. arbuti has a handful of symptoms and signs that can help identify the disease. Cankers are one of the most recognizable symptoms of it, and have two different appearances. The fast growing canker has a smooth margin and an appearance that makes it look burnt, and it is possible to confuse with *F. aesculi*'s burnt canker appearance. The other canker is slow growing, and has an irregular knob shaped margin with a sooty looking sunken canker in the middle. These cankers often spiral around the bark. Other symptoms of the disease are longitudinal cracks that are formed under the bark, and the bark becoming discolored and peeling off. Dieback and decline also are shown, with older trees showing these symptoms first (Elliot, Edmonds, Mayer, 2002). The color of the bark turns to a dark red to purple and then black when infected. The main sign described in literature are the dark spore masses that are seen after the bark has come off, but it also noted that *N. arbuti* has a distinct hyphal structure that makes it easily identifiable (Elliot, 1999).

F. aesculi also has some characteristic symptoms and signs that help identify it. Its symptoms include a deep red bark discoloration when it is infected, which eventually turn black and appears burnt. Again, this stage is where *F. aesculi* and *N. arbuti* are commonly confused. Dieback and decline are also symptoms like with *N. arbuti*. The main sign is its pinhead-sized pycnidia that appear on the healthy branch tips and leaves (Elliot, 1999).

Host plants:

It is well known these pathogens do not only affect madrones, but no one is quite sure if these two species are native or exotic. *F. aesculi* is associated with over thirty other species of plants (United States Department of Agriculture, 2017). *N. arbuti* also has many other hosts including *Amelanchier alnifolia*, *Arctostaphylos uva-ursi*, *Cytisus scoparius*, *Gaultheria shallon*, *Ilex aquifolium*, *Rosa sp.*, *Sorbus sitchensis* and *Spiraea douglasii* (McGregor, Sakaladis, Hamelin, 2016). Due to the amount of different species it is not understood how wide the true range of these pathogens is, and it is now thought that climate may decide the range of the pathogen more than the host range (McGregor, Sakaladis, Hamelin, 2016).

Management Practices:

N. arbuti management practices include reducing mechanical damage, removing inoculum sources, fungicides, and managing competing vegetation (McGregor, Sakaladis, Hamelin 2016). Avoiding mechanical damage is important because wounds are the pathogen's mode of entry. This can be done by minimizing damage from construction, not breaking branches or carving into bark, and using proper pruning methods. Removal of inoculum sources is one of the most effective methods because it gets rid of the spores that are being dispersed. Heavily diseased trees should be destroyed and infected branches should be cut at least one foot below the infected area (Pacific Northwest Extension, 2017). When removing these sources exposing previously shaded madrones bark to direct sun too quickly can cause sunscald. Waiting until the fall or winter when sunlight is less intense or wrap the trunks with a protective layer is one way of preventing damage from sunscald (Pacific Northwest Extension, 2017). Fungicides have been used on high value trees, but it was not mentioned if this method of treatment was

truly effective. Finally, managing competing vegetation will help the madrone because it will let madrones grow with vigor and have a lesser chance of becoming stressed and vulnerable.

F. aesculi has many similar management practices as *N. arbuti* such as avoiding injury, removal of inoculum sources, pruning techniques, and preventing sudden exposure to sunlight (Pacific Northwest Extension, 2017). With *F. aesculi* commonly being noted as attacking water stressed trees, properly watering the infected tree can help drastically. Infrequent waterings that are away from the trunk and go deep into the soil should be used during long droughts (Elliot, 1999). It is emphasized that the watering should be infrequent because madrone is drought tolerant and overwatering can have the same effect as long droughts (Elliot, 1999). Proper watering combined with removing the disease on infected branches can be very useful because it gets rid of any *F. aesculi* feeding saprophytically, and eliminating the chance of the tree getting to the point of water stress, which is when the disease attacks.

While these management practices can be useful to help reduce and help the effects of both diseases, there is also the issue of the multiple hosts. These other hosts could be a large problem for management because of the inability to remove the pathogens from an area, so focusing on disease resistance and tree health may produce better results (M. Elliott, personal communication, 04/06/2017).

Host Impact, economic, and ecological importance:

If madrone were to cease existence then wildlife, forest structure, and the wood products industry would suffer. Wildlife use the berries, twigs, and bark all for a source of food, and cavities within the trees provide optimal nesting habitat for certain species (Oregon State University College of Forestry, 2017). In one article, it was noted as one of the top thirty woody

plants that provided food in the Pacific region (Gurung, Adams, Raphael, 1999). Forest structure would also be impacted because the madrone adds to the diversity of the forest, and provides a source of shade for shade preferring species. Finally, the wood products industry would lose a tree that provides for many uses. Primary uses are flooring and furniture due to its resistance to abrasion and indentation, and can be priced from five to eight dollars per square foot (Whitethorn Hardwoods, 2017). Madrone can also be used for paneling, veneer, and pulpwood (Oregon State University College of Forestry, 2017).

Conclusion:

In conclusion, madrone canker is serving as a problem for madrone because of its ability to kill the tree, its numerous hosts, and the confusion that surrounds it. However, management practices for disease resistance and tree health may be a promising tool to help keep madrone canker under control and madrone trees in the woods for wildlife, forest structure, and timber.

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