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Tree Disease and Wood Decay as Agents of Environmental and Social Change

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Wood decay all around us

The breakdown or decay of wood is a prominent process in landscape health and disease. The bulk of the energy captured and stored by natural woodlands, orchards, and agroforestry operations is allocated to produce wood. The release of that stored energy and the cycling of the constituent mineral elements into environmental pools and other organisms is through processes of wood decay. Wood decay is an ordered process, primarily through the biology of specialized fungi and associated microorganisms and arthropods. Traditionally, plant pathologists viewed wood decay in terms of lost economic value of timber, products, and secondarily as a potential source of risk for structural failure of urban and community trees. Mycologists studied the great diversity of wood decay fungi in terms of taxonomy or natural history. More recent research has focused on the role of wood decay in the development of healthy trees and forests and biogeochemical cycling.

Although valued by some for food or craft materials, wood decay fungi are generally ignored or not even noticed by the general public. Whether escaping popular notice or not, wood decay fungi have had persistent effects on international relations, the history of science, and modern-day environmentalism and medicine, well beyond the limits of both natural history and timber production. The objective of this paper is to show a few of the linkages of wood decay to larger processes of politics, philosophy, and human society.

Wood decay and international power

Geopolitical history in the 16th through 19th Centuries was largely determined by resource acquisition, mercantilist advantage, and military naval actions, all dependent on wooden ships. The need for high-quality wood products both to maintain those forces and to support commerce provided an additional impetus for exploration and colonization.

As detailed by Ainsworth (1976), the attempted invasion of England by the Spanish Armada provides an example of the role of wood decay in European affairs with global implications. As part of the ongoing struggle for European dominance and control of New World resources in the 16th Century, Spain assembled a naval force for the invasion of Britain. British raids on the Spanish coast in 1587, a year before the Armada was launched, damaged some Spanish ships prior to deployment. As importantly, the raids destroyed many of the seasoned barrels intended for use to store food and water for the Armada. The pressing need for replacements was met by new construction, much of which was based on the use of green sapwood, rather than from properly dried heartwood. The low resistance to decay in the new barrels resulted in extensive food spoilage and water contamination prior to Spanish forces reaching the English coast. Structural failure of wooden planks and structural members contributed to ship losses before engagement of the Spanish and English fleets. Although multiple factors were surely in play, the defeat of Spanish forces enhanced the opportunity for England to become a major naval power and an expansionist global force. Part of the expansion was stimulated by the need to acquire from the New World and tropical Asia the timber of appropriate size and decay resistance to support the growing British navy and the commerce of the ever-expanding commercial fleet.

The British navy was not exempt from the hazards of wood decay. Extensive fruiting of wood decay fungi in ship holds and planking of newly commissioned ships was noted in official reports in the 1680s. This was attributed to the lack of availability of oak heartwood, it having mostly been cut from the British Isles over the preceding decades. The introduction of copper plating in ships of the Napoleonic era in the early 19th century helped to protect the exterior of ship hulls from shipworms (boring mollusks), but the interior planking and fittings continued to contain extensive decay and to be unusable even at the time of launching or shortly thereafter.

Wood decay and the germ theory

Well into the 19th Century, mushrooms and other fungi were believed to arise spontaneously from the interaction of soil or dead plant material with the physical environment. With some notable exceptions, scholars continued to interpret the growth of fungi along the conceptual lines of the ancient Greeks, most fully developed by Aristotle. In this view, though life could be maintained from generation to generation through seed production, life was also possible through spontaneously generation under the proper combination of the fundamental four elements of earth, air, fire, and water plus the *pneuma*, the latter conceived as the vital breath or heat.

From a purely observational perspective, spontaneous generation appealed to common sense. Although early microscopists noted mushroom spores in the 17th Century, the mushrooms that sprout from the compost pile did not apparently require seeds. The exposure of dead plant matter to wind, rain, and soil is often associated with the heat of fermentation which can be seen rising from compost piles. The development of thin hyphal threads ramifying within organic matter and the eventual fruiting of mushrooms were all consistent with Aristotle's biology. To move beyond the dominance of Aristotle and to understand wood decay requires a side trip into the pathology of field crops.

The late blight of potato caused by *Phytopthora infestans*, the preeminent agricultural disease of 19th Century Europe, was believed to be related to some adverse combination of rainfall and "bad air", possibly mediated by lightning or through some supernatural agency (Matta 2010). Clearly, the disease was worsened under wet conditions. The fungus associated with necrotic foliage was described and named (as *Botrytis infestans* and later *Peronospora infestans*) in 1845, at the height of the outbreak associated with the Irish Potato Famine.

The prevailing view was that the fungal growth was an excretion or malformation of the plant analogous to a suppurating rash in animals. Growth of the fungus was interpreted as due to inherent defects in the plant, improper cultivation practices, and the environmental conditions. The critical point to this discussion is that the fungus was seen as the *result* of the disease. Field inoculation and laboratory experiments by Heinrich Anton de Bary completed in 1853 established that the fungus *caused* the potato blight. De Bary's research involved a critically important crop and was well recognized by the scientific community. The research on the microbial involvement in the fermentation process by Louis Pasteur published in the late 1850s and 1860s reached a broader industrial and general audience. Although they did not invent the concept of the germ theory, the research by de Bary and Pasteur in the 1850s and 1860s effectively discredited spontaneous generation, although the concept persisted in some quarters, including forestry.

The scientific transition is clear in descriptions of wood decay by the father and son researchers Theodor and Robert Hartig (1805-80 and 1839-1901, respectively). A pioneering anatomist of the microscopic structure of wood as well as a forest entomologist, T. Hartig described fungal hyphae in decaying wood in 1833. He and subsequent researchers interpreted that the hyphae were the *result* of wood decomposition by simple abiotic weathering, consistent with the concept of spontaneous generation (Figure 1). That interpretation was reversed by R. Hartig's description of the hyphae as the *cause* of the decayed wood (Merrill, Lambert, and Liese 1975). The younger Hartig presented foresters and forest scientists a new paradigm, that wood decay was the result of infection by fungi. These fungi had identifiable life cycles and that once initiated, disease progressed according to understandable patterns.

Figure 1. Are Armillaria *rhizomorphs or "shoestrings" the cause or the effect of wood decay?*

Medical uses of wood decay fungi

In the US, wood decay fungi already in use abroad are being assessed for safety and effectiveness (Gargano and others 2017). A few of the most familiar wood decay fungi currently being tested are listed below. Inclusion in the list is not an endorsement of therapeutic value but is simply an indication of how commonly encountered wood decay fungi are being investigated for medicinal properties.

The common turkey tail fungus (*Trametes versicolor*, syn. *Coriolus versicolor*) occurs frequently on recently wounded sapwood or freshly cut stumps and timber in North America (Figure 2). Although most frequently on broadleaved trees, *T. versicolor* occasionally occurs on conifers as well. *Trametes versicolor* produces peptide-linked polysaccharides (short chains of sugar molecules linked to a small protein) as an adjuvant with traditional chemotherapy to reduce rates of tumor growth and to reduce side effects of chemical treatment.

*Figure 2. The turkey tail fungus (*Trametes versicolor*) on maple firewood converts cellulose and lignin into potentially medicinal peptide-polysaccharides.*

Another wound pathogen of broadleaved trees is the split gill fungus (*Schizophyllum commune*) (Figure 3). Although not commonly valued as an edible mushroom in North America, *S. commune* is cultivated as a food item in the south Asian tropics where it is cultivated. Extracts of *S. commune* are broadly anti-microbial and inhibit reverse transcriptase, an important enzyme for virus replication. In addition to potential medical benefits, the white rot decay system that the fungus uses can also breakdown and detoxify some serious pollutants. In part due to the ability to be cultured on a large scale, *S. commune* is one of several fungi in pilot tests to bioremediate landscapes polluted by releases of toxic organic chemicals.

*Figure 3. The split gill fungus (*Schizophyllum commune*, left—upper surface, right—lower surface) produces antiviral compounds as well as having the potential to bioremediate environmental pollution.*

Restricted to trees in the genus *Betula*, the birch polypore (*Fomitopsis betulina* syn. *Piptoporus botulinum*, *Polyporus betulinus*) is distributed across the northern hemisphere (Figure 4), wherever birch is found. Current folk practices include the use of *F. betulina* for immune system support, control of internal parasites such as the *Trichuris* nematode, and as a styptic material. The birch polypore received special attention after the discovery of the Tyrolean Man, nick-named Ötzi, a naturally-formed mummy dated to have died in about 3300 BCE (Peinter and Poder 2000, Pleszczyńska and others 2017). Uncovered by a melting glacier along the alpine border of Austria and Italy, the presence and possessions of Ötzi stimulated research in European culture and technology of the Copper Age and wonder at his journey across inhospitable terrain. Among his posessions, Ötzi carried two wood decay fungi. Pieces of the fruitbody of *F. betulina* were strung on a leather thong and are believed to have been carried for medicinal purposes. Along with flints for striking sparks, Ötzi also carried amadou or tinder derived from *Fomes fomentarius*, the tinder fungus. The hard fruiting bodies of the tinder fungus are beaten to yield the soft and fluffy amadou, perfect to catch sparks and to smolder in the process of fire-starting. The amadou from *F. fomentarius* is also included in several traditional pharmacopoeias to stanch bleeding.

Figure 4. The tinder fungus (Fomes fomentarius) on birch, an important component of ancient technology to use fire.

Pathologists and land managers need to be concerned with the effects of wood decay on the yield of goods and services. Interestingly, the effects of the fungi may be positive and beneficial as well as potentially negative and costly.

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