Wood decay fungi

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Overview

(1) Fungi, wood-decay fungi and why they are awesome! (like, totally!)

(2) Wood, and why it’s awesome! (like, super-awesome!)

(3) What happens when the two awesomenesses interact
Concepts we are covering

(1) Importance of fungi
(2) Fungal succession
(3) Wood Anatomy
(4) Tree Anatomy
(5) Fungal effects on trees (in general)
(6) Types of “rot”
   White    Brown    Soft
   Canker   Heart    Sap
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   - White
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   - Canker
   - Heart
   - Sap
(7) How do the fungi get in?
   - “true heart rots”
   - “wound heart rots”
   - “root and butt rots”
(8) Fungal contribution to hazard
References! (OR: everything good on these slides came from someone smarter than me!)

(1) Cell wall diagrams, wood tissues, wood rot types: 
   Schwarze, F.W., 2008. *Diagnosis and prognosis of the development of wood decay in urban trees.*

(2) Stupsi the Hedgehog: 

(3) Fungal succession on plant material graph: 
   Dr. Kevin Smith, USDA Forest Service

(4) Nice pictures of decay fungi: 
   Glaeser and Smith: Decay fungi of oaks…

(5) Arborist-focused articles: Dr. Chris Luley - 
   https://chrisluleyphd.com/publications/

(6) CODIT: Shigo and Marx, Bulletin 405 USFS 1977
Decay Fungi of Oaks and Associated Hardwoods for Western Arborists

Jessie A. Glaeser and Kevin T. Smith

Examination of trees for the presence and extent of decay should be part of any hazard tree assessment. Identification of the fungi responsible for the decay improves prediction of tree performance and the quality of management decisions, including tree pruning or removal. Scouting for Snider Oak Deaths (SOD) in the West has drawn attention to hardwood tree species, particularly in the urban forest where native or introduced hardwoods may predominate. Consequently, the tree risk assessment specialist needs a working knowledge of the fungi associated with hardwood decay. We present here some of the common fungi responsible for decay of hardwoods, particularly of oak (Quercus spp.), tanoak (Lithocarpus densiflorus), and chinquapin (Castanea spp.) in Western North America.

Experts group wood decay fungi by various criteria. Academic mycologists use evolutionary kinship, often revealed by analysis of microscopic structures and genetic material. Direct observations can group fungi based on habitat, spatial position, and the appearance of the decayed wood (Tainter and Baker, 1996). An eco-nutritional approach groups some wood decay fungi as saprotrophs that attack wood in service or as felled logs, slash, or snags (Toupin et al., 2008) or as pathogens that decay wood in living trees. Pathogenic wood decay fungi can be further subdivided based on the type of wood degraded and the position of the fungi in the living tree. Heartrot fungi can decay heartwood in living trees despite the tree’s ability to produce protective chemicals and low oxygen conditions in the central cylinder (Highley and Kirk, 1979). If sapwood is exposed by mechanical injury, many saprotrophic fungi can act as primary pathogens and directly kill living cells in advance of infection. These include canker rot and many root rot fungi (Shortle et al., 1996). Fruiting bodies of saprotrophic fungi around the outer circumference of the stems can indicate structural weakness, particularly to arborists, tree climbers and land managers.

Wood decay fungi are also categorized by the appearance of decayed wood. White-rot fungi degrade the lignin, cellulose and hemicellulose of wood, leaving behind a white or off-white residue. Some white-rot fungi produce many small pockets of decay throughout the Infected volume of wood. Brown-rot fungi degrade the cellulose and hemicellulose in the wood cell wall but do not significantly degrade the lignin. Brown-rot wood in advanced decay is often seen as more or less cubical fragments. Eventually, brown-rotted wood becomes a brown residue, composed largely of lignin that becomes part of soil humus which resists further degradation. This brown-rot residue is an important component of the carbon sequestered in forest soil. White-rot fungi frequently decay hardwoods, and brown-rot fungi usually colonize conifers, but many exceptions occur. The decayed wood within the tree can take different forms, including “stringy rot,” “spongy rot,” “pocket rot,” “cubical rot,” and “laminated rot.” Each of these decay types has different physical properties that affect the amount of strength remaining in the wood. In brown-rot decay, large amounts of strength loss occur early in the decay process due to the rapid depolymerization of cellulose (Cowling, 1961).

Definitions of mycological terms

Gillberton and Ryvarden, 1987

Anamorph — a ring found on the stipe of certain mushrooms.

Applanate — thin, flattened horizontally. Usually used to describe sessile fruiting bodies or the pileate portion of effused-reflexed fruiting bodies.

Effused-reflexed — a fruiting body that is partially resupinate and partially submerging into the pleu swapping.

Mycelium — the vegetative stage of the fungus, usually observable as a mass of individual threads, termed “hyphae.”

Ochraceous — a yellowish buff color.

Pileus — the portion of a fruiting body with a sterile upper surface and a fertile lower surface.

Resupinate — flat.

Rhizomorph — a macroscopic strand, often resistant to drying, that spreads throughout the soil. Black in Armillaria species.

Sessile — without a stipe.

Stipe — stalk-like or stem-like structure that supports the pileus.

Stipilae — a pair of stipes. The stipe can be central or attached laterally (ecteoryct).

Ungulate — hoof-shaped.
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   “wound heart rots”
   “root and butt rots”
(8) Fungal contribution to hazard
Common Molds: fungi with a sweet tooth…
Wood-decay fungi: the real cleanup crew!

Colonization of soil organic matter
1. Litter—Sugar fungi
2. Compost—Softrot
3. Cellulose—Brownrot
4. Lignocellulose—Whiterot

Little residue with white rot
Stable humus from brown rot
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Wood-eater’s menu options: cellulose or lignin?

Primary wall contains mostly lignin

Secondary wall: contains mostly cellulose
Wood-eater’s menu options: cellulose or lignin?

Secondary wall: contains mostly cellulose

Primary wall contains lignin and pectin (ML)
We need both to have strong wood!

Secondary wall (cellulose) – resists tension

Primary wall (lignin) – resists compression
Brown rot: cellulose degraded; brittle fracture

“Holes in cell walls”
Failure mode: brittle fracture (like breaking a ceramic cup)
Brown rot: cellulose degraded; brittle fracture
Brown rot: cellulose degraded; brittle fracture
White rot: lignin degraded, cellulose remains

Cells “come unglued…”
Failure: ductile break (stringy edges left)
White rot: lignin degraded, cellulose remains
White rot: lignin degraded, cellulose remains

Cells “come unglued…”
Failure: ductile break (stringy edges left)
But wood is “arranged” to make a tree – so, not all wood is the same!
Tissues in a tree

- Xylem
- Phloem
- Bark
- Summerwood
- Springwood
- Rays
- Cambium
Sapwood & Heartwood
A compartment

Vascular elements plug after wounding and complete Wall 1.
But wood is “arranged” to make a tree—so, not all wood is the same!
Heart rot
What to look for:
Body language of trees – may indicate heart rot
Sap rot!
Strength loss much greater with saprot!
Canker rot
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(8) Fungal contribution to hazard
How did they get in?
A typical(?) situation...
Backyard tree failed...! What to do...?

Remove the front yard tree, of course! →
Goal: test this tree for wood-decay fungi, and understand how those fungi affect the chance of failure →
Goals

Study question: which species of fungi are present in failed wood, and how often are they found?

Immediate goal: combining failure reporting with the fungal assay

Ultimate goal: enabling arborists to consider fungal presence within risk assessment
Presidio trees: old, weak, wet and falling — one killed a dog — so park goes into prevention mode
WTFRP: ucancr.edu/sites/treefail

Home

The California Tree Failure Report Program (CTFRP) was established in 1987 to collect quantitative information on the mechanical failure of urban trees (trunk breaks, branch breaks, and uprootings). This information is used to develop "failure profiles" for genera and species to more accurately assess failure probability in standing trees and thereby reduce failure potential in urban forests.

Over 200 tree care professionals in California are cooperating in this effort by systematically inspecting fallen trees and reporting failure details for entry into the CTFRP database. To date (June 23, 2016) 5873 failure reports have been filed.

California Tree Failure Report data is being merged with the International Tree Failure Database.

http://svinetfc8.fs.fed.us/itfdb/

To participate in the international effort, please visit the ITFD web site for instructions.

August, 2015, The ITFD website is off line for the immediate future. Contact Katherine Jones at treefail@mac.com if you have questions.

An occasional e-newsletter, Quick Break, is circulated to CTFRP cooperators. Annual Regional Meetings addressing issues relevant to hazard assessments and failure analysis are presented in January for northern California and February in southern California.
The O F F

Online Failure Form

Now available!
### Back to the study: Steps

1. **Sampling the failed trees**
   1a. Sampling sound wood (control samples!)

2. **Testing the wood for fungal DNA**

3. **Data summary and guidelines**
Sampling

(2) Send the wood (and conk) samples to the Garbelotto Lab in the large *Priority Mail* pack.

Either:

Sample sound - rotten interface

take 4 samples
Possible Test Results:

<table>
<thead>
<tr>
<th>Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fungal DNA</td>
</tr>
<tr>
<td>2. Armillaria spp.</td>
</tr>
<tr>
<td>3. Fomitiporia (P. punctatus, P. robustus)</td>
</tr>
<tr>
<td>4. Fuscoporia (P. contiguous, P. gilvus, P. torulosus)</td>
</tr>
<tr>
<td>5. Ganoderma spp.</td>
</tr>
<tr>
<td>6. Ganoderma adspersum</td>
</tr>
<tr>
<td>7. Ganoderma applanatum</td>
</tr>
<tr>
<td>8. Ganoderma lucidum (Eu)</td>
</tr>
<tr>
<td>9. Ganoderma resinaceum</td>
</tr>
<tr>
<td>11. Inocutis (I. dryophilus)</td>
</tr>
<tr>
<td>12. Kretzschmaria deusta</td>
</tr>
<tr>
<td>13. Inonotus dryadeus</td>
</tr>
<tr>
<td>14. Inonotus s.s. (I. andersonii, I. hispidus, I. obliquus)</td>
</tr>
<tr>
<td>15. Inonotus/Phellinus spp.</td>
</tr>
<tr>
<td>16. Laetiporus spp.</td>
</tr>
<tr>
<td>17. Perenniporia fraxinea</td>
</tr>
<tr>
<td>18. Phellinus s.s. (P. igniarius, P. lundelii, P. tremulae, P. tuberculatus)</td>
</tr>
<tr>
<td>20. Schizophyllum spp.</td>
</tr>
<tr>
<td>22. Trametes spp.</td>
</tr>
</tbody>
</table>
Results

Over 350 sample packets sent out
108 samples received
88 samples processed
Results: tree taxa

- 34% Oaks
- 12% Eucalypts
- 8% Monterey Cypress
- 8% Pines
- 34% Other 26 genera
- 4% Planetrees
- 17% Pines
- 9% Cypress
- 2% Redwoods
- 23% Oaks

Other 95 genera: 37%
Preliminary results: failure location

39% Branch failures

36% Trunk failures

25% Root failures
The most surprising result...

Most samples had >1 fungus!

Number of fungal species found in sample:

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 9
- 10
- 12

Count of samples
Top 5 fungi

- Stereum
- Pleurotus
- Armillaria
- Laetiporus
- Hericium
Results: where in the tree are our fungi
Results: who are they, anyway...

From: Glaeser & Smith, 2013
Results: who are they, anyway…

Ganoderma applanatum

From: Glaeser & Smith, 2013
Results: who are they, anyway...

Schizopyllum commune – top

Schizopyllum commune – gills

Trametes versicolor

From: Glaeser & Smith, 2010
Preliminary results: control samples tree type

- 55% Conifer
- 45% Broadleaf
- 64% Broadleaf
- 71% Broadleaf
- 28% Conifer

64% Broadleaf
35% Conifer
45% Broadleaf
55% Conifer
The less-surprising outcome for control samples

Control samples are mostly fungus-free
Fungi Fungus in control samples

00%

50%

0%
Fungi Fungus in control samples

Schizophyllum commune – top

From: Glaeser & Smith, 2010

From: Gary Emberger, 2008
Discussion

(1) The fungal species and the tree
   Do we believe the DNA results?
   Are the fungal characters of any importance?
   Do the fungi co-occur? (and do we care?)

(2) Visible decay, conks
   Just a quick thought on what we found

(3) Where do we go from here?
   Still processing control samples – stay tuned
   Continue the study? ($120/sample?)
I think the results are real:
fungi are present in failed wood, but not in control samples

Most samples had >1 fungus!

Control samples are mostly fungus-free
Do the characters of our fungi “make sense”

Wood Anatomy

Tree Anatomy

Types of “rot”

- White
- Brown
- Soft
- Canker
- Heart
- Sap
We need both to have strong wood!

Secondary wall (cellulose) – resists tension

Primary wall (lignin) – resists compression
The oddballs… (Stereum, Hericium)
characters of our fungi “make sense”

Types of “rot”

- White
- Brown
- Soft
- Canker
- Heart
- Sap
Most samples had >1 fungus!
decay fungi like company
decay fungi like company

Fungi co-occurring with STEREUM

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stereum Total Samples</td>
<td>31</td>
</tr>
<tr>
<td>Pleurotus</td>
<td>17</td>
</tr>
<tr>
<td>Hericium</td>
<td>16</td>
</tr>
<tr>
<td>Laetiporus</td>
<td>13</td>
</tr>
<tr>
<td>Armillaria</td>
<td>11</td>
</tr>
<tr>
<td>Ganoderma</td>
<td>11</td>
</tr>
<tr>
<td>Schizophyllum</td>
<td>10</td>
</tr>
<tr>
<td>Other (9 fungi)</td>
<td>17</td>
</tr>
<tr>
<td>Stereum alone</td>
<td>3</td>
</tr>
</tbody>
</table>
### Fungal frequency/composition compared with refs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Us</th>
<th>Others…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fungal frequency</td>
<td>87/88</td>
<td>11/11 (Parfitt 2010)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10/9 (Schmidt 2012)</td>
</tr>
<tr>
<td>Fungal species</td>
<td>16</td>
<td>11 (Parfitt 2010)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 (Schmidt 2012)</td>
</tr>
</tbody>
</table>

**Armillaria**
- Fomitiporia
- Fuscoporia
- Ganoderma
- Hericium
- Inonotus
- Laetiporus
- Oxyporus
- Perenniporia
- Phellinus
- Pleurotus
- Pseudolnnonotus
- Sarcocladium
- Schizophyllum
- Stereum
- Stereum
- Trametes
Discussion

(1) The fungal species and the tree
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(2) Visible decay, conks
   Just a quick thought on what we found

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   Continue the study? ($120/sample?)

   We need YOU to continue reporting failures!
Results: fungal taxa vs. obvious decay

Decay was suspected in only half of reports...

- Stereum
- Pleurotus
- Armillaria
- Laetiporus
- Hericium
- Ganoderma
- Schizophyllum
- Trametes
- Other
Conks: a friendly reminder
Discussion

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## Conclusion results in practice

| Many fungi in failed wood | → expect fungi on/in trees  
|                          | → know/recognize most common  
|                          | → expect fungi in odd locations  
|                          | → natural, cannot be eradicated |

| Saprots common in failed wood | → what this means is unclear, but it’s not surprising… |

| More brown rot than I expected | → Recognize *Laetiporus*, and potential for brittle fracture |

| About conks | → Indicate a problem (at least a pinpoint without sound wood)  
|             | → Leave them! useful as a reminder or a warning |
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   Schwarze, F.W., 2008. *Diagnosis and prognosis of the
development of wood decay in urban trees.*

(2) Stupsi the Hedgehog: 

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Thank you! (and please support the Britton Fund!)

<table>
<thead>
<tr>
<th>To all the arborists who sent in samples!</th>
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<tr>
<td>To the research team:</td>
</tr>
<tr>
<td>M. Garbelotto, L. Costello, K. Jones, D. Schmidt</td>
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<td>To the Britton Fund</td>
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<tr>
<td>To you, my favorite audience!</td>
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