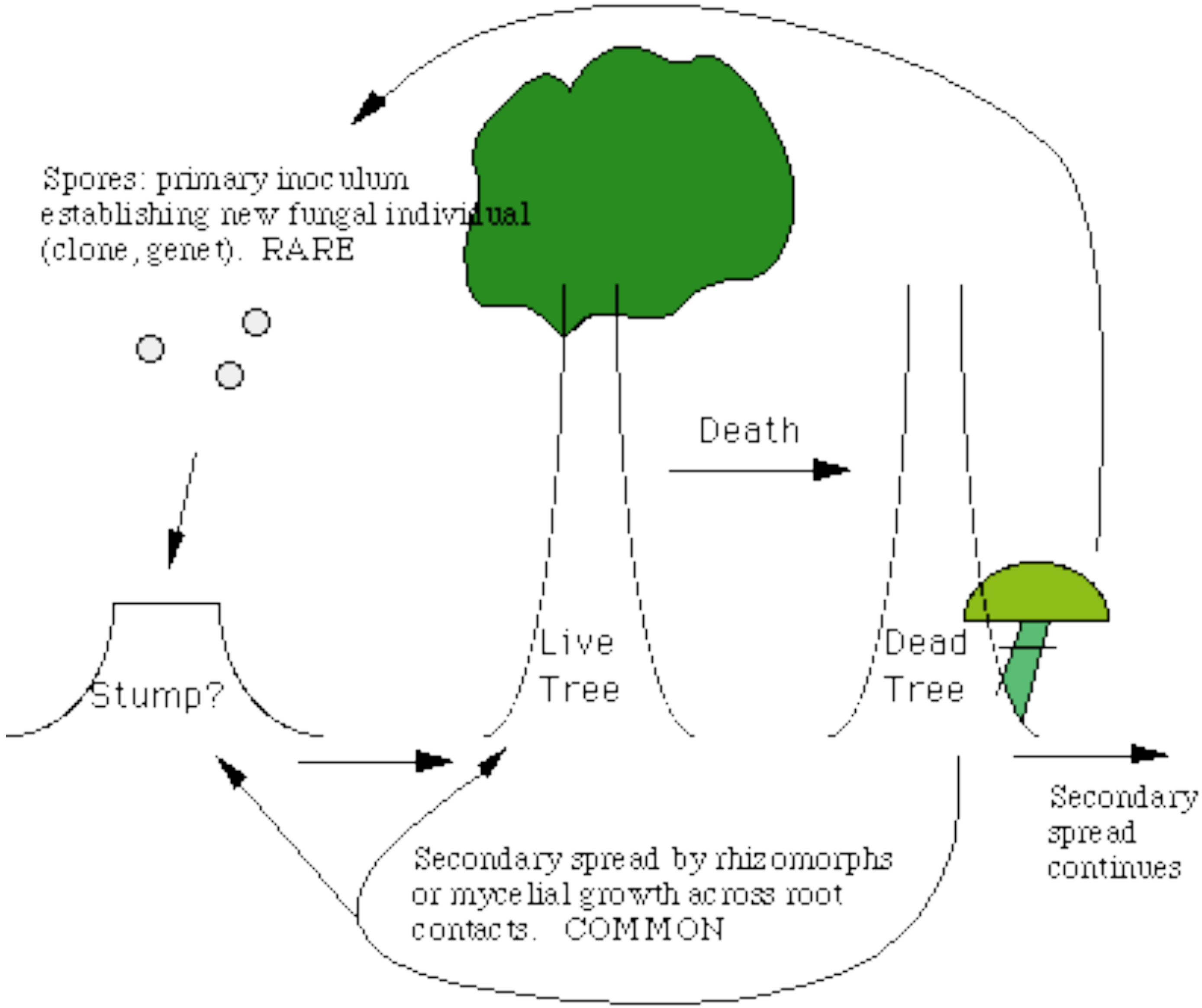
on UHAUL vans:

Armillaria, large, persistent infection centers that spread from tree to tree

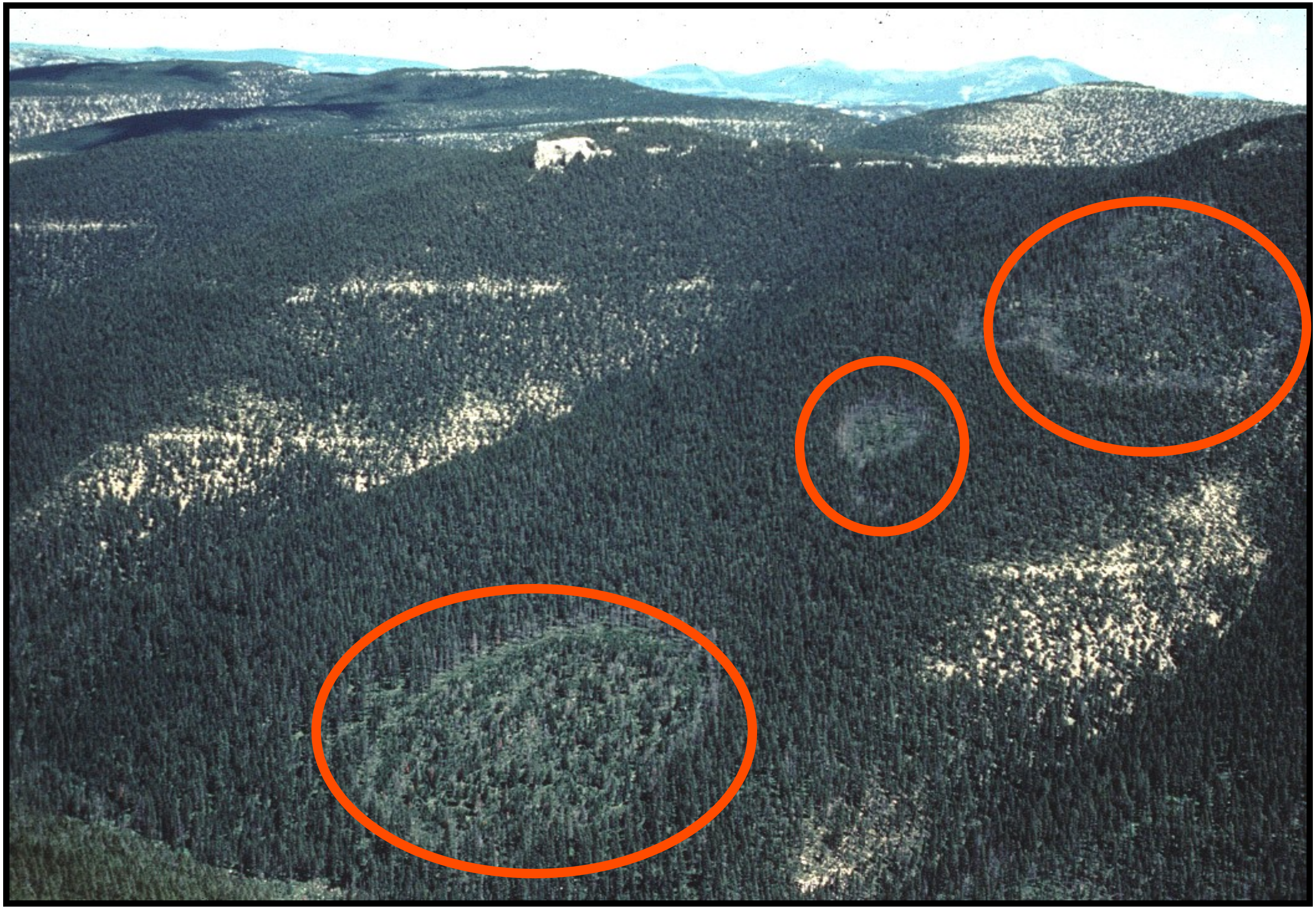


Armillaria mycelial fans form beneath bark

Armillaria - Rhizomorphs

Armillaria mortality centers also create structural/species diversity

Like *P. weirii*, *A. ostoyae* forms large radially expanding infection centers, may survive stand replacing fires



Oregon has world record thallus!

Table 1. Examples of *Armillaria* population studies using somatic incompatibility as a method of genet identification.

Study	Forest type(s)	Location	*Armillaria* spp.	Width (m)[a]	Area (ha)[b]
Adams 1974	Ponderosa pine	Oregon, U.S.A.	*A. mellea* (s. l.)[c]	800, 1410	—
Shaw and Roth 1976	Ponderosa pine	Washington, U.S.A.	*A. mellea* (s. l.)[c]	800	—
Ullrich and Anderson 1978	Maple	Vermont, U.S.A.	*A. mellea* (s. l.)	≤50	—
Korhonen 1978	Mixed conifer – hardwood	Finland	*A. mellea* (s. str.), *A. bulbosa* (resembled), *A. ostoyae*	Normally 10–50, largest 120–150	—
Anderson et al. 1979	Ponderosa pine	Washington, U.S.A.	*A. mellea* (s. l.)[c]	400, 450	—
Kile 1983	Dry sclerophyll eucalypt	Victoria, Australia	*A. luteobubalina*	50–580	0.002–3.5
Kile 1986	Wet sclerophyll eucalypt	Tasmania, Australia	*A. hinnulea*	28[d], 76[e]	—
Klein-Gebbinck et al. 1991*a*	Lodgepole pine	Alberta, Canada	*A. ostoyae*	35–90	—
Smith et al. 1992	Hardwood	Michigan, U.S.A.	*A. gallica*	635	15
Rizzo and Harrington 1993	Mixed conifer – hardwood	New Hampshire, U.S.A.	*A. ostoyae*	Small, 30+	—
Worrall 1994	Mixed conifer – hardwood	New York, U.S.A.	*A. calvescens*	11.7[f]	0.011[f]
			A. gemina	17.1[f]	0.023[f]
			A. gallica	18.5[f]	0.027[f]
			A. ostoyae	10.6[f]	0.009[f]
Rizzo et al. 1995	Red pine – jack pine	Minnesota, U.S.A.	*A. ostoyae*	≤140	—
Legrand et al. 1996	Beech, beech – pine, pine	France	*A. ostoyae*	210	3
			A. cepistipes	130	1
			A. gallica	290	2
Dettman and van der Kamp 2001*a*	Mixed conifer	Central British Columbia, Canada	*A. ostoyae*	—	0.70–15.83
			A. sinapina	30–100	0.07–0.79
Dettman and van der Kamp 2001*b*	Mixed conifer	Southern British Columbia, Canada	*A. ostoyae*	66.1–135.1	1.12[f]
This study	Mixed conifer	Oregon, U.S.A.	*A. ostoyae*	1720–3810	95–965
			NABS X	—	2[g]

[a]Maximum width, or range of widths, between somatically compatible isolates, if provided in citation.
[b]Maximum area, or range of areas, of genets, if provided in citation.
[c]Species was most likely *A. ostoyae*.
[d]Maximum width of an apparently contiguous genet.
[e]Maximum width of an apparently discontinuous genet.
[f]Mean values.
[g]Based on field observations.

Ferguson et al 2003, Can. J. Forestry Research 33: 612-623

The composition and species diversity of mature forests reflects the differential activity of pathogens and decomposers

Annosus (Annosum) root root, Annosus root disease

Heterobasidion annosum *(H. irregulare)*
Bondarzewiaceae, Russulales

Another species complex

Three separate types recognized, intersterility groups
(>>not the same as mating or somatic incompatibility)

P (pine), S (spruce), F (fir) types recognized
P and S types occur in North America
F type affects *Abies alba* in Italy and Balkans

North American P and S types are different from
European P and S

All conifers in western North America can be susceptible

P type infects only pine species

S type infects fir, western hemlock, Douglas-fir, spruce

really separate species but not all named

H. parviporum for S type in Europe

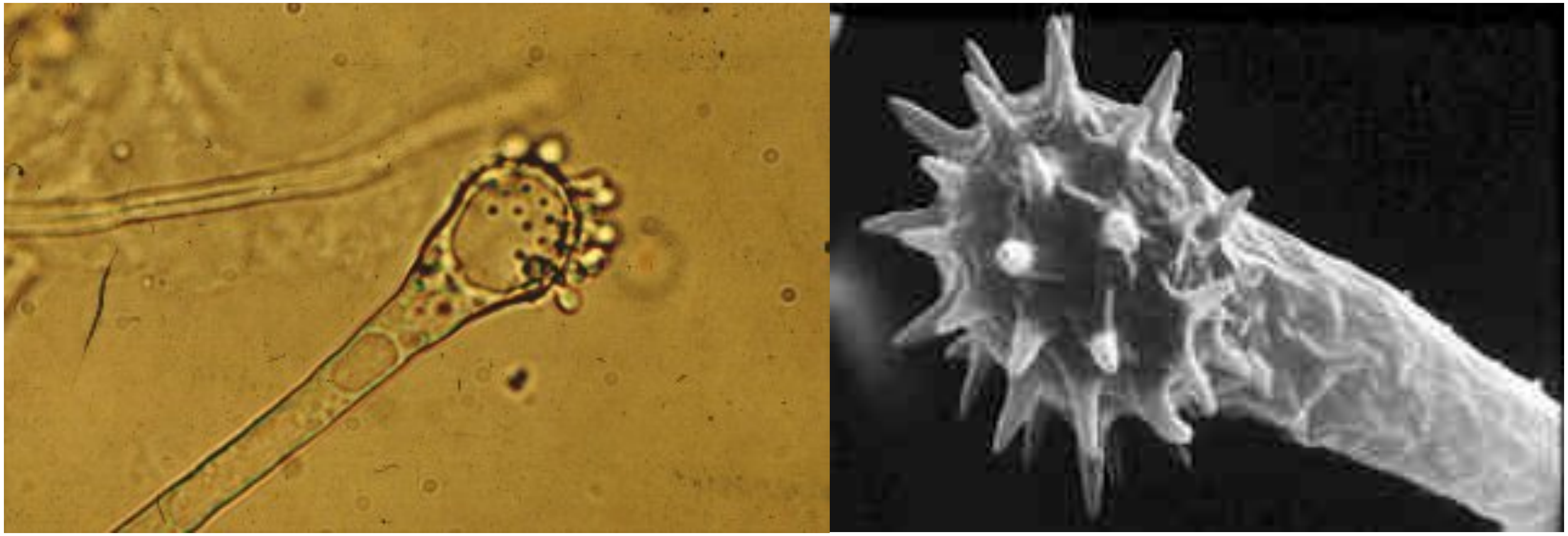
H. abietinum for F type in Europe

In western Oregon, western hemlock S type most common host

In SW Oregon, California, white fir S type

P type affects all pine species

Heterbasidion has an asexual (conidial) state, *Spiniger*



Conidiophore looks similar to a basidium with many sterigmata

Its role in epidemiology of the disease not well documented

Heterobasidion annosum conks inside rotted stump

Basidiocarps of *H. annosum* can be inconspicuous, indicate infected root

Annosus rot rot

Annosus decay in stump

Annosus decay

White rot

Freshly cut stumps are highly susceptible to infection by basidiospores and possibly conidia. Infection can spread by root contact

Borax treatment of stump to prevent infection

Peniophora gigantea used as a bio control treatment

Stem Decays

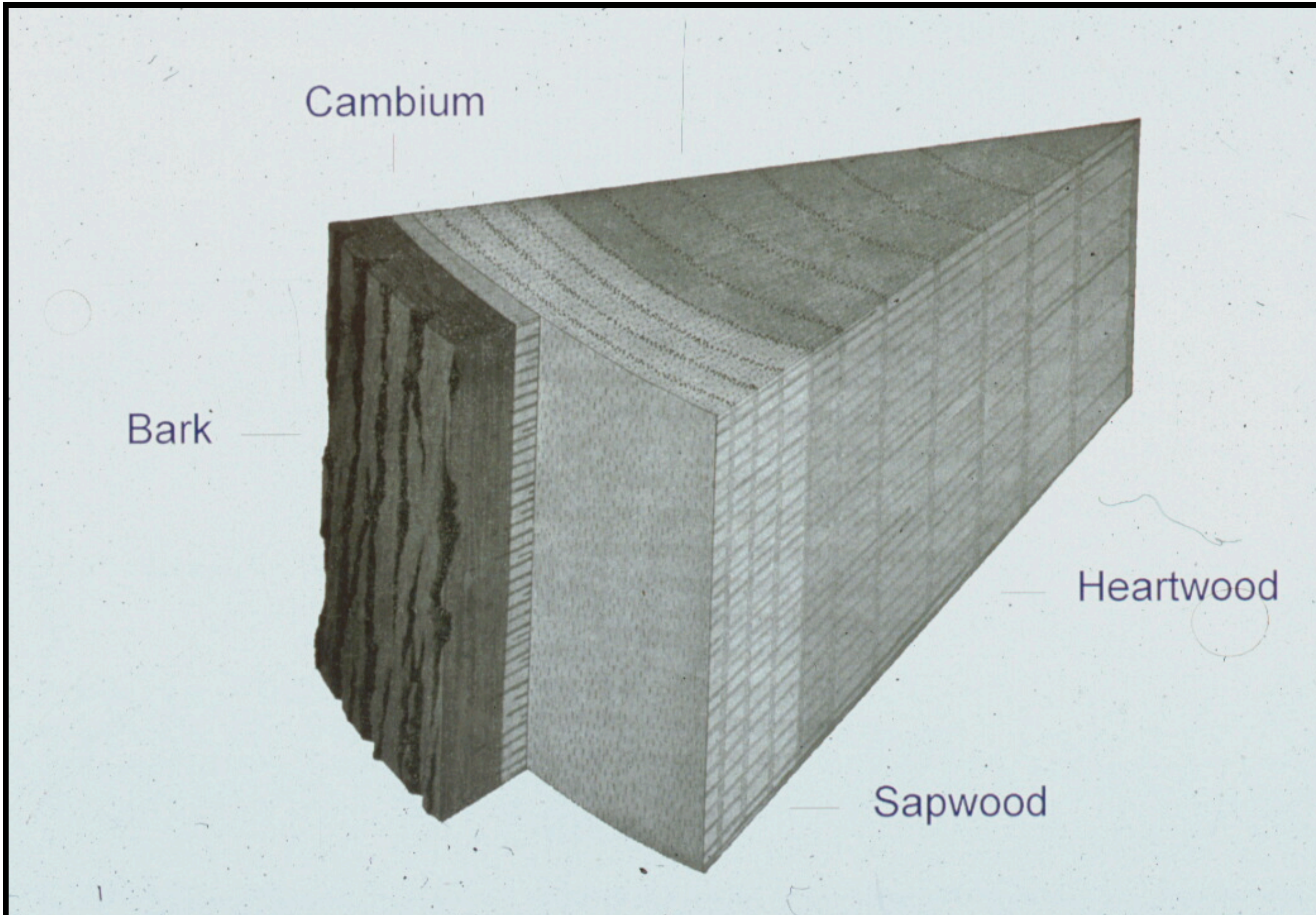
Heart rots, sap rots, top rots, butt rots

Heart rot is decay in living trees, refers to decay that starts in the stem vs. roots

Decay of sapwood only occurs extensively in dead trees

Stem decay fungi are wood decomposers, white rot and brown rot

All important stem decay fungi are basidiomycetes, often a diagnostic conk is present


Cambium
Bark
Heartwood
Sapwood

Live trees rot from the inside → out

heartwood first to decay

Dead trees rot from the outside → in

sapwood first to decay

Living sapwood is resistant to action of decay fungi:

- High water content
- Active wound response
  - Live parenchyma cells in rays react to fungal invasion
  - Accumulation of antifungal substances, resin
  - Deposition of wound periderm

Combined effect is to limit fungal colonization

Heartwood is more susceptible to decay fungi in living trees

- Heartwood lacks active resistance, has lower water content

- All heartwood is dead, so no deposition of wound parenchyma

- Phenolics “extractives” are deposited in heartwood as it forms, making it less hospitable to decay fungi, but some species have evolved tolerance

- Heart rot fungi are specially adapted, there are not many species

So, it follows that infection sites of stem decay in live trees are non living wood:

- Fire scars
- Wounds – storm and animal damage, logging scars
- Branch stubs
- Mistletoe brooms
- Cankers
- Dead or diseased roots

Stem decay fungi cannot penetrate intact bark

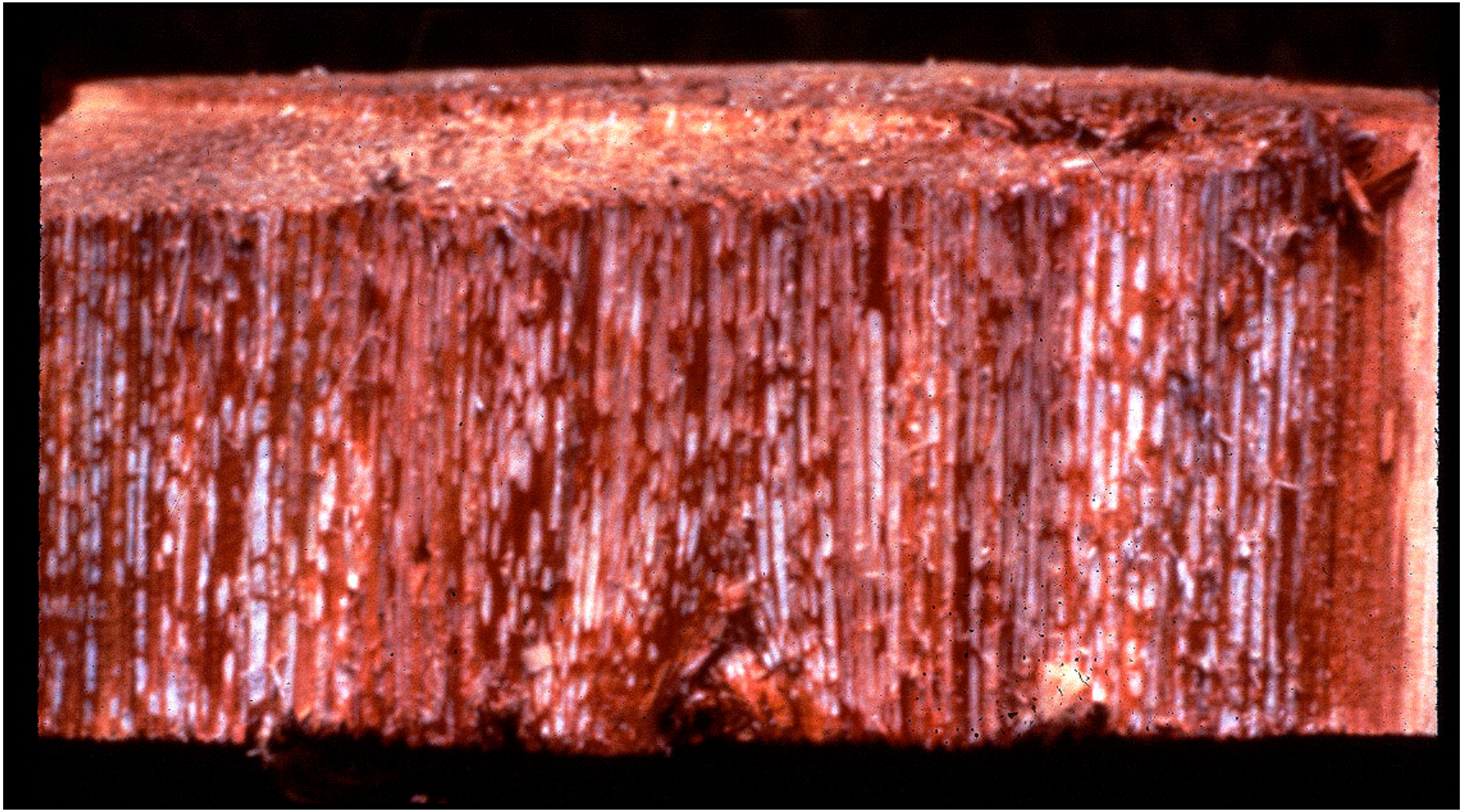
Stem decay provides wildlife habitat

Phellinus hartgii
and
cavity nest

Fungus name: *Phellinus pini*
Disease name: Red ring rot, Conk rot

- Frequent hosts:
  - Douglas-fir, hemlocks, spruces, larch
- One of the most important stem decays in PNW conifer forests in both economic and ecological impact
- Stem decay of most economically important species
- Damage is greater in older, higher value trees
- Predisposes trees to breakage
- creates wildlife habitat, coarse woody debris, stand complexity

White pocket rot caused by *Phellinus pini*



~2-3’ up and 3-5’ down from each or conk

Wound decays and sapwood rots

Infection follows some type of mechanical injury

Species of Fomitopsis
Fomitopsidaceae, Polyporales

Fomitopsis officianalis
Fomitopsis cajanderi
Fomitopsis pinicola

All cause brown rot decay
Species differ in host range, ecology

Fomitopsis cajanderi

Affects all conifer species

Common on Douglas-fir

Spores infect hosts via broken tops and branch stubs.

Nearly all broken tops >1" in diameter are likely to be infected

Infection follows storm breakage—ice, wind, snow

Rot caused by F. cajanderi

Advanced decay is brown, crumbly

Damage caused by Fomitopsis cajanderi

Predisposes trees to
breakage; if crowns regenerate, they are more prone to later breakage and usually are supressed by adjacent undamaged trees

Fungus name: *Fomitopsis officinalis*
Disease name: Brown heartrot

- Hosts are principally:
  - western larch
  - ponderosa pine
  - Douglas-fir

Perennial conks add new growth each year

Brown rot caused by F. officianalis

Fungus name: *Fomitopsis pinicola*
Disease name: Brown crumbly rot, red belt fungus

- Hosts are:
  - All dead conifers
  - Infects live trees via wounds

Fungus name: *Phaeolus schweinitzii*
Disease name: Red-brown butt rot

Polyporaceae, Polyporales

- Hosts are all conifer species
- Often found in very large mature trees
- Infected, severely decayed trees often show no symptoms
- Breakage of stem near groundline is most common tree failure
- Affects large, older trees
- High hazard in residential areas, recreation sites
- Presence of basidiocarp not necessarily indicative
- of severe decay, best method of assessing decay is to drill
- Very damaging in conifer forests throughout Northern Hemisphere

Brown rot caused by *Phaeolus schweinitzii*