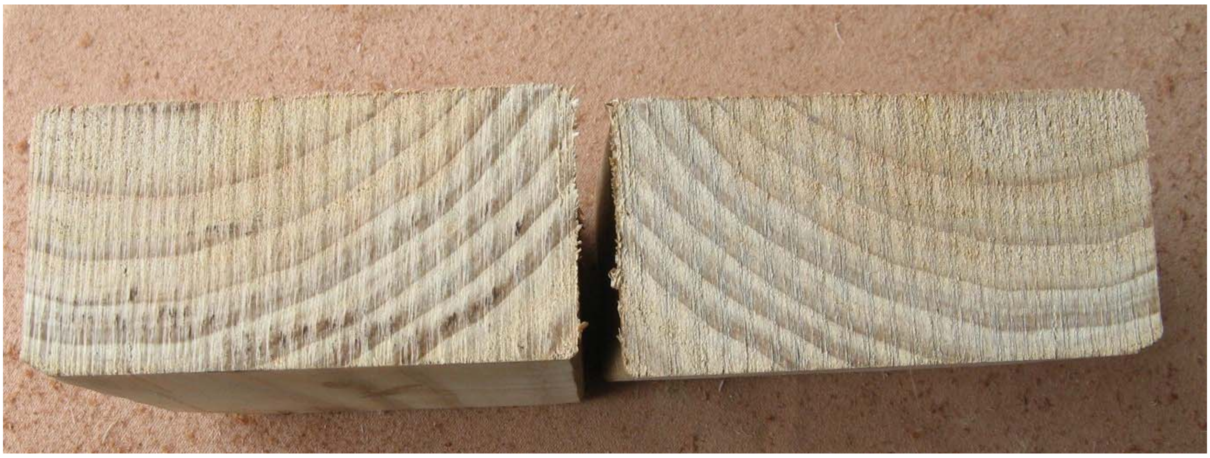
Fit for Purpose?

It is obvious this Pine has seen better days:

But sometimes it can have lost a significant amount of its structural strength when it still looks okay, the next two pictures are of a short length of timber which looks fine to the naked eye – but I sent a chunk cut off the left hand end to the lab and it came back as decayed – having ***"advanced brown rot throughout",*** the suggestion being that timber like this should be replaced.



So how on earth am I supposed to figure out how much timber I have to replace – how far from that damaged bit do I need to go to be confident I have got back to sound wood?. Is it far enough if I find what looks like sound wood 200 mm away? (Like in the above photo)

Well, the main point is – you really can't tell by looking. It actually is possible that the wood seen above may have lost a significant amount of its structural strength – and for that strength loss to be invisible to the naked eye.

To understand how this can be – how a length of Pine can lose so much strength and still look and feel fine – means looking into the structure of the wood.

The Structure of Wood

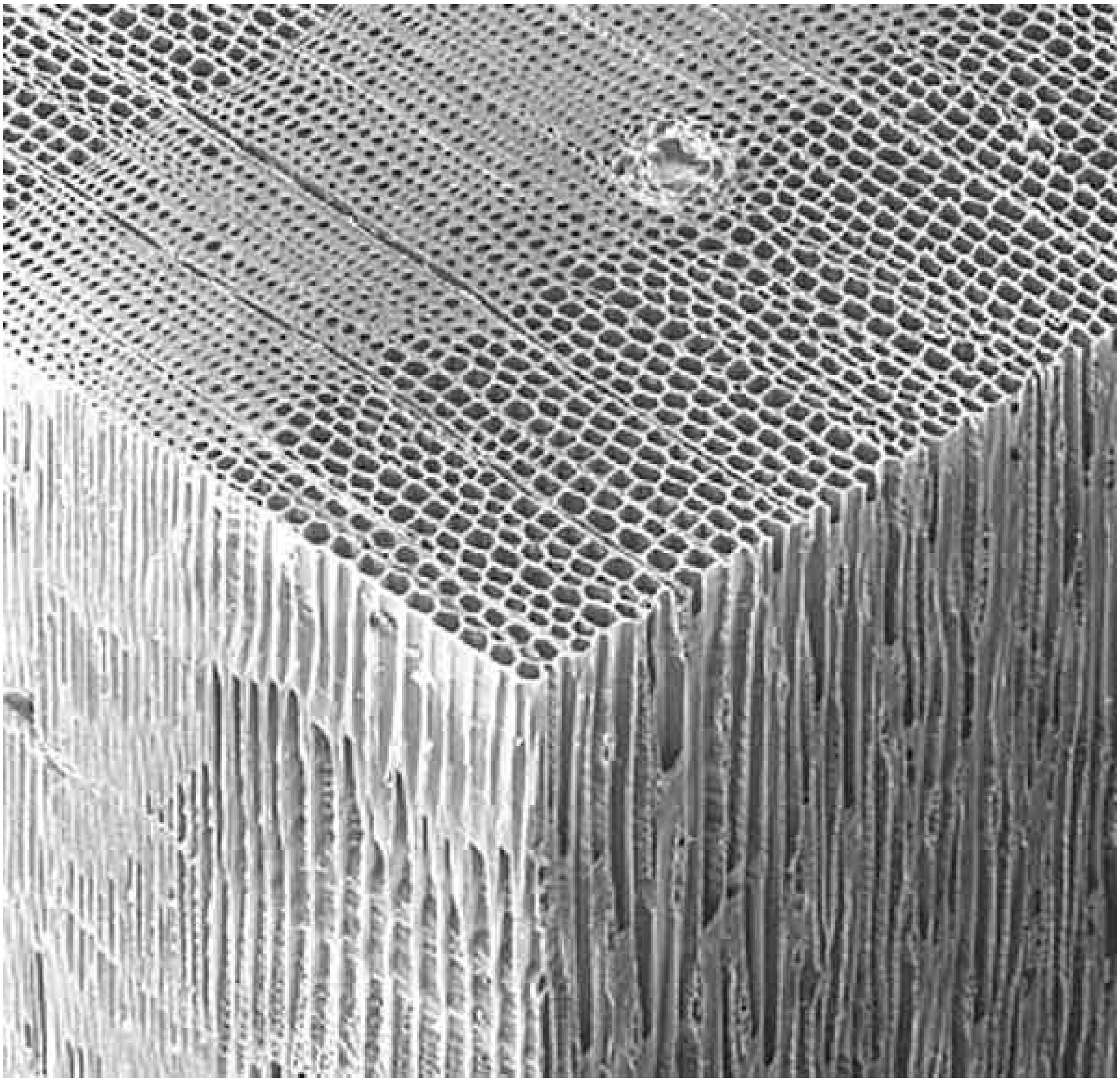
Each length of framing timber comes from the trunk of a tree. It was alive, cutting it down killed it but the fact that it ***was*** alive is important because when growing it had functions which gave it certain characteristics which it still retains even when dead.

Perhaps the main function was as a transport system. The trunk carried stuff in two directions – from the leaves down and from the soil up. Vaguely remember what you learned at school about photosynthesis? Trees, like other plants, trap energy from the sun and use it to convert carbon dioxide and water into sugar and oxygen. The carbon dioxide enters through tiny holes in the leaves and the water is sucked up from the ground below. So sugars go down, and are stored in various locations to power growth, and water and other nutrients comes up, to mix with the carbon dioxide and, when heated by the sun, to create the sugars that power growth.

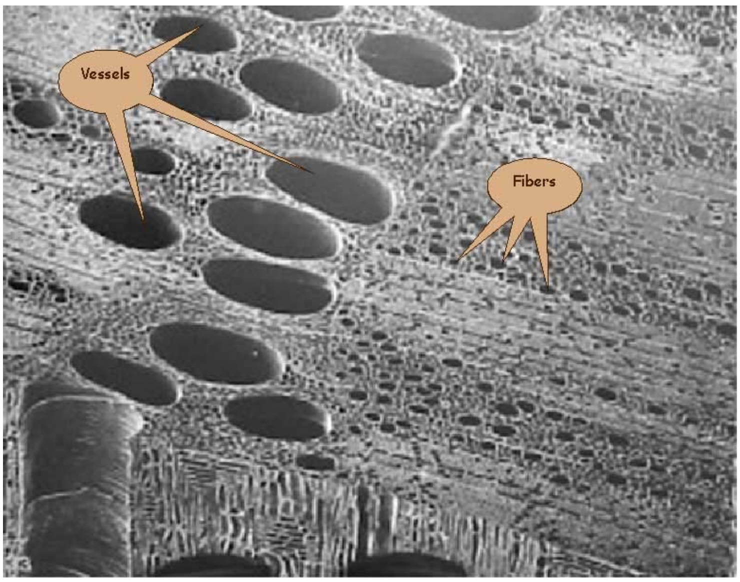
So when comfortable with the idea of the trunk being a transport system, it may not come as much of a surprise to discover this transport system looks a lot like a bunch of straws:

Don't believe me?

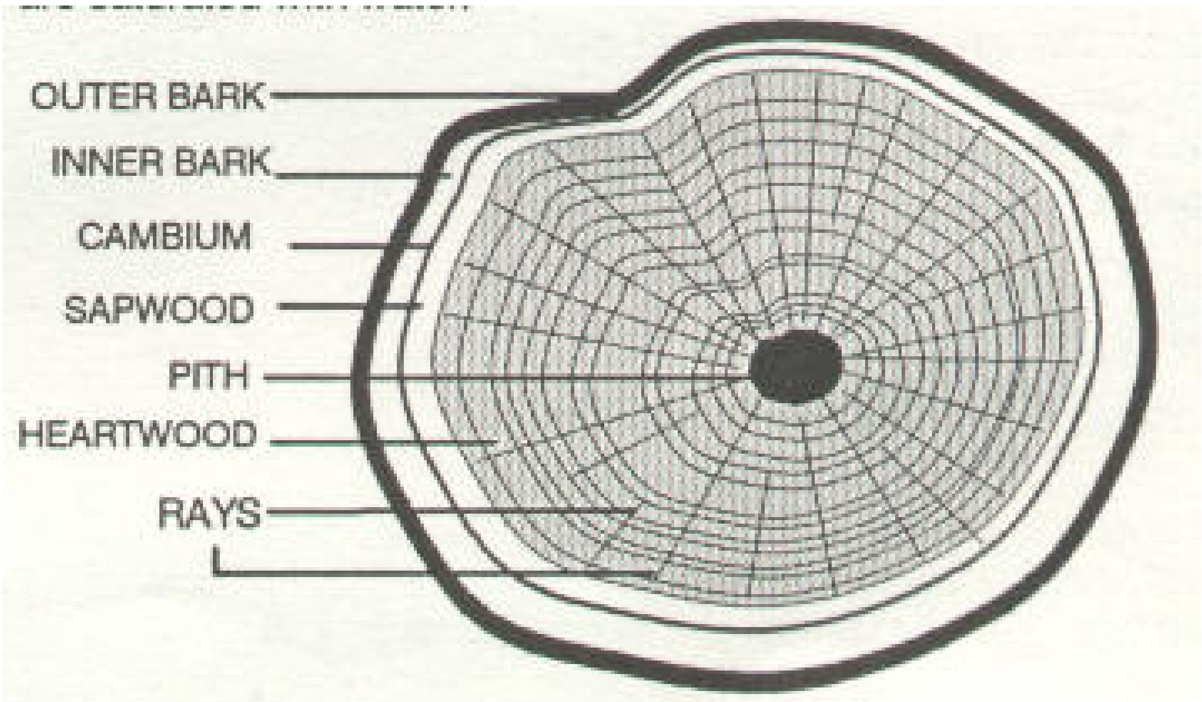
Well, check out a few pictures of real wood then.....

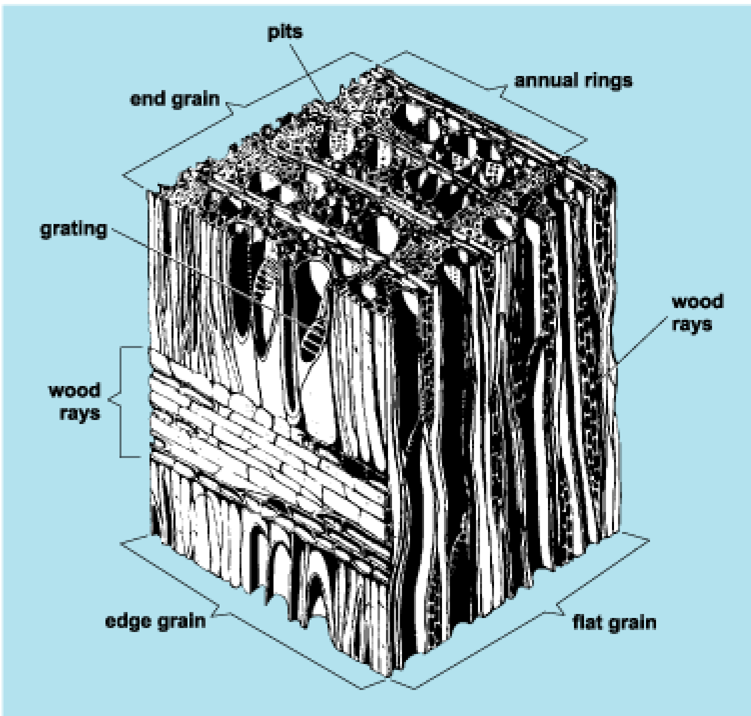


This is what this particular bit of wood looks like under a microscope – you can see it looks like a lot of empty space, but our eyes don't see that, we see solid wood. Unless the tubes are really, really big, which they are in some trees:

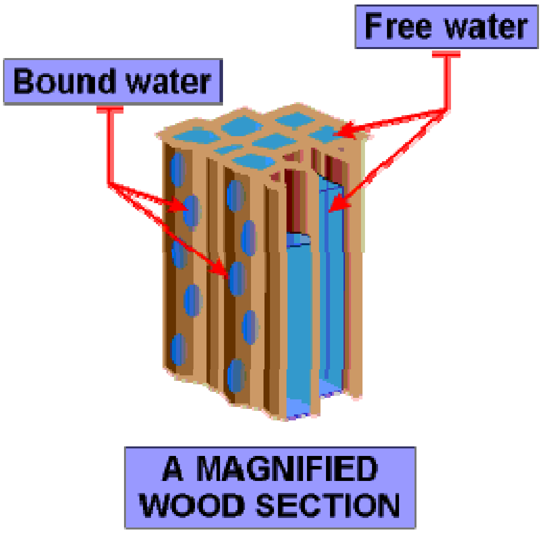


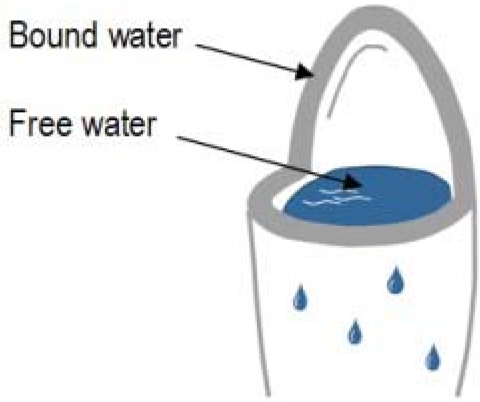
But the straw analogy is far too simple – to pull the water up from beneath the ground, these “vessels” - the tubes the water is carried up – have to be quite sophisticated and some have sort of non return valves, plus there are lines going out horizontally as well as vertically, to distribute nutrients, these are called “rays’:

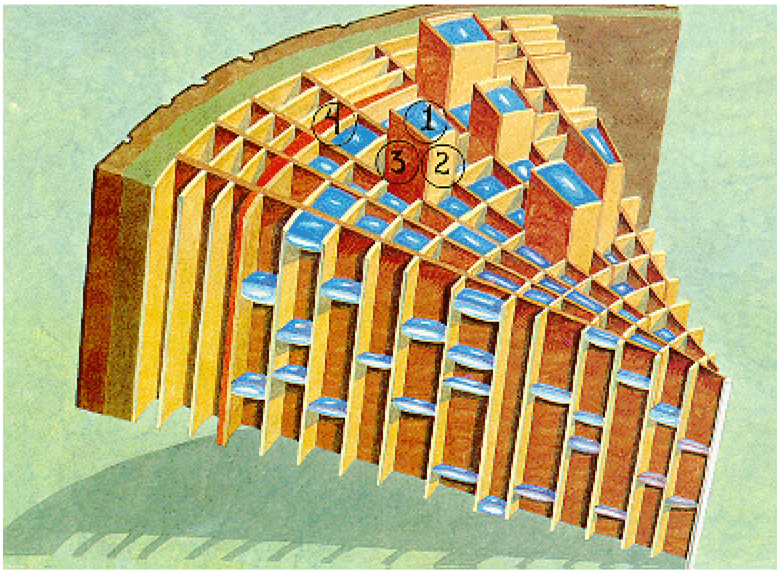




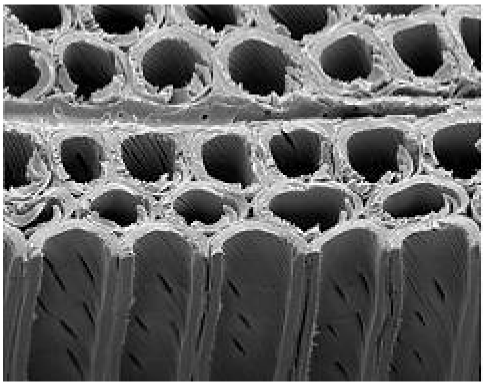
Which means there is a lot more going on than just a collection of straws. But still that crude analogy is useful, because it helps understand how and why both life giving waters and sugars move up and down the trunk when the tree is alive – and how water can migrate in dead wood, giving decay fungi life to spread.



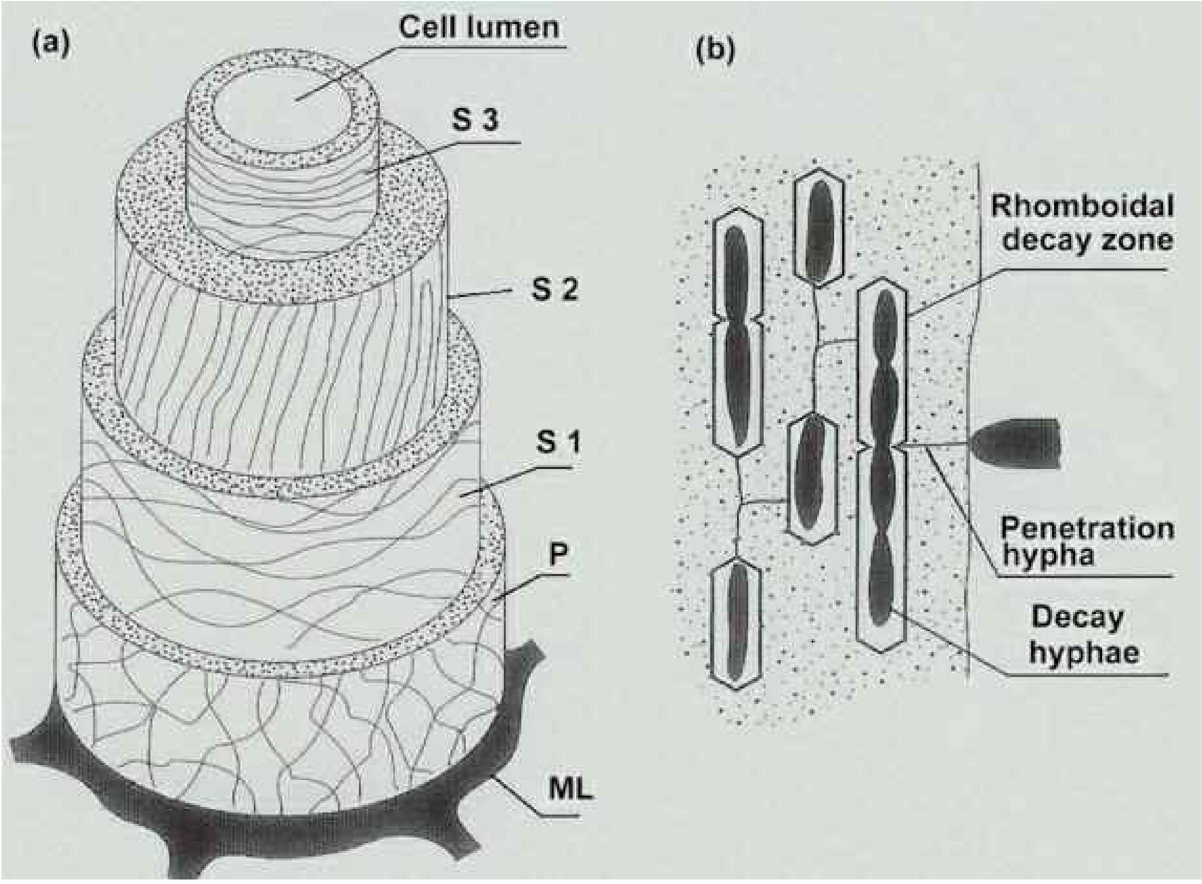




These pictures give some idea of the two ways water is present in living trees – “free water” (liquid) courses up inside the vessels or tubes, but the cell walls also contain “bound” water – water which is soaked into the fibres themselves.



And this is still true after the tree is dead – water can and does exist in both liquid form in the empty vessels and at a microscopic / bound form within the walls of the vessels.

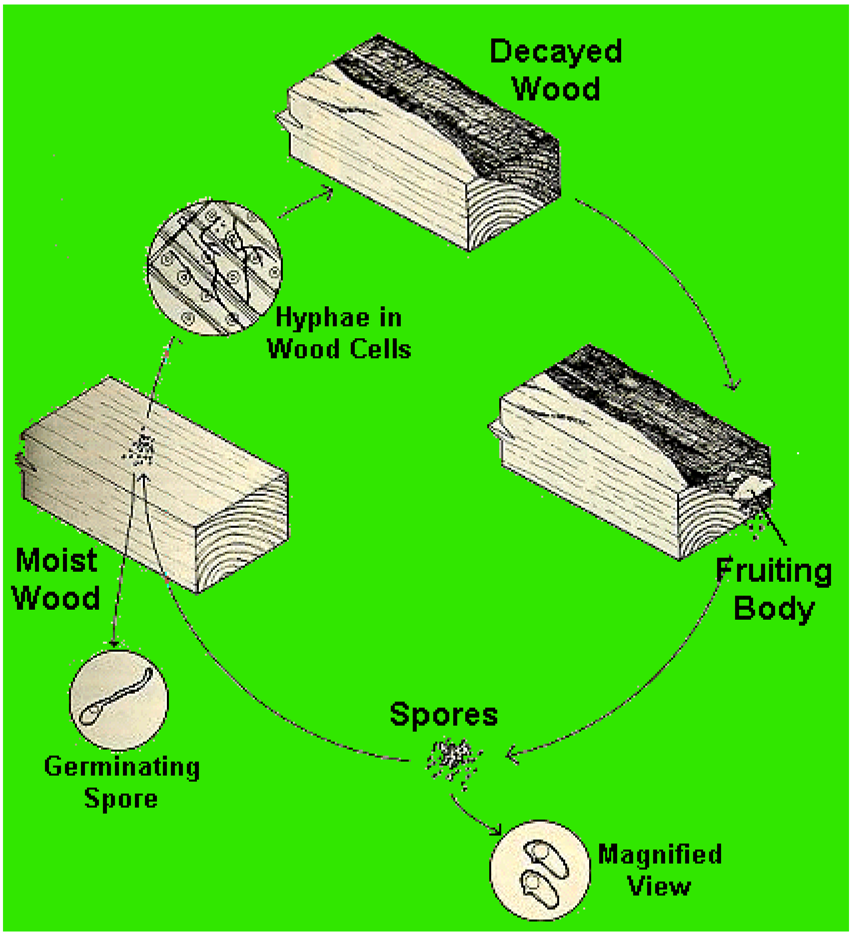


"Lumen" is just a fancy name for a cavity or channel – the empty inside of the straw/tube/vessel. The layers shown here all have functions but the essential point is to recognise the basic form as a bit like bamboo – all the strength is in the walls of each tube.

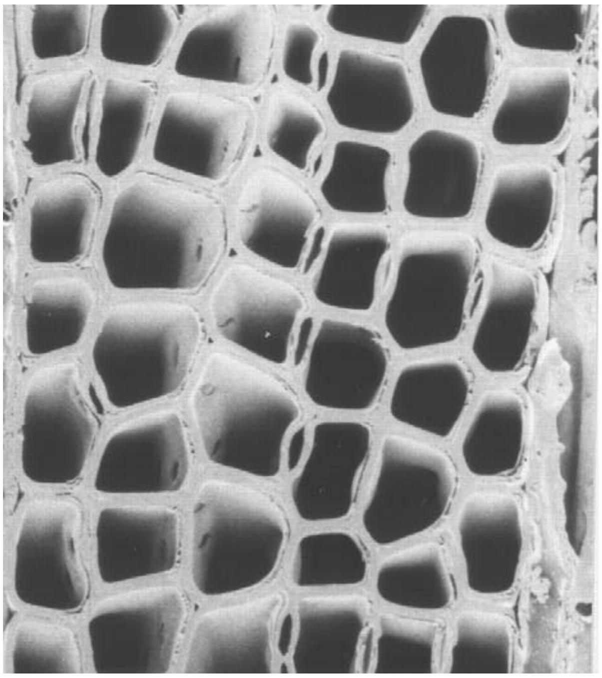
So where does it all go wrong after the tree is killed?

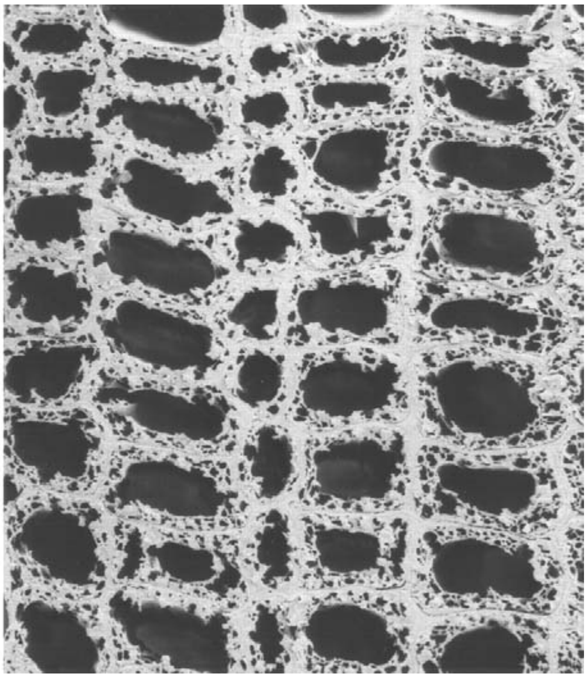
Well, it can go wrong even before the tree dies – this is a photo of a fungi attached to a living tree – but the decay we are talking about really gets off on dead wood.

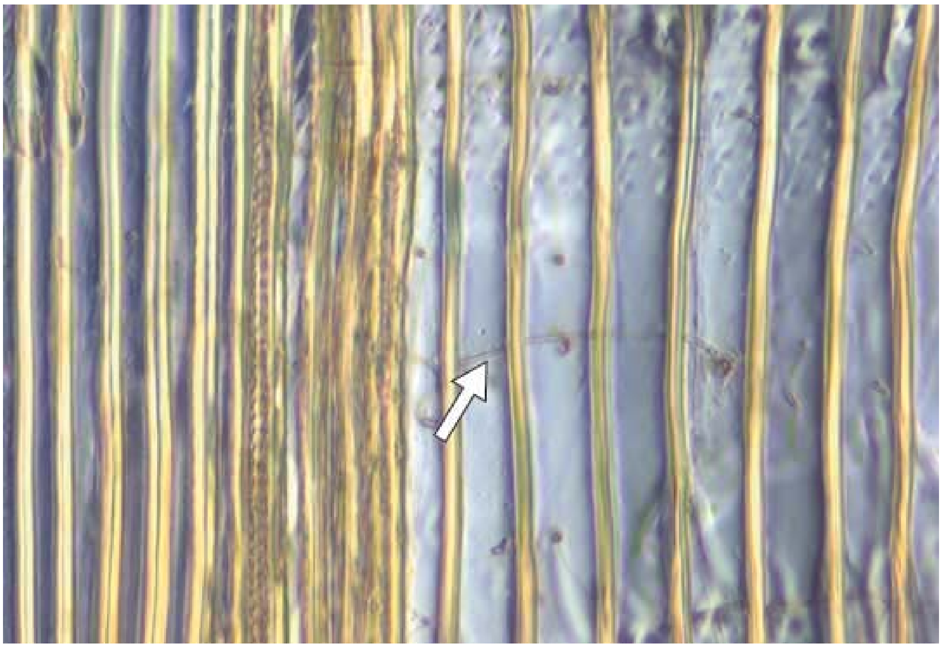
This is how – fungal spores are very common, pretty well everywhere you go in Auckland there is a constant, uninterupted supply just floating around. They need quite a few conditions to germinate, some are shown below. They need a suitable temperature range (check), they need oxygen (check) , and they need something to eat: e.g. wet, untreated Pine framing – once dead, it no longer has any natural resistance to decay..... if it is wet.



These two photos are great: before and after shots of fungal decay in the walls of the tubes that make up the structural strength of the timber – and this level of degradation in the vessel walls is quite possibly invisible to the naked eye.

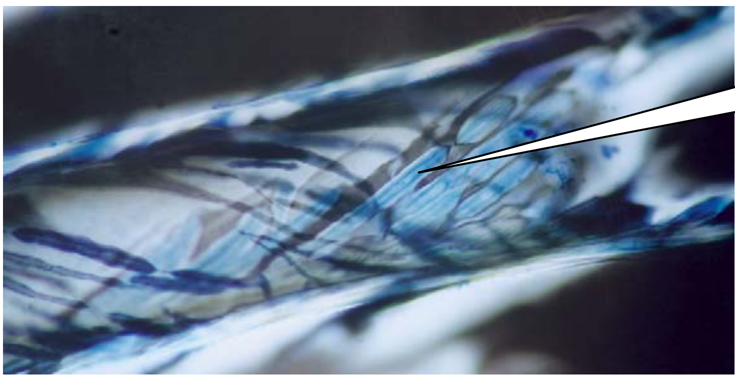






These are very specialised shots – in each case a slice has been taken half way through a vessel/tube, so the vertical yellow lines are the vessel walls and the whitish areas inbetween are looking inside each vessel. The arrow above indicates an early sign of fungal hyphae. They come from this site: http://www.structuremag.org/article.aspx?articleID=388

Diamond-shaped cell-wall erosion typical for soft-rot decay.



These are cavities caused by active soft rot in the wall of a single wood cell (Courtesy Dr Robin Wakeling, Beagle Consultancy Ltd)

So how and why do the decay fungi do this?

Basically in the endless quest for survival and reproduction – they have found ways to utilize various parts of the wood as food. They do this by releasing enzymes that "digest" certain products – in this case, stuff they find in cell walls – and biologists have chosen to categorise different decay fungi on the basis of what they eat (and thereby destroy)

The main groups are soft rot, brown rot and white rot. The amount of moisture present plays a part in which decay fungi is likely to be the most successful: like any other living thing, they survive and thrive within certain limits. All the common fungi in New Zealand grind to a halt if there is not enough moisture within reach: that is why drying the timber stops the advance of the decay. But stopping is not the same as dying for these organisms. They may be primitive, but they are survivors. Lack of moisture just means a rest for them. They can just wait, when the dry comes, wait for as long as it takes, for the life giving moisture to return.

So hopefully now we are beginning to get a few ideas:

1) The decay fungi are tenacious little ****, and not easily killed
2) There can be a lot of destruction going on within the walls of the cells / vessels which we simply cannot see
3) It doesn't take all that much fungal activity to significantly reduce the strength of the walls of those vertical vessels.

And how much of our Pine framing is made up of vessels like this?

According to one site:

Images of magnified sections of pieces of wood have shown scientists how its structure is well suited to transport water up from the roots to the leaves of a tree. ***Over 90 percent of the wood cells are arranged along the axis of the trunk or branch, like thousands of closely packed drinking straws.*** *Water can flow through them up the tree. But what drives the water upwards? Over the last two centuries several possible mechanisms have been suggested, but only one, the cohesion theory, has stood up to experimental investigations."*

(Go here to read more about how trees suck up moisture

http://www.nhm.ac.uk/nature-online/life/plants-fungi/magnificent-trees/session2/index.html

But what we are especially interested in is:

How much damage to those vessel walls is too much?

The problem with answering this question is that it is very difficult to know without having the sort of close look seen in those last two pictures – slicing through the vessel walls and looking for damage within the vessel wall structure itself.

In the absence of that equipment, you could conduct a simple test. Take out a stud you are suspicious of, sit it on a block either end and hit it in the middle with a sledge hammer. A new length of timber will break quite differently to a length which has had the strength sucked out of the vessel walls by decay. The weakened one will tend to snap, leaving only short fibres, because the strength of those longitudinal fibres has been decimated at a microscopic level

Whereas the new one will hopefully take quite a bit more force to break (although, not always – some of the new growth Pine really does seem like crap to me). In any event, the break really should look significantly different – longer fibres, basically, as they should still have lots of longitudinal strength due to having all their cells still intact.

Okay, that's an understandable test, right? But not a terribly practical one when it comes to assessing if a stud that might possibly be decayed can stay in place or should be replaced.

There are quite a few other tests that revolve around trying to figure out how much strength may have been lost, but at present these are all quite crude. The Department of Building and Housing is soon (as of October 2011) to release a publication which will hopefully provide some guidance on this but essentially there are two risks in leaving any decayed timber in place:

1) The decay fungi isn't dead, it's just sleeping, and may spring into life again if the conditions it likes return (e.g. the right amount of moisture)
2) Determining how much residual strength is enough is not easy

Looking at these two: re the first one you could pressure treat the timber which might actually kill the fungi, if you really get the fungicide to diffuse right through. Messy, time consuming and expensive.

But the second one, deciding how much strength has been lost is even more difficult .... is there enough left? It is a challenge – you have to play the engineer, have a good understanding of whatever redundancy exists. For example, in a non braced wall of

a single story building with a light roof in a low wind zone....the bottom plate probably has quite a lot of redundancy, it could probably suffer a fair bit of strength loss and still be fit for purpose. Not so true of a bottom plate to a braced wall under a two story building with a concrete tile roof. So “it all depends” Not an easy call to make in every case.

Hence the building surveyor’s motto:

“If in doubt, take it out” - which usually means the whole length, if it is a stud. But if you want to stop somewhere short of the whole length, going at least a meter along the length, beyond the last sign of decay is next best.

Hopefully now you might be starting to think that only going as far as ***you*** think the decay goes is very very risky. If you are a builder, get someone else to make that call.

And probably NOT me - I usually seem to have more than enough work, thanks for the thought - ask your local building inspector who his Council trusts or look at the list of Registered Building Surveryors at

http://www.nzibs.org.nz/panel/membersnear

Our web site: http://www.bc.org.nz/

Sources tapped for this brief and crude introduction to decay in Pine framing in New Zealand houses:

http://forestpathology.cfans.umn.edu/microbes.htm

http://www.ecometrex.com/rot.htm

http://www.structuremag.org/article.aspx?articleID=388

http://www.answers.com/topic/wood-anatomy

http://www.nhm.ac.uk/nature-online/life/plants-fungi/magnificent-trees/session2/index.html

http://www.bwtse.co.uk/fungal_decay.htm

http://researchcommons.waikato.ac.nz/handle/10289/2637?mode=full&submit_simple=Show+full+item+record

http://www.forestry.gov.uk/fr/INFD-6FMCUS

http://ifbholz.ethz.ch/natureofwood/pc/wp/wp3.html

http://localecologist.blogspot.com/2010_09_01_archive.html

http://chestofbooks.com/home-improvement/woodworking/Exercises-Wood-Working/Parasitic-Plants.html

http://timberplustoolbox.workspacetraining.com.au/toolbox13_05/unit9_selecting_timber/section4_seasoning/lesson3_the_drying_process.htm

http://www.cumpiano.com/Home/Articles/Articles/wood.html

http://www.pnas.org/content/98/23/13346/F1.expansion.html

http://cadam7777777.blogspot.com/p/guitar-care_17.html

http://www.globalwood.org/tech/tech_moisture.htm

http://www.answers.com/topic/lignin