Why are Pine Trees Dropping their Needles?

by Don Peters
July 2010

On July 2nd, Margaret Hagen referenced a note in the UNH Cooperative Extension Education Center Newsletter regarding “Browing Pine Needles”. The full article is at http://extension.unh.edu/news/2010/06/white_pine_needles_turning_bro.html. In it, this needle drop is referred to as “epic”, and is attributed to a fungus called “needlecast”. Vermont has been experiencing the same thing this year (http://www.vtfpr.org/protection/documents/VTFPR_June2010PineNeedlecastUpdate.pdf), and says the cause is under investigation. I did some checking into needle cast diseases, and what I found didn’t match what I’ve seen. In fact, Internet searches turn up a surprising lack of detailed diagnostic images regarding this disease. For example, I couldn’t find *any* photos of what needlecast looks like on the bark of a tree, inside the bark of a tree, and inside the needles of a tree. Such photos would certainly help diagnosis.


1

Curious about this disease, and being of an engineering mind, I set about to gather as much information as I could using the tools I had available—my eyes, my car, my computer, and a digital microscope. I began with no preconceived notion of what others thought this disease might be. Others can verify these results with a $100 digital microscope connected to a computer, should they choose to do so.

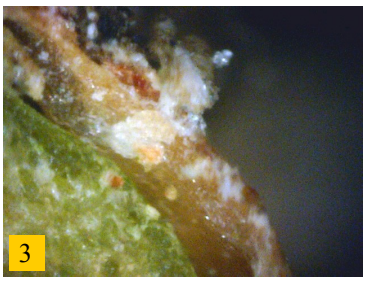
I began by examining my own local area here in Nashua. Then I drove up to Londonderry. I made some trips to Massachusetts. Finally, I noted the condition of the pines as I drove up to the area around North Conway. All along the way I noticed pines shedding their needles. But there were several trends. For one, the needle drop seemed a bit more severe the further north I went. The needle drop also was more pronounced immediately adjacent to roads. And finally, the health of pines was most strongly degraded in wetland areas. Our pines are clearly under some sort of stress—more so than in past years.

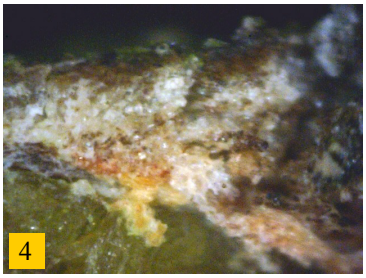

2

I started my detailed investigation by checking out a sick red spruce near my home, since it was typical of others nearby that looked pretty bad. That tree is pictured in photo 1 on the right. You may notice a lot of brown needles on it. I broke off a branch to check it out more closely. That branch is shown in photo 2. The thing I found curious was that entire needles weren’t always totally brown. Rather, very often only half of a needle was brown. More specifically, the half nearest the tip was brown while the base was green. And, the division was pretty sharp. It was as if the stress on the needle increased as you went from the base of the needle to its tip. At some point, the tissue reached a threshold and just simply gave up and died.

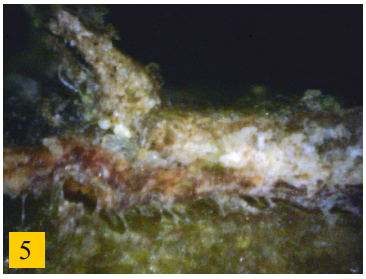
Many of these pictures included here are in relatively high resolution, so you may want to use your PDF viewer to zoom in for a better view.

Since I had a digital microscope, I decided to get a REALLY close-up view. I set it up to 400x and took a few pictures. I began by cutting a 1/8" twig with a razor, mounting it in a vise, and looked right down into its cross-section. Photo 3 show what I saw. What I should have seen was a nice solid green phloem layer under a nice solid brown layer of bark. Instead, there appeared to be a white fungus within the phloem layer, and a white fungus sprinkling the interior of the bark!

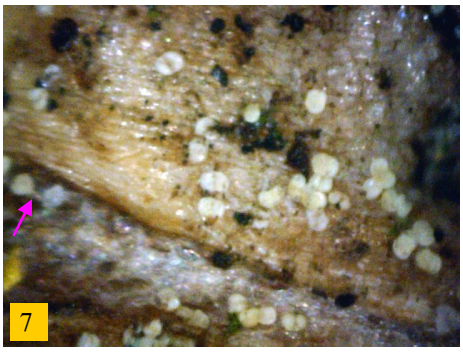


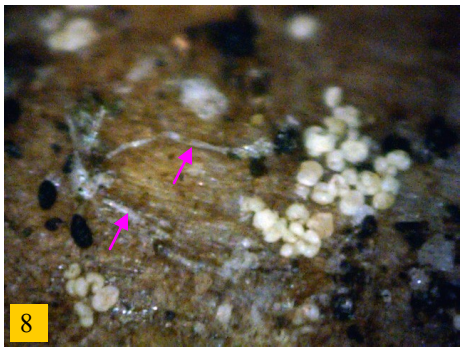


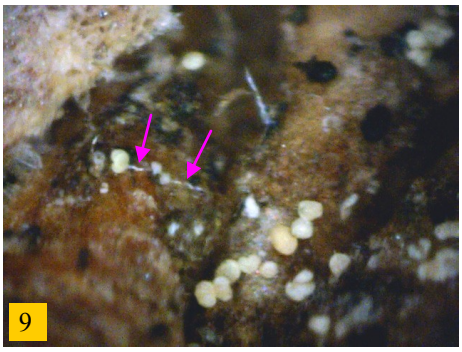
That didn't look good at all. I tried checking out a different area of the bark. Photo 4 show it. This was even worse—the bark was almost totally infiltrated with fungus. Photo 5 shows an area where there's not much left of the bark, and it's separating from the phloem layer. Photo 6 shows total destruction of the phloem and bark layers!



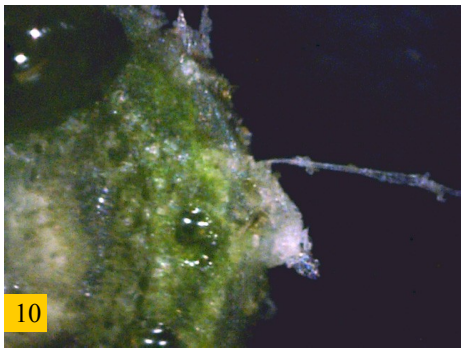
So the bark and phloem were really a mess. But what about the outside of the bark? Well, I checked that out too. Photo 7 shows a section of the bark. It seems to have an abundance of white, bi-lobed objects on it. Could they simply be pollen? The pink arrows points to one of these objects that seems to have a stalk connecting it to the bark. Photo 8 shows another area where these white objects are associated with spider-like hypha (pink arrows). I guessed that these white objects were the spores of the fungus that was permeating the phloem and bark. Check out photo 9. Two of these white objects seem to have appendages extending from them (pin arrows) and going into the wood. Simple pollen would not likely do this.

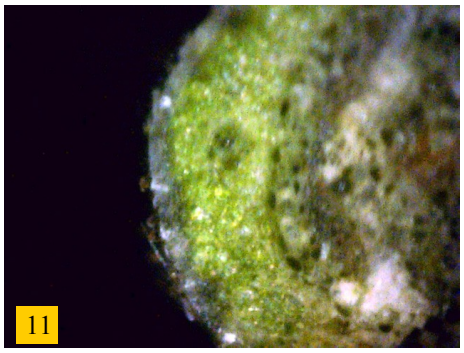


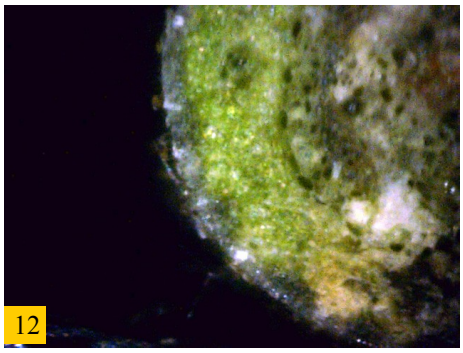




This tree was having some big problems with its bark and nutrient transport system. But how did that affect the needles? It seemed the best way to check was to look inside a needle. So I mounted some needles into a vise, cut them off with a razor, and peered down into them with my microscope. Photo 10 shows a needle with a blob of fungus material on it. The fungus even has a hyphae strand coming off if it. Photo 11 shows that while the outer part of the needle isn't in bad shape, the inner part has quite a bit of fungal material in it. Photo 10 also shows a blob of white fungal material near the center bottom. Interestingly, it seems to have killed off the green needle tissue under and adjacent to it. This white fungal material therefore seems like it could be the cause of the pine needles dying.







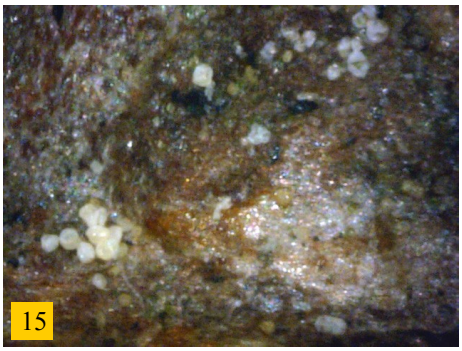
White Pine 1

White pines are far more common than red pines, so people would more likely be apt to notice their decline. During a recent drive to Londonderry, I noticed a few pines that had brown needles. I located one particular white pine that had some brown needles, and broke off a branch. Photo 13 shows what it looks like. You can just barely make out the brown needles.

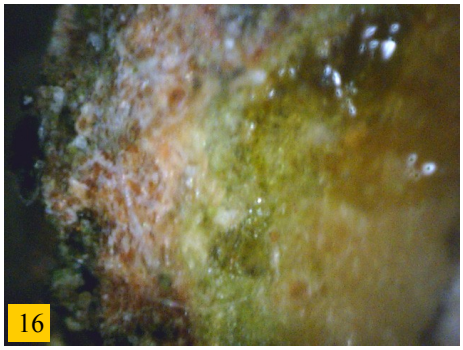

13

I started by checking the bark. Photos 14 and 15 show two different areas of the bark. The same spore-like white objects are present here, just like on the red pine. They have the same bi-lobe appearance, and, if you look closely, there is often a touch of yellow between the two lobes (a fertilized spore?).


14


15

Next, I cut a twig and examined its cross-section. This was a surprise. Photo 16 shows the inner bark almost totally consumed with fine fungal material. Photo 17 also shows tangles of fungal material. Check out the spore object on the bark surface pointed at by the pink arrow— it is attached to the bark by a slender stalk. A particle of pollen would not have this attachment stalk. These stalks are normally hidden underneath the spore — we only see it here because of the side view. Photo 18 also shows cankerous material in and on the outer bark. Finally, photo 19 shows an area where the green phloem is almost totally missing. There is even a void. Look carefully, and you will even see a few of these fungal spores wedged and growing just under the outer bark (pink arrow). More evidence that these white spores are not simply pollen.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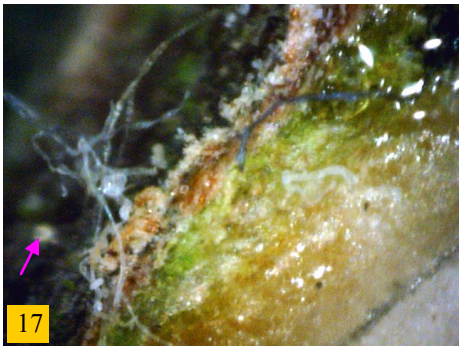
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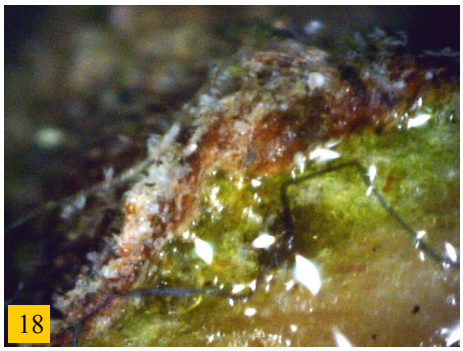
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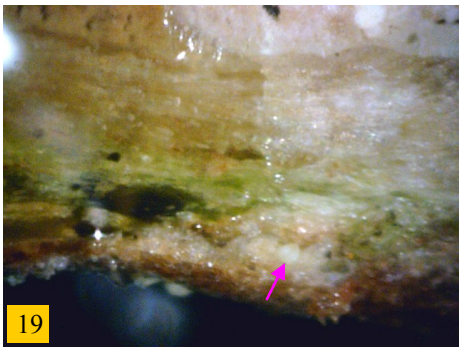
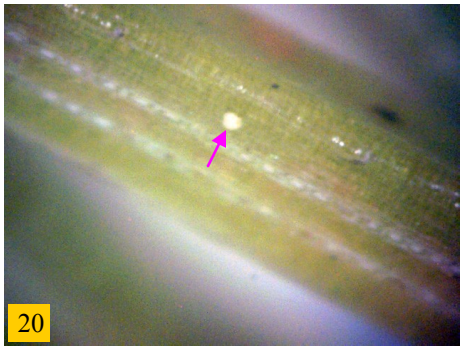

19

I next wondered how this internal fungal infection affected the needles of the white pine. Photo 20 is typical—very few spores or fungus on the outside of the needles. Here is just one. Photo 21 shows a hyphae growing out of the needle. This needle doesn't look bad considering the brown coloration shows it is half-dead!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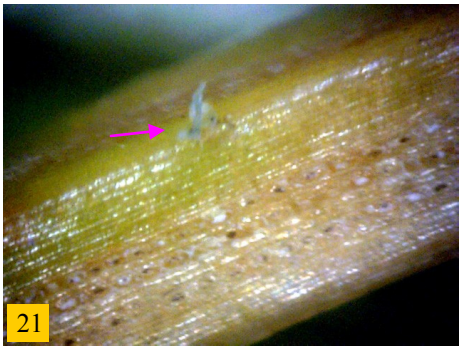
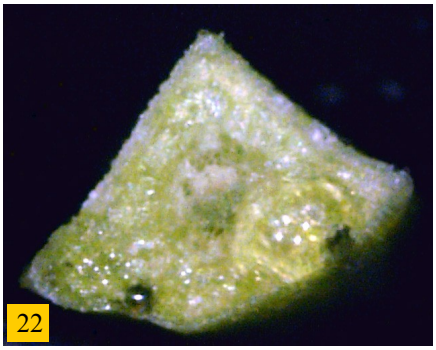

21

Since this white fungus material seems to like to "hide", I decided to look at the cross-section of a needle. Photo 22 shows diffuse white fungal material near the top, and some in the core of the needle. Photo 23 shows a half-dead needle on the left and a live one on the right. The dead one contains more fungal material. The core of the live one is starting to fill with fungus. Photo 24 is similar in that it shows the nutrient-transporting core of the needle getting clogged with fungal material. As the fungus takes over the core, fewer nutrients can reach the tip of the needle, and it dies of starvation.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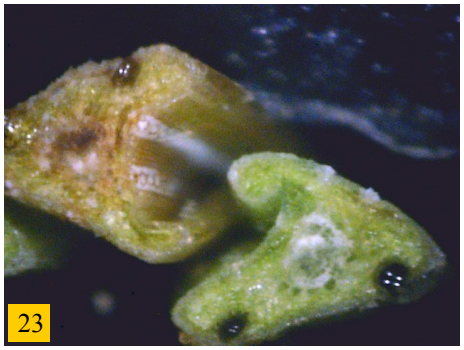

23

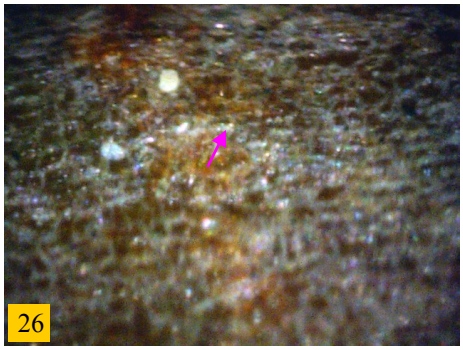

24

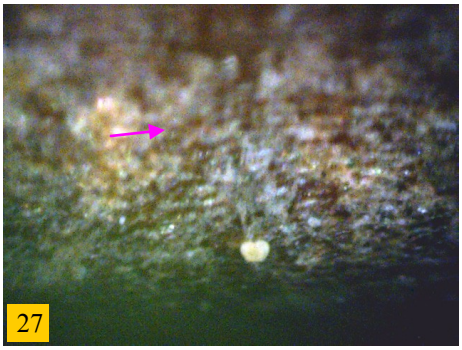
White Pine 2

Of course, because one sick White Pine has these particular symptoms doesn't mean they all do. Consequently, I located another nearby sick White Pine to check it out. This was a relatively small tree located at the edge of a parking lot in Londonderry. It's shown in photo 25 on the right. As you glance at it, it no doubt appears to be healthy. But it in fact contained a number of dying needles that aren't readily visible in this picture.

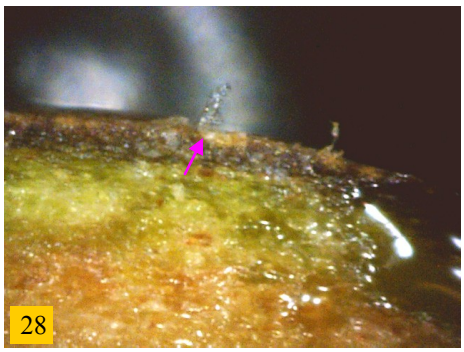

25

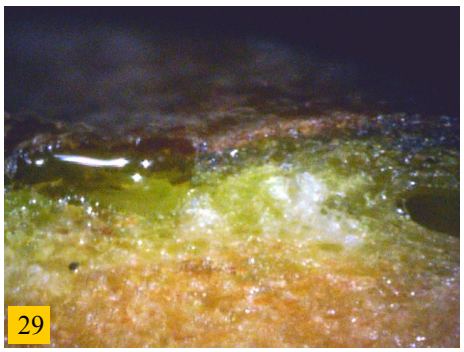
Photos 26 and 27 show portions of the twig's bark surface. As you can see, there are almost no fungal spores visible. This wasn't a big surprise, since the tree didn't look *that* bad.

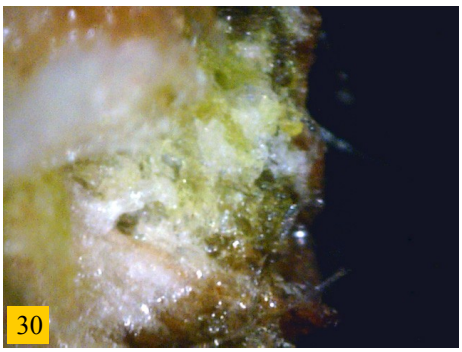




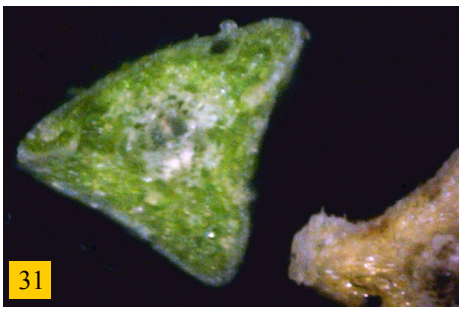
I've found twig cross-sections give a good indication of fungal damage to the bark and phloem. These three photos below illustrate that. Photo 28 shows only minimal damage to the green phloem. Note the hyphae growing out of the bark (pink arrow). Photo 29 shows several patches of white fungal material taking over the green phloem. Finally, photo 30 shows quite a bit of white fungal material within the phloem.







Since there were dead needles on this tree, I wanted to check them out in detail too. I ignored the surfaces of the needles since they didn't exhibit much diagnostic information. On the other hand, the needle cross-sections were much more telling, as shown in photos 31 thru 34.



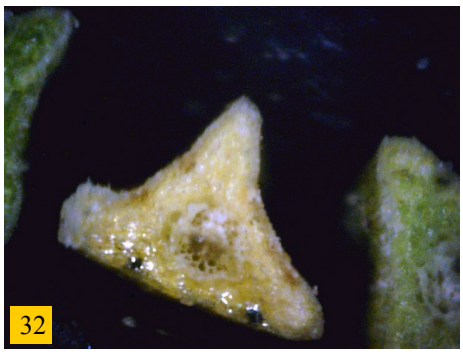
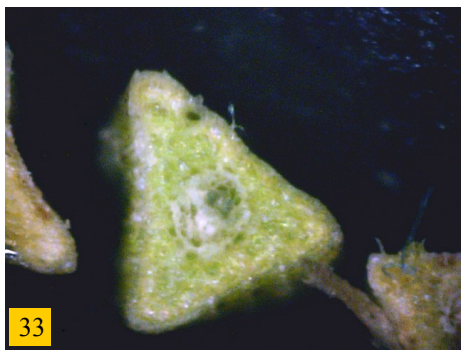
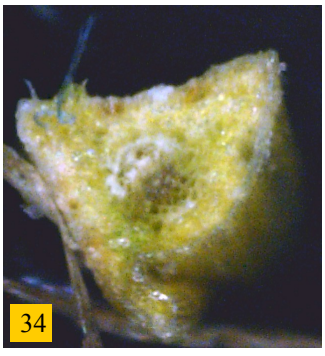


Photo 31 shows a seemingly healthy needle that has been invaded by white fungal material. Photo 32 shows lots of this fungal material in a dead needle. Photo 33 also shows quite a bit of fungal material in a less-than-healthy needle. Finally, Photo 34 shows an almost dead needle that also contains quite a bit of fungal material. It appears that once the fungus blocks about 50% of the center of the needle, the needle begins to die, and the fungus then spreads to the outside of the needle.





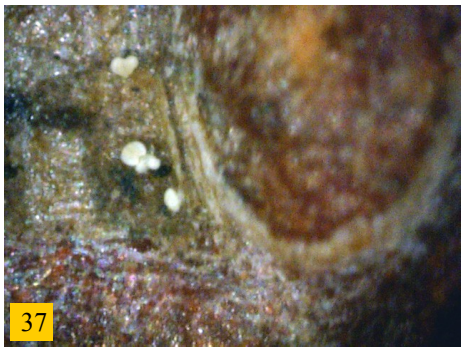
White Pine 3

Several miles away I located another White Pine that was losing some of its needles. As photo 35 shows, the brown needles are more evident on this tree. I snapped off a typical branch for analysis—shown in photo 36. Some needle clusters look healthy, some look half-dead, and one is totally dead. So it looked like a nice typical branch to examine more closely.

35


36

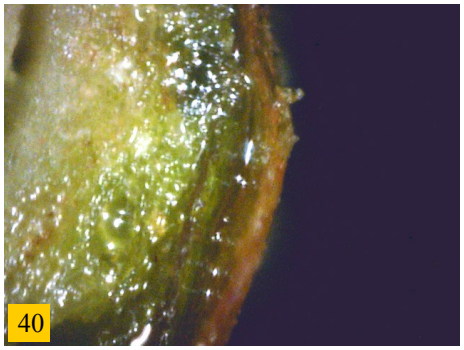
The first thing I did was to examine the bark. Much of it looked relatively clean, as shown in photo 37. However, there were numerous pockets of spores present, as shown in photos 38 and 39. Note that these spores are identical to those we saw in previous pines.


37


38


39

I had expected to find quite a bit of white fungal material when I looked at the cross-section of a twig. Photo 40 shows a diffuse patch deep within the phloem. Photo 41 shows that about half the phloem has been replaced by white fungal material.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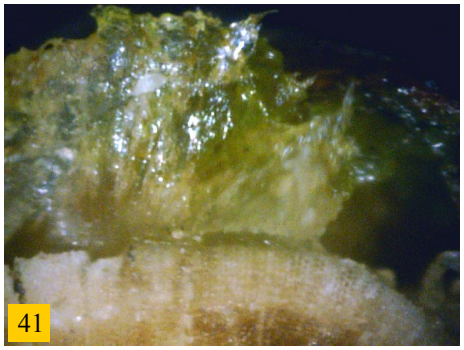
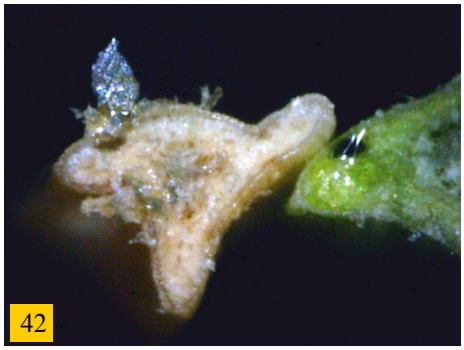
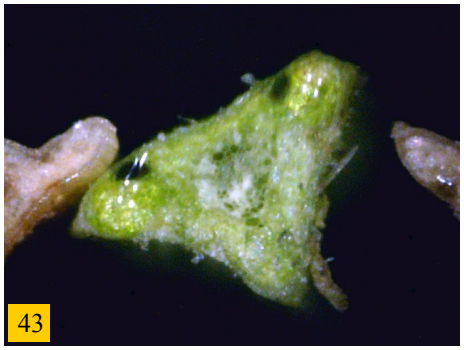
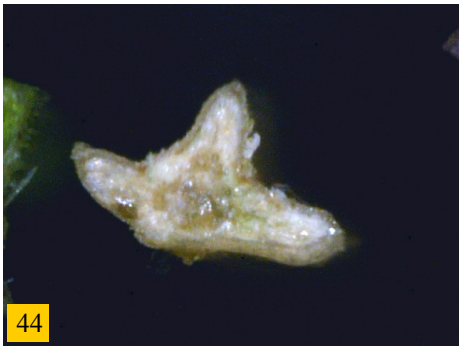

41

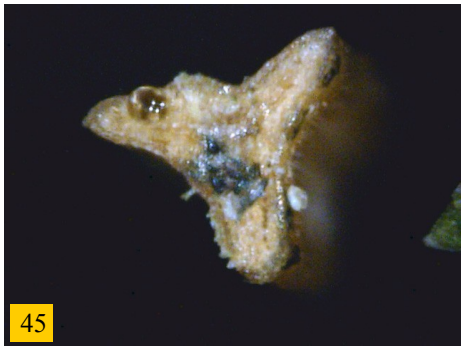
Finally, I checked out a cross-section of the needles on this tree, trying to sample needles that were dead, and those that appeared to be pretty much alive.

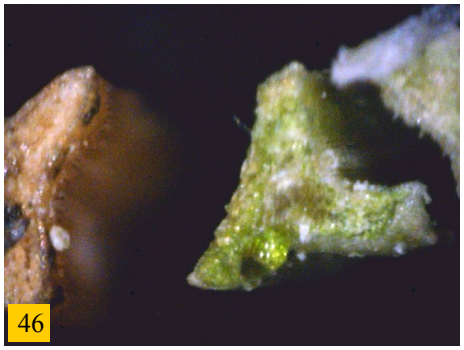
When we think of a “dead” leaf or needle, we think of brown colored tissue. But photo 42 shows a dead needle that is a very light brown. That’s because there is a mixture of two colors here—the dead brown needle tissue and the white of the invading fungus. The partially green needle in photo 42 is shown in full in photo 43. While this needle is still alive, it is being invaded by fungus. Of interest is the fact that the fungus seems to avoid the black sap-containing tubes, attacking the needle core first. Once the plugged core has killed the needle through starvation, the fungus then seems to invade the entire needle, as shown in photo 44. There is so much fungus there that the interior is almost totally white! Photo 45 shows a partial fungal takeover of the needle. Here again, the sap tube area seems most resistant to the fungus. Collectively, photos 45, 46, and 47 show a set of three adjacent needles. The right-most needle is of particular interest, since its light green color indicates that it is both half-alive and half-dead. Once again, the light green color is due to the normal green needle color interspersed with the white fungus color. In fact, you can see pieces of white fungus hanging off the cut edges of this needle.

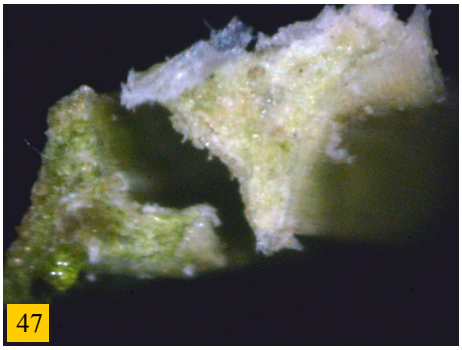










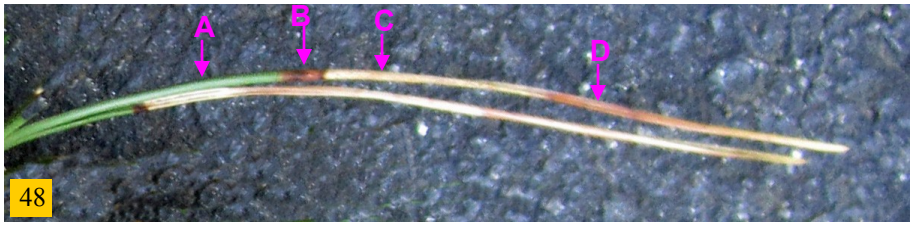


Summary

As has been noted by numerous residents of the state of New Hampshire (and other states), our pines have been dropping their needles during this summer instead of their normal time—in the fall. Typically, this is due to either some environmental factor (e.g., drought) or disease (e.g., needle cast. The suggestion was made that this is a temporary issue, and will go away in a short time.

In an effort to get a better understanding of what was going on, I located 4 pine trees that exhibited this needle drop—one red pine and three white pines. I then used a high power digital microscope to examine the bark of these trees, a cross-section of the twigs of these trees, the needle surfaces, and a cross-section of the needles. About 40 microphotographs were generated for analysis.

What I found appeared to be **a white fungus that invades the tissue of the twigs and needles**. This fungus feeds on the nutrient transport tubes of the tissue—the phloem of the twigs and the center of the needles. As the fungus grows, it chokes off the nutrients needed by the tree, and the tree suffers. In the end case, the needles die. We can match this disease progression to what we see on a half-dead red pine needle, shown in photo 48. At point A the needle is still fully alive. No doubt it is under severe attack, but it's still able to supply enough nutrients to keep its chlorophyll alive. At point B a survival battle is raging, but is being lost as the chlorophyll is dying. At point C the fight is lost, and the white fungus is unimpeded in its growth, feeding on all available nutrients. It permeates the area, hence the needle appears white. At point D there isn't even enough food left for the white fungus, so it, too, begins to die and slowly turn dead-brown. This banding pattern is also apparent on the adjacent needle.



It's been suggested that this needle-drop situation will go away within a month or so. Yet the evidence pictured here shows a **progressive invasion by this fungus**. In other words, the trees are fighting a really tough battle. Tree death won't come soon, as it isn't in the best interest of the fungus to kill off the host that feeds it! Rather, the fungus will likely greatly weaken the tree, reducing its ability to fight off environmental stresses, insects, and other diseases. The fact that this appears to be a fungus, and since fungi like water, could explain why the pines that reside in wet areas are under particular stress.

You may be wondering what the actual name of this fungus is. I don't know. I've done some research on it but **haven't yet been able to identify it**. Many sources ascribe this disease to "needle cast". But these sources often cite black stripes of fruiting bodies. I see none of that. For example, the Connecticut Agricultural Experiment Station has a good website on White Pine Needlecast (http://ct.gov/caes/lib/caes/pdio/documents/canavirgella_needlecast_of_white_pine_04-10r.pdf) showing what to look for on the needle surface and within a needle cross-section (it's rare to see cross-sections), but it doesn't look anything like what I've seen. In fact, this fungus technically might be something related to a fungus—a phytophthora. That's what caused the Irish potato famine in the 1800s. One thing I know it's not—the "sudden oak death" phytophthora found in the western United States (I had a test specifically done for this). One key piece of identifying information on this fungus is the shape, size, and color of its spores. Unfortunately, I don't have a library of fungal spore characteristics to check with. If any of you know of one, be sure to let me know!

It would be helpful if others did some similar research to further characterize and confirm this apparent fungal infection. After all, the more information we know about this infection, the better we will be able to predict its effects… and come up with a way to fight it.

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