Diagnostics – Assessing Callus and Woundwood in Plant Health Care

By Christopher Luley, Ph.D.

Woundwood and callus are often wrongly used interchangeably by arborists (Photo 1). Besides understanding the basic biology behind the terms, assessing callus and woundwood formation in trees can be an important tool in forming diagnostics in the landscape.

Basic biology

The terminology is important because it reflects the biology of wound response of trees and how to apply an assessment of callus and woundwood in field diagnostics.

Callus

Callus is an aggregation of parenchyma cells (thin-walled, living cells in plants found in leaves, wood, bark and other tissues) that forms shortly after wounding. Callus can be formed by the cambium or by parenchyma cells in the sapwood or bark. The important feature of callus to arborists is that it is a short-lived response that occurs soon after wounding if trees are actively growing. Want the best wound-closure response to pruning wounds? Make the cuts during the growing season when trees can form callus and then woundwood.

Callus can be directed by the tree to form cambium and then woundwood, shoots, roots or flowers (Photos 2, and 3A and 3B). In the weeks and months after callus is formed, it becomes lignified, loses its ability to divide and is usually covered or sloughed off by the development of other tissues. Most arborists have never actually seen callus.

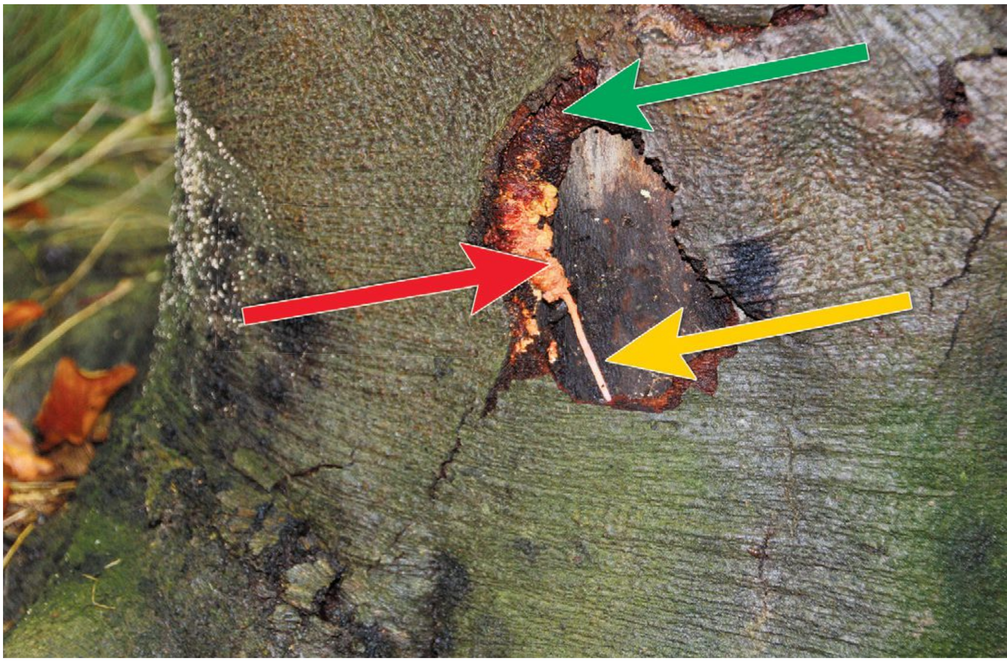

Photo 2: A callus pad (red arrow) forming a root (yellow arrow) on a European beech attacked by Phytophthora bleeding canker (note bleeding). Woundwood is also forming on the edge of the attack (green arrow). All photos courtesy of the author.

Photo 3A: A new shoot on an ash coming from woundwood that was likely initiated by callus.

Photo 1, at left: Woundwood response following a large wound on an oak. Many arborists erroneously refer to this response as callus.

Woundwood

Woundwood was first identified as being different from callus or normal sapwood because cells in newly formed woundwood were observed microscopically to be highly organized like sapwood, but with shorter cells and an absence of vessels. Woundwood was clearly different from callus and normal sapwood (Photo 4). The term was coined in the late 1800s to distinguish between the two types of tissues formed after a tree is wounded (Photo 5).

Here is the confusing part. In some cases, woundwood can be formed from callus after the callus forms a cambial layer. It also can be formed directly from the cambium after wounding. Woundwood is the tissue that is responsible for eventually sealing larger wounds in the years following wounding. In many cases, woundwood effectively seals small wounds, and the tree goes on to grow with little evidence of the original wound.

Woundwood has a number of unique properties (Luley, 2015) such as sometimes containing compounds that are toxic to fungi. It is also the tissue that is often erroneously called "callus." To make matters more complicated, once sapwood regains its normal structure, it is probably not technically woundwood as the term was originally coined.

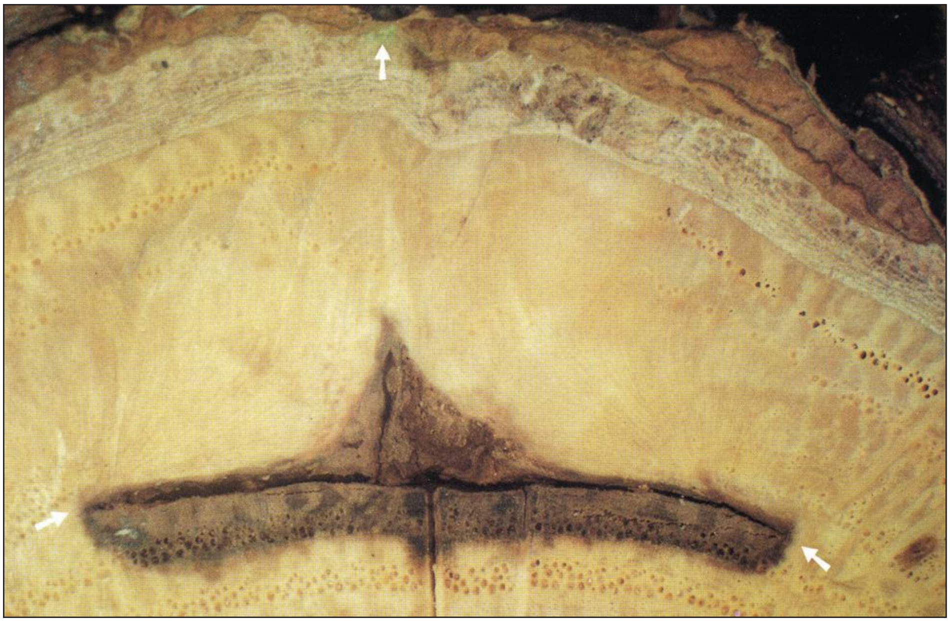

Photo 4: Woundwood at the site of a wound. Note the absence of vessels in the wood and that vessels are starting to form again as the sapwood seals the wound and regains function (Image from Shigo, 1994).

Callus and woundwood in landscape diagnostics

In most cases, arborists are assessing woundwood because of the short-lived nature of callus cells. Callus and woundwood response are also tied to other wound responses in a tree such as barrier-zone formation. As such, close evaluation of woundwood can help identify:

- when a tree was wounded;
- its biological capacity to respond to wounding;
- the impact of pests affecting or attacking woundwood development; and
- the strength of internal response to decay.

Each of these assessments is a detailed topic in itself, but a brief discussion and a few examples taken from each bullet point can illustrate how woundwood assessment can be used in the field.

When a tree was wounded

Woundwood forms after a wounding event in a progression of biological responses. The end result is a gradual seal-

Photo 3B: Aerial roots on a Norway maple trunk coming from woundwood. They are also likely formed after the initial callus response to the wounding.

Photo 5: Woundwood formed after wounding on an ash. Note the barrier zone (red arrow) and that the age of the wound can be determined by counting the rings in the woundwood after the barrier zone.

Photo 6A (left): Annual growth striations in woundwood can help age roughly how old a wound is. Photo 6B (right): Woundwood forming on the surface of an ash where a patch of bark was removed. Also note the woundwood on the edge of the wound.

Photo 7: Trees may show an absence of woundwood response or a weak response, such as on this red oak, because of poor health or a number of other reasons.

ing of the wound from its edges (Photo 6A). However, woundwood can also form on the surface of large wounds (Photo 6B). The annual formation of new tissues on the edge of the wound may leave annual growth striations on the surface (Photo 6A). Internally, woundwood produces annual growth rings that develop beyond the barrier zone, and dissection of a tree can roughly age the time of year the wound occurred and the number of years ago that the tree was wounded (Photo 5).

Biological capacity to respond to woundwood

Trees may or may not form woundwood, or they may show a weak woundwood response for a number of reasons (Luley, 2015). One reason is that some trees may be in poor health or do not have the excess carbohydrate reserves to expend to form woundwood (Photo 7). The absence of woundwood on the edge of a wound raises a lot of concern about the health of the tree and, in the absence of obvious tree-decline symptoms, merits further investigation into the reason for the lack of woundwood.

Impact of pests affecting woundwood development

Woundwood can be attacked by a number of fungi that expand the wound by further attack on the bark, cambium and sapwood. The absence of woundwood, or the presence of dead woundwood, can be a strong indication of pathogen attack and can indicate serious trouble for the tree (Photo 8). There are a limited number of fungi that at-

Photo 8: Woundwood being attacked on a sugar maple. Note dead woundwood in the center of the wound (red arrow) and the discoloration where current woundwood that was cut into also is being attacked (yellow arrow).

tack and kill woundwood, although relatively few fruit on affected tissues, so culturing or DNA/RNA testing of affected tissues often is needed to support field diagnostics.

Strength of internal response to decay

Woundwood formation and eventual annual development is closely tied to the cambial layer in the tree and is therefore closely associated with the health of the tree. Trees with poor woundwood development or ones that have stopped supporting woundwood formation are also unlikely to be able to support defense reactions further inside the tree in sapwood (Photo 9). The strongest defense reactions in sapwood are formed by living parenchyma cells. These parenchyma cells are also dependent on tree health and resources for their support. A tree that is not forming woundwood is unlikely to be strongly defending itself against the internal advance of decay fungi. As such, the absence of woundwood is a proxy for what is happening deeper in a tree.

References

For more information on callus and woundwood, see Luley, C. J. 2015. Biology of callus and woundwood. *Arborist News*. 24(2):12-21.

Christopher J. Luley, Ph.D., is a pathologist with Urban Forest Diagnostics LLC. This article was based on his presentation on the same subject at TCI EXPO in Columbus, Ohio, last fall. To listen to an audio recording of that presentation, go to this page in the digital version of this issue online, under the Publications tab, and click here.

Photo 9: Weak woundwound formation and the absence of woundwood on a sugar maple indicate that the likelihood of internal defense responses to decay also are weak, and decay may be spreading relatively rapidly.