Twigs are 1 year old tissue. Branchlets are 2-3 year old tissue. Branches are shoot tissue separated from a stem or primary axis which is 4 years old and older. Scaffold branches are considered first order (1st) structural units attached to the main stem or large codominant stems. These branches are usually old and large upon which the rest of the crown is arrayed.

Normal branches are generated from a twig, branchlet, branch sequence of an apical shoot. Both branch and apical shoot have continued to grow. Sprout branches are derived from preventitious and adventitious growing points released / generated sometime after the apical shoot tip has grown on or growing from old injury / wound areas.

Branch Definition

Across many definitions of a branch, 15 general descriptors tend to be used. The word branch is derived from language concepts dealing with a foot or paw where toes or claws radiate away from a central point. Figure 1 presents the common descriptors used for a branch. Roughly 46% of descriptors define a branch as a sub-division of the main axis or stem of a tree which diverges from the main stem to expand and extend the tree’s reach. Some terms are used in a size sequence: stem > bough > limb > branch > branchlet > twig.

Branch Attachment

Branches are connected to another branch or stem with a number of clearly defined (and usually visible) forms of tissue connections. In general terms, branches are attached through a cooperative growth pattern at its base where each growing season diameter increases for both branch and stem. Figure 2. As each increases in diameter, all living tissue around the circumference of each branch and stem continue to generate tissues through the phellogen and vascular cambium. Visible components of the branch attachment area include periderm unions, phloem continuity flowing downward toward roots, and xylem confluence / stem flange area. Figure 3.
Unions

The place where periderm of a branch and stem meet generates two visible attributes:

A) a periderm union; and,

B) a stem flange.

The first is a periderm union on the top side of the branch base. A periderm union (sometimes referred to as a bark union or bark ridge) is an external periderm disruption at top of a stem-branch confluence. Periderm unions come in two types – a periderm chine or rimple. A periderm chine is a ridge of periderm tissue pushed up and out in the confluence area. Figure 4. A periderm rimple is formed when periderm tissue is caught internally within the confluence area. Figure 5. A rimple is a crack or wrinkle showing where periderm has been grown around and trapped within the confluence area.

Lengthening Union Line

As both stem and branch continue to expand in diameter, the periderm union’s length around a stem continues to grow. At the moment when secondary growth in the stem and branch confluence area began, the periderm union in the confluence was initiated. With continued diameter growth of stem and branch, periderm of stem and branch grew against each other, was initiated at the top of the confluence, and was continually pushed off to each side of the confluence by diameter growth. Figure 6. Depending upon the branch-stem confluence angle and growth pattern, the periderm union demarcation can be seen on a stem as a straight, drooping, or curving surface disruption line stretching downward (basipetally) and around the stem.

Phloem Continuity

The branch attachment area contains interlaced structural and protective tissues. The phloem transport system and vascular cambium which generated phloem, functions as a two dimensional surface. Phloem and cambium exist as a living film over the surface of the xylem, protected by periderm. The closest to the tree surface exterior phloem reaches occurs at the top of the stem branch confluence. In this location, the secondary cortex is thin and the phellogen is constantly disrupted and regenerating a full periderm, while diameter expansion of the branch and stem continually stretch and thin out the tissues. This confluence zone is susceptible to attack from many environmental agents.

Xylem Confluence

The area where stem and branch meet is a unique zone of overlapping and interlaced tissues from both stem and branch (a tissue confluence zone). Figure 7. An old term for this area was crotch. Branch tissues is this area form the base of a branch and are overlain by stem tissues. Branch tissues are orientated downward (basipetally) and do not turn upward along the stem. Under some circumstances there is a noticeable branch gap in stem tissues under a branch for some distance along a stem until stem tissues reform the stem cylinder.

In summary, a branch is stuck into the side of a stem and the stem tissues separate and enclose the branch base to hold it onto a tree. A branch under this structural form can be compartmentalized off if it is damaged or does not generate enough food and growth regulators for the rest of the tree below the branch. A branch remains reasonably flexible and disposable (through self pruning / compartmentalization), while the tree remains in control of resource allocation and defense at the branch base.
Flange

The stem-branch confluence area is both a defensive zone and mechanical support zone at base of branch where branch tissue is diverted downward (basipetally) toward roots, and stem tissues intermingle with branch tissues and sweep around the branch base. There is no connection between stem xylem and branch xylem above (apically) a branch. The stem flange area (old term = branch collar) for each year is dominantly stem tissue and should not be injured. Pruning or branch removal should eliminate the branch without damaging the stem / stem flange area.

Over years of growth, as both branch and stem grow in diameter, a conical shaped branch base / stem tissue area develops. These shallow nested cones within the stem xylem, from each year’s confluence tissues, comprise the stem flange area over time. The sapwood component of this area is termed a primary defensive zone. The heartwood component of this area, which is usually impregnated with additional extractives and secondary compounds, can be considered a secondary defensive zone.

Supporting Tissue

Mechanical support of a branch by the branch base surrounded and overtopped by stem tissue represents the stem flange. Figure 8. A stem flange is an area at the confluence of stem and branch providing vascular connection and mechanical support to a branch, and defensive potential to the stem. A stem flange is much larger / thicker on the branch base bottom than on top to resist gravity downward, and the wind laterally and upward.

The outward extent or farthest along the branch a stem flange reaches can be visualized using two visible targets. Along the branch top as the confluence zone is approached, just before the periderm union of a branch begins to curve up (or down) in meeting the stem part of the periderm union, is one target. This target represents the edge of the stem flange on the top of the branch and in the confluence area.

Seconds

The second target is on the branch bottom as it approaches the stem. Just before the branch diameter taper rate noticeably changes and thickens the edge of the stem flange. If any modification of branch diameter size or form occurs on the bottom side (swelling or change in surface angle to stem surface), this would be the beginning of the stem flange. Note, these stem flange targets are not in-line with the stem’s vertical surface and may represent a significant nub or stub of tissue reaching beyond the stem surface. This tissue area sticking beyond the stem is the stem flange. Figure 9.

Inner Space

The inward extent of the stem flange is delineated by all past annual cones of intermixed stem and branch tissues in the confluence area (i.e. seen as a knot in a wood plank). The conical shaped volume dwindles down until it nears the pith, or until the annual increment year when the branch initial first developed. This area functions as a complex compartment for decay control. As a branch is shed, these branch associated tissues are sealed off. The stem can quickly grow over the site from all sides generating a circular compartment closure. This area can also, through decay over time, present a small conically shaped cavity in a stem. This cavity is usually limited in volume depending upon branch base size.

Twinned

In some trees where nodes support opposite growing points and organs, where a main axis has been damaged, or where a branch has grown as large as the stem to which it is attached, two types of poor branch growth forms occur. The first poor branch growth form is a fork. Figure 10. A fork is
conjoined stems or branches of roughly the same size where both sides of the confluence is stem-like (equal on both sides). A fork’s defensive zone is compromised or nonexistent, and no stem flange is present.

The second poor branch growth form type is a codominant branch. Figure 11. A codominant branch forms when a secondary branch generated by a primary branch or main stem grows in diameter large enough (>2/3 diameter of originating branch or stem). A codominant branch has a diminished defensive zone and associated wound reaction. A fork union and codominant branch union share many negative characteristics, but are derived from subtly different starting points.
<table>
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<th>Descriptors</th>
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Figure 1: Branch descriptors from common definitions.
Figure 2: Diagram of stem - branch confluence area (stem flange) showing defensive zone (shaded), annual increments of tissues, and enveloping of branch tissues by stem tissues (ovals).
Figure 3: Stem-branch confluence area showing periderm chine (periderm ridge), stem flange area, and defensive zone (shaded).
Figure 4: Upper side of a stem-branch confluence (flange area) with a periderm chine (i.e. ridge or crest).
Figure 5: Upper side of a stem-branch confluence with a periderm rimple (i.e. fold or wrinkle). The rimple periderm union can contain periderm tissues folded inside and grown over.
Figure 6: Diagram representing circular cross-sectional areas (shaded) of a branch base at the confluence with the stem over time (#1 is youngest / smallest size). A bark chine is initiated at the topmost position over the branch (#1 -- note arrow point ▼) where tissues of stem and branch grow against each other. As both stem and branch grow in diameter (#2 - #5), points on the bark chine (arrows) continue to show greater separation.
Figure 7: Upper side of a stem-branch confluence showing periderm union area and defensive zone.
Figure 8: Descriptive model of a pipe held onto a board with a flange (A), and a branch held onto a stem with a combined tissue area acting as a flange (B).
Figure 9: Close view of the stem flange area at a stem - branch confluence. Visible pruning targets: Target A is on the branch side (outside) of bark chine just before tissues begin a curve up into the chine; Target B is on the branch side (outside) of tissue swelling or gathering point on branch underside. Dotted line between A & B represents edge of stem flange.
Figure 10: Diagram of a fork (codominant stems or branches) with bark chine shown. This stem-branch architecture would not provide a defendable stem flange area or defensive zone (DZ) if either side was removed.
Figure 11: Branches too large to leave (i.e. to be removed) on a stem with branch diameter to stem diameter ratios of 2/3 to 1/1 (near same size as the stem). D = diameter.