



The shape of tree leaves is a primary way to identify tree species. The environment, resource availability, social / ecological interactions, and biology of trees and forests all impact leaf size and shape. Tree genetics set boundaries and help optimize leaf forms in the long-term, while stress, strain and physiological functions and dysfunctions constrain leaf forms in the short-term. Appreciating tree leaf macro-anatomy and morphology can help determine tree health, function, and identification.

Leaves can be highly variable in shape and size across a species, for localized gene sets, among individuals, and within a crown of a single tree. New leaves – old leaves, sun leaves – shade leaves, and/or preformed leaves – late-season leaves can all vary greatly in shape and size, or may not vary at all. Figure 1 shows leaf features used here to define tree leaves and aid in identification.

Natural & Human Variation

Into a highly variable leaf world comes tree enthusiasts and dendrologists, each bringing local / regional familiarity and trained observing skills, to categorize and identify tree leaf shapes and associated species. Although science training demands accuracy and precision in observations, human subjectiveness is still present. One person's shape name may represent a different shape concept to someone else.

Native tree shape descriptions are almost as variable across individual observers as are natural leaf variations in the forest. In reviewing a number of different tree identification texts, one native tree species can be given one shape description, or many. This suggests our descriptive process seeks discrete standard stations of shape representing tree leaves and species, instead of the variable length, width, and form of a continuous shape / size gradients for leaves present in a forest.

General Shape

A means of defining native tree leaf shape is through estimating a general overall shape without regard to various lobes, serrations, or undulations of a leaf blade. Two methods of reaching this observation goal are: 1) determine the ratio of leaf length to width; and, 2) define geometric leaf shape forms. Both methods demand observational discipline and precision over time and across observers. Both methods apply a two dimensional simplification to complex leaf shape and size. By using these two methods, an idea of the scope of natural variation for leaf forms can be estimated, and the morphological blending between shapes can be better defined.

Geometry of Form

Broadleaved forms of leaves are called latifolius, and can vary in shape by changes in leaf length to leaf width ratios. This ratio is an estimate of general leaf shape and varies greatly between sun and shade leaves, new and older leaves, and between individuals of the same species. The length to width ratio is one type of imaging for native tree leaves in two dimensions. Figure 2 provide a visual appreciation of length:width ratios where the leaf width is held constant and length varies across four different length:width ratios. Figure 3 helps visualize leaf / leaflet shape and size by holding the length constant while varying the leaf width.

Figure 4 shows the continuous gradient of leaf length to width ratios with the four standard stations of length:width ratios. Along the gradient general leaf / leaflet shape and size can be placed and determined if they reach or exceed thresholds of length:width ratios. Figure 5 provides a master list of

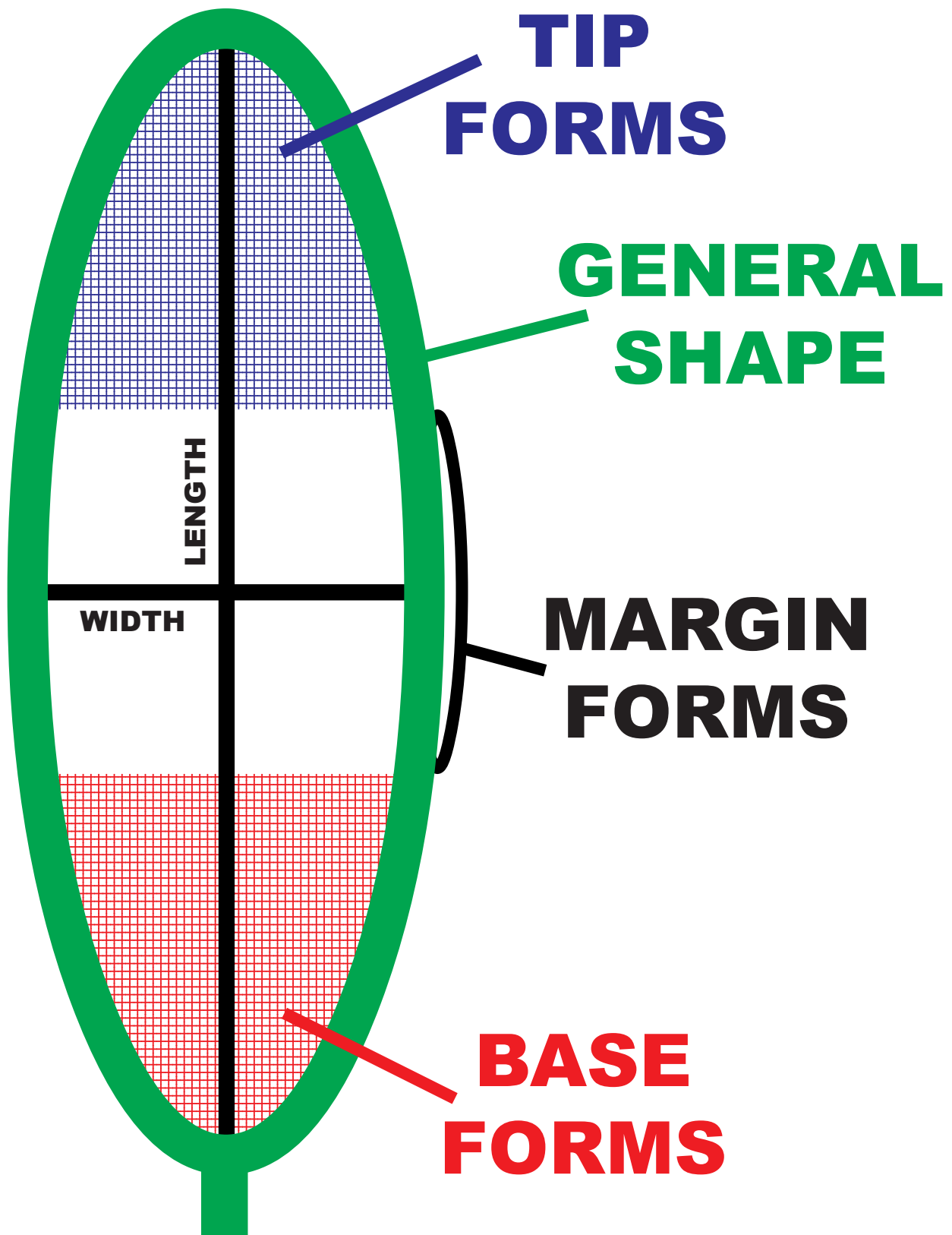


Figure 1: Defining leaf or leaflet shape using general overall shape, length / width values, tip and base types, and margin types.

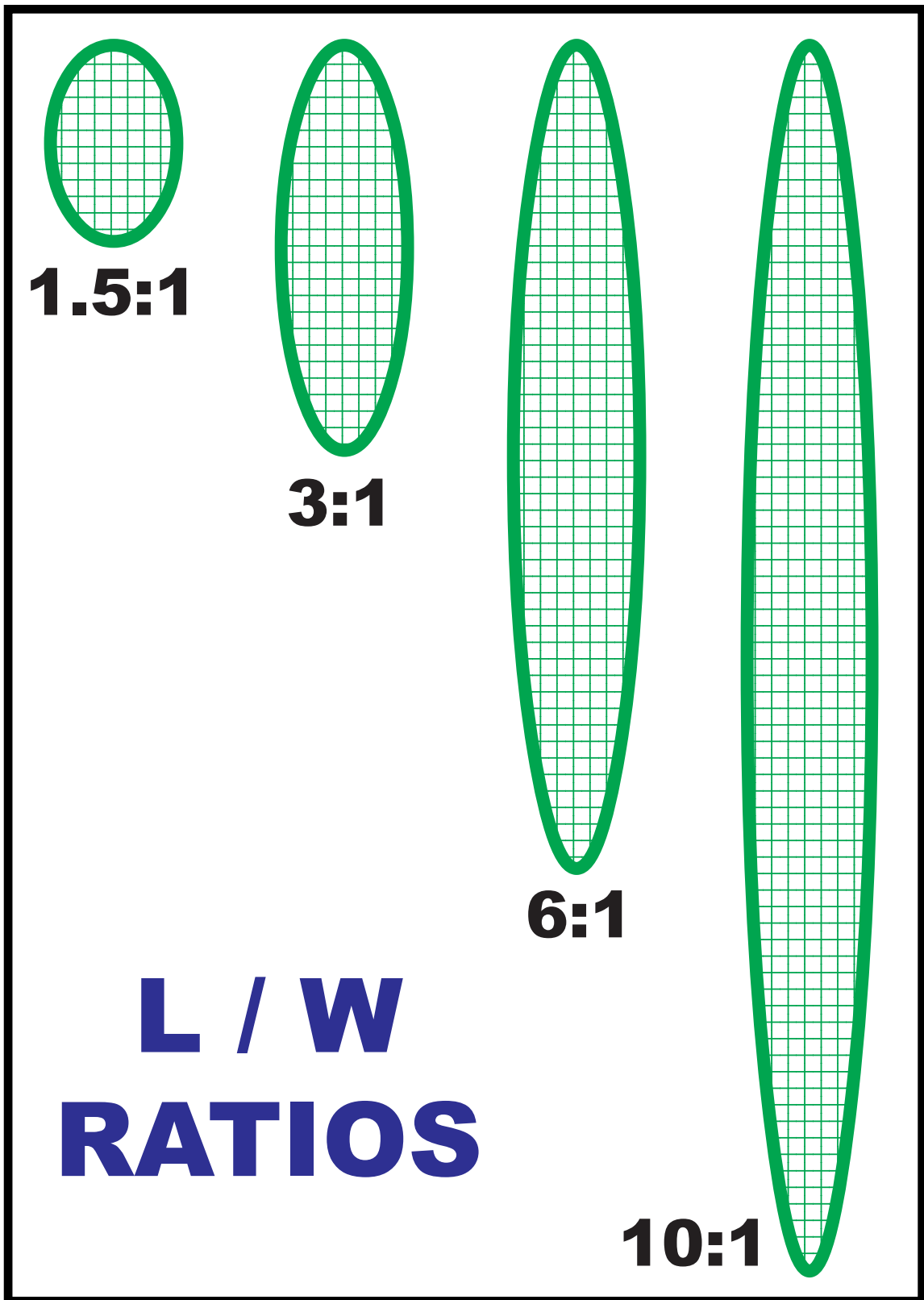


Figure 2: Length to width ratio examples with four shapes all of the same width.

L / W RATIOS

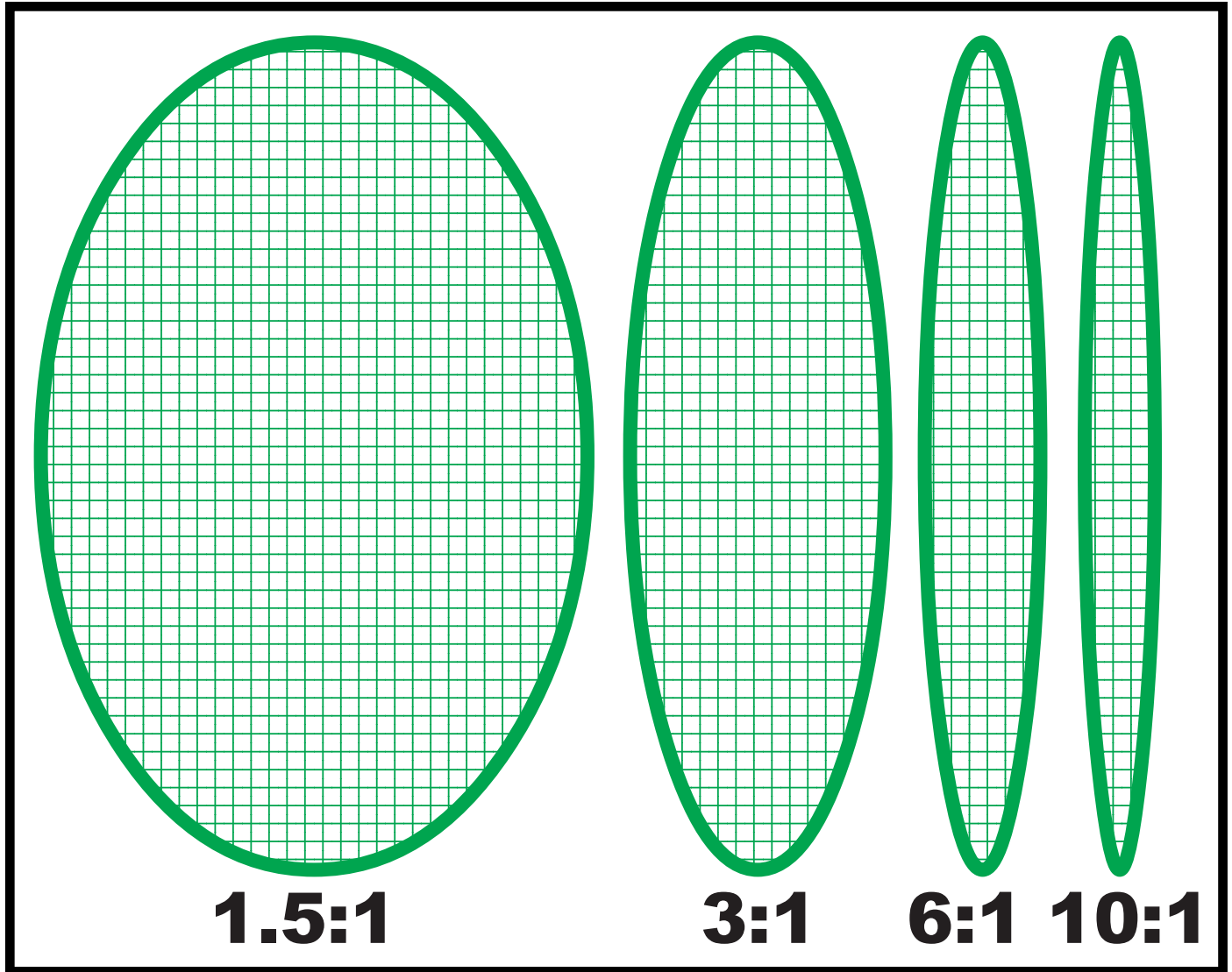


Figure 3: Length to width ratio examples with four shapes all of the same length.

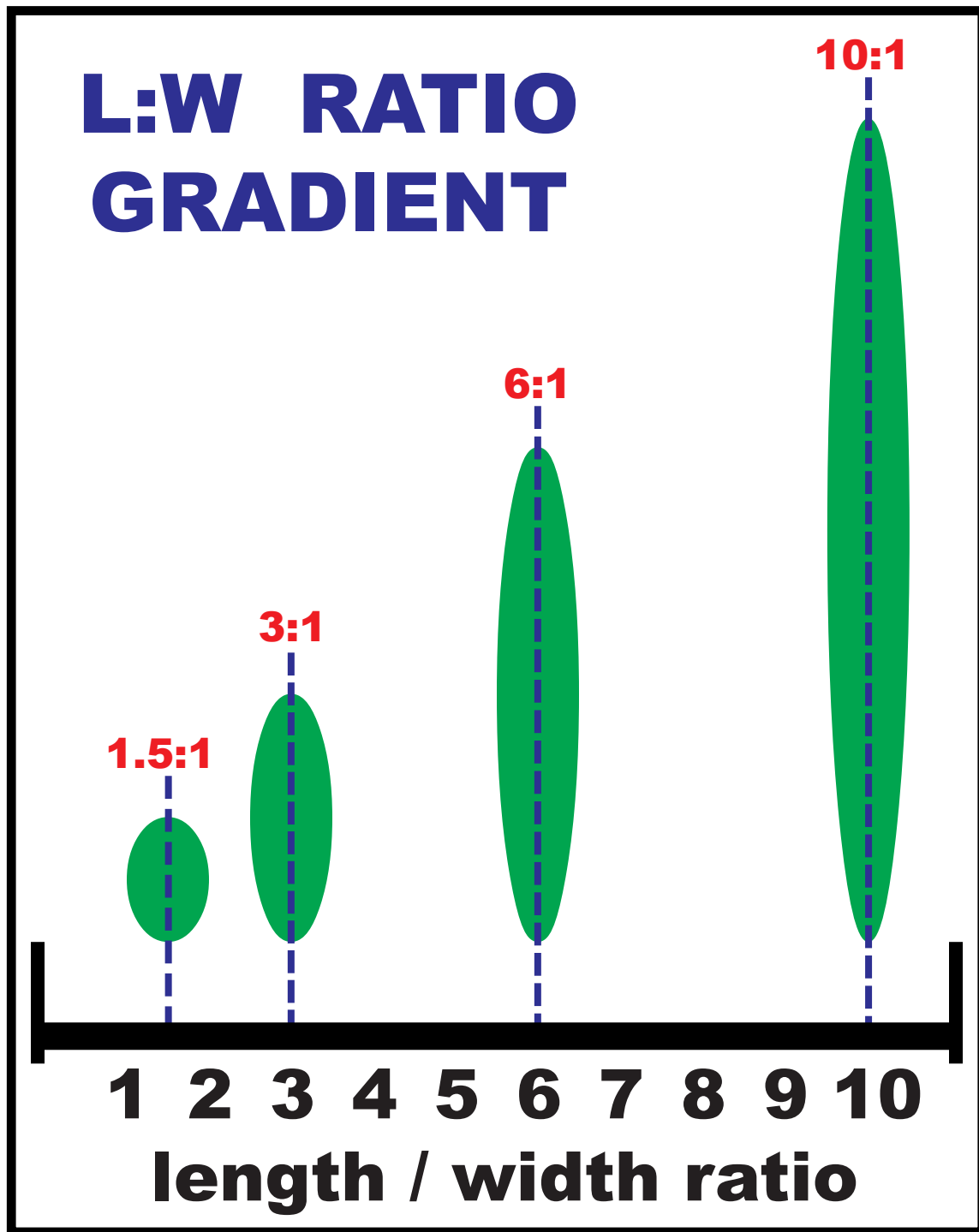


Figure 4: Continuous gradient of leaf length:width ratios and major leaf aspect thresholds.

| general / geometric leaf shape | length to width ratio |
|--|-----------------------------------|
| <u>Orbicular / Rotund</u> (circular / round) | 1:1 ratio |
| Oblate (wider than long) | <1:1 ratio |
| Suborbicular (almost round) | <1.1:1 ratio |
| Orbiculate (wide) | <1.2:1 ratio |
| <u>Elliptical or Narrow Oval</u> (widest in middle – margins curved) | |
| Oval (broad elliptical) | >1.5:1 ratio |
| Elliptic (narrow oval) | >3:1 ratio |
| <u>Oblong</u> (parallel margins / straight sides in middle third of leaf) | |
| Oblong | >1.5:1 ratio |
| Lanate (long narrow) | >6:1 ratio (3:1 to 9:1) |
| <u>Ovate</u> (widest in basal third of leaf – egg-shaped or fat-based) | |
| Ovate (oval-like) | >1.5:1 ratio |
| Lanceolate (long narrow oval-like) | >6:1 ratio (3:1 to 9:1) |
| Subulate (barely tapered, fat-based) | >10:1 ratio |
| <u>Obovate</u> (widest in apical third of leaf – fat-tipped / wide-ended) | |
| Obovate (oval-like) | >1.5:1 ratio |
| Obelliptical (narrow oval-like) | >2:1 ratio |
| Ob lanceolate (long narrow oval-like) | >6:1 ratio (3:1 to 9:1) |
| Obsubulate (barely tapered, fat-ended) | >10:1 ratio |
| <u>Linear</u> (extremely long & narrow -- regardless of widest portion) | >10:1 ratio |

Figure 5: General tree leaf / leaflet blade shape names with length to width ratios.

both general geometric shape criteria and associated length:width ratio values for tree leaves and leaflets. Even though these shapes and values seem objective and easy to apply, observer variation can be great for some tree species.

The second means to describe native tree leaves is by the extent of the leaf blade or lamina. Place a geometric shape line around the outside outline of the leaf or leaflet, and estimate what form most closely describes the outline shape generated. There are six general forms which represent geometric derived leaf shapes:

1. **Orbicular** or rotund shapes are circular or round with a 1:1 length to width ratio. Oblate is a leaf wider than long with a <1:1 ratio. Suborbicular is a term for almost round having a <1.1:1 length to width ratio. Orbiculate has a <1.2:1 length to width ratio and are wide leaves, approaching round. Figure 6.

2. **Elliptical** shaped leaves are a narrow oval shape with base and tip sloped similarly, and is widest in the middle. Several forms of generic elliptical shapes vary by length to width ratios. Oval shapes have a >1.5:1 ratio and are broad elliptical in form, rounded at each end, with constantly curving margins. An elliptical form is considered to have a >3:1 ratio and is described as a narrow oval with constantly curving margins.

3. **Oblong** shaped leaves are longer than wide with parallel margins in the middle of its length, and ends similarly rounded. Oblong leaves can have a length to width ratio of >1.5:1, with parallel sides for the middle third of leaf length. Lanate shaped leaves have a ratio of >6:1 (3:1 to 9:1), with a long narrow form with parallel sides. Figure 7.

4. **Ovate** leaves are oval-like in shape with a longer than wide form (>1.5:1 length to width ratio), which is widest toward their base (i.e. egg-shaped or fat-based or fat-bottomed). Figure 8. A lanceolate leaf shape has a ratio of >6:1 (3:1 to 9:1), and is long and narrow, with its widest portion in the basal third of its length (i.e. long fat-based leaf). Subulate leaf shape (>10:1) is very narrow at its tip and expands little to be narrow at base (i.e. extremely long, barely tapered, fat-based leaf). Figure 9.

5. **Obovate** leaf shapes are oval-like, longer than wide, and widest toward its tip, with a length to width ratio of >1.5:1 (i.e. inverted egg-shaped form, or a fat-tipped / big-ended). Figure 10. Obelliptical leaves are almost elliptical (narrow oval-like) in form with their widest portion above / beyond leaf center with a length to width ratio of >2:1. Oblanceolate describes a leaf shape with a >6:1 (3:1 to 9:1) ratio, and is a long narrow oval like shape with its widest point in the apical third of the leaf (i.e. long fat-tipped leaf). Obovate shaped leaves (>10:1) are very narrow at their base, expanding little to be narrow at their tip (i.e. extremely long, barely tapered, fat-tipped leaf).

6. **Linear** leaf shapes are very long and narrow, with a length to width ratio >10:1 regardless of where the widest portion of the leaf is located along its length. Figure 11. The margins are almost parallel. Angustifoliate is a historic term for narrow leaves. Subulate and obovate forms can also be considered linear.

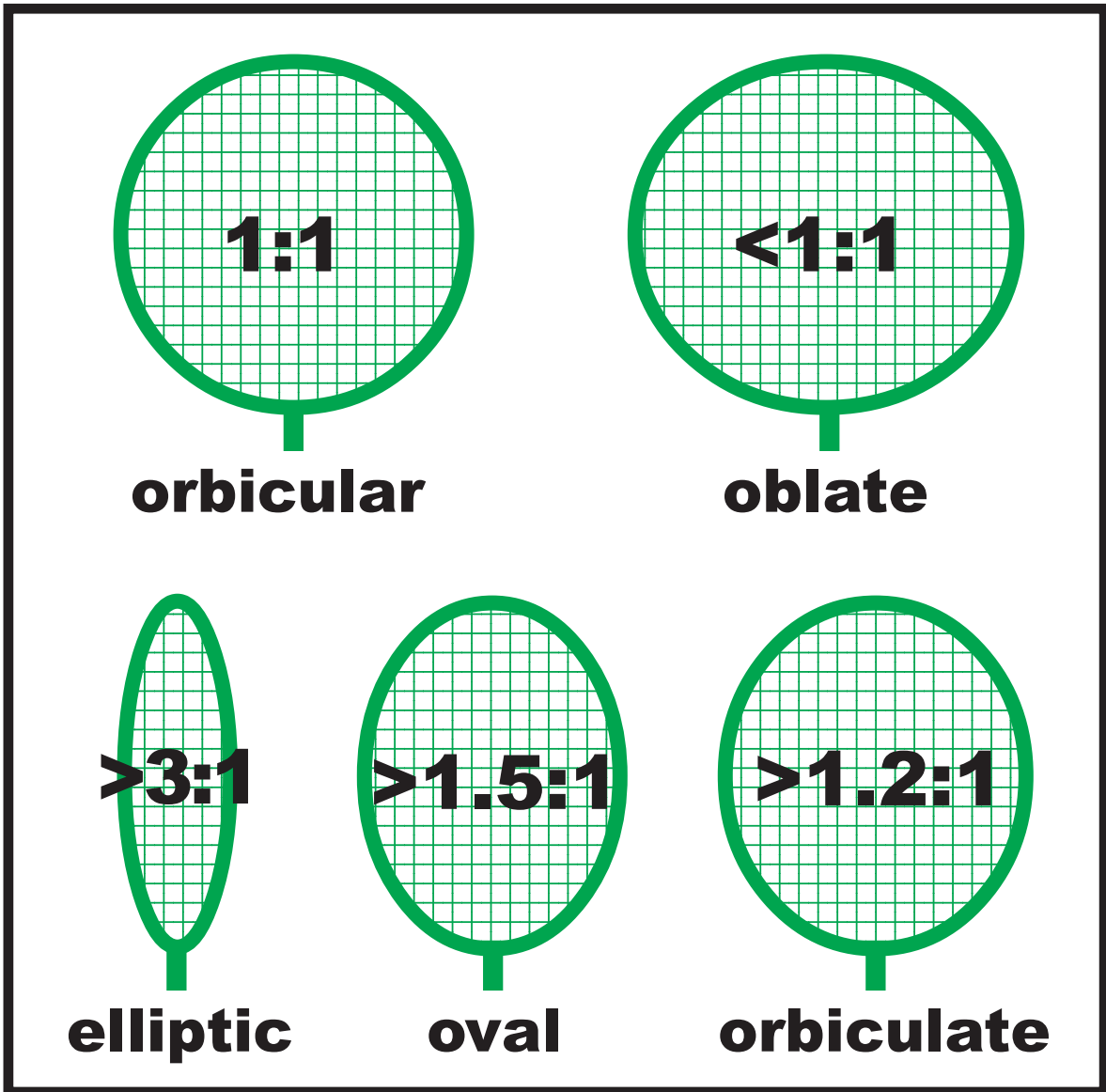


Figure 6: Listing of general tree leaf blade shapes which are widest in the middle with curved margins, associated length to width ratios, and geometric based names.

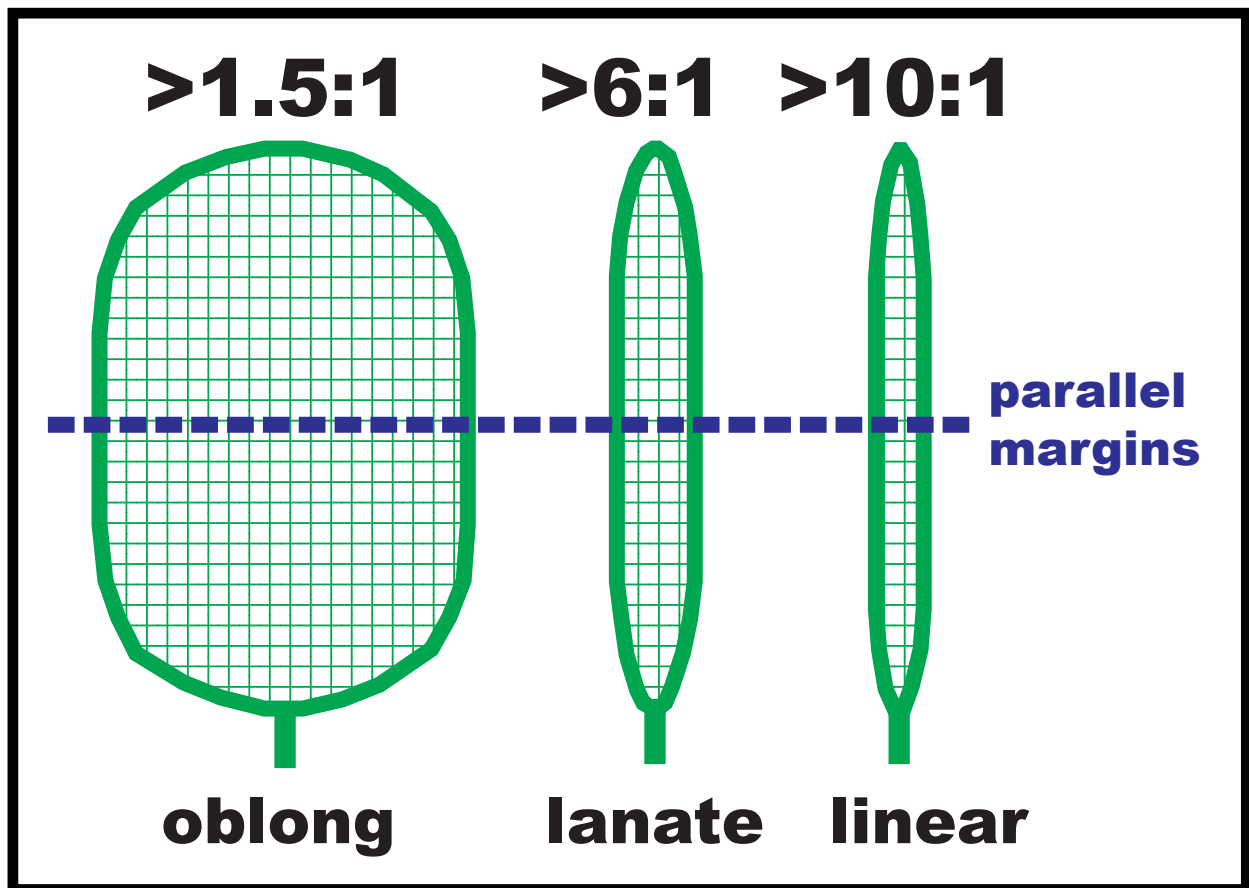


Figure 7: Listing of general tree leaf blade shapes which are widest in the middle with parallel margins, associated length to width ratios, and geometric based names.

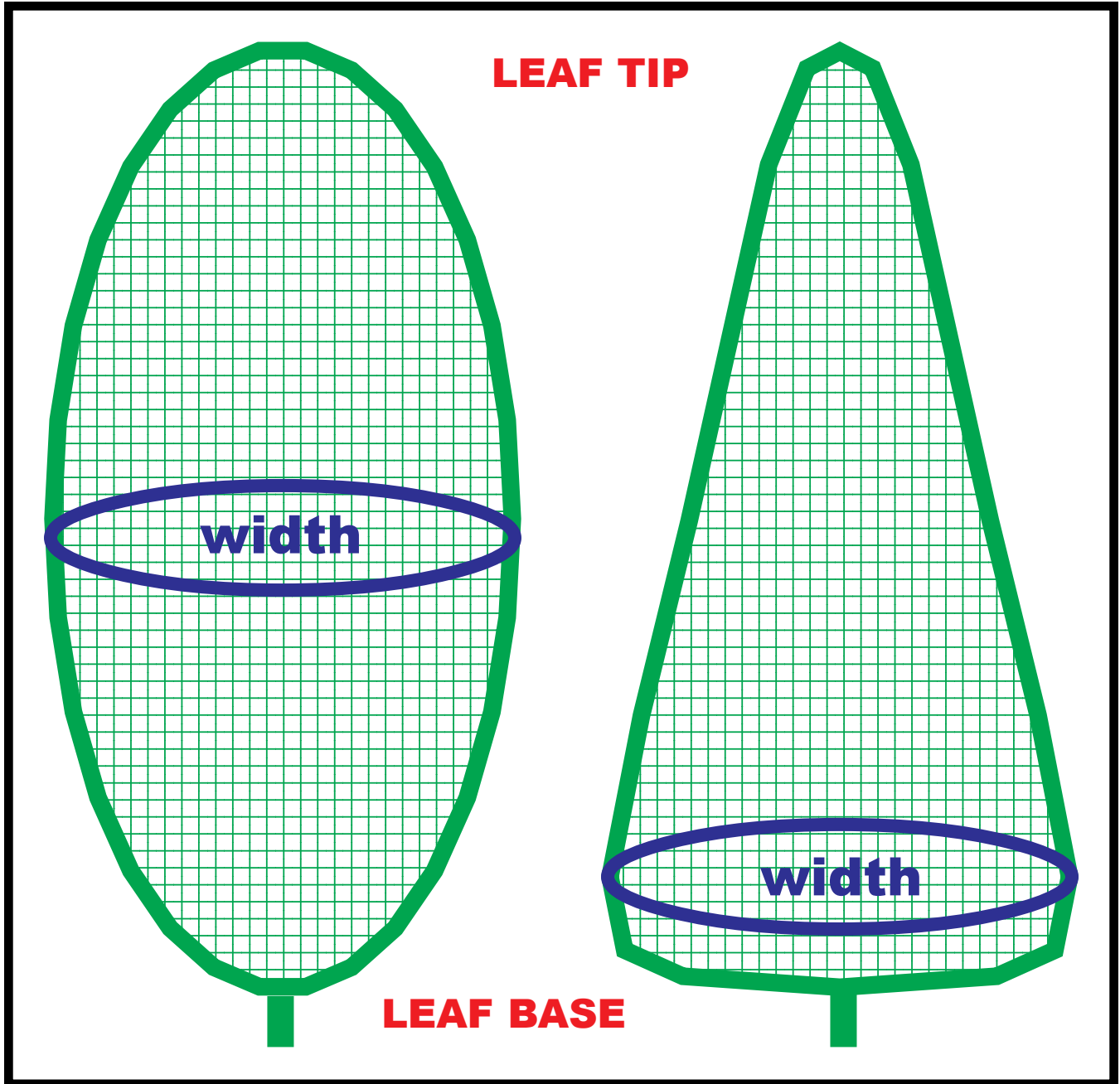


Figure 8: Tree leaf blade shape names are based upon general forms determined by where along a leaf length it is widest -- across the middle, toward its tip, or toward its base.

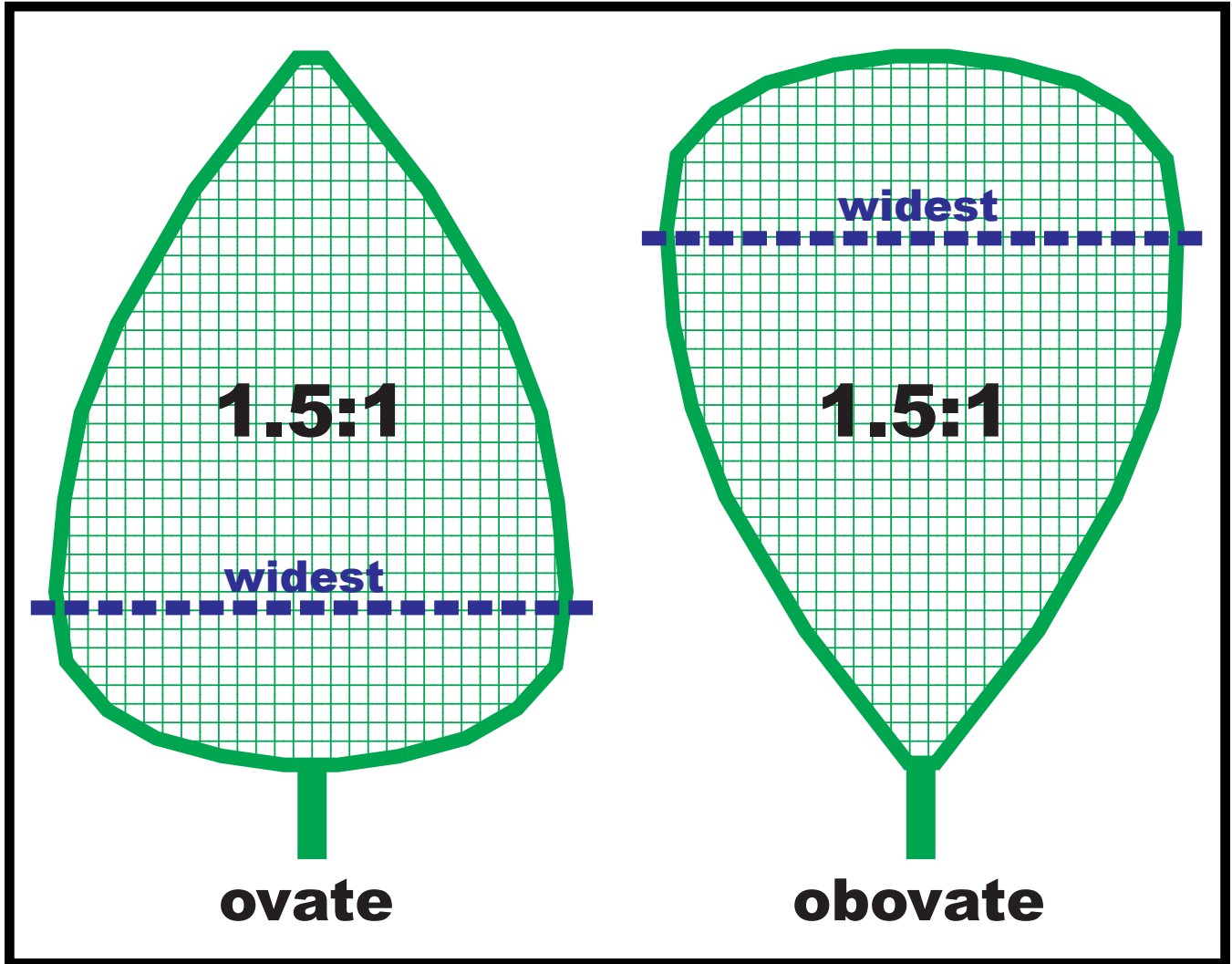


Figure 9: General oval-like tree leaf blade shapes which are widest at either end, with length to width ratios, and names.

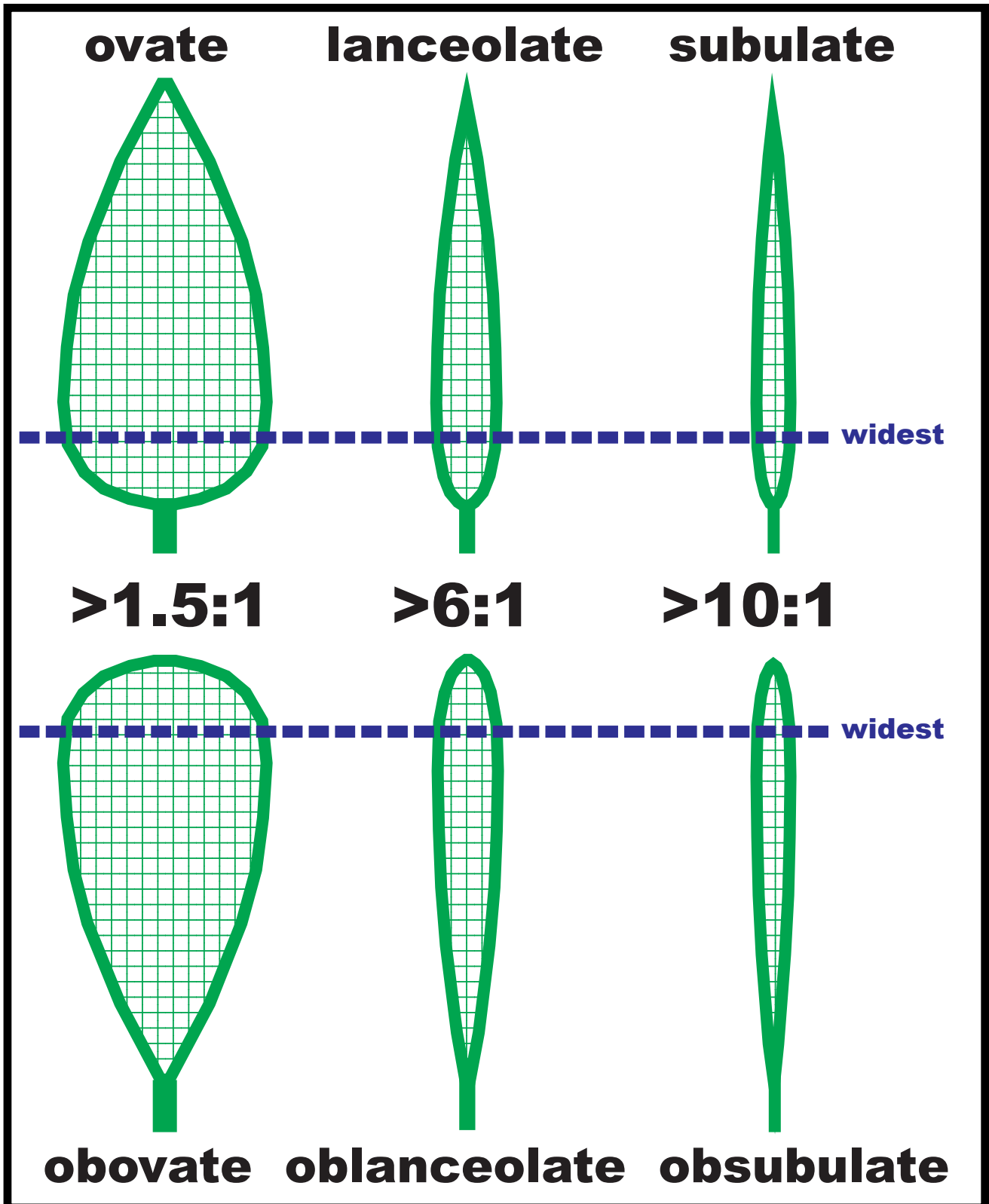


Figure 10: Listing of general oval-form tree leaf blade shapes which are widest at either end, with associated length to width ratios, and geometric based names.

The prefix "ob" means away from the leaf base.

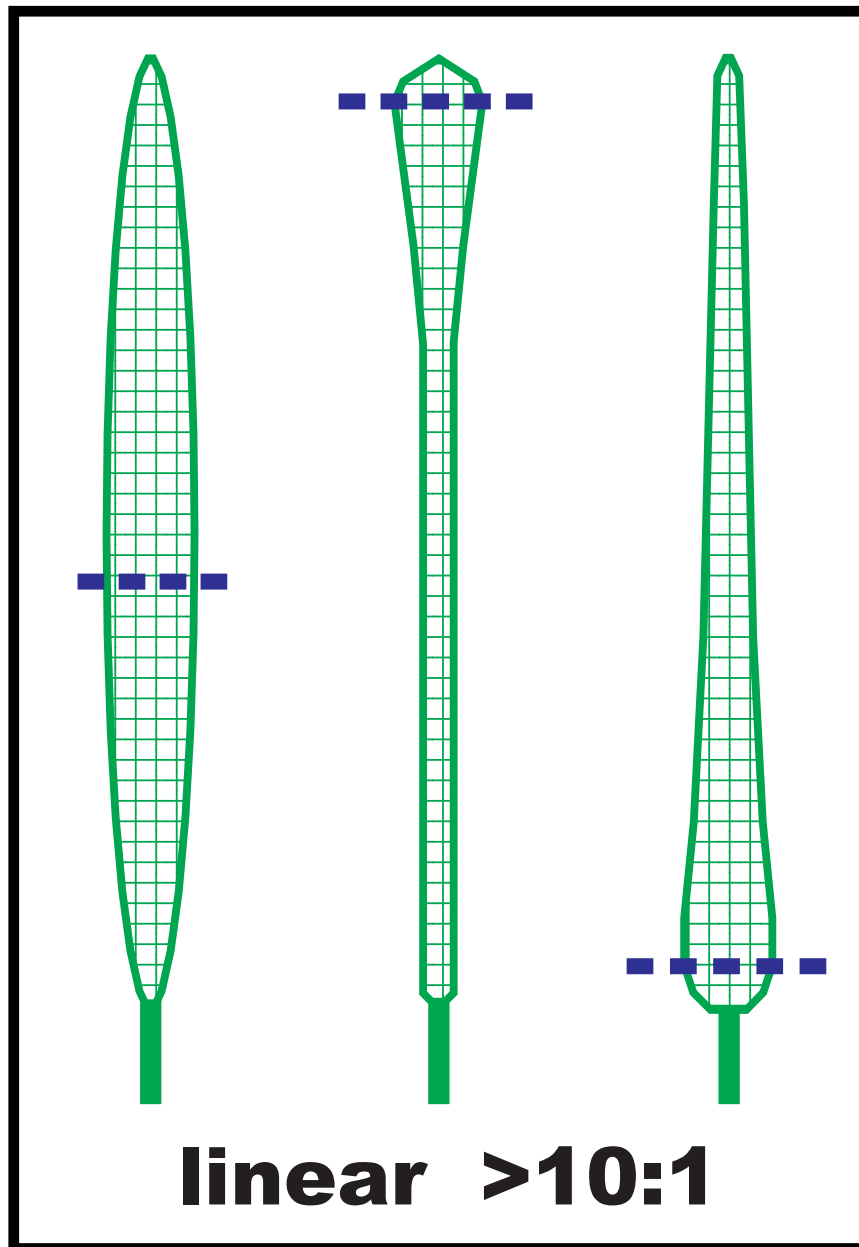


Figure 11: Long, narrow tree leaf blade shapes which can be widest anywhere along their length, with associated length to width ratio, and generic name.

Figure 12 summarizes leaf / leaflet shapes for field use in tree species identification. It must be noted word descriptions tend to over-inflate length:width ratios beyond actual measured length:width ratios of leaves. For example, authors using the term elliptic (>3:1 L:W ratio) may be viewing a leaf with a L:W ratio of <1.8:1, which approaching an oval shape. The cause of this perception issue for giving general shape names with implied larger L:W ratios than actual measured leaf values, is an observational bias.

Special Leaves

Along with the previous listed geometric shape descriptions for leaves / leaflets, there are a number of special or complex shapes used in describing tree leaves. Figure 13 lists special leaf / leaflet shapes and definitions. Some are described below, but this list is not comprehensive, and hybrid forms and combinations exist and have been cited.

Cordate is a heart-shaped leaf which is a generally ovate form with a pointed tip and a heart-shaped notched base. Obcordate is an inverted heart-shaped leaf. Deltoid or deltate is a triangle-shaped leaf with its widest part at the base. Obdeltoid is an inverted triangle-shaped leaf.

Lyrate is a lyre-shaped leaf with a large rounded apical lobe and much smaller basal lobes. Panduriform is a fiddle-shaped leaf which is obovate with concave sides and two small basal lobes. Rhombic is a diamond-shaped leaf with four sides and two oblique angles (i.e. rhomboid form). Quadrate is a square shape. Spatulate is a leaf with a spatula-shape, or is broad near its rounded tip with a quick narrowing taper to its base.

There are two arrowhead-shaped leaf forms usually described: hastate is a leaf with pointed basal lobes pointed outward; and, sagittate is a leaf with pointed basal lobes pointed downward. Two names for kidney shaped leaves, which are wider than long with a broad basal notch are nephroid or reniform. Some leaves have a shape which can appear cut-off or truncated. Praemorse leaf shapes have an abruptly terminated (truncate) end. A truncate leaf shape appears cut-off perpendicular to mid-vein. Figure 14 provides images of select special leaf / leaflet shapes with field codes.

Native Tree Leaves

Figure 15 is a long multi-page list which provides leaf / leaflet length to width ratios, and associated descriptive geometric based names for native tree species with simple leaves. Figure 16 shows similar information for compound leaflets. In compound leaves, the listed ratios and shapes are for individual leaflets, not entire compound leaves.

Remember, all the descriptive terms listed are from an individual observer or text, and each are correct for the leaves examined. A summary or blending of multiple leaf descriptions, as well as location along the length:width ratio gradient, can provide the best visualization of a tree species' leaf / leaflet size and shape.

Simply Compounded

Figure 17 provides a gradient (between 0.1:1 and 11:1 L:W ratio) along which native tree leaf length and width ratios vary. The length:width ratios are separated into simple leaves and compound leaflets. There appears to be an optimum leaf/leaflet shape for our native trees between 1.5:1 and 3.3:1 length:width ratio. Compound leaf leaflets have a much smaller range of length:width ratios than simple leaves.

Figure 18 shows the percent of shape descriptors used for native tree species leaves / leaflets which included 225 native tree species with 469 associated shape descriptors. Native trees with com-

GENERIC LEAF SHAPES

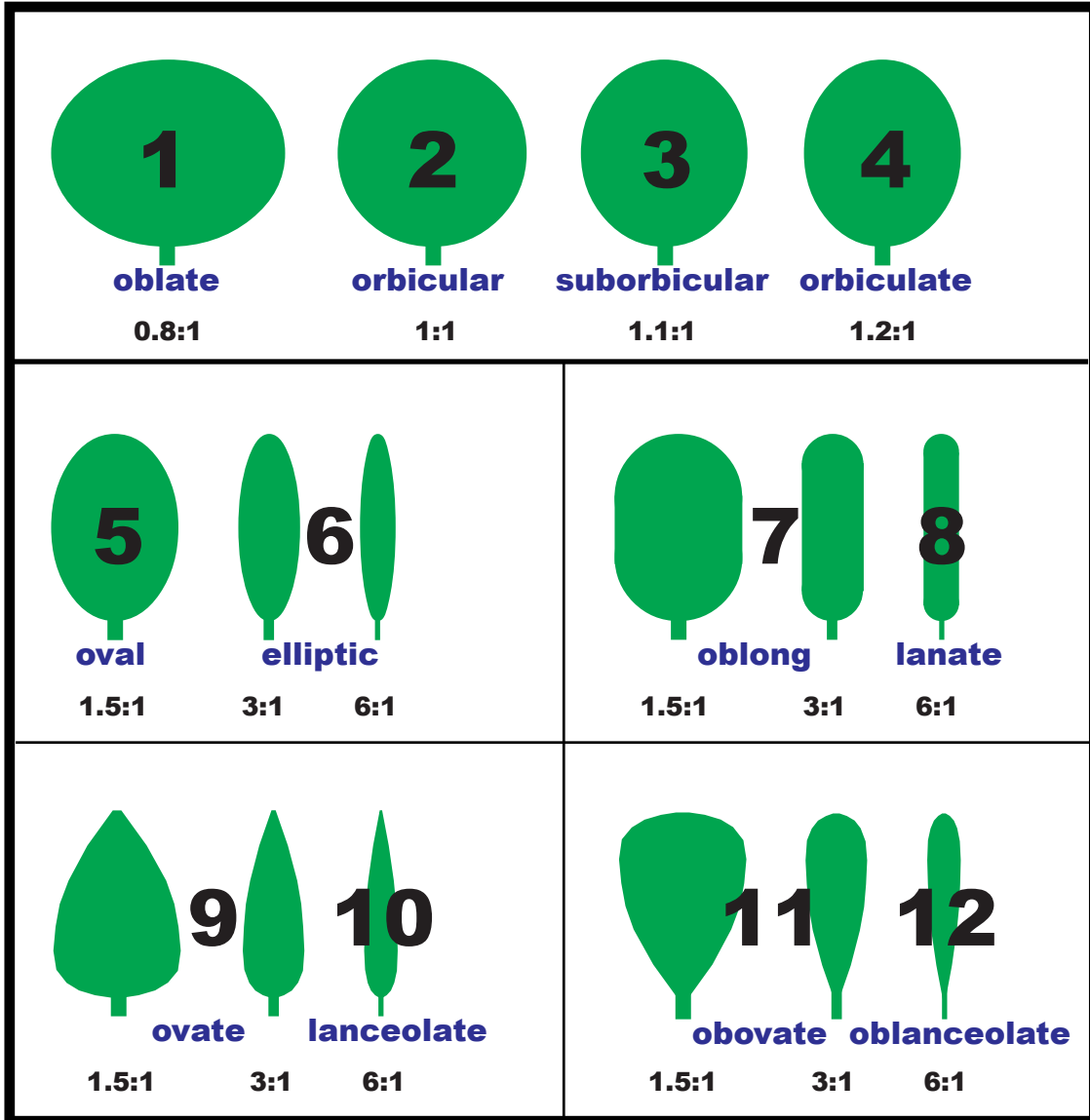


Figure 12: Field guide of generic leaf / leaflet forms, geometric based shape names, and associated code numbers.

Special Leaf / Leaflet Shapes

| name | description |
|--------------------------------|---|
| Cordate | = heart-shape – pointed tip & heart-shaped wide notched base |
| Obcordate | = inverted heart-shape |
| Deltoid / Deltate | = triangle-shaped -- widest at base |
| Obdeltoid | = inverted triangle-shape |
| Lyrate | = lyre-shaped – large rounded apical lobe & much smaller basal lobes |
| Panduriform | = fiddle-shaped obovate with concave sides & two small basal lobes |
| Rhombic | = diamond-shaped -- four sides & two oblique angles (rhomboid) |
| Spatulate | = spatula-shape – broad near rounded tip with quickly narrowing taper to base |
| Hastate | = arrow-head – basal lobes pointed outward |
| Sagittate | = arrow-head – basal lobes pointed downward |
| Nephroid / Reniform | = kidney-shaped – wider than long with broad basal notch |
| Praemorse | = abruptly terminated (truncate) apical end |

Figure 13: Selected special tree leaf / leaflet blade shape names with simple descriptions.

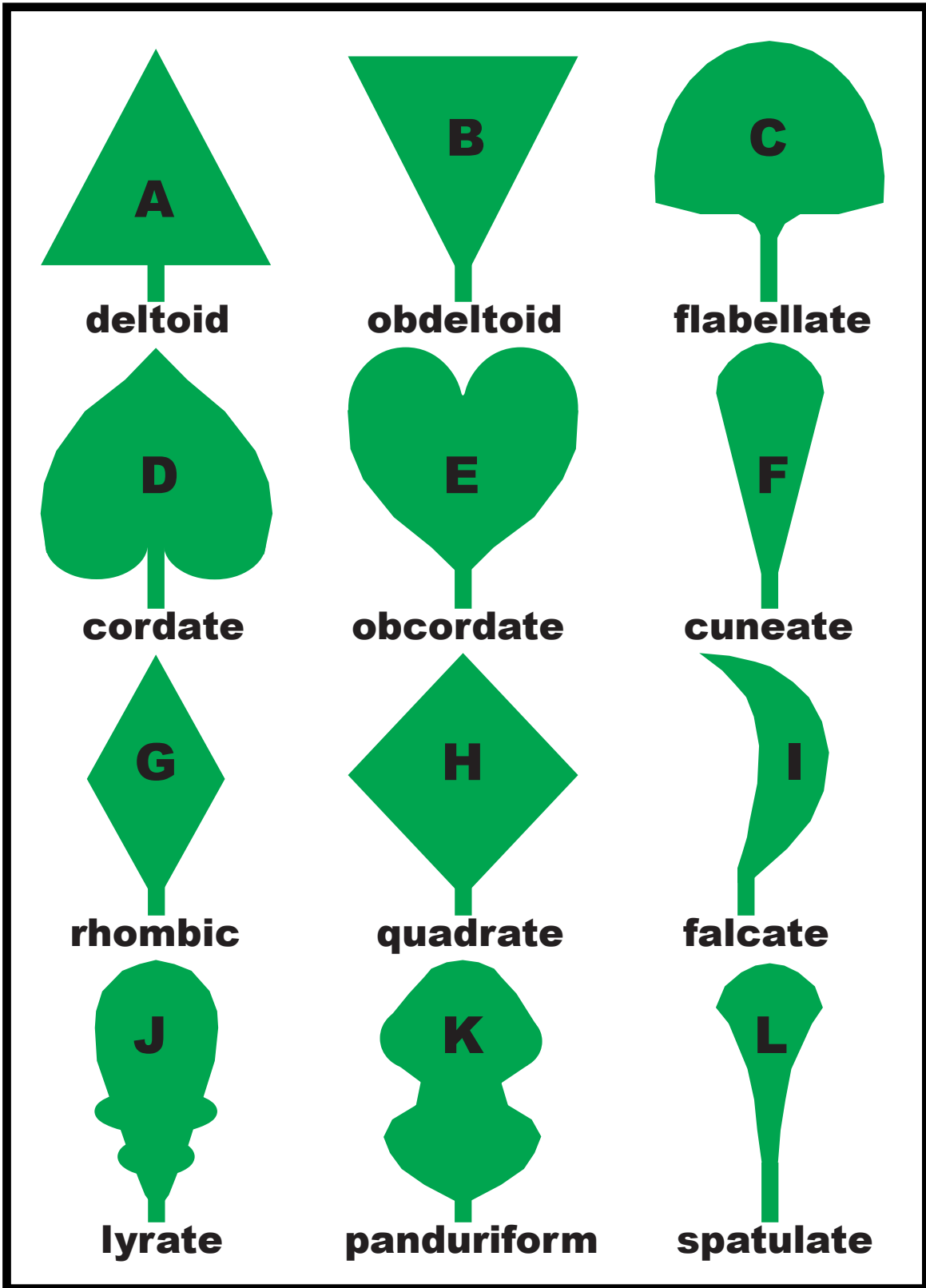


Figure 14: Special tree leaf / leaflet forms, shape name, and code letter.

| scientific name | common name | L:W | description |
|----------------------------------|------------------------|------------|----------------------------|
| <i>Acer barbatum</i> | Southern sugar maple | 1.0 | orbicular suborbicular |
| <i>Acer leucoderme</i> | chalk maple | 1.0 | orbicular suborbicular |
| <i>Acer nigrum</i> | black maple | 1.0 | suborbicular orbiculate |
| <i>Acer pensylvanicum</i> | striped maple | 1.1 | oval obovate |
| <i>Acer rubrum</i> | red maple | 1.2 | suborbicular ovate |
| <i>Acer saccharinum</i> | silver maple | 1.1 | orbiculate ovate |
| <i>Acer saccharum</i> | sugar maple | 1.0 | suborbicular |
| <i>Acer spicatum</i> | mountain maple | 1.0 | suborbicular ovate |
| <i>Alnus serrulata</i> | hazel alder | 1.7 | oval elliptic obovate |
| <i>Amelanchier arborea</i> | serviceberry | 2.0 | elliptic ovate |
| <i>Asimina parviflora</i> | dwarf pawpaw | 2.0 | obovate |
| <i>Asimina triloba</i> | pawpaw | 2.1 | oblong obovate |
| <i>Baccharis halimifolia</i> | Eastern baccharis | 1.9 | elliptic ovate cuneate |
| <i>Betula alleghaniensis</i> | yellow birch | 2.5 | elliptic oblong ovate |
| <i>Betula lenta</i> | sweet birch | 1.7 | elliptic ovate |
| <i>Betula nigra</i> | river birch | 1.3 | ovate rhombic |
| <i>Carpinus caroliniana</i> | S. Ameri hornbeam | 2.0 | oval ovate |
| <i>Castanea dentata</i> | American chestnut | 3.0 | elliptic oblong |
| <i>Castanea pumila</i> | chinquapin | 2.0 | oval elliptic oblong |
| <i>Catalpa bignonioides</i> | Southern catalpa | 1.5 | ovate cordate |
| <i>Celtis laevigata</i> | sugarberry | 3.0 | elliptic ovate lanceolate |
| <i>Celtis occidentalis</i> | hackberry | 2.0 | ovate lanceolate |
| <i>Celtis tenuifolia</i> | Georgia hackberry | 2.0 | ovate |
| <i>Cephalanthus occidentalis</i> | buttonbush | 2.0 | oval elliptic ovate |
| <i>Cercis canadensis</i> | redbud | 1.0 | orbiculate ovate |
| <i>Chionanthus virginicus</i> | fringetree | 2.5 | elliptic ovate |
| <i>Clethra acuminata</i> | sweet pepperbush | 1.6 | oval elliptic |
| <i>Cliftonia monophylla</i> | buckwheat tree | 2.5 | elliptic ovate |
| <i>Cornus alternifolia</i> | alternate-leaf dogwood | 2.0 | oval elliptic |
| <i>Cornus florida</i> | flowering dogwood | 1.9 | oval elliptic |
| <i>Cornus foemina</i> | swamp dogwood | 1.8 | oval ovate |
| <i>Cotinus obovatus</i> | smoketree | 1.9 | oval obovate |
| <i>Crataegus aestivalis</i> | mayhaw | 2.5 | elliptic ovate cuneate |
| <i>Crataegus aprica</i> | sunny hawthorn | 1.4 | elliptic |
| <i>Crataegus calpodendron</i> | pear hawthorn | 1.5 | elliptic ovate |
| <i>Crataegus crus-galli</i> | cockspur hawthorn | 2.0 | elliptic obovate spatulate |
| <i>Crataegus flava</i> | yellow hawthorn | 1.3 | elliptic obovate cuneate |
| <i>Crataegus intricata</i> | Biltmore hawthorn | 1.3 | elliptic ovate |

Figure 15: Native tree species simple leaf shape descriptions and length:width ratios.

| scientific name | common name | L:W | description |
|-------------------------------|-----------------------|------------|---------------------------|
| <i>Crataegus marshallii</i> | parsley hawthorn | 1.3 | ovate |
| <i>Crataegus phaenopyrum</i> | Washington hawthorn | 1.4 | ovate deltoid |
| <i>Crataegus pruinosa</i> | waxy-fruit hawthorn | 1.3 | elliptic ovate |
| <i>Crataegus pulcherrima</i> | beautiful hawthorn | 1.3 | orbiculate elliptic ovate |
| <i>Crataegus punctata</i> | dotted hawthorn | 1.5 | elliptic obovate |
| <i>Crataegus spathulata</i> | littlehip hawthorn | 1.5 | spatulate |
| <i>Crataegus triflora</i> | three-flower hawthorn | 1.4 | elliptic ovate |
| <i>Crataegus uniflora</i> | dwarf hawthorn | 1.3 | obovate cuneate |
| <i>Crataegus viridis</i> | green hawthorn | 1.7 | elliptic rhombic |
| <i>Cyrilla parvifolia</i> | littleleaf titi | 3.8 | elliptic obovate |
| <i>Cyrilla racemiflora</i> | swamp titi | 3.3 | oblong obovate |
| <i>Diospyros virginiana</i> | persimmon | 1.9 | oval elliptic ovate |
| <i>Elliottia racemosa</i> | Georgia plume | 2.5 | elliptic oblong |
| <i>Euonymus atropurpureus</i> | burningbush | 2.4 | elliptic ovate |
| <i>Fagus grandifolia</i> | American beech | 1.9 | oval elliptic ovate |
| <i>Forestiera acuminata</i> | swamp-privet | 4.0 | ovate rhombic |
| <i>Forestiera segregata</i> | Florida-privet | 2.8 | elliptic rhombic |
| <i>Franklinia alatamaha</i> | Franklin tree | 2.5 | oblong ovate obovate |
| <i>Gordonia lasianthus</i> | loblolly bay | 3.0 | elliptic ovate |
| <i>Halesia carolina</i> | little silverbell | 2.3 | oval elliptic obovate |
| <i>Halesia diptera</i> | two-wing silverbell | 1.8 | oval elliptic obovate |
| <i>Halesia tetraptera</i> | mountain silverbell | 1.7 | oval elliptic obovate |
| <i>Hamamelis virginiana</i> | American witch-hazel | 1.7 | oval obovate |
| <i>Ilex ambigua</i> | Carolina holly | 2.0 | elliptic ovate |
| <i>Ilex amelanchier</i> | sarvis holly | 1.9 | elliptic ovate obovate |
| <i>Ilex cassine</i> | dahoon | 2.9 | oblong obovate |
| <i>Ilex coriacea</i> | large gallberry | 1.7 | elliptic obovate |
| <i>Ilex decidua</i> | possumhaw | 2.5 | ovate obovate spatulate |
| <i>Ilex longipes</i> | Georgia holly | 2.0 | ovate obovate |
| <i>Ilex montana</i> | mountain holly | 2.3 | oval ovate |
| <i>Ilex myrtifolia</i> | myrtle dahoon | 4.0 | elliptic lanate |
| <i>Ilex opaca</i> | American holly | 2.7 | oval ovate |
| <i>Ilex verticillata</i> | winterberry | 2.1 | elliptic obovate |
| <i>Ilex vomitoria</i> | yaupon | 3.4 | oval elliptic |
| <i>Illicium floridanum</i> | Florida anisetree | 3.0 | elliptic ovate |
| <i>Illicium parviflorum</i> | yellow anisetree | 2.5 | elliptic |

Figure 15: Native tree species simple leaf shape descriptions and length:width ratios. (continued)

| scientific name | common name | L:W | description |
|--------------------------------|---------------------|------------|------------------------------|
| <i>Kalmia latifolia</i> | mountain-laurel | 2.7 | elliptic ovate |
| <i>Leitneria floridana</i> | corkwood | 2.4 | elliptic ovate lanceolate |
| <i>Liquidambar styraciflua</i> | sweetgum | 1.0 | orbicular suborbicular |
| <i>Liriodendron tulipifera</i> | yellow-poplar | 1.0 | oblate orbicular |
| <i>Lyonia ferruginea</i> | staggerbush | 3.5 | elliptic oblong |
| <i>Magnolia acuminata</i> | mt. cucumber-tree | 1.5 | oval ovate |
| <i>Magnolia cordata</i> | Pied. cucumber-tree | 2.0 | oblong obovate |
| <i>Magnolia fraseri</i> | mountain magnolia | 2.3 | obovate |
| <i>Magnolia grandiflora</i> | Southern magnolia | 1.6 | oval elliptic |
| <i>Magnolia macrophylla</i> | bigleaf magnolia | 3.0 | oblong obovate |
| <i>Magnolia pyramidata</i> | pyramid magnolia | 2.0 | obovate |
| <i>Magnolia tripetala</i> | umbrella-tree | 2.0 | oval elliptic obovate |
| <i>Magnolia virginiana</i> | sweetbay | 2.4 | oval elliptic oblong |
| <i>Malus angustifolia</i> | Southern crabapple | 1.7 | oval elliptic |
| <i>Malus coronaria</i> | sweet crabapple | 2.2 | ovate |
| <i>Morus rubra</i> | red mulberry | 1.5 | suborbicular ovate |
| <i>Myrica cerifera</i> | wax-myrtle | 5.8 | oblanceolate |
| <i>Myrica heterophylla</i> | evergreen bayberry | 2.2 | elliptic obovate |
| <i>Myrica inodora</i> | odorless bayberry | 2.7 | elliptic obovate |
| <i>Nyssa aquatica</i> | water tupelo | 2.0 | oval ovate |
| <i>Nyssa biflora</i> | swamp tupelo | 1.8 | elliptic lanate oblanceolate |
| <i>Nyssa ogeche</i> | Ogeeche-lime | 2.2 | oval elliptic oblong |
| <i>Nyssa sylvatica</i> | blackgum | 1.7 | oval elliptic oblong |
| <i>Osmanthus americanus</i> | devilwood | 3.3 | elliptic ovate |
| <i>Ostrya virginiana</i> | Eastern hophornbeam | 2.5 | oval ovate |
| <i>Oxydendrum arboreum</i> | sourwood | 2.8 | oval elliptic ovate |
| <i>Persea borbonia</i> | red-bay | 3.3 | elliptic ovate |
| <i>Persea palustris</i> | swamp-bay | 3.0 | oval elliptic ovate |
| <i>Pinckneya bracteata</i> | fevertree | 2.0 | oval elliptic |
| <i>Planera aquatica</i> | water-elm | 2.5 | ovate deltoid |
| <i>Platanus occidentalis</i> | American sycamore | 1.0 | orbiculate oval ovate |
| <i>Populus deltoides</i> | Eastern cottonwood | 1.5 | ovate deltoid |
| <i>Populus heterophylla</i> | swamp cottonwood | 1.3 | ovate deltoid |
| <i>Prunus alabamensis</i> | Alabama cherry | 1.8 | oval ovate |
| <i>Prunus americana</i> | American plum | 2.2 | oval elliptic obovate |
| <i>Prunus angustifolia</i> | Chickasaw plum | 2.5 | ovate |

Figure 15: Native tree species simple leaf shape descriptions and length:width ratios. (continued)

| scientific name | common name | L:W | description |
|-------------------------------|----------------------|------------|----------------------------|
| <i>Prunus caroliniana</i> | laurelcherry | 2.7 | elliptic |
| <i>Prunus pensylvanica</i> | fire cherry | 3.8 | elliptic falcate |
| <i>Prunus serotina</i> | black cherry | 2.8 | elliptic |
| <i>Prunus umbellata</i> | flatwoods plum | 1.9 | elliptic ovate |
| <i>Quercus alba</i> | white oak | 2.0 | elliptic obovate |
| <i>Quercus arkansana</i> | Arkansas oak | 1.7 | ovate obovate |
| <i>Quercus austrina</i> | bluff oak | 2.0 | obovate |
| <i>Quercus breviloba</i> | Gulf oak | 2.0 | elliptic obovate |
| <i>Quercus chapmanii</i> | Chapman oak | 2.1 | oblong obovate |
| <i>Quercus coccinea</i> | scarlet oak | 1.3 | oval elliptic obovate |
| <i>Quercus falcata</i> | Southern red oak | 1.6 | elliptic ovate |
| <i>Quercus geminata</i> | sand live oak | 2.0 | elliptic |
| <i>Quercus georgiana</i> | Georgia oak | 1.6 | oval elliptic |
| <i>Quercus hemisphaerica</i> | laurel oak | 2.6 | elliptic ovate |
| <i>Quercus imbricaria</i> | shingle oak | 2.7 | elliptic oblong lanceolate |
| <i>Quercus incana</i> | bluejack oak | 3.2 | elliptic oblong ovate |
| <i>Quercus laevis</i> | turkey oak | 1.3 | oval ovate deltoid |
| <i>Quercus laurifolia</i> | swamp laurel oak | 2.8 | oblong ovate rhombic |
| <i>Quercus lyrata</i> | overcup oak | 1.9 | oblong |
| <i>Quercus margaretta</i> | sand post oak | 1.6 | obovate |
| <i>Quercus marilandica</i> | blackjack oak | 1.2 | obovate obdeltoid |
| <i>Quercus michauxii</i> | swamp chestnut oak | 1.8 | obovate |
| <i>Quercus minima</i> | dwarf live oak | 2.4 | obovate oblanceolate |
| <i>Quercus montana</i> | chestnut oak | 2.6 | oval elliptic obovate |
| <i>Quercus muehlenbergii</i> | chinquapin oak | 1.9 | elliptic ovate obovate |
| <i>Quercus myrtifolia</i> | myrtle oak | 2.0 | elliptic obovate |
| <i>Quercus nigra</i> | water oak | 2.3 | oblong obovate cuneate |
| <i>Quercus oglethorpensis</i> | Oglethorpe oak | 3.3 | elliptic obovate |
| <i>Quercus pagoda</i> | cherrybark oak | 1.9 | ovate obovate |
| <i>Quercus palustris</i> | pin oak | 1.3 | elliptic oblong |
| <i>Quercus phellos</i> | willow oak | 4.8 | lanate lanceolate |
| <i>Quercus prinoides</i> | dwarf chinquapin oak | 2.2 | obovate |
| <i>Quercus rubra</i> | Northern red oak | 1.6 | oval elliptic |
| <i>Quercus shumardii</i> | Shumard's oak | 1.5 | oval elliptic oblong |
| <i>Quercus similis</i> | swamp post oak | 2.4 | obovate |
| <i>Quercus sinuata</i> | bastard (Durand) oak | 2.7 | elliptic ovate rhombic |
| <i>Quercus stellata</i> | post oak | 1.5 | oval obovate |
| <i>Quercus velutina</i> | black oak | 1.6 | oval obovate |
| <i>Quercus virginiana</i> | live oak | 2.1 | elliptic oblong |

Figure 15: Native tree species simple leaf shape descriptions and length:width ratios. (continued)

| scientific name | common name | L:W | description |
|---------------------------------|----------------------|------------|-------------------------------|
| <i>Rhamnus caroliniana</i> | buckthorn | 3.0 | oval elliptic |
| <i>Rhododendron catawbiense</i> | purple-laurel | 2.3 | oval elliptic |
| <i>Rhododendron maximum</i> | rosebay-laurel | 3.3 | elliptic oblong |
| <i>Salix caroliniana</i> | Coastal Plain willow | 5.0 | ovate lanceolate |
| <i>Salix floridana</i> | Florida willow | 3.0 | elliptic oblong |
| <i>Salix nigra</i> | black willow | 6.3 | lanceolate falcate |
| <i>Salix sericea</i> | silky willow | 4.0 | elliptic lanceolate |
| <i>Sassafras albidum</i> | sassafras | 1.3 | elliptic ovate |
| <i>Sideroxylon lanuginosa</i> | gum bumelia | 3.0 | elliptic obovate cuneate |
| <i>Sideroxylon lycioides</i> | buckthorn bumelia | 3.1 | elliptic oblanceolate cuneate |
| <i>Sideroxylon tenax</i> | tough bumelia | 2.1 | obovate cuneate |
| <i>Stewartia malacodendron</i> | silky camellia | 2.1 | oval elliptic |
| <i>Stewartia ovata</i> | mountain camellia | 1.9 | elliptic ovate |
| <i>Styrax americanus</i> | American snowbell | 1.8 | oval ovate |
| <i>Styrax grandifolius</i> | bigleaf snowbell | 1.4 | orbiculate oval |
| <i>Symplocos tinctoria</i> | sweetleaf | 2.5 | elliptic ovate |
| <i>Tilia americana</i> | American basswood | 1.2 | orbiculate oval ovate cordate |
| <i>Tilia caroliniana</i> | Carolina basswood | 1.1 | orbiculate ovate |
| <i>Tilia floridana</i> | Florida basswood | 1.6 | orbiculate ovate |
| <i>Tilia heterophylla</i> | white basswood | 1.2 | orbiculate ovate |
| <i>Ulmus alata</i> | winged elm | 2.1 | elliptic ovate obovate |
| <i>Ulmus americana</i> | American elm | 2.2 | elliptic ovate |
| <i>Ulmus rubra</i> | slippery elm | 2.1 | oval ovate |
| <i>Ulmus serotina</i> | September elm | 1.9 | elliptic ovate |
| <i>Vaccinium arboreum</i> | farkleberry | 1.9 | oval elliptic obovate |
| <i>Viburnum cassinoides</i> | Northern possumhaw | 1.9 | elliptic ovate |
| <i>Viburnum dentatum</i> | Southern arrowwood | 1.1 | oval ovate |
| <i>Viburnum lentago</i> | nannyberry | 1.6 | elliptic |
| <i>Viburnum nudum</i> | Southern possumhaw | 2.0 | elliptic |
| <i>Viburnum obovatum</i> | small-leaf arrowwood | 1.9 | obovate spatulate |
| <i>Viburnum prunifolium</i> | blackhaw | 1.5 | oval elliptic |
| <i>Viburnum rufidulum</i> | rusty blackhaw | 1.6 | elliptic |
| <i>Yucca aloifolia</i> | Spanish-bayonet | 11.1 | lanate |
| <i>Yucca gloriosa</i> | moundlilly yucca | 10.9 | lanate |

Figure 15: Native tree species simple leaf shape descriptions and length:width ratios. (continued)

| scientific name | common name | L:W | description |
|-----------------------------------|----------------------|-----|-----------------------------|
| <i>Acer negundo</i> | boxelder | 1.8 | elliptic ovate |
| <i>Aesculus flava</i> | yellow buckeye | 3.0 | elliptic obovate |
| <i>Aesculus glabra</i> | Ohio buckeye | 2.4 | elliptic obovate |
| <i>Aesculus parviflora</i> | bottlebrush buckeye | 2.0 | lanceolate obovate |
| <i>Aesculus pavia</i> | red buckeye | 2.5 | elliptic |
| <i>Aesculus sylvatica</i> | Georgia buckeye | 2.4 | elliptic ovate |
| <i>Aralia spinosa</i> | devil's walkingstick | 2.7 | elliptic ovate |
| <i>Carya aquatica</i> | water hickory | 3.3 | ovate lanceolate falcate |
| <i>Carya australis</i> | Southern shag hick | 2.9 | ovate obovate |
| <i>Carya cordiformis</i> | bitternut hickory | 5.5 | ovate lanceolate |
| <i>Carya glabra</i> | pignut hickory | 1.7 | ovate obovate |
| <i>Carya laciniosa</i> | shellbark hickory | 1.9 | ovate lanceolate obovate |
| <i>Carya myristiciformis</i> | nutmeg hickory | 2.3 | ovate |
| <i>Carya ovalis</i> | red hickory | 3.5 | ovate |
| <i>Carya ovata</i> | shagbark hickory | 1.6 | elliptic ovate obovate |
| <i>Carya pallida</i> | sand hickory | 2.7 | elliptic ovate |
| <i>Carya tomentosa</i> | mockernut hickory | 2.0 | oval elliptic ovate |
| <i>Cladrastis kentukea</i> | yellowwood | 2.3 | elliptic ovate |
| <i>Fraxinus americana</i> | white ash | 2.0 | elliptic ovate |
| <i>Fraxinus caroliniana</i> | Carolina ash | 2.3 | oval ovate |
| <i>Fraxinus pennsylvanica</i> | green ash | 3.3 | elliptic ovate |
| <i>Fraxinus profunda</i> | pumpkin ash | 2.3 | oval ovate |
| <i>Fraxinus quadrangulata</i> | blue ash | 3.0 | ovate lanceolate |
| <i>Gleditsia aquatica</i> | water locust | 2.3 | oblong |
| <i>Gleditsia triacanthos</i> | honeylocust | 2.5 | oval oblong |
| <i>Juglans cinerea</i> | butternut | 1.8 | oblong ovate lanceolate |
| <i>Juglans nigra</i> | black walnut | 2.0 | ovate lanceolate |
| <i>Ptelea trifoliata</i> | hoptree | 2.0 | elliptic ovate |
| <i>Rhus copallinum</i> | winged sumac | 2.3 | oblong ovate lanceolate |
| <i>Rhus glabra</i> | smooth sumac | 2.7 | ovate |
| <i>Rhus typhina</i> | staghorn sumac | 4.4 | ovate lanceolate falcate |
| <i>Robinia hispida</i> | pink locust | 1.9 | oval |
| <i>Robinia pseudoacacia</i> | black locust | 2.4 | oval elliptic |
| <i>Robinia viscosa</i> | clammy locust | 1.9 | oval elliptic ovate |
| <i>Sambucus canadensis</i> | American elder | 2.0 | elliptic |
| <i>Sambucus simpsonii</i> | Southern elder | 3.8 | elliptic ovate |
| <i>Sapindus marginatus</i> | Florida soapberry | 2.4 | elliptic lanceolate falcate |
| <i>Sorbus americana</i> | Amer. mountain-ash | 3.9 | lanceolate |
| <i>Staphylea trifolia</i> | bladdernut | 3.3 | elliptic |
| <i>Toxicodendron vernix</i> | poison sumac | 1.8 | elliptic ovate |
| <i>Zanthoxylum americanum</i> | prickly-ash | 1.5 | elliptic ovate |
| <i>Zanthoxylum clava-herculis</i> | Hercules' club | 2.0 | ovate lanceolate falcate |

Figure 16: Native tree species compound leaf / leaflet shape descriptions and length:width ratios.

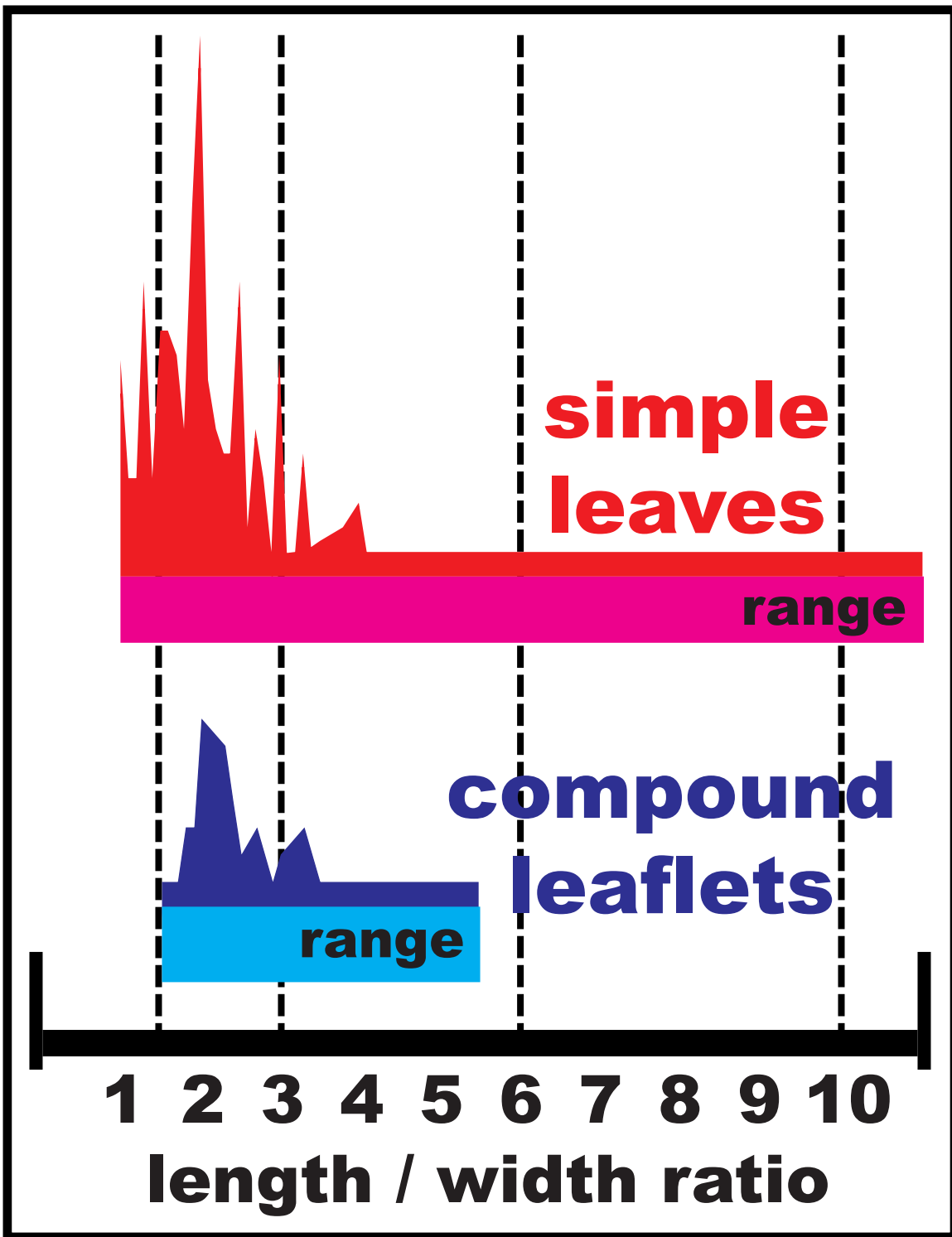


Figure 17: Range and distribution of leaf / leaflet length:width ratios for native trees.
 Note between 1.5:1 and 3.3:1 length:width ratios lie most native trees

LEAF / LEAFLET SHAPE DESCRIPTORS

| descriptor | simple leaf | compound leaflet |
|---------------------|--------------|------------------|
| oblate | 0.3% | — |
| orbicular | 1.0% | — |
| suborbicular | 2.0% | — |
| orbiculate | 2.6% | — |
| oval | 14.0% | 8% |
| elliptic | 27.0% | 24% |
| oblong | 6.0% | 4% |
| lanate | 1.3% | — |
| ovate | 21.0% | 36% |
| lanceolate | 2.0% | 14% |
| obovate | 14.5% | 9% |
| oblanceolate | 1.0% | — |
| cuneate | 2.0% | — |
| rhombic | 1.5% | — |
| deltoid | 1.3% | — |
| spatulate | 1.0% | — |
| cordate | 0.6% | — |
| falcate | 0.6% | 5% |
| obdeltoid | 0.3% | — |

Figure 18: Percent of shape descriptors used for native tree species leaves / leaflets. (225 species / 469 descriptors)

pound leaves had 85 different descriptors applied to leaflet shapes of 42 species. For compound leaflets, there were nine (9) single word entry descriptors, 23 double entry descriptors, and ten (10) triple descriptors for leaflets shape.

Native trees with simple leaves had 384 different shape descriptor terms applied for 183 tree species. For simple leaves, there were 26 single word entry descriptors, 114 double entry descriptors, 42 triple entry descriptors, and a single species whose composite shape was described by four descriptor terms across multiple authors. Note for many tree species, multiple authors could not determine shape with a single word concept, or for some trees, could not determine shape even with two word descriptions.

Gymnos

There are few general gymnosperm / needle-like leaf shapes usually cited. Many gymnosperm trees have needle, scale, or awl shaped leaves. Needle shaped leaves are also described as acerose (meaning needle-shaped), or acicular (meaning slender needle-shaped). Needle is a general term for linear or acicular shaped leaves (i.e. *Pinus* spp.).

Scale-like leaves are small, short, overlapping, sessile and appressed to the twig. Awl-like or subulate leaves are short, narrow, stiff, and sharp pointed (i.e. *Juniperus* spp). Figure 19 provides native gymnosperm tree leaf / needle number per bundle, average length in inches, and length:width ratios. The length:width ratios for needle leaf trees are not highly descriptive.

Confusions

When word concepts are used to define and describe biological structures under changing conditions over a single growing season or over many years, as well as for many individual trees and populations, confusion regarding leaf / leaflet shape definitions among observers will exist. Across a number of authors there has been variation and lack of precision using several shape descriptive terms. Three simple examples of descriptive confusion are given below:

- 1) Oval versus elliptical leaf shapes -- some authors use the term “broadly elliptical” shape, while others use the term “oval” shape to symbolize the same leaf shape. Some authors do not use the term “oval.”
- 2) Lance-shaped versus lanceolate leaf shapes -- some authors use “lance-shaped” for all ovate and lanceolate shapes, while others use separate “ovate” and “lanceolate” terms. Some authors use “broadly ovate” for “ovate” shapes, and “narrowly ovate” for “lanceolate.”
- 3) Elongated elliptical versus oblong leaf shapes -- some authors use the term “elongated elliptical” shape for “oblong” leaf shapes.

There are many other examples of indeterminate or variable shape definition among authors. Tree leaf shapes are in the eye, mind, and training of the beholder. Each tree observer can be quite precise for their own work, but shape definitions may not translate exactly across studies by other authors.

Leaf / Leaflet Ends

Each tree leaf can be divided into three length portions: a middle third; an apical third; and, a basal third. Figure 20. The shapes of these specific leaf areas can help better define and describe a tree leaf for identification. Once a general leaf/leaflet shape is determined using methods above, the leaf / leaflet tip, base, and margin can be defined.

NEEDLE / SCALE / AWL SHAPED LEAVES

| scientific name | common name | needle number | needle length | L:W |
|-------------------------------|---------------------|---------------|---------------|-----|
| <i>Abies fraseri</i> | Fraser fir | 1 | 1 | 8 |
| <i>Chamaecyparis thyoides</i> | Atlantic whitecedar | scale | 0.1 | -- |
| <i>Juniperus communis</i> | common juniper | scale / awl | 0.1 | -- |
| <i>Juniperus silicicola</i> | Southern redcedar | scale / awl | 0.1 | -- |
| <i>Juniperus virginiana</i> | Eastern redcedar | scale / awl | 0.1 | -- |
| <i>Pinus echinata</i> | shortleaf pine | 2-3 | 4 | 32 |
| <i>Pinus elliotii</i> | slash pine | 2-3 | 9 | 72 |
| <i>Pinus glabra</i> | spruce pine | 2 | 3 | 24 |
| <i>Pinus palustris</i> | longleaf pine | 3 | 14 | 112 |
| <i>Pinus pungens</i> | table mountain pine | 2-3 | 2 | 16 |
| <i>Pinus rigida</i> | pitch pine | 2-3-5 | 4 | 32 |
| <i>Pinus serotina</i> | pond pine | 3-5 | 7 | 56 |
| <i>Pinus strobus</i> | Eastern white pine | 5 | 4 | 32 |
| <i>Pinus taeda</i> | loblolly pine | 3 | 7 | 56 |
| <i>Pinus virginiana</i> | Virginia pine | 2 | 2 | 16 |
| <i>Taxodium ascendens</i> | pond-cypress | 1 | 0.5 | 4 |
| <i>Taxodium distichum</i> | bald-cypress | 1 | 0.5 | 4 |
| <i>Torreya taxifolia</i> | torreya | 1 | 1.5 | 12 |
| <i>Tsuga canadensis</i> | Eastern hemlock | 1 | 0.75 | 6 |
| <i>Tsuga caroliniana</i> | Carolina hemlock | 1 | 0.75 | 6 |

Figure 19: Native gymnosperm tree leaf / needle number per bundle, average length in inches, and length:width ratios.

Note length:width ratios in needle leaf trees are not highly descriptive.

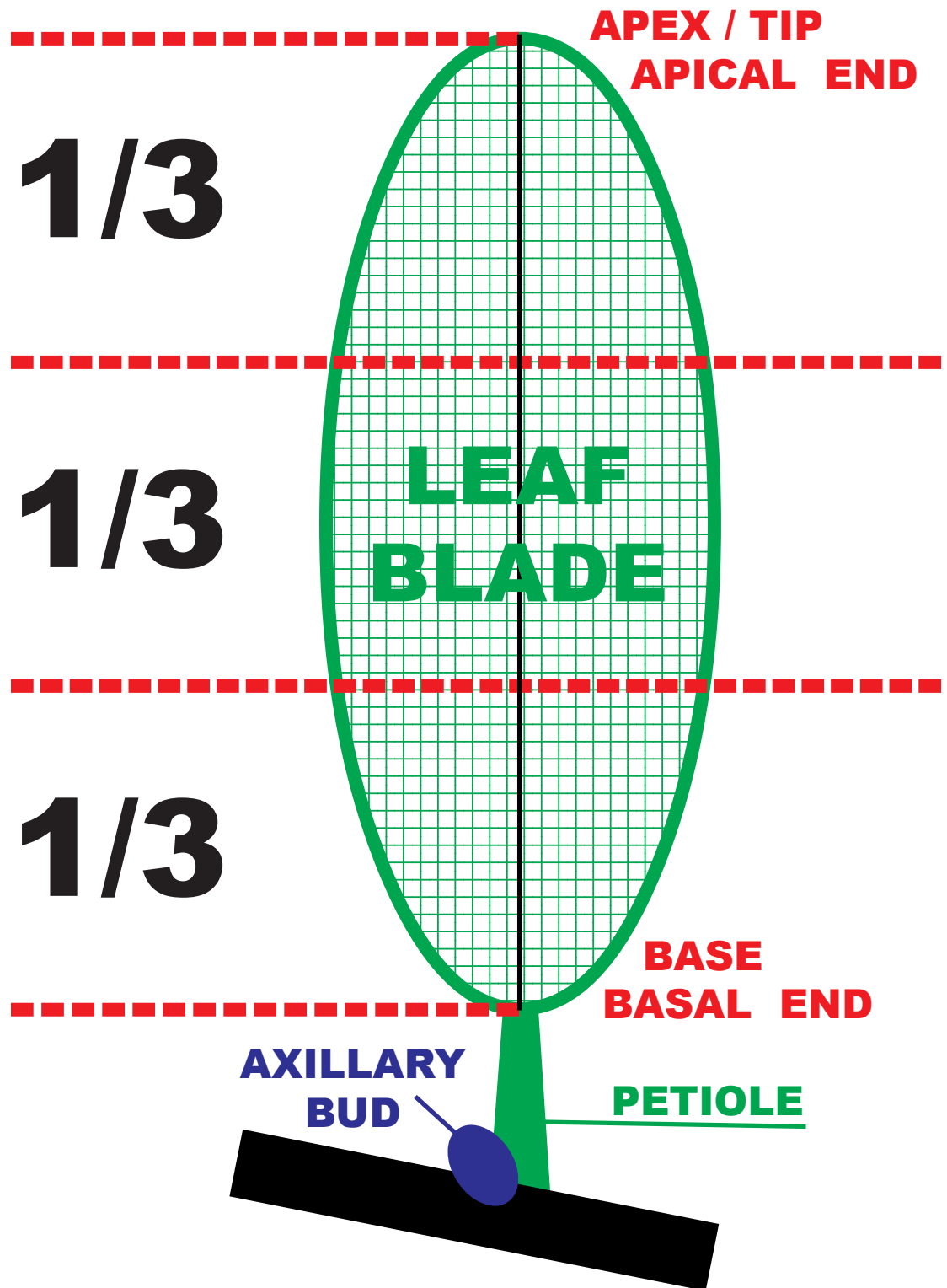


Figure 20: Simple leaf showing three areas of a leaf blade -- tip, middle, and base thirds. The axillary bud is not part of a leaf, but grows from the twig at the base of a leaf and shows where a leaf begins.

Tips

The apex or tip area of a leaf or leaflet is the apical 33% of leaf length. A rounded leaf apex has a smooth arc at its tip. An obtuse leaf tip shape is pointed at an angle $>90^\circ$. An acute tip is short pointed with an angle $<90^\circ$. An acute leaf apex shape has many more subtle or more precise descriptions. Subacute is a leaf end with a slightly sharp and short pointed tip with an angle of $<90^\circ$. Cuspidate end shape has a sharp, short, stiff, thick point. Pungens end shape has a rigid, sharp, thick point.

An acuminate end shape has a long, narrow, gradually tapered pointed tip with an angle $<90^\circ$. Aristate end shapes are narrowed to a point with a stiff bristle at its tip. Aristulate shapes have a minute point with a stiff bristle at the tip. Attenuate is a slender, long-tapering tip with an angle $<90^\circ$. Caudate end shape has a tail-like, long, slender tip. Apiculate has a minute, short, slender, abrupt pointed tip. Figure 21. There exist differences in author perceptions and naming of apical tips between terms “acute” and “acuminate.”

Notched

Three terms help describe leaf tips with notches: retuse has a shallow narrow notch in a round tip; emarginate has a shallow broad notch; and, obcordate has an inverse heart-shaped with wide notch in the tip. Figure 22. Leaf tips can appear truncated or cut-off, and three nearly identical terms can help describe this form: truncate is where the leaf end appear cutoff straight across, perpendicular to the midvein; and, abrupt or praemorse where the leaf tip is terminated abruptly or suddenly.

Figure 23 shows the percent of native tree species with different apical / tip forms. Note most native tree species leaf / leaflet apical tip descriptors are concentrated in the acute and acuminate forms.

Very End

The most apical portion of a leaf or leaflet is the terminal end point. At the very end of the apical part of a leaf can be a characteristic apex tip or terminal point. An apex terminus is the end-most point of a leaf margin where the midvein ends.

There are five general terms usually used in describing the terminus or end-point of a leaf: mucronate is where the midvein ends with a short small peg-like bristle; mucronulate is where the midvein ends with a minute short small peg-like bristle; spinose is where the midvein ends with a sharp or dull spine; retuse is where the midvein ends at a shallow sinus; and, muticous is where the midvein end is blunt with no point or spine.

Bases

Tree leaves and leaflets can have distinct shaped or forms of leaf bases. The leaf / leaflet attachment point to its supporting twig can be in three types. Leaf lamina can be attached directly to a twig and is called sessile. Lamina can also be attached to the twig with a petiole (simple leaf), or a rachis (compound leaf). Figure 24. A leaf / leaflet base or bottom represents an area of the basal or bottom 33% of leaf length. Shapes are described around any protruding petiole or rachis, and represent just the leaf blade basal portion. Figure 25 shows selected leaf / leaflet basal forms.

Leaf base shapes can be rounded with a smooth arc, or form an obtuse angle ($>90^\circ$). Leaf base shapes can be acute which is pointed with an angle of $<90^\circ$. A cuneate base is wedge-shaped with an angle $<90^\circ$. A decurrent leaf base shows a progressively decreasing angle as the petiole is approached, with an angle $<90^\circ$.

A truncate leaf base appears cutoff straight across the blade, perpendicular to the midvein. The term flat can also be used to describe the leaf lamina attached to its petiole / rachis at 90° to make a

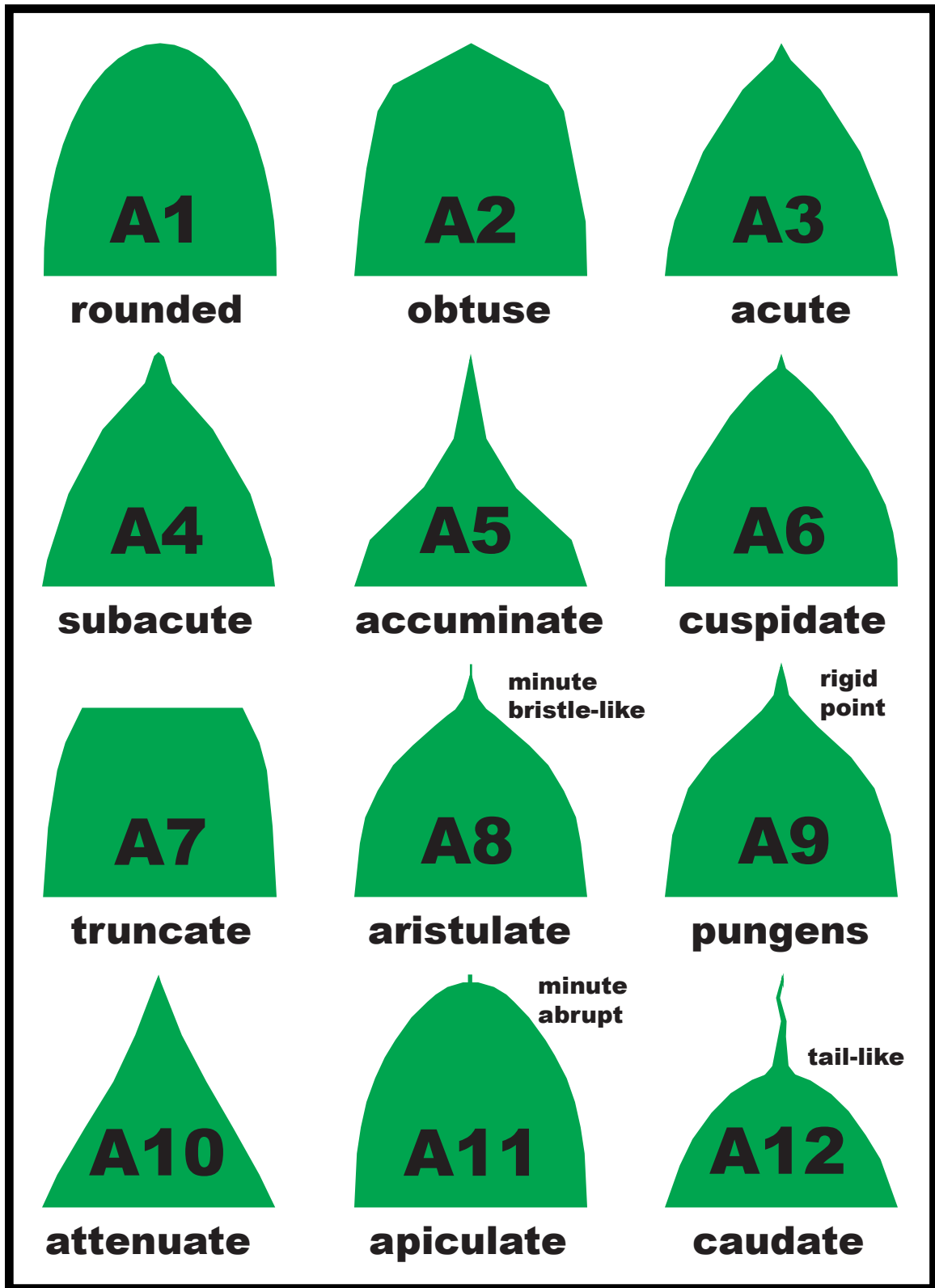


Figure 21: Tree leaf / leaflet apical end / tip shapes, identification codes, and names.



retuse
(narrow shallow)



emarginate
(wide shallow)



obcordate
(wide deep)

Figure 22: Tree leaf / leaflet apical tip notch shapes, names, and codes.

TIP DESCRIPTORS

| code | form / shape name | percent |
|---|--------------------------|----------------|
| A1 | = ROUNDED | 15% |
| A2 | = OBTUSE | 15% |
| A3 | = ACUTE | 36% |
| A4 | = SUBACUTE | 2% |
| A5 | = ACCUMINATE | 24% |
| A6 | = CUSPIDATE | 5% |
| A7 | = TRUNCATE | 0.3% |
| A8 | = ARISTULATE | 0.3% |
| A9 | = PUNGENS | 0.7% |
| A10 | = ATTENUATE | 0.3% |
| A11 | = APICULATE | — |
| A12 | = CAUDATE | — |
| A13 | = RETUSE | 1% |
| A14 | = EMARGINATE | 0.4% |
| total = 385 leaf / leaflet tip descriptors | | |

Figure 23: Percent of native tree species with leaves / leaflets having specific tip forms or shapes.

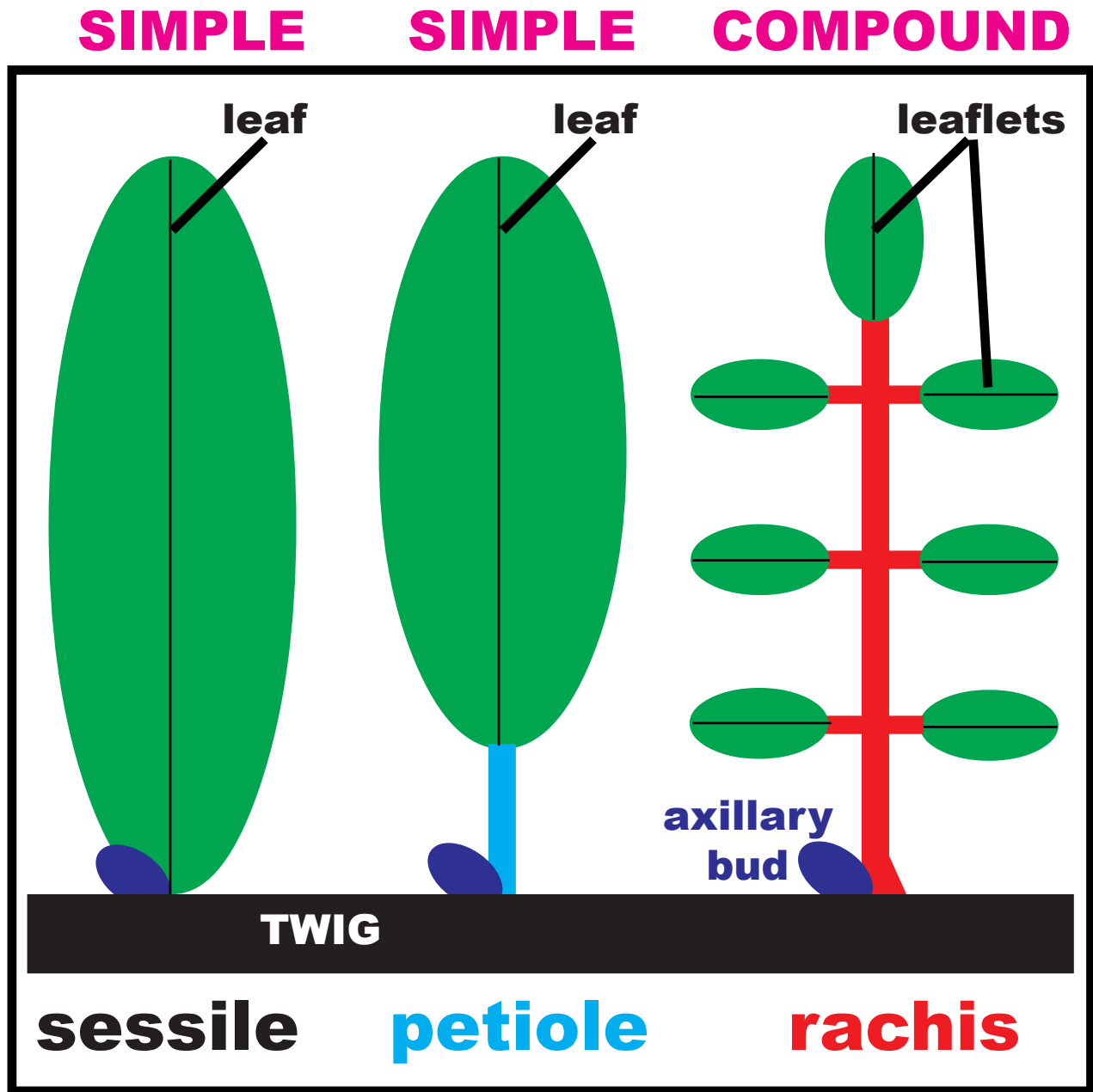


Figure 24: Tree leaf base attachment forms.

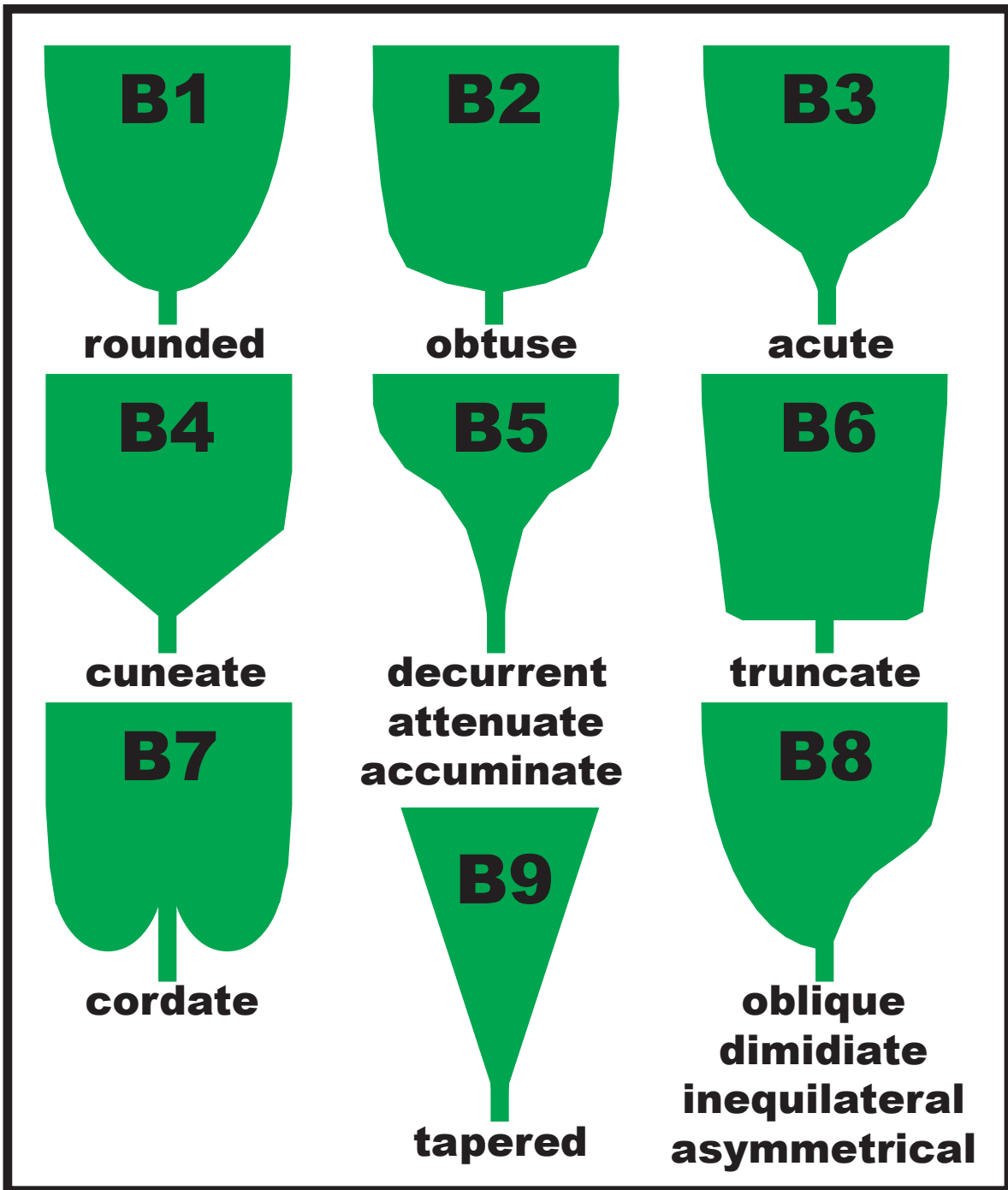


Figure 25: Tree leaf / leaflet base shapes, identification code, and name.

BASE DESCRIPTORS

| code | form / shape name | percent |
|---|--|----------------|
| B1 | = ROUNDED | 24% |
| B2 | = OBTUSE | 6% |
| B3 | = ACUTE | 14% |
| B4 | = CUNEATE | 22% |
| B5 | = DECURRENT, ATTENUATE, ACCUMINATE | 6% |
| B6 | = TRUNCATE | 3% |
| B7 | = CORDATE | 6% |
| B8 | = OBLIQUE, DIMIDIATE, INEQUILATERAL, ASYMMETRICAL | 6% |
| B9 | = TAPERED | 12% |
| B10 | = AURICULATE | 0.8% |
| B11 | = SAGITTATE | — |
| B12 | = HASTATE | 0.2% |
| total = 430 leaf / leaflet tip descriptors | | |

Figure 26: Percent of native tree species with leaves / leaflets having specific base forms or shapes.

straight linear base. Cordate leaf bases have a sinus making a heart-shape. Figure 26 provides the percent of native tree species with different basal / base forms. Note base descriptors "rounded" and "cuneate" (wedge-shaped) comprise a large number of native tree species base shapes. There are differences between authors in using the terms "cuneate" and "tapered" base, which leads to description problems.

Basal Peculiarities

Several terms are used to describe leaf base lobes or projections. A lobate leaf base has projections. Figure 27. Auriculate has small rounded lobes at the leaf base beside the petiole. Saggitate has large pointed lobes at the leaf base. Hastate has large pointed lobes facing away from base at $>45^\circ$ angle. These lobes and projections may be further highlighted in leaves where the petiole attaches farther into the leaf blade than its base edge / margin. A peltate leaf base has a petiole which is attached in the middle of its leaf blade.

Some tree species have leaf / leaflet bases which are not symmetrical across the petiole connection. An oblique, dimidiate, or inequilateral leaf base is asymmetrical or lop-sided. A leaf base which is equal on both sides of the petiole junction is termed aequilateral. A leaf base is termed clasping when its blade partially or completely surrounds its twig.

Definition Flexibility

Because leaf shapes are subject to environmental stress, physiological dysfunction, and pests, leaves on a tree may not form as expected. Teratology means abnormal development or mistakes in shape formation and growth (i.e. a teratological error or fault in leaf shape).

Figure 28 is a long list of different native tree species leaf / leaflet tips and base forms. Remember these are all tips and bases which have been listed by authors for each species. These descriptors should be considered, and used as, composite forms or shapes. Figure 29 shows the code key for the previous figure, giving word descriptors for each tip or base code value.

Figure 30 summarizes native tree species leaf / leaflet tip and base forms. There were more (~6%) base descriptors than tip descriptors used by different authors. Observers categorized leaf / leaflet tips predominantly into five (5) different forms, while roughly categorizing most bases into nine (9) different forms.

Leaf / Leaflet Margins

Tree leaves have highly variable margins, many of which are unique and genetically conserved enough to help with species identification. Leaves can be divided into margins with no defining characters (i.e. straight, entire, or smooth), and margins which have projections or indentations.

Tree leaf margins are termed entire when the margin is a smooth edge without projections, indentations, or significant undulations. Additional terms for entire leaves are edentate which means no teeth or lobes, and smooth meaning an edge with no indentations. The words smooth and straight are generically used to represent entire leaf margins.

Indentations

Lobed and toothed leaf margins can be important attributes for tree identifications. Lobes on a leaf margin have sinuses between them which are indented $>25\%$ the leaf blade distance to the mid-vein (or leaf radius). Toothed leaf margins have projections or points with spaces between indented $<\sim 10\%$ the leaf blade distance to the mid-vein (or leaf radius). Generally lobes are large and consume large leaf surface areas, while marginal teeth are small running along the leaf edge.

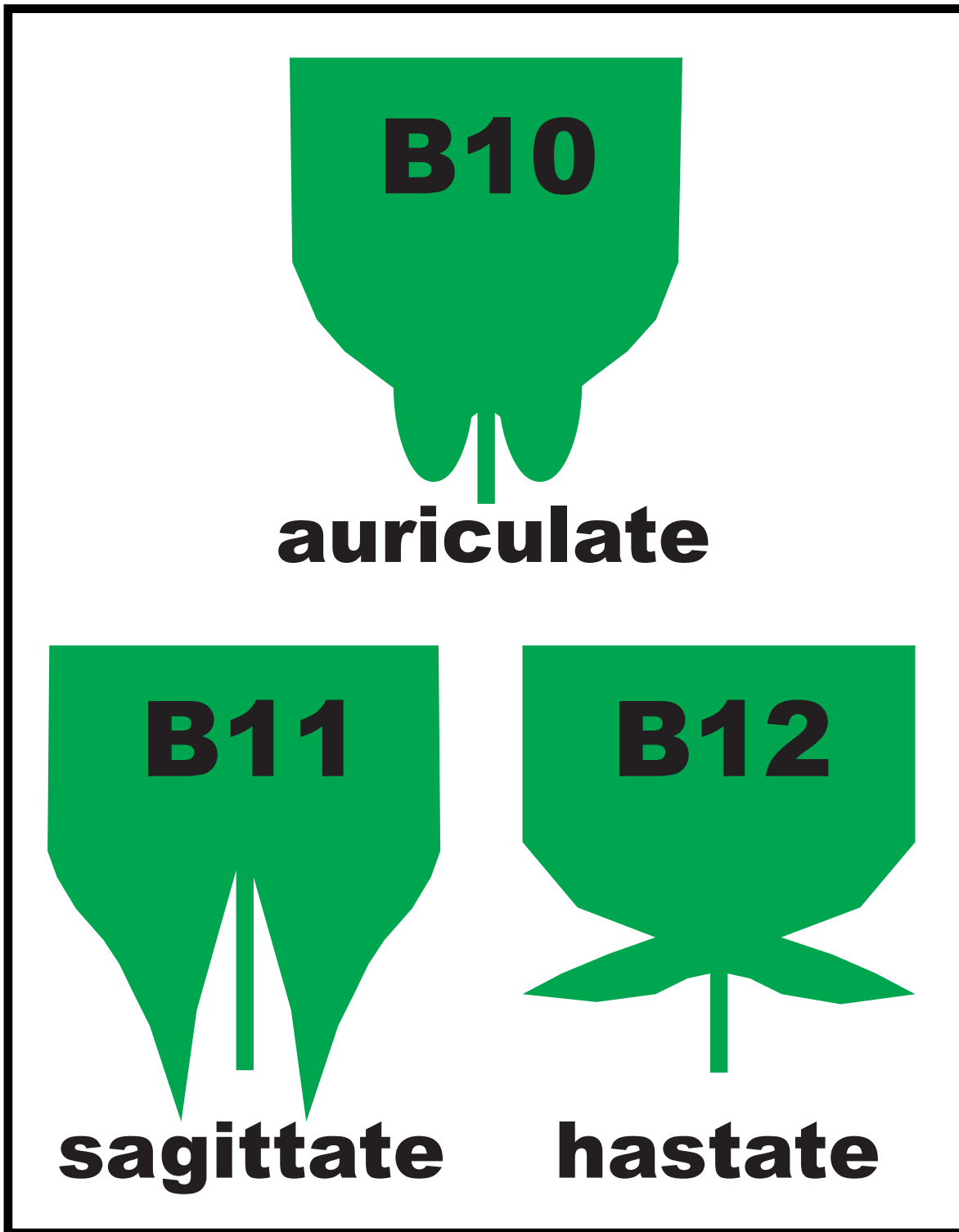


Figure 27: Basal lobes (lobate projections) on tree leaf / leaflet margins.

| scientific name | common name | tip form | base form |
|----------------------------------|---------------------------|----------|-------------|
| <i>Acer barbatum</i> | Southern sugar maple | A1 A3 | B7 |
| <i>Acer leucoderme</i> | chalk maple | A1 A5 | B7 |
| <i>Acer negundo</i> * | boxelder | A5 | B1 |
| <i>Acer nigrum</i> | black maple | A5 | B7 |
| <i>Acer pensylvanicum</i> | striped maple | A5 | B1 B7 |
| <i>Acer rubrum</i> | red maple | A3 A5 | B6 B7 |
| <i>Acer saccharinum</i> | silver maple | A5 | B6 |
| <i>Acer saccharum</i> | sugar maple | A5 | B6 B7 |
| <i>Acer spicatum</i> | Mountain maple | A3 A5 | B7 |
| <i>Aesculus flava</i> * | yellow buckeye | A3 A5 | B3 B4 B9 |
| <i>Aesculus glabra</i> * | Ohio buckeye | A5 | B4 B9 |
| <i>Aesculus parviflora</i> * | bottlebrush buckeye | A5 | B2 B4 |
| <i>Aesculus pavia</i> * | red buckeye | A3 | B3 B9 |
| <i>Aesculus sylvatica</i> * | Georgia buckeye | A3 | B9 |
| <i>Alnus serrulata</i> | hazel alder | A1 A2 | B1 |
| <i>Amelanchier arborea</i> | serviceberry | A2 A3 | B1 B7 |
| <i>Aralia spinosa</i> * | devil's walkingstick | A3 A5 | B1 B4 |
| <i>Asimina parviflora</i> | dwarf pawpaw | A3 A5 | B4 |
| <i>Asimina triloba</i> | pawpaw | A3 B3 | B5 B9 |
| <i>Baccharis halimifolia</i> | Eastern baccharis | A2 A3 | B5 B9 |
| <i>Betula alleghaniensis</i> | yellow birch | A3 A5 | B1 B7 B8 |
| <i>Betula lenta</i> | sweet birch | A3 A5 | B1 B7 |
| <i>Betula nigra</i> | river birch | A3 | B2 B4 |
| <i>Carpinus caroliniana</i> | S. American hornbeam | A3 A5 | B1 B8 |
| <i>Carya aquatica</i> * | water hickory | A5 | B1 B3 |
| <i>Carya australis</i> * | Southern shagbark hickory | A3 A5 | B4 B9 |
| <i>Carya cordiformis</i> * | bitternut hickory | A5 B1 | B4 B9 |
| <i>Carya glabra</i> * | pignut hickory | A3 A5 | B1 B4 |
| <i>Carya laciniosa</i> * | shellbark hickory | A3 A5 | B4 B9 |
| <i>Carya myristiciformis</i> * | nutmeg hickory | A3 A5 | B4 B9 |
| <i>Carya ovalis</i> * | red hickory | A2 A5 | B1 B8 |
| <i>Carya ovata</i> * | shagbark hickory | A3 A5 | B4 |
| <i>Carya pallida</i> * | sand hickory | A3 A5 | B4 B9 |
| <i>Carya tomentosa</i> * | mockernut hickory | A3 A5 | B4 B8 |
| <i>Castanea dentata</i> | American chestnut | A4 A5 | B3 |
| <i>Castanea pumila</i> | chinquapin | A3 | B1 B8 B10 |
| <i>Catalpa bignonioides</i> | Southern catalpa | A5 | B7 |
| <i>Celtis laevigata</i> | sugarberry | A3 A5 | B1 B3 |
| <i>Celtis occidentalis</i> | hackberry | A5 | B1 B2 B8 |
| <i>Celtis tenuifolia</i> | Georgia hackberry | A3 | B1 B8 |
| <i>Cephalanthus occidentalis</i> | buttonbush | A3 A5 | B1 B3 B4 B9 |
| <i>Cercis canadensis</i> | redbud | A3 | B6 B7 |
| <i>Chionanthus virginicus</i> | fringetree | A3 | B4 B5 B9 |
| <i>Cladrastis kentukea</i> * | yellowwood | A3 | B1 |
| <i>Clethra acuminata</i> | sweet pepperbush | A3 A5 | B2 B3 |

Figure 28: Native tree species leaf / leaflet composite tip and base form. (* = compound leaves)

| scientific name | common name | tip form | base form |
|---------------------------------|------------------------|-----------------|------------------|
| <i>Cliftonia monophylla</i> | buckwheat tree | A1 A2 A13 A14 | B4 B9 |
| <i>Cornus alternifolia</i> | alternate-leaf dogwood | A5 B1 | B4 |
| <i>Cornus florida</i> | flowering dogwood | A3 B1 | B5 |
| <i>Cornus foemina</i> | swamp dogwood | A3 A5 B1 | B3 |
| <i>Cotinus obovatus</i> | smoketree | A1 A2 A13 | B3 |
| <i>Crataegus aestivalis</i> | mayhaw | A2 A3 | B9 |
| <i>Crataegus aprica</i> | sunny hawthorn | A2 A3 | B4 B5 |
| <i>Crataegus calpodendron</i> | pear hawthorn | A3 A5 | B3 |
| <i>Crataegus crus-galli</i> | cockspur hawthorn | A2 A3 | B9 |
| <i>Crataegus flava</i> | yellow hawthorn | A1 A2 A3 | B4 B9 |
| <i>Crataegus intricata</i> | Biltmore hawthorn | A2 A3 | B1 B3 |
| <i>Crataegus marshallii</i> | parsley hawthorn | A2 A3 | B4 B6 |
| <i>Crataegus phaenopyrum</i> | Washington hawthorn | A3 | B4 B6 |
| <i>Crataegus pruinosa</i> | waxy-fruit hawthorn | A3 | B1 B2 |
| <i>Crataegus pulcherrima</i> | beautiful hawthorn | A3 | B9 |
| <i>Crataegus punctata</i> | dotted hawthorn | A1 A2 | B5 B9 |
| <i>Crataegus spathulata</i> | littlehip hawthorn | A1 | B9 |
| <i>Crataegus triflora</i> | three-flower hawthorn | A3 | B1 B2 |
| <i>Crataegus uniflora</i> | dwarf hawthorn | A1 A2 | B4 B9 |
| <i>Crataegus viridis</i> | green hawthorn | A3 | B9 |
| <i>Cyrilla parvifolia</i> | littleleaf titi | A2 A3 | B4 B9 |
| <i>Cyrilla racemiflora</i> | swamp titi | A1 A2 A3 A13 | B4 |
| <i>Diospyros virginiana</i> | persimmon | A3 A5 | B3 |
| <i>Elliottia racemosa</i> | Georgia plume | A3 A6 | B5 |
| <i>Euonymus atropurpureus</i> | burningbush | A5 | B1 B3 B4 |
| <i>Fagus grandifolia</i> | American beech | A3 A5 | B4 |
| <i>Forestiera acuminata</i> | swamp-privet | A3 A5 | B3 B4 B9 |
| <i>Forestiera segregata</i> | Florida-privet | A1 A2 | B3 B9 |
| <i>Franklinia alatomaha</i> | Franklin tree | A3 | B9 |
| <i>Fraxinus americana</i> * | white ash | A3 | B1 |
| <i>Fraxinus caroliniana</i> * | Carolina ash | A5 | B1 B4 |
| <i>Fraxinus pennsylvanica</i> * | green ash | A3 A5 | B3 B4 |
| <i>Fraxinus profunda</i> * | pumpkin ash | A3 A5 | B1 B4 |
| <i>Fraxinus quadrangulata</i> * | blue ash | A5 | B1 B3 |
| <i>Gleditsia aquatica</i> * | water locust | A1 | B1 |
| <i>Gleditsia triacanthos</i> * | honeylocust | A1 | B1 |
| <i>Gordonia lasianthus</i> | loblolly bay | A2 A3 | B4 |
| <i>Halesia carolina</i> | little silverbell | A3 A5 | B1 B4 |
| <i>Halesia diptera</i> | two-wing silverbell | A3 A5 | B1 B4 |
| <i>Halesia tetraptera</i> | mountain silverbell | A3 | B1 B4 |
| <i>Hamamelis virginiana</i> | American witch-hazel | A1 A3 A5 | B8 |
| <i>Ilex ambigua</i> | Carolina holly | A2 A5 | B3 B5 |
| <i>Ilex amelanchar</i> | sarvis holly | A3 | B1 B9 |
| <i>Ilex cassine</i> | dahoon | A1 A2 | B4 B9 |
| <i>Ilex coriacea</i> | large gallberry | A3 | B3 B4 |
| <i>Ilex decidua</i> | possumhaw | A2 A3 A5 | B4 B9 |

Figure 28: Native tree species leaf / leaflet composite tip and base form. CONTINUED (* = compound leaves)

| scientific name | common name | tip form | base form |
|--------------------------------|------------------------|----------|-------------|
| <i>Ilex longipes</i> | Georgia holly | A3 A5 | B4 B9 |
| <i>Ilex montana</i> | mountain holly | A3 A5 | B3 B4 |
| <i>Ilex myrtifolia</i> | myrtle dahoon | A6 A8 | B3 |
| <i>Ilex opaca</i> | American holly | A3 A6 A9 | B1 B2 |
| <i>Ilex verticillata</i> | winterberry | A4 A5 | B3 B5 |
| <i>Ilex vomitoria</i> | yaupon | A1 A2 | B1 |
| <i>Illicium floridanum</i> | Florida anisetree | A5 B3 | B4 |
| <i>Illicium parviflorum</i> | yellow anisetree | A1 A2 A3 | B1 B2 |
| <i>Juglans cinerea</i> * | butternut | A3 A5 | B1 B8 |
| <i>Juglans nigra</i> * | black walnut | A3 A5 | B1 B8 |
| <i>Kalmia latifolia</i> | mountain-laurel | A3 A6 | B3 B4 |
| <i>Leitneria floridana</i> | corkwood | A3 | B4 |
| <i>Liquidambar styraciflua</i> | sweetgum | A5 | B7 B12 |
| <i>Liriodendron tulipifera</i> | yellow-poplar | A7 A14 | B3 B6 |
| <i>Lyonia ferruginea</i> | staggerbush | A1 A2 A6 | B5 B9 |
| <i>Magnolia acuminata</i> | mountain cucumber-tree | A3 | B1 B3 B4 |
| <i>Magnolia cordata</i> | Piedmont cucumber-tree | A3 | B1 B4 |
| <i>Magnolia fraseri</i> | mountain magnolia | A2 A3 | B5 B10 |
| <i>Magnolia grandiflora</i> | Southern magnolia | A3 A4 | B3 |
| <i>Magnolia macrophylla</i> | bigleaf magnolia | A2 A3 | B1 B7 B10 |
| <i>Magnolia pyramidata</i> | pyramid magnolia | A2 A3 | B10 |
| <i>Magnolia tripetala</i> | umbrella-tree | A2 A3 | B3 B4 |
| <i>Magnolia virginiana</i> | sweetbay | A2 A3 | B1 B3 B4 |
| <i>Malus angustifolia</i> | Southern crabapple | A2 A5 | B3 |
| <i>Malus coronaria</i> | sweet crabapple | A2 A3 | B1 B4 |
| <i>Morus rubra</i> | red mulberry | A3 A5 | B2 B6 B7 B8 |
| <i>Myrica cerifera</i> | wax-myrtle | A1 A3 | B4 B9 |
| <i>Myrica heterophylla</i> | evergreen bayberry | A2 A3 | B3 B9 |
| <i>Myrica inodora</i> | odorless bayberry | A1 A2 | B9 |
| <i>Nyssa aquatica</i> | water tupelo | A3 A5 | B4 B5 |
| <i>Nyssa biflora</i> | swamp tupelo | A1 A2 A4 | B1 B4 B5 |
| <i>Nyssa ogeche</i> | Ogeeche-lime | A1 A2 A6 | B1 B2 |
| <i>Nyssa sylvatica</i> | blackgum | A3 A5 | B1 B4 B5 |
| <i>Osmanthus americanus</i> | devilwood | A1 A3 | B4 B9 |
| <i>Ostrya virginiana</i> | Eastern hophornbeam | A3 A5 | B1 B7 B8 |
| <i>Oxydendrum arboreum</i> | sourwood | A3 | B1 B3 |
| <i>Persea borbonia</i> | red-bay | A2 A3 A5 | B3 B5 |
| <i>Persea palustris</i> | swamp-bay | A2 A3 | B9 |
| <i>Pinckneya bracteata</i> | fevertree | A3 | B1 B3 B4 |
| <i>Planera aquatica</i> | water-elm | A2 A3 | B1 B4 B8 |
| <i>Platanus occidentalis</i> | American sycamore | A3 | B4 |
| <i>Populus deltoides</i> | Eastern cottonwood | A3 A5 | B6 |
| <i>Populus heterophylla</i> | swamp cottonwood | A1 A2 | B1 B7 |
| <i>Prunus alabamensis</i> | Alabama cherry | A1 A2 A3 | B1 B2 |
| <i>Prunus americana</i> | American plum | A5 | B1 B4 B5 |
| <i>Prunus angustifolia</i> | Chickasaw plum | A3 | B1 |

Figure 28: Native tree species leaf / leaflet composite tip and base form. CONTINUED (* = compound leaves)

| scientific name | common name | tip form | base form |
|---------------------------------|----------------------|-----------------|------------------|
| <i>Prunus caroliniana</i> | laurelcherry | A3 A5 | B4 |
| <i>Prunus pensylvanica</i> | fire cherry | A5 | B1 |
| <i>Prunus serotina</i> | black cherry | A3 | B1 B3 |
| <i>Prunus umbellata</i> | flatwoods plum | A3 | B1 B2 |
| <i>Ptelea trifoliata</i> * | hoptree | A3 A5 | B4 |
| <i>Quercus alba</i> | white oak | A1 | B3 B4 B9 |
| <i>Quercus arkansana</i> | Arkansas oak | A1 | B3 B4 |
| <i>Quercus austrina</i> | bluff oak | A1 | B4 B5 |
| <i>Quercus breviloba</i> | Gulf oak | A1 A2 | B1 B4 |
| <i>Quercus chapmanii</i> | Chapman oak | A1 | B4 B9 |
| <i>Quercus coccinea</i> | scarlet oak | A3 A5 | B1 B2 B6 |
| <i>Quercus falcata</i> | Southern red oak | A6 | B1 B2 |
| <i>Quercus geminata</i> | sand live oak | A1 A6 | B4 |
| <i>Quercus georgiana</i> | Georgia oak | A3 A4 | B2 B3 B4 B5 |
| <i>Quercus hemisphaerica</i> | laurel oak | A1 A3 A6 | B1 B2 B3 |
| <i>Quercus imbricaria</i> | shingle oak | A2 A3 A6 | B1 B2 B3 B9 |
| <i>Quercus incana</i> | bluejack oak | A1 A2 A3 A6 | B1 B3 |
| <i>Quercus laevis</i> | turkey oak | A6 | B1 B3 B4 B5 |
| <i>Quercus laurifolia</i> | swamp laurel oak | A1 A2 A3 | B4 |
| <i>Quercus lyrata</i> | overcup oak | A1 A3 A6 | B3 B4 B9 |
| <i>Quercus margaretta</i> | sand post oak | A1 | B1 B3 B4 |
| <i>Quercus marilandica</i> | blackjack oak | A1 A2 | B1 |
| <i>Quercus michauxii</i> | swamp chestnut oak | A1 | B1 B5 |
| <i>Quercus minima</i> | dwarf live oak | A1 A3 | B1 |
| <i>Quercus montana</i> | chestnut oak | A5 | B3 |
| <i>Quercus muehlenbergii</i> | chinquapin oak | A3 | B4 B9 |
| <i>Quercus myrtifolia</i> | myrtle oak | A1 A2 A6 | B1 B2 |
| <i>Quercus nigra</i> | water oak | A6 | B4 B5 B9 |
| <i>Quercus oglethorpensis</i> | Oglethorpe oak | A1 A2 | B1 |
| <i>Quercus pagoda</i> | cherrybark oak | A3 | B1 B4 B5 |
| <i>Quercus palustris</i> | pin oak | A3 A4 | B3 B4 |
| <i>Quercus phellos</i> | willow oak | A3 | B3 |
| <i>Quercus prinoides</i> | dwarf chinquapin oak | A1 | B4 |
| <i>Quercus rubra</i> | Northern red oak | A3 A5 | B1 B3 B4 B6 |
| <i>Quercus shumardii</i> | Shumard's oak | A3 A5 A6 | B4 B5 |
| <i>Quercus similis</i> | swamp post oak | A1 | B1 |
| <i>Quercus sinuata</i> | bastard (Durand) oak | A1 | B3 B5 |
| <i>Quercus stellata</i> | post oak | A1 A13B | 1 B5 |
| <i>Quercus velutina</i> | black oak | A3 A5 | B1 B2 B3 B6 |
| <i>Quercus virginiana</i> | live oak | A1 A6 | B4 B5 B9 |
| <i>Rhamnus caroliniana</i> | buckthorn | A3 A5 | B1 B3 B7 |
| <i>Rhododendron catawbiense</i> | purple-laurel | A1 A2 | B1 |
| <i>Rhododendron maximum</i> | rosebay-laurel | A3 | B1 B3 B4 |
| <i>Rhus copallinum</i> * | winged sumac | A3 A5 | B3 B4 B8 |
| <i>Rhus glabra</i> * | smooth sumac | A5 | B1 B8 |

Figure 28: Native tree species leaf / leaflet composite tip and base form. CONTINUED (* = compound leaves)

| scientific name | common name | tip form | base form |
|-------------------------------------|-----------------------|--------------|-----------|
| <i>Rhus typhina</i> * | staghorn sumac | A5 A10 | B1 B7 |
| <i>Robinia hispida</i> * | pink locust | A1 A3 A6 | B1 |
| <i>Robinia pseudoacacia</i> * | black locust | A1 A2 A6 A14 | B1 B2 |
| <i>Robinia viscosa</i> * | clammy locust | A6 | B1 B2 |
| <i>Salix caroliniana</i> | Coastal Plain willow | A5 | B1 |
| <i>Salix floridana</i> | Florida willow | A3 | B1 B7 |
| <i>Salix nigra</i> | black willow | A5 | B1 B4 |
| <i>Salix sericea</i> | silky willow | A3 A5 | B1 |
| <i>Sambucus canadensis</i> * | American elder | A5 | B1 B2 |
| <i>Sambucus simpsonii</i> * | Southern elder | A5 | B4 B9 |
| <i>Sapindus marginatus</i> * | Florida soapberry | A2 A5 | B8 |
| <i>Sassafras albidum</i> | sassafras | A1 A2 | B3 B5 |
| <i>Sideroxylon lanuginosa</i> | gum bumelia | A1 A2 | B4 B9 |
| <i>Sideroxylon lycioides</i> | buckthorn bumelia | A1 | B9 |
| <i>Sideroxylon tenax</i> | tough bumelia | A1 | B9 |
| <i>Sorbus americana</i> * | American mountain-ash | A3 A5 | B1 |
| <i>Staphylea trifolia</i> * | bladdernut | A3 A5 | B1 B3 |
| <i>Stewartia malacodendron</i> | silky camellia | A3 A5 | B4 B5 |
| <i>Stewartia ovata</i> | mountain camellia | A3 A5 | B4 B9 |
| <i>Styrax americanus</i> | American snowbell | A3 | B4 B9 |
| <i>Styrax grandifolius</i> | bigleaf snowbell | A3 | B4 B9 |
| <i>Symplocos tinctoria</i> | sweetleaf | A3 A5 | B2 B4 |
| <i>Tilia americana</i> | American basswood | A3 A5 | B6 B7 B8 |
| <i>Tilia caroliniana</i> | Carolina basswood | A5 | B7 B8 |
| <i>Tilia floridana</i> | Florida basswood | A3 | B6 B7 B8 |
| <i>Tilia heterophylla</i> | white basswood | A5 | B7 B8 |
| <i>Toxicodendron vernix</i> * | poison sumac | A3 | B3 B4 |
| <i>Ulmus alata</i> | winged elm | A3 | B1 B8 |
| <i>Ulmus americana</i> | American elm | A5 | B1 B8 |
| <i>Ulmus rubra</i> | slippery elm | A5 | B1 B8 |
| <i>Ulmus serotina</i> | September elm | A5 | B1 B8 |
| <i>Vaccinium arboreum</i> | farkleberry | A1 A2 A3 | B1 B3 |
| <i>Viburnum cassinoides</i> | Northern possumhaw | A3 | B1 B4 |
| <i>Viburnum dentatum</i> | Southern arrowwood | A3 | B1 B7 |
| <i>Viburnum lentago</i> | nannyberry | A3 | B3 B4 |
| <i>Viburnum nudum</i> | Southern possumhaw | A2 A3 | B3 B4 |
| <i>Viburnum obovatum</i> | small-leaf arrowwood | A1 A2 | B9 |
| <i>Viburnum prunifolium</i> | blackhaw | A1 A2 | B1 B4 |
| <i>Viburnum rufidulum</i> | rusty blackhaw | A1 A2 | B4 |
| <i>Yucca aloifolia</i> | Spanish-bayonet | A9 | B1 |
| <i>Yucca gloriosa</i> | moundlilly yucca | A9 | B1 |
| <i>Zanthoxylum americanum</i> * | prickly-ash | A2 A3 | B1 B2 |
| <i>Zanthoxylum clava-herculis</i> * | Hercules' club | A3 A5 | B4 B8 |

Figure 28: Native tree species leaf / leaflet composite tip and base form. CONTINUED (* = compound leaves)

-- KEY IS ON FOLLOWING PAGE --

TIP / BASE FORM KEY

| <u>TIP CODE</u> | <u>FORM / SHAPE</u> | <u>BASE CODE</u> | <u>FORM / SHAPE</u> |
|----------------------------|--------------------------------|-----------------------------|--|
| A1 | = ROUNDED | B1 | = ROUNDED |
| A2 | = OBTUSE | B2 | = OBTUSE |
| A3 | = ACUTE | B3 | = ACUTE |
| A4 | = SUBACUTE | B4 | = CUNEATE |
| A5 | = ACCUMINATE | B5 | = DECURRENT, ATTENUATE, ACCUMINATE |
| A6 | = CUSPIDATE | B6 | = TRUNCATE |
| A7 | = TRUNCATE | B7 | = CORDATE |
| A8 | = ARISTULATE | B8 | = OBLIQUE, DIMIDIATE, INEQUILATERAL, ASYMMETRICAL |
| A9 | = PUNGENS | B9 | = TAPERED |
| A10 | = ATTENUATE | B10 | = AURICULATE |
| A11 | = APICULATE | B11 | = SAGITTATE |
| A12 | = CAUDATE | B12 | = HASTATE |
| A13 | = RETUSE | | |
| A14 | = EMARGINATE | | |

Figure 29: Native tree species leaf / leaflet composite tip and base form or shape code key.

**LEAF / LEAFLET
TIP & BASE
DESCRIPTORS
= 815**

**TIP DESCRIPTORS
= 47% (5 dominant forms)**

**BASE DESCRIPTORS
= 53% (9 dominant forms)**

Figure 30: Total number of tip and base descriptors for 225 native tree species leaves and leaflets from all sources.

Some leaf margins have highly irregular patterns of indentations and projections appearing damaged, chewed, or eroded. This leaf margin form is called erose. Erose leaf margins can be divided into two general forms: eroseulate which has slightly irregular teeth and sinuses appearing damaged, chewed, or eroded; and, suberose which has somewhat gnawed or eroded teeth. Figure 31.

Leaf margins can be covered to various degrees with trichomes. The general term for a leaf edge with trichomes is termed fringed. There has been four terms used for a fringed leaf margin, not including more detailed trichome descriptions. A ciliate leaf margin has a fringed edge with short trichomes. A ciliatulate margin is a fringe edge with widely spaced and dispersed trichomes. Ciliolate leaf margins are fringed with minute trichomes. Fimbriate is a generic term for a fringed leaf margin.

Marginal Forms

Leaf margins can have edge waves, which are regular shallow projections and sinuses, or waves along their margin. Waved leaf margins are generally divided into three forms: (Figure 32) repand waved margins which are slightly wavy toward and away from midvein along the margin; sinuate waved margins which are shallow, gentle non-vascularized projections and sinuses; and undulate waved margins which are down (toward abaxial surface) and up (toward adaxial surface) gentle curves, but with no strongly repeating projections or sinuses of a wave. Figure 33 lists native tree species with undulate, sinuate, and repand margins.

There are several confusing uses of marginal wave terminology by a number of authors. The term “wavy” has been used for undulate, sinuate, and repand. In some cases, “wavy” has been used for crenate teeth. The word “wavy” is not a precise nor effective term.

Some tree leaves have leaf margins which appear to be rolled, with the margin turned under or rolled upward towards itself. Figure 34. Rolled leaf margins can be characteristic of a number of trees. There are four rolled leaf margins usually cited: evolute margins are rolled downward toward abaxial side of leaf; revolute margins are rolled downward toward abaxial side of a leaf; inrolled margins are curled up and inward toward the adaxial side of a leaf; and, involute margins are rolled up and inward toward adaxial side of leaf. Figure 35.

The total number and percent of native tree species with “wavy” or “rolled” edges / margins are given in Figure 36. A significant number (24%) of native tree species leaves / leaflets have some form of undulate, sinuate, or repand margins

Leaf / Leaflet Teeth

Tree leaf margins can have a variety of teeth and crenations. A leaf is considered toothed if only one tooth is displayed. A leaf tooth is a marginal (not at the tip) vascularized, pointed projection with associated sinuses, with the length of the sinus less than ~10% of the distance between the leaf margin and mid-vein. With each leaf tooth projection is a leaf sinus indentation. Leaf teeth sinuses are admedial indentations, incisions, or embayments from a leaf / leaflet margin immediately in front of, or between, any exmedial projections like teeth, which can have either a rounded or angular bottom.

There are three general tooth types: dentate; serrate; and, crenate. Dentate marginal teeth are pointed and aligned perpendicular to the leaf margin. Serrate marginal teeth are pointed and inclined or directed toward the leaf tip. Serrate or serrated are generically used to represent leaves with both dentate and serrate leaf margins. Crenate marginal teeth have smooth, shallow, rounded projections and are not pointed. Figure 37. Crenate marginal projections should not be confused with repand or sinuate margins.

Leaf Margin Appearance

| margin name | description |
|-----------------|--|
| erose | = margin edge minutely serrate & irregular -- appears damaged or chewed |
| sinuous | = margin edge has smooth shallow curves with no vein ends |
| undulate | = margin edge has smooth shallow curves up & down across the plane of the leaf blade |
| revolute | = margin edge turned down or rolled in abaxial direction |
| involute | = margin edge turned up or rolled in an adaxial direction |

Figure 31: Selected special tree leaf / leaflet blade margin appearance names and simple descriptions.

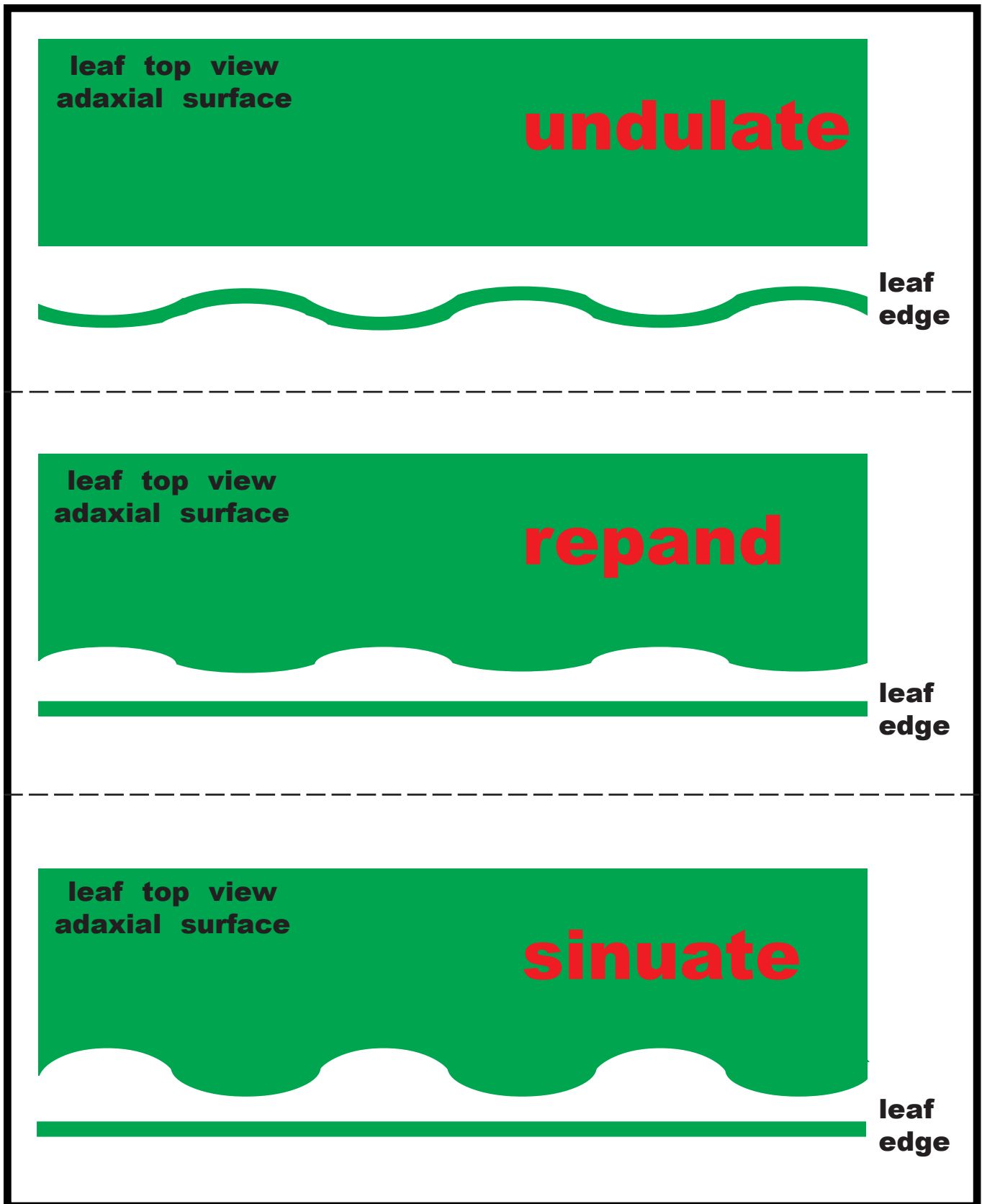


Figure 32: Wavy tree leaf / leaflet margin edges.
(Note -- not lobes or crenate teeth)

UNDULATE, SINUATE, REPAND

| | | | |
|----------------------------------|------------------------|-------------------------------|----------------------|
| <i>Acer leucoderme</i> | chalk maple | <i>Persea borbonia</i> | red-bay |
| <i>Acer nigrum</i> | black maple | <i>Prunus angustifolia</i> | Chickasaw plum |
| <i>Acer rubrum</i> | red maple | <i>Prunus caroliniana</i> | laurelcherry |
| <i>Acer saccharum</i> | sugar maple | <i>Quercus breviloba</i> | Gulf oak |
| <i>Alnus serrulata</i> | hazel alder | <i>Quercus chapmanii</i> | Chapman oak |
| <i>Asimina parviflora</i> | dwarf pawpaw | <i>Quercus geminata</i> | sand live oak |
| <i>Catalpa bignonioides</i> | Southern catalpa | <i>Quercus imbricaria</i> | shingle oak |
| <i>Celtis laevigata</i> | sugarberry | <i>Quercus laurifolia</i> | swamp laurel oak |
| <i>Cephalanthus occidentalis</i> | buttonbush | <i>Quercus michauxii</i> | swamp chestnut oak |
| <i>Chionanthus virginicus</i> | fringetree | <i>Quercus minima</i> | dwarf live oak |
| <i>Cornus florida</i> | flowering dogwood | <i>Quercus muehlenbergii</i> | chinquapin oak |
| <i>Cotinus obovatus</i> | smoketree | <i>Quercus myrtifolia</i> | myrtle oak |
| <i>Crataegus spathulata</i> | littlehip hawthorn | <i>Quercus oglethorpensis</i> | Oglethorpe oak |
| <i>Gleditsia aquatica</i> * | water locust | <i>Quercus phellos</i> | willow oak |
| <i>Gleditsia triacanthos</i> * | honeylocust | <i>Quercus prinoides</i> | dwarf chinquapin oak |
| <i>Hamamelis virginiana</i> | American witch-hazel | <i>Quercus sinuata</i> | bastard (Durand) oak |
| <i>Ilex ambigua</i> | Carolina holly | <i>Quercus virginiana</i> | live oak |
| <i>Ilex cassine</i> | dahoon | <i>Rhododendron</i> | |
| <i>Ilex decidua</i> | possumhaw | <i> catawbiense</i> | purple-laurel |
| <i>Ilex myrtifolia</i> | myrtle dahoon | <i>Rhododendron maximum</i> | rosebay-laurel |
| <i>Ilex vomitoria</i> | yaupon | <i>Sambucus simpsonii</i> * | Southern elder |
| <i>Leitneria floridana</i> | corkwood | <i>Viburnum cassinoides</i> | Northern possumhaw |
| <i>Lyonia ferruginea</i> | staggerbush | <i>Viburnum nudum</i> | Southern possumhaw |
| <i>Magnolia acuminata</i> | mountain cucumber-tree | <i>Viburnum obovatum</i> | small-leaf arrowwood |
| <i>Magnolia cordata</i> | Piedmont cucumber-tree | <i>Zanthoxylum</i> | |
| <i>Magnolia grandiflora</i> | Southern magnolia | <i> americanum</i> * | prickly-ash |
| <i>Magnolia tripetala</i> | umbrella-tree | <i>Zanthoxylum</i> | |
| <i>Myrica inodora</i> | odorless bayberry | <i> clava-herculis</i> * | Hercules' club |
| <i>Osmanthus americanus</i> | devilwood | | |
| <i>Platanus occidentalis</i> | American sycamore | | |

Figure 33: Native tree species leaves / leaflets with undulate, sinuate, and / or repand margins
(* = compound leaves)

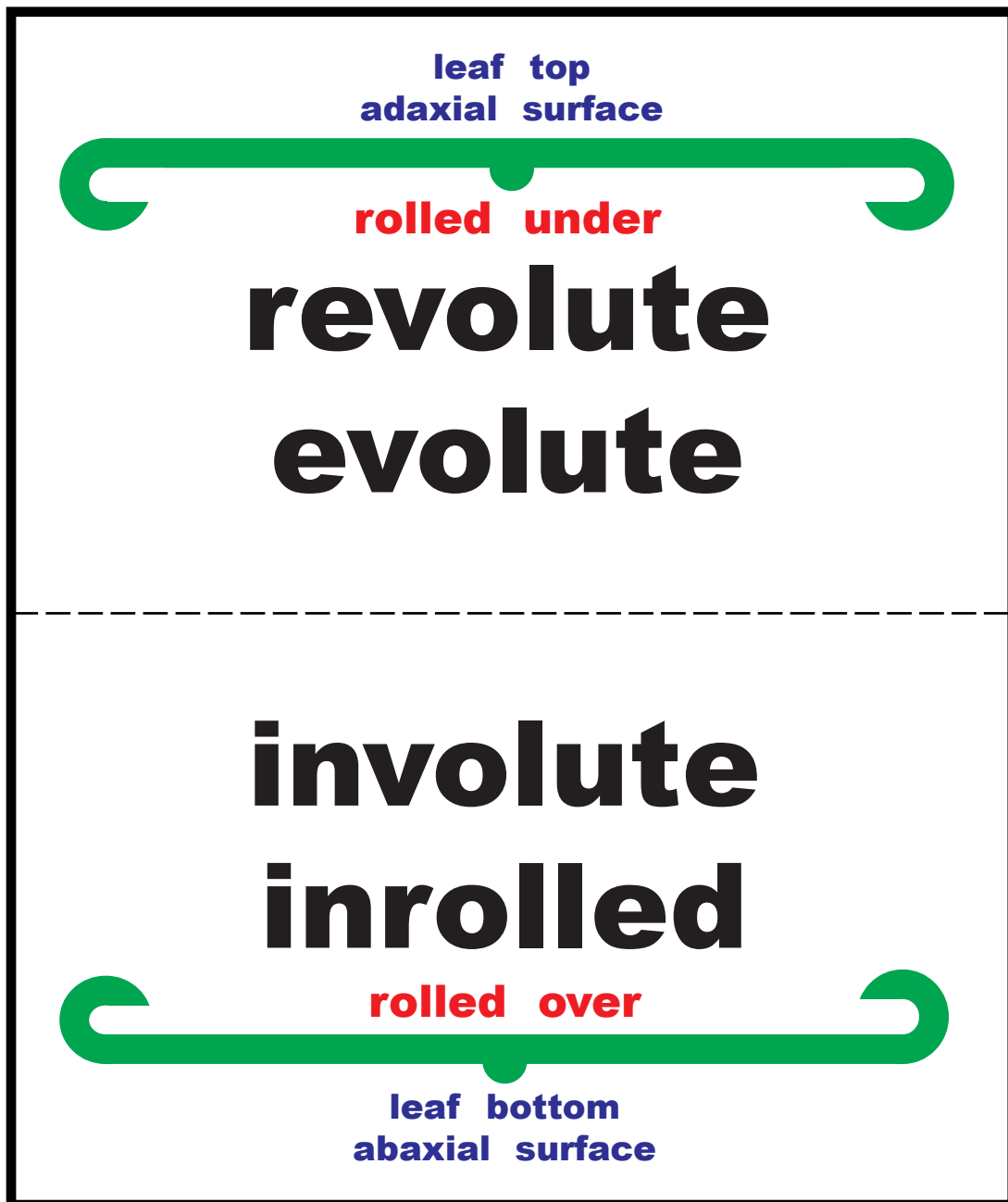


Figure 34: Rolled tree leaf / leaflet margin edge.

ROLLED MARGINS

| | |
|---|----------------------|
| <i>Asimina parviflora</i> | dwarf pawpaw |
| <i>Ilex cassine</i> | dahoon |
| <i>Ilex myrtifolia</i> | myrtle dahoon |
| <i>Leitneria floridana</i> | corkwood |
| <i>Lyonia ferruginea</i> | staggerbush |
| <i>Magnolia grandiflora</i> | Southern magnolia |
| <i>Myrica inodora</i> | odorless bayberry |
| <i>Osmanthus americanus</i> | devilwood |
| <i>Persea borbonia</i> | red-bay |
| <i>Prunus angustifolia</i> ⁱ | Chickasaw plum |
| <i>Prunus caroliniana</i> | laurelcherry |
| <i>Quercus geminata</i> | sand live oak |
| <i>Quercus imbricaria</i> | shingle oak |
| <i>Quercus myrtifolia</i> | myrtle oak |
| <i>Quercus virginiana</i> | live oak |
| <i>Rhododendron catawbiense</i> | purple-laurel |
| <i>Rhododendron maximum</i> | rosebay-laurel |
| <i>Viburnum nudum</i> | Southern possumhaw |
| <i>Viburnum obovatum</i> | small-leaf arrowwood |

Figure 35: Native tree species leaves / leaflets with revolute or involute margins
(i = involute leaves)

TREE LEAF / LEAFLET MARGINS

**UNDULATE, SINUATE,
AND/OR REPAND
= 55 (24%)**

**REVOLUTE (18) OR
INVOLUTE (1)
= 19 (8%)**

Figure 36: Native tree leaf / leaflet margin forms.
Values are number of species and percent of
all 225 native tree species surveyed.

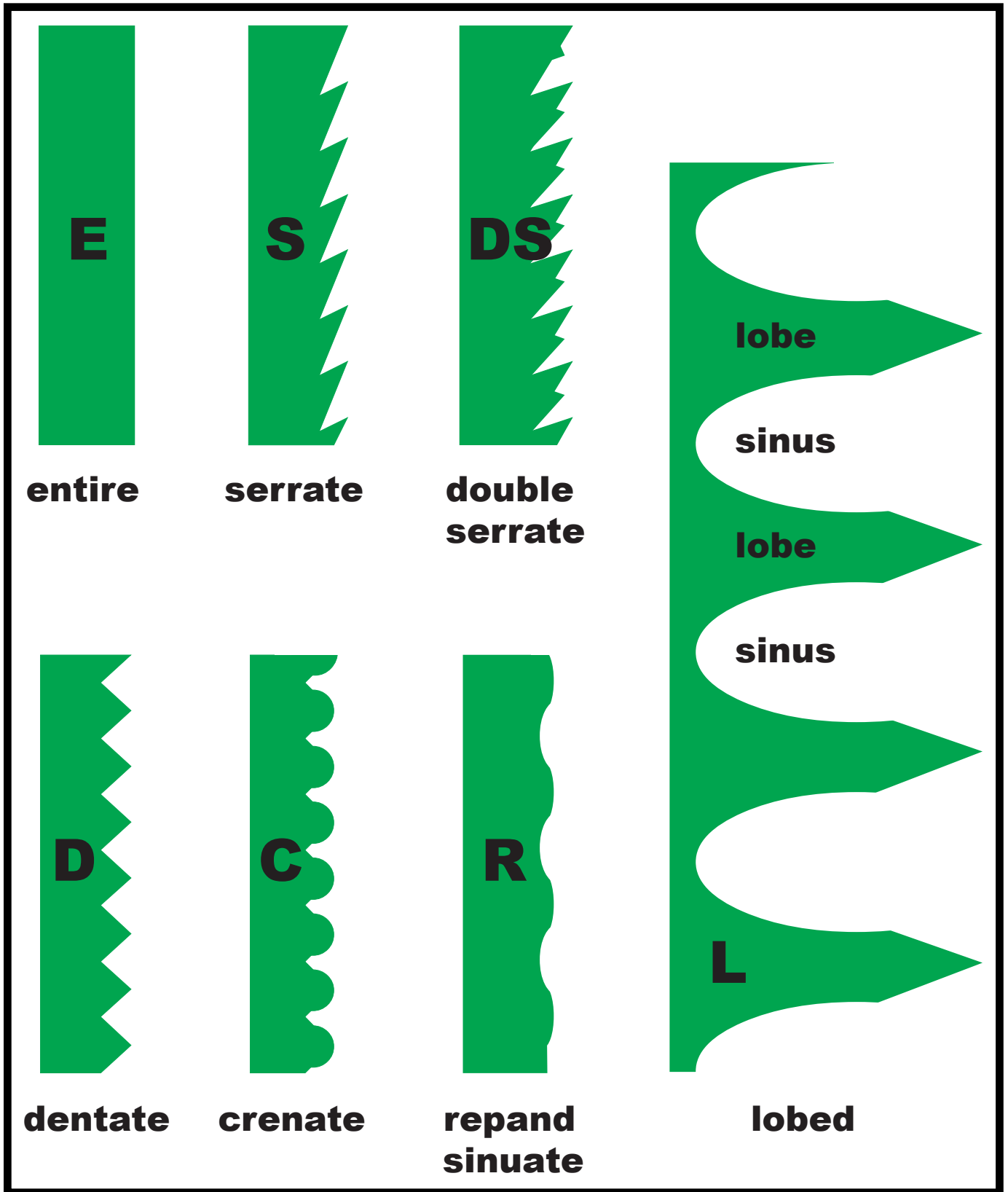


Figure 37: Tree leaf / leaflet margin forms, identification code, and name -- as edge-viewed from above.

Teeth Types

Dentate teeth are pointed perpendicular to the leaf margin. Dentate leaf margins can differ in the shape or form of each tooth tip. Cited dentate tip shapes include: acute, obtuse, acuminate, attenuate, mucronate, and glandular. Another form of dentate teeth is termed denticulate or denticle, having minute teeth pointed perpendicular to the leaf margin.

Serrate teeth forms are pointed and inclined toward the leaf tip. Serrate leaf margins differ in each tooth tip shape. Cited serrate tip shapes include: acute, obtuse, acuminate, attenuate, mucronate, and glandular. Serrate teeth forms can also be further described by a number of terms. Serrulate has small teeth angled toward tip. Incurved has long sharp teeth curved back toward the margin. Double serrate has large teeth, with smaller teeth on each large tooth. Biserrate is another name for double serrate. Glandular serrate has small teeth tipped with glands, or in some cases can appear as glands alone. Remotely serrate has small widely scattered teeth along a leaf margin.

Crenations are marginal (not at the leaf tip) with smooth rounded vascularized projections (i.e. teeth) without points. Associated sinuses are less than ~10% of the distance between the leaf margin and mid-vein. Crenate means leaf marginal projection tips are rounded with no point. Two types of crenate projections are usually cited: dentate crenate with rounded projections perpendicular to the leaf margin; and, serrate crenate with rounded projections arising at an angle to the leaf margin. Crenulate is a form with minute, gently rounded projections. Gimped is another term historically used for crenate, meaning rounded projections. Scalloped is a form of crenate projections which are very gently rounded. Again, crenations are marginal teeth or projections, which should be differentiated from undulate, repand or sinuous margins.

Teeth Gaps

The spacing between each single tooth or projection can be regular and similar. Spacing can also be irregular, with spaces between teeth or crenations wide and sparse, or narrow and dense. The number and pattern of teeth and projections can aid in leaf identification. In addition to single tooth and crenation spacing, multiple patterns may overlay each other, generating compound double or triple forms. A double form has teeth or crenations with smaller teeth or crenations on each of their edges.

Some leaf margins have teeth with sharp, elongated points designed to shed water. These drip points or awn points appear on leaf ends or margins, and facilitate rain and dew shedding off the leaf / leaflet tip or end. A leaf margin or tooth tip is termed awned when there is a stiff bristle on the end. An elongated margin point can be considered a drip point.

Leaf / Leaflet Lobes

A number of tree leaves have lobes (i.e. lobation). A leaf lobe is an exmedial marginal leaf projection (not at the tip), and an associated sinus which is more than 25% of the distance from the projection tip to the midvein. A leaf / leaflet is considered lobed if only one lobe exists.

Between leaf lobes are lobe sinuses. A leaf lobe sinus is an admedial indentation, incision, or embayment from the leaf margin immediately in front of, or between, any exmedial projections like lobes. Sinuses can have either a rounded or angular bottom. Determining lobe and sinus shapes and forms can help identify many tree leaves.

Lobe Types

Lobes on leaves have many forms and shapes. Common lobe patterns on leaves are palmately lobed and pinnately lobed. Figure 38. Palmately lobed leaves have major veins and lobe axes radiating from the leaf base. Palmate lobing can be divided into two additional forms: palmatisect,

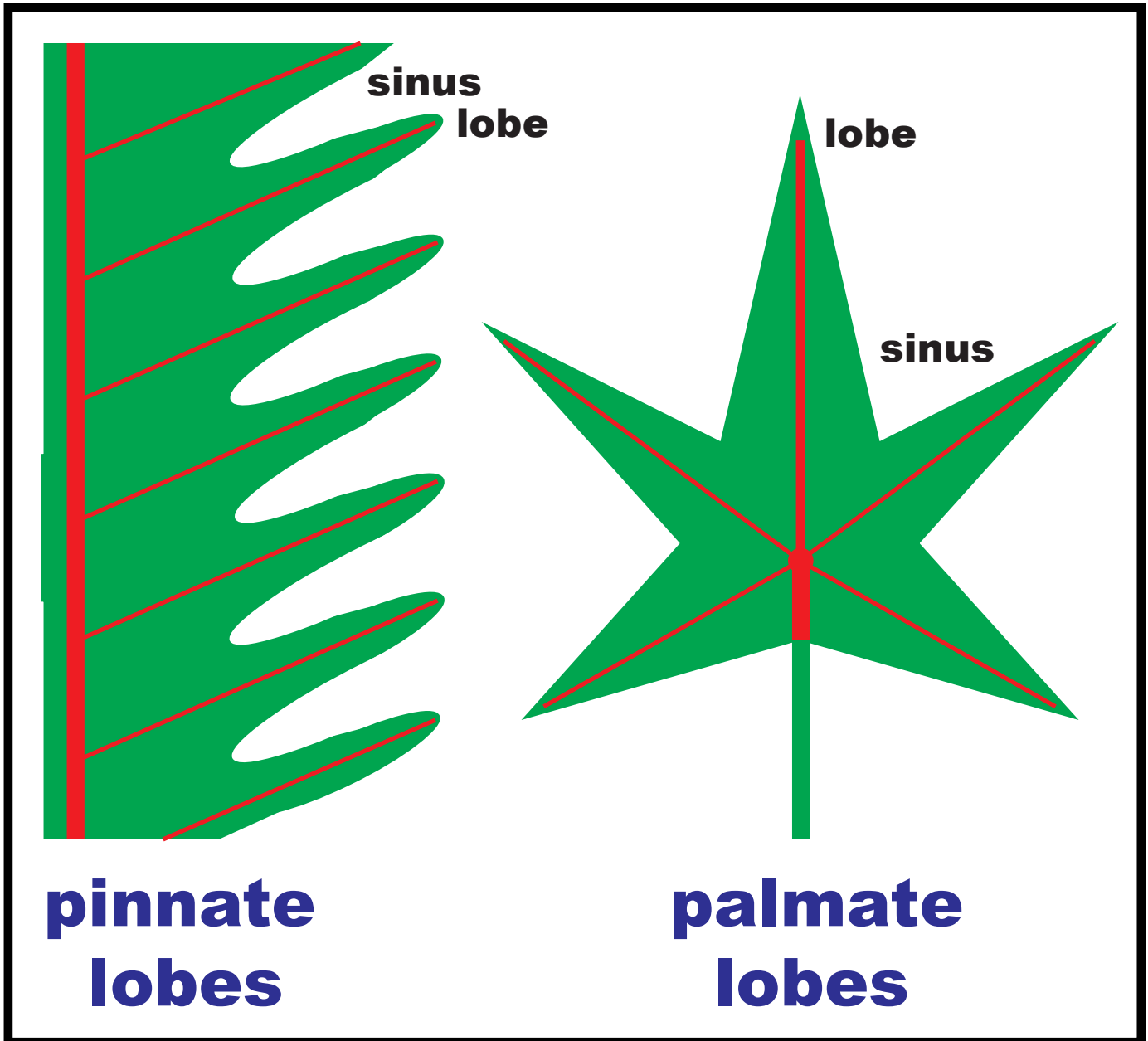


Figure 38: Two primary lobe forms on tree leaves / leaflets.

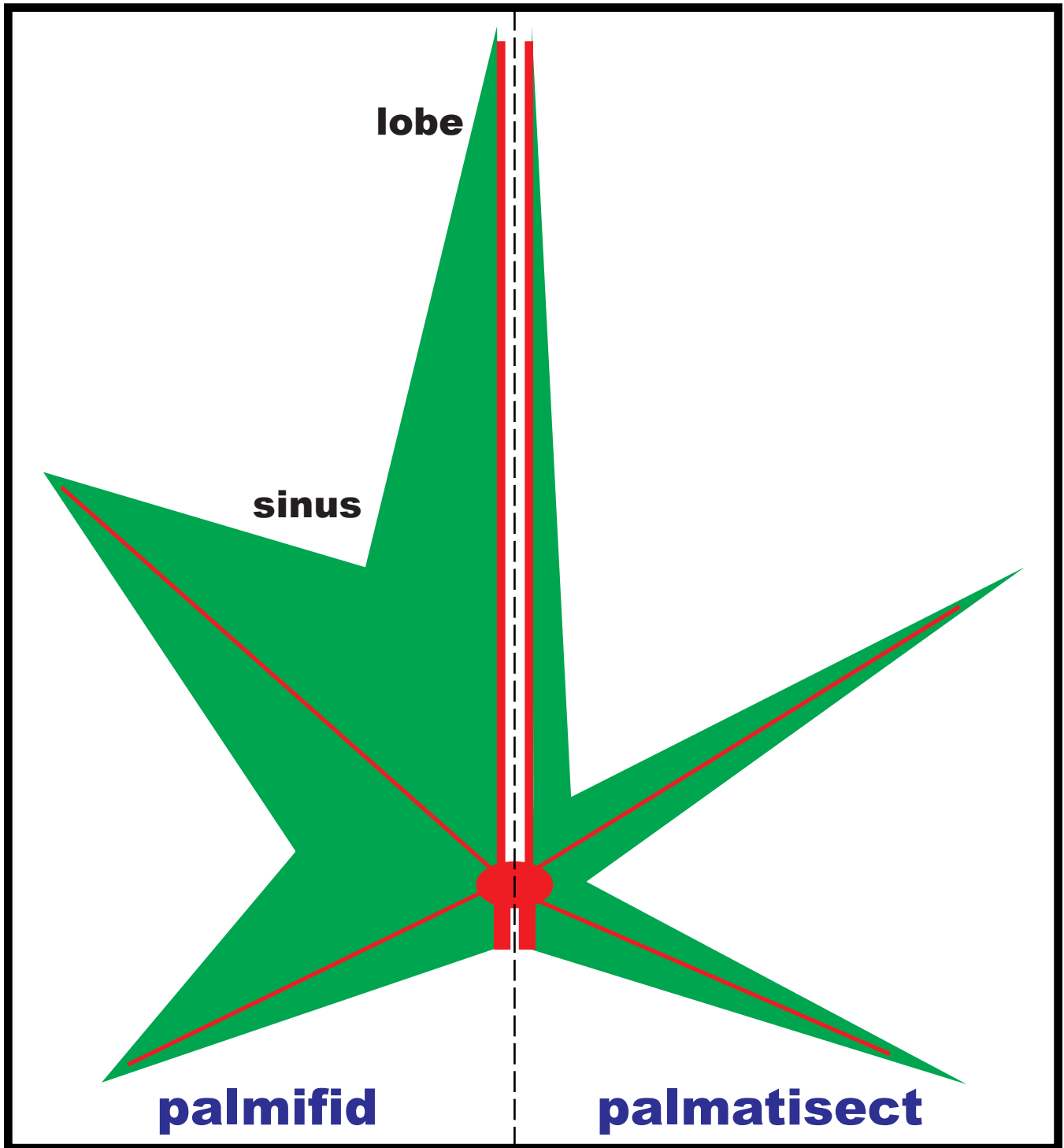


Figure 39: Two types of palmate lobe forms, based upon sinus depth to mid-vein, on tree leaves / leaflets.

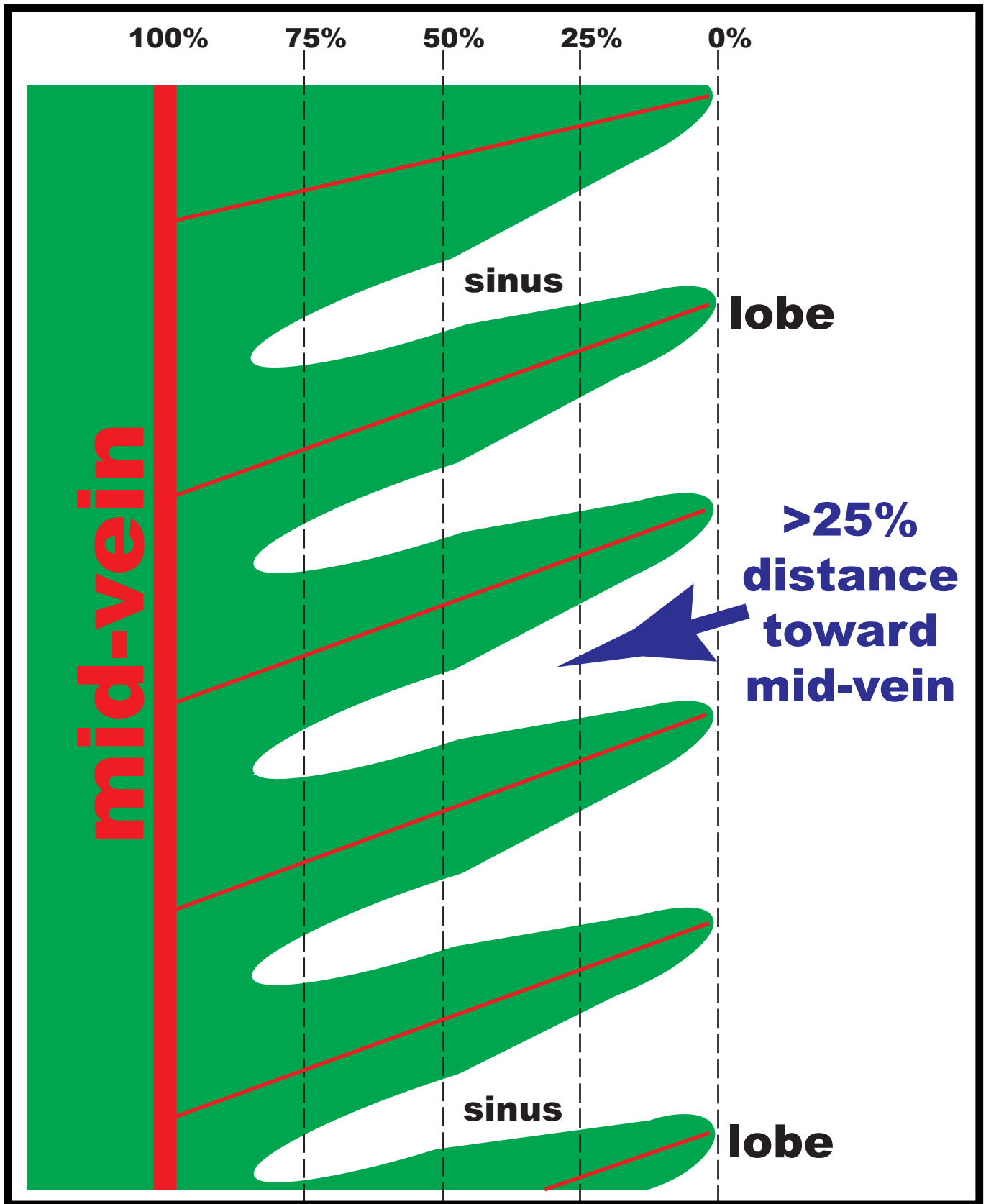


Figure 40: Defining a pinnate lobe and associated sinus on a tree leaf / leaflet margin.

which is a palmately lobed simple leaf where incised sinuses reach almost to the main vein; and, palmifid, with palmately arraigned moderate depth sinuses. Figure 39.

Pinnately lobed leaves have major veins and lobe axes arising along the mid-vein. Figure 40. Pinnate lobing can be divided into three additional forms: pinnatisect, where a pinnately lobed simple leaf has incised sinuses which reach almost to the midvein; pinnatifid, where a pinnately lobed leaf has deep sinuses but not to the midvein; and, pinnatilobate, where leaves have shallow pinnate lobes. Figure 41.

Lobe Shapes & Size

There are a number of specific shaped lobing forms. A combination form is termed a palmately and pinnately lobed leaf, where at least one palmate leaf lobe has pinnate lobes. Other special leaf lobing types include: bilobed with two lobes; bipartite which is deeply divided into two lobes; cleft which is a deeply cut leaf at least halfway to mid-vein with narrow sharp-ended sinuses; dissected lobed leaves are deeply divided into numerous narrow lobes; incised with very deeply cut lobes almost to mid-vein with narrow sharp-ended sinuses; lacerate appearing cut or clefted irregularly as if torn; lacinate with pointed lobes having deep narrow irregular sinuses; lobulate lobed leaves which are divided into small lobes; lobule lobing with small lobes on a larger lobe; multifid with a leaf cut into many narrow segments or lobes; and, runcinate where lobes are angled back toward the leaf base. Figure 42. The use of these different special leaf lobe terms can demonstrate subtle differences, or can be more of an author's preference for use or generalizing.

Margin Types

Figure 43 provides a list of native tree species with entire margins. Remember some of these species can have both serrate, lobed, and entire margins. In these cases, species were listed in multiple margin form lists. Figure 44 lists native tree species generating serrate margins of various types. Figure 45 lists native tree species with lobed margins, with or without serrations. The number of lobes present for each tree species is also listed.

Figure 46 shows an accounting of entire, serrate, and lobed native tree species, and associated different combinations cited of margin forms. Note a majority (60%) of native tree species examined generate various types of serrated leaves and leaflets.

Shade Impacts

The broad general shape of the entire leaf or leaflet can be determined by fitting a leaf within the bounds of a geometric shape. The effective shade diameter of a leaf or leaflet is determined by the area of the largest oval which can fit within a leaf outline which does not cross the leaf margin (i.e. does not include leaf areas in teeth or lobes) converted into an equivalent circular area. This effective shade diameter of a leaf can be used to determine the direct shade cone (umbra) distance behind a leaf opposite the sun.

This direct shade distance (~65X effective shade diameter behind a leaf) defines an area with a limited amount of sunlight available for other leaves and other trees behind the first. The indirect shade area or volume (penumbra -- partial shade) may contain a significant amount of light energy of varying photosynthetic quality including partial shade and sunflecks, which some resource tolerant tree species can utilize. Leaf size and shape impact direct and indirect shade density and extent, and so impacts available light resources for the ecological space behind / beneath. Figure 47.

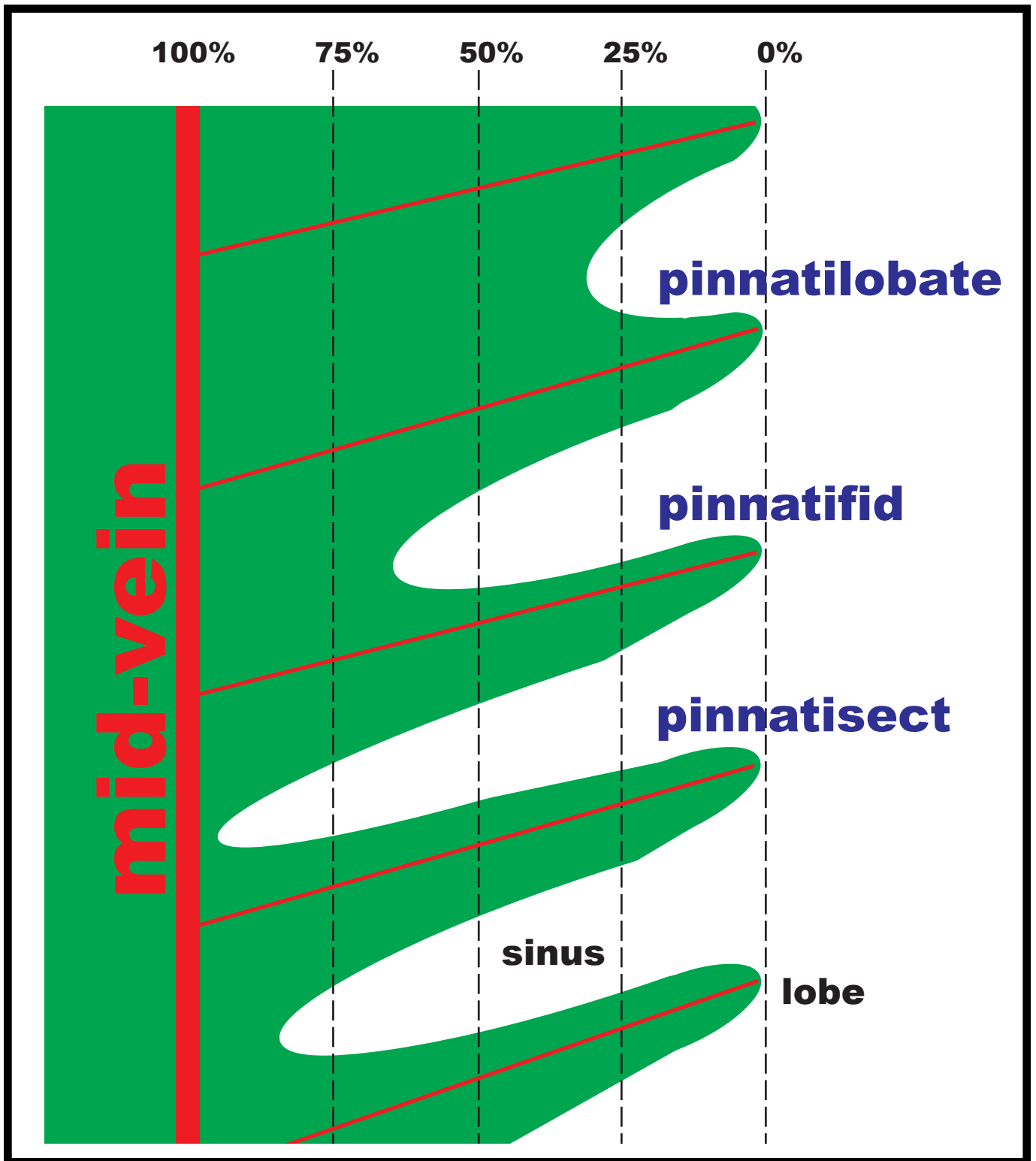


Figure 41: Defining types of pinnate lobes, based upon sinus depth toward mid-vein, on tree leaf / leaflet margins.

Specialized Leaf / Leaflet Lobe Forms

| | |
|--|--|
| palmately & pinnately lobed | = combination form with at least one palmate lobe having pinnate lobes |
| bilobed | = two lobes |
| bipartite | = deeply divided into two lobes |
| cleft | = deeply cut at least halfway to mid-vein with narrow sharp-ended sinuses |
| dissected | = deeply cut with numerous narrow lobes |
| incised | = deeply cut almost to mid-vein with narrow sharp-ended sinuses |
| lacerate | = appear cut or clefted irregularly as if torn |
| laciniate | = pointed lobes with deep narrow irregular sinuses |
| lobulate | = divided into small lobes |
| lobule | = small lobes on a larger lobe |
| multifid | = many narrow segments or lobes |
| runcinate | = lobes angled back toward leaf base |

(Note: these terms represents subtle differences / researcher preferences)

Figure 42: Selected tree leaf / leaflet blade lobe forms.

ENTIRE MARGINS

| | | | |
|----------------------------------|---------------------------|-------------------------------------|-------------------------|
| <i>Asimina parviflora</i> | dwarf pawpaw | <i>Magnolia virginiana</i> | sweetbay |
| <i>Asimina triloba</i> | pawpaw | <i>Myrica cerifera</i> | wax-myrtle |
| <i>Baccharis halimifolia</i> | Eastern baccharis | <i>Myrica heterophylla</i> | evergreen bayberry |
| <i>Carya aquatica</i> * | water hickory | <i>Myrica inodora</i> | odorless bayberry |
| <i>Catalpa bignonioides</i> | Southern catalpa | <i>Nyssa aquatica</i> | water tupelo |
| <i>Celtis laevigata</i> | sugarberry | <i>Nyssa biflora</i> | swamp tupelo |
| <i>Celtis tenuifolia</i> | Georgia hackberry | <i>Nyssa ogeche</i> | Ogeeche-lime |
| <i>Cephalanthus occidentalis</i> | buttonbush | <i>Nyssa sylvatica</i> | blackgum |
| <i>Cercis canadensis</i> | redbud | <i>Osmanthus americanus</i> | devilwood |
| <i>Chionanthus virginicus</i> | fringetree | <i>Oxydendrum arboreum</i> | sourwood |
| <i>Cladrastis kentukea</i> * | yellowwood | <i>Persea borbonia</i> | red-bay |
| <i>Cliftonia monophylla</i> | buckwheat tree | <i>Persea palustris</i> | swamp-bay |
| <i>Cornus alternifolia</i> | alternate-leaf dogwood | <i>Pinckneya bracteata</i> | fevertree |
| <i>Cornus florida</i> | flowering dogwood | <i>Prunus caroliniana</i> | laurelcherry |
| <i>Cornus foemina</i> | swamp dogwood | <i>Ptelea trifoliata</i> * | hoptree |
| <i>Cotinus obovatus</i> | smoketree | <i>Quercus chapmanii</i> | Chapman oak |
| <i>Cyrilla parvifolia</i> | littleleaf titi | <i>Quercus geminata</i> | sand live oak |
| <i>Cyrilla racemiflora</i> | swamp titi | <i>Quercus hemisphaerica</i> | laurel oak |
| <i>Diospyros virginiana</i> | persimmon | <i>Quercus imbricaria</i> | shingle oak |
| <i>Elliottia racemosa</i> | Georgia plume | <i>Quercus incana</i> | bluejack oak |
| <i>Forestiera acuminata</i> | swamp-privet | <i>Quercus minima</i> | dwarf live oak |
| <i>Forestiera segregata</i> | Florida-privet | <i>Quercus myrtifolia</i> | myrtle oak |
| <i>Franklinia alata</i> | Franklin tree | <i>Quercus oglethorpensis</i> | Oglethorpe oak |
| <i>Fraxinus americana</i> * | white ash | <i>Quercus phellos</i> | willow oak |
| <i>Fraxinus pennsylvanica</i> * | green ash | <i>Quercus virginiana</i> | live oak |
| <i>Fraxinus profunda</i> * | pumpkin ash | <i>Rhododendron catawbiense</i> | purple-laurel |
| <i>Ilex amelanchar</i> | sarvis holly | <i>Rhododendron maximum</i> | rosebay-laurel |
| <i>Ilex cassine</i> | dahoon | <i>Rhus copallinum</i> * | winged sumac |
| <i>Ilex coriacea</i> | large gallberry | <i>Robinia hispida</i> * | pink locust |
| <i>Ilex myrtifolia</i> | myrtle dahoon | <i>Robinia pseudoacacia</i> * | black locust |
| <i>Illicium floridanum</i> | Florida anisetree | <i>Robinia viscosa</i> * | clammy locust |
| <i>Illicium parviflorum</i> | yellow anisetree | <i>Sapindus marginatus</i> * | Florida soapberry |
| <i>Kalmia latifolia</i> | mountain-laurel | <i>Sideroxylon lanuginosa</i> | gum bumelia |
| <i>Leitneria floridana</i> | corkwood | <i>Sideroxylon lycioides</i> | buckthorn bumelia |
| <i>Lyonia ferruginea</i> | staggerbush | <i>Sideroxylon tenax</i> | tough bumelia |
| <i>Magnolia acuminata</i> | mountain cucumber-tree | <i>Styrax americanus</i> | American snowbell |
| <i>Magnolia cordata</i> | Piedmont cucumber-tree | <i>Styrax grandifolius</i> | bigleaf snowbell |
| <i>Magnolia fraseri</i> | mountain magnolia | <i>Symplocos tinctoria</i> | sweetleaf |
| <i>Magnolia grandiflora</i> | Southern magnolia | <i>Toxicodendron vernix</i> * | poison sumac |
| <i>Magnolia macrophylla</i> | bigleaf magnolia | <i>Vaccinium arboreum</i> | farkleberry |
| <i>Magnolia pyramidata</i> | pyramid magnolia | <i>Viburnum nudum</i> | Southern possumhaw |
| <i>Magnolia tripetala</i> | umbrella-tree | <i>Viburnum obovatum</i> | small-leaf arrowwood |
| | | <i>Yucca gloriosa</i> | moundlilly yucca |
| | | <i>Zanthoxylum clava-herculis</i> * | Hercules' club |

Figure 43: Native tree species leaves / leaflets

SERRATE MARGINS

| | | | |
|--|----------------------------|---|-----------------------|
| <i>Acer negundo</i> * | boxelder | <i>Crataegus intricata</i> ^X | Biltmore hawthorn |
| <i>Acer pensylvanicum</i> ^X | striped maple | <i>Crataegus marshallii</i> | parsley hawthorn |
| <i>Acer rubrum</i> | red maple | <i>Crataegus phaenopyrum</i> | Washington hawthorn |
| <i>Acer saccharinum</i> ^X | silver maple | | |
| <i>Acer spicatum</i> | mountain maple | <i>Crataegus pruinosa</i> ^X | waxy-fruit hawthorn |
| <i>Aesculus flava</i> * | yellow buckeye | | |
| <i>Aesculus glabra</i> * | Ohio buckeye | <i>Crataegus pulcherrima</i> | beautiful hawthorn |
| <i>Aesculus parviflora</i> * | bottlebrush buckeye | <i>Crataegus punctata</i> ^X | dotted hawthorn |
| | | <i>Crataegus spathulata</i> | littlehip hawthorn |
| <i>Aesculus pavia</i> * | red buckeye | <i>Crataegus triflora</i> | three-flower hawthorn |
| <i>Aesculus sylvatica</i> * | Georgia buckeye | | |
| <i>Alnus serrulata</i> ^X | hazel alder | <i>Crataegus uniflora</i> | dwarf hawthorn |
| <i>Amelanchier arborea</i> | serviceberry | <i>Crataegus viridis</i> | green hawthorn |
| <i>Aralia spinosa</i> * | devil's walkingstick | <i>Euonymus atropurpureus</i> ^X | burningbush |
| <i>Baccharis halimifolia</i> | Eastern baccharis | <i>Fagus grandifolia</i> | American beech |
| <i>Betula alleghaniensis</i> ^X | yellow birch | <i>Forestiera acuminata</i> | swamp-privet |
| <i>Betula lenta</i> ^X | sweet birch | <i>Forestiera segregata</i> | Florida-privet |
| <i>Betula nigra</i> ^X | river birch | <i>Fraxinus americana</i> * | white ash |
| <i>Carpinus caroliniana</i> ^X | Southern American hornbeam | <i>Fraxinus caroliniana</i> * | Carolina ash |
| | | <i>Fraxinus pennsylvanica</i> * | green ash |
| <i>Carya aquatica</i> * | water hickory | <i>Fraxinus profunda</i> * | pumpkin ash |
| <i>Carya australis</i> * | Southern shagbark hickory | <i>Fraxinus quadrangulata</i> * | blue ash |
| | | <i>Gleditsia aquatica</i> ^{* C} | water locust |
| <i>Carya cordiformis</i> * | bitternut hickory | <i>Gleditsia triacanthos</i> ^{* C} | honeylocust |
| <i>Carya glabra</i> * | pignut hickory | <i>Gordonia lasianthus</i> | loblolly bay |
| <i>Carya laciniosa</i> * | shellbark hickory | <i>Halesia carolina</i> | little silverbell |
| <i>Carya myristiciformis</i> * | nutmeg hickory | <i>Halesia diptera</i> | two-wing silverbell |
| <i>Carya ovalis</i> * | red hickory | <i>Halesia tetraptera</i> | mountain silverbell |
| <i>Carya ovata</i> * | shagbark hickory | <i>Hamamelis virginiana</i> ^C | American witch-hazel |
| <i>Carya pallida</i> * | sand hickory | | |
| <i>Carya tomentosa</i> * | mockernut hickory | <i>Ilex ambigua</i> | Carolina holly |
| <i>Castanea dentata</i> | American chestnut | <i>Ilex amelanchier</i> | sarvis holly |
| <i>Castanea pumila</i> | chinquapin | <i>Ilex cassine</i> | dahoon |
| <i>Celtis laevigata</i> | sugarberry | <i>Ilex decidua</i> | possumhaw |
| <i>Celtis occidentalis</i> | hackberry | <i>Ilex longipes</i> | Georgia holly |
| <i>Celtis tenuifolia</i> | Georgia hackberry | <i>Ilex montana</i> | mountain holly |
| <i>Clethra acuminata</i> | sweet pepperbush | <i>Ilex opaca</i> ^D | American holly |
| <i>Crataegus aestivalis</i> | mayhaw | <i>Ilex verticillata</i> | winterberry |
| <i>Crataegus aprica</i> ^C | sunny hawthorn | <i>Ilex vomitoria</i> ^C | yaupon |
| <i>Crataegus calpodendron</i> ^X | pear hawthorn | <i>Juglans cinerea</i> * | butternut |
| <i>Crataegus crus-galli</i> | cockspur hawthorn | <i>Juglans nigra</i> * | black walnut |
| <i>Crataegus flava</i> ^X | yellow hawthorn | <i>Liquidambar styraciflua</i> | sweetgum |

Figure 44: Native tree species leaves / leaflets with serrate margins.

X = DOUBLE SERRATE; C = CRENATE; D = DENTATE; * = COMPOUND LEAF LEAFLETS

SERRATE MARGINS

| | | | |
|---|----------------------|---|-----------------------|
| <i>Malus angustifolia</i> ^c | Southern crabapple | <i>Salix floridana</i> | Florida willow |
| <i>Malus coronaria</i> ^x | sweet crabapple | <i>Salix nigra</i> | black willow |
| <i>Morus rubra</i> | red mulberry | <i>Salix sericea</i> | silky willow |
| <i>Myrica cerifera</i> | wax-myrtle | <i>Sambucus canadensis</i> [*] | American elder |
| <i>Myrica heterophylla</i> | evergreen bayberry | <i>Sambucus simpsonii</i> [*] | Southern elder |
| <i>Nyssa aquatica</i> | water tupelo | <i>Sorbus americana</i> [*] | American mountain-ash |
| <i>Nyssa sylvatica</i> | blackgum | <i>Staphylea trifolia</i> [*] | bladdernut |
| <i>Ostrya virginiana</i> ^x | Eastern hophornbeam | <i>Stewartia malacodendron</i> | silky camellia |
| <i>Oxydendrum arboreum</i> | sourwood | <i>Stewartia ovata</i> | mountain camellia |
| <i>Planera aquatica</i> ^x | water-elm | <i>Styrax americanus</i> | American snowbell |
| <i>Platanus occidentalis</i> | American sycamore | <i>Styrax grandifolius</i> | bigleaf snowbell |
| <i>Populus deltoides</i> | Eastern cottonwood | <i>Symplocos tinctoria</i> | sweetleaf |
| <i>Populus heterophylla</i> | swamp cottonwood | <i>Tilia americana</i> | American basswood |
| <i>Prunus alabamensis</i> | Alabama cherry | <i>Tilia caroliniana</i> ^d | Carolina basswood |
| <i>Prunus americana</i> ^x | American plum | <i>Tilia floridana</i> | Florida basswood |
| <i>Prunus angustifolia</i> | Chickasaw plum | <i>Tilia heterophylla</i> | white basswood |
| <i>Prunus caroliniana</i> | laurelcherry | <i>Ulmus alata</i> ^x | winged elm |
| <i>Prunus pensylvanica</i> | fire cherry | <i>Ulmus americana</i> ^x | American elm |
| <i>Prunus serotina</i> | black cherry | <i>Ulmus rubra</i> ^x | slippery elm |
| <i>Prunus umbellata</i> | flatwoods plum | <i>Ulmus serotina</i> ^x | September elm |
| <i>Ptelea trifoliata</i> ^{*c} | hoptree | <i>Viburnum cassinoides</i> ^c | Northern possumhaw |
| <i>Quercus michauxii</i> ^c | swamp chestnut oak | <i>Viburnum dentatum</i> | Southern arrowwood |
| <i>Quercus montana</i> ^c | chestnut oak | <i>Viburnum lentago</i> | nannyberry |
| <i>Quercus muehlenbergii</i> | chinquapin oak | <i>Viburnum obovatum</i> | small-leaf arrowwood |
| <i>Quercus prinoides</i> ^c | dwarf chinquapin oak | <i>Viburnum prunifolium</i> | blackhaw |
| <i>Quercus sinuata</i> | bastard (Durand) oak | <i>Viburnum rufidulum</i> | rusty blackhaw |
| <i>Rhamnus caroliniana</i> ^c | buckthorn | <i>Yucca aloifolia</i> | Spanish-bayonet |
| <i>Rhus glabra</i> [*] | smooth sumac | <i>Zanthoxylum americanum</i> ^{*c} | prickly-ash |
| <i>Rhus typhina</i> [*] | staghorn sumac | <i>Zanthoxylum clava-herculis</i> ^{*c} | Hercules' club |
| <i>Salix caroliniana</i> | Coastal Plain willow | | |

Figure 44: Native tree species leaves / leaflets with serrate margins. CONTINUED

X = DOUBLE SERRATE; C = CRENATE; D = DENTATE; * = COMPOUND LEAF LEAFLETS

LOBED MARGINS

| | | |
|--------------------------------|----------------------|-------|
| <i>Acer barbatum</i> | Southern sugar maple | 3-5L |
| <i>Acer leucoderme</i> | chalk maple | 3-5L |
| <i>Acer negundo</i> * | boxelder | 0-3L |
| <i>Acer nigrum</i> | black maple | 3L |
| <i>Acer pensylvanicum</i> | striped maple | 3L |
| <i>Acer rubrum</i> | red maple | 3-5L |
| <i>Acer saccharinum</i> | silver maple | 5L |
| <i>Acer saccharum</i> | sugar maple | 3-5L |
| <i>Acer spicatum</i> | mountain maple | 3-5L |
| <i>Crataegus aestivalis</i> | mayhaw | 0-3L |
| <i>Crataegus calpodendron</i> | pear hawthorn | 0-3L |
| <i>Crataegus flava</i> | yellow hawthorn | 0-3L |
| <i>Crataegus intricata</i> | Biltmore hawthorn | 0-5L |
| <i>Crataegus marshallii</i> | parsley hawthorn | 5-11L |
| <i>Crataegus phaenopyrum</i> | Washington hawthorn | 0-5L |
| <i>Crataegus pruinosa</i> | waxy-fruit hawthorn | 6-8L |
| <i>Crataegus pulcherrima</i> | beautiful hawthorn | 4-6L |
| <i>Crataegus punctata</i> | dotted hawthorn | 0-3L |
| <i>Crataegus spathulata</i> | littlehip hawthorn | 0-3L |
| <i>Crataegus viridis</i> | green hawthorn | 3L |
| <i>Liquidambar styraciflua</i> | sweetgum | 5-7L |
| <i>Liriodendron tulipifera</i> | yellow-poplar | 4-6L |
| <i>Morus rubra</i> | red mulberry | 0-3L |
| <i>Platanus occidentalis</i> | American sycamore | 3-5L |
| <i>Quercus alba</i> | white oak | 5-9L |
| <i>Quercus arkansana</i> | Arkansas oak | 3L |
| <i>Quercus austrina</i> | bluff oak | 3-7L |
| <i>Quercus breviloba</i> | Gulf oak | 3-7L |
| <i>Quercus coccinea</i> | scarlet oak | 7-9L |
| <i>Quercus falcata</i> | Southern red oak | 3-7L |
| <i>Quercus georgiana</i> | Georgia oak | 3-5L |
| <i>Quercus laevis</i> | turkey oak | 3-7L |
| <i>Quercus laurifolia</i> | swamp laurel oak | 0-3L |
| <i>Quercus lyrata</i> | overcup oak | 7-11L |
| <i>Quercus margaretta</i> | sand post oak | 3-5L |
| <i>Quercus marilandica</i> | blackjack oak | 0-3L |
| <i>Quercus nigra</i> | water oak | 0-3L |
| <i>Quercus pagoda</i> | cherrybark oak | 5-11L |
| <i>Quercus palustris</i> | pin oak | 5-7L |
| <i>Quercus rubra</i> | Northern red oak | 7-11L |
| <i>Quercus shumardii</i> | Shumard's oak | 5-9L |
| <i>Quercus similis</i> | swamp post oak | 4-6L |
| <i>Quercus sinuata</i> | bastard (Durand) oak | 3-5L |
| <i>Quercus stellata</i> | post oak | 5-7L |
| <i>Quercus velutina</i> | black oak | 7-9L |
| <i>Sassafras albidum</i> | sassafras | 0-3L |

Figure 45: Native tree species leaves with lobed margins.

The numeric values listed are the range of lobes found on leaves.

TREE LEAF / LEAFLET MARGINS

| | |
|---|------|
| A. ENTIRE | = 63 |
| 1) SERRATE OR ENTIRE | = 21 |
| 2) CRENATE OR ENTIRE | = 2 |
| = 86 (38%) | |
| B. SERRATE | = 65 |
| 1) DOUBLE SERRATE | = 13 |
| 2) SERRATE OR ENTIRE | = 21 |
| 3) SERRATE OR CRENATE | = 12 |
| 4) CRENATE OR ENTIRE | = 2 |
| 5) SERRATE OR DENTATE | = 2 |
| 6) SERRATE OR DOUBLE SERRATE | = 1 |
| 7) SERRATE & LOBED | = 13 |
| 8) DOUBLE SERRATE & LOBED | = 2 |
| 9) SERRATE OR DOUBLE SERRATE & LOBED | = 5 |
| = 136 (60%) | |
| C. LOBED | = 26 |
| 1) SERRATE & LOBED | = 13 |
| 2) DOUBLE SERRATE & LOBED | = 2 |
| 3) SERRATE OR DOUBLE SERRATE & LOBED | = 5 |
| = 46 (20%) | |

Figure 46: Native tree leaf / leaflet margin types.

Values = number of species and percent of all 225 native tree species surveyed.

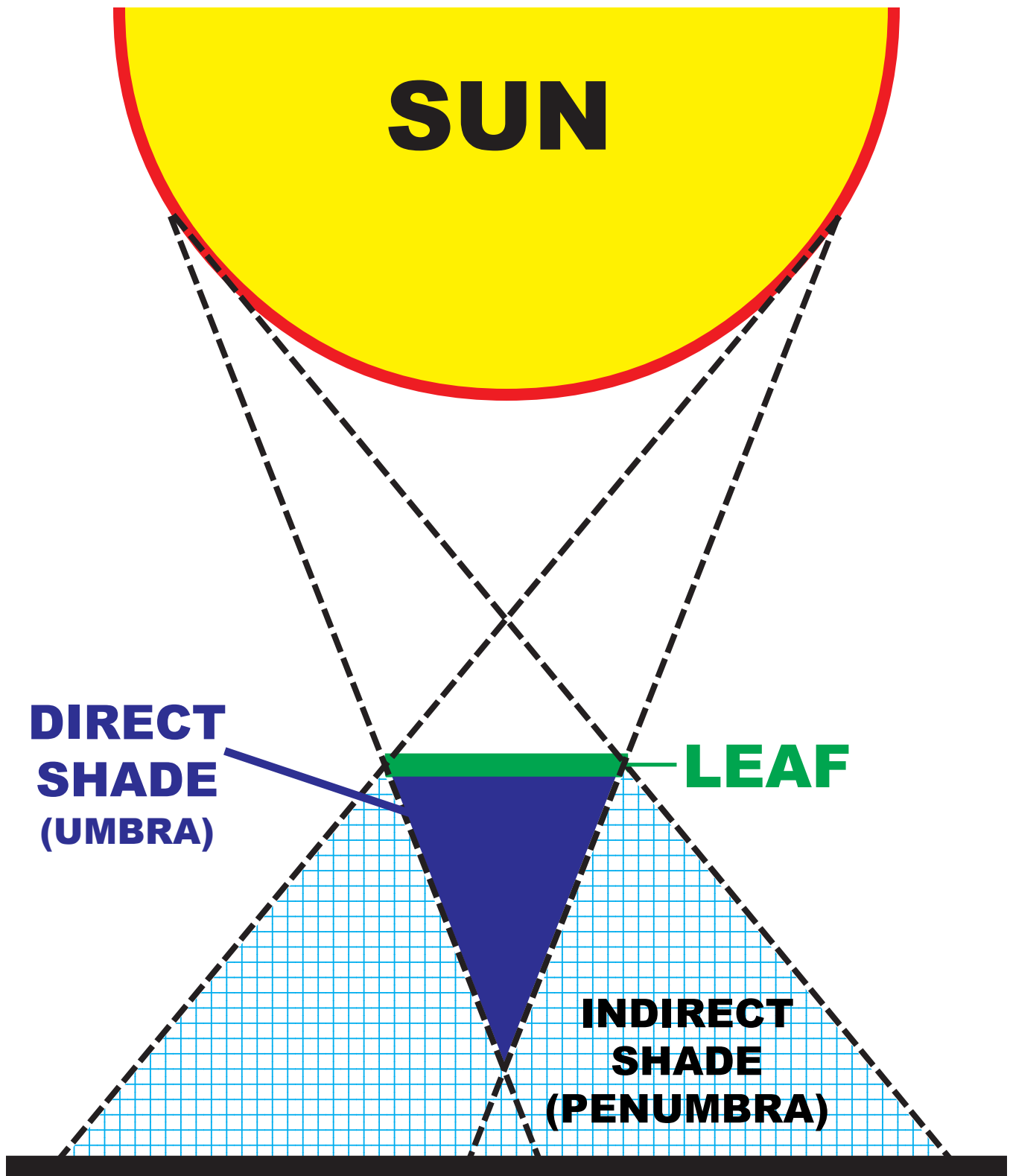


Figure 47: Direct (dense) shade volume (cone) behind a tree leaf with a given effective shade diameter.

Conclusions

Tree leaf / leaflet shapes and sizes are diverse and variable. All leaves perform a number of similar tasks both internally and externally, but these functions can be effectively completed using many different naturally honed shapes and sizes. Trees have generated many ways for leaves to be successful. The appearance of tree leaves can help identify tree species, genera, and growth problems. Tree leaves serve as windows into tree health and lineage.

Select Tree Leaf Reference Literature

- Coombes, A.J. 2010. **The Book of Leaves: A Leaf-By-Leaf Guide to Six Hundred of the World's Great Trees.** University of Chicago Press – Ivy Press, Chicago, IL. Pp.656.
- Duncan, W. H. & M.B. Duncan. 1988. **Trees of the Southeastern United States.** Wormsloe Foundation Publication #18. University of Georgia Press, Athens, GA. Pp.322.
- Ellis, B., D.C. Daly, L.J. Hickey, K.R. Johnson, J.D. Mitchell, P. Wilf & S.L. Wing. 2009. **Manual of Leaf Architecture.** New York Botanical Garden Press, Comstock Publishing Associates, Cornell University Press, Ithaca, NY. Pp.190.
- Harrar, E.S. & J.G. Harrar. 1962. **Guide to Southern Trees** (2nd edition). Dover Publications, New York, NY. Pp.709.
- Harris, J.G. & M.W. Harris. 2001. **Plant Identification Terminology: An Illustrated Glossary** (2nd edition). Spring Lake Publishing, Spring Lake, UT. Pp.216.
- Kirkman, L.K., C.L. Brown & D.J. Leopold. 2007. **Native Trees of the Southeast: A Identification Guide.** Timber Press, Portland, OR. Pp.370.
- Lance, R. 2014. **Haws: A Guide to Hawthorns of the Southeastern United States.** Ron Lance, Mills River, NC. Pp.518.
- Little, E.L. 1980. **Audubon Society Field Guide to North American Trees – Eastern Region.** Chanticleer Press, Alfred A. Knopf, New York, NY. Pp.714.
- Nelson, G., C.J. Earle & R. Spellenberg. 2014. **Trees of Eastern North America.** Princeton University Press, Princeton, NJ. Pp.720.
- Preston, R.J. 1976. **North American Trees** (3rd edition). Iowa State University Press, Ames, IA. Pp.399.
- Stein, J., D. Binion & R. Acciavatti. 2003. **Field Guide to Native Oak Species of Eastern North America.** USDA-Forest Service, Forest Health Technology Enterprise Team, FHTET-2003-01. Pp.164.



Outreach

Warnell School of Forestry & Natural Resources

UNIVERSITY OF GEORGIA

Citation:

Coder, Kim D. 2019. Tree anatomy: Leaf shape & form.
Warnell School of Forestry & Natural Resources,
University of Georgia, Outreach Publication
WSFNR-19-31. Pp.68.

Publication WSNR-19-31

Sept. 2019

The University of Georgia Warnell School of Forestry and Natural Resources offers educational programs, assistance and materials to all people without regard to race, color, national origin, age, gender or disability.

The University of Georgia is committed to principles of equal opportunity and affirmative action.