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Tree Anatomy: Leaf Shape & Form

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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 ratioswhere 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 continuos 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 thrusholds of length:width ratios. Figure 5 provides a master list of both general geometric shape criteria and associated leangth: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).

Obsubulate 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 obsubulate forms can also be considered linear.

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 obervational 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 compund 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 seperated 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 compound 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 seperate "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 indeterminant 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 basil 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.

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°. An acute tip is short pointed with an angle <90°. 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°. Cuspidate end shape has a sharp, short, stiff, thick point. Pungens end shape has a rigid, sharp, thick point.

An accuminate end shape has a long, narrow, gradually tapered pointed tip with an angle <90°. 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°. 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 “accuminate.”

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 speciaes leaf / leaflet apical tip descriptors are concentrated in the acute and accuminate 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 midvien 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°). Leaf base shapes can be acute which is pointed with an angle of <90°. A cuneate base is wedge-shaped with an angle <90°. A decurrent leaf base shows a progressively decreasing angle as the petiole is approached, with an angle <90°.

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 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° 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 decriptors 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 <~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.

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 perdindicular 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.

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, accuminate, 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, accuminate, 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 a 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 axises radiating from the leaf base. Palmate lobing can be divided into two additional forms: palmatisect, 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 axises 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; laciniate 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 sunflects, 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.

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.

Citation:

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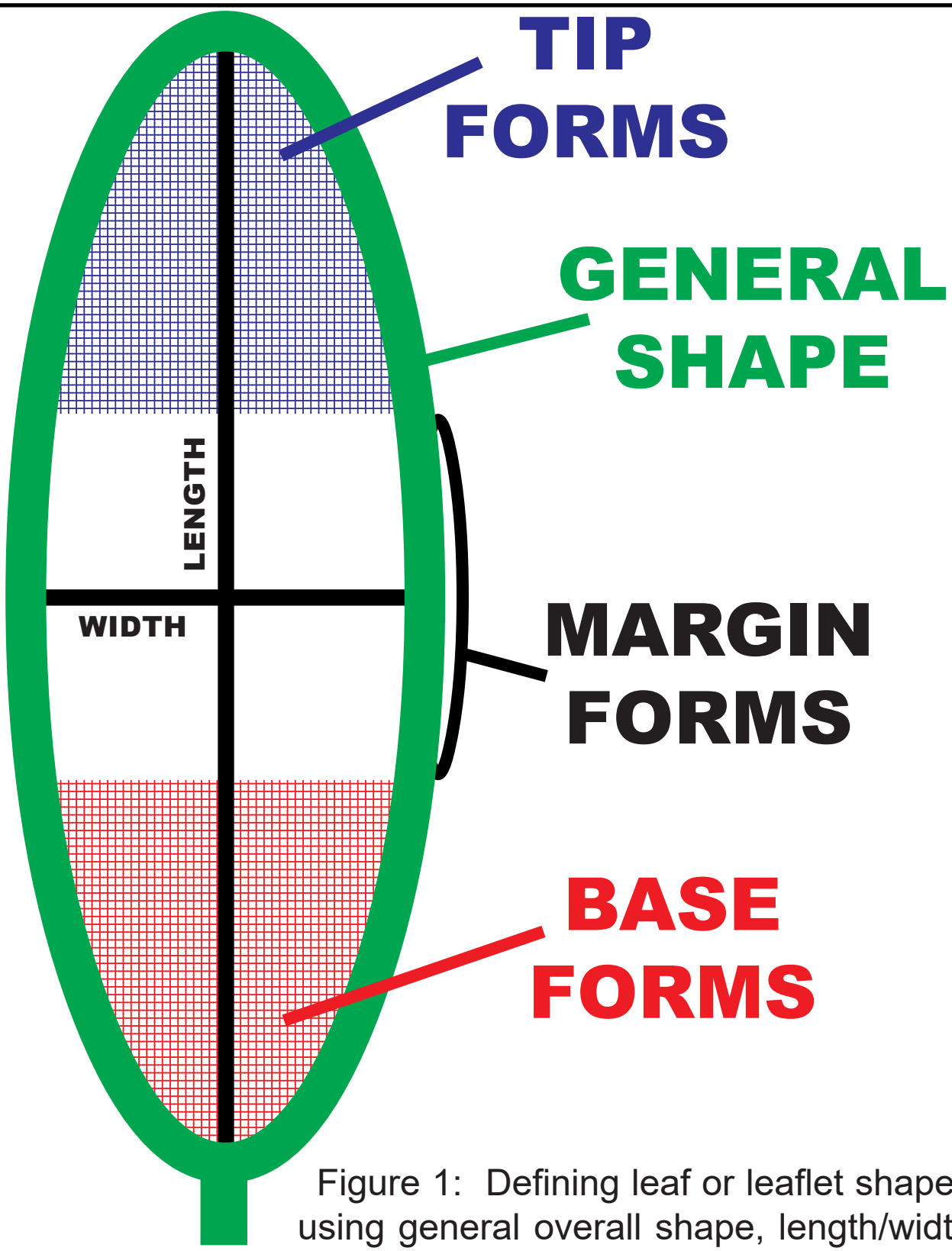

Figure 1: Defining leaf or leaflet shape using general overall shape, length/width values, tip and base types, and margin types.

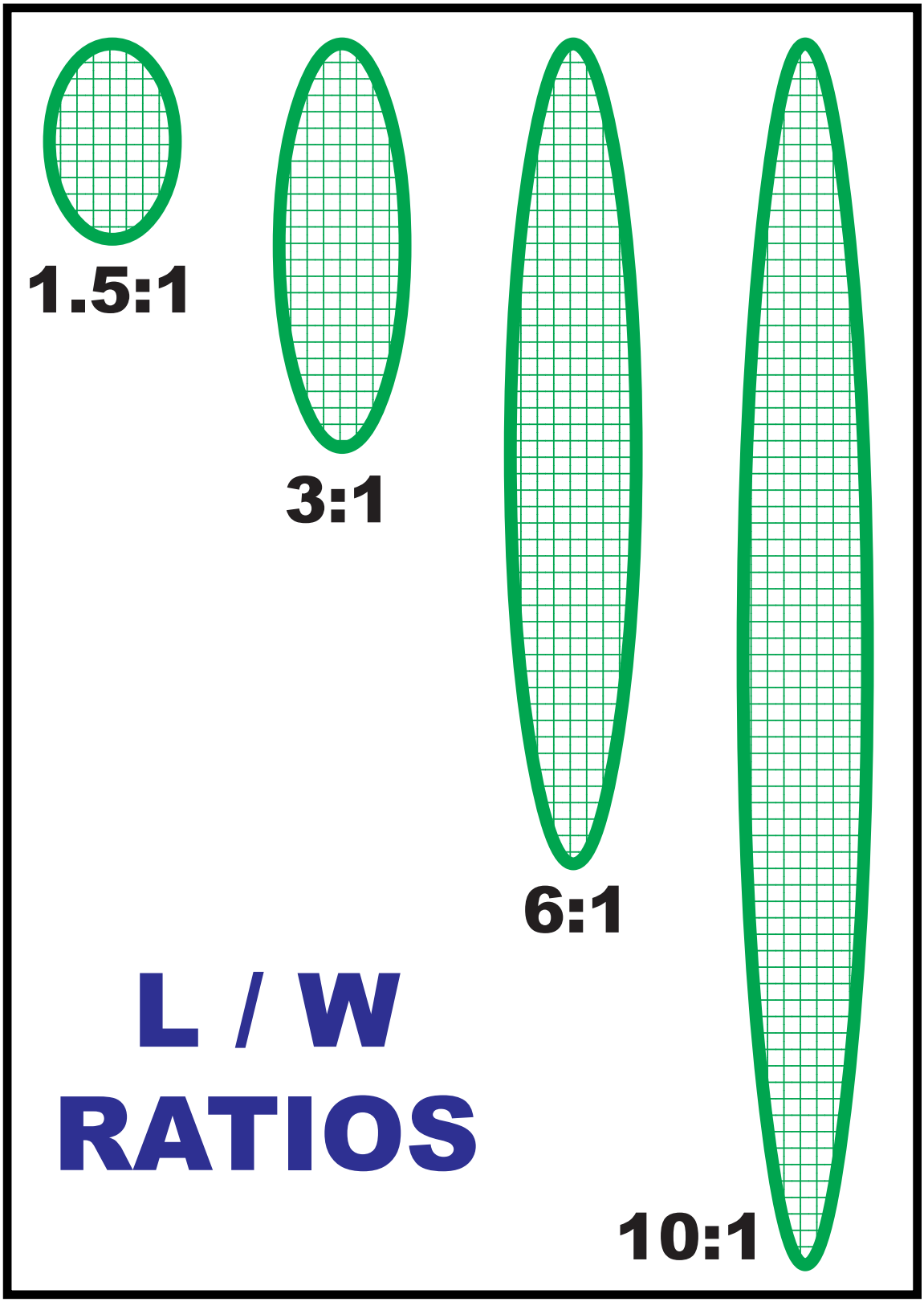

Figure 2: Length to width ratio examples with four shapes all of the same width.

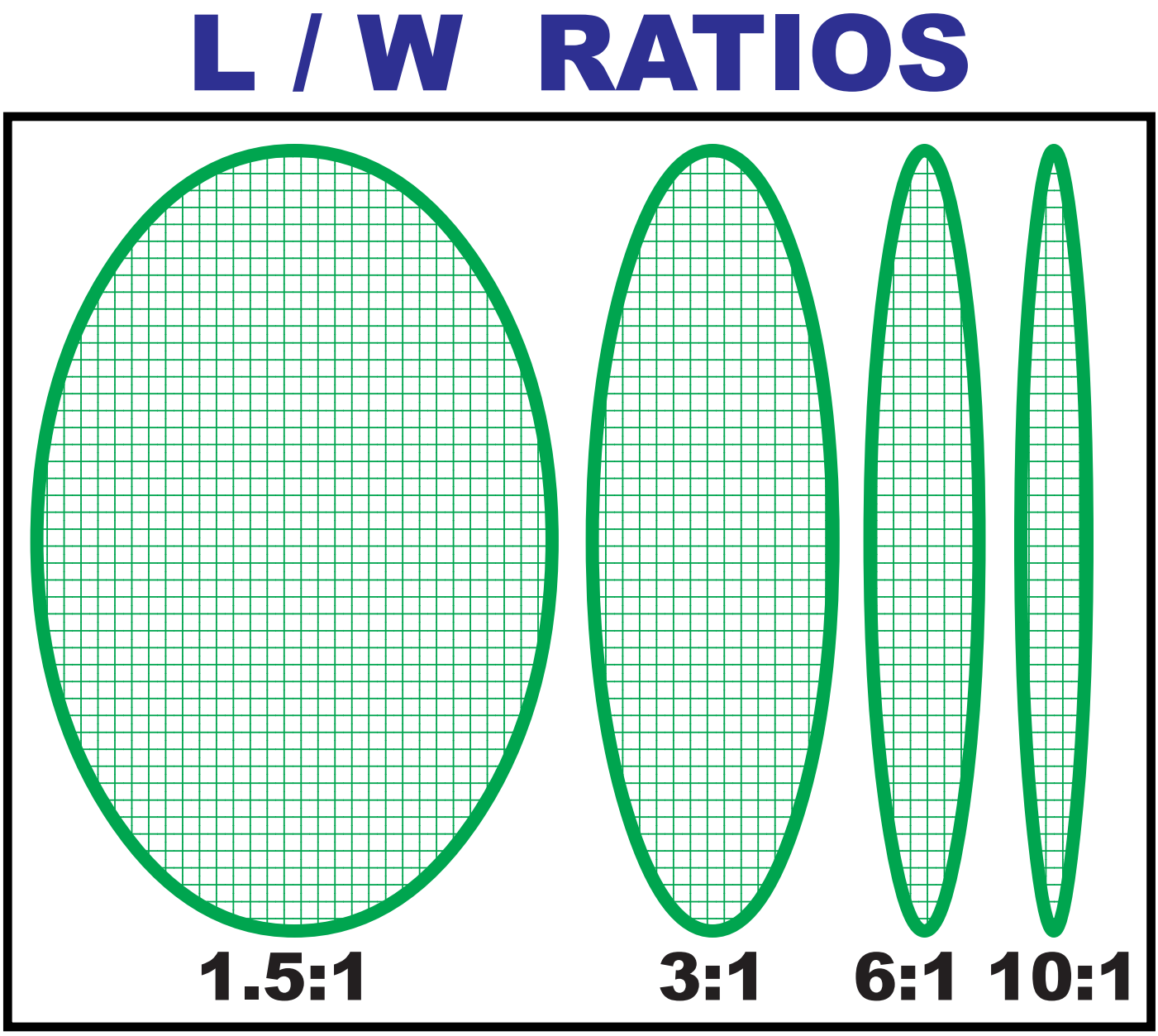

Figure 3: Length to width ratio examples with four shapes all of the same length.

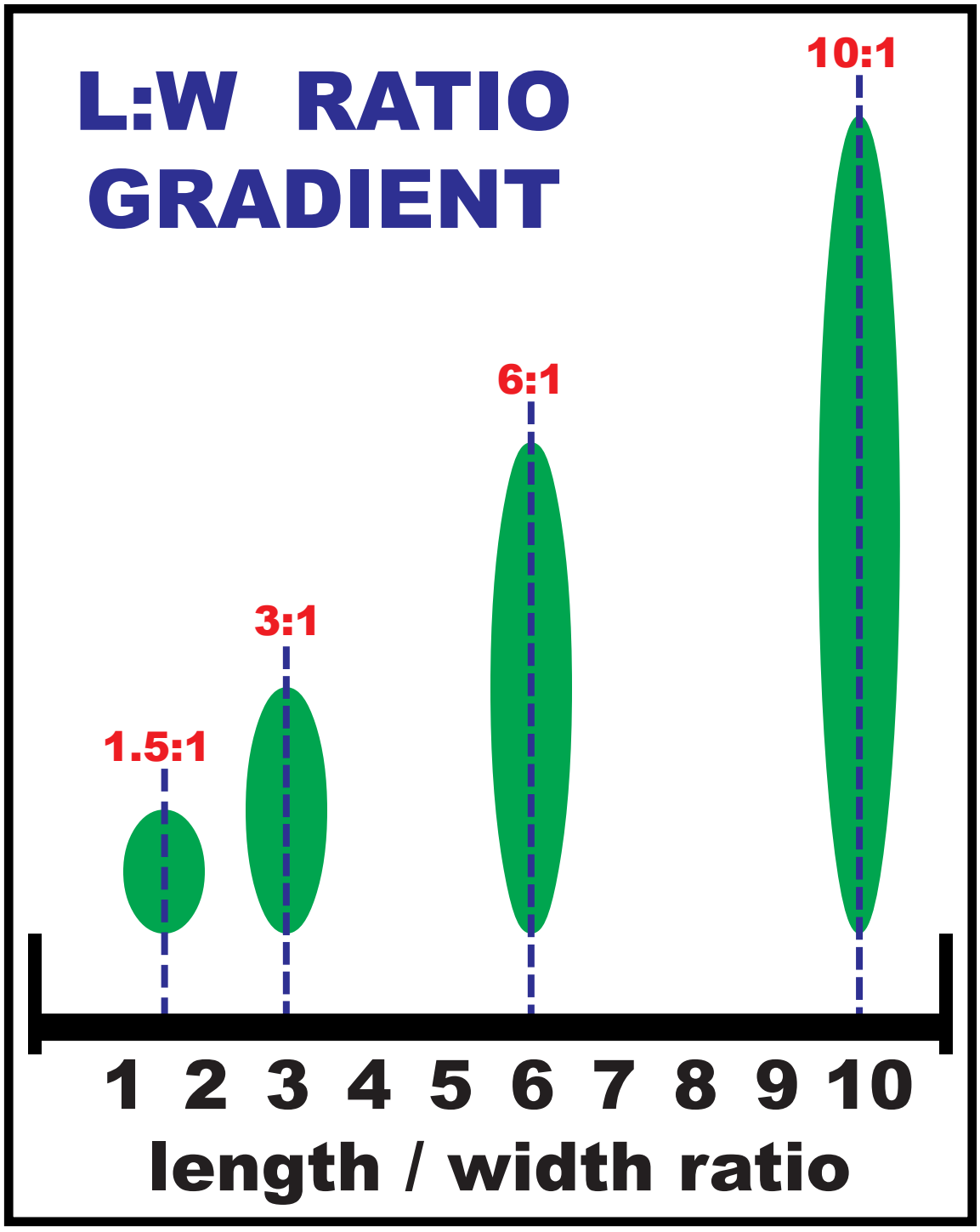

Figure 4: Continuous gradient of leaf length:width ratios and major leaf aspect thresholds.

general / geometric leaf shape		length to width ratio
Orbicular / Rotund	(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
Elliptical or Narrow Oval	(widest in middle – margins curved)	
Oval	(broad elliptical)	>1.5:1 ratio
Elliptic	(narrow oval)	>3:1 ratio
Oblong	(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)
Ovate	(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
Obovate	(widest in apical third of leaf – fat-tipped / wide-ended)	
Obovate	(oval-like)	>1.5:1 ratio
Obelliptical	(narrow oval-like)	>2:1 ratio
Oblanceolate	(long narrow oval-like)	>6:1 ratio (3:1 to 9:1)
Obsubulate	(barely tapered, fat-ended)	>10:1 ratio
Linear	(extremely long & narrow -- regardless of widest portion)	>10:1 ratio

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

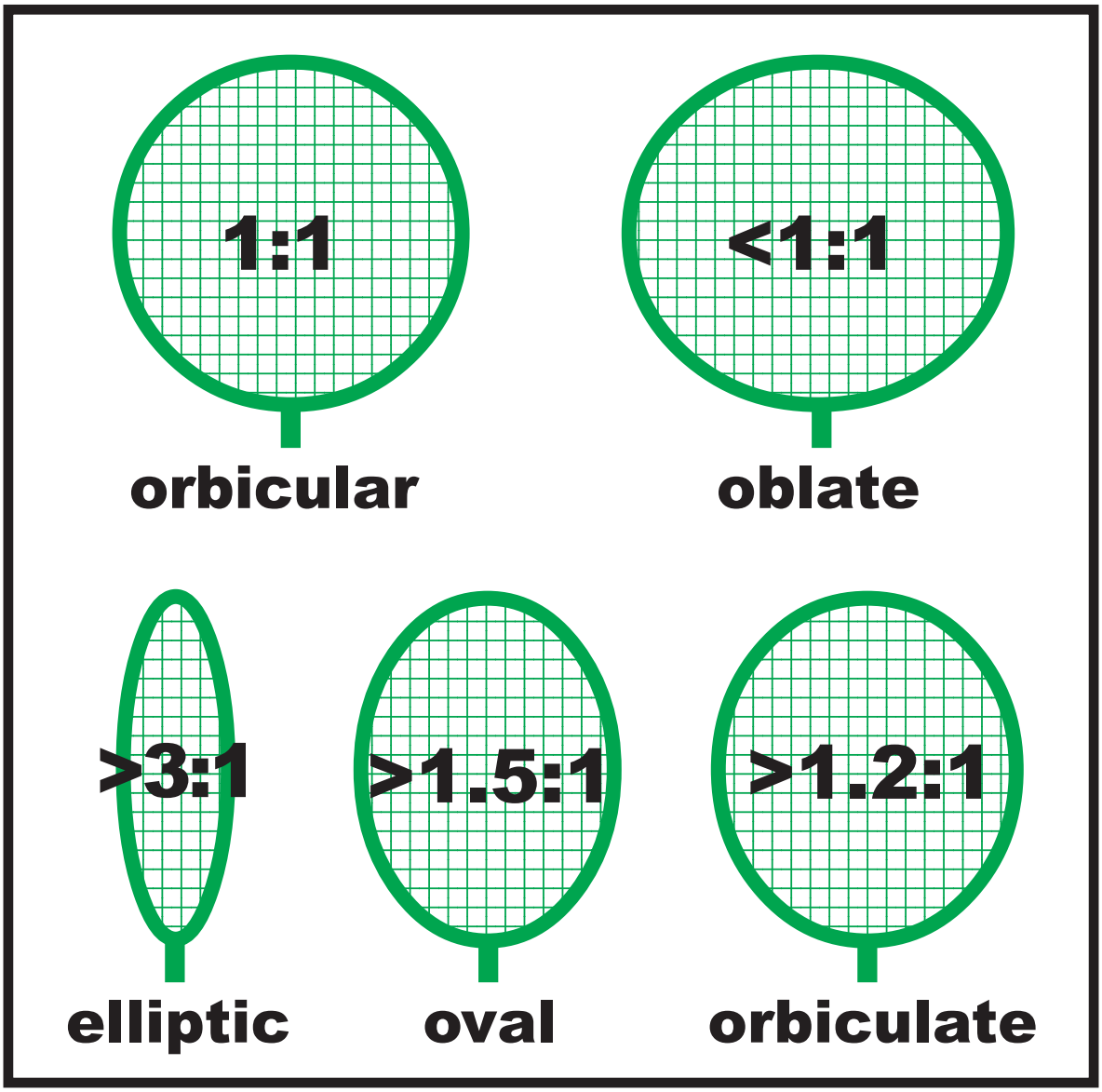

Figure 6: Listing of general tree leaf blade shapes which are widest in the middle with curved margins, associated length to width ratios, and geometric based names.

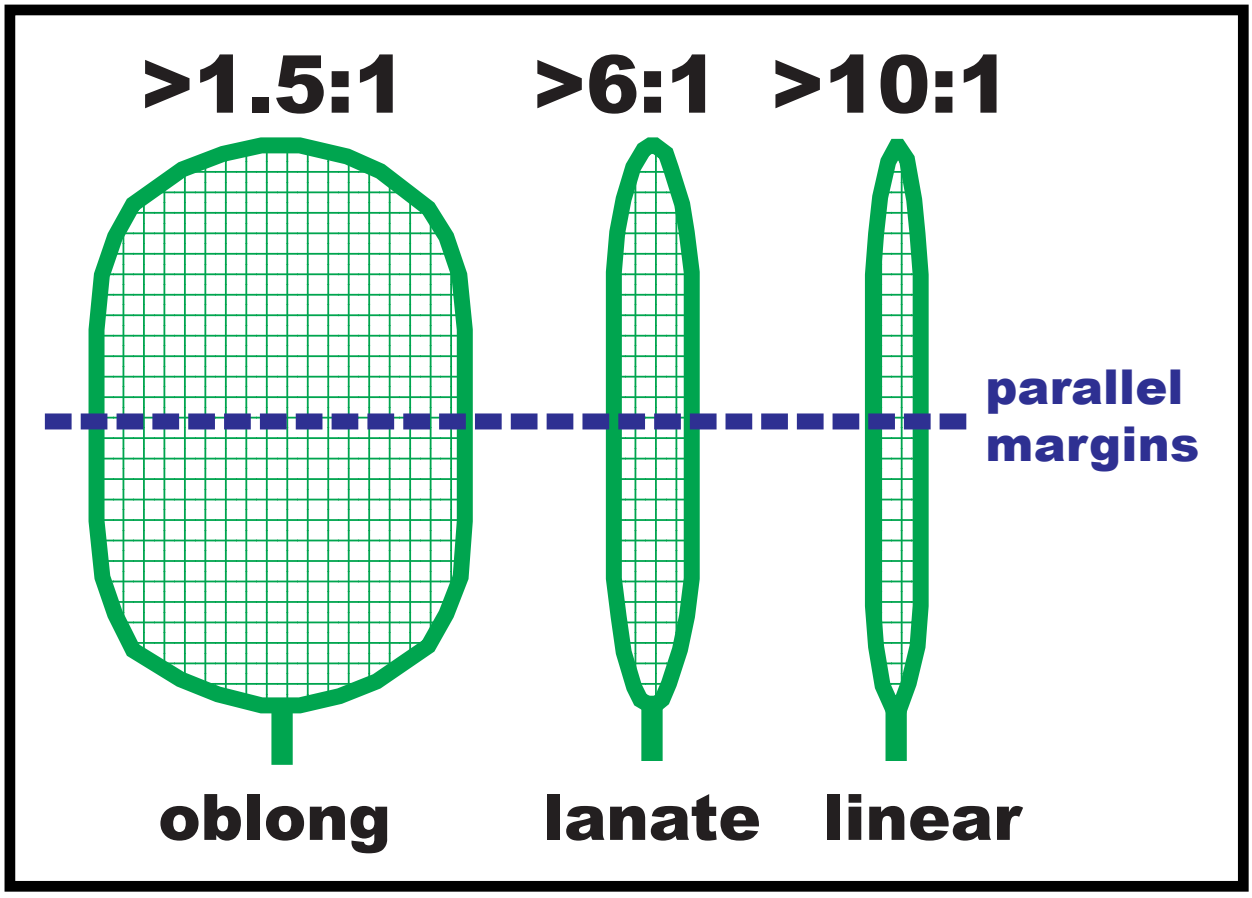

Figure 7: Listing of general tree leaf blade shapes which are widest in the middle with parallel margins, associated length to width ratios, and geometric based names.

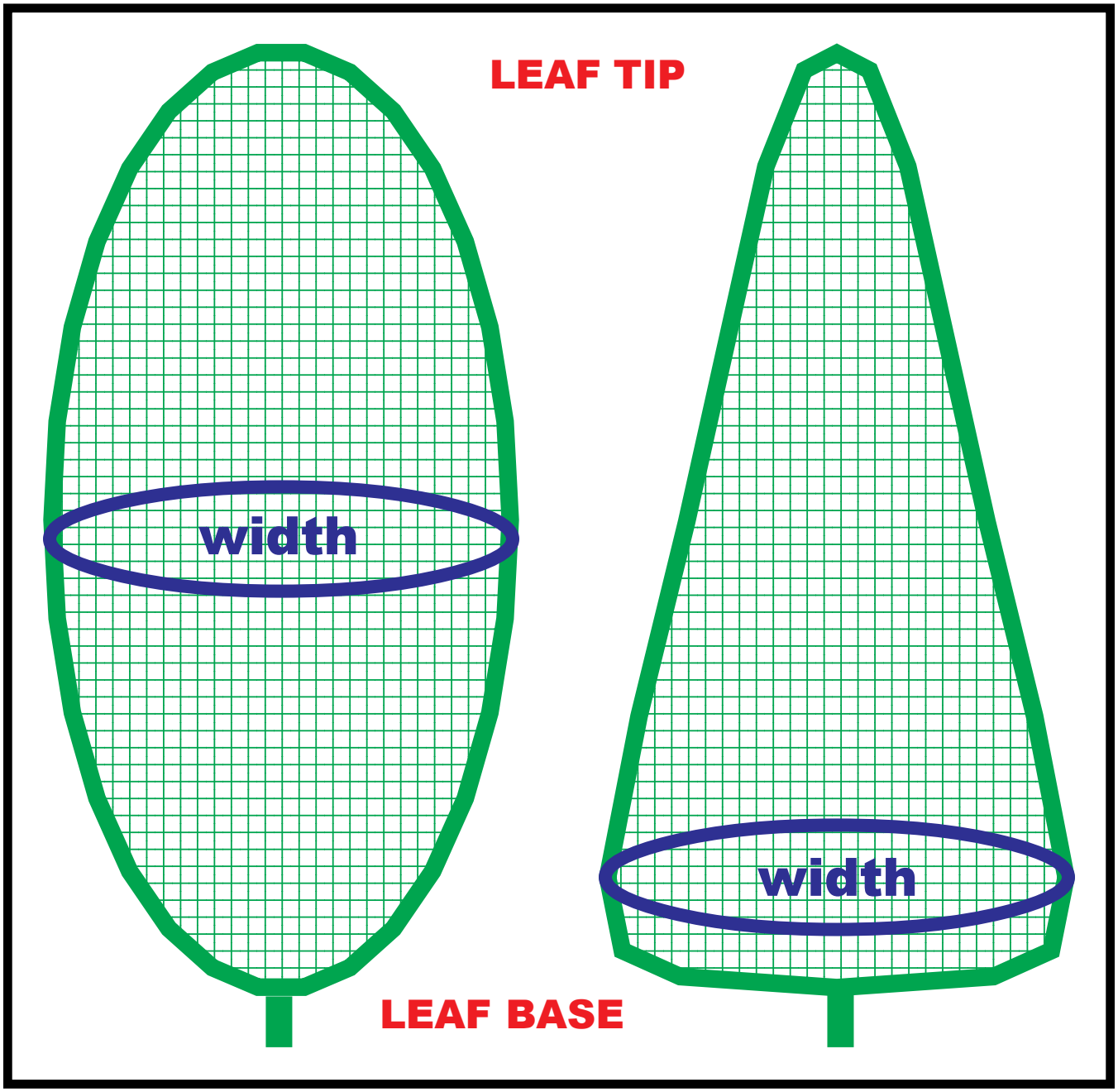

Figure 8: Tree leaf blade shape names are based upon general forms determined by where along a leaf length it is widest -- across the middle, toward its tip, or toward its base.

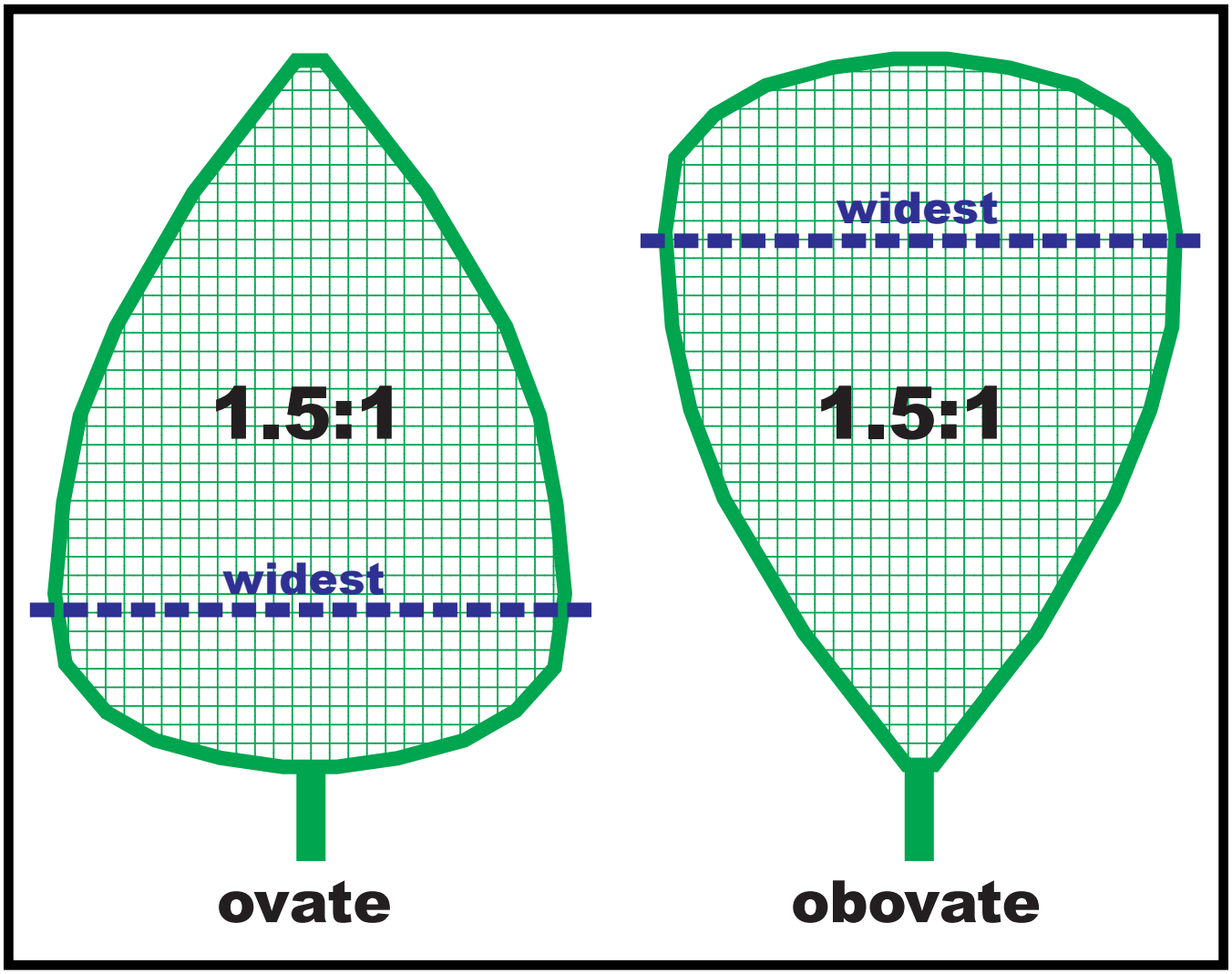

Figure 9: General oval-like tree leaf blade shapes which are widest at either end, with length to width ratios, and names.

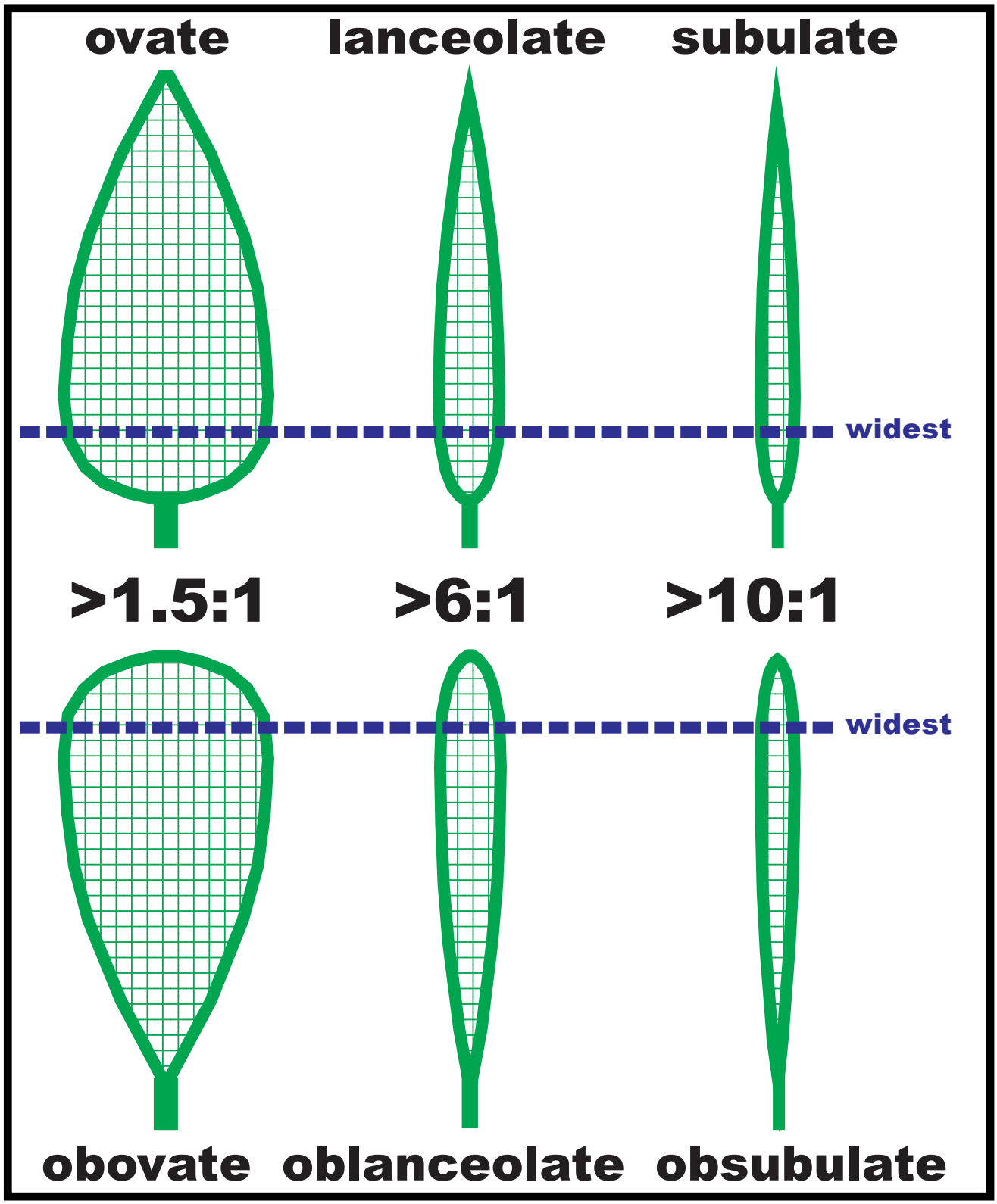

Figure 10: Listing of general oval-form tree leaf blade shapes which are widest at either end, with associated length to width ratios, and geometric based names.

The prefix “ob” means away from the leaf base.

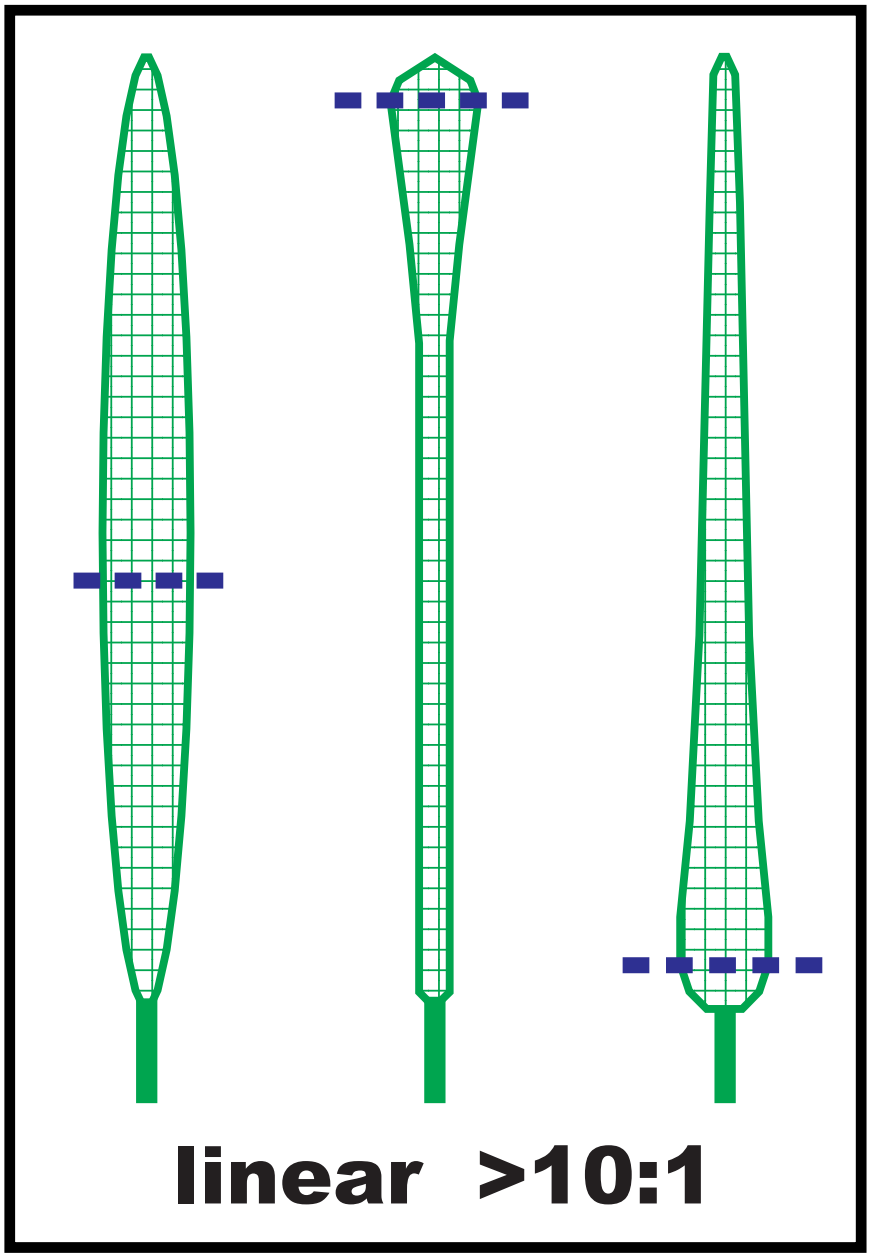

Figure 11: Long, narrow tree leaf blade shapes which can be widest anywhere along their length, with associated length to width ratio, and generic name.

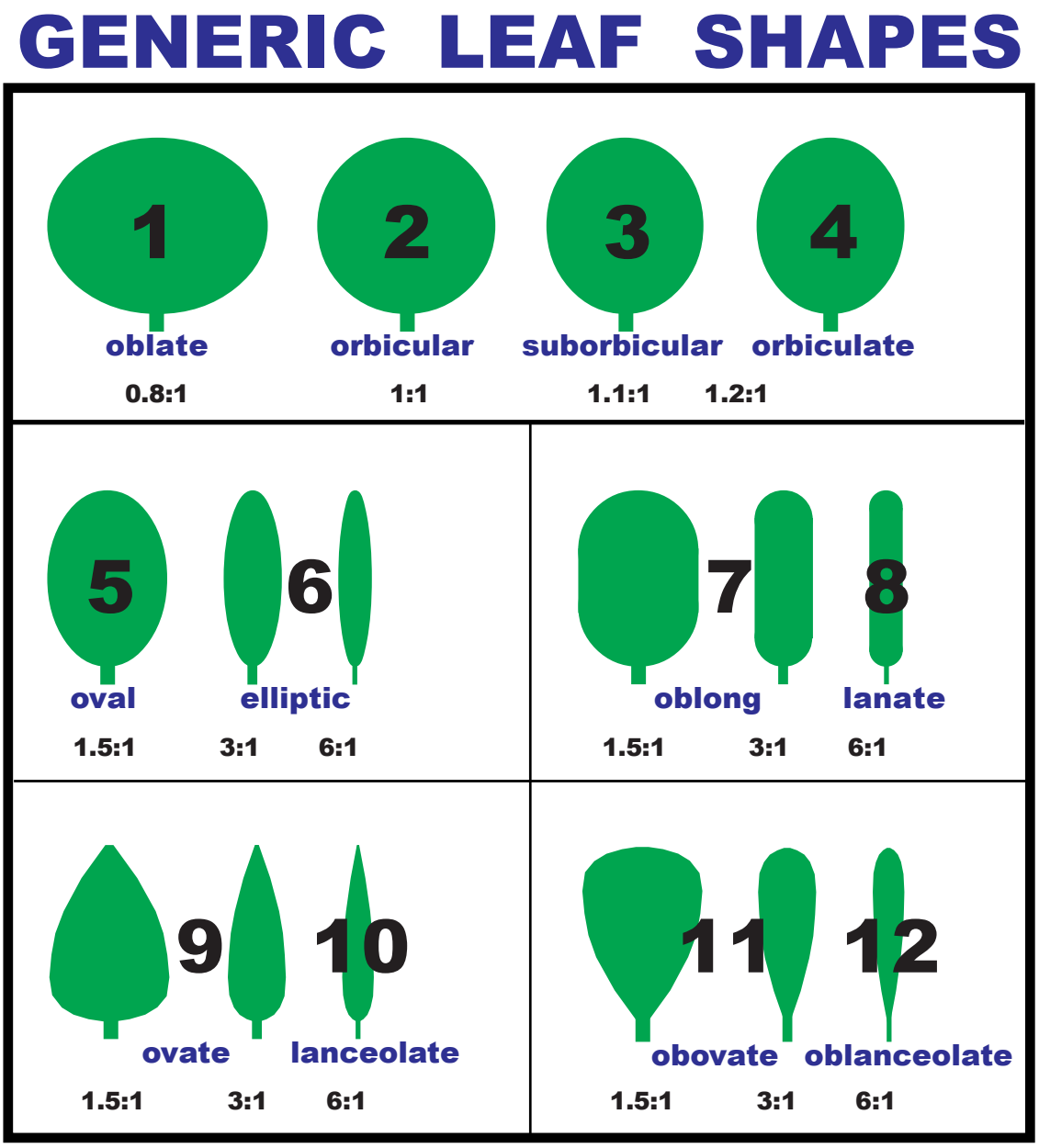

Figure 12: Field guide of generic leaf / leaflet forms, geometric based shape names, and associated code numbers.

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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.

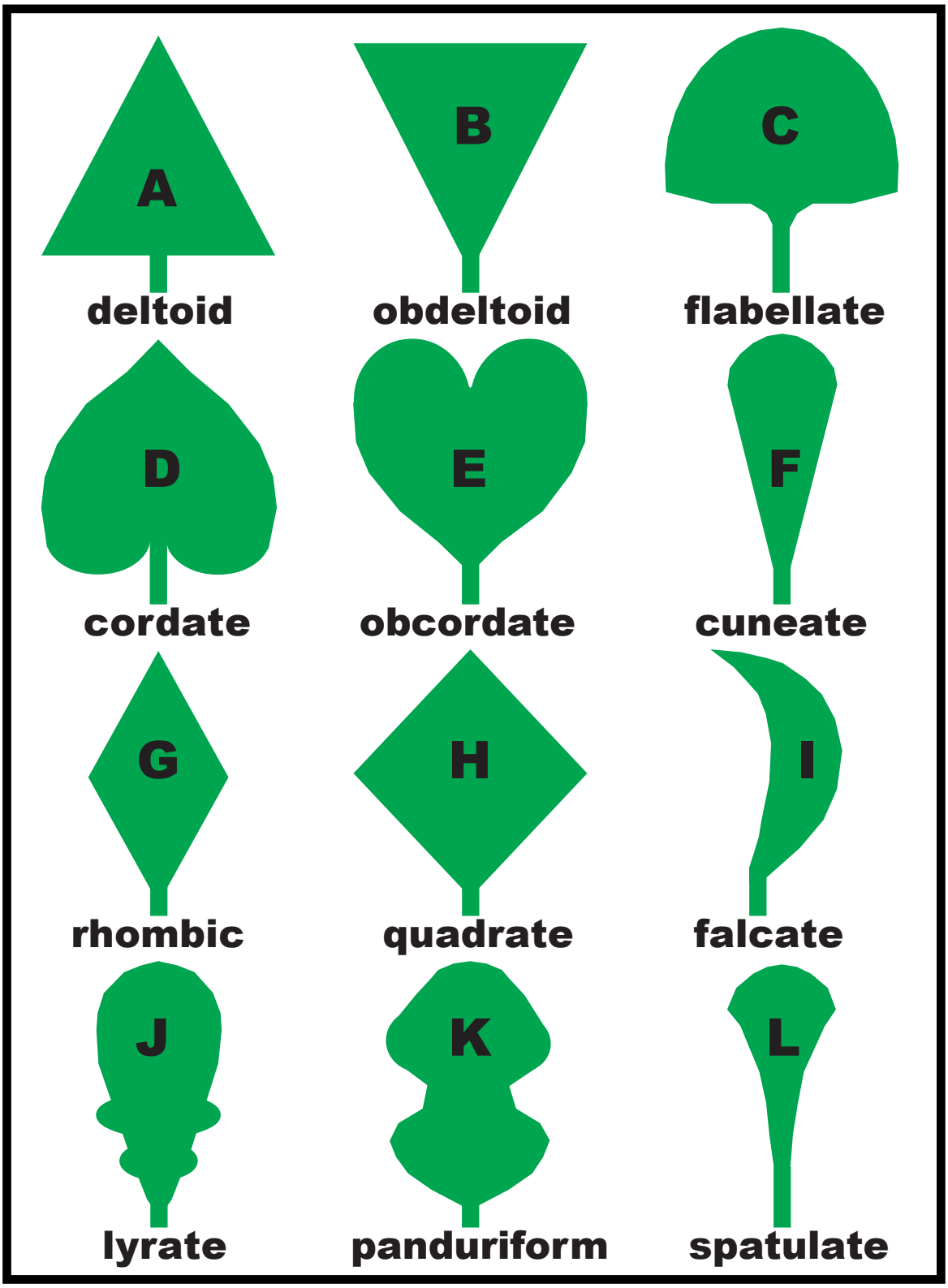

Figure 14: Special tree leaf / leaflet forms, shape name, and code letter.

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

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

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

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

scientific name	common name	L:W	description
Ilex longipes	Georgia holly	2.0	ovate obovate
Ilex montana	mountain holly	2.3	oval ovate
Ilex myrtifolia	myrtle dahoon	4.0	elliptic lanate
Ilex opaca	American holly	2.7	oval ovate
Ilex verticillata	winterberry	2.1	elliptic obovate
Ilex vomitoria	yaupon	3.4	oval elliptic
Illicium floridanum	Florida anisetree	3.0	elliptic ovate
Illicium parviflorum	yellow anisetree	2.5	elliptic
Kalmia latifolia	mountain-laurel	2.7	elliptic ovate
Leitneria floridana	corkwood	2.4	elliptic ovate lanceolate
Liquidambar styraciflua	sweetgum	1.0	orbicular suborbicular
Liriodendron tulipifera	yellow-poplar	1.0	oblate orbicular
Lyonia ferruginea	staggerbush	3.5	elliptic oblong
Magnolia acuminata	mt. cucumber-tree	1.5	oval ovate
Magnolia cordata	Pied. cucumber-tree	2.0	oblong obovate
Magnolia fraseri	mountain magnolia	2.3	obovate
Magnolia grandiflora	Southern magnolia	1.6	oval elliptic
Magnolia macrophylla	bigleaf magnolia	3.0	oblong obovate
Magnolia pyramidata	pyramid magnolia	2.0	obovate
Magnolia tripetala	umbrella-tree	2.0	oval elliptic obovate
Magnolia virginiana	sweetbay	2.4	oval elliptic oblong
Malus angustifolia	Southern crabapple	1.7	oval elliptic
Malus coronaria	sweet crabapple	2.2	ovate
Morus rubra	red mulberry	1.5	suborbicular ovate
Myrica cerifera	wax-myrtle	5.8	oblanceolate
Myrica heterophylla	evergreen bayberry	2.2	elliptic obovate
Myrica inodora	odorless bayberry	2.7	elliptic obovate
Nyssa aquatica	water tupelo	2.0	oval ovate
Nyssa biflora	swamp tupelo	1.8	elliptic lanate oblanceolate
Nyssa ogeche	Ogeeche-lime	2.2	oval elliptic oblong
Nyssa sylvatica	blackgum	1.7	oval elliptic oblong

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

scientific name	common name	L:W	description
Osmanthus americanus	devilwood	3.3	elliptic ovate
Ostrya virginiana	Eastern hophornbeam	2.5	oval ovate
Oxydendrum arboreum	sourwood	2.8	oval elliptic ovate
Persea borbonia	red-bay	3.3	elliptic ovate
Persea palustris	swamp-bay	3.0	oval elliptic ovate
Pinckneya bracteata	fevertree	2.0	oval elliptic
Planera aquatica	water-elm	2.5	ovate deltoid
Platanus occidentalis	American sycamore	1.0	orbiculate oval ovate
Populus deltoides	Eastern cottonwood	1.5	ovate deltoid
Populus heterophylla	swamp cottonwood	1.3	ovate deltoid
Prunus alabamensis	Alabama cherry	1.8	oval ovate
Prunus americana	American plum	2.2	oval elliptic obovate
Prunus angustifolia	Chickasaw plum	2.5	ovate
Prunus caroliniana	laurelcherry	2.7	elliptic
Prunus pensylvanica	fire cherry	3.8	elliptic falcate
Prunus serotina	black cherry	2.8	elliptic
Prunus umbellata	flatwoods plum	1.9	elliptic ovate
Quercus alba	white oak	2.0	elliptic obovate
Quercus arkansana	Arkansas oak	1.7	ovate obovate
Quercus austrina	bluff oak	2.0	obovate
Quercus breviloba	Gulf oak	2.0	elliptic obovate
Quercus chapmanii	Chapman oak	2.1	oblong obovate
Quercus coccinea	scarlet oak	1.3	oval elliptic obovate
Quercus falcata	Southern red oak	1.6	elliptic ovate
Quercus geminata	sand live oak	2.0	elliptic
Quercus georgiana	Georgia oak	1.6	oval elliptic
Quercus hemisphaerica	laurel oak	2.6	elliptic ovate
Quercus imbricaria	shingle oak	2.7	elliptic oblong lanceolate
Quercus incana	bluejack oak	3.2	elliptic oblong ovate
Quercus laevis	turkey oak	1.3	oval ovate deltoid
Quercus laurifolia	swamp laurel oak	2.8	oblong ovate rhombic
Quercus lyrata	overcup oak	1.9	oblong
Quercus margaretta	sand post oak	1.6	obovate
Quercus marilandica	blackjack oak	1.2	obovate obdeltoid
Quercus michauxii	swamp chestnut oak	1.8	obovate

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

scientific name	common name	L:W	description
Quercus minima	dwarf live oak	2.4	obovate oblanceolate
Quercus montana	chestnut oak	2.6	oval elliptic obovate
Quercus muehlenbergii	chinquapin oak	1.9	elliptic ovate obovate
Quercus myrtifolia	myrtle oak	2.0	elliptic obovate
Quercus nigra	water oak	2.3	oblong obovate cuneate
Quercus oglethorpensis	Oglethorpe oak	3.3	elliptic obovate
Quercus pagoda	cherrybark oak	1.9	ovate obovate
Quercus palustris	pin oak	1.3	elliptic oblong
Quercus phellos	willow oak	4.8	lanate lanceolate
Quercus prinoides	dwarf chinquapin oak	2.2	obovate
Quercus rubra	Northern red oak	1.6	oval elliptic
Quercus shumardii	Shumard's oak	1.5	oval elliptic oblong
Quercus similis	swamp post oak	2.4	obovate
Quercus sinuata	bastard (Durand) oak	2.7	elliptic ovate rhombic
Quercus stellata	post oak	1.5	oval obovate
Quercus velutina	black oak	1.6	oval obovate
Quercus virginiana	live oak	2.1	elliptic oblong
Rhamnus caroliniana	buckthorn	3.0	oval elliptic
Rhododendron catawbiense	purple-laurel	2.3	oval elliptic
Rhododendron maximum	rosebay-laurel	3.3	elliptic oblong
Salix caroliniana	Coastal Plain willow	5.0	ovate lanceolate
Salix floridana	Florida willow	3.0	elliptic oblong
Salix nigra	black willow	6.3	lanceolate falcate
Salix sericea	silky willow	4.0	elliptic lanceolate
Sassafras albidum	sassafras	1.3	elliptic ovate
Sideroxylon lanuginosa	gum bumelia	3.0	elliptic obovate cuneate
Sideroxylon lycioides	buckthorn bumelia	3.1	elliptic oblanceolate cuneate
Sideroxylon tenax	tough bumelia	2.1	obovate cuneate
Stewartia malacodendron	silky camellia	2.1	oval elliptic
Stewartia ovata	mountain camellia	1.9	elliptic ovate
Styrax americanus	American snowbell	1.8	oval ovate
Styrax grandifolius	bigleaf snowbell	1.4	orbiculate oval
Symplocos tinctoria	sweetleaf	2.5	elliptic ovate

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

scientific name	common name	L:W	description
Tilia americana	American basswood	1.2	orbiculate oval ovate cordate
Tilia caroliniana	Carolina basswood	1.1	orbiculate ovate
Tilia floridana	Florida basswood	1.6	orbiculate ovate
Tilia heterophylla	white basswood	1.2	orbiculate ovate
Ulmus alata	winged elm	2.1	elliptic ovate obovate
Ulmus americana	American elm	2.2	elliptic ovate
Ulmus rubra	slippery elm	2.1	oval ovate
Ulmus serotina	September elm	1.9	elliptic ovate
Vaccinium arboreum	farkleberry	1.9	oval elliptic obovate
Viburnum cassinoides	Northern possumhaw	1.9	elliptic ovate
Viburnum dentatum	Southern arrowwood	1.1	oval ovate
Viburnum lentago	nannyberry	1.6	elliptic
Viburnum nudum	Southern possumhaw	2.0	elliptic
Viburnum obovatum	small-leaf arrowwood	1.9	obovate spatulate
Viburnum prunifolium	blackhaw	1.5	oval elliptic
Viburnum rufidulum	rusty blackhaw	1.6	elliptic
Yucca aloifolia	Spanish-bayonet	11.1	lanate
Yucca gloriosa	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
Acer negundo	boxelder	1.8	elliptic ovate
Aesculus flava	yellow buckeye	3.0	elliptic obovate
Aesculus glabra	Ohio buckeye	2.4	elliptic obovate
Aesculus parviflora	bottlebrush buckeye	2.0	lanceolate obovate
Aesculus pavia	red buckeye	2.5	elliptic
Aesculus sylvatica	Georgia buckeye	2.4	elliptic ovate
Aralia spinosa	devil's walkingstick	2.7	elliptic ovate
Carya aquatica	water hickory	3.3	ovate lanceolate falcate
Carya australis	Southern shag hick	2.9	ovate obovate
Carya cordiformis	bitternut hickory	5.5	ovate lanceolate
Carya glabra	pignut hickory	1.7	ovate obovate
Carya laciniosa	shellbark hickory	1.9	ovate lanceolate obovate
Carya myristiciformis	nutmeg hickory	2.3	ovate
Carya ovalis	red hickory	3.5	ovate
Carya ovata	shagbark hickory	1.6	elliptic ovate obovate
Carya pallida	sand hickory	2.7	elliptic ovate
Carya tomentosa	mockernut hickory	2.0	oval elliptic ovate
Cladrastis kentukea	yellowwood	2.3	elliptic ovate
Fraxinus americana	white ash	2.0	elliptic ovate
Fraxinus caroliniana	Carolina ash	2.3	oval ovate
Fraxinus pennsylvanica	green ash	3.3	elliptic ovate
Fraxinus profunda	pumpkin ash	2.3	oval ovate
Fraxinus quadrangulata	blue ash	3.0	ovate lanceolate
Gleditsia aquatica	water locust	2.3	oblong
Gleditsia triacanthos	honeylocust	2.5	oval oblong
Juglans cinerea	butternut	1.8	oblong ovate lanceolate
Juglans nigra	black walnut	2.0	ovate lanceolate
Ptelea trifoliata	hoptree	2.0	elliptic ovate
Rhus copallinum	winged sumac	2.3	oblong ovate lanceolate
Rhus glabra	smooth sumac	2.7	ovate
Rhus typhina	staghorn sumac	4.4	ovate lanceolate falcate
Robinia hispida	pink locust	1.9	oval

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

scientific name	common name	L:W	description
Robinia pseudoacacia	black locust	2.4	oval elliptic
Robinia viscosa	clammy locust	1.9	oval elliptic ovate
Sambucus canadensis	American elder	2.0	elliptic
Sambucus simpsonii	Southern elder	3.8	elliptic ovate
Sapindus marginatus	Florida soapberry	2.4	elliptic lanceolate falcate
Sorbus americana	Amer. mountain-ash	3.9	lanceolate
Staphylea trifolia	bladdernut	3.3	elliptic
Toxicodendron vernix	poison sumac	1.8	elliptic ovate
Zanthoxylum americanum	prickly-ash	1.5	elliptic ovate
Zanthoxylum clava-herculis	Hercules' club	2.0	ovate lanceolate falcate

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

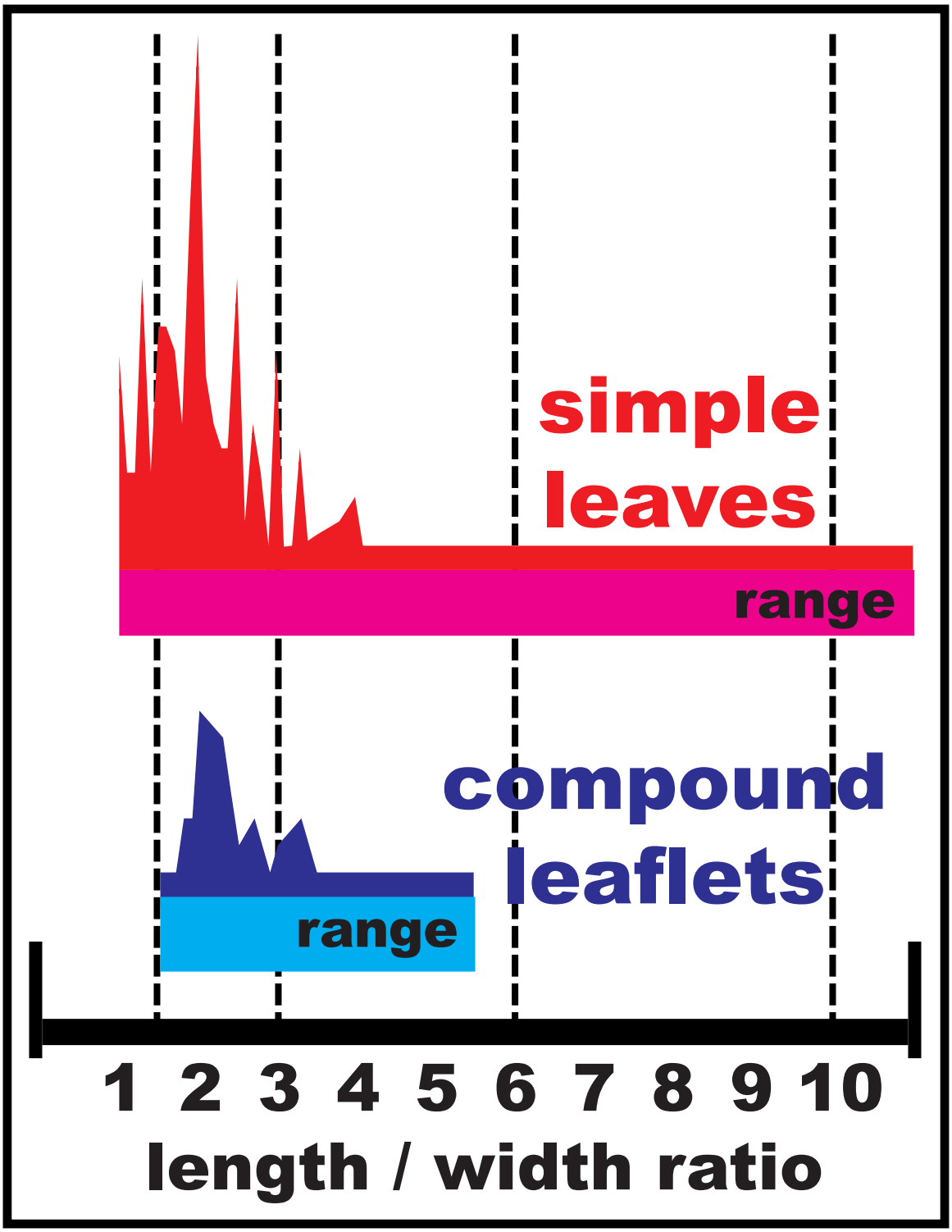

Figure 17: Range and distribution of leaf / leaflet length:width ratios for native trees.
Note between 1.5:1 and 3.3:1 length:width ratios lie most native trees

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)

NEEDLE / SCALE / AWL SHAPED LEAVES

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

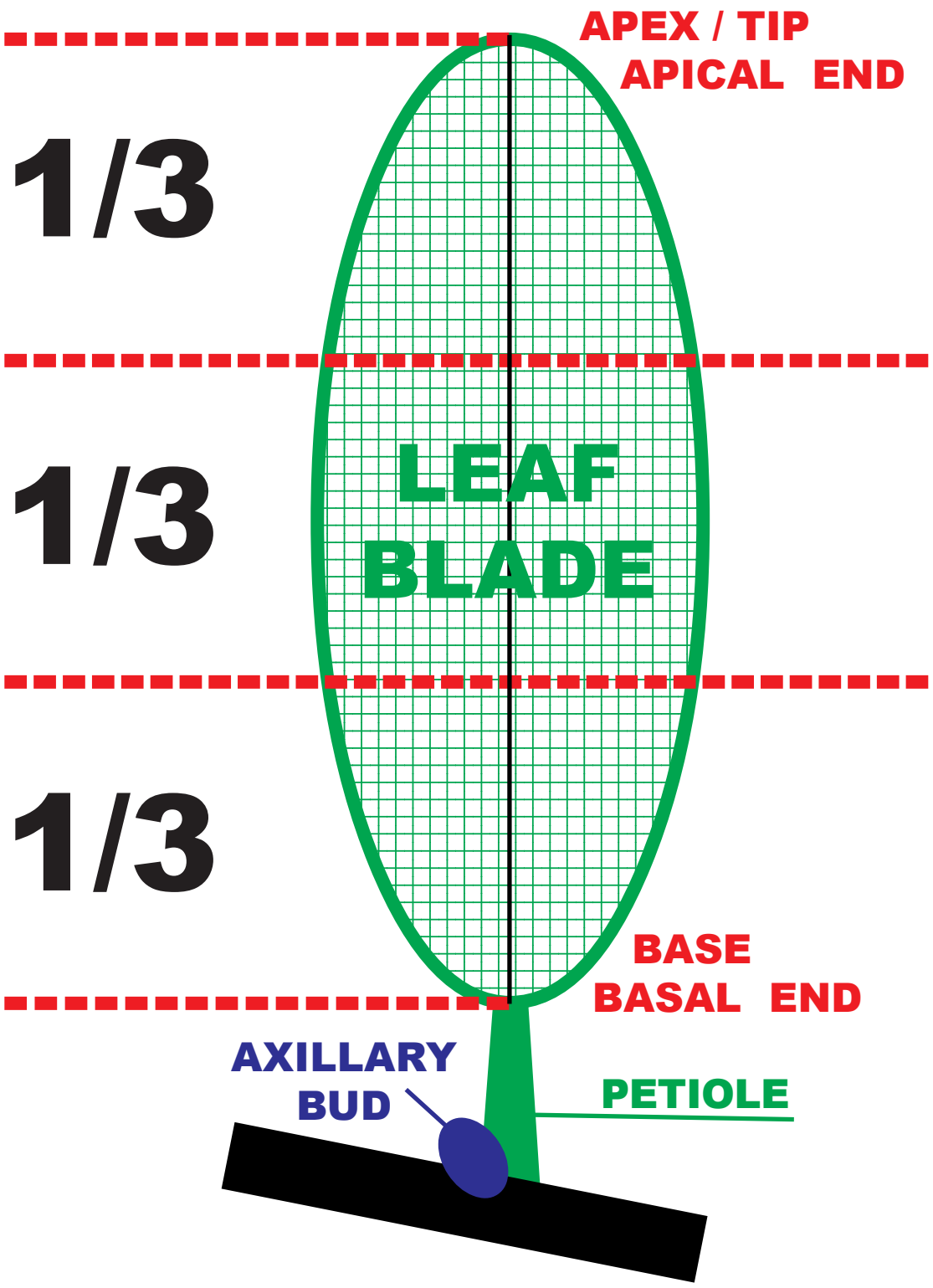

Figure 20: Simple leaf showing three areas of a leaf blade -- tip, middle, and base thirds. The axillary bud is not part of a leaf, but grows from the twig at the base of a leaf and shows where a leaf begins.

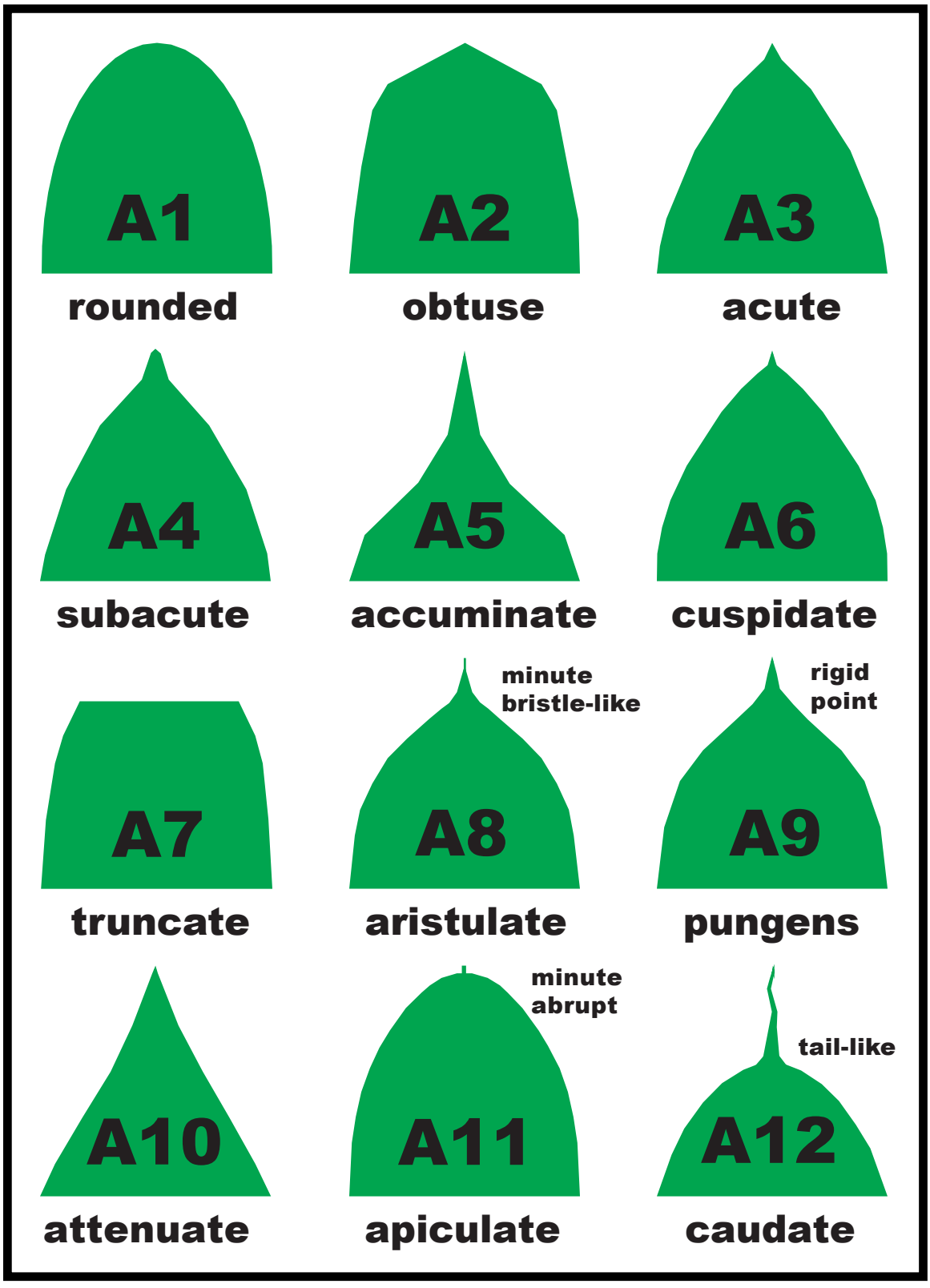

Figure 21: Tree leaf / leaflet apical end / tip shapes, identification codes, and names.

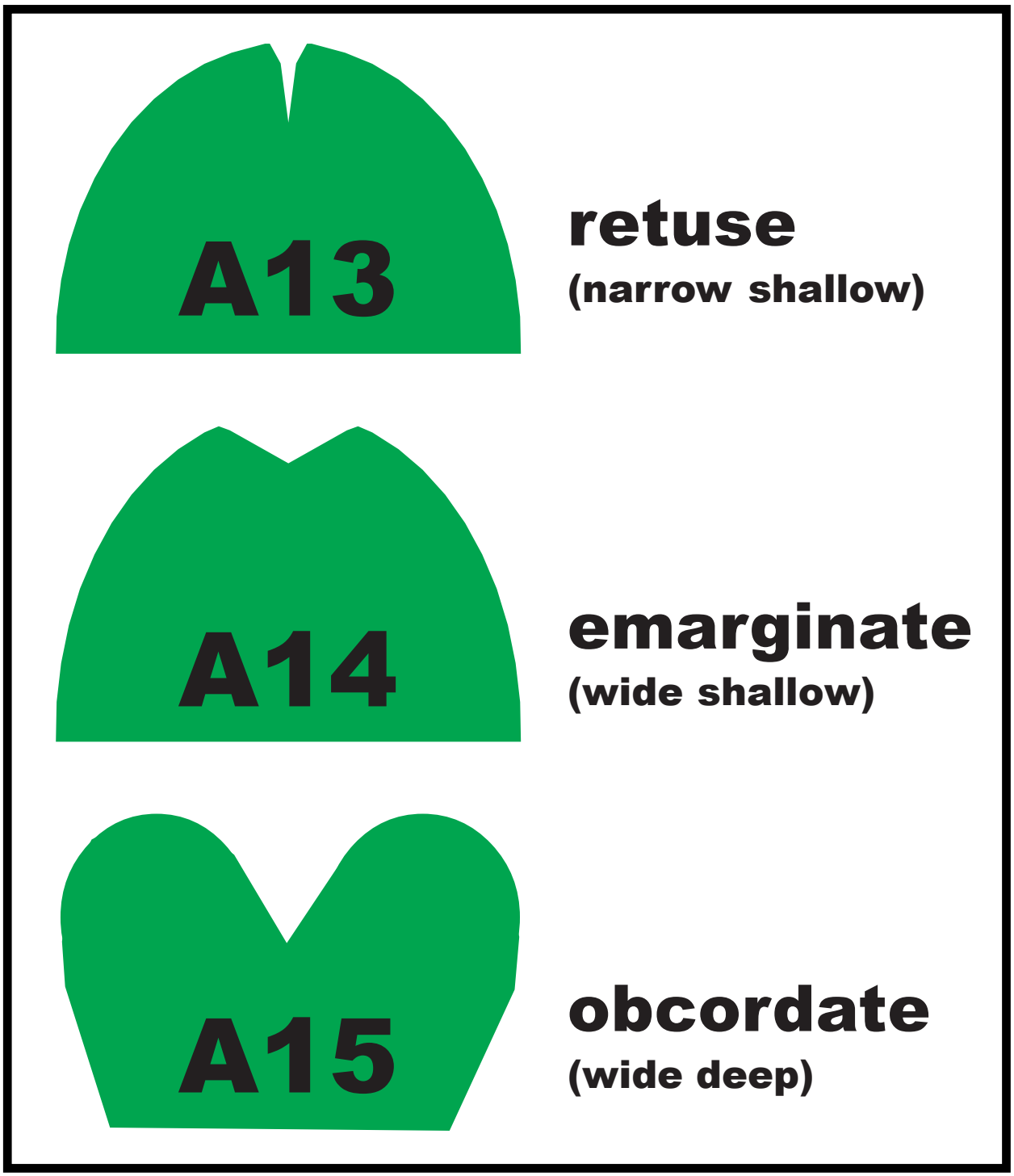

Figure 22: Tree leaf / leaflet apical tip notch shapes, names, and codes.

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.

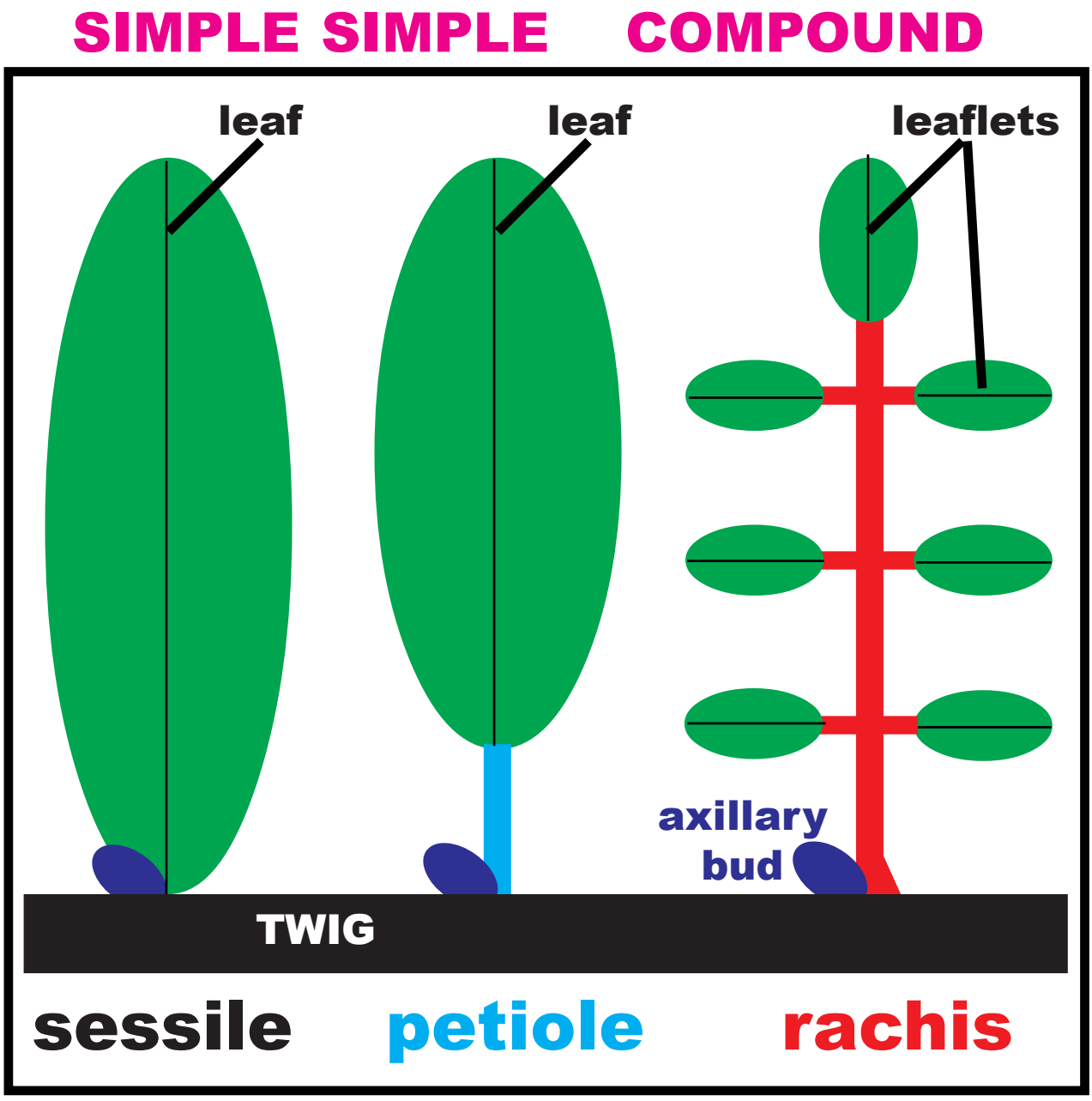

Figure 24: Tree leaf base attachment forms.

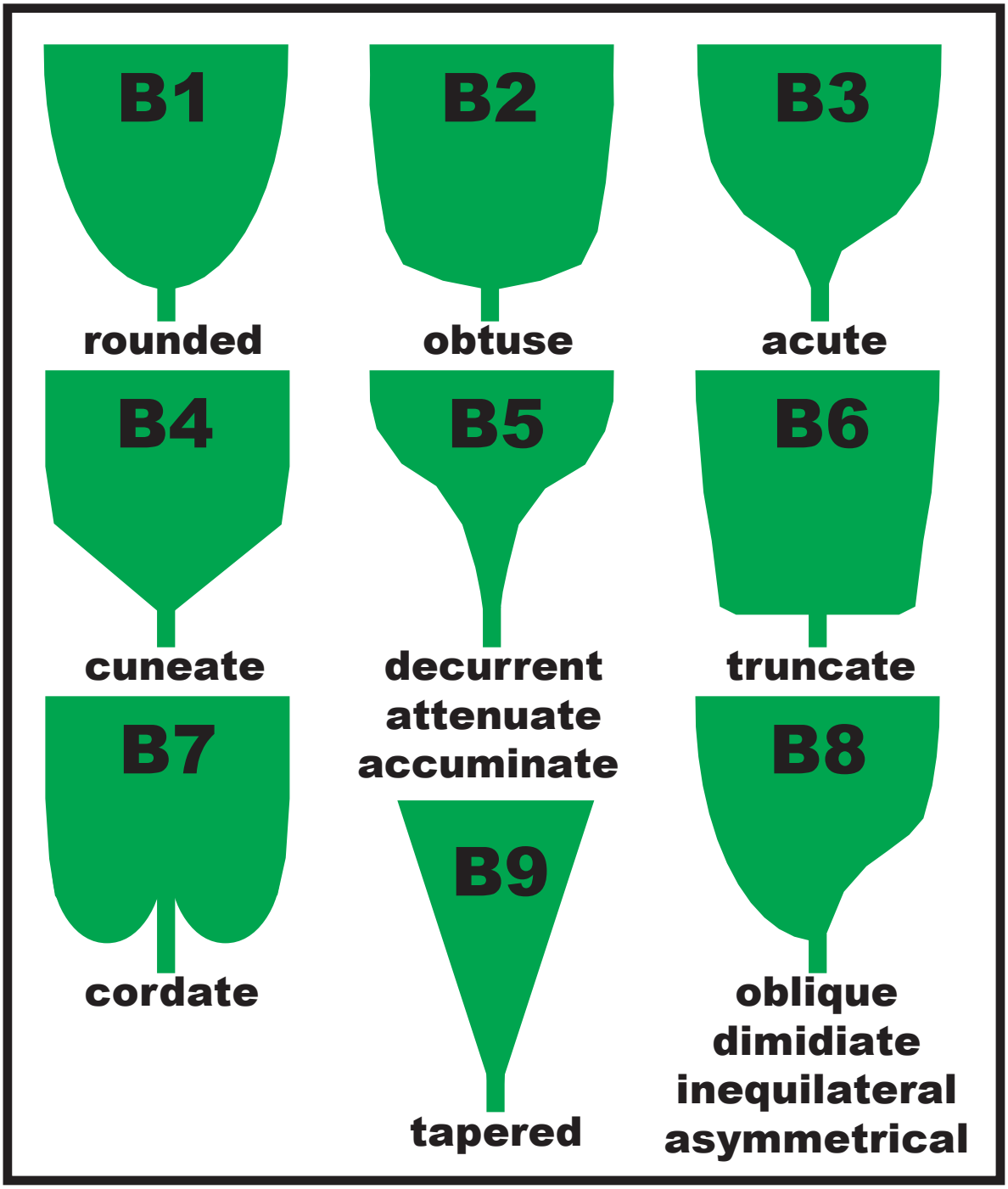

Figure 25: Tree leaf / leaflet base shapes, identification code, and name.

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.

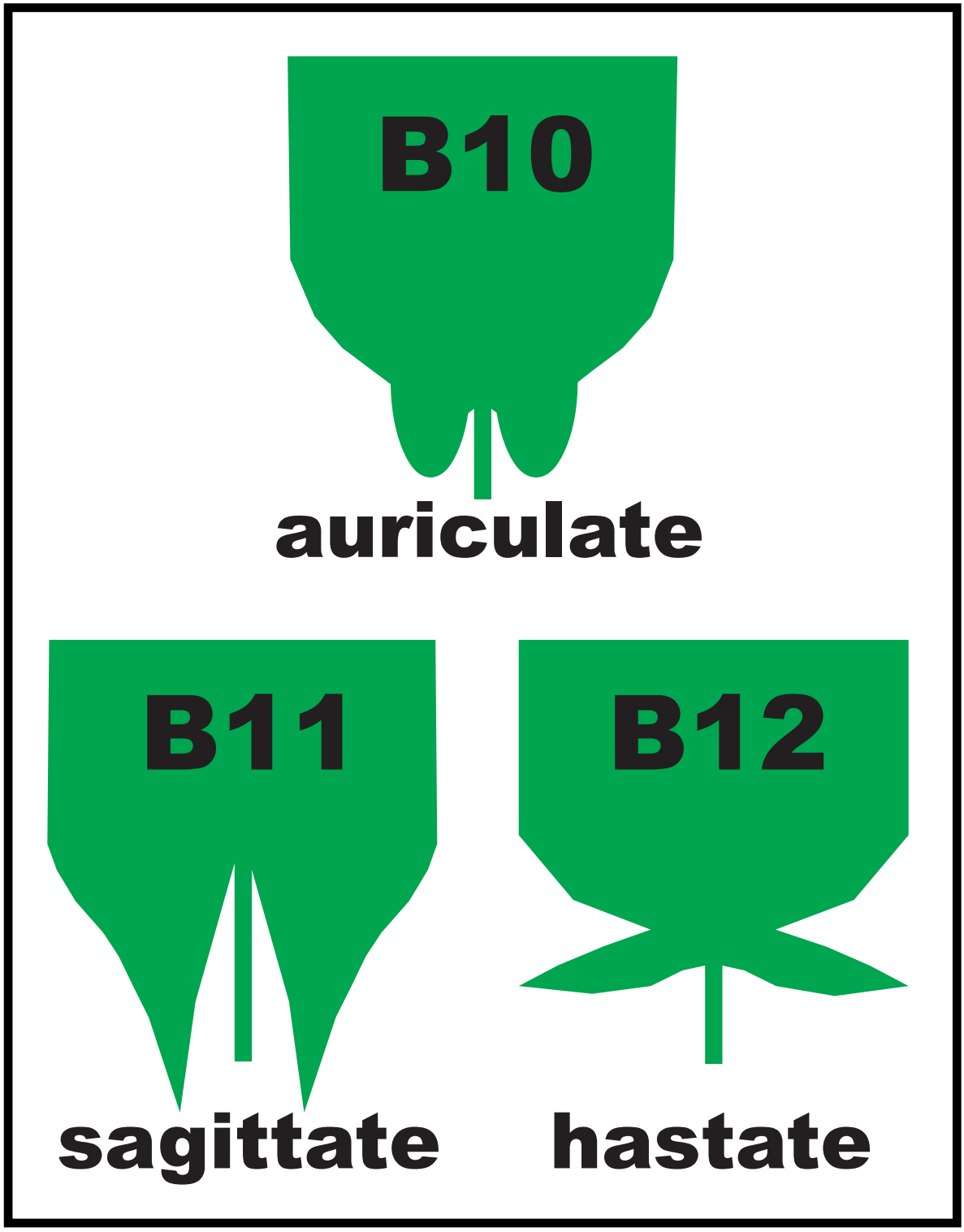

Figure 27: Basal lobes (lobate projections) on tree leaf / leaflet margins.

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

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

scientific name	common name	tip form	base form
Cercis canadensis	redbud	A3	B6 B7
Chionanthus virginicus	fringetree	A3	B4 B5 B9
Cladrastis kentukea *	yellowwood	A3	B1
Clethra acuminata	sweet pepperbush	A3 A5	B2 B3
Cliftonia monophylla	buckwheat tree	A1 A2 A13 A14	B4 B9
Cornus alternifolia	alternate-leaf dogwood	A5 B1	B4
Cornus florida	flowering dogwood	A3 B1	B5
Cornus foemina	swamp dogwood	A3 A5 B1	B3
Cotinus obovatus	smoketree	A1 A2 A13	B3
Crataegus aestivalis	mayhaw	A2 A3	B9
Crataegus aprica	sunny hawthorn	A2 A3	B4 B5
Crataegus calpodendron	pear hawthorn	A3 A5	B3
Crataegus crus-galli	cockspur hawthorn	A2 A3	B9
Crataegus flava	yellow hawthorn	A1 A2 A3	B4 B9
Crataegus intricata	Biltmore hawthorn	A2 A3	B1 B3
Crataegus marshallii	parsley hawthorn	A2 A3	B4 B6
Crataegus phaenopyrum	Washington hawthorn	A3	B4 B6
Crataegus pruinosa	waxy-fruit hawthorn	A3	B1 B2
Crataegus pulcherrima	beautiful hawthorn	A3	B9
Crataegus punctata	dotted hawthorn	A1 A2	B5 B9
Crataegus spathulata	littlehip hawthorn	A1	B9
Crataegus triflora	three-flower hawthorn	A3	B1 B2
Crataegus uniflora	dwarf hawthorn	A1 A2	B4 B9
Crataegus viridis	green hawthorn	A3	B9
Cyrilla parvifolia	littleleaf titi	A2 A3	B4 B9
Cyrilla racemiflora	swamp titi	A1 A2 A3 A13	B4
Diospyros virginiana	persimmon	A3 A5	B3
Elliottia racemosa	Georgia plume	A3 A6	B5
Euonymus atropurpureus	burningbush	A5	B1 B3 B4
Fagus grandifolia	American beech	A3 A5	B4
Forestiera acuminata	swamp-privet	A3 A5	B3 B4 B9
Forestiera segregata	Florida-privet	A1 A2	B3 B9
Franklinia alatamaha	Franklin tree	A3	B9
Fraxinus americana *	white ash	A3	B1
Fraxinus caroliniana *	Carolina ash	A5	B1 B4
Fraxinus pennsylvanica *	green ash	A3 A5	B3 B4
Fraxinus profunda *	pumpkin ash	A3 A5	B1 B4
Fraxinus quadrangulata *	blue ash	A5	B1 B3
Gleditsia aquatica *	water locust	A1	B1
Gleditsia triacanthos *	honeylocust	A1	B1
Gordonia lasianthus	loblolly bay	A2 A3	B4

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

scientific name	common name	tip form	base form
Halesia carolina	little silverbell	A3 A5	B1 B4
Halesia diptera	two-wing silverbell	A3 A5	B1 B4
Halesia tetraptera	mountain silverbell	A3	B1 B4
Hamamelis virginiana	American witch-hazel	A1 A3 A5	B8
Ilex ambigua	Carolina holly	A2 A5	B3 B5
Ilex amelanchier	sarvis holly	A3	B1 B9
Ilex cassine	dahoon	A1 A2	B4 B9
Ilex coriacea	large gallberry	A3	B3 B4
Ilex decidua	possumhaw	A2 A3 A5	B4 B9
Ilex longipes	Georgia holly	A3 A5	B4 B9
Ilex montana	mountain holly	A3 A5	B3 B4
Ilex myrtifolia	myrtle dahoon	A6 A8	B3
Ilex opaca	American holly	A3 A6 A9	B1 B2
Ilex verticillata	winterberry	A4 A5	B3 B5
Ilex vomitoria	yaupon	A1 A2	B1
Illicium floridanum	Florida anisetree	A5 B3	B4
Illicium parviflorum	yellow anisetree	A1 A2 A3	B1 B2
Juglans cinerea *	butternut	A3 A5	B1 B8
Juglans nigra *	black walnut	A3 A5	B1 B8
Kalmia latifolia	mountain-laurel	A3 A6	B3 B4
Leitneria floridana	corkwood	A3	B4
Liquidambar styraciflua	sweetgum	A5	B7 B12
Liriodendron tulipifera	yellow-poplar	A7 A14	B3 B6
Lyonia ferruginea	staggerbush	A1 A2 A6	B5 B9
Magnolia acuminata	mountain cucumber-tree	A3	B1 B3 B4
Magnolia cordata	Piedmont cucumber-tree	A3	B1 B4
Magnolia fraseri	mountain magnolia	A2 A3	B5 B10
Magnolia grandiflora	Southern magnolia	A3 A4	B3
Magnolia macrophylla	bigleaf magnolia	A2 A3	B1 B7 B10
Magnolia pyramidata	pyramid magnolia	A2 A3	B10
Magnolia tripetala	umbrella-tree	A2 A3	B3 B4
Magnolia virginiana	sweetbay	A2 A3	B1 B3 B4
Malus angustifolia	Southern crabapple	A2 A5	B3
Malus coronaria	sweet crabapple	A2 A3	B1 B4
Morus rubra	red mulberry	A3 A5	B2 B6 B7 B8
Myrica cerifera	wax-myrtle	A1 A3	B4 B9
Myrica heterophylla	evergreen bayberry	A2 A3	B3 B9
Myrica inodora	odorless bayberry	A1 A2	B9
Nyssa aquatica	water tupelo	A3 A5	B4 B5
Nyssa biflora	swamp tupelo	A1 A2 A4	B1 B4 B5
Nyssa ogeche	Ogeeche-lime	A1 A2 A6	B1 B2
Nyssa sylvatica	blackgum	A3 A5	B1 B4 B5

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

scientific name	common name	tip form	base form
Osmanthus americanus	devilwood	A1 A3	B4 B9
Ostrya virginiana	Eastern hophornbeam	A3 A5	B1 B7 B8
Oxydendrum arboreum	sourwood	A3	B1 B3
Persea borbonia	red-bay	A2 A3 A5	B3 B5
Persea palustris	swamp-bay	A2 A3	B9
Pinckneya bracteata	fevertree	A3	B1 B3 B4
Planera aquatica	water-elm	A2 A3	B1 B4 B8
Platanus occidentalis	American sycamore	A3	B4
Populus deltoides	Eastern cottonwood	A3 A5	B6
Populus heterophylla	swamp cottonwood	A1 A2	B1 B7
Prunus alabamensis	Alabama cherry	A1 A2 A3	B1 B2
Prunus americana	American plum	A5	B1 B4 B5
Prunus angustifolia	Chickasaw plum	A3	B1
Prunus caroliniana	laurelcherry	A3 A5	B4
Prunus pensylvanica	fire cherry	A5	B1
Prunus serotina	black cherry	A3	B1 B3
Prunus umbellata	flatwoods plum	A3	B1 B2
Ptelea trifoliata *	hoptree	A3 A5	B4
Quercus alba	white oak	A1	B3 B4 B9
Quercus arkansana	Arkansas oak	A1	B3 B4
Quercus austrina	bluff oak	A1	B4 B5
Quercus breviloba	Gulf oak	A1 A2	B1 B4
Quercus chapmanii	Chapman oak	A1	B4 B9
Quercus coccinea	scarlet oak	A3 A5	B1 B2 B6
Quercus falcata	Southern red oak	A6	B1 B2
Quercus geminata	sand live oak	A1 A6	B4
Quercus georgiana	Georgia oak	A3 A4	B2 B3 B4 B5
Quercus hemisphaerica	laurel oak	A1 A3 A6	B1 B2 B3
Quercus imbricaria	shingle oak	A2 A3 A6	B1 B2 B3 B9
Quercus incana	bluejack oak	A1 A2 A3 A6	B1 B3
Quercus laevis	turkey oak	A6	B1 B3 B4 B5
Quercus laurifolia	swamp laurel oak	A1 A2 A3	B4
Quercus lyrata	overcup oak	A1 A3 A6	B3 B4 B9
Quercus margaretta	sand post oak	A1	B1 B3 B4
Quercus marilandica	blackjack oak	A1 A2	B1
Quercus michauxii	swamp chestnut oak	A1	B1 B5
Quercus minima	dwarf live oak	A1 A3	B1
Quercus montana	chestnut oak	A5	B3
Quercus muehlenbergii	chinquapin oak	A3	B4 B9
Quercus myrtifolia	myrtle oak	A1 A2 A6	B1 B2
Quercus nigra	water oak	A6	B4 B5 B9

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

scientific name	common name	tip form	base form
Quercus oglethorpensis	Oglethorpe oak	A1 A2	B1
Quercus pagoda	cherrybark oak	A3	B1 B4 B5
Quercus palustris	pin oak	A3 A4	B3 B4
Quercus phellos	willow oak	A3	B3
Quercus prinoides	dwarf chinquapin oak	A1	B4
Quercus rubra	Northern red oak	A3 A5	B1 B3 B4 B6
Quercus shumardii	Shumard's oak	A3 A5 A6	B4 B5
Quercus similis	swamp post oak	A1	B1
Quercus sinuata	bastard (Durand) oak	A1	B3 B5
Quercus stellata	post oak	A1 A13	B1 B5
Quercus velutina	black oak	A3 A5	B1 B2 B3 B6
Quercus virginiana	live oak	A1 A6	B4 B5 B9
Rhamnus caroliniana	buckthorn	A3 A5	B1 B3 B7
Rhododendron catawbiense	purple-laurel	A1 A2	B1
Rhododendron maximum	rosebay-laurel	A3	B1 B3 B4
Rhus copallinum *	winged sumac	A3 A5	B3 B4 B8
Rhus glabra *	smooth sumac	A5	B1 B8
Rhus typhina *	staghorn sumac	A5 A10	B1 B7
*Robinia hispida**	pink locust	A1 A3 A6	B1
Robinia pseudoacacia *	black locust	A1 A2 A6 A14	B1 B2
Robinia viscosa *	clammy locust	A6	B1 B2
Salix caroliniana	Coastal Plain willow	A5	B1
Salix floridana	Florida willow	A3	B1 B7
Salix nigra	black willow	A5	B1 B4
Salix sericea	silky willow	A3 A5	B1
Sambucus canadensis *	American elder	A5	B1 B2
Sambucus simpsonii *	Southern elder	A5	B4 B9
Sapindus marginatus *	Florida soapberry	A2 A5	B8
Sassafras albidum	sassafras	A1 A2	B3 B5
Sideroxylon lanuginosa	gum bumelia	A1 A2	B4 B9
Sideroxylon lycioides	buckthorn bumelia	A1	B9
Sideroxylon tenax	tough bumelia	A1	B9
Sorbus americana *	American mountain-ash	A3 A5	B1
Staphylea trifolia *	bladdernut	A3 A5	B1 B3
Stewartia malacodendron	silky camellia	A3 A5	B4 B5
Stewartia ovata	mountain camellia	A3 A5	B4 B9
Styrax americanus	American snowbell	A3	B4 B9
Styrax grandifolius	bigleaf snowbell	A3	B4 B9
Symplocos tinctoria	sweetleaf	A3 A5	B2 B4

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

scientific name	common name	tip form	base form
Tilia americana	American basswood	A3 A5	B6 B7 B8
Tilia caroliniana	Carolina basswood	A5	B7 B8
Tilia floridana	Florida basswood	A3	B6 B7 B8
Tilia heterophylla	white basswood	A5	B7 B8
Toxicodendron vernix *	poison sumac	A3	B3 B4
Ulmus alata	winged elm	A3	B1 B8
Ulmus americana	American elm	A5	B1 B8
Ulmus rubra	slippery elm	A5	B1 B8
Ulmus serotina	September elm	A5	B1 B8
Vaccinium arboreum	farkleberry	A1 A2 A3	B1 B3
Viburnum cassinoides	Northern possumhaw	A3	B1 B4
Viburnum dentatum	Southern arrowwood	A3	B1 B7
Viburnum lentago	nannyberry	A3	B3 B4
Viburnum nudum	Southern possumhaw	A2 A3	B3 B4
Viburnum obovatum	small-leaf arrowwood	A1 A2	B9
Viburnum prunifolium	blackhaw	A1 A2	B1 B4
Viburnum rufidulum	rusty blackhaw	A1 A2	B4
Yucca aloifolia	Spanish-bayonet	A9	B1
Yucca gloriosa	moundlilly yucca	A9	B1
Zanthoxylum americanum *	prickly-ash	A2 A3	B1 B2
Zanthoxylum clava-herculis *	Hercules' club	A3 A5	B4 B8

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

TIP / BASE FORM KEY

TIP CODE		FORM / SHAPE
A1	=	ROUNDED
A2	=	OBTUSE
A3	=	ACUTE
A4	=	SUBACUTE B4 = CUNEATE
A5	=	ACCUMINATE
A6	=	CUSPIDATE
A7	=	TRUNCATE
A8	=	ARISTULATE
A9	=	PUNGENS
A10	=	ATTENUATE
A11	=	APICULATE
A12	=	CAUDATE
A13	=	RETUSE
A14	=	EMARGINATE

BASE CODE		FORM / SHAPE
B1	=	ROUNDED
B2	=	OBTUSE
B3	=	ACUTE
B5	=	DECURRENT, ATTENUATE, ACCUMINATE
B6	=	TRUNCATE
B7	=	CORDATE
B8	=	OBLIQUE, DIMIDIATE, INEQUILATERAL, ASYMMETRICAL
B9	=	TAPERED
B10	=	AURICULATE
B11	=	SAGITTATE
B12	=	HASTATE

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

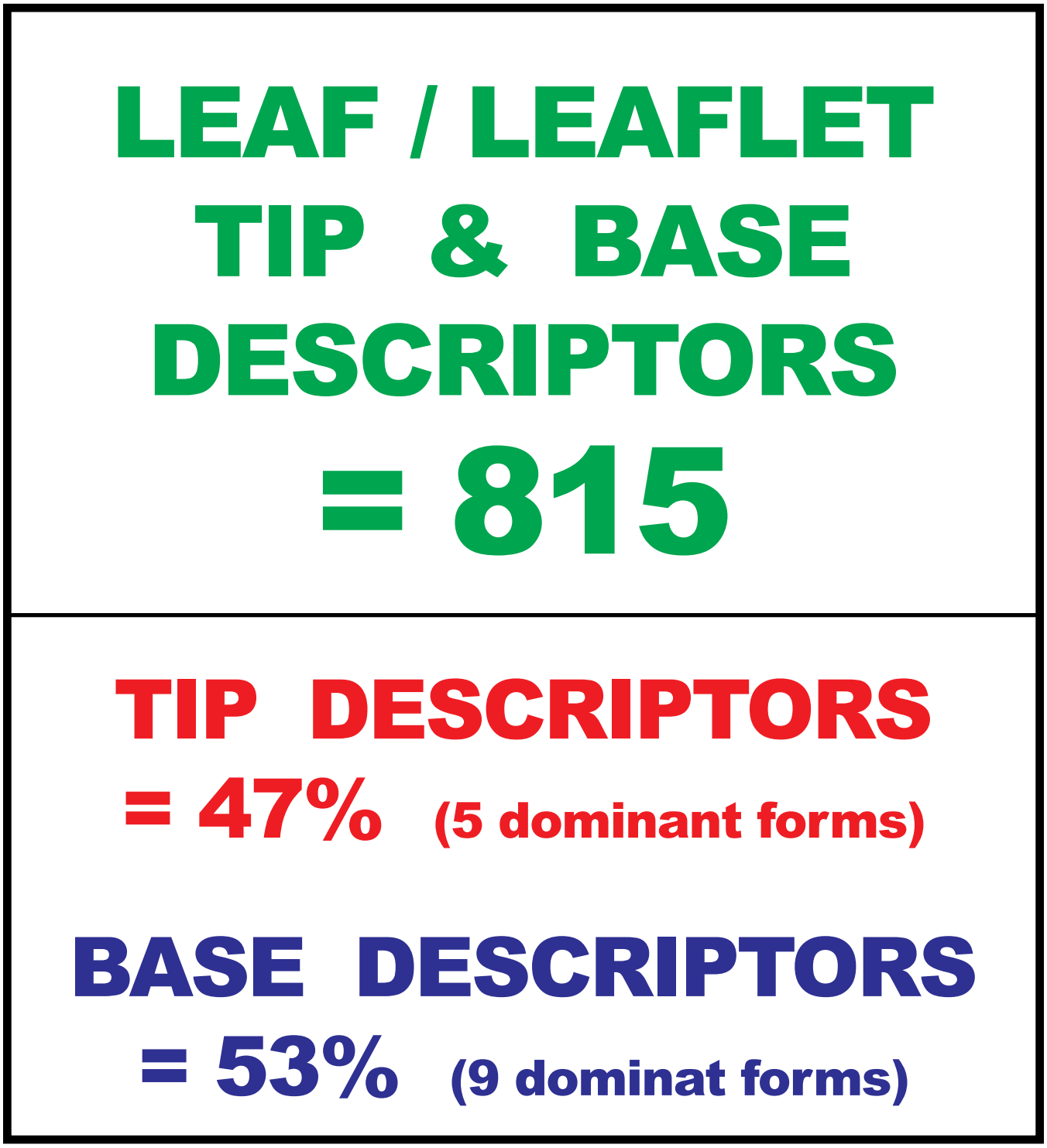

Figure 30: Total number of tip and base descriptors for 225 native tree species leaves and leaflets from all sources.

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.

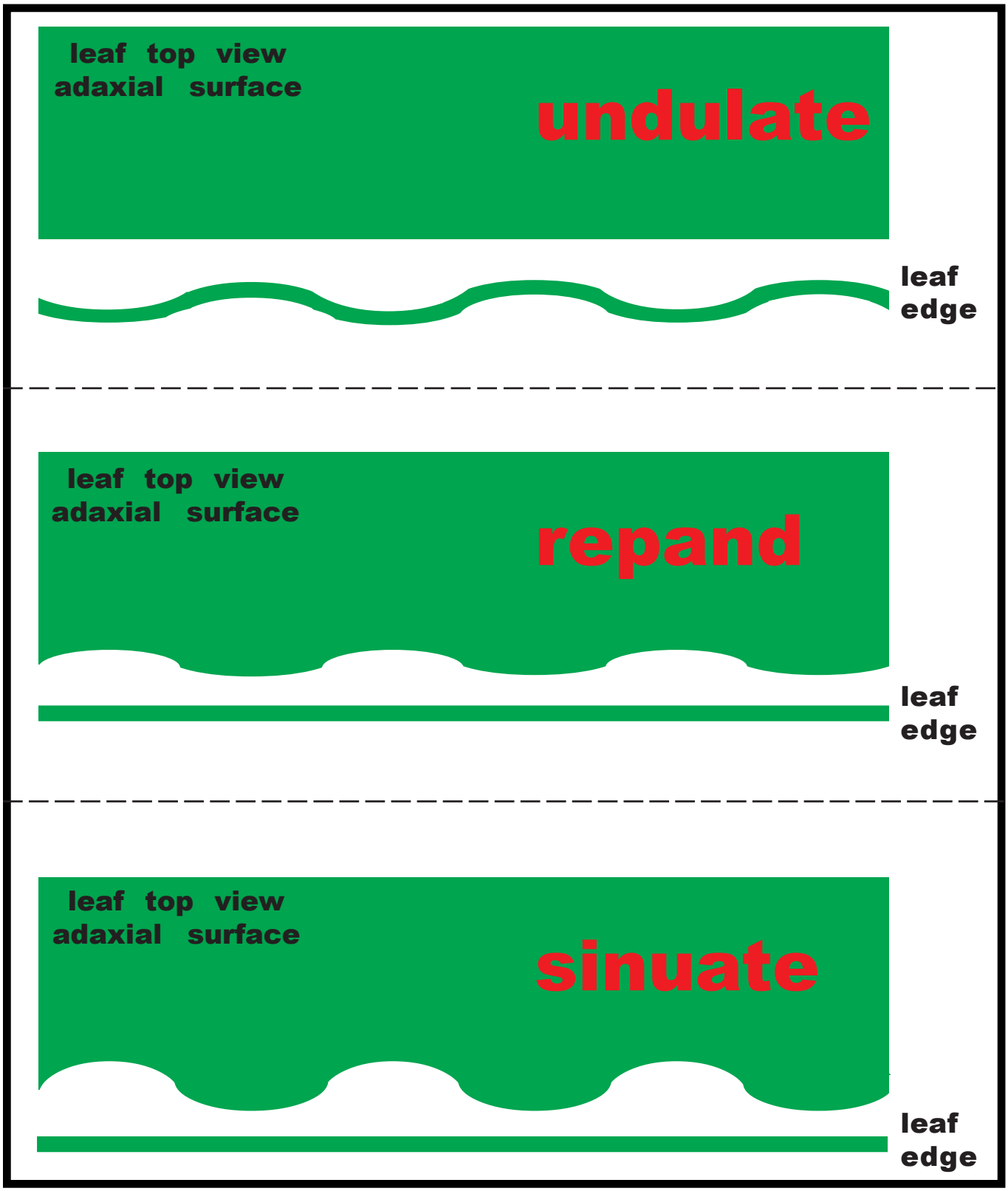

Figure 32: Wavy tree leaf / leaflet margin edges.
(Note -- not lobes or crenate teeth)

UNDULATE, SINUATE, REPAND

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

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

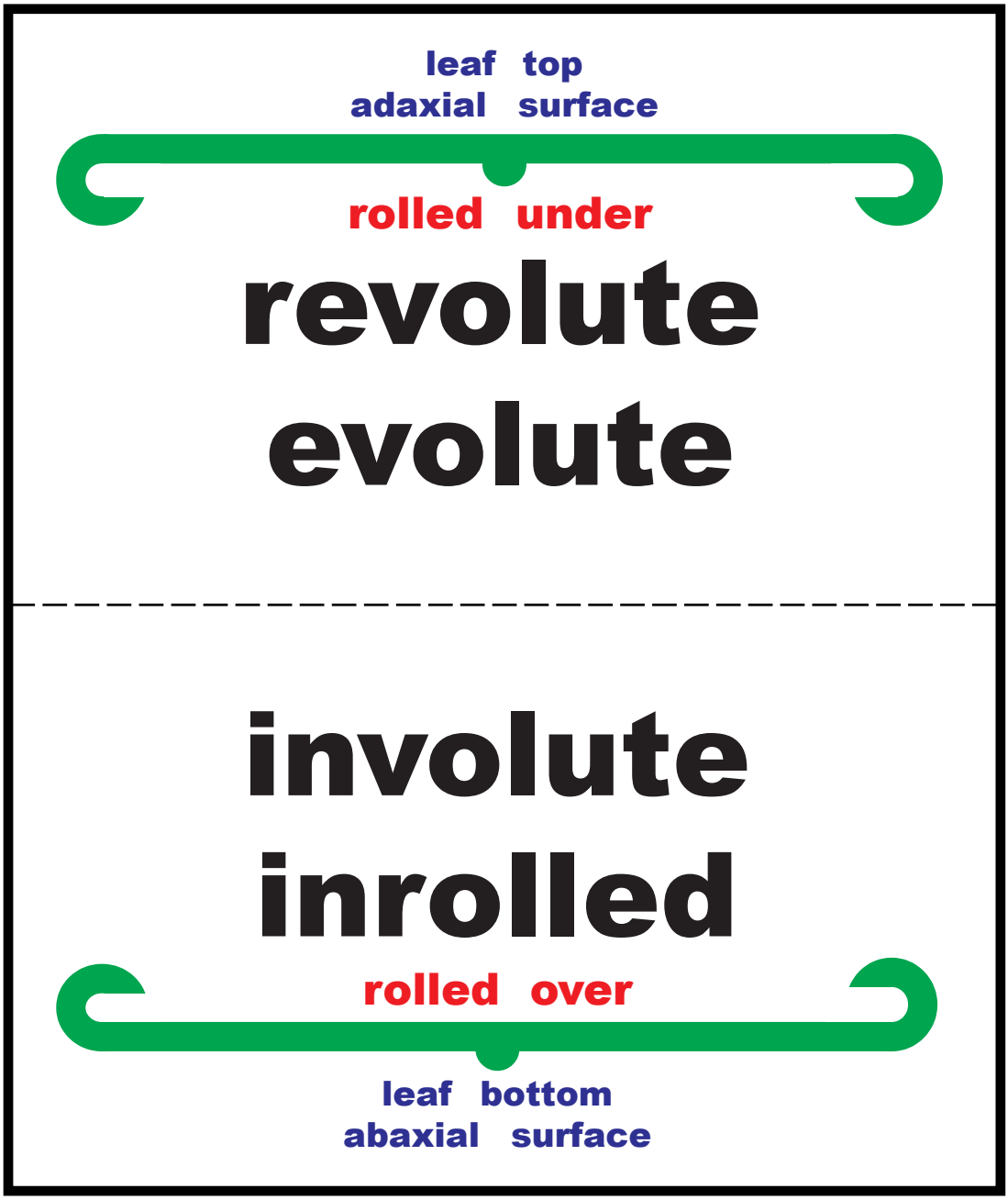

Figure 34: Rolled tree leaf / leaflet margin edge.

ROLLED MARGINS

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

Figure 35: Native tree species leaves / leaflets with revolute or involute margins

(i = involute leaves)

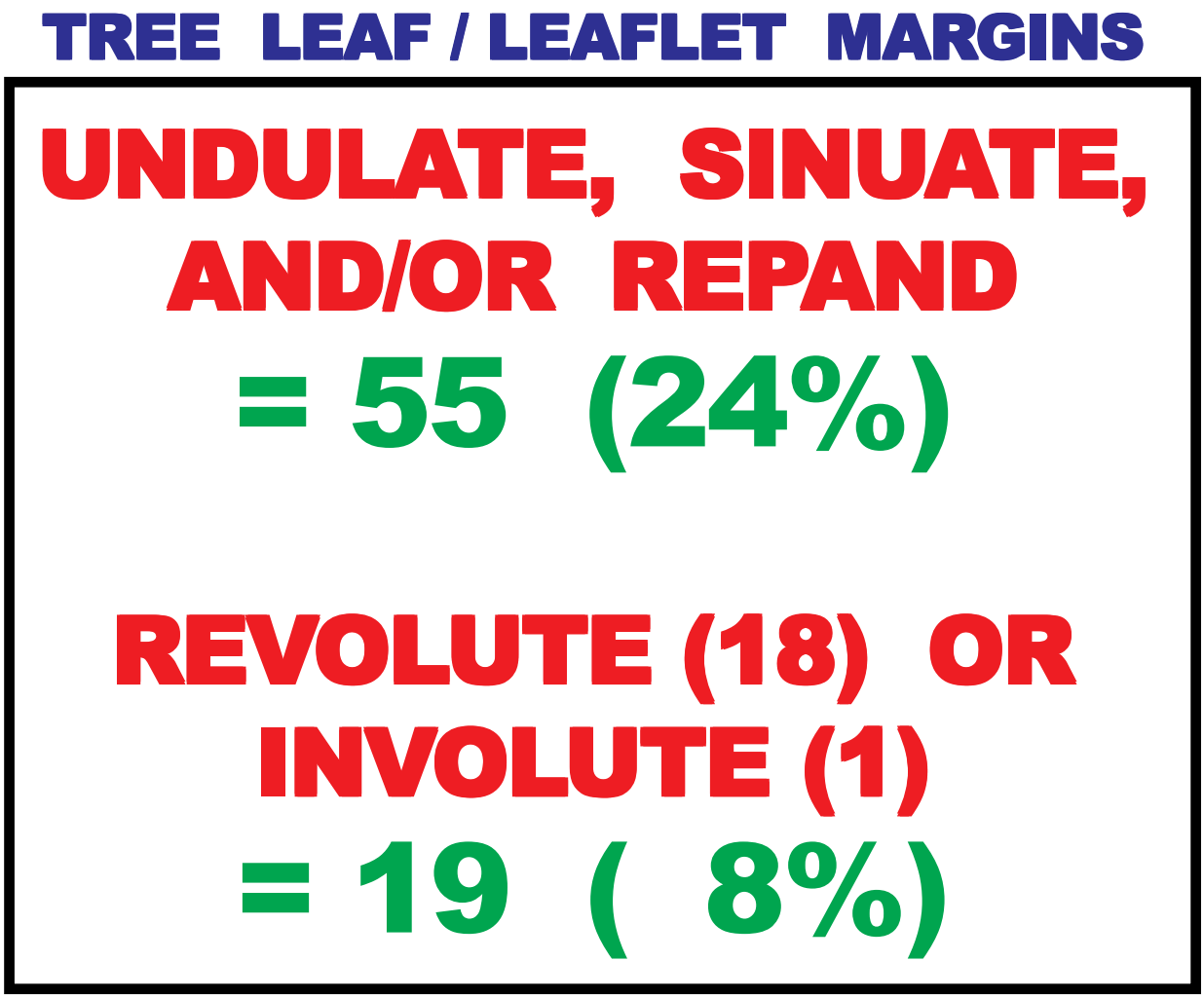

Figure 36: Native tree leaf / leaflet margin forms.
Values are number of species and percent of all 225 native tree species surveyed.

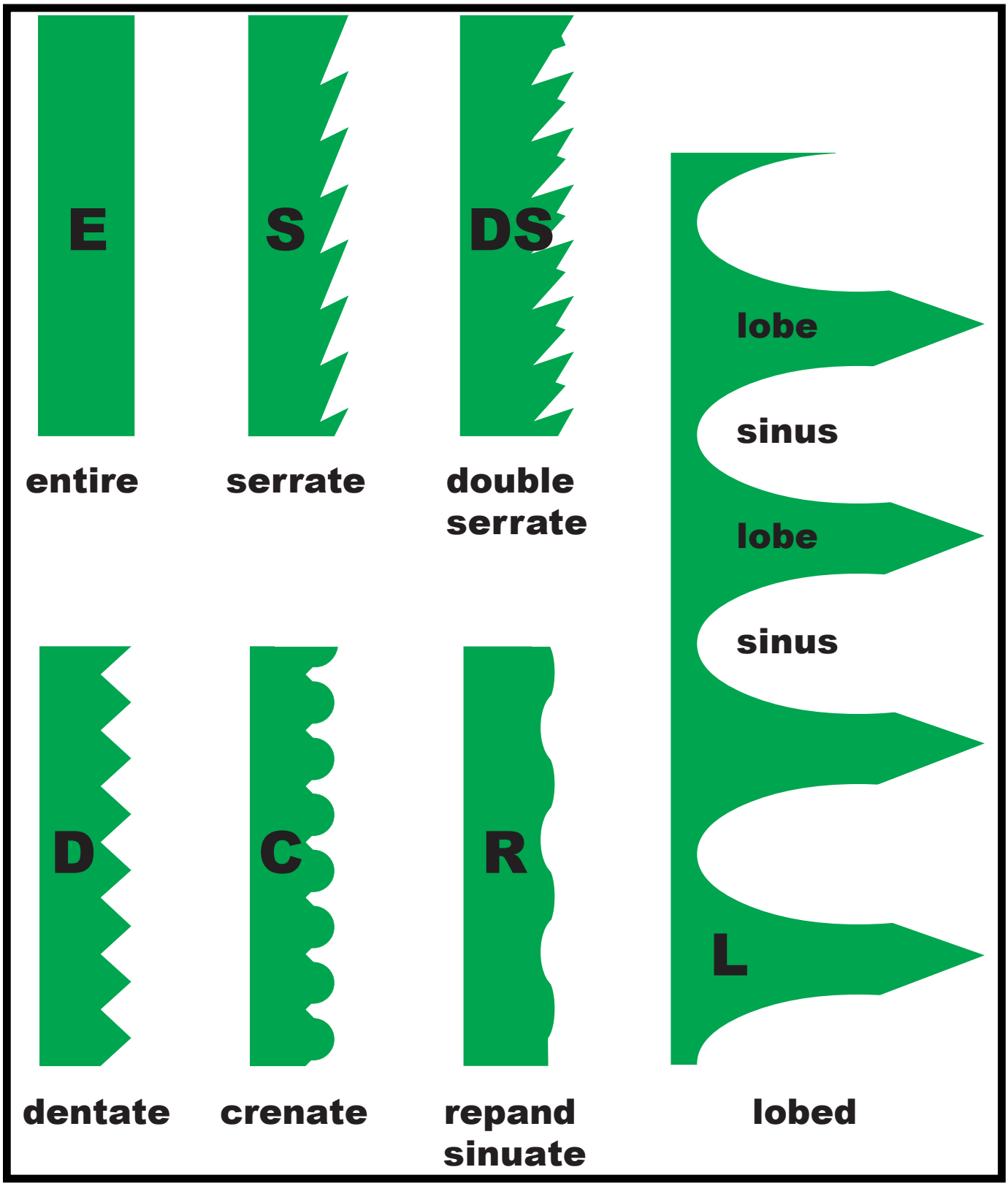

Figure 37: Tree leaf / leaflet margin forms, identification code, and name -- as edge-viewed from above.

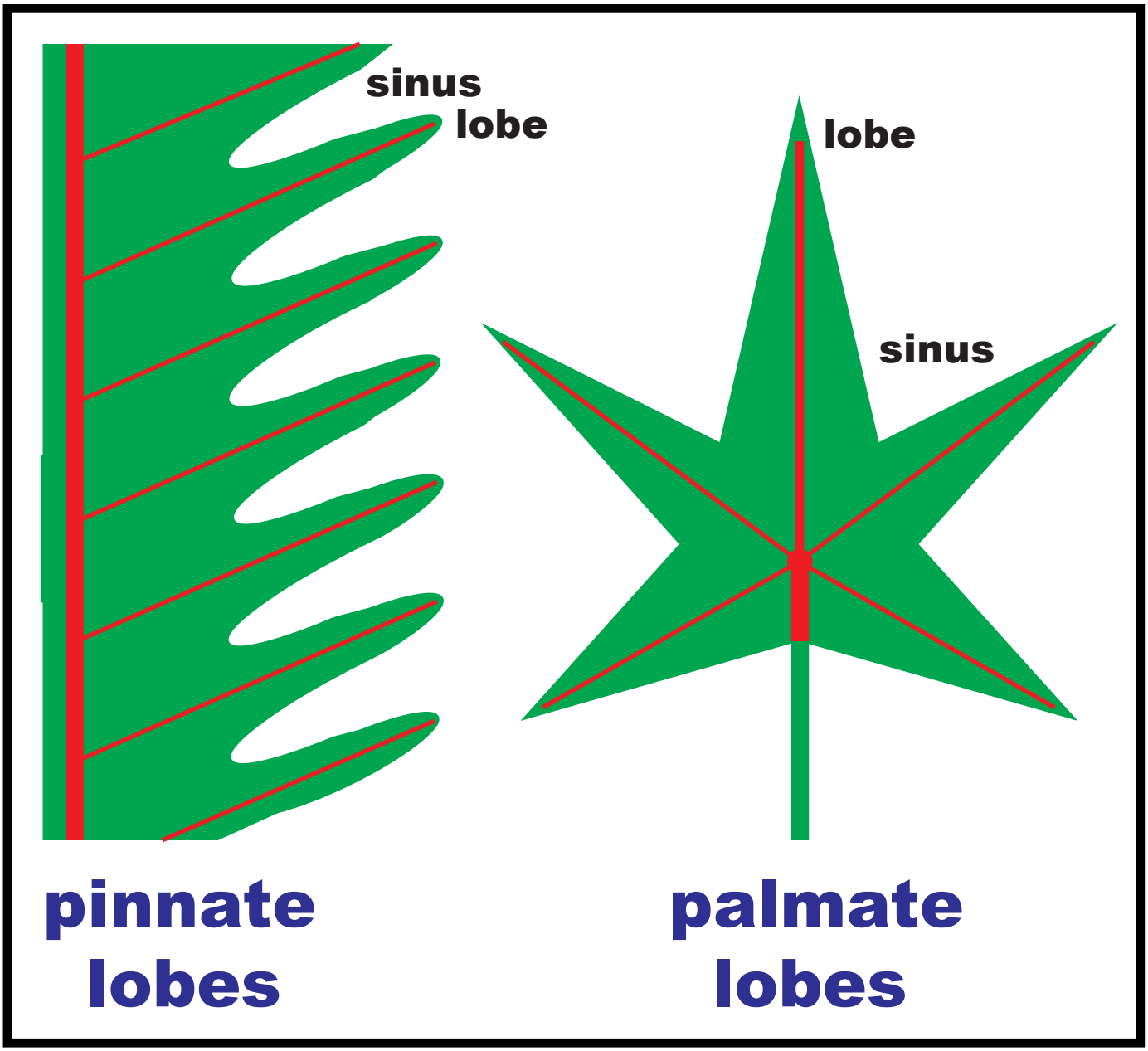

Figure 38: Two primary lobe forms on tree leaves / leaflets.

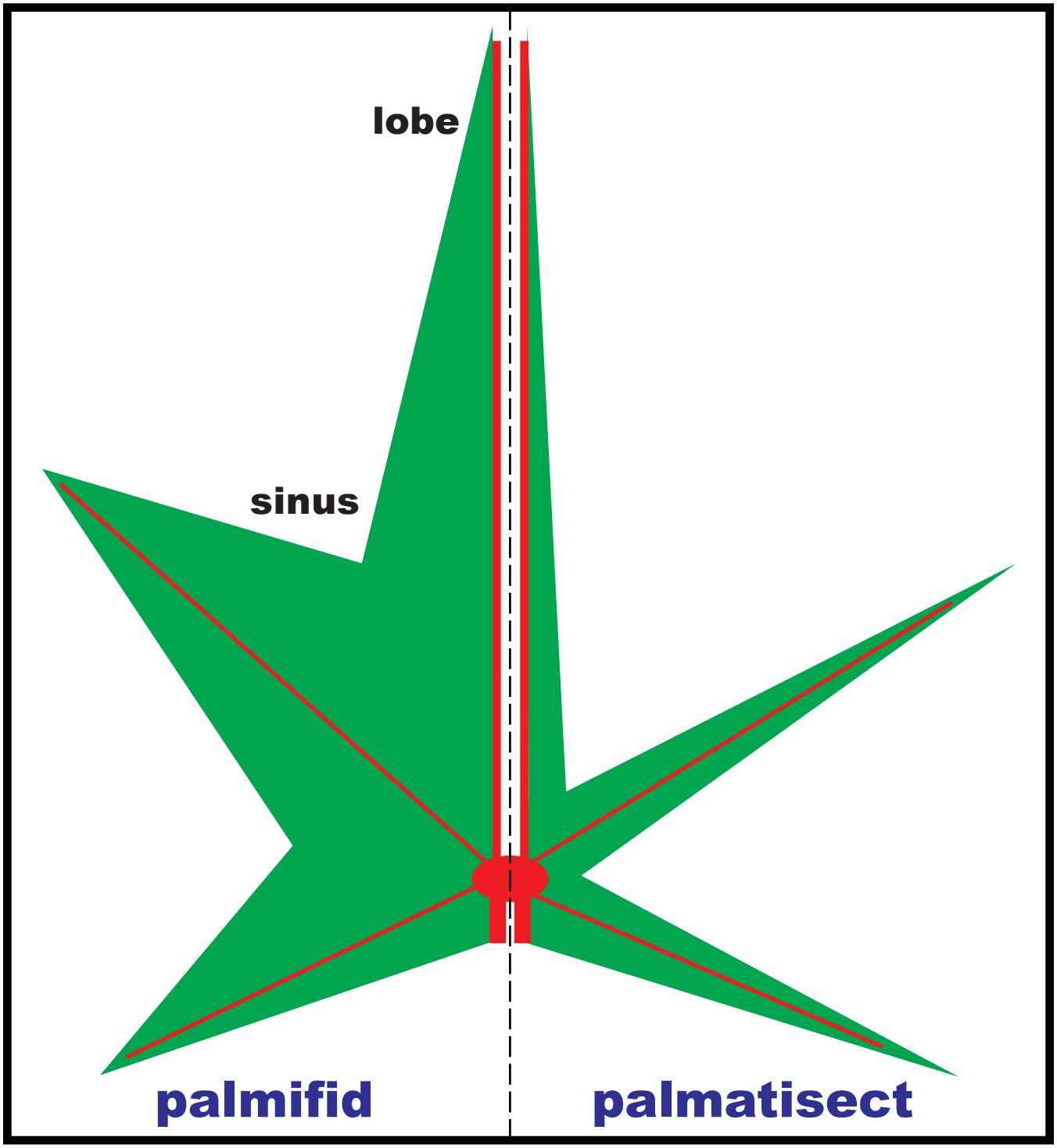

Figure 39: Two types of palmate lobe forms, based upon sinus depth to mid-vein, on tree leaves / leaflets.

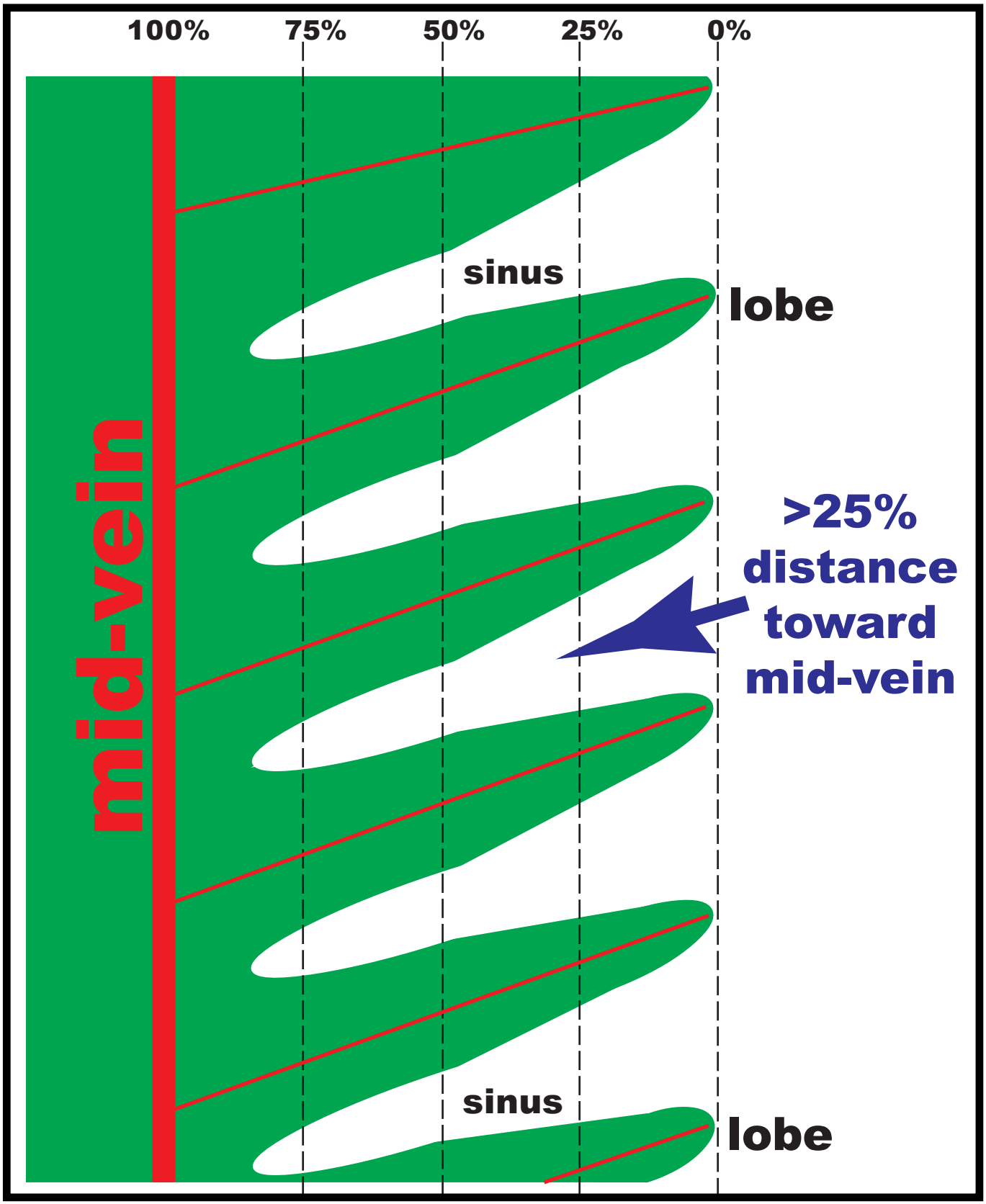

Figure 40: Defining a pinnate lobe and associated sinus on a tree leaf / leaflet margin.

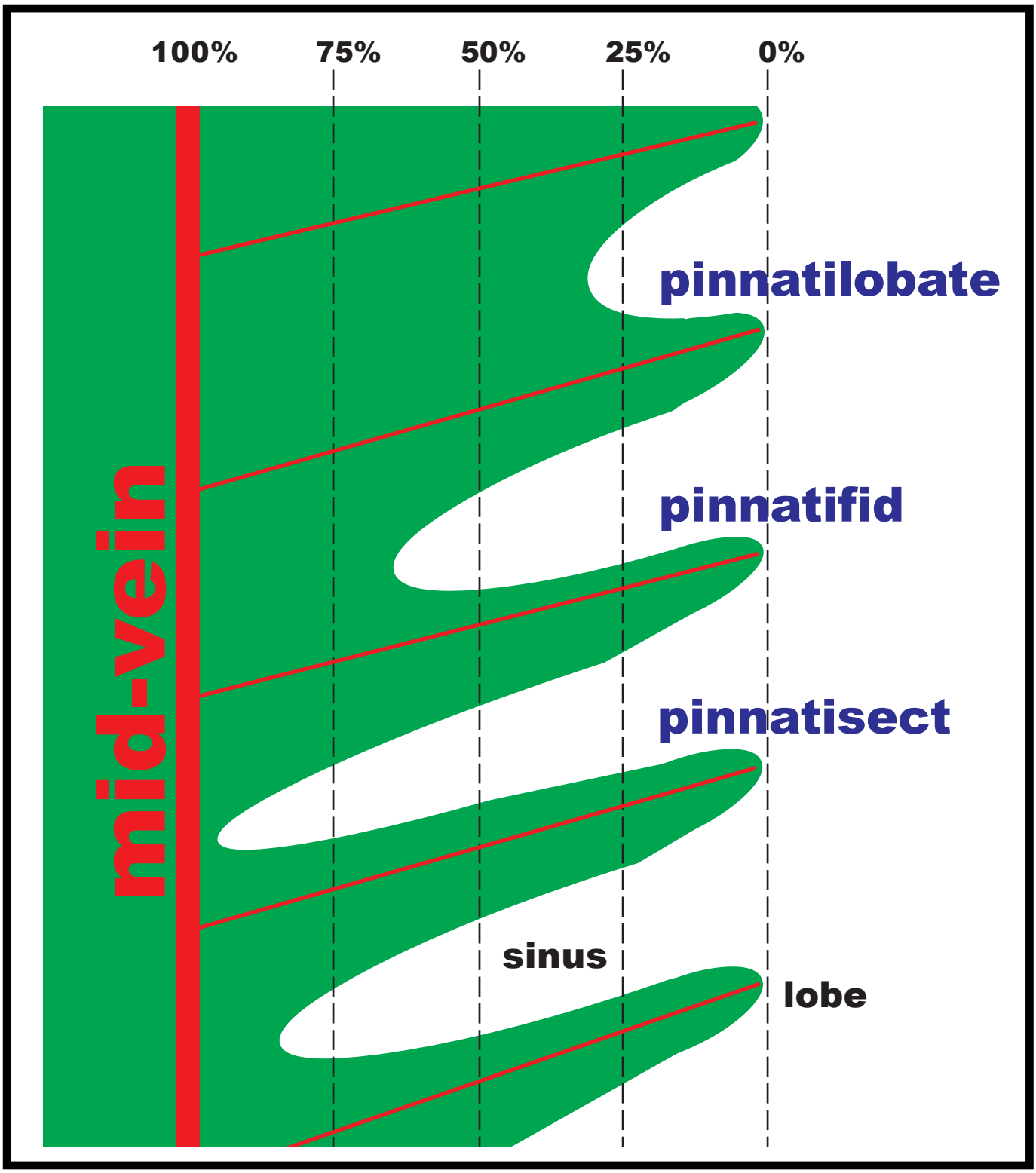

Figure 41: Defining types of pinnate lobes, based upon sinus depth toward mid-vein, on tree leaf / leaflet margins.

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.

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

Figure 43: Native tree species leaves / leaflets with entire margins. (* = compound leaves)

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

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

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

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

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

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

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

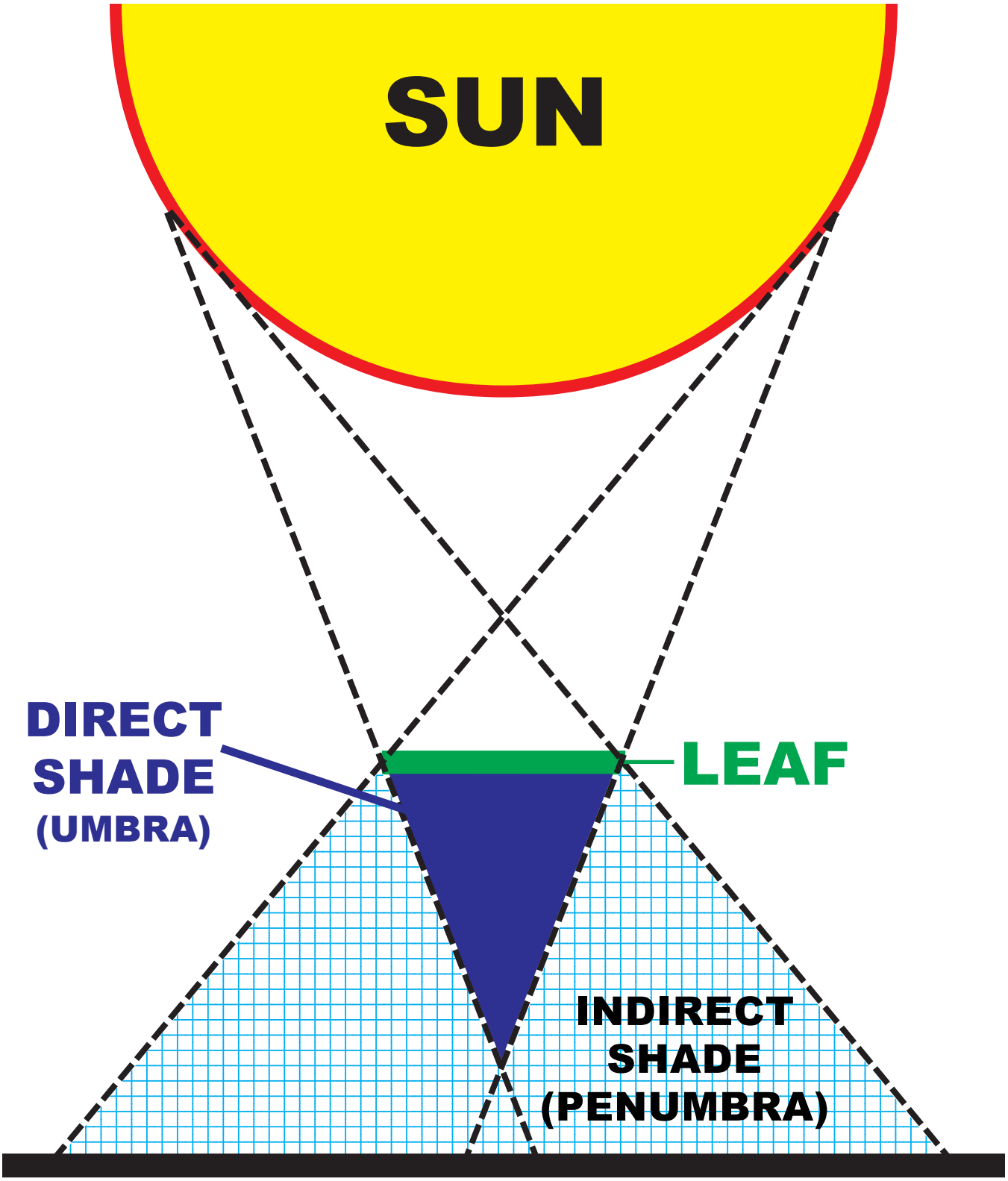

Figure 47: Direct (dense) shade volume (cone) behind a tree leaf with a given effective shade diameter.