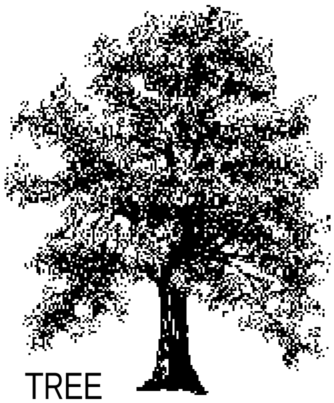

TREE
BIOMECHANICS
SERIES

Crown Shape Factors & Volumes

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Many of the models for determining loads and forces in tree structural systems depend upon crown shape. Tree crown shapes are integral to a variety of models because volume estimates, surface area estimates, or various types of two dimensional crown projections are directly related to crown shape. Calculating crown shape in a natural setting under dynamic loads requires continuous changes (over a variety of time and spacial scales) with growth, damage, and applied forces.

Because of varying tree crown shape, reach, extent, and internal positioning of branches and leaf tissues (crown density impacts), mechanic loads and structural resistances are difficult to calculate. Most models published have consolidated all the variation in tree crowns by using calculations for solid geometric objects. Using formulae which represent geometric solids or surfaces help simplify mechanical models. Choice of an appropriate solid object formula to represent tree crown shape remains subject to much debate depending upon tree species, biometric attributes of trees and models involved, and discretion of the researcher.

To assist tree biomechanic specialists to better appreciate crown shapes and calculation means, this publication was developed. This publication uses the standard gradient of tree crown shapes used in forestry, arboriculture, and ecology. Table 1 provides the names and the formulae for a variety of different idealized crown shapes. Note that within the various formulae for crown shape, the only portion which changes is a single decimal multiplier value.

The formulae presented here represent one family of associated shapes or objects. Remember these formulae represent a calculated volume for an idealized shape. There are many different shapes, within the height and diameter constraints of the formulae, which could have the same volume (or the same calculated volume could be contained within many different shapes).

Table 2 is provided to allow comparison of crown shape volumes between different crown shapes, and within a single crown form, varying by crown height and crown diameter. Note these values in Table 2 are approximations and have been rounded for simplicity. Figure 1 helps graphically define idealized tree crown shapes which have the same diameter and height.

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Table 1: Tree crown volume estimates for different crown shape models. Shape numbers run from 1-10 with progressively decreasing volumes. Crown shape value is a formula multiplier where a right cylinder is 8/8, 1/1, or 1.0, and the rest of the shape formulas are some fraction of a right cylinder's volume. Crown shape formula uses crown diameter and crown height in feet to calculate crown volumes in cubic feet. Crown shape name is a symbolic approximation for visualizing shape based upon solid geometric figures. Figure 1 describes the shapes involved.

shape number	shape value	shape formula	shape name
S1	8/8 (1.0)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.7854)	CYLINDER
S2	7/8 (0.875)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.6872)	ROUNDED-EDGE CYLINDER
S3	3/4 (0.75)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.5891)	ELONGATED SPHEROID
S4	2/3 (0.667)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.5236)	SPHEROID
S5	5/8 (0.625)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.4909)	EXPANDED PARABOLOID
S6	1/2 (0.5)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.3927)	PARABOLOID
S7	3/8 (0.375)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.2945)	FAT CONE
S8	1/3 (0.333)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.2619)	CONE
S9	1/4 (0.25)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.1964)	NEILOID
S10	1/8 (0.125)	$(\text{Crown Diameter})^2$ x (Crown Height) x (0.0982)	THIN NEILOID

Table 2: Tree crown volumes in cubic feet by shape factor (formula). Crown volumes are provided across five crown diameters (20-100 feet in diameter) and four crown heights (25-100 feet in height) to show the calculated volumes arising from different crown shape formulas. Figure 1 presents a graphical definition of crown shapes.

crown diameter (feet)	selected crown heights (feet) 100	75	50	25
				(S1 cylinder)
20	31,416	23,562	15,708	7,854
40	125,664	94,248	62,832	31,416
60	282,744	212,058	141,372	70,686
80	502,656	376,992	251,328	125,664
100	785,400	589,050	392,700	196,350
				(S2 rounded-edge cylinder)
20	27,488	20,616	13,744	6,872
40	109,952	82,464	54,976	27,488
60	247,392	185,544	123,696	61,848
80	439,808	329,856	219,904	109,952
100	687,200	515,400	343,600	171,800
				(S3 elongated spheroid)
20	23,564	17,673	11,782	5,891
40	94,256	70,692	47,128	23,564
60	212,076	159,057	106,038	53,019
80	377,024	282,768	188,512	94,256
100	589,100	441,825	294,550	147,275
				(S4 spheroid)
20	20,944	15,708	10,472	5,236
40	83,776	62,832	41,888	20,944
60	188,496	141,372	94,248	47,124
80	335,104	251,328	167,552	83,776
100	523,600	392,700	261,800	130,900
				(S5 expanded paraboloid)
20	19,636	14,727	9,818	4,909
40	78,544	58,908	39,272	19,636
60	176,724	132,543	88,362	44,181
80	314,176	235,632	157,088	78,544
100	490,900	368,175	245,450	122,725

(Table 2 continued on page 4)

Table 2: (continued from page 3) Tree crown volumes in cubic feet by shape factor.

crown diameter (feet)	selected crown heights (feet) 100	75	50	25
				(S6 paraboloid)
20	15,708	11,781	7,854	3,927
40	62,832	47,124	31,416	15,708
60	141,372	106,029	70,686	35,343
80	251,328	188,496	125,664	62,832
100	392,700	294,525	196,350	98,175
				(S7 fat cone)
20	11,780	8,835	5,890	2,945
40	47,120	35,340	23,560	11,780
60	106,020	79,515	53,010	26,505
80	188,480	141,360	94,240	47,120
100	294,500	220,875	147,250	73,625
				(S8 cone)
20	10,476	7,857	5,238	2,619
40	41,904	31,428	20,952	10,476
60	94,284	70,713	47,142	23,571
80	167,616	125,712	83,808	41,904
100	261,900	196,425	130,950	65,475
				(S9 neiloid)
20	7,856	5,892	3,928	1,964
40	31,424	23,568	15,712	7,856
60	70,704	53,028	35,352	17,676
80	125,696	94,272	62,848	31,424
100	196,400	147,300	98,200	49,100
				(S10 thin neiloid)
20	3,928	2,946	1,964	982
40	15,712	11,784	7,856	3,928
60	35,352	26,514	17,676	8,838
80	62,848	47,136	31,424	15,712
100	98,200	73,650	49,100	24,550

Figure 1: Example two-dimensional side view of idealized crown shapes with crown shape factor number and generic name. See Table 1 for construction formulae. All shapes are found along a calculation gradient from S1 (multiplier 0.7854) to S10 (multiplier 0.0982).

WIDEST DISTANCE SIDE-TO-SIDE = CROWN DIAMETER (D)

LONGEST DISTANCE UP-AND-DOWN = CROWN HEIGHT (H)

CROSS-SECTION FOR ALL SHAPES IS CIRCULAR