



Trees have a long relationship with people. They are both utility and amenity. Trees can evoke awe, mysticism, and reverence. Trees represent great public and private values. Trees most noticed and celebrated by people and communities are the one-tenth of one-percent of trees which approach the limits of their maximum size, reach, extent, and age. These singular, historic, culturally significant, and massive extreme trees become symbols and icons of life on Earth, and our role model in environmental stewardship and sustainability.

What Is A Tree?

Figure 1 is a conglomeration of definitions and concepts about trees from legal and word definitions in North America. For example, 20 percent of all definitions specifically state a tree is a plant. Concentrated in 63% of all descriptors for trees are four terms: plant, woody, single stem, and tall. If broad stem diameter, branching, and perennial growth habit concepts are added, 87% of all the descriptors are represented.

At its most basic level, defining a tree is not species based, but is a structural definition. A tree is represented by a type of plant architecture recognizable by non-technical people. The most basic concepts for defining a tree are -- a large, tall, woody, perennial plant with a single, unbranched, erect, self-supporting stem holding an elevated and distinct crown of branches, and which is greater than 10 feet in height and greater than 3 inches in diameter. Everyone tends to have their own tree definition.

The structure and architecture of a tree help define its past, present, and future appearance and continued growth. The four tree metrics most people list to represent maximum limits of tree expression are height, girth, mass, and longevity.

HEIGHT -- TALLEST

Measuring tree height is fraught with problems, and errors can be significant (>12% error). The two accepted means of measuring accurate tree height is by a climber dropping a measuring tape down from the top of a tree, or by using laser range finders. Carefully measured (not estimated) height values are available for many trees. The tallest trees alive and standing are provided here. In the past, tall tree lists had error-prone measures and estimates, plus some involved rough paced measures of downed trees. In some cases, old tall trees previously listed have been logged or damaged.

Figure 2 lists the twenty-three tree species which contain the tallest trees in the world greater than 269 feet in height. These are scientifically confirmed measures of living trees. The height in feet is listed for the tallest individual within each species, as of the date of this publication. Redwood is by far the tallest tree on the planet. Eucalyptus represents the tallest angiosperm. *Shorea* / meranti represents the tallest tropical tree. Height records fall rapidly with inclusion of more species, providing a maximum height for most trees of less than 150 feet.

World-wide, there are more than 20 tree species individuals with an estimated or measured height greater than 250 feet not listed here. Some of these claims are difficult to verify, or repeat the measures, many due to the remoteness of the tree. Only living trees measured with climbers or laser instruments are here provided.

Figure 3 is a list of the 20 tallest individual trees, regardless of species, in the world. All these trees exceed 300 feet in verified height. Redwoods occupy the first twelve spots. The tallest tree in the

world with a confirmed height measure is the Hyperion redwood at 380 feet. It should be noted the tallest trees grow in isolated areas of cloud forests in temperate climatic zones (mountain slopes in California, USA, and Tasmania, Australia), and in isolated valleys of dense tropical rainforests.

In the past there have been claims of taller trees than currently listed. In the Western coastal forests of the United States, four trees were measured and cited as the tallest, but were logged or killed:

- 1) a redwood (Sequoia sempervirens) 390 feet tall (1905 record);
- 2) a coastal Douglas-fir (Pseudotsuga menziesii) 466 feet tall (1897 record);
- 3) a coastal Douglas-fir (Pseudotsuga menziesii) 393 feet tall (1897 record); and,
- 4) a giant sequoia (Sequoiadendron giganteum) 320 feet tall.

NOTE: None of these heights could be verified.

In Australian eucalyptus forests, two species and four trees were cited for extreme height:

- 1) blue gum (Eucalyptus globulus) 331 feet tall;
- 2) mountain-ashe (Eucalyptus regnans) 459 feet tall (1872 record);
- 3) mountain-ashe (Eucalyptus regnans) 435 feet tall (1872 record); and,
- 4) mountain-ashe (Eucalyptus regnans) 375 feet tall (1884 record).

NOTE: All of these trees were logged. None of these heights could be verified.

GIRTH -- LARGEST DIAMETER

Tree diameter / circumference is usually simple to measure. This measure is made at a standard height, usually at 4.5 feet above the soil surface (i.e. known as dbh). The 4.5 feet above the ground measuring point clears many buttress roots and root base / stem base swellings. Usually a tape is pulled around the circumference passing over any indentations while maintaining the tape at 4.5 feet above the ground. These circumference inches are then divided by *pi* (3.14159) to yield a diameter measure (in the same units). A commercial diameter tape marked in *pi* inches is easy to use.

Figure 4 is a list of the nineteen species of trees which contain individuals with the largest measured stem diameters (dbh). In older popular literature, the girth (circumference) of stem bases was measured anywhere between ground level and 60 inches above the ground. These older measures may have included multiple stems and buttressed stem bases, and so have been discarded.

The largest trees in diameter are Montezuma cypress, baobab, and giant sequoia. A number of trees with large diameters are not necessarily the tallest, and tall trees are not always the largest in diameter. Some trees shrink and swell significantly over a growing season and can produce variable diameter measures, like baobabs (Adansonia spp.). Multi-stemmed trees, or trees with many consolidated aerial roots around the stem base degrade any diameter measure. There are more than 60 tree species which have individuals with diameters claimed to exceed 14 feet dbh.

BIGGEST -- GREATEST STEM VOLUME

Measuring tree volumes is extremely difficult. Trunk measures, plus branches and root systems, can add large volumes to total tree tissues. For almost all volume measures, only the above ground main stem is measured, or estimated by calculation, without providing for cull or accounting for cavities, decay, or openings. Volume estimates are made in cubic feet. The largest volume occurs in trees with large diameters, tall stems, and small tapors.

Figure 5 presents the eleven species individuals with the largest volumes, reliably measured. Giant sequoia and redwood trees enclose extremely large volumes of space filled with both living and dead woody material. There are 12 individual giant sequoias (Sequoiadendron giganteum) larger in stem

volume than the next largest individual of any other tree species. There are clonal trees which represent greater weight and volume measures than any tree listed here.

OLDEST -- LONGEST LIVED

Longevity is one defining component for trees. Aging trees is fraught with huge inaccuracies. The age of a tree is difficult to determine, and older trees are associated by humans with large tree diameters. Many large trees are younger than you think. This is why trees which do reach immense size, without the aid of human exaggeration or ignorance, are so unique and rare.

Some trees have been properly aged only upon death through full examination of the stem base. For living trees, estimates from branches, increment cores, and wedge-shaped dead areas have been used. In one case, a seedling from the original Bodhi tree of the Buddha was documented as planted in 288 BC, and is the oldest historic record of a living human-planted tree at 2,307 years old.

Tree age is most accurately determined by counting annual growth increments using increment cores taken from the stem. Accuracy of the count depends upon whether a microscope or naked eye is used. In addition, height above the ground where a core was removed represents a count of annual growth increments above that point. The number of annual growth increments to reach that height must be added to the total count.

Indistinct annual increments, false rings, wood decay, and wood cavities (especially within the center of the tree stem base) conspire to make aging trees difficult. Fallen or cut branch aging has many additional problems, especially with sprout-origin branches. Ring-porous temperate trees usually present the most clear annual increment demarcations. Some diffuse porous architecture trees require a careful microscopic examination for accurate aging. Some tropical trees may show wet / dry season increments, or no increments at all.

Figure 6 provides the best estimate for 15 non-clonal tree species individuals which have lived longer than 1,500 years. Bristlecone pine is by far the eldest of all tree species with an individual reaching greater than 5,000 years of age. Note there are two bristlecone pines on the list, *Pinus longaeva* and *Pinus aristata* -- the latter living half as long as the former.

Human Perception Problems -- A large growing tree species on a resource-rich site can grow fast to a large size. In contrast, a small statured tree may still be very old. For example, a Southern live oak (*Quercus virginiana*) on a great site was found to be adding and sustaining more than 3/4 diameter inch per year over a one hundred year period, generating a large girth tree, but relatively young in age. Age and diameter are not strongly related, which leads to large errors when using aging formulae, human memory / comparisons, or "estimates." For all their great height, the oldest redwood is far younger than individuals of many tree species.

Humans can continue to add years to trees without scientific basis. For example, in the case of one famous Southern live oak (*Quercus virginiana*), over a 25 year period of time, a tourism development group added more than 300 years to the tree's age without additional input. There are a number of trees where circumstantial evidence, folklore, and exaggerations retold many times have generated old age claims. Sometimes due to inner cavities and decay, an accurate measure can not be made, but may be estimated based on average growth rates. A number of trees have been claimed to be old, but these claims can not be verified. In some cases, tree owners and/or conservators do not want an accurate age determined.

There are some individual trees which have been claimed to be of great age. Figure 7 provides a list of tree age claims by species which may be accurate, but which can not be verified. Some of these trees are now dead.

SPECIAL OLDEST / BIGGEST -- CLONAL TREES

Trees which vegetatively reproduce can hold and control a site for many years. Stem portions may have grown and fallen, but root tissues continue to resprout new stems. Many generations of stems with identical genetic components are grown. Root portions have also grown / expanded and died. Some root tissues with identical gene sets may not be attached to one another anymore, but are still generating identical stem sprouts. In addition, some trees generate new trees through layering, where branches recline on the ground, form roots and then new shoots, moving the clonal tree outward away from the initial stem.

Clonal trees present a number of issues in determining tissue volume, total organism size and age. For many people, the basic single stem tree definition prohibits consideration of root mass / stem mass in age determinations. Figure 8 presents a selected list of clonal trees which have been brought forward as the oldest “trees” on Earth. Given this view of clonal trees, there are sure to be many hundreds more clonal trees present which would challenge for age and size records.

Clonal tree group “Pando” is a Utah mountain hillside of male quaking aspen (Populus tremuloides) covering more than 100 acres with almost 50,000 stems, each averaging 130 years of age. Pando is estimated to have existed on the site for nearly 80,000 years. The Palmer oak (Quercus palmeri) clonal tree system is a traditional oak regeneration system where new shoots continue to be generated from old root systems. In this case, one of these identical gene set oak groups is estimated to be 13,000 years old.

The huon-pine (Lagarostrobus franklinii – a podocarp, not in the pine family) can reproduce vegetatively with individual trees living less than 4,000 years, but identical gene sets on the site have existed for more than 10,000 years. In Sweden, many (i.e. >15) Norway spruce (Picea abies) trees have vegetatively layered away from parent stems to generate clonal trees. The oldest identical gene set group found so far is estimated to be >9,500 years old. Each short Norway spruce stem lives no more than 500-600 years, but root age can be more than 18 times older.

CONCLUSIONS

Trees which are tall, large, and old capture people’s attention. Beyond knowing the growth limits of individual trees and species, tree extremes help place important trees into human context. People’s communities, civilizations, structures, and even our own size and age, can be dwarfed by trees.

descriptor	percent	cumulative percent
PLANT	20%	
WOODY	16	
SINGLE STEM	14	
TALL / HEIGHT	13	
-----		63%
BRANCHED	9	
PERENNIAL	8	
GIRTH / DIAMETER	7	
-----		87%
ELEVATED CROWN	4	
DISTINCT CROWN	3	
SELF-SUPPORTING	3	
-----		97%
LOWER STEM		
WITHOUT BRANCHES	2	
ERECT STEM	1	
-----		100%

Figure 1: Relative frequency of descriptors defining a tree.
(155 descriptors in 45 definitions)

TALLEST

#	height	scientific name	common name
1	380 ft	<u>Sequoia sempervirens</u>	redwood
2	330 ft	<u>Eucalyptus regnans</u> (tallest angiosperm)	mountain-ashe
3	329 ft	<u>Pseudotsuga menziesii</u>	coastal Douglas-fir
4	318 ft	<u>Shorea fagueteria</u> (tallest tropical)	yellow meranti
5	317 ft	<u>Picea sitchensis</u>	sitka spruce
6	314 ft	<u>Sequoiadendron giganteum</u>	giant sequoia
7	299 ft	<u>Eucalyptus viminalis</u>	mannan gum
8	298 ft	<u>Eucalyptus globulus</u>	Tasmanian blue gum
9	295 ft	<u>Abies procera</u>	noble fir
10	288 ft	<u>Eucalyptus delegatensis</u>	alpine-ashe
10	288 ft	<u>Petersianthus quadrialatus</u>	Philippine rosewood
11	282 ft	<u>Eucalyptus obliqua</u>	brown-top stringbark
12	281 ft	<u>Koompassia excelsa</u>	mengaris
13	279 ft	<u>Eucalyptus diversicolor</u>	karri
14	278 ft	<u>Shorea argentifolia</u>	dark red meranti
15	277 ft	<u>Shorea superba</u>	magnificent meranti
15	277 ft	<u>Eucalyptus nitens</u>	shining gum
16	274 ft	<u>Pinus lambertiana</u>	sugar pine
17	273 ft	<u>Tsuga heterophylla</u>	Western hemlock
18	272 ft	<u>Hopea nutans</u>	giam
19	270 ft	<u>Shorea smithiana</u>	light red meranti
20	270 ft	<u>Shorea johorensis</u>	meranti majau
21	269 ft	<u>Pinus ponderosa</u>	ponderosa pine

Figure 2: Ranked list of tree species (23 species) which contain the tallest (in feet) individuals in the world (>269ft).

#	height	scientific name	common name	tree name / location
1	380 ft	<u>Sequoia sempervirens</u>	redwood	Hyperion, CA, USA
2	376 ft	<u>Sequoia sempervirens</u>	redwood	Helios, CA, USA
3	371 ft	<u>Sequoia sempervirens</u>	redwood	Icarus, CA, USA
3	371 ft	<u>Sequoia sempervirens</u>	redwood	Stratosphere Giant, CA, USA
4	369 ft	<u>Sequoia sempervirens</u>	redwood	Lauralyn, CA, USA
4	369 ft	<u>Sequoia sempervirens</u>	redwood	National Geographic Society, CA, USA
4	369 ft	<u>Sequoia sempervirens</u>	redwood	Orion, CA, USA
4	369 ft	<u>Sequoia sempervirens</u>	redwood	Paradox, CA, USA
4	369 ft	<u>Sequoia sempervirens</u>	redwood	Rockefeller, CA, USA
5	368 ft	<u>Sequoia sempervirens</u>	redwood	Mendocino, CA, USA
6	367 ft	<u>Sequoia sempervirens</u>	redwood	Federation Giant, CA, USA
7	363 ft	<u>Sequoia sempervirens</u>	redwood	Deadalus, CA, USA
8	330 ft	<u>Eucalyptus regnans</u>	mt.-ashe	Centurion, Tas, AUS
9	329 ft	<u>Pseudotsuga menziesii</u>	Douglas-fir	Doerner Fir, CA, USA
10	325 ft	<u>Sequoia sempervirens</u>	redwood	Stout Tree, CA, USA
11	318 ft	<u>Eucalyptus regnans</u>	mt.-ashe	Icarus' Dream, Tas, AUS
11	318 ft	<u>Shorea faguettiana</u>	y. meranti	Sabah, Borneo
12	317 ft	<u>Picea sitchensis</u>	sitka spruce	Prairie Creek Spruce, CA, USA
13	314 ft	<u>Sequoiadendron giganteum</u>	giant sequoia	CA, USA
14	308 ft	<u>Sequoia sempervirens</u>	redwood	Del Norte Titan, CA, USA

Figure 3: List of the twenty tallest (exceeding 300 feet in height) individual trees in the world.

LARGEST DIAMETER

#	diameter	scientific name	common name
1	38 ft	<u>Taxodium mucronatum</u>	Montezuma cypress
2	35 ft	<u>Adansonia digitata</u>	baobab
3	30 ft	<u>Sequoiadendron giganteum</u>	giant sequoia
4	29 ft	<u>Adansonia za</u>	za baobab
4	29 ft	<u>Sequoia sempervirens</u>	redwood
5	27 ft	<u>Cinnamomum camphora</u>	camphor tree
6	22 ft	<u>Eucalyptus obliqua</u>	Australian oak
7	21 ft	<u>Eucalyptus regnans</u>	swamp gum / mt. ashe
8	20 ft	<u>Thuja plicata</u>	Western redcedar
9	19 ft	<u>Eucalyptus delegatensis</u>	alpine-ashe
10	18 ft	<u>Picea sitchensis</u>	sitka spruce
10	18 ft	<u>Dracaena draco</u>	Canary Island dragon tree
10	18 ft	<u>Agathis australis</u>	kauri
11	17 ft	<u>Cryptomeria japonica</u>	sugi
12	16 ft	<u>Fitzroya cupressoides</u>	alerce
13	15 ft	<u>Quercus robur</u>	pedunculate oak
14	14 ft	<u>Pseudotsuga menziesii</u>	coastal Douglas-fir
14	14 ft	<u>Quercus petraea</u>	sessil oak
14	14 ft	<u>Taxus baccata</u>	European yew

Figure 4: Ranked list of tree species (19 species) with individuals of the greatest diameter (dbh feet) in the world.

LARGEST VOLUME

#	volume	scientific name	common name
1	52,521 ft ³	<u>Sequoiadendron giganteum</u>	giant sequoia
2	38,322 ft ³	<u>Sequoia sempervirens</u>	redwood
3	26,490 ft ³	<u>Taxodium mucronatum</u>	Montezuma cypress
4	18,225 ft ³	<u>Agathis australis</u>	kauri
5	15,900 ft ³	<u>Thuja plicata</u>	Western redcedar
6	13,810 ft ³	<u>Eucalyptus regnans</u>	swamp gum / mt. ash
7	13,000 ft ³	<u>Eucalyptus globulus</u>	Tasmanian blue gum
8	12,327 ft ³	<u>Pseudotsuga menziesii</u>	coastal Douglas-fir
9	11,903 ft ³	<u>Picea sitchensis</u>	sitka spruce
10	11,900 ft ³	<u>Eucalyptus obliqua</u>	Australian oak
11	10,102 ft ³	<u>Eucalyptus delegatensis</u>	alpine ashe

Figure 5: Ranked list of living tree species (11 species) with the largest volume (in cubic feet) individuals in the world.

OLDEST

#	age in years	scientific name	common name
1	5,068 yrs	<u>Pinus longaeva</u>	bristlecone pine
2	3,647 yrs	<u>Fitzroya cupressoides</u>	alerce
3	3,201 yrs	<u>Sequoiadendron giganteum</u>	giant sequoia
4	2,459 yrs	<u>Pinus aristata</u>	Rocky Mountain bristlecone pine
5	2,419 yrs	<u>Adansonia digitata</u>	African baobab
6	2,307 yrs	<u>Ficus religiosa</u> (oldest verified human planted tree)	sacred fig
7	2,200 yrs	<u>Juniperus occidentalis</u>	Western juniper
8	2,111 yrs	<u>Pinus balfouriana</u>	foxtail pine
9	1,943 yrs	<u>Larix lyalli</u>	subalpine larch
10	1,890 yrs	<u>Juniperus scopulorum</u>	Rocky Mountain juniper
11	1,805 yrs	<u>Cryptomeria japonica</u>	sugi
12	1,719 yrs	<u>Pinus flexilis</u>	limber pine
13	1,677 yrs	<u>Thuja occidentalis</u>	Northern whitecedar
14	1,650 yrs	<u>Taxodium distichum</u> (oldest verified tree age in Eastern US)	baldcypress
15	1,636 yrs	<u>Callitropsis nootkatensis</u>	Alaskan cypress

Figure 6: Ranked list of tree species (15 species) with the oldest (in years) verified living non-clonal individuals in the world.

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age claimed	species	common name
4,000 yrs	<u>Cupressus sempervirens</u>	Mediterranean cypress
4,000 yrs	<u>Lagarostrobos franklinii</u>	huon-pine
3,500 yrs	<u>Taxus baccata</u>	European yew
2,675 yrs	<u>Juniperus occidentalis</u>	Western juniper
2,620 yrs	<u>Castanea sativa</u>	sweet chestnut
2,200 yrs	<u>Sequoia sempervirens</u>	redwood
2,065 yrs	<u>Platanus orientalis</u>	oriental plane
2,065 yrs	<u>Olea europaea</u>	olive
1,980 yrs	<u>Larix decidua</u>	European larch
1,900 yrs	<u>Cinnamomum camphora</u>	camphor tree
1,800 yrs	<u>Podocarpus totara</u>	totara
1,800 yrs	<u>Araucaria araucana</u>	monkey-puzzle
1,659 yrs	<u>Quercus robur</u>	pedunculate oak
1,500 yrs	<u>Adansonia gregorii</u>	boab
1,500 yrs	<u>Quercus virginiana</u>	Southern live oak

Figure 7: List of tree age claims which may be accurate, but which can not be / have not been, verified.

OLDEST CLONAL

#	age in years	scientific name	common name
1	80,000 yrs	<u>Populus tremuloides</u>	quaking aspen
2	13,000 yrs	<u>Quercus palmeri</u>	Palmer oak
3	10,000 yrs	<u>Lagarostrobos franklinii</u>	huon-pine
4	9,550 yrs	<u>Picea abies</u>	Norway spruce

Figure 8: Ranked list of tree species with the oldest (in years) living clonal individuals in the world.



Outreach

Warnell School of Forestry & Natural Resources

UNIVERSITY OF GEORGIA

Thompson Mills Forest & State Arboretum of Georgia

Citation:

Coder, Kim D. 2019. Extreme trees: Tallest, biggest and oldest. Warnell School of Forestry & Natural Resources, University of Georgia, Thompson Mills Forest & State Arboretum Outreach Product. ARBORETUM-19-4. Pp.13.

ARBORETUM-19-4

June 2019

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