

Tree Planting and Air Quality

A Ventura County Air Pollution Control District Advisory

Tree planting is becoming an increasingly popular program with many municipalities, local governments and community organizations due to their multiple positive environmental attributes. These consist of reducing energy demand, alleviating urban heat island effect, enhancing air quality, beautifying communities, and many more.

Trees and Air Quality Correlation

- Reduce Ozone (O₃)
- Reduce Particulates
- Reduce CO₂
- Reduce Heat Island Effect

Center for Urban Forest Research says, “Millions of us live in areas where air pollution can cause serious health problems. Ground-level ozone and airborne particles are two pollutants that pose the greatest threat to human health. Carbon dioxide (CO₂), once thought to be the product of perfect combustion, is also now considered a pollution concern. Fortunately, trees play an important role in cleaning the air and making our communities healthier places to live. Knowing trees characteristics, we can increase their role as air pollution control devices.

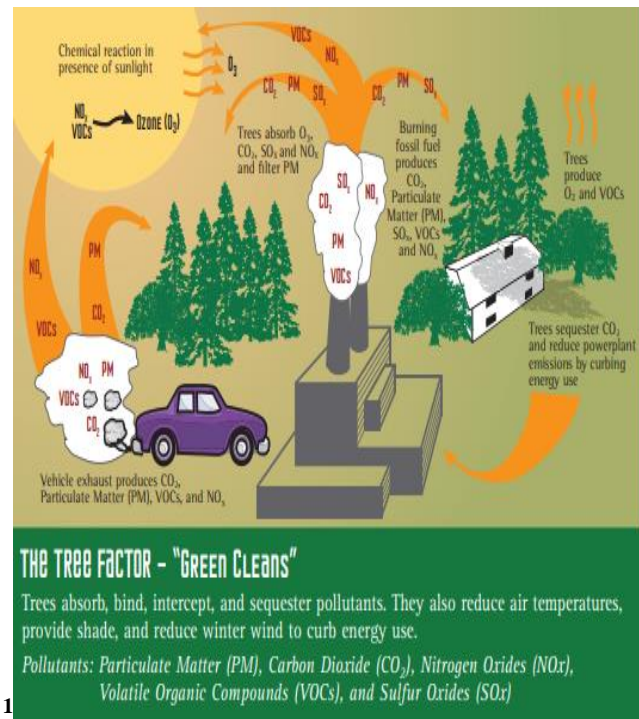


Fig 1. Tree diagram of pollutant filtering

Ozone, Particulates and CO₂ Pollution

Ground-level ozone and airborne particulates are among the pollutants that pose the greatest threat to human health. Carbon dioxide (CO₂) is also a pollution concern due to its global warming potential and contribution in altering the planet’s climate. Trees are very effective in helping clean the air by filtering out pollutants, absorbing CO₂ and making our communities healthier places to live.

¹ https://www.sactree.com/assets/files/greenprint/benefits_of_trees/air_quality/treestheairpollutionsolution72006.pdf

Heat Island Effect

The term heat island describes a built-up metropolitan urban area that is much warmer than the surrounding rural area due to habitat fragmentation and development. Heat islands form as vegetation is replaced by asphalt and concrete for roads, buildings and other structures, which tend to absorb and trap rather than reflect the sun’s heat as well as heat generated by other human activities, causing surface and ambient temperatures to rise. Heat islands increase summer-time peak energy demand, demand for air conditioning and exacerbate smog and greenhouse gas emissions. Planting trees is a key and effective strategy in combatting the heat island effect and can help reduce peak temperatures and cool the surrounding areas by 2-9°F.²

This graph below was published by Nasa to show data with air conditioning systems. How this relates to the heat island effect can be clearly seen anywhere near tree canopy cover. There is a decline in the need for AC and a lower outside temperature near vegetated spaces comparative to the urban development zones.

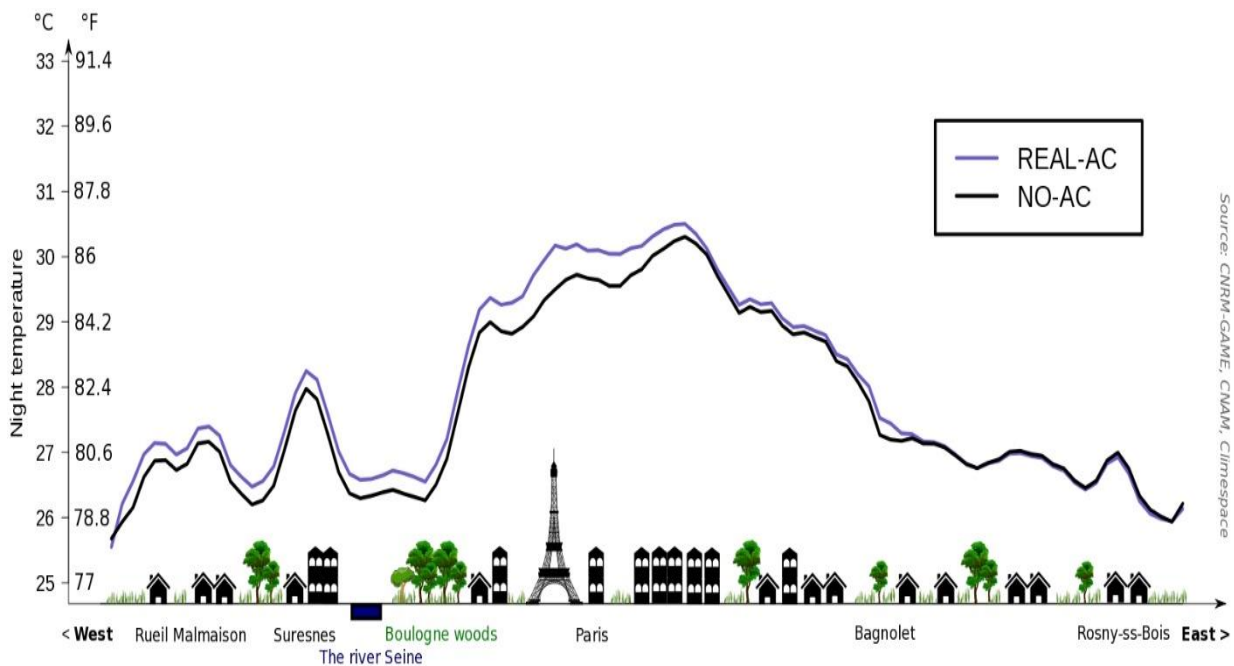


Fig 2. 2003 heat wave in Paris. Air conditioning systems release waste heat into the atmosphere. This graph by Météo France/Cécile de Munck, published by Nasa shows indications of a decrease in temperature over vegetated spaces.³

Key Factors to Consider in Selecting Trees

While the positive attributes of tree planting are many, not all trees are created equal or appropriate for planting in all locations. For example, while trees in general may provide some

² https://www.sactree.com/assets/files/greenprint/benefits_of_trees/air_quality/NASAUrbanHeatIslandDescription.pdf

³ <https://www.nasa.gov/topics/earth/features/heat-island-sprawl.html>

level of filtration for particulate and gaseous pollutants, their biogenic emissions may impact adversely local ozone (smog) reduction efforts. Likewise, the demand for water may vary greatly among different tree species, a critical characteristic in geographic areas with scarce water resources. Therefore, to optimize the environmental attributes of tree planting and help communities realize the full potential of such programs, there are several key factors that individuals and organizations engaged in such programs must consider that are germane to the specific geographic location where the tree planting is to take place.

Here are Some Key Factors to Consider in Selecting Trees

- Size, shape, growth rate, root structure and life span.
- All trees enhance deposition of particulate matter and gaseous air pollutants like ozone and nitric oxide.
- Trees absorb carbon dioxide, a significant greenhouse gas.
- Select trees with **low biogenic emission rates**.
[See below for advice](#)
- Select **native species** to your area.
- Select **drought tolerant/ fire resistant** species.
- Select trees releasing **lesser pollen**. Some trees release irritating pollens which can be an air quality irritant as well as a public health issue.
- Consider leaf/seed drop characteristics and ensure trees selected are in harmony with local agricultural cultivation practices.⁴

List of Trees

Despite the many positive attributes of tree planting mentioned above, many species of trees emit varying quantities of highly photochemically reactive hydrocarbons (isoprene, terpenes). Such hydrocarbon emissions contribute to the formation of harmful ground level ozone (smog), exacerbating further the smog problem that many communities in Southern California experience. There is great variation in emissions rates among species, strong dependence of such rates to ambient temperature changes, and some variation in the chemical structure and photochemical reactivity of the emitted compounds.

Therefore, planting of high-emitting tree species on a large scale has the potential to adversely affect air quality rather than enhance it. To prevent or minimize this unintended consequence, we are providing a list of native trees to Southern California or arborous shrubs that have the best benefits and potential for the local area of Ventura County. The following lists

⁴ https://www.ca-ilg.org/sites/main/files/file-attachments/resources__BAAQMD_Trees__Air_Quality.pdf

reflect direct emission measurements from tree and shrub species found in the Southern California. Overall the combined list of species is ranked according to total (isoprene and monoterpenes) biogenic emission rate on an hourly basis. Even though the ranking of the trees is particular to Southern California, the same concept can be applied to other geographic areas to assist in planting of low-emitting urban forests (Benjamin et al. 1996).⁵ Each tree was cross referenced with <https://selectree.calpoly.edu/> & <https://calflora.org//> for it's characteristics and native inheritance. This is a good habit to cross reference plants and trees on these databases before planting.

A list of several suggested native species in California that could be more beneficial to plant than others with consideration to biogenic emissions is provided below. The list is organized in three tables:

- Table 1- Low Emitters (Air Quality Beneficial)
- Table 2- Moderate Emitters (Next Best Option for Air Quality)
- Table 3- High Emitters (Plant Sparingly)

Most trees listed included in all three tables have shown signs of some native relationship to Ventura County. Also, the tables provide information about tree characteristics and tree types as described on the legend below.

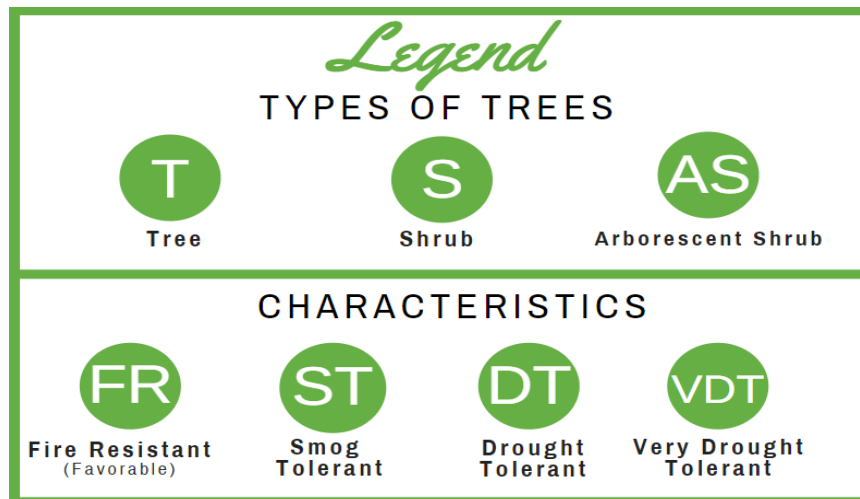


Fig 3. Legend detailing specific characteristics of the trees listed below. Each tree characteristics can be cross referenced with the selectree glossary.⁶

⁵ Michael, T. B., M. Sudol, L. Bloch, and A. M. Winer. 1996. Low-emitting urban forests: A taxonomic methodology for assigning isoprene and monoterpene emission rates. *Atmospheric Environment* **30**: 1437-1452

⁶ <https://selectree.calpoly.edu/tree-characteristics-glossary/>



Low Emitters: < 1.0

Table 1: Trees and shrubs ranked by sum of hourly emission rate of isoprene and monoterpenes.
 *All trees listed are suggestions of native tree species to plant for Southern California (specifically Ventura County).

Common Name	Botanical Name	Characteristics (Reference Legend)	Iso. + Mono. $\mu\text{g}(\text{g dry leaf wt})^{-1} \text{h}^{-1}$
Madrone	<i>Arbutus menziesii</i>	T, FR, DT	0.0
Peninsular Manzanita	<i>Arctostaphylos glandulosa</i>	S	0.0
Bigberry Manzanita	<i>Arctostaphylos glauca</i>	AS, FR, DT	0.0
Dr. Hurd Manzanita	<i>Arctostaphylos manzanita</i>	AS, FR, DT	0.0
Hoaryleaf Ceanothus	<i>Ceanothus crassifolius</i>	S, DT	0.0
Mountain Mahogany	<i>Cercocarpus betuloides</i>	AS, VDT	0.0
Curly-Leaf Mountain Mahogany	<i>Cercocarpus ledfolius</i>	AS, VDT	0.0
Summer Holly	<i>Comarostaphylis diversifolia</i>	AS, FR	0.0
California Buckwheat	<i>Eriogonum fasciculatum</i>	S	0.0
Foothill Ash	<i>Fraxinus dipetala</i>	T, DT, FR	0.0
Arizona Ash	<i>Fraxinus velutina</i>	T, ST, FR	0.0
Modesto Ash	<i>Fraxinus velutina 'Modesto'</i>	T, ST, FR	0.0
Montebello Ash	<i>Fraxinus velutina coriacea</i>	T, FR	0.0
Sugarbush	<i>Rhus ovata</i>	S, DT	0.0

Common Name	Botanical Name	Characteristics (Reference Legend)	Iso. + Mono. $\mu\text{g}(\text{g dry leaf wt})^{-1} \text{h}^{-1}$
Red Coastal Elderberry	<i>Sambucus callicarpa</i>	AS	0.0
Blue Elderberry	<i>Sambucus glauca</i>	AS	0.0
Hairy Blue Elderberry	<i>Sambucus Mexicana</i>	AS	0.0
Western Redbud	<i>Cercis occidentalis</i>	AS, DT, FR	0.0
Mountain Serviceberry	<i>Amelanchier alnifolia</i>	AS	0.1
Toyon	<i>Heteromeles arbutifolia</i>	AS, DT	0.1
Catalina Ironwood	<i>LyonothamnusJoribundus aspenqolia</i>	T, DT	0.1
Hollyleaf Cherry	<i>Prunus ilicifolia</i>	T, FR	0.1
Catalina Cherry	<i>Prunus lyonii</i>	T, DT, FR	0.1
Chamise	<i>Adenostoma fasciculatum</i>	S, DT	0.1
California Juniper	<i>Juniperus californica</i>	AS, DT	0.6
Foothill Pine/ Bull Pine	<i>Pinus sabiniana</i>	T, VDT	0.6
Incense Cedar	<i>Calocedrus decurrens</i>	T, DT, FR	0.8

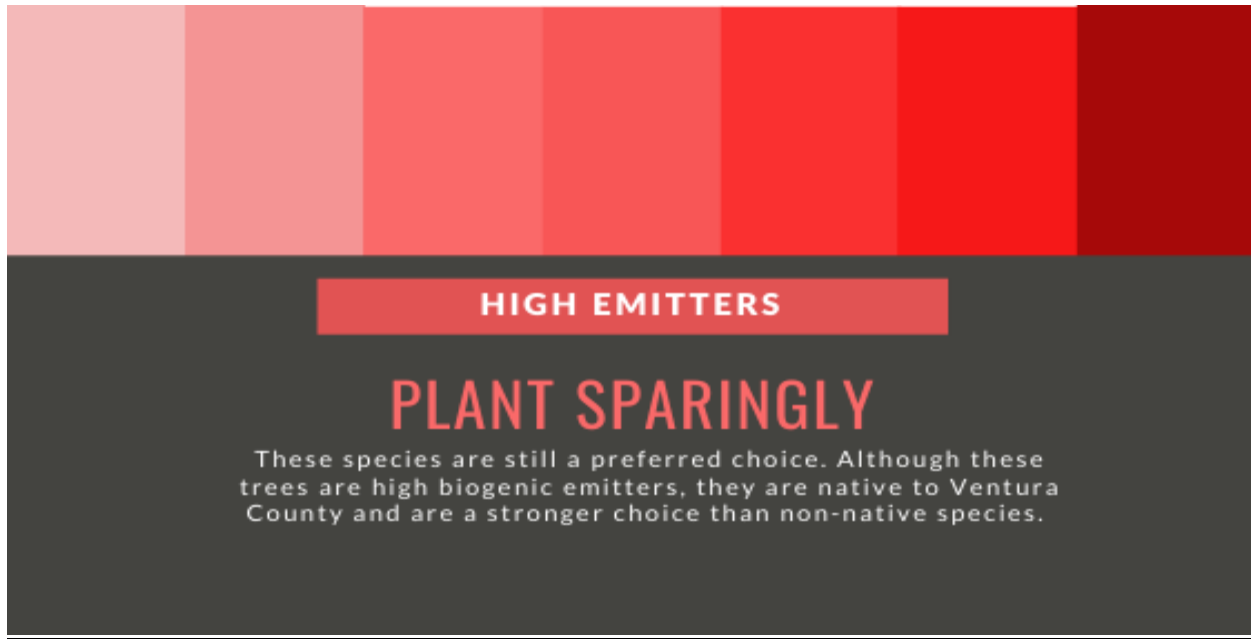
MODERATE EMITTERS

NEXT BEST OPTION
Next best option for better air quality.

Moderate Emitters: Between 1.0 and 10.0

Table 2: Trees and shrubs ranked by sum of hourly emission rate of isoprene and monoterpenes.
 *All trees listed are suggestions of native tree species to plant for Southern California (specifically Ventura County).

Common Name	Botanical Name	Characteristics (Reference Legend)	Iso. + Mono. $\mu\text{g}(\text{g dry leaf wt})^{-1} \text{h}^{-1}$
Bigcone Douglas Fir	<i>Pseudotsuga macrocarpa</i>	T, DT	1.1
Tecate Cypress	<i>Cupressus forbesii</i>	T, DT	1.7
California Walnut	<i>Juglans californica</i>	T, DT	1.8
Greenbark	<i>Ceanothus spinosus</i>	T, DT	1.8
Blue Blossom	<i>Ceanothus thyrsiflorus</i>	T, FR	2.4
Bigleaf Maple	<i>Acer macrophyllum</i>	T, DT, FR	2.8
Box Elder	<i>Acer negundo</i>	T, FR	2.8
Valley Oak	<i>Quercus lobata</i>	T, FR	3.4
Knobcone Pine	<i>Pinus attenuata</i>	T, VDT	3.5
Coulter Pine	<i>Pinus coulteri</i>	T, DT	3.5
Limbar Pine	<i>Pinus flexilis</i>	T, DT	3.5
Jeffery Pine	<i>Pinus jeffreyi</i>	T, DT	3.5
Sugar Pine	<i>Pinus lambertiana</i>	T	3.5
Singleleaf Pinyon Pine	<i>Pinus monophylla</i>	T, DT	3.5
Bishop Pine	<i>Pinus muricata</i>	T	3.5
Ponderosa Pine	<i>Pinus Ponderosa</i>	T	3.5
Torrey Pine	<i>Pinus torreyana</i>	T, DT	3.5
White Fir	<i>Abies concolor</i>	T, DT	4.3
Chaparral Whitehorn	<i>Ceanothus leucodermis</i>	S	5.4
California Laurel	<i>Umbellularia californica</i>	T, DT	5.7
Desert Willow	<i>Chilopsis linearis</i>	T, VDT	5.9
Black Sage	<i>Salvia mellifera</i>	S	8.3
Blue Oak	<i>Quercus douglasii</i>	T	8.7
California Fan Palm	<i>Washingtonia filifera</i>	T, DT	9.9



HIGH EMITTERS

PLANT SPARINGLY

These species are still a preferred choice. Although these trees are high biogenic emitters, they are native to Ventura County and are a stronger choice than non-native species.

High Emitters: > 10.0

Table 3: Trees and shrubs ranked by sum of hourly emission rate of isoprene and monoterpenes.
 *All trees listed are suggestions of native tree species to plant for Southern California (specifically Ventura County).

Common Name	Botanical Name	Characteristics (Reference Legend)	Iso. + Mono. $\mu\text{g}(\text{g dry leaf wt})^{-1} \text{h}^{-1}$
Western Sycamore	<i>Platanus racemose</i>	T, FR	10.9
Interior Live Oak	<i>Quercus wislizeni</i>	T	12.5
Woolly Blue Curles	<i>Trichostema lanatum</i>	S	17.7
Pacific Wax-Myrtle	<i>Morella californica</i>	T, FR, DT	23.2
Black Willow	<i>Salix gooddingii</i>	T	25.2
Canyon Live Oak	<i>Quercus chrysolepis</i>	T, DT	25.4
Leather Oak	<i>Quercus durata</i>	T, VDT	25.4
Mesa Oak	<i>Quercus engelmannii</i>	T	25.4
California Sagebrush	<i>Artemisia californica</i>	S	28.3
Coyote Brush	<i>Baccharis pilularis</i>	S	28.3
Coffeeberry	<i>Rhamnus californica</i>	AS, DT, FR	29.3
California Scrub Oak	<i>Quercus dumosa</i>	T, VDT, FR	29.8
Coast Live Oak	<i>Quercus agrifolia</i>	T, FR	35.3
Hollyleaf Redberry	<i>Rhamnus crocea ilicifolia</i>	AS, DT, FR	41.9

Common Name	Botanical Name	Characteristics (Reference Legend)	Iso. + Mono. $\mu\text{g}(\text{g dry leaf wt})^{-1} \text{h}^{-1}$
Fremont Cottonwood	<i>Populus fremontii</i>	T, FR	43.6
Black Cottonwood	<i>Populus trichocarpa</i>	T, FR	43.6
Pacific Willow	<i>Salix lasiandra</i>	T, FR	50.9
Arroyo Willow	<i>Salix lasiolepis</i>	T, FR	50.9
Oregon White Oak	<i>Quercus garryana</i>	T	59.8

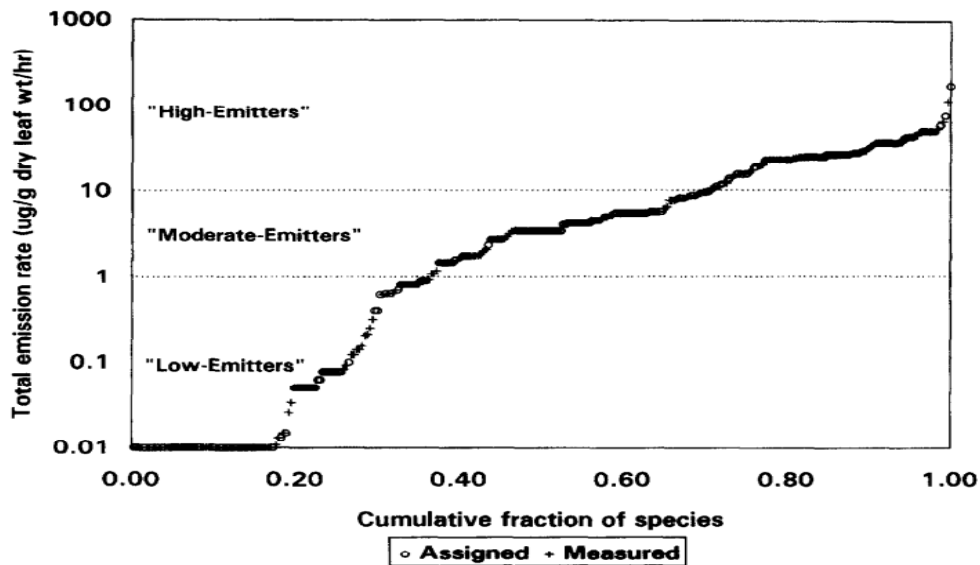


Fig 4. Above is a graph of low, moderate and high emitters based on their isoprene and monoterpenes count.⁷

Fruit Trees

The following are a list of fruit trees that are great options for planting in Southern California, although local climates can vary. These species are great options for planting alternatives in backyards, community gardens and school gardens.⁸ Although most of these species are non-native to California, they thrive well because of their suitability to Southern California’s Mediterranean climate.⁹

- Apples (*Malus domestica*)
- Figs (*Ficus carica L.*)
- Loquat

⁷ Michael, T. B., M. Sudol, L. Bloch, and A. M. Winer. 1996. Low-emitting urban forests: A taxonomic methodology for assigning isoprene and monoterpene emission rates. *Atmospheric Environment* 30: 1437-1452

⁸ <https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=31172>

⁹ <http://homeorchard.ucanr.edu/>

- Persimmon (*Diospyros kaki*)
- Pomegranate (*Punica granatum L.*)
- Mango
- Olive (*Olea europaea L.*)
- Guavas
- Peaches (*Prunus persica*)
- Nectarine
- Pear (*Pyrus communis L.*)

On-line Resources on Trees and Air Quality

- ❖ [California Polytechnic State University, San Luis Obispo's Urban Forest Ecosystems Institute](#) provides a useful on-line tree selection website called "SelecTree." Many tree characteristics, including the biogenic emissions for 232 different tree species, can be searched using this web-based tool.

Please visit <https://selectree.calpoly.edu/> for more information.

- ❖ [The Calflora Database](#) is a nonprofit organization dedicated to providing information about California plant biodiversity for use in Education, Research and Conservation. Calflora is structured as a digital library to fulfill the following objectives:
 - To serve as a repository for information on California wild plants in electronic formats from diverse sources, including public agencies, academic institutions, private organizations, and individuals.
 - To provide this information in readily usable electronic formats for scientific, conservation, and educational purposes.
 - To serve public information needs related to scientific study, land management, environmental analysis, education, and appreciation of California plant life.

Please visit <https://www.calflora.org/> for more information.

- ❖ [The U.S. Forest Service's Center for Urban Forest Research at UC Davis](#) is an excellent resource for research and reports on urban forests, including extensive research on the relationship between urban forestry and climate change. The website also contains a "Tree Carbon Calculator".

Please visit https://www.fs.fed.us/psw/topics/urban_forestry/ for more information.

- ❖ [The California Air Resources Board](#) provides a helpful website on "Trees and Air Quality." The website contains information and links to other on-line resources organized by various air quality aspects of trees and plants such as cooling properties, pollutant removal, biogenic emissions, biogenic allergens, and general tree selection.

Please visit <https://ww3.arb.ca.gov/research/ecosys/tree-aq/tree-aq.htm> for more information.

- ❖ **Arbor Day Foundation** is the largest nonprofit membership organization that are devoted to planting trees. They were founded in 1972 and have over 1 million members that have supported the foundation to plant over 350 million trees worldwide in and around our communities for a greener and healthier future.

Please visit <https://www.arborday.org/> for more information.

Selecting a Healthy Tree

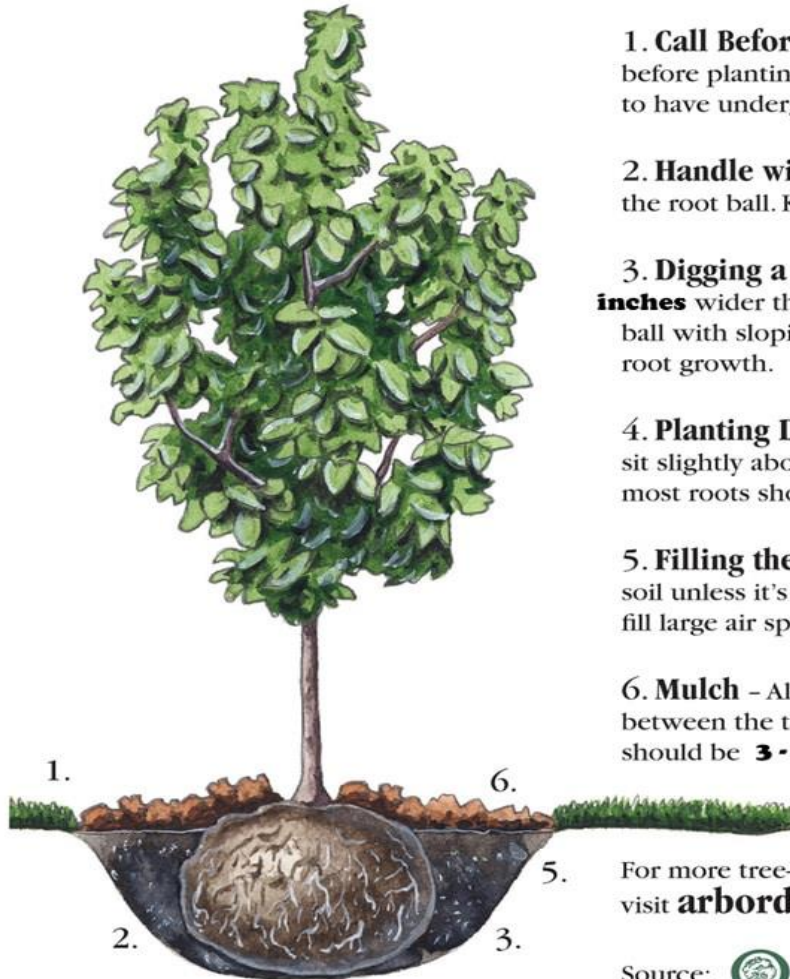
- Bright, healthy bark
- Tree and limbs free of insects and mechanical injury
- Roots should be moist and fibrous
- Straight trunk/ good structure
- Check for circling roots. You don't want circular roots. You want roots that will spread out to anchor the tree and collect proper nutrients.

Tree Planting Tips

The Arbor Day Foundation provides the following six very useful tree planting tips.

1. **Call before you dig** - In other words, know if you have any pipes or wires underneath your planting site.
2. **Handle with care** – Always secure the root ball and make sure roots are moist until they are properly planted. Newly planted trees require more frequent watering than established trees and shrubs. University of Minnesota has a great breakdown of generic water management for newly planted & established trees.ⁱ
3. **Digging a Proper Hole** – Dig 2 to 6 inches wider than the diameter of the root ball. Having angled or sloping sides allow the root to growth stronger.
4. **Planting Depth** – Cover most of the root with slightly enough trunk flare showing (trunk flare is the portion where the first main roots attach to the trunk).
5. **Filling the Hole** – Cover hole with native soil. Soil choice matters as that is what lets water percolate through (when in doubt, choose soil based off plant type). Tap down soil gently until firm to fill the large air spaces.
6. **Mulch** – Allow 1 to 2 inches of clearance between the trunk and the mulch. You don't want to dry out the plant. Mulch should be 3-4 inches deep.

Six things you should know when planting a tree.



1. Call Before You Dig – Several days before planting, call **Miss Dig @ 811** to have underground utilities located.

2. Handle with Care – Always lift tree by the root ball. Keep roots moist until planting.

3. Digging a Proper Hole – **Dig 2 - 6 inches** wider than the diameter of the root ball with sloping sides to allow for proper root growth.

4. Planting Depth – The trunk flare should sit slightly above ground level and the top-most roots should be buried **2 - 4** inches.

5. Filling the Hole – Backfill with native soil unless it's all clay. Tamp in soil gently to fill large air spaces.

6. Mulch – Allow 1 to 2 inch clearance between the trunk and the mulch. Mulch should be **3 - 4** inches deep.

5. For more tree-planting tips and information, visit **arborday.org**.

Source:  **Arbor Day Foundation**[™]
Modified By: **Bundschuh Landscape Center** 90075201

Fig 5. Please visit <https://www.arborday.org/trees/tips/> for proper instruction on tree planting and care.

If you have any questions about this advisory, or have questions about tree planting, please contact:

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ⁱ <https://extension.umn.edu/planting-and-growing-guides/watering-newly-planted-trees-and-shrubs#:~:text=Newly%20planted%20trees%20or%20shrubs,every%202%20to%203%20days.>