



Using Trees to Save Energy

Thoughtful planning and careful design of landscapes can save energy and money for homeowners, condominiums, commercial properties, and public facilities. Trees modify temperatures and energy use by providing shade, absorbing heat, controlling winds, and evaporating water from leaf surfaces.

In urban and developed areas, “heat islands” are created by decreased wind, increased hard surfaces from buildings and paved areas, and heat generated by air-conditioning exhaust, automobiles, and human activities. These heat islands are, on average, 5–9°F warmer than rural or open areas surrounding them. Appropriate use of trees will successfully relieve heat islands. Three trees per house can slow heat buildup and city heat-island effects, saving significant cooling costs.

In Hawaii, planting trees saves energy by reducing overall energy consumption and peaks in use of air conditioners and cooling fans. Reducing energy use lowers utility bills. Air-conditioning costs in homes and offices can be reduced significantly with the use of properly located trees and shrubs. Decreasing peak-load demand helps avoid power shortages. Lower demand, in turn, delays the need for expanded facilities, thus keeping costs down for the consumer.

Because of the diverse terrain of ridges, valleys, and flat lands of the islands, Hawaii has a multitude of “microclimates.” Microclimates are localized conditions that vary from surrounding areas because of differences in wind, rainfall, cloud cover, elevation,

and temperature. Microclimates can even differ on an individual homesite—contrast the temperature on the east side versus the west side of a house or fence in the afternoon.

Trees regulate temperature and climate by reducing heat and regulating winds. Even in our subtropical climate, chilling seasonal and storm winds sometimes need to be blocked. Trees can provide warmer comfort zones for these situations.

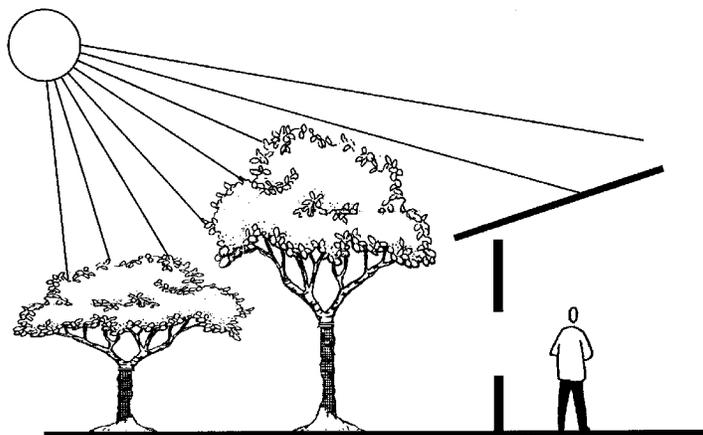
Well placed and well chosen trees make living and working spaces more pleasant and comfortable. The intrinsic value of the landscape, as well as energy savings, will increase over time because trees increase in value as they grow larger and provide more protection from sun and wind.

Trees contribute to energy savings in other, subtle ways. More trees in the landscape can mean less lawn area and reduced need for mowing. Well designed outdoor areas encourage cooking and dining out on warm days, conserving energy by not heating up the kitchen. Planting trees is also environmentally and ecologically

sound. Besides saving energy, trees absorb carbon dioxide, a contributor to global warming. Trees produce oxygen, reduce erosion, protect and enrich the soil, and provide homes for diverse wildlife.

The keys to using trees for energy savings are thorough *site analysis*, an effective *design* of the area, and selection of *the right tree for the right place*.

In 50 years, one tree produces \$30,000 in oxygen, recycles \$35,000 in water, and removes \$60,000 of air pollution.



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Site analysis

Evaluate the existing climactic and environmental conditions of the site. There may be several natural or man-made microclimates in an area.

- Observe the sun's path throughout the day. The seasonal variations in the sun's orientation and altitude in Hawaii are illustrated on page 8. Most of the sun's energy will hit the east and west walls of a building. The late afternoon sun in the west produces the most heat, resulting in the highest energy consumption for cooling on hot days.
- Determine wind patterns. From which direction does the prevailing wind blow? Are there structures or natural barriers that block, alter, or create a particular pattern? Is there a "wind tunnel"? Do you want to *use* or *control* the wind?
- Note the slope of the land and earth forms that may affect the amount of light or wind.
- What collects and stores heat in the area? Buildings attract, reflect, and hold unwanted summer warmth. Windows exposed to sun not only heat the interiors but also reflect back onto adjacent areas. Glossy building surfaces such as mirrored walls intensify reflected heat and glare. Paved areas such as driveways, streets,

walkways, and lanais are heat sinks. All of these raise surrounding air temperatures.

- What is already providing shade and reducing temperatures in the area? Take note of buildings and structures, as well as vegetation on-site and off-site that affect the property.

Design

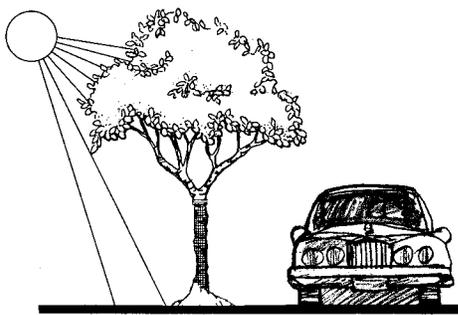
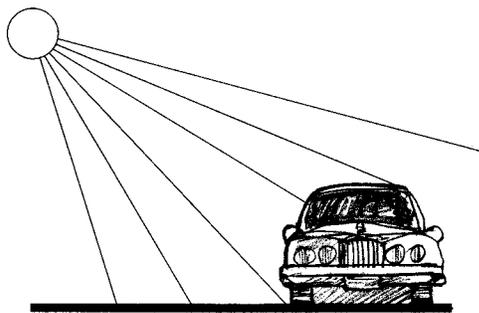
Make a detailed sketch of the area, including buildings, walls or fences, boundaries, existing vegetation, streets and walkways, and surrounding areas. Locate any air conditioners on the building or the site. Note all overhead and underground utility lines in the vicinity. Include on the sketch any solar collectors for heating water, etc., that have been installed on the property or those adjoining. The collectors must receive as much direct sunlight as possible for maximum efficiency.

Evaluate the needs and desires of the occupants for (1) privacy, (2) screening from noise and other outside influences, and (3) outdoor living and working areas. Now you are ready to make decisions regarding the use of trees for shading, wind control, and cooling.

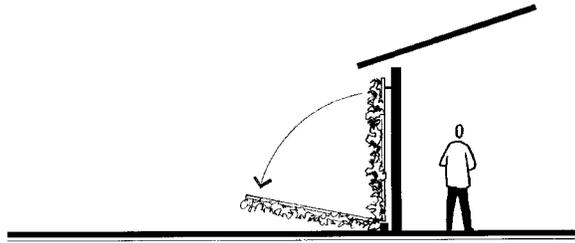
Shading

From the site analysis, you can now determine which areas would benefit from shading and sun control.

- Outdoor compressor/condenser units of air conditioning systems use less energy if they and the surrounding areas are shaded from direct sun for the entire day. Take care not to block the air flow with shrubs, hedges, low trees, or fences. If the warm discharge air cannot escape, the intake air temperature will be raised, requiring more energy to cool it.
- Tall trees can shade roofs and significantly reduce temperatures of building interiors. These trees should be planted no closer than 15 ft from a building to avoid damage to the structure from roots or branches. Take care with the design of this area. Trees can be placed and maintained to avoid blocking desirable views.
- Shading west-facing windows and walls with medium-size trees reduces afternoon heat. These should be planted no closer than 10 ft from structures.
- Smaller trees might be espaliered (trained to grow flat on a surface) against the side of a wall that receives a lot of full sun. This blocks a great deal of sun before it can hit the wall and heat it up. Alternatively, build a trellis next to the wall, and encourage vine growth on



Shading a car preserves the finish and reduces the need for air-conditioning on startup.



A hinged trellis can be lowered for ease of maintaining the house and also avoids hiding places for “critters.”

the trellis. Hinge the trellis at the bottom so that it can be lowered for cleaning, painting, and maintaining the wall. Be sure to check for aggressiveness of roots, however, before planting this close to a wall.

- Uncovered parking areas also need to be considered. Shading reduces vehicle air conditioner use. Avoid trees with weak branches, messy fruit, or those that attract birds.
- One tree can serve several purposes. Take care not to plant too many trees, which can keep a building damp and uncomfortable, even in hot weather. If there are already trees on the site, consider the canopy and what changes or additions would be advantageous.

Wind control

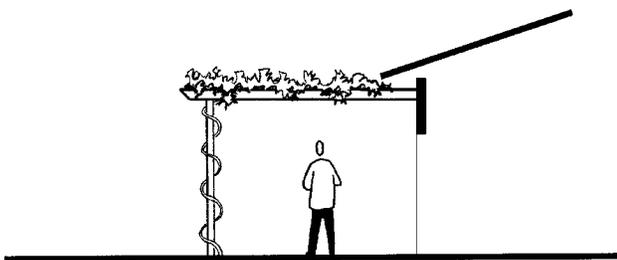
In Hawaii, prevailing winds are from the north-northeast year round. Thoughtful tree placement can use and control these winds for optimal comfort. Trees may be used to create wind channels, which guide air and wind circulation, or windbreaks, which block winds.

Natural cooling. Trade winds offer welcome cooling for the warmest months and should be maximized

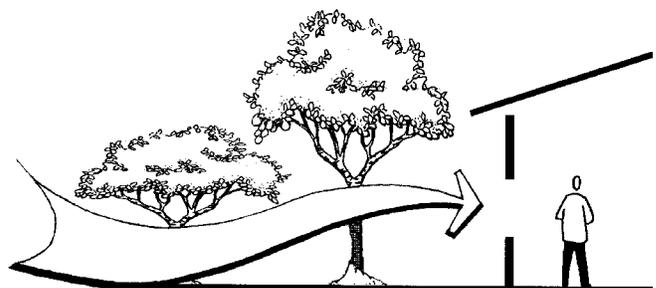
on the site. Trees on the north and northeast side of the area should be strategically located to channel these breezes toward the windows and outdoor living areas. Low-branching trees should be avoided, or trimmed up to allow air passage. The design can also include low shrubs to assist in deflecting winds into the desired areas. Plants used to screen windows should be located far enough away to allow unrestricted air movement.

With air-conditioning. If buildings do use air conditioning, trees should be used as windbreaks to restrict the infiltration of hot, humid outside air around windows, doors, and through cracks. Studies have shown that heat gain by infiltration is actually higher than gain by radiation and conduction through windows and walls. Therefore, a multilayered windbreak should be designed to divert prevailing winds. It is also helpful to create a dead air space along and close to walls that face the winds by installing plantings 4–5 ft away from foundation walls.

Too much cold wind. Because Hawaii’s wind direction is relatively constant year-round, sometimes a choice must be made. Most situations call for use of winds for cooling purposes. Occasionally, a situation exists where colder storm or winter winds or very strong winds can be a problem. In this case, it may be more prudent to plant windbreaks to effectively block these chilling winds, rather than to channel them for summer cooling. Tall evergreens and low-branching trees can be used. Plant them at a distance from the building equal to four to six times their effective height. Prune to retain low branches to best block wind. The wider the planting, the more blockage. Where space is available, stagger the trees when planting more than one row. Allow some wind penetration. Impenetrable windbreaks create a partial vacuum on the protected side, reducing their effectiveness.



Vines on an overhead trellis are an attractive way to shade a lanai.



The lower branches of the tree at left are pruned to allow air through; the taller tree shades the house.

Cooling by evaporation

Heat from hot air passing over and under leaf surfaces is partially absorbed by evaporation of surface moisture. The process cools the air surrounding leaves and lowers air temperatures by as much as 9°F. The more leaf surface in an area, the cooler the surrounding air temperatures. To maximize cooling effects, keep leaf surface and amount of vegetation in mind when designing and selecting plants.

After considering the necessary additions and subtractions that will increase energy efficiency on the site, draw circles or symbols on your design sketch to represent trees that will be added to the landscape.

Tree selection

The final step before planting is choosing the appropriate trees. There are several factors to consider when choosing and planting trees.

- Always know the eventual size (height and width), growth habits (fast or slow growing), strength, and life expectancy of a tree. Many publications give only plant heights. If no information is available regarding mature branch spread, estimate it at approximately the same as mature tree height. Do not assume a tree growing larger than the desired height can easily and inexpensively be pruned to keep it in bounds. Generally, it can't. To determine the planting distance from structures, divide the mature branch spread in half. To plant next to other trees, take one half the mature branch spread of *both* trees.
- Find out about the structure and growth habit of the roots and whether or not they are aggressive. Use trees with non-aggressive roots close to buildings, driveways, and lanais. Remember that roots can cause damage to sidewalks, driveways, drain fields, and septic tanks, as well as foundations.
- Don't forget that roots and branches can interfere with neighboring properties. Know your property boundaries when selecting and locating trees.
- Determine if there is a particular view that should be preserved or blocked, and what size tree would be required.
- A tree's shade potential depends on its canopy shape and the density of the shadow that is created. Trees are either columnar, oval, round, vase-shaped, weeping, pyramidal, or irregular. Wide oval and vase-shaped canopies provide the most shade when the sun is high

above the horizon. The shape should also be considered in relation to the space where the tree is to grow. Leaf size, leaf texture, and the tree's branching habit define the density or openness of the canopy.

- Know if the tree will drop messy fruit, flowers, branches, or leaves that create maintenance problems. Trees that drop fruit or have brittle or soft wood that can break easily should not be planted over outdoor living areas.
- If power lines are in the vicinity, remember the "15-foot rule"—within 15 ft of lines, trees should be no more than 15 ft tall at maturity.
- Some tree species are invasive, reproducing prolifically, taking over, and threatening other trees, plants, and natural areas. Avoid choosing these for landscape use.

Some suggested trees for the landscape

Following is a sampling of plants to consider for use in energy conservation. By all means, consider all of the wide variety of trees suitable for Hawaii's landscapes. *Note:* Tree sizes and growth habits vary greatly under different conditions. Mature heights and spreads given here are based on averages of trees in reasonable growing conditions. Growing conditions, climate changes, weather conditions, soil, maintenance level, and many other factors influence growth.

Trees less than 30 ft tall

Crimson bottle brush (*Callistemon citrinus*)

The bottle brush has a lacy canopy that provides moderate shade and allows the growth of understory plants. Brilliant red, brush-like flowers appear in the spring. Its mature height is approximately 20 ft, with a narrow crown spread of about 10 ft. Another bottle brush species, *C. viminalis* (weeping bottle brush), has more willowy, weeping branches. It grows to the same size. Both species are sun-loving, moderately wind-tolerant, but not salt tolerant. They grow well in all soil types and require occasional watering during dry periods. Average growth rate is medium, and the roots are non-aggressive.

Kalamona, scrambled eggs (*Cassia glauca*)

Kalamona grows to about 20 ft, with a spread of 15 ft at maturity. Bright yellow flowers bloom year round. It grows very well in sandy soils but poorly in clayey soils.

Kalamona will grow in sun or partial shade and has high drought and wind tolerance but low salt tolerance. It is fast growing, with a non-aggressive root system.

Autograph tree (*Clusia rosea*)

A round-headed tree with about a 20-ft spread and height of about 25 ft, the autograph tree has thick, round, and waxy leaves. Light pink flowers occur in the spring. It is insect resistant, grows well in salt air, and is highly drought and wind tolerant. It tolerates most soil types but is slow growing. Roots are semi-aggressive.

Silver buttonwood (*Conocarpus erectus* var. *sericeus*)

An attractive tree that grows to about 20 ft, with a spread of about 10 ft, this variety has silvery, soft leaves. It can be grown as a shrub or shaped into a tree. It is highly wind, drought, and salt tolerant and grows well in a wide range of soils. It is slow growing, and its roots are non-aggressive.

Royal poinciana (*Delonix regia* species)

This showy tree reaches heights of 20–30 ft, with a wide spread of up to 50 ft or more. It is somewhat flat-topped in shape, with bright orange-red or sometimes yellow flowers. It is fast growing, with medium wind, salt, and drought tolerance. Its roots are aggressive and shallow. It loses its leaves every winter, prior to flowering. Seed pods are large, foot-long, and plentiful. The tree produces abundant litter from flowers, branches, leaves, and seed pods, but this may be tolerable in exchange for the spectacular flowering. Not recommended for over lanais and parking areas, or confined root areas.

Madagascar olive (*Noronhia emarginata*)

This upright tree grows to about 30 ft in height and about 20 ft in width. It responds to pruning to make it round-headed. It has high wind tolerance, medium salt and drought tolerance, and grows best in sandy or moist low-land soils. Its purple fruits are edible but can be messy. Its roots are non-aggressive.

Plumeria (various *Plumeria* species and cultivars)

Most plumerias (or frangipani) grow to about 25 ft, with a 20-ft wide, round head. Flower color can be red, white, pink, yellow, or variegated. They prefer hot, dry climates and grow best in sandy or well drained soils. They are moderately wind tolerant but not salt tolerant. Most plumeria species lose their leaves during winter months. The Singapore plumeria (*Plumeria obtusa*) remains more

or less evergreen year round. Growth rate is moderate, and roots are non-aggressive. The leaves and flowers can be messy.

Milo (*Thespesia populnea*)

A native tree of the Hawaiian and Pacific islands, Milo grows to 25 ft, with a spreading crown. It is especially good in dry soils near beaches, although it adapts to many climates. Full sun is best, and salt and wind tolerance are excellent. It is fast growing with non-aggressive roots. Yellow, hibiscus-like flowers and seed pods create ground litter.

Be-still tree (*Thevetia peruviana*)

Also known as yellow oleander, this tree grows to about 20 ft, with a spread of 20 ft. The foliage is full, shiny, and dark green, with yellow, apricot, or white flowers year round. It can also be grown as a large shrub. It is fast growing and withstands drastic pruning, making it a good choice for a screen or hedge. Growth and flowering are best in full sun, but it will do well in partial shade. Rich, sandy, well drained soil is best, but it will grow in any soil type. It has good wind and drought tolerance and moderate salt tolerance. *Note:* all parts of the plant are poisonous—it is not recommended near children or pets.

Beach heliotrope (*Tournefortia argentea*)

This tree grows to 25 ft high, with a spread of up to 25 ft. Its leaves are covered with silky, whitish hairs, and its flowers are gray and silky. Beach heliotrope grows best in full sun and sandy soil. It is highly drought, wind, and salt tolerant; an excellent beach tree. The growth rate is medium, and the roots are non-aggressive.

Trees 30 ft or more tall

Rainbow shower tree (*Cassia x nealiae*)

The mature height of this hybrid is 30–40 ft, with a spread of up to 35 ft. Rainbow shower tree prefers full sun and grows moderately well in sandy to clayey soils. It is not salt tolerant but is moderately wind and drought tolerant. The rainbow shower tree has beautiful rose, pink, or yellow flower clusters from spring to fall. To choose a particular color, look for named cultivars. Some of the known cultivars are ‘Wilhelmina Tenney’, which has red, yellow, and white blossoms in each cluster; ‘Queen’s Hospital White’ or ‘Queen’s White’, which has yellow-orange blossoms, changing to almost white with matu-

urity; and ‘Lunalilo Yellow’, with rich golden-yellow blossoms, gradually becoming lighter yellow. The rainbow shower is preferred among the shower trees because of its lack of seed pods. Annual pruning aids in shaping and flower production. The root system is non-aggressive.

Kou (true kou) (*Cordia subcordata*)

This 40-ft, oval-headed tree is native to Hawaii and other Pacific islands. It is well suited to wind and salt air but also grows well inland. Kou prefers full sun and is moderately drought tolerant. It is fast growing, producing clusters of small orange flowers in the spring and summer, followed by white fruits. Insect damage can be a problem but can be controlled by spraying with biorational insecticides. Its roots are non-aggressive.

False olive (*Elaeodendron orientale*)

False olive has a mature height of 35 ft, and a 35-foot wide, rounded head. Leaves are a rich, dark green. Small, non-showy flowers are produced from summer to fall, maturing to greenish-yellow, inedible fruits that resemble true olives. False olive will grow in full sun or partial shade and in sandy to clayey soils. It is not drought or salt tolerant, and wind tolerance is medium. Its roots are non-aggressive.

Fern tree (*Filicium decipiens*)

Fern tree grows to 40 ft in height and spreads to a 25-ft, round canopy. Its leaves are dark green, deeply lobed, and fern-like in appearance. The flowers are inconspicuous, but decorative purple fruits can be messy for a 2–3 week period during summer. It grows well in any soil, likes full sun, and is not drought or salt tolerant. It will tolerate moderate winds. Its root system is non-aggressive.

Olive (*Olea europea*)

The olive tree grows to a 35-ft tree with narrow, silvery leaves and a gray, twisted, ropy trunk. It is very distinctive in the landscape. It is slow growing and prefers sandy soils with good drainage. Olive grows from sea level to 4000 ft in Hawaii. It is highly drought and wind tolerant and is moderately tolerant of salt. It seldom fruits in Hawaii. At the base of the trunk it produces prolific root shoots, which may require pruning. Its roots are non-aggressive.

Allspice (*Pimenta dioica*)

Allspice, the source of the culinary spice, grows to about

30 ft high, with an oval head spreading to 20 ft. The allspice has dense, fragrant leaves throughout the year and clusters of small, cream-colored flowers in the early summer. The muscled trunk peels attractively to give a mottled beige and brown appearance. The tree prefers regular moisture but will grow successfully in dry areas with some irrigation. It is preferred because of its non-aggressive root system. The small, purple fruits can be messy in the fall and easily sprout to seedlings. Allspice may escape cultivation and become naturalized if planted in moist, fertile areas near forests, because its fruits are attractive to birds.

Silver trumpet tree, yellow trumpet tree (*Tabebuia aurea*)

A low-maintenance, upright tree growing to 20–35 ft in height, silver trumpet has showy, yellow, trumpet-shaped flowers in the spring and summer and silvery-gray leaves. The tree grows in full sun or partial shade and prefers well drained, sandy soils. It is moderately salt and wind tolerant and will grow in dry locations once established. Its growth rate is moderate, and the roots are non-aggressive.

Pink tecoma (*Tabebuia pentaphylla*)

Pink tecoma has a mature height of 40 ft, with a spread of 25 ft. It has a somewhat irregular, upright to oval shape. The tree may require early training to produce a single leader for a well shaped canopy. Clusters of pink, purple, or white trumpet-shaped flowers bloom year-round. Flower drop is prolific, and seedlings sprout easily. It prefers full sun, and blooms best in hot, dry areas with sandy or well drained soils. It is very wind tolerant and is not salt tolerant. Its roots are non-aggressive.

Trees not recommended

Many trees have desirable characteristics, such as flowers, scent, or interesting bark, but should nevertheless *not* be planted in the landscape because they can be invasive or dangerous. Some trees are known to proliferate, take over, and threaten other trees and plants. To avoid problems with invasive species, do not plant the following trees: African tulip tree (*Spathodea campanulata*), Christmas berry (*Schinus terebinthi-folius*), fiddlewood (*Citharexylum spinosum*), guava (common, *Psidium guajava*, and strawberry, *P. cattleianum*), hau tree (*Hibiscus tiliaceus*), octopus tree (*Brassia actinophylla* or *Schefflera digitata*), mangrove (*Rhizophora*

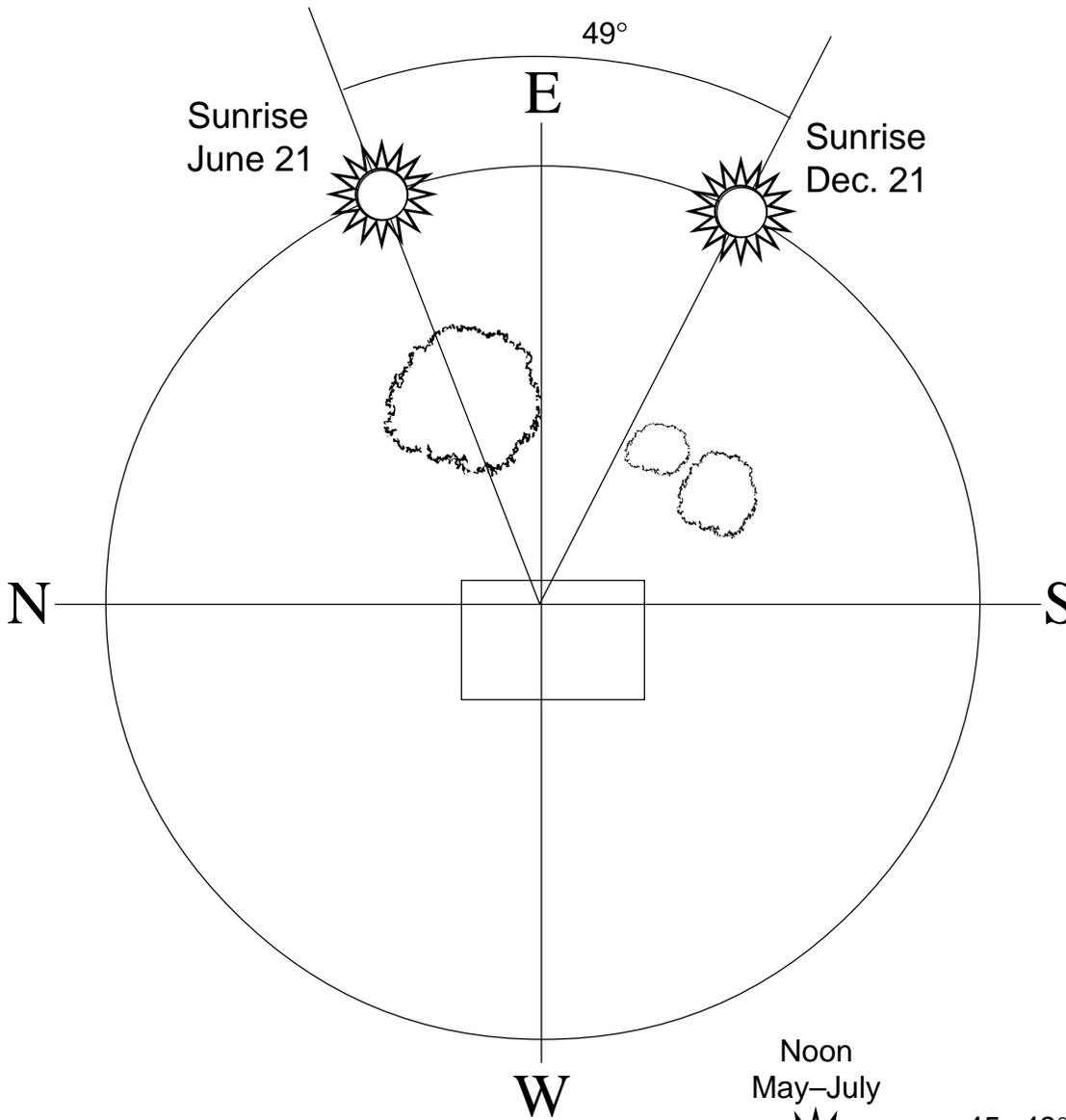
species), or silky oak (*Grevillea robusta*).

Fast growing trees are often brittle, with branches that break easily in the wind. The following trees should not be planted because they can unexpectedly drop large branches: lemon-scented gum (*Eucalyptus maculata* var. *citriodora*), Mindanao gum (*Eucalyptus deglupta*), and swamp mahogany (*Eucalyptus robusta*). Check with nurseries and other sources to find suitable substitutes for these potentially troublesome species.

Careful site study and planning, careful selection and planting of appropriate trees, and good continuing maintenance will result in a comfortable, attractive, and energy-conserving landscape for years to come.

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Illustrations on p. 1-3 by Jerome Renick; information for the illustrations on p. 8 was contributed by Victor Olgyay, UH School of Architecture.



Seasonal differences in the sun's orientation at sunrise and sunset (above) and its midday altitude (right) in Hawaii should be considered when planning locations for trees in the landscape. Values shown are for 21° north latitude.

