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Live Oak:

Historic Ecological Structures

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Live oak (Quercus virginiana) is an ecological and cultural icon of the Southern United States. The species live oak has a diverse set of individual traits across many types of sites, and contains a number of varieties and hybrids. Live oak can be a massive spreading tree along the lower Coastal Plain. Live oak can also be a small, wind-swept tree growing on sand ridges near the ocean. Live oak is much more varied than its steriotype.

Live oaks are ecological structures with great canopy and root spread outward from a large diameter, squat stem. The trees are sources of food, protection, and support to a host of other plants and animals. They are life centers and life generators whereever they grow. Live oaks also represent a marker for the history of this nation, and the nations which have come before. Live oaks have served humans and animals as food, fuel, lumber, chemicals, and shade. Today live oak represents both an biological and social heritage.

Spiritial

For humans, live oaks generate awe, reverence, utility, and a sense of place. There are many live oak treaty trees or assemby trees across the South. Live oak is symbolic of history, survival, struggle, and romance. For example, live oaks were the focus of this nation's first publicly owned timber reserves for building naval vessels. The largest trees were valuable to sailing ship builders because of their branch shapes and wood strength. As such, live oaks were also one of the first trees to suffer forest-wide timber thief and old growth decimation in North America.

The mystic feelings and grandeur of the Spanish moss draped, monstrous live oaks are an emblem of both the old and new South. Live oak lined drives, streets, and squares make them the pillars of their communities. Live oaks are important enough to people to have their own society. The "Live Oak Society" was founded in 1934, and is active today, to promote the conservation and appreciation of large live oaks. Because of its many positive and life-affirming attributes, live oak was selected to represent the State of Georgia as its state tree.

Family

Oaks are in the beech (Fagaceae) family. The oaks (Quercus spp.) are the largest genera of trees in the United States. The nation's oak species are composed of approximately 58 trees and 12 shrubs. From these species there are more than 70 recognized hybrids (both natural and human designed). One of these unique species of oak is live oak.

Names

The scientific name for live oak is Quercus virginiana, officially named in 1768. The Latin and Celtic derived meaning of the scientific name is a "fine tree of Virginia." There still remains some confusion regarding live oak taxonomy dealing with varieties, hybrids, and regional differences. Other scientific names which have been used in the past for live oak at one time or another are Quercus andromeda, Q. eximea, Q. fusiformis, Q. geminata, Q. maritima, Q. oleoides var. quaterna, Q. sempervirens, and Q. virens.

Quercus virginiana is the currently accepted scientific name for the typic, standard live oak found growing along the Atlantic and Gulf coasts and inland, across the Southeastern and Southcentral United States. Across its native range live oak has many common names most derived from its evergreen habit, its geographical location, or its preference for growing site. Some common names for Quercus virginiana are: live oak, Virginia live oak, Virginia oak, Southern live oak, bay live oak, Spanish live oak, encino, sand live oak, and scrub live oak. Some of these common names are also used for other species of oaks.

Range

Live oak is found growing and reproducing on the lower coastal plain of the Southeastern and Southcentral United States. Its range begins on the extreme eastern coast of Virginia, south in a narrow band along the ocean to the middle of the South Carolina coast where its range begins to expand farther inland. The range of live oak continues to expand inland as it moves south, growing across the southern 1/4 of Georgia and covering all of Florida south to the first few Florida Keys. Live oak grows along the Florida panhandle and around Mobile Bay, on across the Southern-most two tiers of counties in Mississippi. Live oak grows across the Southern third of Louisiana, except for some barrier islands and scattered parts of the most Southern Parishes. Live oak's range continues into Texas and narrows to hug the coast until just past Port Lavaca, Texas. Figure 1 provides a range map for live oak.

Soils & Sites

Live oak is found in both single and mixed species forests, dotting savannas and as occasional clumps in grasslands along the lower coastal plain and lower Mississippi valley. Live oak grows in soils ranging from heavy textures (clay loams), to sands with layers of organic materials or fine particles. Live oak can be found dominating some maritime forests, especially where fire periodicity and duration are limited. Live oak is found on higher topographic sites as well as hammocks in marshes and swamps. Live oak hugs the coastline and is rarely found above 300 feet above sea level.

Live oaks grow across a wide range of sites with many moisture regimes – ranging from dry to moist. Live oak will survive well on both dry sites and in wet areas, effectively handling short duration flooding if water is moving and drainage is good. Good soil drainage is a key resource component for sustained live oak growth. Required precipitation range is 40-65 inches of water per year, preferably in Spring and Summer. Soil is usually acidic, ranging between pH of 5.5 and 6.5.

Hot Water

Live oak is considered a facultative upland species usually found in non-wetland soils and upland sites, even if surrounded by wetland areas, seeps, springs, bayheads, and swamps. Live oak requires 1-3 feet of well-aerated soil above the local water saturation levels. For best growth, a well-drained sandy loam or heavier

soil, which maintains a good moisture content but is not wet, is ideal. Live oaks need large amounts of soil volume to occupy, colonize, and hold, in order to grow large and old.

One important constraint on live oak growth is heat and soil moisture. Live oak handles heat well when combined with plenty of precipitation in the growing season. Live oak grows in national heat zones 7 through 11. Live oak tolerates limited summer droughts. The vascular architecture of live oak is designed for hot days and nights with plenty of precipitation. The farther North and West live oak ranges, the greater are evaporative forces drying growing season soils, and the greater are heat loads on living tissues, both of which limit survival.

Northern Limits

The Northern boundary for the native range of live oak is controlled both by cold temperatures, and by summer dryness and evaporative index. Live oak does well in cold hardiness zones 8b through 11. Live oak's Northern growth limit for temperature is roughly the 42^{o}F minimum sustained winter air temperature zone. Sites which provide non-freezing temperatures maximize the chances for live oak survival. There are some single specimens and multiple stem stands of northern outliers of planted live oaks which can be found in protected areas.

Growth Tolerance

Live oak is intermediate among forest trees in tolerance of competition and resource scarcity, such as shade. Live oak is relatively fast growing and long lived. Shoots continue to elongate throughout the growing season. Young live oaks are susceptible to fire damage. Short intervals between fires can eliminate live oak regeneration on a site. Because of sprouts from stumps and tops of large roots, and its intermediate tolerance of resource scarcity, live oak can successionally hold onto a site for decades. As a result of this vegetative reproduction, live oaks tend to grow in a clump (copse) or family group.

Live oak is tolerant of salt spray on foliage compared with other plants. Moderately high concentrations of salt in soils is tolerated if drainage remains good and the soil is not saturated. Live oak does not handle salt water flooding or brackish soil water well. Live oak is intermediate to intolerant (i.e. becoming more intolerant with age) of construction damage and soil compaction. Live oak is cited as tolerant to sulfur dioxide air pollution, and phenoxy and dicamba pesticides.

Size

Live oak is a medium height tree which develops a massive diameter but short stem over time. Primary branches can grow to be large in diameter and long. A number of branches are generated low on the trunk, growing large in diameter and, if space is available and pruning treatments not applied, can many times remain wide spreading and almost horizontal. Branch spread in large mature trees can easily be greater than tree height. Branches can recline on the soil surface and some form roots where they touch the soil.

The theoretical maximum size reached by a live oak could be 80 feet tall, 13 feet in diameter, and 170 feet crown diameter or 85 feet branch spread radius. An expected normal mature size is around 40-65 feet tall, 4-6 feet in diameter, and 80-110 feet crown diameter. Figure 2 shows mature tree sizes in one geographic location. Example tree height and stem diameters are given in Figure 3 for a highly stressed site.

Shape

At a distance, natural crown shape appears as a short, shallow, and widespread dome of dense appearing foliage. Mature live oaks tend to have a crown spread to tree height ratio of 1.2 to 2.0. An example of live oak crown area per tree diameter in one geographic location is given in Figure 4. For trees on highly stressed sites, Figure 5 provides crown and stem diameters. Part of the dense foliage appearance is the concentration of leaves around the outside edge of crowns. This leaf concentration is due to both leaf physiology not functioning well under shaded conditions well (i.e. few shade leaves), and the growth of many small twigs holding many

leaves clustered near the ends. Actually, live oak crowns have been found to not be any more dense in total than most other broadleaf trees. There is only a limited amount of sunlight impacting an area at any one time, and trees optimize leaf developement for light capture. Greater leaf density would lead to serious problems in photosynthetic efficiency. Interfering plant leaves, like Spanish moss, mistletoe, or vines, can build up and shade out live oak leaves.

In poorly drained or very thin soil, the basal trunk flair of live oak may be buttressed as large root tops around the stem base grow upward forming I-beam, T-beam, and plank shaped supporting structures. The root plate area (zone of rapid taper) around the trunk base is relatively large in diameter compared with other trees, containing a number of large diameter roots growing horizontally just below the soil surface. A relatively large root plate area is generated in aging live oaks because of the biomechanical necessities of supporting a wide-spreading crown and limited ecologically viable soil depth.

Ageless

On a good site, a live oak should reach mature proportional size in under 75 years. In a limited number of samples, live oaks on good open sites grew as much as 0.75 inches per year in diameter and sustained this level of growth over many decades. The largest trees of the native range, especially along the Atlantic coast, are seldom over 250 years old with a maximum expected lifespan of 500 years. Many old large trees have myths developed around them regarding their age and historic value. Many large live oaks are not as old as people believe. In addition, some large diameter live oaks may actually be composed of a number of sprouts from an old stump which have grown together. Due to the hardness of the wood and the decay columns in old live oaks, it is many times difficult to accurately determine actual tree age.

Identification

Identifying live oak is more than recognizing the nearly evergreen leaves and Spanish moss drapes. Live oak, especially when the tree is small or juvenile, can be mistaken for several other trees. Key live oak attributes and characters are described below and can help with both the identification and appreciation of this majestic tree.

Leaves -- Live oak leaves grow alternately along twigs. Leaves are simple, unlobed, thick, stiff, and leathery. Leaves are elliptical to elongated-elliptical in shape with a more-or-less wedge-shaped base. Live oak is considered evergreen because leaves remain green and persist on a tree until after new leaves expand the following Spring. Leaves are 1.5 to 4.5 inches long and ½ to 2 inches wide. The leaf edge is smooth to slightly wavy, with rarely a few scattered teeth especially on juvenile shoots. The leaf edge is slightly curled under, not tightly rolled. The leaf tip is rounded without a bristle tip. Leaf shape and size are highly variable, especially in special habitats and physiographic locations. Leaf shape varies so widely, live oak has been misidentified or formed into small regional varieties in the past.

Live oak leaves are shiny dark green in color on top and gray-green below. The underside is covered with many tricombes (plant hairs). Live oak tricombes are star-shaped (stellate). The main vein on the underside is yellowish in color. Side leaf veins can be visualized by the slight depressions they form on the leaf's upper surface. The side veins unite just before the outer leaf edge. The leaf petiole is stiff and short (~1/4 inch long).

There are at least seven evergreen or persistent leaved oaks with overlapping ranges with live oak. These oaks are: Chapman oak (Q. chapmanii), Darlington oak (Q. hemisphaerica), bluejack oak (Q. incana), laurel oak (Q. x laurifolia), Texas live oak (Q. fusiformis), dwarf live oak (Q. minima), sand live oak (Q. geminata), and various varieties and hybrids of live oak (Q. virginiana). Live, sand live, dwarf live, Texas live, and bluejack all have stellate tricombes on leaf undersides and have a leaf edge which is thickened and rolls beneath. Live oak, dwarf live, Texas live, and sand live oak have a rounded leaf tip without a bristle tip. Because of the closely related nature of the live oak species, varieties, and hybrids, identification can be difficult.

Flowers -- Live oak flowers are wind pollinated. Live oak is monoecious (both sexes on the same tree), but each flower is either male or female. Flowers are functional in Spring from February to March for about two weeks. The male flowers are a light yellow-colored dangling catkin 2-3 inches long. Male flowers develop in last year's leaf axils. Several female flowers are found on one-inch long, pale green spikes growing from the current year's leaf axils. Female flowers have a bright red stigma.

Different forms of live oak maintain their genetic uniqueness by flowering at slightly different times. For example, typical live oak flowers several weeks before sand live oak in the same area. Live oak becomes sexually mature relatively quickly. Stump and root sprouts are sexually mature and flower the next year after expansion. Seedlings become sexually mature and flower about five years after germination. Full flower production does not occur for 7-12 years. Trees older than 100 years old usually do not generate as many female flowers as middle-aged trees with full crowns, although some flowering does continue to the end of life.

Acorns -- Live oaks generate an oblong, barrel-shaped acorn 3/4 to 1 inch long with a short point at the end. Acorns are held at the end of a long stem (1-4 inch long peduncle). Acorns grow in clusters of up to five per clump with 2-3 per clump typical. The acorn cap is bowl-like, top-shaped, and covers 1/3 to ½ of the acorn. The acorn cap has thin reddish-brown, hairy scales.

As in the rest of the white oak group, live oak acorns mature and are ready to germinate at the end of the current growing season. Acorns mature by October to a dark blackish-brown color and fall by January 1. Acorns contain an embryo surrounded by two fleshy cotyledons enclosed by a hard outer shell. Figure 6 shows a simplified diagram of a live oak acorn. The inner surface of the acorn shell is smooth. Live oak acorns are not viable for long, and quickly die and decay.

The acorn is small but sweet tasting with a slightly bitter after-taste. The acorns are used by a host of wildlife species. Many animals eat, distribute, or cache live oak acorns (mammals, opossums, and birds). The small size of acorns allow for major caching of seeds by relatively small animals. Early native American cultures within the live oak range used live oak acorns for food (rinsing the bitter tannins out with water), and for a cooking oil (boil crushed acorns -- skimming oil off of the top of the water). Live oak acorns contain approximately 5% protein and 6% fat.

Acorn production is usually good every year with little periodicity (no masting cycle). There are approximately 20-25 acorns per ounce. Acorns will germinate immediately on moist, warm, mineral soil. Acorns not germinated by mid-Spring can be considered dead due to pests (especially from Curculio spp. weevils). To minimize acorn production, an ethephon containing growth regulation chemical can be applied at a 30 ounces per 10 gallons of water rate (following current label guidlines). At this rate little foliage damage is visible. Live oaks should be treated to prevent seed set in early Spring when female flowers are at full bloom.

Bark & Twigs -- Live oak periderm has a range of colors modified by exposure and surface growths. Periderm can be dark-brown, greyish-brown, or dark reddish-brown, but is generally described as a medium brown. The periderm has shallow furrows with flat scaly ridges between. Periderm is rough, divided into rough squares, and intermediate among regional tree species in thickness when mature, but thin while juvenile. Periderm on branches reclining onto soil or close to ground can be discolored by abrasion or by soil splash staining from rain. Live oak bark sustained limited use in the past for generating tannins for leather.

Twigs are stiff, but slender and hairy. The pith is solid and continuous. Winter buds are blunt on the ends and about 1/16 inch long. Buds have chestnut brown scales with tiny white hairs at the margins. Leaf scars are half round with the main bundle scar clearly present. Twigs have minute stipule scars. Sprouts from stumps and the tops of large roots, and young twigs, provide forage for a number of animals.

Roots -- Live oak root systems are wide-spreading and shallow, requiring good drainage and plenty of oxygen. When calculating root system extent and size for young trees, unlike in other tree species, there is no

strong relationship between root spread and crown spread. The root plate (zone of rapid taper or structural root area) can be calculated by using the diameter measure of the stem at 4.5 feet above the soil measured in inches multiplied by 0.9 to yield the diameter of the root plate in feet (centered on the trunk). For example, a 20 inch diameter live oak tree would have a root plate diameter in an unconstrained area of 18 feet (9 feet radius out from the trunk). It is essential in live oak to conserve its root plate area and prevent paving, trenching, compaction and other forms of root or soil damage from occurring.

Live oaks generate roots running just below the soil surface coming from the stem base or from large branches permanently in steady contact with the soil surface. These roots can generate new sprouts seen growing around live oaks and are a good source for reproduction cuttings. Live oak root systems are large and well interconnected both within and between trees. Many times separate stems will share an interconnected root system because they arose from the same stump, and so will have the same genetic content (copse or clonal system). Live oak roots can be naturally or artificially infected with ectomycorrhizae fungi, a beneficial symbiant. Ectomycorrhizae fungi infection increases fine root mass in mature live oaks on stressed sites.

Wood -- Live oak wood is extremely dense and hard, making it strong and durable in use. Live oak heartwood averages 54 pounds of dry weight per cubic foot and almost 90 pounds of wet / green weight per cubic foot. Unlike the other oaks in the region, live oak xylem is diffuse porous making and the annual increments difficult to count. False ring (annual increment) production can occur. Sapwood is whitish in color and heartwood is greyish-brown. There are a few broad rays and many narrow rays present. The wood has no noticeable odor or taste.

Wood density values provide for a hot burning and high energy content fuelwood or charcoal. In the past, strength and durability of live oak wood prevented most hand powered sawing, and so planks were seldom generated. Historically hubs of wheels and machine cogs were hewed and carved from live oak. The most celebrated use of live oak wood was using the natural shape of branches and stems in building ribs and knees of wooden ship frames. The frame work would be of live oak, the exterior shell of longleaf pine, the masts of longleaf or white pine, and the interior trim of the captain's quarters of redbay (i.e. a live oak forest neighbor).

Early lumber producers found the wood difficult to work, and hard on labor and equipment. The wood is heavy and can be deceptive in how much different sized parts weight. The weight of standing live oak tree parts has two components, weight of the wood material and weight of the moisture in the wood. The moisture content of living live oak xylem and associated tissues can vary greatly. In live oak an estimate of greenwood moisture content in a living tree is 70-80% on an oven-dry basis.

Table 1 estimates how many cubic feet of woody material is in a given branch, stem or root segment based upon its average diameter (outside the bark) and length of the segment considered. Bark weight, cavities, soil, included foreign materials, and atypical growths are not included in the volume estimates and the subsequent weight calculation. Segment weight can be estimated from multiplying the volume in cubic feet determined in Table 1 by the average greenwood density of live oak in pounds per cubic feet (~90 lbs/ft^3). The formula is: [90 (lbs/ft^3) X volume of live oak segment (ft^3)] = Estimated Weight of Live Oak Segment (lbs.). For example, a branch with an average diameter of 10 inches weights 54 pounds for each foot of length, or 324 pounds for a 6 feet long segment.

Sorting Out Live Oaks

Live oak identification is more difficult in different parts of its native range where varieties and closely related species exist. Live oak is placed within the white oak group due to its flowering and fruiting characteristics. Unlike most other oaks its shoot growth pattern is indeterminate and manifold, and so its wood is diffuse porous. Across its range, different scientists have visualized the live oak species differently depending upon specific trees and sites observed.

Unique tree localities and physiographic regions, coupled with the variability of leaf forms have all led to different sortings and subdividing of live oak varieties. Add to this natural variability, the plasticity of leaf appearance from site to site with hybridization, compounded with confusion over similar looking associated species in the same area, and live oak identification becomes complex with tremendous range of identification difficulties. To recognize the genetic concept of live oak requires more carefully clarifying of species, cultivars, hybrids, and varieties.

Historic Varieties

Live oak has been seen as having a number of varieties depending upon how detailed an observer wants to be and how much of the live oak range is reviewed. There is a functional value in reviewing a list of historic Sargent live oak varieties, which are based primarily on site and leaf size, to demonstrate the variability of live oak as seen by one trained observer at the turn of the last century. Note – even though the leaves may change sizes, the acorn and flower sizes are almost always conserved across all live oak varieties. Table 2 lists the historical Sargent live oak varieties by name and where they are found. Figure 7 provides a loaction map for these historic live oak varieties.

Current Species

The Cuban live oak, once considered a live oak variety (Quercus virginiana var. sagreana) is now considered a variety of a separate species (Quercus oleoides var. sagreana). Cuban live oak is thought by some to be an ancient hybrid of Q. virginiana var. geminata and Q. oleoides.

Quercus minima is now the scientific name for dwarf live oak In the recent past, dwarf live oak was called (Quercus virginiana var. minima, or Quercus virginiana var. dentata). Dwarf live oak is now considered a separate species and not a variety of live oak. Dwarf live oak is a small leaved shrub on beach sands of the lower coastal plain from Southeastern North Carolina to Eastern Texas including coastal Florida. Unfortunately for clear thinking regarding this species, dwarf live oak does hybridize with live oak.

Texas live oak (Q. fusiformis) was considered a scrubby, upland variety of live oak once called Q. virginiana var. fusiformis or Quercus oleoides var. quaterna, but is now seen as a unique species. Texas live oak is a shrubby, small tree with small leaves and elongated fruit growing on dry, upland, and inland sites in central Texas with spots in Southwestern Oklahoma & Northeastern Mexico. Texas live oak and live oak generate hybrids in Texas where their ranges overlap.

Until recently a shrubby variety of live oak was called maritime live oak (Quercus virginiana var. maritima). This small statured variety was found on sand dunes back away from the water's edge along beaches. This maritime live oak variety was misidentified early in the last century but has now been reclassified as a variety of Quercus x laurifolia. This variety is partially equivalent to Quercus hemisphaerica (Darlington Oak). This tree has red oak group traits including bristle tipped leaves which fall just before new leaves in early Spring. The acorns have thin saucer shaped caps, not the top- or bowl-shaped caps of live oak. There is now no maritime live oak classification accepted.

Modern Varieties

The most commonly accepted varieties of live oak today are: 1 = Quercus virginiana var. virginiana – the typical live oak across its range; and, 2 = Quercus virginiana var. geminata -- the sand live oak of the lower coastal plain growing upon sand dunes and sand ridges from Southeast North Carolina around the Coastal Plain to Southeast Louisiana.

For many dendrologists, sand live oak can be considered a separate species (Quercus geminata). Sand live oak is a small to medium sized tree with paired acorns on the end of each seed stalk. Sand live oak leaves have edges more tightly curled under than typical live oak. The top leaf surface shows indentations above where leaf veins occur. The tricombes (hairs) on the leaf underside are both star-shaped and upright. Sand live

oak flowers roughly 2 to 3 weeks after live oak (Quercus virginiana var. virginiana). Sand live oaks are typically 30-40 feet tall and two feet in diameter, growing in a clump (called a "copse"). Generally, mature sand live oak has about 1/2 the stem diameter and only 2/3 the crown diameter of mature live oak. The largest sand live oaks reach 65 feet tall, 5 feet in stem diameter, and 100 feet in crown spread.

Hybrids & Cultivars

Live oak forms a number of hybrids with other oaks. Cataloged hybrids include crosses with: Q. bicolor (= x nessina); Q. durandii; Q. fusiformis; Q. lyrata (= x comptoniae -- a fast growing tree with good cold tolerance for hardiness zones 7-9); Q. macrocarpa; Q. minima (= x succulenta -- a Quercus geminata cross); and, Q. stellata (= x harbisonii).

In addition to hybrids, there are a number of live oak cultivars: Boardwalk 'FBQV22' with a pyramidal shaped crown, a strong central leader, and perpendicular branch angles; Cathedral 'SDLN' (PP#12,015) with a dense canopy, a strong central leader, and evenly spaced branches; Grandview Gold (gold colored foliage); Highrise 'QVTIA' (PP#11,219) with a strongly upright / columnar crown and dominant leader; Millennium 'CLTF2' (PP# 11,097) with large dark green leaves, and strong stem and branch taper; Parkside 'FBQV1' with a dense canopy broadly pyramidal in shape and with perpendicularly attached branches; and, Shadowlawn. Not all cultivars listed in the literature can be found currently in the commercial nursery trade.

Collect & Sow

Growing live oaks from seed must be completed with care. Live oak acorns can be collected after October from trees. Acorns on the ground have a much lower germination percentage due to pests (like weevils) and from drying. See Figure 8. Remove any acorn caps remaining attached and float test acorns in a bucket of water – discarding floating acorns, caps and debris. Also, remove any acorns with small holes, shell cracks, or fungal growth. Do not use hot water baths or microwave heating to kill weevils within acorns as germination is severely impacted. Figure 9.

The larger the acorns, the greater success in germination and early growth. Immediately sow acorns in good, well-drained but moist, mineral soil. Acorn storage is not recommended as fungal pests and drying quickly destroy germination potential. Short storage periods under cool, moist (high relative humidity not wet) conditions can be used for several weeks. Do not allow acorn moisture contents to drop below 35%.

Live oak acorns have no cold requirement before germination and should be quickly planted in Fall. Sow acorns eight inches apart and cover with 1/3 inch of mineral soil and 1 inch of a low density, organic mulch on top. Protect the germination area from animal thieves and beware of fungal rots initiated by over-watering. Germination should begin within days and be completed in four weeks. The new radicle (root) will quickly expand into the soil and grow fat on the nutritive materials extracted from acorn cotyledons. The embryo is now extremely prone to both under-watering and over-watering damage. Partial shade on a site can be beneficial because it allows for germination but helps prevent the emerging radicals from drying out. Transplant strong growing seedling live oaks with large lateral root systems (possess a number of large diameter roots) to field growing areas. Grow live oaks 2-8 years to meet management objectives.

Planting

Successful planting of live oak is similar to other trees. Some of the most important differences are reviewed here. The site should be open with full sun. Live oak produces few shade leaves even when young and needs full sunlight to grow. Little interference from other plants, especially turf, vines, and shrubs is essential. Either use chemical and physical weeding, or a light mulch, to maintain a plant free zone around the live oak base. Be cautious in using herbicides to not damage tree roots or stem base. The site must be moist with adequate water supplies but must also be well drained. Poor soil drainage kills many young and newly planted live oaks.

If not self grown, any live oak selected should come from a reputable nursery which used local genetic stock. Young trees of live oak need to be root pruned a number of times as they grow, and hardened off before planting. Hardening means holding the root pruned dug trees in the ground for several months. Late Summer, Fall or early Winter digging is successful as long as the tree has been root pruned multiple times. Non-root pruned trees have poor survival compared with root pruned trees. Do not use fall transplanting with live oaks. Spring transplanting assures good root colonization.

Usually field grown and ball-and-burlapped (B&B) live oaks which have been root pruned multiple times and hardened off survive better, and significantly out-perform, container grown trees. If containerized trees are used, the outer inch of the container soil should be shaved away with a sharp shovel at planting time. Smaller container trees tend to out-perform larger container trees due to root constraint problems being magnified as tree are transfered to progressively larger containers. These root constraints can last a long time after planting. There is no size difference advantage across trees which are root pruned and hardened field grown.

Go Shallow & Wide

Excavate a large planting suacer (wide not deep). Make vertical slices all the way around the saucer into the surrounding soil to provide root growth channels. Cultivate the site ahead of time, if no tree roots are present from other trees. It is critical trees are not planted any deeper than the middle of the lateral root tops, except in course textured sand where slightly deeper (1-2 inches below grade) planting depth is not detrimental. Figure 10. Usually the primary lateral roots should be clearly visible 1-2 inches above the soil surface at the tree base. No intermixed, layered, or surface applied soil amendments should be used in live oak planting saucers. Minimize fertilization, if any is used at all, for the first year.

Irrigation should be started immediately with the amount determined by site drainage. Apply water over the root ball with extra over the surrounding saucer area and native soil. Water should always be allowed to pass down through the planting site, not accumulate around the roots. Irrigate live oaks a minimum of two times a week for the first growing season, and once a week for the second growing season and during extended drought periods. Control competing weeds for at least the first three years. Maintain a clear soil surface area closely around the base of a newly planted tree.

Established ?

Live oaks can be considered established on their site based upon root to crown spread ratio. Figure 11. As the root spread to crown spread reaches 3-4, measured around the tree at multiple points, the live oak is considered to have been successfully established and is well connected to the ecological system which will sustain the tree into the future. The more horizontal open soil surface area provided, the greater chance for success. Providing more soil depth is not usually valuable for live oak because of limitations in drainage and aeration.

Planting Summary

Proper planting when root growth can be quickly started is essential. Spring planting is effective. Field grown, root pruned, and hardened young trees make great candidates for planting. Plenty of water, paired with plenty of soil drainage, in a large, shallow, and wide-spread planting area is ideal. Do not amend the planting saucer backfill soil. Do not fertilize in the first growing season. Use a thin layer of a lightweight, non-compressible organic mulch over the planting site except for the six inches immediately around the stem base. Key components to good management of live oak throughout its life will be water, space, training, great soil, and wound prevention.

Training

Training is difficult in live oak because it requires some intensive pruning early to prevent young live oaks from becoming more bush-like. But do not abusively prune young trees. Patience is required! Crowns in small

trees should be raised only slowly. Figure 12 suggests the slow pace of any required crown raising. Keep as many green branches on a tree as possible. Subordinate (node-centered branch reduction) any branch approaching 1/3 the diameter of the main stem at the point where it is connected (i.e. stem-branch confluence).

If subordination or reduction pruning is needed, it must be severe in order to keep remaining branches growing well. At least 50% of a side branch need to be reduced to effectively shift growth to the rest of the branch and tree. Try to conserve a single dominant stem pathway from stem base to the highest point in the crown. In oak wilt areas only, use a commercial pruning paint on wounds, and do not prune in Spring and early Summer. As a tree matures to fit its available soil and air volume, small amounts of directional pruning can be used to maintain shape and site objectives.

Aging live oaks will tend to develop spreading low branches. Be sure to allow enough space for this natural process or keep the tree well trained throughout its life. Always prune branches growing in undesirable directions before they reach 1/3 the diameter of the stem (where branch is attached) in order to minimize decay and discoloration, and maximize effective growth over the pruning wound. There are upright cultivars for use in relatively narrow spaces.

Knowing Limitations

Environmental factors such as freezing temperatures, hot summer droughts, and fires can severely damage or kill live oak. Young live oaks are especially susceptible to fire damage. Live oaks do best in groups or clumps where each tree shades the base and soil of other surrounding trees. Sustaining soil health under live oak includes: good soil organic matter delivered as compost in a thin layer over the soil surface several times a year; good soil drainage and minimizing compaction (fence or place other plant materials to prevent vehicular parking and pedestrians); adequate water supplemented any time of year during drought periods; and, carefully planned light fertilization and liming based upon the tree's life stage, and soil and tissue testing.

Old growth trees need plenty of space to mine for resources with plenty of water throughout the Spring and Summer. Soil drainage is one of the most important features of sustaining good live oak growth. Soil compaction, pavements, building activities and grade changes can all negatively impact soil drainage and initiate many, quickly compounding problems in old trees. Preventing both soil and tissue damage is key to sustaining old tree survival and growth.

Traditional Competition

Beware of over-planting the wide understory beneath old trees. Traditional landscapes were successful because many competing root systems were not stacked on top of each other beneath live oak crowns. Go light with the stocking density of plant materials beneath live oaks, especially old trees. Live oaks should not be covered with vines. If vines are used at all, they should be maintained below six feet up the tree's trunk. Do not allow vines to climb the trunk, especially to the first branch union. Do not allow a dense ground cover to live under a tree if the ground cover receives full sun during large portions of the day. Well tended but thin organic mulch and compost layers beneath live oak accentuates tree beauty and size, as well as providing an ecologically healthy soil.

Live oak is particularly light demanding because it generates few, if any, shade leaves. This puts live oak at a competitive disadvantage when surrounded by more shade tolerant species of trees which can steal light resource space and grow taller than the live oak. The interference of other trees with live oak crown areas can be severe and cause live oak loss. Figure 13 shows live oak growth plummates with increasing crown interference. Live oak should be placed in an open-grown landscape position. Ground, side, and overtopping trees and plants must be disturbed, disrupted and cleared often. Low intensity burning, grazing, chemical control, and weeding are important treatments in live oak culture.

Conserving Crowns

Middle-aged and older live oaks redirect height growth energy and utilize wide spreading crowns to gather resources and control the site. Once this crown width to tree height geometry is set, live oak rarely regains height growth capabilities even if forced from side competition. Traditional open grown live oaks approach a crown width to tree height ratio of around 1.2 - 2.0, symbolizing a wide-spreading large tree rather than a compact tall tree. If side and overtopping interference from other trees is allowed to impact live oaks, they will begin showing significant crown decline and dieback over 10-20 years leading to a decline spiral. Figure 14 shows how crown interference can compromise live oak health. A decline spiral initiated by more than 50% crown interference usually is unrecoverable, even if immediately remediated.

Old live oak trees should not be propped, have hardware installed such as lights, or have trunk periderm painted – as immediate and long-term tree injuries can result. The old tradition of white-wash liming of trunks may disrupt some of the soil-overwintering pests, but should be avoided as a tree damaging treatment. Good arboricultural practices required to make trees biologically efficient and structurally sound should be applied by skilled arborists. Cable and bracing, and lightning protection hardware installation are common and valuable therapeutic treatments. Seeking pest and stress management expertise is a great investment.

Storm Survival

Live oaks grow in hurricane prone areas. Live oak is cited as being resistant to hurricane wind forces and surviving with only minor to moderate damage. In one major hurricane event, 30% of live oaks were undamaged, 50% had bent and broken limbs, 16% were heavily defoliated, 5% had broken tops, 2% had broken stems, and 3% were uprooted or knocked down. In another storm event, live oaks were found to uproot rather than break. Arborists were able to successfully lift some of these uprooted trees back into place (in cases where prompt actions and carefully designed cable support systems could be applied -- associated with relatively minor root damage.) A good pruning program helped live oaks be more resistant to winds, especially through reduction pruning. In summary, live oaks tend to loose leaves and small branches, escaping major damage in most storms. In other words, within the live oak forest, short and fat survives over tall and thin.

Historic Tragedy

Live oaks have dense, hard, and strong wood which is resistant to weather, water, and mechanical strain. The massive, low, curved branches and sweeping stems were useless for straight-grained, dried lumber as made from other trees. But the natural growth pattern of live oak made the perfect structural components for wooden sailing ships. Live oak forests first seen by Europeans were storm pruned, extensive, and contained many massive individual trees. Commerce and war of the 1700's generated demand for this premium wood for ship hull ribs, knees, and support parts. The old growth live oak forests were decimated by European nations, colonists, and early acts of our new nation.

"Live-oaking" was a way of life for Northern ship builders. Live oaks accessible to water transport were targets. Large trees were first cut to see if they were sound, and then divided into the largest and most effective parts for use in ship design. Many trees damaged by centuries of storms, were cut only to reveal they were internally decayed and would not meet the stringent specifications of New England, Atlantic Canadians, or English shipwrights. These cut trees were left to rot. No new trees were planted nor sprouts conserved. Sustainable forest management was nonexistent.

Hired gangs of loggers and carpenters from all over were dispatched to hunt and convert live oaks into wooden ship components. The new United States of America federal government attached preserves, laws and bounties to live oak trees. Tree poaching, timber theft on public and private lands, federal agent corruption, and timber pirates were so common (and results so lucrative), only the demise of easily accessible live oaks and iron boat hulls halted live oak tree slaying and forest destruction. Major parts of the Atlantic coast old-growth live oak forests were gone by 1870. The Gulf coast live oaks were conserved more effectively for a longer period of time.

Thinking Big

We today cannot imagine the tree sizes, numbers, and distribution of live oak forests of the 1700's. What is lost cannot be recreated except through our appreciation of history and a celebration of some of the remaining tree giants (i.e. survivors). See Appendix 1. Live oaks are today visible pillars, ceilings, and walls of old Southern coastal landscapes and line older streets, squares, and parks, while large wooden sailing ships of commerce and war are but a romantic memory.

Live Oak Pests

Live oak has relatively few serious pests other than humans. Most pests found in live oak are secondary to other key stresses generated by climatic and soil changes. Abiotic problems, especially cold, construction damage, poor soil drainage, and summer droughts make live oak more susceptible to a number of pests.

Table 3 provides pest names, descriptions, and impact ranking in landscapes, along streets and in parklands. Table 4 provides a reorganized list of the same pest names by impact rankings. Note local pest problems can occur in any area, but not represent widespread impacts across live oak's range. Pests with local consequences would receive a lower impact ranking in these tables than pests with potential range-wide impacts. These tables list the most probable non-vertebrate pests across the native range of live oak. This list is not comprehensive but covers most important pests of live oak as defined in the literature.

Number One !

Live oak has a limited number of pests which cause serious damage. Foremost among live oak pests is oak wilt caused by a fungi Ceratocystis fagacearum. Oak wilt is especially damaging in the Western portion of live oak's native range. Oak wilt was first described in 1944 with its initial discovery in Wisconsin. The pathogen is believed to be a recent introduction into the United States. Oak wilt is a vascular pathogen which colonizes water conducting vessels in the outer ten or so annual increments of sapwood. Almost all new tree infections in live oaks are caused by the fungus growing in one tree growing through roots into other trees. Live oaks tend to grow as sprouts from a shared root system (clonal) and develop root grafts with other live oaks in the area. The oak wilt fungus can travel through root grafts and spread up to 100 feet per year. Chemical root barriers can be installed in trenches to control fungal spread.

In rare cases, the oak wilt fungi generates fungal mats on infected live oaks. Insects (i.e. Nitidulide beetles) feed upon these mats on warm Spring days and then move to other trees and initiate new infections. Wounds from logging, pruning, galls, bark borers, or other types of bark damaging events can draw many insects and be the initiation site for new oak wilt infections in live oaks. Pruning wounds covered with wound paint interferes with insect colonization and feeding, minimizing infections. Live oak wood, dead less than one year, can still harbor living fungi capable of infecting new trees. Firewood should not be moved from infection sites.

Live oak symptoms of oak wilt infection include stunted leaves on trunk sprouts, leaves wilting in late Spring, veinal death in leaves, and massive twig dieback progressively spreading throughout the crown. The most susceptible trees usually die in 4 - 6 months, others survive for several years. Approximately 10% of the stricken trees survive the infection altogether with major crown loss. Tree survivability suggests a limited form of native resistance is present within live oaks. Oak wilt is heavy in Texas live oak (Q. fusiformis) of Central Texas, moderate in Texas live oak / live oak (Q. fusiform / Q. virginiana) hybrids, and lighter in typical live oak (Q. virginiana). Live oak as a species is only now being challenged. Over time, oak wilt should continue to expand its range throughout the live oak range.

Other Pests

Live oak has a number of additional serious pests which can cause problems. These major pests which can have a significant impact on live oak are: Cryphonectria parasitica -- Chestnut blight; oak decline syn-

drome; Hypoxylon atropunctatum – Hypoxylon canker; Phytophthora cactorum – bleeding canker; and, Curculio spp. – acorn weevils destroying a high percentage of the acorn crop.

Live oak has many pests which at times takes advantage of a weakened or damaged tree. These pests include: anthracnose; Armillaria mellea -- shoe string root rot; Botryosphaeria rhodina -- bot canker; Callirhytis operator – wooly flower gall; Clitocybe tabescens – mushroom root rot; Coryneum japonicum – Coryneum twig canker; Diplodia -- Diplodia canker; Enaphalodes rufulus -- red oak borer; Endothia gyrosa – Endothia canker; Phoradendron serotinum -- mistletoe; Prionoxystus robiniae – carpenterworm; and, Xyletta fastidiosa -- bacterial leaf scorch.

Epiphytes

Live oak periderm surfaces provide a rich ecology in support of many living things. There are three noticable and common epiphytes associated with live oaks. These are Spanish moss (Tillandsia usneoides), ball moss (Tillandsia recurvata), and resurrection fern (Pleopeltis polypodiodes). They are not parasitic, but instead live only upon what rain and the periderm of the tree can provide. They occupy crown volume and bark area, and so can become so dense as to shade tree foliage and increase wind loading. After major storm events, epiphytes tend to increase in numbers for several years and then return to pre-storm numbers as live oak foliage density and crown structure recovers.

For example, the two Tillandsia species (of the pineapple family) absorb water through their surfaces, requiring regular rainfall and relatively high humidity to grow well. Both of these epiphytes depend upon specific lichen communities on the bark surface for fixed nitrogen and other materials. The Tillandsia species maximize their growth around ½ full sunlight, opening stomates and absorbing carbon dioxide only at night, or for short periods immediately after rain in the daytime. There are a number of other epiphytes which occupy live oak bark surfaces, ranging from common algae to endangered orchid species.

Summing Up Problems

As in all other tree species, the biotic and abiotic features of the environment conspire to damage and kill live oak. Both shortages of essential resources (like drought) and abusive site resource enrichment (like over-fertilization) can accentuate tree stress. Neighboring biological systems (biotics) survive by taking resources, or by adding toxins to resources, used by live oaks stressed in the environment. Although most pests have primarily secondary and tertiary roles, they deserve managerial notice and treatment within a professional tree health care program.

Conclusions

Live oaks are historic ecological structures. Live oaks are sources of food, protection, and support to a host of other plants and animals. They are life-centers and life-generators where they grow. For people, live oak is a difficult tree to precisely identify, carefully grow, properly transplant, appropriately train, and sustainably manage across time. Live oak represent a marker of the history of this nation, and the nations which have come before. They have been, and remain a factory, product, and ecological treasure. Understandings about live oak are in great demand for use in new plantings and for ancient tree conservation. Part of these understandings is how live oak presents a complex biological, ecological, and risk management problem. Today live oaks represent both an essential ecological structure and a valuable cultural heritage.

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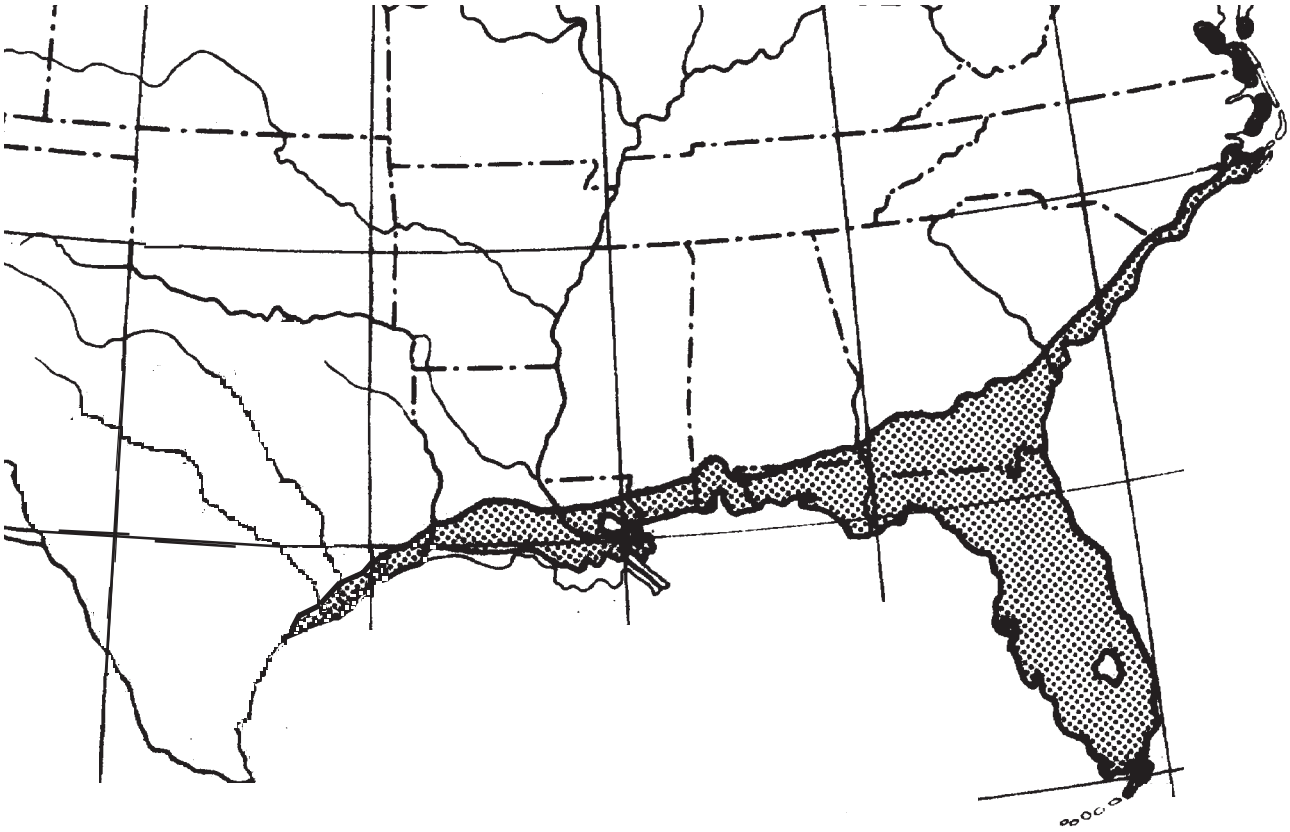

Figure 1: Live oak (Quercus virginiana var. virginiana) native range.

Modified from:

1) Little, Elbert L., Jr. 1971. **Atlas of United States Trees: Volume #1 -- Conifers and Important Hardwoods.** USDA-Forest Service, Miscellaneous Publication #1146. Washington D.C.

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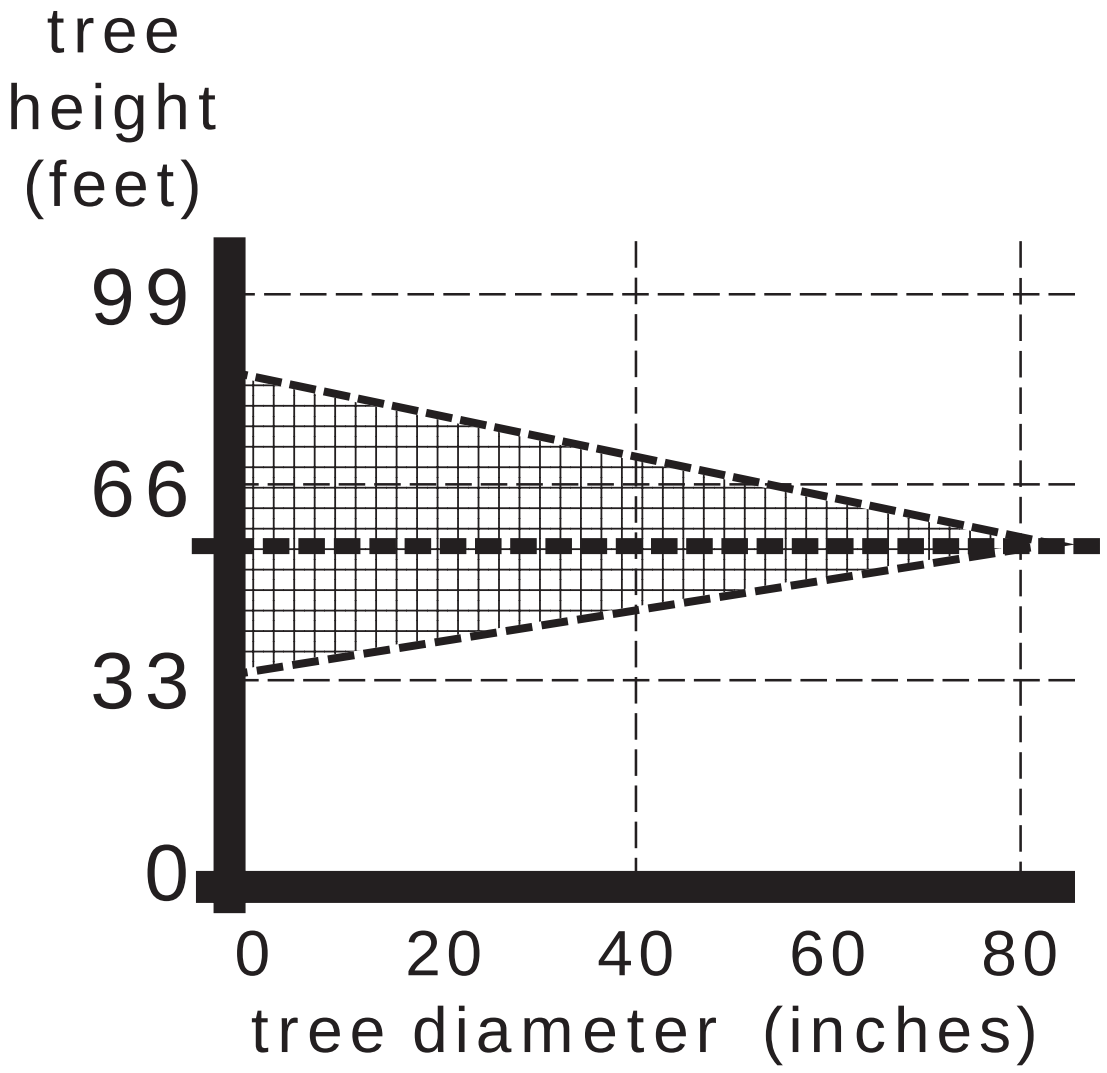


Figure 2: A range of open-grown, middle-aged live oak heights in feet and diameters in inches for one geographic area within the live oak's native range. Average tree height centered around 55 feet tall.
(modified from Spector & Putz 2006)

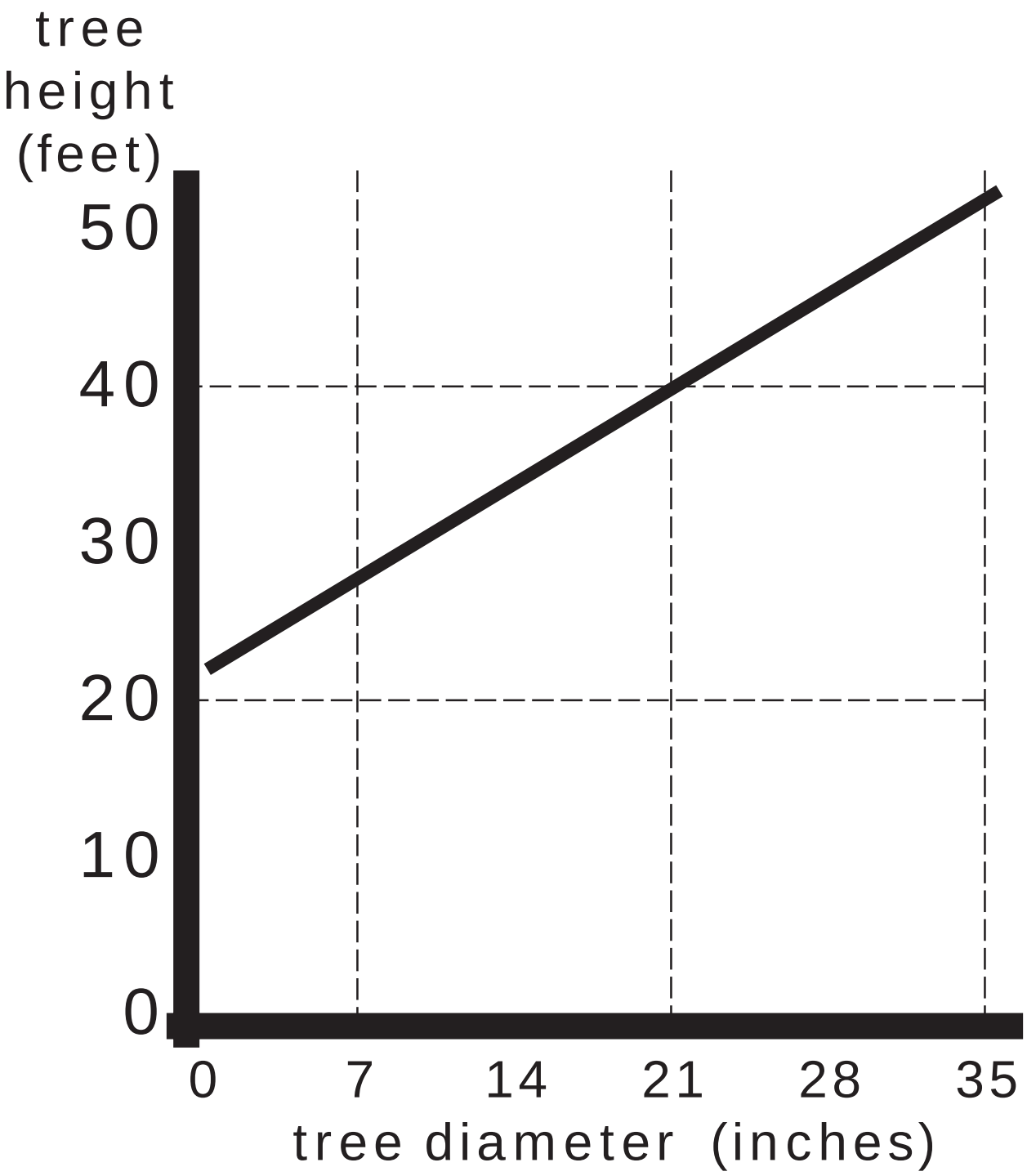


Figure 3: A range of tree height in feet and tree diameters in inches for live oaks growing in parking lots within one geographic area of live oak's native range.

(modified from Grabosky & Gilman, 2004)

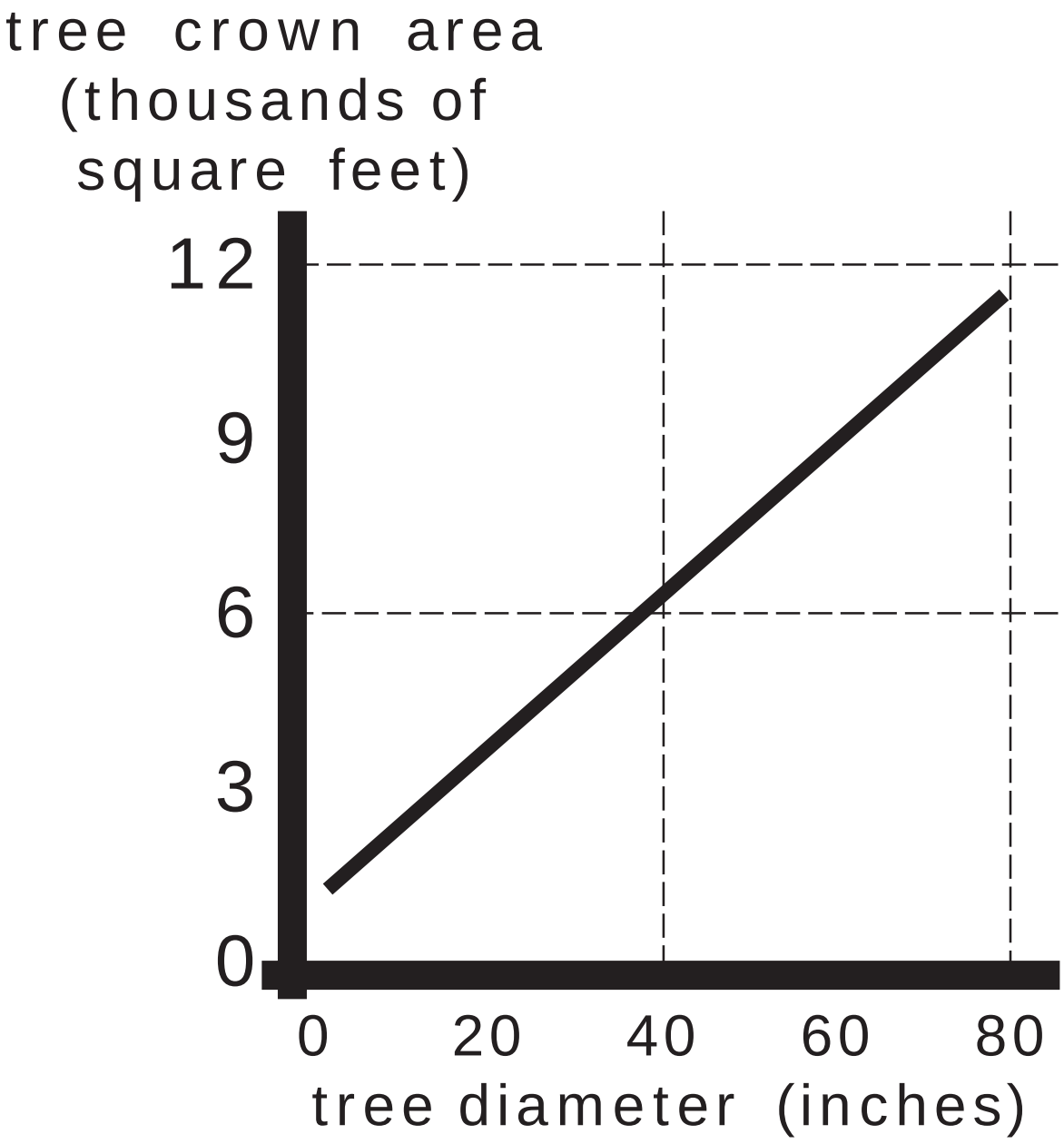


Figure 4: A range of open-grown, middle-aged live oak crown areas in square feet and tree diameters in inches for one geographic area within live oak's native range. (modified from Spector & Putz 2006)

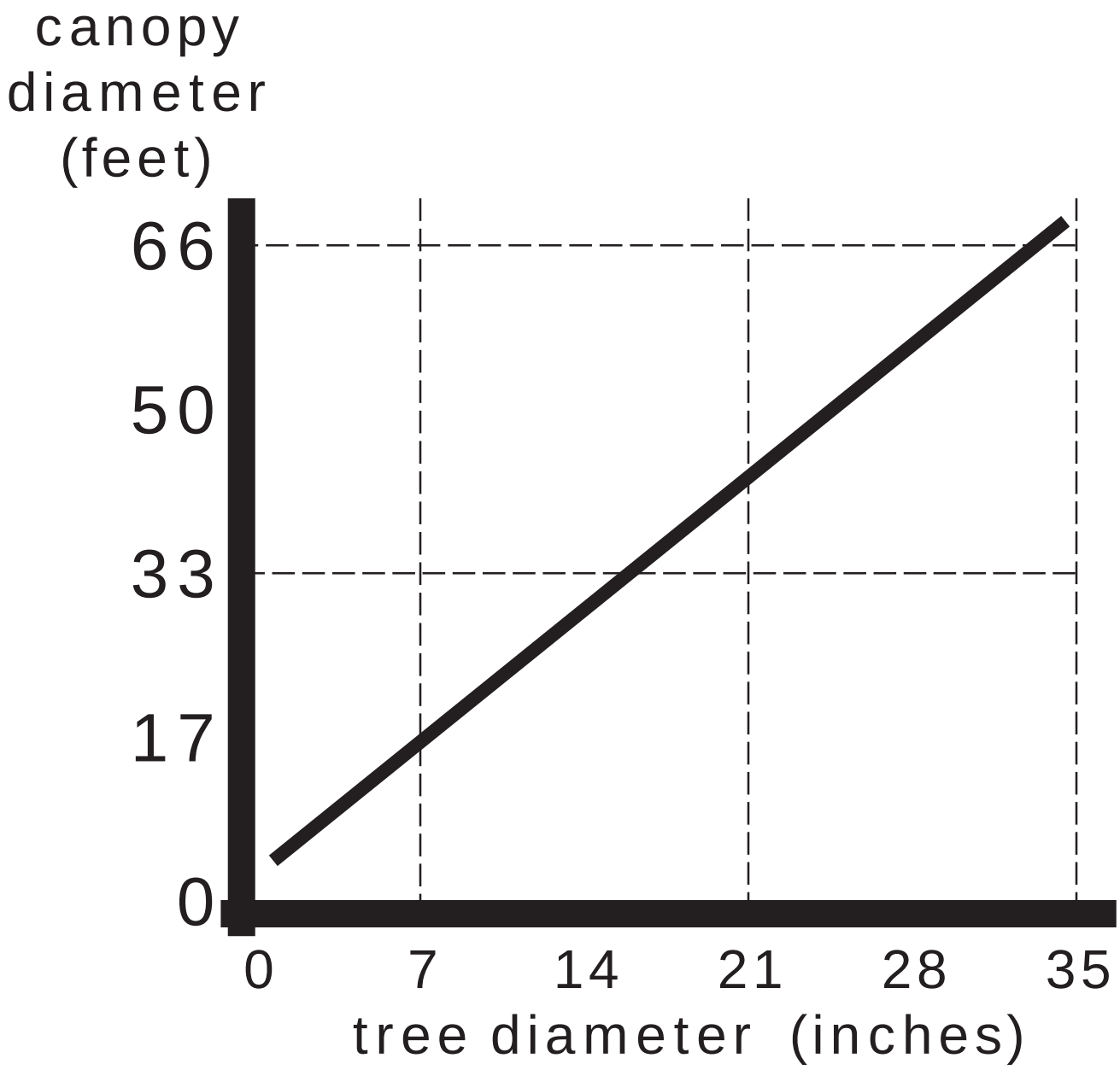


Figure 5: A range of canopy diameters in feet and tree diameters in inches for live oaks growing in parking lots within one geographic area of live oak's native range. (modified from Grabosky & Gilman, 2004)

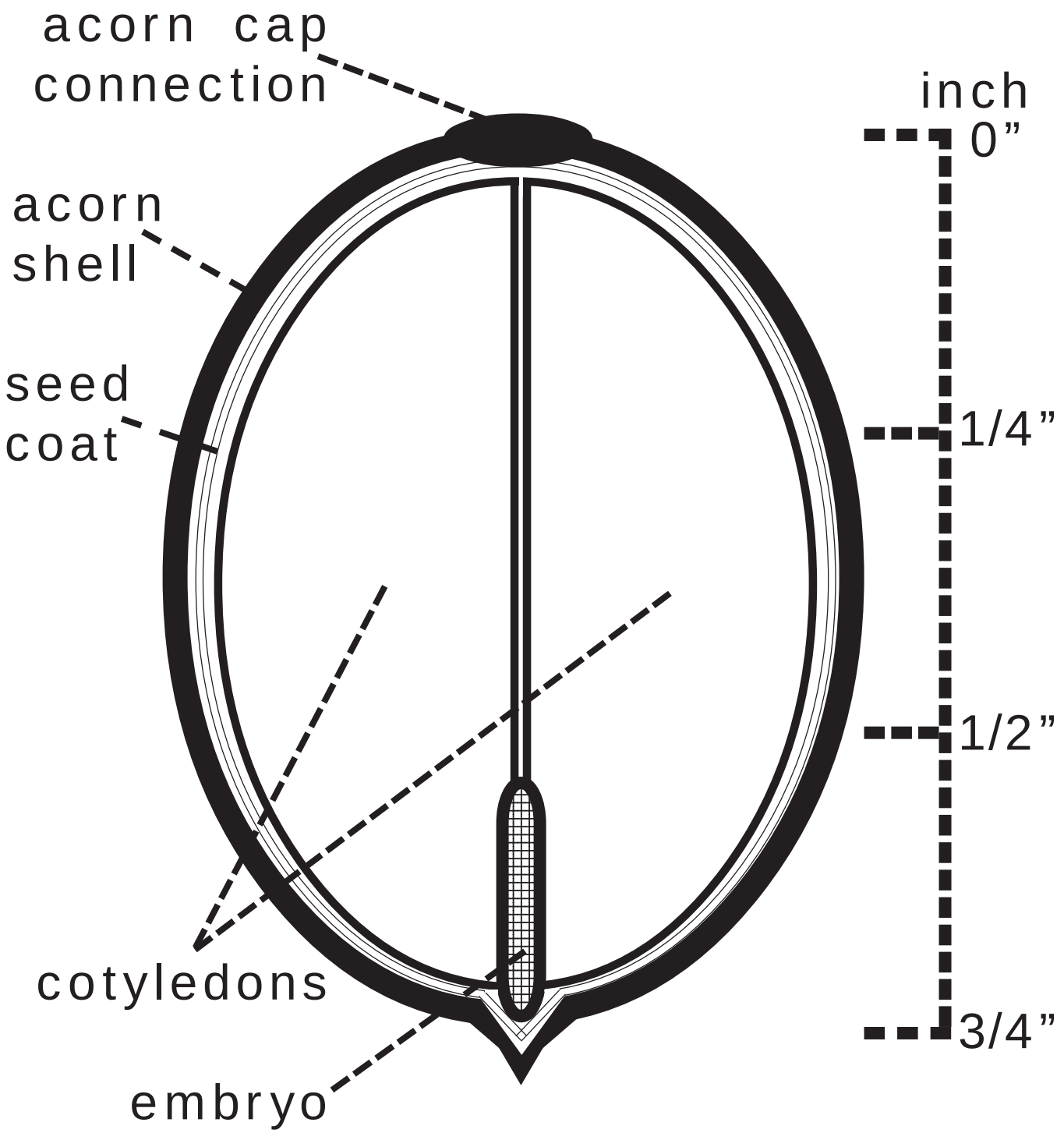


Figure 6: Idealized live oak acorn cut longitudinally.
Size selected as average for SE Georgia.

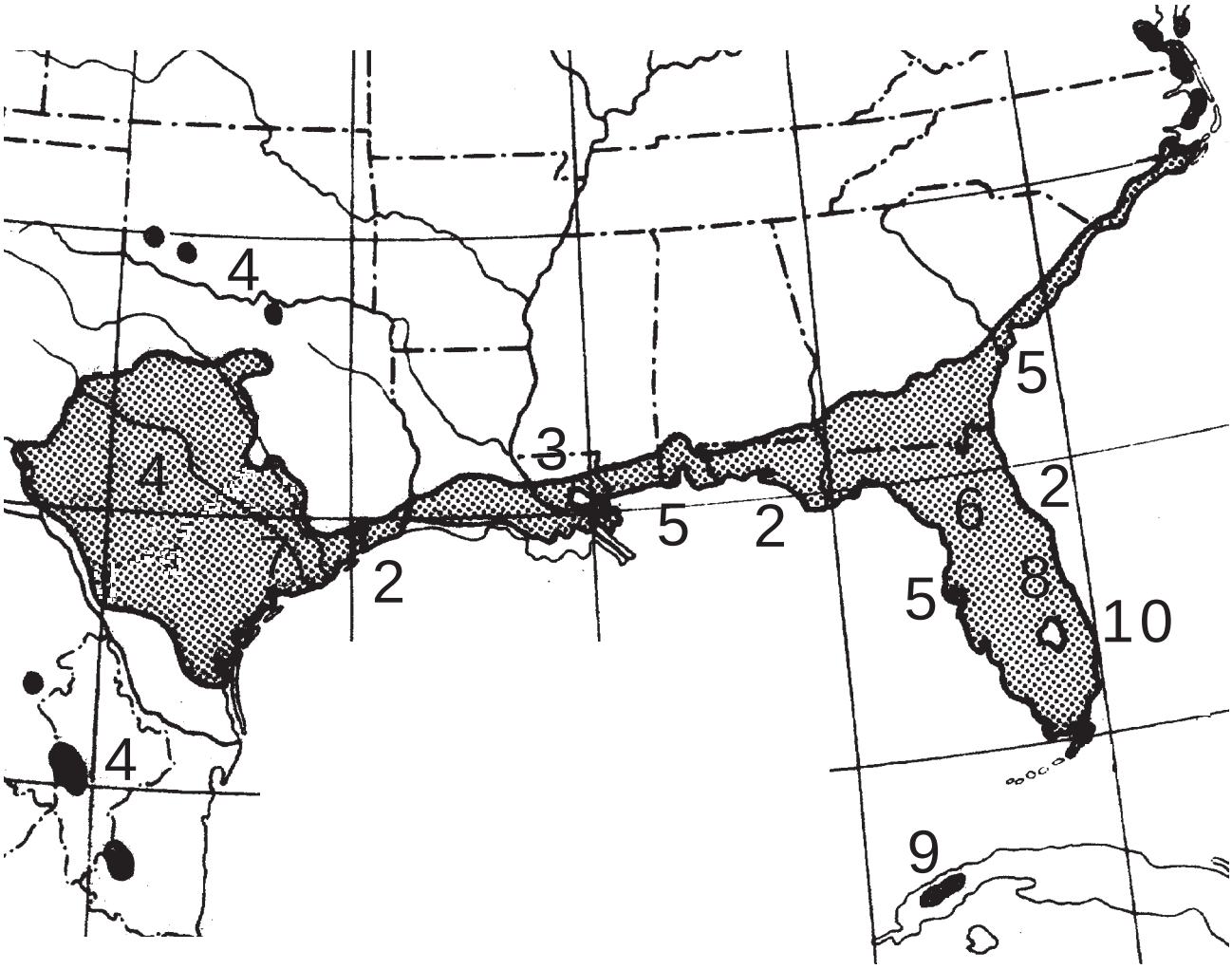


Figure 7: Live oak historic varieties locations. Numbers correspond to different varieties of live oak identified by Sargent as presented in Table 2.

Modified from:

Little, Elbert L., Jr. 1971. Atlas of U.S. Trees: Vol. #1 -- Conifers and Important Hardwoods. USDA-Forest Service, Misc. Pub. #1146. Washington D.C.; and,

Sargent, Charles S. 1965 (reprint 1922 original). Manual of the Trees of North America: Vol. #1. Dover Publishing, New York.

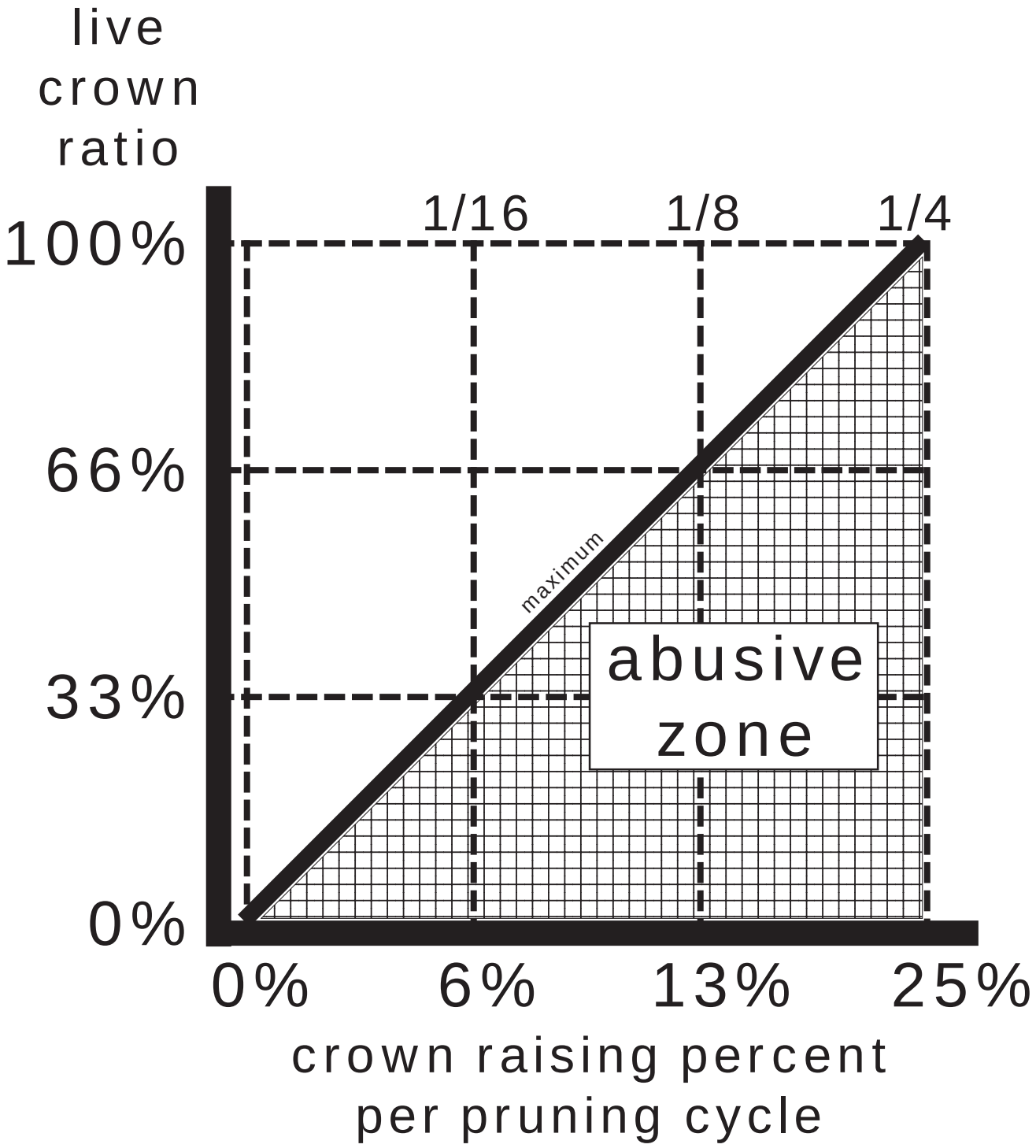


Figure 12: Coder Crown Raising Dose Assessment per pruning cycle for live oaks. Graph is the percent of live oak crown (live crown ratio basis) that can be raised / removed, if warranted, every pruning cycle in a crown raising process.

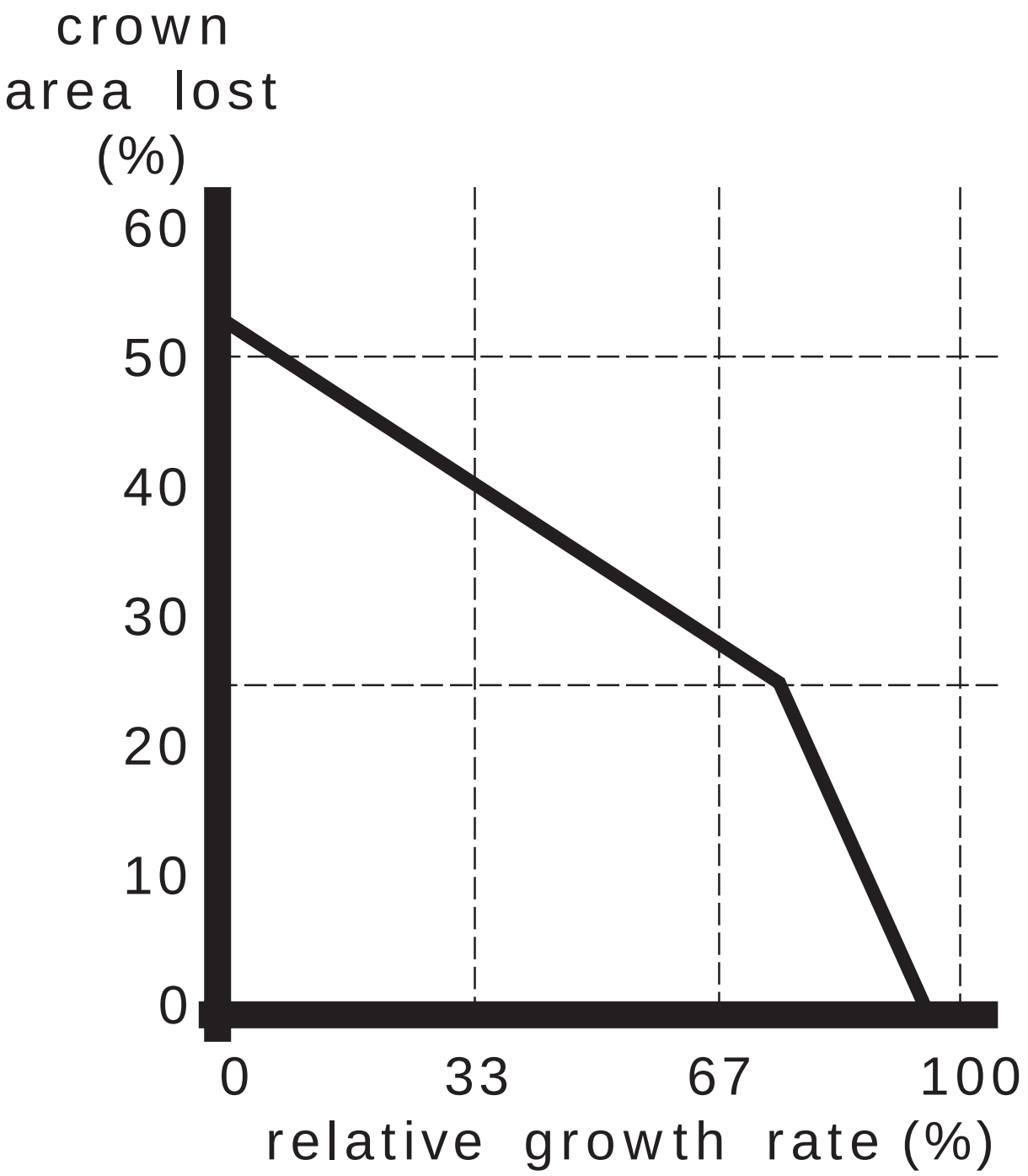


Figure 13: Live oak crown area (percent) lost to side and overtopping light interference from surrounding trees and associated relative growth rate.
(derived from Spector & Putz 2006)

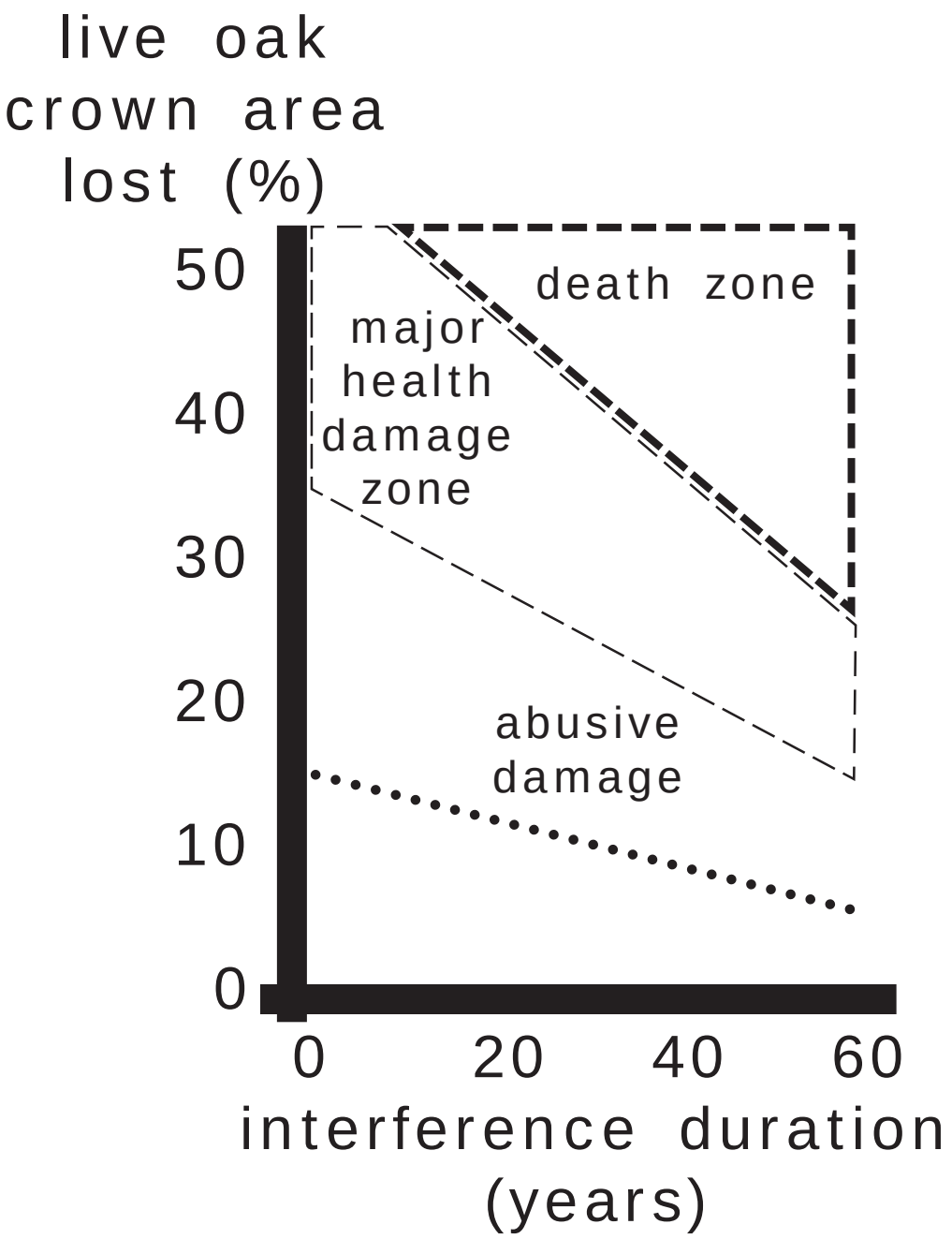


Figure 14: Live oak crown interference problems from side and over-topping trees by percent live oak crown loss and years of interference. Note these values are not from crown raising or reduction pruning, which represents much less crown loss before tree damage presents. (derived from Spector & Putz 2006)

germination percent =
{0.94 - [0.031 X (acorn weight loss percent)] } X 100

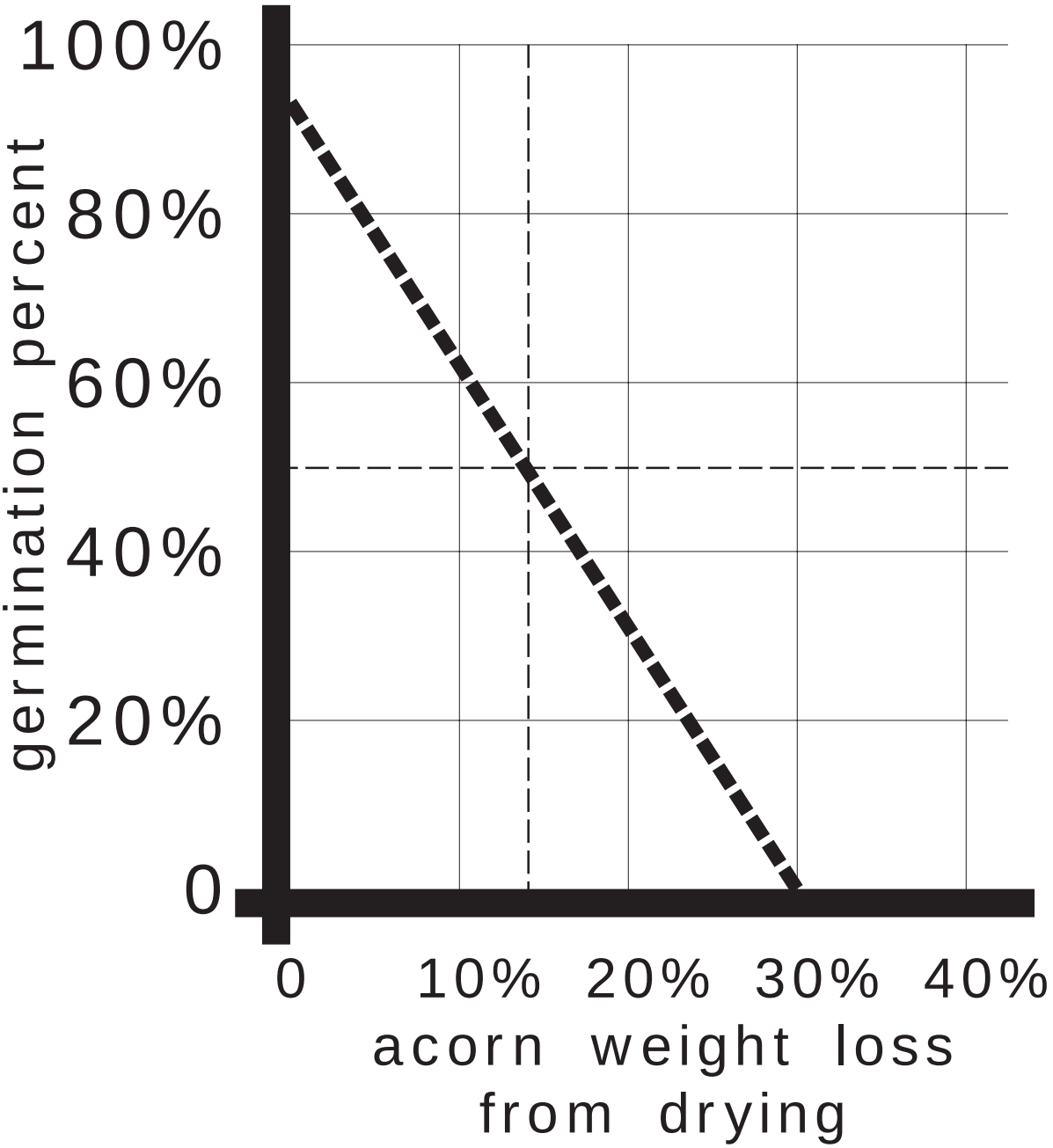


Figure 8: Estimated live oak acorn germination percentage as acorns dry. Note a 50% reduction in germination percentage is reached as acorn weight drops 14% from green, on-tree weight.

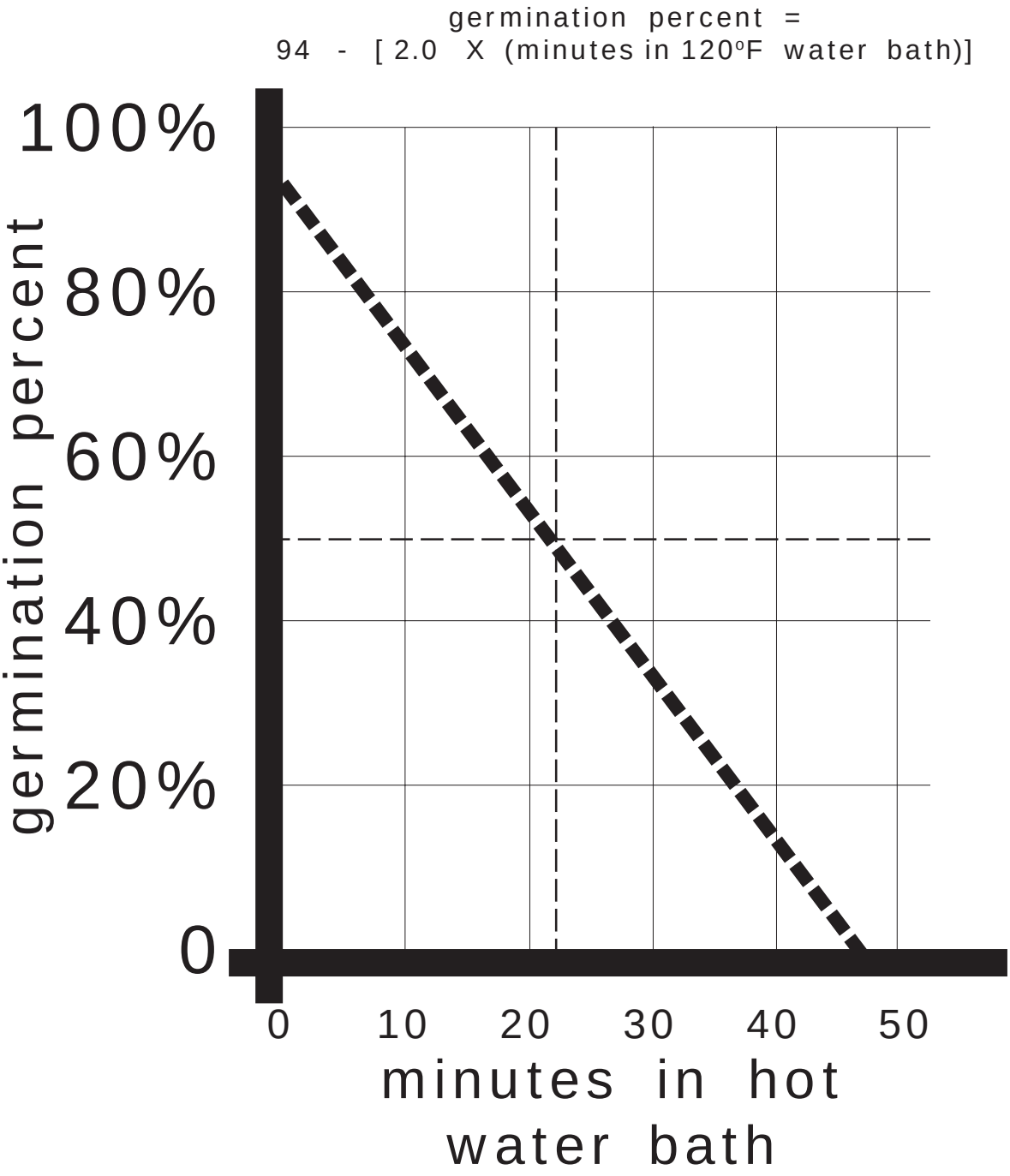


Figure 9: Estimated live oak acorn germination percentage as acorns are heated in a 120°F water bath in order to kill internal insect pests.

Note a 50% reduction in germination percentage as acorns are bathed for 22 minutes. Hot water baths or microwave heating are NOT recommended for live oak acorns in order to kill pests before planting.

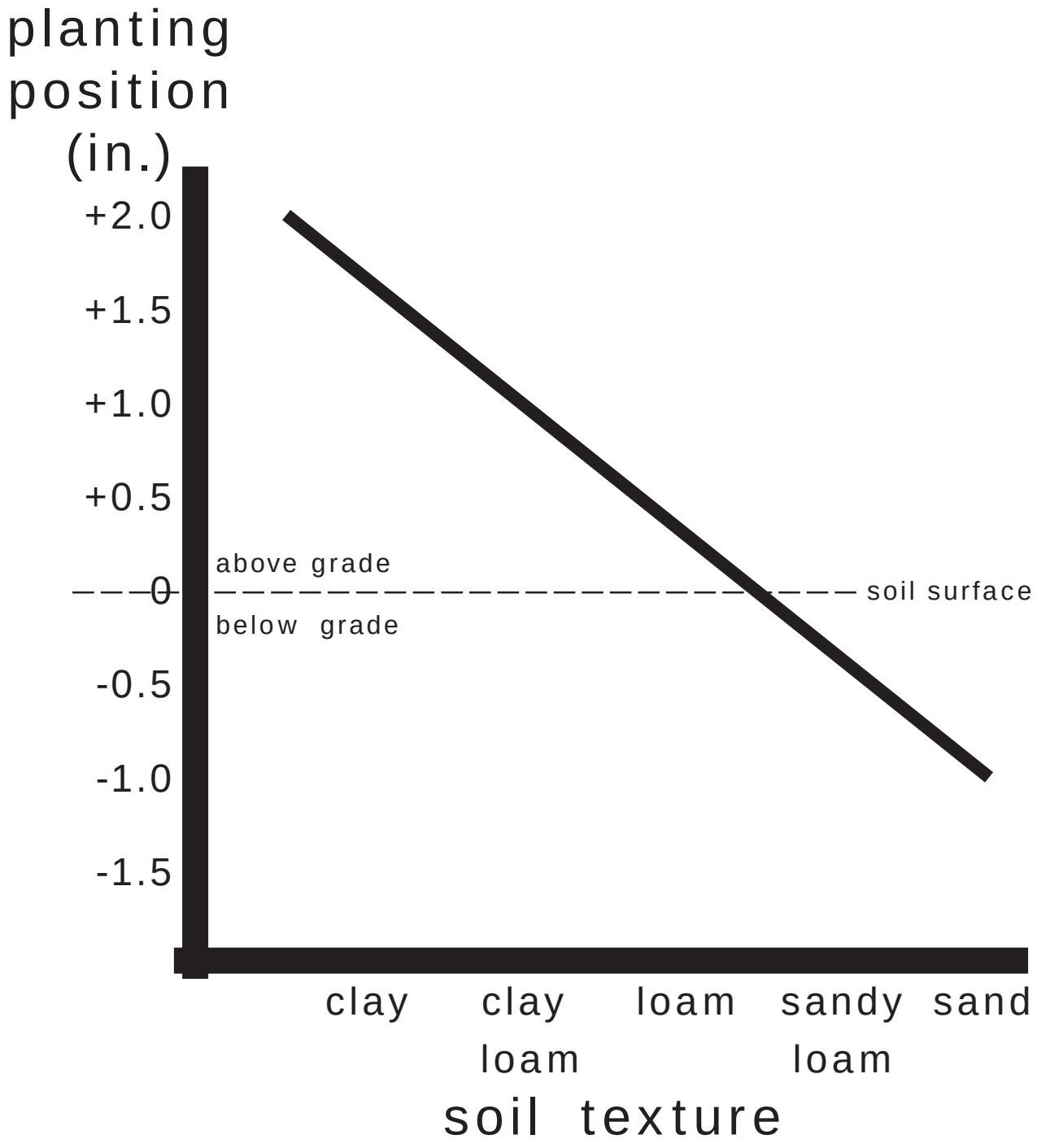


Figure 10: Planting position below or above grade for live oaks based upon soil texture. The planting position is measured between the stem base where 2-3 large lateral roots diverge and the surrounding mineral soil surface.

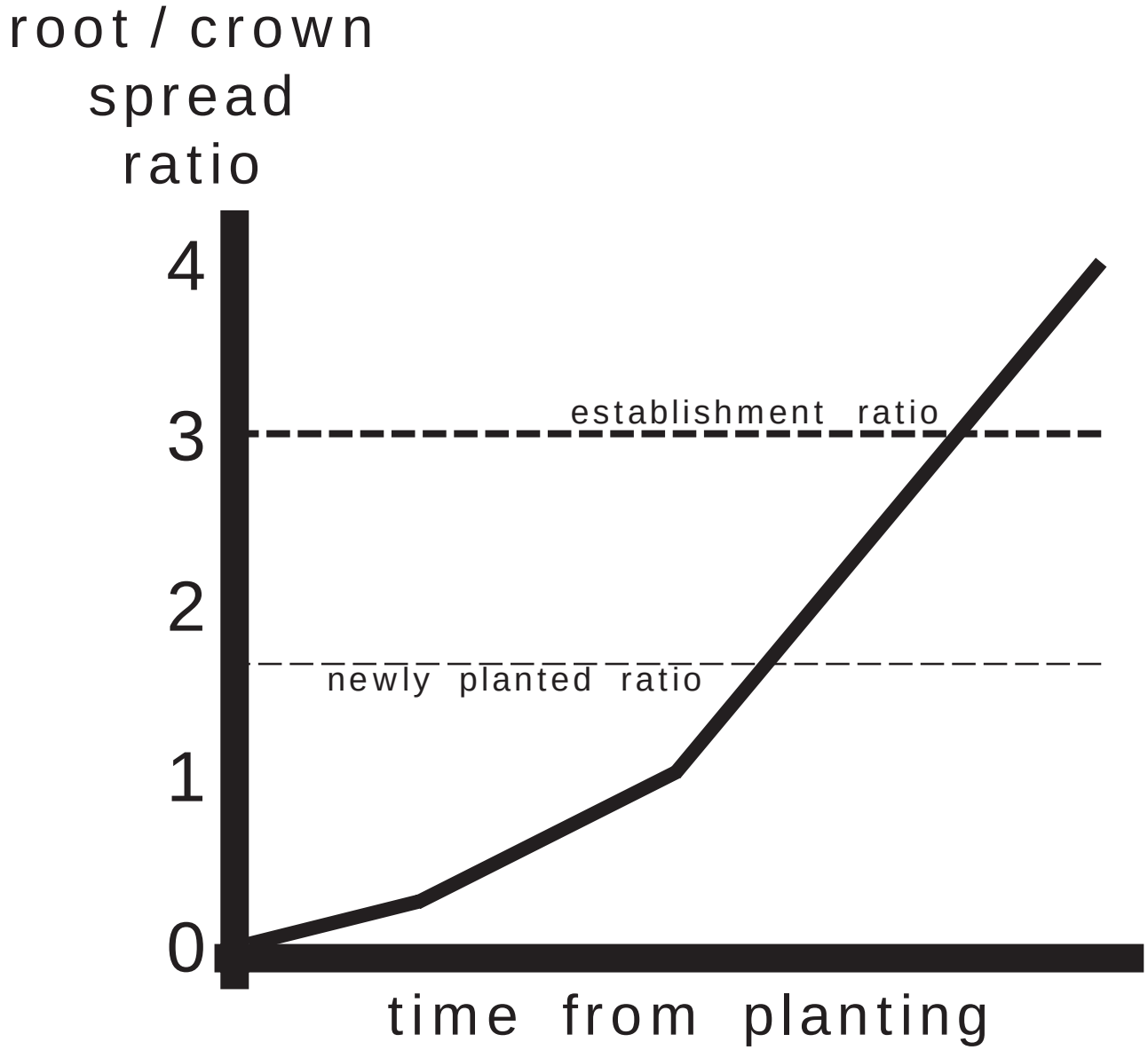


Figure 11: Live oak establishment time after planting based upon root spread to crown spread ratio. A live oak is considered to be established when root/crown spread ratio reaches or exceeds 3.0. (from Gilman et.al. 2010)

Table 1: Approximate number of cubic feet (ft^3) in a segement of live oak branch, stem or root with a given average diameter or circumference (in.) and a given length (ft.).

diameter (inches)	circumference (inches)	length (feet) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	6.3	0.02	0.04	0.07	0.09	0.11	0.13	0.15	0.17	0.2	0.2	0.2	0.3	0.3	0.3	0.3
3	9.4	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.4	0.5	0.5	0.6	0.6	0.7	0.7
4	13	0.1	0.2	0.3	0.35	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.1	1.2	1.3
5	16	0.1	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.8	1.9	2.1
6	19	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
7	22	0.3	0.5	0.8	1.1	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.5	3.7	4.0
8	25	0.4	0.7	1.1	1.4	1.8	2.1	2.4	2.8	3.1	3.5	3.8	4.2	4.5	5.0	5
9	28	0.4	0.9	1.3	1.8	2.2	2.7	3.1	3.5	4.0	4.4	5	5	6	6	7
10	31	0.6	1.1	1.6	2.2	2.7	3.3	3.8	4.4	5.0	6	6	7	7	8	8
12	38	0.8	1.6	2	3	3.9	5	6	6	7	8	9	9	10	11	12
14	44	1.1	2	3	4	5	6	8	9	10	11	12	13	14	15	16
16	50	1.4	3	4	6	7	8	10	11	13	14	15	17	18	20	21
18	57	1.8	4	5	7	9	11	12	14	16	18	20	21	23	25	27
20	63	2.2	4	7	9	11	13	15	18	20	22	24	26	28	31	33
22	69	2.6	5	8	11	13.	16	19	21	24	26	29	32	34	37	40
24	75	3.1	6	9	13	16	19	22	25	28	31	35	38	41	44	47
26	82	3.7	7	11	15	18	22	26	30	33	37	41	44	48	52	55
28	88	4.3	9	13	17	21	26	30	34	39	43	47	51	56	60	64
30	94	4.9	10	15	20	25	30	34	39	44	49	54	59	64	69	74
32	101	6	11	17	22	28	34	39	45	50	56	62	67	73	78	84
34	107	6	13	19	25	32	38	44	51	57	63	69	76	82	88	95
36	113	7	14	21	28	35	42	50	57	64	71	78	85	92	99	106
38	119	8	16	24	32	39	47	55	63	71	79	87	95	102	110	118
40	126	9	18	26	35	44	52	61	70	79	87	96	105	114	122	131
42	132	10	19	29	39	48	58	67	77	87	96	106	116	125	135	144
44	138	11	21	32	42	53	63	74	85	95	106	116	127	137	148	159
46	145	12	23	35	46	58	69	81	92	104	116	127	139	150	162	173
48	151	13	25	38	50	63	75	88	101	113	126	138	151	164	176	189
50	157	14	27	41	55	68	82	96	109	123	136	150	164	177	191	205
55	173	17	33	50	66	83	99	116	132	149	165	182	198	215	231	248
60	189	20	39	59	79	98	118	138	157	177	197	216	236	255	275	295
65	204	23	46	69	92	115	138	161	184	208	231	254	277	300	323	346
70	220	27	54	80	107	134	160	187	214	241	267	294	321	348	374	401
75	236	31	61	92	123	155	184	215	246	276	307	338	368	399	430	460

Estimated live oak branch, stem, or root segment weight in pounds determined by:
[90 (lbs/ft^3) X volume of live oak segment as determined above (ft^3)].

Table 2: Historical listing of Sargent's live oak varieties and where they were found. Map numbers correspond to Figure 7. (* = now considered a seperate species)

map #	genus	species	variety/ form name	description
1.	Quercus	virginiana	virginiana	typical live oak across range
2.			dentata* (minima)	shrubs on coastal sand dunes across live oak range
3.			eximea	narrow leaved, small trees of Eastcentral Louisiana
4.			fusiformis*	small leaved, small trees of Westcentral Texas with spots in Southwest Oklahoma & Northeast Mexico
5.			geminata*	medium sized trees on sandy soils from North Carolina to Mississippi
6.			grandifolia	large leaf form in Florida
7.			macrophylla	large leaved, medium sized trees in Texas
8.			pygmaea	leaves with small lobes near end on small shrubs, acorn almost enclosed by cap with short stalk in Florida (hybrid w/ Q. chapmani)
9.			sagreana*	Cuban live oak on Western end of island
10.			virescens	leaves bright green with few tricobes on medium sized trees in Central and Southern Florida

Table 3: Live oak pests and general impact importance ranking value.

Note importance is not based upon the frequency of which a pest is found, but represents the impact on long term tree health and structure across live oak's range. Great potential pest impacts on tree health or structure would receive a high ranking. Some pests have small impacts and would receive a low ranking.

Pest impact importance rankings: A = most impact on tree health; B = moderate impact on tree health; and, C = small impact on tree health.

scientific name of pest	common name of pest	impact rating	simple description
Insects & Mites:			
Andricus kingi	cynipid gall wasp	C	general gall former
Andricus laniger	live oak wooly leaf gall	C	general gall former
Anomoea laticlavia	locust leaf beetle	B	both adults and larvae feed on leaves
Archodontes melanopus	live oak stump borer	B	eggs are laid just below the soil surface at tree base with larvae eating into stump base and major roots causing a large gall to form and stump sprouts to form – a big larva up to 3.5 inches long
Argyrotaenia quercifoliana	oak leaf roller moth	B	defoliates trees as a light green caterpillar (<1 inch long) with amber yellow head
Arnoldiola atra	gall midge	C	attacks buds of live oak
Brachys tesselatus	scrub oak leaf miner	B	adults and larvae feed on leaves
Callirhytis cornigera	horned oak gall	B	gall formed on twigs
Callirhytis operator	wooly flower gall	B	causes galls on male catkins and then emerge to infest current acorn crop
Cameraria spp.	oak leaf miner	B	moth larvae leaving splotched bleached foliage similar to some leaf necrosis diseases in appearance -- rake up and discard fallen leaves

Table 3: Live oak pests and general impact importance ranking value. (continued)

scientific name of pest	common name of pest	impact rating	simple description
Insects & Mites (continued):			
Cincinnus melsheimeri	Melsheimer's sack bearer	C	larvae makes leaf shelter for itself and moves it as feeds on leaves
Curculio spp.	acorn weevils	A	most of acorns are lost – larvae are off-white, fat and roll into a cupped shape.
Disholcaspis cinerosa	gall wasp	C	gall forming wasp whose generations alternate between branch galls and leaf galls
Enaphalodes rufulus	red oak borer	B	bark borer damaging trees larger than 2 inches in caliper and doubling attack for every inch larger tree grows in size
Johnella virginiana	vagrant eriophyid mite	C	initiates leaf curl but no gall
Mesolecanium nigrofasciatum	terrapin scale or black-banded scale	B	crawlers in early Spring moving to main leaf veins and then in late Summer scales move to twigs – adults dark orange in color with radiating black lines
Odontocynips nebulosa	root gall wasp	B	subterranean wasp initiating large galls on absorbing roots
Oiketicus abbotii	bagworm	B	relatively large bag (2-3 inches long) with twig pieces attached around the exterior
Orgyia leucostigma	white-marked tussock moth	B	in late Spring eggs in old grey cocoons hatch and larvae skeletonize leaves then later move to eating entire leaf blade – orange head with yellow body and tufts of hairs
Paleacrita vernata	Spring cankerworm	C	larvae dark colored with two yellow stripes skeletonizing leaves at branch tips
Parallelodiplosis florida	Florida gall midge	C	causes elongated swellings (galls) on leaf veins

Table 3: Live oak pests and general impact importance ranking value. (continued)

scientific name of pest	common name of pest	impact rating	simple description
Insects & Mites (continued):			
Platycotis vittata	oak treehopper	C	sucking insect but worst damage is the female cutting open slits in twigs to lay eggs - slits callous over leaving scars
Prionoxystus robiniae	carpenterworm	B	wood boring insect with a long life cycle in live oak – large larvae is hairy and dark pink hatching on bark surface and boring into the tree – mature larva is greenish white with a dark brown head – starts life in sapwood then expands late in larval life to heartwood, always keeping an open tunnel entrance free from callous growth
Stilbosis quadricustatella	leaf miner	B	skeltonizes live oak leaves
Diseases & Higher Plants:			
Armillaria mellea	shoe string root rot	B	golden honey-colored mushrooms at the tree base and dark brown "shoe-string-like" bands of hyphae under bark
Apiognomonia quercina Discula quercina	anthracnose	B	wet weather in Spring generates large irregular dead areas on leaves – begins on low shady branches and causes leaf defoliation and some blade distortion, with occasional shoot dieback
Botryosphaeria quercuum	oak bot canker	B	bark lesions in Summer cause twig flagging, wilting and browning of leaves, and dieback – an usual bark resident
Botryosphaeria rhodina	common bot canker	B	takes advantage of oak wilt damage, pruning wounds, and stress in trees to cause bark lesions or cankers -- an usual bark resident

Table 3: Live oak pests and general impact importance ranking value. (continued)

scientific name of pest	common name of pest	impact rating	simple description
Diseases & Higher Plants (continued):			
Cassytha filiformis	cassytha plant	C	parasitic vine (higher plant) on harsh sites -- vine is orange-brown in color with a tangle of long runners twinning counter clockwise around host tissue
Ceratocystis fagacearum	oak wilt	A+	systemic vascular disease which causes tree wilting with leaf bronzing and discoloration eventually leading to dead leaf tips, twig dieback, and tree defoliation -- death can take from 4 months to several seasons -- dieback is progressive through crown
Clitocybe tabescens	mushroom root rot	B	far Southern version of Armillaria mellea root rot
Coryneum japonicum	Coryneum twig canker	B	twig and branch dieback, distortion of the leaves, and premature leaf drop
Cryphonectria parasitica Endothium parasitica	chestnut blight	A	trunk and branch cankers under bark and hard to see until the bark falls off – causes crown decline and chlorotic leaves
Dendrothele acerina Hyphoderma baculorubrense	smooth patch	C	rots off outer periderm areas which fall off leaving smooth looking periderm patches
Endothia gyrosa	Endothia canker	B	started by wounds on limbs, trunks and exposed roots, and by drought stress – sunken, slightly orange canker with small bumps on its surface
Hypoxylon atropunctatum	Hypoxylon canker	A	irregular canker which invades weakened trunks and branches producing thin, light brown to grey fungal mats exposed as bark falls away
Monochaetia desmazierii	late leaf spot	C	large brown spots on leaves in late Summer

Table 3: Live oak pests and general impact importance ranking value. (continued)

scientific name of pest	common name of pest	impact rating	simple description
Diseases & Higher Plants (continued):			
Perenniporia phloiophila	bark rot	C	decays outer periderm without leaving smooth patches on large limbs and trunks – pore surface is cream color to pale brown – flat fungal mats grow between periderm ridges
Phoradendron serotinum	American mistletoe	B	parasitic plant spread by birds and successful on stressed, slow growing trees
Phytophthora cactorum	bleeding canker	A	root collar rot which destroy living cell connections in tree causing leaf yellowing, premature leaf drop, leaf stunting, twig dieback, and oozing liquids from lesions
Polyporus dryophylus	heartwood rot	C	heartwood decay organism
Tillandsia usneoides	Spanish moss	C	epiphyte (higher plant) which, in great abundance, shades out live oak foliage
Xyletta fastidiosa	bacterial leaf scorch	B	tree defoliation, flushes of distorted leaves with dead margins and tips, and twig dieback
((many causes))	oak decline syndrome	A	many organisms and stress factors combine to make tree less effective and efficient in gathering resources to the point of twig & branch death, slow growth, and stunted chlorotic leaves. A combination of poor wound reactions, soil compaction, poor soil drainage, summer drought, and constant stress year after year cause loss of resource space and lack of internal controls for growth and defense.

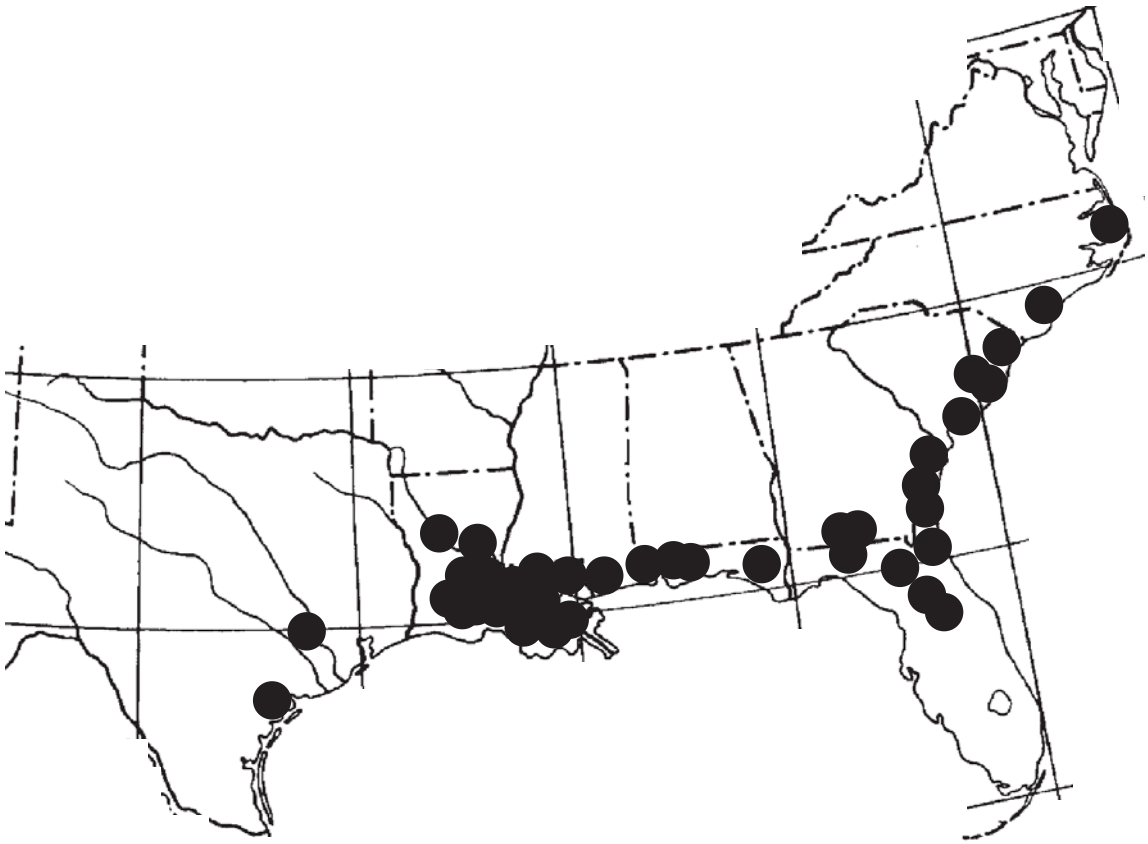
Table 4: Pest list categorized by live oak health and structure impact rank.

scientific name of pest	common name of pest	impact rank
Ceratocystis fagacearum	oak wilt	A+
Cryphonectria parasitica	chestnut blight	A
Curculio spp.	acorn weevils	A
Hypoxylon atropunctatum	Hypoxylon canker	A
Phytophthora cactorum	bleeding canker	A
((many causes))	oak decline syndrome	A
Apiognomonia quercina	anthracnose	B
Discula quercina	anthracnose	B
Armillaria mellea	shoe string root rot	B
Anomoea laticlavia	locust leaf beetle	B
Archodontes melanopus	live oak stump borer	B
Argyrotaenia quercifoliana	oak leaf roller moth	B
Botryosphaeria quercuum	oak bot canker	B
Botryosphaeria rhodina	common bot canker	B
Brachys tesselatus	scrub oak leaf miner	B
Callirhytis cornigera	horned oak gall	B
Callirhytis operator	wooly flower gall	B
Cameraria spp.	oak leaf miner	B
Clitocybe tabescens	mushroom root rot	B
Coryneum japonicum	Coryneum twig canker	B
Enaphalodes rufulus	red oak borer	B
Endothia gyrosa	Endothia canker	B
Mesolecanium nigrofasciatum	terrapin or black-banded scale	B
Odontocynips nebulosa	root gall wasp	B
Oiketicus abbotii	bagworm	B
Orgyia leucostigma	white-marked tussock moth	B
Phoradendron serotinum	mistletoe	B
Prionoxystus robiniae	carpenterworm	B
Stilbosis quadricustatella	leaf miner	B
Xyletta fastidiosa	bacterial leaf scorch	B
Andricus kingi	cynipid gall wasp	C
Andricus laniger	live oak wooly leaf gall	C
Arnoldiola atra	gall midge	C
Cassytha filiformis	cassytha plant	C
Cincinnus melsheimeri	Melsheimer's sack bearer	C
Dendrothele acerina	smooth patch	C

(continued)

Table 4: Pest list categorized by live oak health and structure impact rank. (continued)

scientific name of pest	common name of pest	impact rank
Disholcaspis cinerosa	gall wasp	C
Hyphoderma baculorubrense	smooth patch	C
Johnella virginiana	vagrant eriophyid mite	C
Monochaetia desmazierii	late leaf spot	C
Paleacrita vernata	Spring cankerworm	C
Parallelodiplosis florida	Florida gall midge	C
Perenniporia phloiophila	bark rot	C
Platycotis vittata	oak treehopper	C
Polyporus dryophylus	heartwood rot	C
Tillandsia usneoides	Spanish moss	C



Appendix 1: General location of the largest (i.e. >8 feet stem diameter) living live oaks.

(from Live Oak Society registrations available on-line)