Conservation Issues

Introduction, Impact on Native Habitats, and Management of a Woody Invader, the Chinese Tallow Tree, *Sapium sebiferum* (L.) Roxb.

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ABSTRACT: Chinese tallow, *Sapium sebiferum* (L.) Roxb., is a subtropical deciduous tree native to China, where its seeds are used for a variety of products including soap, candles, and oil. This species was introduced to the United States in the late 1700s. The Bureau of Plant Industry (U.S. Department of Agriculture) established plantations of tallow along the Gulf Coast in the early 1900s to study its feasibility as an agricultural crop. At this time it became a popular ornamental. Because of tolerance to different types of soils, rapid growth, precocity, high fecundity, and the presence of few pests or pathogens in the United States, Chinese tallow spread to a variety of natural habitats in the southeastern United States. Native prairies invaded by Chinese tallow suffered altered ecosystem structure as a result of the monospecific stands of tallow trees that persisted. Currently, tallow is controlled by mechanical means, but some herbicides are effective.

Index terms: Chinese tallow tree, coastal prairie, exotic species, *Sapium sebiferum*

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INTRODUCTION

The Chinese tallow tree, *Sapium sebiferum* (L.) Roxb., is a woody invader that replaces natural habitats in the southeastern United States. We discuss the history of introduction of this species, summarize information on its biology, note impacts on native habitats, and review current and forecasted methods for management. Unless noted otherwise, plant taxonomy follows Correll and Johnston (1979).

CHARACTERISTICS, LIFE HISTORY, AND PHYSIOLOGY

Sapium sebiferum (L.) Roxb. (Euphorbiaceae) is a subtropical, deciduous tree native to China and Japan (Mabberly 1987). Common names include Chinese tallow, Chinese tallowberry, popcorn tree (clusters of white seeds remain on the tree after capsules dehisce), chicken tree (commonly planted near chicken coops in Louisiana), and Florida aspen (aspenlike leaf-shape). Synonyms include *Croton sebifera* Linn., *Stillingia sebifera* Willd. (Roxburgh 1832), and *Triadica sebifera* (L.) Small (Radford et al. 1964).

Tree form varies from low-spreading and multiforked to tall and columnar (Scheld et al. 1984). In the United States, height ranges from 3 to 10 m (Correll and Johnston 1979); the National Champion tallow tree in Goodrich, Texas, is 15.5 m tall with a diameter at breast height (dbh) of 112 cm (Texas Forest Service 1995). The bark is rough and gray; the sap is milky, and the leaves are simple, entire, and alternate, rarely opposite (Correll and Johnston 1979). Leaf blades are rhombic, apically acuminate, 3–7 (–9) cm long with petioles longer than blades. Leaves have a pair of glands at the blade-petiole junction, which exude a sugary fluid in late summer–fall (Correll and Johnston 1979, Scheld et al. 1984).

Tallow flowers from April to June. The inflorescence is a spikelike thyrse. Staminate flowers occur in fascicles of 3–15 along the length of the spike; 1–5 pistillate flowers occur at the base (Lin et al. 1958). On some plants, female flowers mature first, on others, males mature first (called dichogamy; M.Vrecenar et al., unpubl. data). The two kinds of inflorescences differ morphologically (Lin et al. 1958). Those in which female flowers mature first produce "grape-type" inflorescences in which pediceled pods are arranged spirally around the base of the inflorescence. "Eagle-claw" inflorescences begin as all-male thyrses, but, after several weeks, male florets die and thyrses drop off. Two or more smaller inflorescence branches grow at the base of the original inflorescence, each with a few female florets and a reduced number of male florets.

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Fruits are three-lobed capsules approximately 1 cm long that mature and dehisce September–November in the United States (Correll and Johnston 1979, Scheld et al. 1984). Seeds, 7–8 mm long and covered with a chalky white coating of tallow, remain attached to the placenta after dehiscence. The vegetable tallow of the seed coat contains palmitic and oleic fatty acids, while the seed kernel contains linoleic and linolenic fatty acids (Hooper 1904; Jamieson and McKinney 1938; Howes 1949; Khan et al. 1973; Draper 1982; Scheld et al. 1980, 1984).

Water and birds may disperse seeds. Seeds accumulate around oxbow margins as water recedes after heavy rain or flooding. Seeds are consumed by pileated woodpeckers (*Dryocopus pileatus*) and boat-tailed grackles (*Quisaculus major*) in Florida (Jubinsky and Anderson 1996) and Texas, as well as by other species (W. Conway, graduate student, Department of Range Management, Texas Tech University, Lubbock, pers. com.).

Viability of seeds averages 95% and germination is 26%–65% in the laboratory (Bruce 1993, E.G. Glumac et al., unpubl. data). Germination is highest January–February (55%–60%) and lowest in late fall and early spring (21%–46%). Germination is 6% in Texas prairie (Bruce 1993) and 0%–10% in mature floodplain forests in Louisiana (Harper 1995), with 10%–50% of seeds viable after 1 year in the soil in Louisiana. Seeds in sealed metal cans remain viable 7 years, with maximum germination occurring after 1–2 years of storage E.G. Glumac et al.,unpubl. data).

Nearly half of trees flowered by the third year of life on the coastal prairie of Texas (Scheld et al. 1984). In Taiwan, average seed yield is approximately 1,400 seeds for coppiced three-year-old trees, approximately 103,000 seeds for 20-year-old trees, and approximately 51,000 seeds after 50 years (Lin et al. 1958). Cultivated, mature trees produce approximately 310,000 seeds on the Texas coastal prairie (Gray 1950, Scheld et al. 1980), and approximately 8,000 seeds in bottomland hardwood forests in southern Louisiana (Harper 1995). Tallow also reproduces vegetatively, resprouting after being cut or burned (Bonner 1974).

In Taiwan, tallow is cultivated in soils with pH ranging from 3.9 to 8.5 (Lin et al. 1958). It grows in poorly or well-drained sites on clay or sandy soil, and withstands brackish water in salt marshes (Hunt 1947, Conner and Askew 1993, Conner 1994). In east Texas, it invades wet clay prairies and freshwater marshes. It is seldom found in brackish or salt marshes or on the sandy barriers along the Gulf of Mexico, although it occurs in wet portions of a barrier island forest in South Carolina (Helm et al. 1991). North of the coastal prairie of Texas, tallow is not abundant or vigorous on coarse, droughty soils. In the delta south of New Orleans, tallow grows on roadsides, spoil banks, forest edges, and forest gaps (White et al. 1983, Harper 1995).

Rapid growth of tallow seedlings equals or greatly exceeds that of native species. Growth rate of seedlings during the year of germination ranged from 0.076 cm day^{-1} under mature tallow and in prairie to 0.33 cm day^{-1} in cleared prairie plots (Bruce 1993). Seedling height averaged 22 cm by the end of the first growing season. Growth rate of seedlings is comparable to or greater than that for both shade-tolerant and shade-intolerant native trees, whether in deep shade or forest gaps (Jones and McLeod 1989, 1990; Hall 1993). Compared to other woody species, tallow has an intermediate tolerance to root competition from forest understory trees (Jones and Sharitz 1990).

In direct sunlight, tallow can grow 2.8 m tall 2 years after germination (Scheld and Cowles 1981). In a river floodplain forest in southeastern Texas, height growth of individuals 50–140 cm tall was 23 cm $year^{-1}$, which is 2–10 times that of native species, and sapling radial increment growth was 1.6–2 mm $year^{-1}$ (Hall 1993, Harper 1995). Maximum radial growth was 4.5 mm $year^{-1}$ for a 17-cm dbh tree on the Texas coastal prairie (Harcombe et al. 1993), and 6 mm $year^{-1}$ in a river floodplain forest in Louisiana (Harper 1995).

Minor herbivory has been recorded for Chinese tallow in the United States. Insects take 0.3%–1% of leaf area compared to 25.8% for green ash (Jones and Sharitz 1990) and 5%–15% for native willow and hackberry on the coastal prairie of Texas (G. N. Cameron, unpubl. data). A black mold (*Pullularia)* may attack the waxy seed covering, penetrate the kernel, and destroy the embryo (Scheld et al. 1980). In Japan, some insects, such as bagworm (*Eumeta*) feed on leaves of tallow (Nishida 1983), and in China, at least 26 species of herbivorous insects occur on tallow trees along with several species of disease-causing bacteria (Zhang and Lin 1994).

INTRODUCTION AND DISTRIBUTION

Tallow has been cultivated in China for 14 centuries for soap (wax seed coat), fuel (wood pulp), candles (wax seed coat), drying oil (seed kernel), black dye (leaves), honey (nectar), and protein meal (seed kernel) (Potts 1946, Scheld et al. 1984). Tallow grows in every province in China south of latitude 30° N and as far north as 36°N along the eastern coast (Draper 1982). Tallow has been introduced worldwide and is naturalized in Japan, Formosa, India, Pakistan, central and southern Europe, Martinique, and the Sudan (Hsu 1928, Jamieson and McKinney 1938, Lin et al. 1958, Khan et al. 1973).

Introduction of tallow into the United States commonly is attributed to Andre Michaux (Hunt 1947); however, tallow was observed in the United States in 1784, at least 2 years before Michaux arrived in Charleston, South Carolina (Schoepf 1911). This occurrence is consistent with the account that Chinese tallow was first introduced into the United States by Benjamin Franklin, who sent seeds to Dr. Noble Wimberly Jones, a gentleman farmer in Georgia, in 1772 (Bell 1966). In the United States, naturalized populations occur from south Texas eastward along the Gulf Coast to Florida and up the east coast to North Carolina (near 36°N) (Radford et al. 1964). In Florida, tallow occurs in 38 of 67 counties ranging from the Florida/Alabama border, east to Jacksonville, and as far south as Tampa; naturalized populations occur in 13 of these counties, typically adjacent to low-lying areas (Jubin-

sky 1995). Tallow occurs as far north as Grenada, Neshoba, Newton, and Washington Counties in Mississippi (S.T. McDaniel, Professor, Department of Botany, Mississippi State University, pers. com.), and is naturalized to about the fall line in Alabama, Georgia, and South Carolina, although planted specimens survive farther inland (R. Jones, Professor, Department of Biology, Viriginia Polytechnic Institute and State University, Blacksburg, pers. com.). Tallow occurs in Oklahoma (Vines 1960), but is not naturalized (M. Palmer, Professor, Department of Botany, Oklahoma State University, Stillwater, pers. com.). Tallow is planted in southern California, but is apparently not naturalizing there either (S. Brigham, Buena Creek Gardens, San Marcos, California, pers. com.).

The U.S. Bureau of Plant Industry, U.S. Department of Agriculture, introduced Chinese tallow to Texas in 1900–1910 to study its commercial viability (Jamieson and McKinney 1938, Howes 1949). Tallow spread from these stands, from ornamental plantings established because of tallow's rapid growth, ability to thrive in heavy, clay soils, and showy fall colors (John Teas, Teas Nursery, Houston, pers. com.), and from seeds sown by beekeepers because tallow is an important nectar source for commercial honeys (Lieux 1975). Also, approximately 20,000 seedlings were distributed to farmers across a 320-km belt inland from the Gulf Coast in 1949 to promote its use as an oilseed crop (Gray 1950). By the 1940s, tallow had spread throughout the Texas coastal prairie, but was restricted to riparian areas (Davis et al. 1946). After naturalization along such waterways, upland habitats were invaded (Hsu 1928, Jamieson and McKinney 1938, Lin et al. 1958, Khan et al. 1973, Scheld et al. 1984).

The spread of tallow northward probably is limited by cold-intolerance (Draper 1982, Dirr 1990). We observed substantial branch death and canopy loss in mature trees in Houston in 1989 when temperature was below freezing for 36 hours, reaching a minimum of -5°C. Based on these observations, inspection of the USDA Plant Hardiness Zone map (Cathey 1990), and one known distribution map (Odenwald and Turner, n.d.), we believe that the northern limit for naturalization of tallow from Arkansas to Georgia occurs in Plant Hardiness Zone 7b (average minimum winter temperatures of -12°C to -15°C (5°F–10°F). This inference is supported by data from China showing that the average minimum winter temperature for growth is -15°C and the average minimum for oilseed production is -10°C (Zhang and Lin 1994).

IMPACT OF CHINESE TALLOW INVASION

Chinese tallow has altered species composition, community structure, and ecosystem processes in native coastal prairie in Texas. Harcombe et al. (1993) found that tallow stands approximately 15 years old had significantly higher net primary productivity than adjacent native prairie. Cameron and Spencer (1989) discovered that the concentration of nutrients in the soil also was affected; P, K, NO_3 -N, Zn, Mn, and Fe were significantly higher and Mg and Na were significantly lower in soil in tallow woodland than in adjacent native prairie.

Tallow invades coastal prairie and displaces native grasses. The original coastal prairie community was dominated by little bluestem (*Schizachyrium scoparium*), brownseed (*Paspalum plicatulum*), and Indian grass (*Sorgastrum nutans*) (Smeins et al. 1991). Fewer than 10 years after invasion by tallow, cover is predominantly woody vegetation, 98% of which is tallow; and basal area and stem density of tallow increase 2–3 orders of magnitude during invasion (Bruce et al. 1995). Tallow may be the first tree species to invade prairies simply because it produces and disperses seed more effectively than native tree species, which may not invade until tallow first changes prairie conditions in some way (i.e., facilitation). This idea is substantiated by presence of native hackberry (*Celtis laevigata*), Texas yaupon (*Ilex vomitoria*), and American elm (*Ulmus americana*) in tallow woodlands but not in prairies. However, extremely low densities of these species in tallow woodlands (Bruce *et al.* 1995) may reflect later

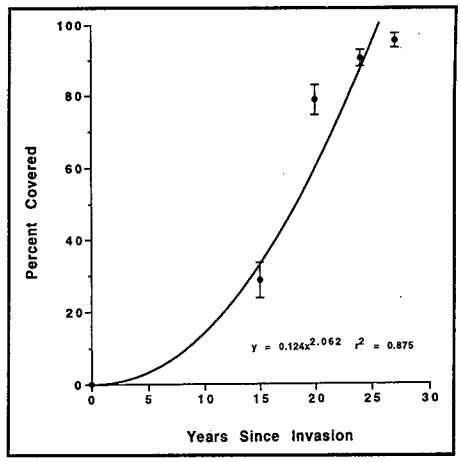

Figure 1. Rate at which Chinese tallow attained a closed canopy stand on the Upper Coastal Prairie of Texas. Bars indicate 1 standard error and formula is the regression equation for the line.

seed-bearing ages of native species (*S. sebiferum*, 3 years; *Pinus taeda*, 5 years; *Celtis laevigata*, 15 years; *Quercus nigra*, 20 years; Lin et al. 1958; U.S. Forest Service 1974).

We determined rates of canopy closure by stands of tallow that invaded prairie in the Houston area. We selected ten areas at the University of Houston Coastal Center, 56 km southeast of Houston, that were occupied by native coastal prairie in 1958, and the amount of each area covered by Chinese tallow canopy was measured from aerial photographs taken in 1958 (no tallow present), 1973, 1978, 1982, and 1985. Full canopy closure was attained within 20–25 years (Figure 1).

Tallow also has invaded riparian areas south of Houston (range from 6%–38% of stand basal area and 800–67,000 stems >2.5 cm [dbh] ha^{-1}; Oliver 1990); floodplains in the Big Thicket National Preserve in east Texas (22,600 seedlings ha^{-1}, 1,074 saplings ha^{-1}, and trees constituting 10% stand basal area with 62 >4 cm (dbh) ha^{-1}; P.A. Harcombe, unpubl. data); mature floodplain forests south of New Orleans (786 trees ha^{-1}; Harper 1995); cheniers of Louisiana (rank 1–3 in importance in chenier woodland samples; H. Meyer, Department of Biology, McNeese State University, Lake Charles, Louisiana, pers. com.); and barrier island northeast of

Charleston, South Carolina (account for 79% of stems ha^{-1} with trees averaging 10.9 m tall; Helm et al. 1991). In wetlands and lake margins near Lake Jackson, Florida, density of Chinese tallow trees reached 4,520 stems ha^{-1} in less than 20 years (cf. 4,430 stems ha^{-1} for tallow on the Texas coastal prairie, Bruce et al. 1995), whereas density for all other woody species combined was $\leq$550 stems ha^{-1} (Jubinsky 1995). Density, percent cover, and relative frequency of tallow seedlings were significantly greater than for all other tree species combined (Jubinsky 1995, Jubinsky and Anderson 1996).

MANAGEMENT OF CHINESE TALLOW

Sheep and goats will eat leaves of tallow (Ansari and Nand 1987). While there is anecdotal evidence that cattle suppress tallow, toxicity of the plant to cattle limits the effectiveness of control by grazing (Russell et al. 1969). Rotating high-density herds of cattle for short periods of time among fenced pastures of native prairie in southeastern Texas is effective against encroachment by the native shrub *Baccharis halimifolia*, but is less effective for tallow even though cattle will eat seedlings <6 cm tall (M. Kramer, Armand Bayou Nature Center, Houston, pers. com.).

Mechanical removal of tallow with heavy equipment is not suitable in most natural areas because soils and nontarget vegetation may be disturbed. However, this method of control can be applied along canals and utility rights-of-way and similar areas adjacent to infested wetlands or in restored areas. In southeastern Texas, where tallow is widespread, farmers and ranchers commonly bulldoze tallow, disk the soil, and plant pasture grass (T. Smith, Natural Resources Conservation Service, Liberty, Texas, pers. com.). However, several years of intensive maintenance are required to ensure control. Felling trees in place and removing entire seedlings manually are the only forms of mechanical control currently being used on Chinese tallow in

Table 1. Chemical control recommended for Chinese tallow tree (modified from Hutton [1995] and Welch [1993]).

Herbicide	Broadcast Rate/Acre[1]	Individual Plant Treatment[1]	Spray Volume	Time to Apply	Remarks
Grazon P + D	1 gal (2.5 lb)	1 gal (2.5 lb)[2]	5–15 gal as aerial spray or 10–25 gals for ground broadcast application; thoroughly wet foliage for individual treatment	spring or fall	
Grazon PC	1 qt (0.5 lb)	2 qt (1 lb)[2]		spring or fall	
Tank mix Grazon PC with Remedy	1 qt (0.5 lb) Grazon PC + 1 pt (0.5 lb) Remedy	2 qt (1 lb) Grazon PC + 1 qt (1 lb) Remedy[2]		spring or fall	
Velpar L		4 ml/2.54 cm stem diameter or 1 m canopy diameter		late winter to mid-spring	apply to soil surface within 1 m of stem base; if > 1 4-ml application needed, place equally around plant
Spike 20P		0.5 oz pellets (0.1 oz)/ 45 sq ft or 5-10 cm stem diameter		anytime during year; Oct–April optimal	apply evenly on soil under plant canopy and 0.3 m beyond canopy edge; do not use on marshy or poorly drained sites nor on clay soils

[1] active ingredient rate in parentheses

[2] mix with 1–2 qt of surfactant to make 100 gal mixture

Florida, and in sensitive natural areas or areas being restored along the coast of Texas. Hand removal of saplings with a tree wrench is restricted to trees <1 m tall. Systemic herbicides (e.g., Chopper®, Pathway®, or Grazon®) must be applied to stumps to prevent root sprouting and regrowth.

Prescribed burning controls tallow <2 m tall (M. Kramer, Armand Bayou Nature Center, Houston, pers. com.). Hot summer fires have the greatest effect.

The basal bark technique of applying herbicide to the bark around the circumference of a tree (Langeland 1990) has been used for control of tallow by the Florida Department of Environmental Protection, the Florida Exotic Pest Plant Council, Florida Native Plant Society, the Florida Nature Conservancy, and The Nature Conservancy of Texas. Tallow is controlled in Florida by applying 11% Garlon 4® (triclopyr) with a surfactant (JLB Oil Plus) and glyphosate (Rodeo®) to trees <15 cm dbh, and a 20% solution to trees with dbh >15 cm (Jubinsky 1995, Jubinsky and Anderson 1996). In Texas, control of tallow can be achieved with Grazon P+D®, Grazon PC®, a tank mix of Grazon PC® + Remedy®, Velpar L®, and Spike 20P® (Table 1; Hutton 1995, Welch 1993).

To be effective, control for tallow must be continued for a 3- to 5-year period, and treated areas must be monitored for regrowth of treated individuals and reinvasion. For example, seedlings were still emerging from seeds in the soil on two herbicide-treated plots at St. Andrews State Park, Florida, 5 years after initial treatment (G. Jubinsky, unpubl. data).

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LITERATURE CITED

Ansari, A.A. and G. Nand. 1987. Little known economic plants of Pauri Garhwal. Indian Journal of Forestry 10:316-317.

Bell, M. III. 1966. Some notes and reflections upon a letter from Benjamin Franklin to Noble Wimberly Jones, October 7, 1772. Ashantilly Press, Darien, Ga.

Bonner, F.T. 1974. *Sapium sebiferum* (L.) Roxb. Tallowtree. P. 760 *in* C.S. Schopmeyer, ed., Seeds of Woody Plants in the United States. Agricultural Handbook 450, U.S. Department of Agriculture, Washington, D.C.

Bruce, K.A. 1993. Factors affecting the biological invasion of the exotic Chinese tallow tree, *Sapium sebiferum*, in the Gulf Coast Prairie of Texas. MS thesis, University of Houston, Tex. 155 p.

Bruce, K.A., G.N. Cameron, and P.A. Harcombe. 1995. Initiation of a new woodland type on the Texas Coastal Prairie by the Chinese tallow tree (*Sapium sebiferum* (L.) Roxb.). Bulletin of the Torrey Botanical Club 122:215-225.

Cameron, G.N. and S.R. Spencer. 1989. Rapid leaf decay and nutrient release in a Chinese tallow forest. Oecologia 80:222-228.

Cathey, H.M. 1990. USDA plant hardiness zone map. Miscellaneous Publication 1475, U.S. Department of Agriculture, Agricultural Research Service, Washington, D.C.

Conner, W.H. 1994. The effect of salinity and waterlogging on growth and survival of baldcypress and Chinese tallow seedlings. Journal of Coastal Research 10:1045-1049.

Conner, W.H. and G.R. Askew. 1993. Impact of saltwater flooding on red maple, redbay, and Chinese tallow seedlings. Castanea 58:214-219.

Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas (2nd printing). The University of Texas at Dallas, Richardson. 1881 p.

Davis, W.S., R. Stanger, W.L. Nash, J. Kucera, and A. Surface. 1946. District Program: Brazoria-Galveston Soil Conservation District No. 318, Texas. U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.

Dirr, M.A. 1990. Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses. 4th Ed. Stipes Publishing, Champaign, Ill. 1007 p.

Draper, H.M., III. 1982. New oil seed crops for fuels and chemicals: ecological and agricultural considerations. Ph.D. diss., Washington University, St. Louis, Mo. 609 p.

Gray, R.S. 1950. Chinese tallow, a four-way crop. Farm Journal (August):124.

Hall, R.B.W. 1993. Sapling growth and recruitment as affected by flooding and canopy gap formation in a river floodplain forest in southeast Texas. Ph.D. diss., Rice University, Houston, Tex. 260 p.

Harcombe, P.A., G.N. Cameron, and E.G. Glumac. 1993. Aboveground net primary productivity in adjacent grassland and woodland on the coastal prairie of Texas. Journal of Vegetation Science 4:521-530.

Harper, M.G. 1995. A model of the invasion of Chinese tallow tree (*Sapium sebiferum* [L.] Roxb.) into a bottomland-hardwood forest in Louisiana. MS thesis, Tulane University, New Orleans, La. 116 p.

Helm, A.C., N.S. Nicholas, S.M. Zedaker, and S.T. Young. 1991. Maritime forests on Bull Island, Cape Romain, South Carolina. Bulletin of the Torrey Boranical Club 118:170-175.

Hooper, D. 1904. *Sapium sebiferum* (the Chinese Tallow Tree.). Chinese or vegetable

tallow. Its preparation, uses, and composition. Pp. 11-18 *in* The Agricultural Ledger, No. 2. Vegetable Product Series, No. 79. Oil and Oilseeds.

Howes, F.N. 1949. The Chinese tallow tree (*Sapium sebiferum* Roxb.)—a source of drying oil. Kew Bulletin 4: 573-80.

Hunt, K.W. 1947. The Charleston woody flora. American Midland Naturalist 37:670-756.

Hutton, B.N. 1995. Chinese tallowtree control methods. Brazoria County Extension Service, Angleton, Tex.

Hsu, B.H. 1928. A systematical examination of Chinese tallow seeds and oil. The China Journal 9:244-251.

Jamieson, G.S. and R.S. McKinney. 1938. Stillingia oil. Oil and Soap 15:295-296.

Jones, R.H. and K.W. McLeod. 1989. Shade tolerance in seedlings of Chinese tallow tree, American sycamore, and cherrybark oak. Bulletin of the Torrey Botanical Club 116:371-377.

_____. 1990. Growth and photosynthetic responses to light environment in Chinese tallowtree and Carolina ash seedlings. Forest Science 36:851-862.

Jones, R.H. and R.R. Sharitz. 1990. Effects of root competition and flooding on growth of Chinese tallow tree seedlings. Canadian Journal of Forest Research 20:573-578.

Jubinsky, G. 1995. Chinese tallow (*Sapium sebiferum*). Rev. Ed. Report No. TSS 93-03, Florida Department of Environmental Protection, Bureau of Aquatic Plant Management, Technical Services Section, Tallahassee. 12 p.

Jubinsky, G. and L.C. Anderson. 1996. The invasive potential of Chinese tallow-tree (*Sapium sebiferum* Roxb.) in the southeast. Castanea 61:226-231.

Khan, F.W., K. Khan, and M.N. Malik. 1973. Vegetable tallow and stillingia oil from the fruits of *Sapium sebiferum* Roxb. The Pakistan Journal of Forestry 23:257-266.

Langeland, K. (ed.). 1990. Exotic woody plant control. Circular 868, University of Florida Cooperative Extension Service and Exotic Plant Pest Council, Gainesville.

Lieux, M.H. 1975. Dominant pollen types recovered from commercial Louisiana honeys. Economic Botany 29:87-96.

Lin, W.C., A.C. Chen, C.J. Tseng, and S.G. Hwang. 1958. An investigation and study of Chinese tallow tree in Taiwan (*Sapium sebiferum*, Roxb.). Bulletin of Taiwan Forestry Research Institute 57:1-37.

Mabberly, D.J. 1987. The Plant-Book: A Portable Dictionary of the Higher Plants. Cambridge University Press, Cambridge, England. 706 p.

Nishida, E. 1983. Biologies and parasite complexes of two bagworms, *Eumeta japonica* and *Eumeta minuscula* (Lepidoptera, Psychidae), in Japan. Kontyu (Tokyo) 51:394-411.

Odenwald, N.G. and J.R. Turner. (no date). Plants for the South, a Guide for Landscape Design. Claitor's Publishing Division, Baton Rouge, La. 565 p.

Oliver, M.A. 1990. Prairie and forest vegetation of the Armand Bayou Nature Center, Harris County, Texas. MA thesis, Rice University, Houston, Tex. 176 p.

Potts, W.M. 1946. The Chinese tallow tree as a chemurgic crop. The Chemurgic Digest 22:374-375.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1964. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill. 1183 p.

Roxburgh, W. 1832. Flora Indica or Descriptions of Indian Plants, Vol. 3. W. Thacker and Co., Calcutta, India.

Russell, L.H., W.L. Schwartz, and J.W. Dollahite. 1969. Toxicity of Chinese tallow tree (*Sapium sebiferum*) for ruminants. American Journal of Veterinary Research 30:1233-1238.

Scheld, H.W. and J.R. Cowles. 1981. Woody biomass potential of the Chinese tallow tree. Economic Botany 35:391-397.

Scheld, H.W., N.B. Bell, G.N. Cameron, J.R. Cowles, C.R. Engler, A.D. Krikorian, and E.B. Schultz. 1980. The Chinese tallow tree as a cash and petroleum-substitute crop. Pp. 97-112 *in* Tree Crops for Energy Co-production on Farms. Publication SERI/CP-622-1086, U.S. Department of Energy and Solar Energy Research Institute, Washington, D.C.

Scheld, H.W., J.R. Cowles, C.R. Engler, R. Kleiman, and E.B. Schultz, Jr. 1984. Seeds of the Chinese tallow tree as a source of chemicals and fuels. Pp. 97-111 *in* E.B. Schultz, Jr., and R.P. Morgan, eds., Fuels and Chemicals from Oil Seeds: Technology and Policy Options. AAAS Selected Symposium 91. Westview Press, Boulder, Colo.

Schoepf, J.D. 1911. Reise durch einige der mittlern und sudlichen vereinigten nordamerikanichen Staaten nach ost-Florida und den Bahama Inseln unternommen in den Jahren 1783 und 1784. Extracts from the translation by Alfred J. Morrison. Bulletin of the Lloyd Library of Botany, Pharmacy, and Material Medicine 16:1-39.

Smeins, F.E., D.D. Diamond, and C.W. Hanselka. 1991. Coastal prairie. Pp. 269-290 *in* R.T. Coupland, ed., Ecosystems of the World, Natural Grassland: Introduction and Western Hemisphere. Elsevier, Amsterdam, Netherlands.

Texas Forest Service. 1995. Texas big tree registry. Texas Forest Service, Texas A&M University System, Abilene.

U.S. Forest Service. 1974. Seeds of Woody Plants in the United States. Agriculture Handbook 450, U.S. Department of Agriculture, Washington, D.C. 883 p.

Vines, R.A. 1960. Trees, Shrubs and Woody Vines of the Southwest. University of Texas Press, Austin.

Welch, T.G. 1993. Chemical weed and brush control suggestions for rangeland. Publication B-1466, Texas Agricultural Extension Service, College Station.

White, D.A., S.P Darwin, and L.B. Thien. 1983. Plants and plant communities of Jean Lafitte National Historic Park, Louisiana. Tulane Studies in Zoology and Botany 24:101-129.

Zhang, K. and Y. Lin. 1994. Chinese Tallow. China Forestry Press, Beijing. 460 p.