Ailanthus altissima (Mill.) Swingle **Ailanthus**

Simaroubaceae Quassia family

James H. Miller

Ailanthus *(Ailanthus altissima),* also called tree-of-heaven, Chinese sumac, paradise-tree, and copal-tree (fig. 1), is an introduced species that has become widely naturalized across the continent. Ailanthus has found an extremely wide variety of places to establish itself, from urban areas to reclaimed surface-mined lands. Its successful reproduction on impoverished soils and in harsh environments results from its ability to sprout from the roots and to seed prolifically. Ailanthus is found as an upper-canopy component, with varying frequency, in the eastern hardwood forests, apparently spreading by sprouting after harvest disturbance.

Figure *1-Ailanthus.*

The author is Research Forester, Southern Forest Experiment Station, New Orleans, LA.

Habitat

Native Range

Ailanthus, a native of China, was first introduced into the United States from England to Philadelphia, PA, in 1784. Extensive plantings in cities during the 1800's has resulted in its naturalization across the United States. An eastern range extends from Massachusetts, west to southern Ontario, southwest to Iowa, south to Texas, and east to northern Florida. It is found in less abundance from New Mexico west to California and north to Washington.

Climate

Because of its wide distribution, ailanthus grows under a variety of climatic conditions. Within the naturalized range of the species, the climate can be temperate to subtropical and humid to arid. In arid regions bordering the Great Plains, low precipitation, from 360 to 610 mm (14 to 24 in) annually with 8 dry months, can be tolerated *(7),* whereas in humid localities in the southern Appalachians rainfall can exceed 2290 mm (90 in) annually *(15).* Annual maximum and minimum temperatures are -9" and 36" C (15" and 97" F). Extreme cold and prolonged snow cover restricts the elevational range to the lower slopes of the Rocky Mountains and prolonged cold temperatures have reportedly caused dieback, but resprouting occurs *(1,7).*

Soils and Topography

Ailanthus grows best in loamy, moist soils but tolerates a wide range of textures, stoniness, and pH. On the dry end of the moisture spectrum it is drought hardy, and on the wet end it cannot tolerate flooding. The species is widely recognized by the urban populace since it frequently occupies and covers untended areas in cities. The species' tolerance of harsh sites led to testing for strip mine reclamation; a study in eastern Kentucky found ailanthus better adapted to acid spoil than to calcareous spoil and capable of growing on spoils with low to moderate phosphorus *(17).* Soils on which ailanthus is most commonly found are within the orders Ultisols, Inceptisols, and Entisols.

Associated Forest Cover

Because of ailanthus' scattered and disjunct occurrence over a wide geographical range, a listing of associated species would have little significance. Forest stands around cities are common areas of invasion and establishment, but it may be an occasional or minor component of forests following disturbance anywhere within its naturalized range.

Life History

Reproduction and Early Growth

Flowering and Fruiting-The yellowish-green flowers of ailanthus appear from mid-April to July, south to north, depending on latitude. The flowers are arranged in large panicles at the ends of new shoots. A dioecious species, it bears male and female flowers on different trees, with male trees producing three to four times more flowers than are usually found on female trees *(11)*. Male flowers are more conspicuous than female ones, emitting a disagreeable odor that attracts numerous insects. The foul odor of the male flowers makes the tree less favored for ornamental plantings in cities.

Seed Production and Dissemination-Pollination occurs in the spring and clusters of seed ripen from September to October. The fruit is a samara with the seed in the center of a thin, oblong wing, well adapted for wind dispersal. The ripe samaras are greenish yellow or reddish brown. The seed usually persists on the female tree through the winter, characterizing their appearance, but can be dispersed any time from October to the following spring. The species is a prolific seeder; the most abundant seed production is from trees that are 12 to 20 years.

After collection, seeds should be spread to air-dry. Number of seeds per kilogram averages from 27,000 to 33,000 (12,235 to 14,970/lb) and germination after cold stratification averages 65 to 85 percent *(7,18)*. Seeds should be stored dry in sealed containers. The recommended cold stratification is 5" C (41" F) in moist sand for 60 days.

Seedling Development-Seeds can be sown immediately upon ripening or stratified until spring. In nurseries, seeds are usually sown in the spring and seedlings transplanted early the following spring. Germination is epigeal. Vigorous first-year seedling growth of 1 to 2 m (3.3 to 6.6 ft) has been reported *(1,11)*. Average survival on 11 different plantings in Indiana strip mines was 74 percent after the first growing season and then decreased to 58 percent after the first winter (5). This illustrates the winter damage and mortality frequently reported *(1,7)*.

Because ailanthus is intolerant of shade, reproduction in natural stands appears sparse and erratic except by sprouting.

Vegetative Reproduction-The dense thickets of ailanthus reproduction on disturbed soils of road cuts and city building sites develop from root sprouts. Prolific root and stump sprouting has discouraged use of ailanthus as an ornamental species. After death or injury of the main stem the wide-spreading shallow root system can give rise to an abundance of sprouts. Sprouts have shown first-year height growth of 3 to 4 m (10 to 13 ft) (19). Thus, the species can be easily propagated from either root cuttings or from coppicing.

Sapling and Pole Stages to Maturity

Growth and Yield-Information on the growth and yield of ailanthus in the United States at this time is lacking. Maximum heights are often reported as 17 to 27 m (56 to 90 ft) and a maximum d.b.h. as 100 cm (40 in) *(10,12)*. A short-lived species, it lives *30* to 50 years *(20)*. On arid sites, 15 m (50 ft) or more of height growth can be reached in 25 years, with a straight bole for 10 to 12 m (33 to 40 ft) (7). At a New England location, trees reached a 10 to 15 m (33 to 49 ft) height and 9 to 11 cm (3.7 to 4.3 in) d.b.h. in 30 years *(11)*.

Rooting Habit-Ailanthus roots are shallow spreading, often apparent at the soil surface, and roots near the trunk thicken into enlarged storage structures. These large rounded structures are assumed to be for water storage, contributing to the drought hardiness of the species (4). There is a general absence of a taproot with most roots present in the upper 46 cm (18 in) of soil. Within this zone, the deeper roots send numerous small roots to the surface. Adventitious shoots may arise from any of the surface roots.

Reaction to Competition-Ailanthus is a successional pioneer species, intolerant of shade (8). It competes successfully in mixed stands of hardwoods throughout its range, indicating that it was present at the start of stand establishment.

Allelopathic effects on over 35 species of hardwoods and 34 species of conifers have been demonstrated for water extracts of ailanthus leaves *(14)*. Only white ash *(Fraxinus americana)* was not adversely affected. Germination and growth of slash

and Monterey pines *(Pinus elliottii* and *l? radiata)* were inhibited by scattering leaves of ailanthus collected in June and July on the seed bed surface, while leaves collected in October stimulated germination and growth (22). Such studies point to a strong allelopathic role for ailanthus in forest succession.

Damaging Agents-The species is relatively resistant to insect predation (7). Three insect species are known to feed on ailanthus foliage, however (2). Most noted of the foliage feeders in the eastern range, especially in the South, is the ailanthus webworm *(Atteva punctella).* Larvae from this insect feed on leaves enclosed in a frail, silken web. Another larval feeder, imported from Asia, is the Cynthia moth *(Samia Cynthia).* Ailanthus is the preferred host for this insect, but wild cherry and plum can also become infested. The Asiatic garden beetle *(Maladera castanea)* feeds on numerous plants during night flights, including ailanthus.

Although many fungi have been reported on the leaves and twigs of ailanthus, the tree suffers little from disease, and its pathology need rarely be a consideration in its culture (9). If ailanthus can be said to be subject to a major disease it would be Verticillium wilt *(Verticillium albo-atrum).* Many trees were killed by this soil-borne wilt in Philadelphia in 1936. Shoestring root rot *(Armillaria mellea)* has been reported in trees in New York *(16).*

While this tree is rated moderately susceptible to Phymatotrichum root rot *(Phymatotrichum omnivorum)* in Texas, it is considered most satisfactory for planting in the southern parts of Texas root rot belt *(20,23).*

In Texas, seeds are eaten by a number of birds, including the pine grosbeak and the crossbill (21). Occasional browsing by deer has also been reported.

Wind, snow, and hard freezes are damaging to tops of seedlings, while mature trees are resistant to ice breakage (3). Resprouting usually occurs, although repeated damage leads to a reduction in seedling survival.

Special Uses

Ailanthus's main importance remains in urban forestry, the original purpose of its importation into the United States. The species tolerance of noxious emissions of gases and various dusts assures its continued use for plantings in industrial environments. Tolerance of poor soils and low soil moisture dictates its selection for city plantings in arid climates as well as shelterbelt plantings and on strip mine reclamation projects, although its unfavorable traits (odor and root sprouting) have decreased city plantings. Root sprouting into fields is also a problem in shelterbelt plantings.

Pollinating insects are attracted by the male flowers. Honey from ailanthus has been reported as having an initial foul taste that disappears with aging, resulting in an exceptionally good tasting honey *(13).*

Genetics

In the two centuries since its introduction into North America, ailanthus has probably become differentiated into genetically different subpopulations based on seed traits. Seed characteristics of ailanthus have been identified as traits that differentiate varieties and geographical strains. Ailanthus with bright red samaras compared to the more common greenish yellow has been named *Ailanthus altissima* var. *erythrocarpa* (Carr.) Rehd. A study of 11 seed sources from California and Eastern States found that seed width and weight were correlated with latitude (6). Northern sources have wider, heavier seed than the more southern sources.

Literature Cited

1. Adamik, K., and F. E. Brauns. 1957. Ailanthus *glandulosa* (Tree-of-heaven) as a pulpwood. Part II. TAPPI 40:522–527.
2. Baker, Whiteford L. 1972. Eastern forest insects. U.S. Department of Agriculture, Miscellaneous Publication 1175. Washington, DC. 642 p.
3. Croxton, W. C. 1939. A study of the tolerance of trees to breakage by ice accumulation. Ecology 20:71–73.
4. Davies, P. A. 1944. The root system of *Ailanthus altissima.* Transactions of the Kentucky Academy of Sciences 11(3–4):33–35.
5. DenUyl, Daniel. 1962. Survival and growth of hardwood plantations on strip mine spoil banks in Indiana. Journal of Forestry 60:603–606.
6. Feret, Peter P., R. L. Bryant, and J. A. Ramsey. 1974. Genetic variation among American seed sources of *Ailanthus altissima* (Mill.) Swingle. Scientia Horticulturae 2:405–411.
7. Goor, A. Y., and C. W. Barney. 1968. Forest tree planting in arid zones. Ronald Press, New York. 409 p.
8. Grime, J. P. 1965. Shade tolerance in flowering plants. Nature 208(5006):161–163.
9. Hepting, George H. 1971. Diseases of forest and shade trees of the United States. U.S. Department of Agriculture, Agriculture Handbook 386. Washington, DC. 658 p.
10. Hottes, Alfred Carl. 1952. The book of trees. 3d ed. A. T. De La Mare, New York. 440 p.
11. Hu, Shiu-Ying. 1979. Ailanthus. Arnoldia 39(2):29–50.
12. Illick, Joseph S., and E. F. Brouse. 1926. The ailanthus tree in Pennsylvania. Pennsylvania Department of Forestry and Water Bulletin 38:1–29.
13. Melville, R. 1944. Ailanthus, source of peculiar London honey. Nature 134:640.

14. Mergen, F. 1959. A toxic principle in the leaves of *Ailanthus*. Botanical Gazette 121:32–36.
15. Patterson, D. T. 1976. The history and distribution of five exotic weeds in North Carolina. Castanea 41(2):177–180.
16. Pirone, P. P. 1959. Tree maintenance, 3d ed. Oxford University Press, New York. 436 p.
17. Plass, W. T. 1975. An evaluation of trees and shrubs for planting surface-mine spoils. USDA Forest Service, Research Paper NE-137. Northeastern Forest Experiment Station, Upper Darby, PA. 8 p.
18. Schopmeyer, C. S., tech. coord. 1974. Seeds of woody plants in the United States. U.S. Department of Agriculture, Agriculture Handbook 450. Washington, DC. 883 p.
19. Swingle, W. T. 1916. The early European history and the botanical name of the tree-of-heaven, ***Ailanthus altissima.*** Journal of the Washington Academy of Sciences 6:409–498.
20. U.S. Department of Agriculture. 1949. Trees. Yearbook of Agriculture 1949. Washington, DC. 944 p.
21. Vines, Robert A. 1977. Trees of East Texas. University of Texas Press, Austin and London. 538 p.
22. Voigt, G. W., and F. Mergen. 1962. Seasonal variation in toxicity of ***Ailanthus*** leaves on pine seedlings. Botanical Gazette 123(4):262–265.
23. Wright, Ernest, and H. R. Wells. 1948. Tests on the adaptability of trees and shrubs to shelterbelt planting on certain *Phymatotrichum* root rot infested soils in Oklahoma and Texas. Journal of Forestry 46:256–262.