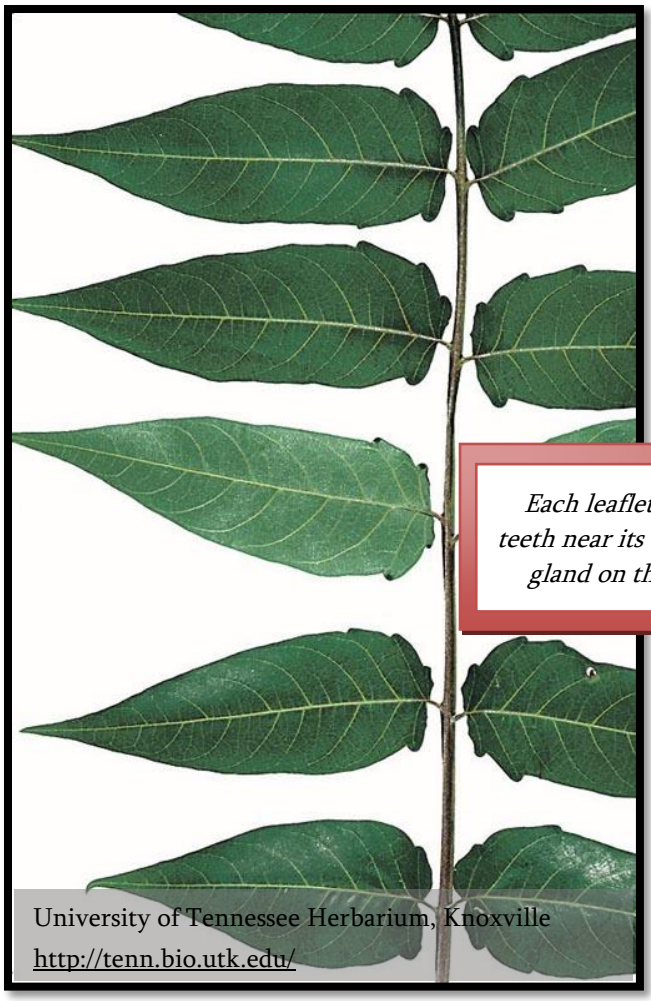
TREE-OF-HEAVEN *(Ailanthus altissima)*


University of Tennessee Herbarium, Knoxville
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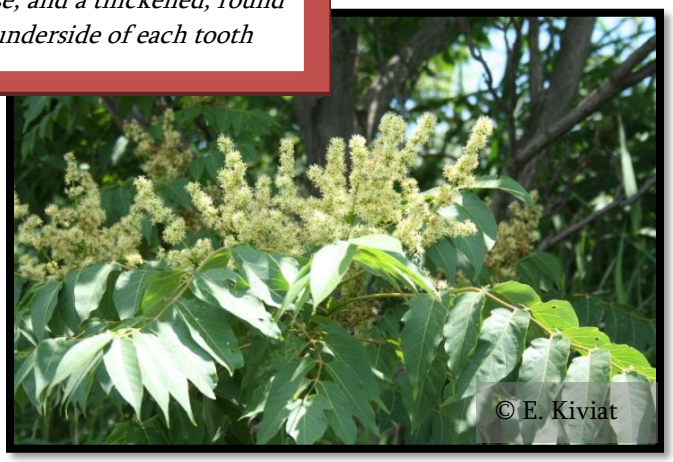
Bark of a medium-sized tree

Each leaflet has one or a few rounded teeth near its base, and a thickened, round gland on the underside of each tooth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A fast-growing tree to 20 m with large, compound leaves composed of 10-40 leaflets. Leaves and stems have a strong, unpleasant odor (likened to stale peanut butter) when crushed. In summer and fall, large drooping clusters of winged seeds are visible.

Native to central China and Taiwan, tree-of-heaven is now invasive around the world. In the US, it became widely available to gardeners in the 1820s and is now most abundant in the East, Upper Midwest, Pacific Northwest, and California.

Similar species: Several sumac (*Rhus*) species are most similar to tree-of-heaven. It can be distinguished from sumac as well as other trees with compound leaves by the presence of glands near the base of each leaflet. Also, tree-of-heaven has clear sap, while that of sumac is milky and sticky. Ashes (*Fraxinus*) have opposite leaves, and walnut and butternut (*Juglans*) leaflets are evenly toothed along the margins. Tree-of-heaven has a unique odor when bruised.

Tree-of-heaven

Where found: Tree-of-heaven is shade-intolerant, and usually found in open areas with disturbed, mineral soils.[1] It can grow in a wide range of soil types and conditions, and is tolerant of drought and most industrial pollutants. Tree-of-heaven also grows in dry-end wetlands, including estuaries.[2] Most common in urban areas and along roadsides, tree-of-heaven is also becoming an increasingly common component of young deciduous forests and forests with past disturbance (such as logging). It is most invasive in eastern deciduous forests.[1] Tree-of-heaven may become established in the forest interior by seed germination in canopy gaps. Mature trees produce numerous root sprouts (up to 27 m away from the trunk) that can persist for decades in the understory waiting for a gap to open, behaving much like the seedlings of shade-tolerant native forest trees.[3,4] Current forest disturbances such as oak defoliation, hemlock die-off, pipeline construction, and increased flooding from severe storms are all contributing to the spread of this species.[4]

Threats/benefits: Tree-of-heaven grows much faster than native trees in eastern forests, and its leaf litter has a higher nutrient content. Nutrient cycling is accelerated under its canopy, and this has the potential to alter forest composition: faster nutrient cycling benefits nonnative trees and certain native trees over others.[5] It also produces allelopathic chemicals in its roots and leaves that are toxic to other plants, microbes, and rodents.[1] Red oak, sugar maple, and red maple seedling growth was inhibited in its presence, and stimulated when the toxins were neutralized.[6,7] Native plant richness was lower under tree-of-heaven than under native trees in a European forest.[8] In urban areas, its root system can damage water facilities, archaeological sites, and walls and foundations of buildings.[1] In humans, exposure to the sap of tree-of-heaven can cause a severe rash[9] and potentially myocarditis (inflammation of the heart) and other symptoms.[10]

Tree-of-heaven has several economic uses: it is a source of chemicals with potentially important medical and agricultural (as an organic herbicide) uses; its wood can be used for wood products, firewood, or pulpwood for paper; and it can be planted as a shelterbelt to increase agricultural production in harsh, dry areas. Tree-of-heaven can also be useful for erosion prevention and reclamation on degraded lands such as landfills, mine spoils, and salinized soils.[11] Its potential to spread by seed into natural areas may outweigh the benefits of such uses in most situations. White-tailed deer (leaves), eastern cottontail (bark), northern cardinal (seeds), and insects (leaves) eat tree-of-heaven.[12] Tree-of-heaven supports macrofungi (including oyster mushrooms), and edible species can be cultivated as part of its control.[13]

Reproduction: Tree-of-heaven flowers in the spring and winged seeds develop in late summer-fall; seed production is prolific. Even very young, small trees may flower and produce seed. Seeds are dispersed by wind, water, and sometimes by rodents or birds, from fall through the following spring. Germination rates are high, but the seeds are short-lived in the seed bank (1-2 years). Tree-of heaven has an impressive ability to reproduce by vegetative sprouting from roots, root crown, and trunk. Root sprouts can produce new trees up to 27 m from the main trunk. Extensive root-

sprouting may occur even in the absence of damage to the main trunk, but is much greater after top growth is cut or damaged.[1]

Management Goals:

- Remove trees in a way that minimizes root sprouting; kill root sprouts annually until root is dead.
- Remove seedlings until seed bank is depleted.
- Monitor annually to prevent re-establishment, especially if there are seed sources nearby.

Management Methods:

- Kill sapling-sized stems (over 1 m tall) and mature trees over the course of one or two years; a slower death results in fewer resprouts. Do not cut trunks/stems without further treatment: this results in abundant resprouting and is worse than doing nothing.[14] Even two cuttings per year for four years did not have any effect on biomass or stem density, only stem height (in the Mediterranean).[15]
- In winter or early spring, partially girdle trees and sapling-sized stems, by carefully using a drawknife to remove 12-14" of bark (but not the cambium underneath), around the whole circumference of the trunk. When this method was used in an Ohio forest, all tree crowns were dead by the end of the growing season, although most had stump sprouts. The following year, 64% had no stump sprouts, and the others had few sprouts. To speed mortality, stump sprouts can be cut (or simply broken by stomping) each year until root is dead.[13]
- A similar method, using a drawknife to partially girdle the tree each year in late summer (1/4-1/2 of circumference, 6" cut, removing all cambium) resulted in 47% mortality (no stump sprouts) after 1-2 treatments, or 34% mortality after 3-4 treatments; trees in the former group were smaller, and were probably fully girdled in 1-2 years.[16]
- After crowns and smaller stems have been killed (to prevent seed production) hand-pull new seedlings (< 60 cm tall) for one or two years until seed bank is exhausted. Spot-mulching after pulling seedlings may lessen soil disturbance and germination of tree-of-heaven and other invasive plants.[17]
- Wear protective gear (gloves, long sleeves, glasses) and avoid inhalation of particles from the tree when cutting or girdling tree-of-heaven.
- Monitor the site to prevent establishment of other invasives; in one case, removal of tree-of-heaven (with herbicide) resulted in recolonization of native herbs the following year.[14]
- Minimize soil and canopy disturbance and monitor annually to prevent re-establishment, especially if there are seed sources nearby.

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