



**Tree of Heaven**

*Ailanthus altissima* (Mill.) Swingle  
Quassia family (Simaroubaceae)

**NATIVE RANGE**

Central China

**DESCRIPTION**

Tree-of-heaven, also known ailanthus, Chinese sumac, and stinking shumac, is a deciduous tree in the mostly tropical quassia family. Mature trees can reach 80 feet in height. Ailanthus has smooth stems with pale gray bark and twigs which are light chestnut brown, especially in the dormant season. Its large compound leaves are 1-4 feet in length, alternate, and composed of 10-41 smaller leaflets. Each leaflet has one or more glandular teeth along the lower margin. The leaf margins are otherwise entire or lacking teeth. Ailanthus is a dioecious (“two houses”) plant meaning that male and female flowers occur on separate plants. Flowers occur in large terminal clusters and are small and pale yellow to greenish. Flat, twisted, winged fruits each containing a single central seed are produced on female trees in late summer to early fall and may remain on the trees for long periods of time. The wood of ailanthus is soft, weak, coarse-grained, and creamy white to light brown in color. All parts of the tree, especially the leaves and flowers, have a nutty or burned nut odor.



**Look-alikes:** It is important not to confuse native shrubs and trees with ailanthus. Native sumacs (*Rhus*) and trees like ash (*Fraxinus*), hickory (*Carya*), black walnut, butternut and pecan (*Juglans*) can be distinguished from tree-of-heaven by having completely serrated (toothed) leaf margins.

**ECOLOGICAL THREAT**

Tree-of-heaven is a fast-growing tree and a prolific seeder, that can take over sites, replacing native plants and forming dense thickets. Ailanthus also produces chemicals that prevent the establishment of other plant species nearby. Its root system may be extensive and has been known to cause damage to sewers and foundations.



**DISTRIBUTION IN THE UNITED STATES**

Tree-of-heaven occurs in many states across the continental U.S. and Hawaii and to date has been reported to be invasive in natural areas in 30 states (see map).

**HABITAT IN THE UNITED STATES**

Tree-of-heaven is a common tree in disturbed urban areas, where it sprouts up just about anywhere, including alleys, sidewalks, parking lots, and streets. For example, the book “A Tree Grows in Brooklyn,” by Betty Smith, is based on the tree-of-heaven. Away from cities, ailanthus is commonly seen in fields, and along roadsides, fencerows, woodland edges and forest openings. It occurs as seedlings that pop up by the hundreds in recently planted fields and as persistent thickets in rocky, untillable areas. Nationally, ailanthus is recognized to be a serious agricultural pest.

**BACKGROUND**

Tree-of-heaven was first introduced to America by a gardener in Philadelphia, PA, in 1784, and by 1840 was commonly available from nurseries. The species was also brought into California mainly by the Chinese who came to California

during the goldrush in the mid-1800s. Today it is frequently found in abandoned mining sites there. The history of ailanthus in China is as old as the written language of the country.

### **BIOLOGY & SPREAD**

Tree-of-heaven reproduces both sexually (by seeds) and asexually through vegetative sprouting. Flowering occurs late in the spring. Ailanthus is dioecious, with male and female flowers on separate plants. The fruits, or samaras, occur in terminal clusters on female plants during the summer, and may persist on the tree through the winter. One study reports that an individual tree can produce as many as 325,000 seeds per year. Established trees also produce numerous suckers from the roots and resprout vigorously from cut stumps and root fragments.



### **MANAGEMENT OPTIONS**

Elimination of Ailanthus requires diligence, due to its abundant seed production, high seed germination rate, and vegetative reproduction. Followup monitoring and treatment when needed should be an integral part of any serious ailanthus management program. Regardless of method selected, treated areas should be rechecked one or more times a year and any new suckers or seedlings treated (cut, sprayed or pulled) as soon as possible, especially before they are able to rebuild root reserves. Establishing a thick cover of trees (non-invasive and preferably native) or grass sod will help shade out and discourage establishment of ailanthus seedlings. Targeting large female trees for control will help reduce spread of ailanthus by seed.

#### **Biological**

Several fungal pathogens are being investigated as potential biological controls for ailanthus. Two of these, *Verticillium dahliae* and *Fusarium oxysporum*, have been isolated from dead and dying ailanthus trees in New York and in southern and western Virginia. A disease affecting ailanthus in PA was studied using inoculations in the lab and on canopy field trees; the agent was identified to be *Verticillium albo-atrum* and is being suggested as a potential biocontrol agent pending further studies including risk analysis. None are available for use at this time however.

#### **Manual**

Young seedlings may be pulled or dug up, preferably when soil is moist. Care must be taken to remove the entire plant including all roots and fragments, as these will almost certainly regrow. Root suckers appear similar to seedlings, but would be connected to a pre-existing lateral root, and would be nearly impossible to remove effectively.



#### **Mechanical**

Cutting alone is usually counter-productive because ailanthus responds by producing large numbers of stump sprouts and root suckers. However, for small infestations, repeated cutting of sprouts over time can exhaust the plants reserves and may be successful if continued for many years or where heavy shade exists. If possible, the initial cutting should be in early summer in order to impact the tree when its root reserves are lowest. Cutting large seed producing female trees would at least temporarily reduce spread by this method.

#### **Chemical**

The most effective method of ailanthus control seems to be through the use of herbicides, which may be applied as a foliar (to the leaves), basal bark, cut stump, or hack and squirt treatment. Keep in mind that it is relatively easy to kill the above ground portion of ailanthus trees, you need to kill or seriously damage the root system to prevent or limit stump sprouting and root suckering. Always be extremely careful with herbicide applications in the vicinity of valuable ornamental shrubs and trees.

*Foliar sprays* applied when trees are in full leaf are very effective, and should be the method of choice where ailanthus size and distribution allow effective spray coverage of all foliage without unacceptable contact with nearby desirable vegetation or applicator. Where ailanthus is in association with other exotic weed species, as is often the case, foliar spray allows treatment of the entire area at one time. Limitations of the method are the seasonal time frame, the need to transport a larger, more diluted volume of spray material, and the fact that rapid growing ailanthus are often out of

effective reach. The non-selective herbicide glyphosate (e.g., Roundup®, Rodeo®, Accord®), will kill or injure almost any plant, herbaceous or woody, contacted by the spray. Triclopyr (e.g., Garlon® 3A, Garlon® 4) is selective for broadleaf and woody plants and will not kill grasses contacted by the spray. Both glyphosate and triclopyr are systemic herbicides, meaning that they are absorbed by plants and are carried to the root systems. These herbicides have low soil activity, so do not pose a threat to groundwater if applied properly and at recommended label rates. Both glyphosate and triclopyr should be mixed with water and a small amount (0.5%, or as per label) of a non-ionic surfactant (except for Roundup®, which contains a surfactant) to help the spray spread over and penetrate the leaves. The mixture should be applied to leaves and green stems, including sprouts and suckers, until thoroughly wet but not to the point of runoff. With backpack sprayers, concentrations of 2% of a typical glyphosate product such as Roundup® or Accord® applied June 15 - September 15, or 1.5% of a 4 lb./gallon triclopyr product such as Garlon® 4, or 2% of a 3 lb./gallon triclopyr product such as Garlon® 3A applied June 1-September 1 have worked well in the Mid-Atlantic area, with slightly greater effectiveness for the triclopyr products. For higher volume applications such as would be applied by a truck mounted sprayer, the concentration for these products could be reduced by 0.5% to 1-1.5%. Other herbicides which have shown to be effective for foliar application of ailanthus are imazapyr (e.g., Arsenal®, Chopper®), and metsulfuron methyl (e.g., Escort®).

*Basal bark* application is one of the easiest methods and does not require any cutting. It works best during late winter/early spring and in summer. The base of the tree stem must be free of snow, ice, or water on the bark from recent rainfall, though precipitation following application is inconsequential. Late winter/early spring (February 15 -April 15, Mid-Atlantic) is generally the most productive time, since vegetation near the base of the trees is usually absent or leafless. Late spring and early summer applications (April 15-June 1, Mid-Atlantic), when plant fluids are moving upwards to support new growth, are questionable. Application during the summer (June 1-September 15, Mid-Atlantic) works very well as long as vegetation is not a hindrance, and allows lower concentrations of herbicide to be used. Fall to mid-winter applications (October-January) have given poor results. Mix up a solution of 20% (as low as 10% in summer depending on objectives) concentration of oil-soluble triclopyr product (e.g., Garlon® 4) in 80% oil (fuel oil, diesel, kerosene, mineral oil, or special vegetable oils). With these diluents some applicators add a pine oil based additive (e.g., Cide-Kick® II) at the rate of 10%, which helps penetrate the bark and eliminate any unpleasant odor. Some companies market diluents based on mineral or vegetable oils specifically designed for basal bark application, which should be considered for use in sensitive areas. Another option is to use a pre-mixed, ready-to-use triclopyr product designed for basal bark (and cut stump) application (e.g., Pathfinder® II). Using a handheld or backpack type sprayer, apply the mixture in a 12 inch wide band around the entire circumference of the tree base with no "skips". The basal bark method is generally used for trees that are less than 6 inches in diameter, though slightly larger stems may also be treated effectively by thoroughly treating bark up to 24 inches in height. Follow-up foliar herbicide application (see above) to basal sprouts and root suckers may be necessary. Another herbicide which has been shown to be effective for basal bark control of ailanthus is imazapyr (e.g., Chopper®, Stalker®). This is sometimes used in a combination with triclopyr at a concentration of 15% Garlon® 4 and 5% Stalker® in 80% oil dilutant.

The *hack-and-squirt or injection* method is very effective and minimizes sprouting and suckering when applied during the summer. Root suckering will be an increasing problem in the fall, winter and spring. This method requires first making downward-angled cuts into the sapwood around the tree trunk at a comfortable height, using a hand ax. With spray bottle or wand in the other hand, squirt a straight (100%) concentration of a water-soluble triclopyr product (e.g., Garlon® 3A) into the cuts within a minute or two, applying 1-2 milliliters into each cut (typically 1-2 squirts of a trigger squirt bottle) so that the bottom of the cut is covered, but liquid doesn't run out of it. Generally, you would make about 1 hack cut for each inch of diameter plus one (i.e., for a 10 inch diameter tree, make about 11 cuts). Space the cuts so that about 1-2 inches of uncut living tissue remains between them. A continuous line of cuts around the trunk would likely cause the tree to go into emergency response mode and react by producing basal sprouts and root suckers. For this reason, girdling or frilling (girdling followed by herbicide) is not highly recommended unless long term follow-up treatment is possible. While spaced injection works well for ailanthus, it is not as effective on some other species. This method can be used with trees of any size, though it is most productive with stems over 2 inches in diameter. This method is relatively easy for one person to do, with hatchet in one hand and spray bottle in the other, but should be done with a buddy nearby in case of an accident. Monitor the treatment area and be prepared to follow-up with a foliar application the next year to control any basal sprouts or root suckers that might emerge. Glyphosate products have sometimes been recommended for control of ailanthus using this method, but several field trials have shown consistently poor long-term control of basal sprouts and root suckers at any time of year. Other herbicides which have shown to be effective for hack-and-squirt control of ailanthus during the growing season are dicamba (e.g., Banvel®, Vanquish®), imazapyr (e.g., Arsenal® A.C., Chopper®), and 2,4-D + picloram (e.g., Pathway®). Dicamba is particularly effective in October.

The *cut stump* method is useful in areas where the trees need to be removed from the site and will be cut as part of the process. While situations exist that dictate this method over the others given above, felling trees is usually less effective in killing the root system, slower, more labor intensive, and more hazardous to personnel than other methods. This method is likely to be most successful during the growing season, with diminishing success through the early fall. Dormant season applications may prevent resprouting from the stump itself, but will do little to inhibit root suckering. However, at any time of year, if the tree must be cut it is better to treat the stump than not. Application of herbicide to the cut stumps must be conducted immediately after cutting, within 5-15 minutes of the cut with water soluble formulations, longer with oil mixtures, to ensure uptake of the chemical before the plant seals the cut area off. The mixture may be painted on with a paint brush or sprayed on using a spray bottle or backpack sprayer. A mixture of 20% Garlon® 4 plus 80% oil dilutant, as for basal bark spraying (above), may be used. In this case the whole stump surface and sides to the ground line would be sprayed. Another option is to use Garlon® 3A at 100%, treating only the outer 1/3 of the stump surface. Be prepared to follow-up with a foliar application the next year to control any stump sprouts or root suckers which emerge. Other herbicides which have shown to be effective in stump treatment of ailanthus are the same as those listed above for hack and squirt or injection.

**USE PESTICIDES WISELY:** Always read the entire pesticide label carefully, follow all mixing and application instructions and wear all recommended personal protective gear and clothing. Contact your state department of agriculture for any additional pesticide use requirements, restrictions or recommendations.

**NOTICE:** mention of pesticide products on this page does not constitute endorsement of any material.

## CONTACTS

For more information on the management of Tree-of-heaven, please contact:

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## SUGGESTED ALTERNATIVE PLANTS

Many lovely native trees and shrubs make excellent substitutes for Ailanthus and are readily available. Some examples for the eastern United States include deciduous shrubs such as staghorn sumac (*Rhus typhina*), smooth sumac (*Rhus glabra*), fringe-tree (*Chionanthus virginicus*), black walnut (*Juglans nigra*), butternut (*Juglans cinerea*) and hickories (*Carya*). Whenever possible, use plant species that are native and adapted to the ecological region where you live. They will be more valuable to the wildlife species that have evolved with them and depend upon them for food and shelter. Check with your local native plant society for recommendations and sources of native plants.

## OTHER LINKS

- <http://www.invasive.org/search/action.cfm?q=Ailanthus%20altissima>
- <http://nbii-nin.ciesin.columbia.edu/ipane/icat/browse.do?specield=30>

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