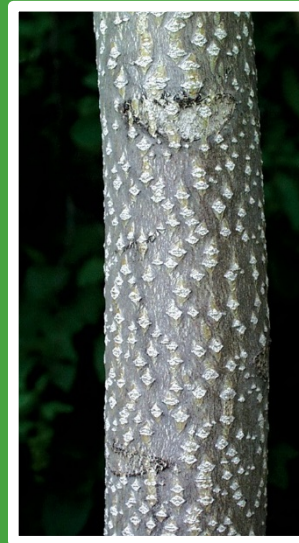


# Field Guide for Managing Tree-of-heaven in the Southwest



## Cover Photos

*Left: L.J. Mehrhoff, University of Connecticut, Bugwood.org*

*Upper right: Chuck Barger, University of Georgia, Bugwood.org*

*Lower right: Paul Wray, Iowa State University, Bugwood.org*

---

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at [http://www.ascr.usda.gov/complaint\\_filing\\_cust.html](http://www.ascr.usda.gov/complaint_filing_cust.html) and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: [program.intake@usda.gov](mailto:program.intake@usda.gov).

USDA is an equal opportunity provider, employer and lender.

---

# Tree-of-heaven (*Ailanthus altissima* (Mill.) Swingle; synonyms: *A. glandulosa*, *Toxicodendron altissimum*)

Quassia family (Simaroubaceae)

---

Tree-of-heaven is an invasive tree in southwestern States that has been listed as a noxious weed in New Mexico. This field guide serves as the U.S. Forest Service's recommendations for management of tree-of-heaven in forests, woodlands, and riparian areas associated with its Southwestern Region. The Southwestern Region covers Arizona and New Mexico, which together have 11 national forests. The Region also administers 4 national grasslands located in northeastern New Mexico, western Oklahoma, and the Texas panhandle.

## Description

Tree-of-heaven (synonyms: ailanthus, Chinese sumac, stinking sumac, paradise tree, copal tree, Brooklyn palm) is a fast growing tree that was introduced as an ornamental into the United States from China. Both its common and scientific name refer to its rather tall height (60 to 80 feet). Tree-of-heaven is dioecious with female trees producing clusters of persistent, one-seeded, winged fruit that resemble those found on maples. Male trees produce groups of staminate flowers that smell like burnt peanuts or cashews.

## Growth Characteristics

- Deciduous tree; 60 to 80 feet tall; 80 foot crown width; up to 3 foot trunk diameter.
- Perennial but generally a short-lived tree (30 to 50 years). Beige to light brown wood is soft, weak and coarse-grained; breaks easily.
- Bark is light brown to pale grey when mature; smooth bark becomes rough and fissured on trunk.
- Branches are grey, glossy and smooth with raised dots that become fissures with age. Twigs are reddish-brown and velvety.
- Pinnately compound leaf (1 to 4 feet long) with 10 to 41 leaflets (2 to 7 inches long).

- Dark green, broadly lanceolate leaflets; margins entire with teeth or lobes at the base; light green veins and whitish green underneath with glandular red dots near lobes.
- Dioecious; numerous, small, yellow-green flowers on 8 to 16 inch panicles; produced mostly in June and July in New Mexico. Staminate flowers malodorous.
- Persistent, propeller-like fruits (1.5-inch-long samaras); fruit turns pale green to tan to reddish as it matures. Fruits occur in dense clusters.
- Seed is both sexually and asexually produced with up to 300,000 seeds per tree in a year. In general, seeds are not long lived and usually do not persist in the seed bank for more than a year or two.

## Ecology

### Impacts/Threats

Tree-of-heaven is an extremely competitive, fast-growing tree with young sprouts growing as much as 10 to 15 feet in a year. Once established, it can overrun native vegetation by developing dense thickets of cloned trees. It can dominate colonized sites indefinitely through re-sprouting and root suckering. Coupled with its size and structural weakness, the rapid rate of spread and growth of tree-of-heaven makes it an acute hazard along roadsides. In urban areas, tree-of-heaven roots can damage sewer lines and structures.

### Site/Distribution

Tree-of-heaven establishes readily along roadsides, fence rows, railways, woodland edges, forest openings, or in riparian zones. It is often found in waste areas or disturbed sites such as old fields and abandoned areas (e.g., mining communities). The species is intolerant of flooding and deep shade; but it can occur in areas where trees normally do not grow such as cliff crevices or paved areas (parking lots, sidewalks, etc.). Tree-of-heaven is widespread across the United States (especially in eastern forests and

woodlands), but infestations tend to be more localized in the Southwest.

### **Spread**

Tree-of-heaven is a prolific seed producer; and its seed may be dispersed via wind, water, birds, and farm or road equipment. However, the majority of new plants within an area are usually from root sprouts. If the top is removed or the stump is cut, new sprouts from lateral roots may occur 50 to 90 feet from the parent tree.

### **Invasive Features**

Tree-of-heaven is highly adaptable and can grow under limiting or harsh conditions such as soils that are saline, nutrient poor, or highly compacted. It will also grow in areas affected by heat, drought, or pollution. Allelopathic chemicals in leaves, bark, roots, and seed inhibit growth and germination of surrounding plants.

## **Management**

It is very difficult to control tree-of-heaven once established. Strategies to control populations require long-term planning, integrated management, and follow-up monitoring. A commitment to repeated management actions is a must. The following actions should be considered when planning a management approach:

- Maintain healthy plant communities to limit tree-of-heaven establishment. Minimize disturbance and/or promptly revegetate disturbed or bare ground areas with desirable native species.
- Conduct surveys, map known infestations, and monitor for tree-of-heaven, especially on roadsides, fence lines, trails, waterways, parking lots, etc. Keep annual records of reported infestations.
- Combine mechanical, cultural, and chemical methods for most effective control of tree-of-heaven.
- Implement a monitoring and follow-up treatment plan in areas where control practices have been made to further suppress root sprouts and seedlings.

Table 1 summarizes some management options for controlling tree-of-heaven under various situations. Further details on these management options are explained below.

Choice of individual control method(s) for tree-of-heaven depends on the extent and density of infestation, current land use, and site conditions (accessibility, terrain, microclimate, other flora and fauna present, etc.). Other important considerations include treatment effectiveness, overall cost, and number of years needed to achieve control. More than one control method may be needed for a particular site.

## **Physical Control**

Tree-of-heaven is not easily controlled by simple cutting or by other mechanical means. Not only do trees re-sprout with tremendous vigor, but massive root suckering also occurs, which in some cases results in many more new stems spreading over a wider area. There are several practical techniques that can help make physical control of tree-of-heaven more effective. These include (1) cutting trees before they become too large; (2) cutting trees in early summer when root reserves are lowest; (3) cutting regrowth repeatedly and frequently, and applying herbicide to cut surfaces; and (4) providing shade from competitive native plants after control efforts.

### **Manual Methods**

**Hand pulling** – Very young seedlings can be pulled or dug up, depending on soil conditions. Seedlings are easily distinguished from root sprouts by their slender stems, trifoliate leaflets, and cotyledons (if still present). Pull when soils are moist and be sure to remove the entire root.

**Grubbing** – For saplings or young trees, hand grubbing or mechanical extraction of roots may be effective. However, grubbing is usually not practical for mature trees or dense stands. Removal of the entire root is necessary for control of individual trees.

### **Mechanical Methods**

**Mowing** – After larger trees have been cut to ground level, re-sprouting wood is soft enough to be mowed at regular intervals, which can stress root reserves lead to fewer root suckers. However, an infrequent mowing cycle may allow the sprouts to spread and become too tall to mow. Mowing is more effective when followed by a chemical treatment. *Mowing equipment should be cleaned after use to prevent movement of seeds into un-infested areas.*

**Table 1. Management options\***

Site	Physical Control	Cultural Control	Biological Control	Chemical Control
Roadsides, fence lines, rights-of-way, and non-crop areas	Cut larger top growth to ground level in spring or early summer; use mowing as a follow-up treatment at regular intervals throughout the growing season. Tools for cutting include loppers, machetes, brush cutters, and power saws. A cutting method is more effective as a treatment if followed up with chemical treatment.	Educate road crews to identify and report infestations along roads.  Coordinate control efforts with other land managers.	Consider using goats in combination with herbicide spraying.	Methods include foliar application, basal bark spray, cut-stump; injection, application of herbicide to cut areas. Use targeted application with a systemic herbicide.
Pasture, rangeland, or riparian corridors	Hand pull or dig out very young seedlings. Older seedlings/saplings need to be root grubbed or girdled at the base.  Physical methods alone are generally not recommended as they often result in significant basal and root sprouting. If used, follow up with a chemical treatment.	After removal of tree-of-heaven, monitor or root sprouts and seedlings; then cut, pull, or spray them. Bag and dispose of seed in a landfill or by burning.  Place signs near trailheads or road corridors; educate public to identify and report infestations.	Same as above.	Methods include foliar application, basal bark spray, cut stump, stem injection. In aquatic or riparian areas, use herbicides approved for use in these areas.  For mature trees, apply herbicide in cuts made in the bark by a girdling or drilling method. Grooves in the bark should be made all around the trunk, and the cut should be deep enough to go through the cambial layer down into nonliving layers. Girdle or drill in June and early July.
Forest openings, fields, and/or extensive, dense infestations	Physical methods alone are generally not recommended as they often result in significant basal and root sprouting. If used, follow up with a chemical treatment.	Before timber harvest or construction, locate and eradicate all life stages of tree-of-heaven that are present.	Same as above.	Apply herbicide via aerial or broadcast foliar spray, basal bark spray, cut stump, or injection method. Avoid desirable tree species, if present.
Wilderness, other natural areas, and/or small infestations	Remove very young seedlings by hand; most effective in loose, rain-moistened soils. Be sure to remove entire seedling root. Not practical for older seedlings or root sprouts unless accompanied with herbicide application.	Place signs near trailheads; educate public to identify and report infestations.	Same as above.	Individual plant treatment (IPT) methods including foliar application, basal bark spray, cut stump, or stem injection. Leave treated plants in place so they can easily be monitored later for regrowth.

\*Choice of a particular management option must be in compliance with existing regulations for the land resource.

### **Prescribed Fire**

Controlled burning is likely to favor further spread of tree-of-heaven since prolific root and stump sprouting occurs in response to fire stress. Scorching or heat girdling individual plants by using a blowtorch or flamethrower may be an option, but monitoring and follow-up treatment of root and stump sprouts will be required.

### **Cultural Control**

Early detection and plant removal are critical in managing this species. Coordinated efforts should be made between land managers, the local public, and road crews, etc., on identification of tree-of-heaven so suspected infestations can be reported. Vehicles, humans, and livestock should be discouraged from traveling through infested areas; and a program to check and remove seeds from vehicles and livestock after going through infested areas should be considered.



## **Biological Control**

### ***Grazing***

Tree-of-heaven usually has low palatability for grazers; however, livestock (cattle, sheep, and goats) and deer will consume it during certain times of the year under specific circumstances. Goats will eat leaves and bark. Deer will browse leaves during the summer—especially in shady, forested areas. Under heavy grazing pressure, livestock will remove new suckers and sprouts. Use of grazing in combination with herbicide spraying may be effective in certain situations.

### ***Classical Biological Control***

A number of insects and diseases affect tree-of-heaven; however, there are no classical biocontrol agents currently approved for use in the United States.

## **Chemical Control**

Application of herbicide is usually the most effective way to kill the root system of mature tree-of-heaven and to control regrowth from cut trees that occurs as sprouts or root suckers. There are several registered products that can be applied in a variety of ways including (1) foliage application, (2) topical application to cut stems and stumps, (3) injection into the trunk, and (4) basal spraying.

Although aboveground portions of tree-of-heaven are relatively easy to suppress or kill with herbicide treatment, it is also important to control the root system. Therefore, special attention should be paid to selection of the correct herbicide, optimal application rate, and appropriate time to obtain good results. It is important to read and carefully follow all instructions and warnings provided on the herbicide label. Aquatically approved herbicide formulations and surfactants must be used in or near water.

### ***Herbicide Control Methods***

**Foliar spraying** may be used to control younger trees or low growing tree-of-heaven infestations that can easily be covered with a spray solution. Apply herbicide to fully expanded leaves by using a backpack sprayer for individual plant treatment (IPT) or treat clusters of trees

using a tractor or truck-mounted sprayer (broadcast application). Thoroughly wet all green leaves and shoots, especially near the top of the tree. Care should always be taken when using any herbicide not to spray near nontarget plants. Any equipment used to spray herbicide should be calibrated.

Table 2 below provides herbicide recommendations for foliar spraying. The two most common herbicides used on tree-of-heaven with the foliar spray approach are glyphosate and triclopyr. These systemic herbicides are absorbed through leaves and stems and then transported to the root system. They have low soil activity so they pose little risk to groundwater if applied properly. When using a backpack sprayer, a 2 percent solution of either glyphosate or imazapyr is effective on healthy trees that are fully leafed-out. A new herbicide option that has not been widely tested for foliar application is Viewpoint®. This product is a combination of aminocyclopyrachlor, imazapyr, and metsulfuron. Consult the label closely when mixing or applying any herbicide solution. Use of a nonionic surfactant (0.5 percent or as per label) is often recommended to ensure even coverage and, thus, greater herbicide uptake into the leaves. However, some herbicides come premixed with a surfactant; and the label should always be checked for mixing directions.

**Basal bark spraying** is an effective control method that does not require cutting. This method is optimally used when tree-of-heaven is fully leafed but before it begins to show fall color. However, basal bark spraying can be labor intensive and is most appropriate for treating small infestations or isolated trees, especially those with trunk diameters between 4 and 8 inches. For trunks less than 6 inches in diameter, a continuous 12-inch wide band should be sprayed around the tree base. For trunks greater than 6 inches, apply a 24-inch band. Add a dye to the solution to aid in determining coverage. Consult the herbicide label for mixing and application directions.

The most commonly recommended herbicide for low-volume basal bark spraying is triclopyr mixed as a 20 percent herbicide:80 percent crop oil solution. A mixture of 20 percent picloram:20 percent triclopyr:60 percent crop oil can improve the effectiveness of control;

**Table 2. Herbicide recommendations for foliar spraying**

Common Chemical Name (active ingredient)	Product Example <sup>1</sup>	Broadcast Treatment (rate per acre)	Spot Treatment (spray solution) <sup>2</sup>	Time of Application	Remarks
Glyphosate	Roundup Pro (41%) [others available]	2–5 quarts	2% (use with 0.5% surfactant and a blue indicator dye)	Summer/early fall; apply when tree is actively growing and fully leafed, but before fall color begins.	Nonselective herbicide; overspray can injure surrounding plants and open more area for weeds.
Imazapyr	Arsenal Habitat Chopper Stalker [others available]	Arsenal: 1–1.5 pints Chopper: 2–3 pints	Arsenal: 1–5% Chopper: 5%	Same as above.	Nonselective herbicide; overspray can injure surrounding plants and open additional area for weeds. In addition to spray drift, non-target plants may also be killed or injured by imazapyr through runoff, residue movement in soil, or root exudates from treated plants.
Aminocyclopyrachlor + imazapyr + metsulfuron methyl	Viewpoint	13–20 ounces	Consult label for spot applications.	Apply as high volume or broadcast foliar spray.	Nonselective herbicide used on non-crop sites; may cause temporary injury to some grass species.
Triclopyr	Garlon 4 Remedy [others available]	3–6 quarts	1–2%	Summer/early fall; apply when tree is actively growing and fully leafed, but before fall color	Selective, systemic herbicide; will not impact grasses but can harm other trees, shrubs, and broadleaf plants.
Dicamba	Vanquish Banvel [others available]	2 quarts	5%	Same as above.	Same as above.

<sup>1</sup> Trade names for products are provided for example purposes only, and other products with the same active ingredient(s) may be available. Individual product labels should be examined for specific information and appropriate use with tree-of-heaven.

<sup>2</sup> Spray solution is the herbicide/water ratio in a spray mix that may be used for spot treatment with backpack or hand-held sprayers. The amount of product applied during an annual growing season must not exceed the maximum application rate per acre as specified by the product label – refer to the product label for the site type and application.

however, a certified applicator must be used to apply the mixture since picloram is a restricted-use product. Stalker® (imazapyr) has also been shown to be effective for basal bark control. It can be used alone or in combination with Garlon® 4 (triclopyr) at a concentration of 5 percent Stalker®, 15 percent Garlon®, and 80 percent oil diluent. Wetting around the entire trunk is necessary for good control.

A backpack sprayer fitted with an adjustable cone nozzle can be used for basal bark spraying. Apply herbicide using approximately 30 psi and spray until the bark is wet, but not running off (approximately 3/4 teaspoon of mixture

per inch of stem diameter). Leave treated trees standing in place so they can be revisited the next year and, if necessary, new foliage can be spot sprayed.

IPT cut stump treatment is often used in areas where mechanical treatments or foliar-applied herbicide spraying are restricted due to logistical considerations or when there is a need to be highly selective for protection of nontarget vegetation. The treatment involves hand cutting or chain sawing a tree as close to the ground surface as reasonable. The cut surface should be horizontal to the ground to minimize runoff, and any residual sawdust over the cut surface should be removed prior to herbicide application.

Herbicide is then applied to the stump with a paintbrush, hand-held spray bottle, or backpack sprayer. The herbicide must be applied to the cut surface within 5 minutes after cutting to ensure uptake of the chemical before the cut area is sealed off by the plant. For cut stumps larger than 4 inches in diameter, herbicide should be applied to the cambial layer lying just inside the bark ring. The top, sides, and exposed roots of smaller cut stumps (including those occurring in clumps) should be thoroughly wetted with herbicide. Cut trunks, limbs, and other top growth should then be disposed of in an acceptable manner such as stack piles or chipped.

For cut stump treatments, a solution of triclopyr ester or imazapyr should be used in a mixture with bark oil or crop oil. The herbicide:oil mixture ratio can vary from 33:67 to 50:50 v/v depending on the number and size of plants to be treated and the application technique used. A lower ratio (33:67) is typically used when applications are made with a low volume backpack sprayer or hand-held spray bottle, whereas a higher ratio (50:50) can be used when the solution is brushed directly onto the cut stump. A blue indicator dye should be added to the spray mixture to show that a stump has been treated.

The mortality rate from cut-stump treatments is directly related to care taken when treating cut surfaces. Control can be 60 to 80 percent under optimal conditions, but overall plant kills may be much lower due to difficulties associated with this method. Therefore, follow-up treatment using ground-based foliar applications should be anticipated.

**Girdling or frilling with herbicide** is effective for tree-of-heaven with large diameter trunks (i.e., greater than 8 inches) and thick, mature bark. Using an ax or hatchet, make a horizontal cut or groove (0.5 to 1.5 inches deep and 2 to 8 inches wide) through bark and cambial tissue around the entire circumference of the trunk. The width and depth of the groove should be in proportion to the tree's diameter. Girdling can be done more quickly if a chain saw is used to make two horizontal cuts through the bark that are circumferential around the entire trunk; one cut should be 2 to 4 inches above the other. Frilling is a variation of

girdling in which the groove made by an ax or hatchet around the tree still has the partially severed bark and wood attached at the bottom of the groove to allow retention of the applied herbicide.

Tree-of-heaven should not be girdled or frilled without chemical treatment as it will respond by producing fast growing root and stem sprouts. **Cut surfaces from girdling or frilling must be sprayed or painted until thoroughly wet by applying a herbicide solution within 5 minutes.** Commonly used herbicides for this method include a 2 to 5 percent solution with either glyphosate, imazapyr, triclopyr, or picloram with 2,4-D. The most effective time for using this method is during summer (June or early July) when tree-of-heaven has fully leafed-out and is actively growing. Leave the tree in place following girdling or frilling to reduce stump sprouting.

**Stem injection (hack-and-squirt)** is similar to the frilling method described above except that the bark is not continuously cut around the tree trunk. Using a hand ax or hatchet, a line of downward-angled or nearly vertical cuts are spaced about an inch apart around the trunk at a convenient height. Cuts should be made so as to leave a partially severed piece of bark and cambium attached at the bottom of the cut. **With a spray bottle or wand in the other hand, squirt the herbicide directly onto all cut areas within 5 minutes of cutting.** On average, there will be one hack/squirt per each inch of stem diameter. There are some commercially available cutting tools (hatchets) that are equipped to allow the herbicide to be directly injected with each cut. If using a spray bottle, read the herbicide label to determine the exact quantity of chemical to be used in each cut. About 1 milliliter of a fairly concentrated herbicide solution should be applied to each cut. Generally, 1 to 2 squirts from a quart or pint trigger spray bottle is equivalent to 1 to 2 milliliters (1/4 to 1/2 teaspoon). Apply herbicide so that it is wet within the cut but such that the solution is not running out. Triclopyr is most often recommended for the hack-and-squirt method although other herbicides (imazapyr, dicamba, and picloram) may also be used. However, glyphosate has usually been found not to be as effective with this particular cut surface approach.



## Management Strategies

Control efforts for tree-of-heaven should focus first on preventing establishment in new areas. Next, small infestations should be treated; mature female trees located on otherwise healthy sites should especially be targeted to help reduce the seed available for germination. Finally, large infestations should be removed or at least controlled.

Treatments adopted for control of tree-of-heaven should stress the root system and lead to a reduction in seed production. For example, a treatment regimen can be started early in the summer when root reserves are at their lowest and repeated as necessary to keep root reserves low. Various methods for tree-of-heaven control are available, and the local situation usually dictates the best approach to follow. A popular approach is to use a basal spray or a cut surface treatment initially and then follow this up later by using a foliar active herbicide to spot spray new seedlings, sprouts, and root suckers.

Once controlled, restoration activities may be used to help prevent the problem from recurring. Since tree-of-heaven is relatively shade-intolerant, establishment of competing vegetation should be encouraged following control efforts. This includes establishing a thick cover of desirable trees, shrubs, and grasses.

Persistence and a long-term commitment are a must for tree-of-heaven control. Complete control will likely require 1 to 5 years of continuous planning and integrated management. Since it is ordinarily useless to treat an area only one time without retreatment, sufficient resources must be allocated for the area where control is attempted. After initial treatment, it is important that resources are also available to respray or retreat the treated area as necessary. Regardless of the strategy used, the key to successful long-term control of tree-of-heaven is to monitor treated areas for several years after initial treatment. Always be prepared to remove any new plants quickly. Failure to perform follow-up monitoring and treatment could result in a return to pretreatment densities.

## References and Further Information

- Burch, P.L. and S.M. Zedaker. 2003. Removing the Invasive Tree *Ailanthus altissima* and Restoring Natural Cover. *Journal of Arboriculture* 29(1):18-24. Available at <http://www.treelink.org/joa/2003/jan/03Burch.pdf> (accessed May 2010).
- Davison, J.C., E. Smith, and L.M. Wilson. 2007. Livestock Grazing Guidelines for Controlling Noxious Weeds in the Western United States. A Western Region Sustainable Agriculture, Research and Education Project. Publication EB-06-05. Available at [http://www.cnr.uidaho.edu/rx-grazing/Livestock\\_Graizng\\_Guidelines%28Davison\\_et\\_al.%202007%29.pdf](http://www.cnr.uidaho.edu/rx-grazing/Livestock_Graizng_Guidelines%28Davison_et_al.%202007%29.pdf) (accessed May 2010).
- DiTomaso, J. and G. Kyser. 2001. Trial of Several Herbicides and Application Techniques for Control of *Ailanthus altissima*, Upper Putah Creek, Yolo County. *In* M. Kelly (ed.). *Proc. of the California Exotic Pest Plant Council Symp. Vol. 6: 2000-2002.* pp. 125. Available at <http://www.cal-ipc.org/symposia/archive/pdf/18602.pdf> (accessed May 2010).
- Heiligmann, R.B. 2006. Controlling Undesirable Trees, Shrubs and Vines in Your Woodland. Available at [http://www.wildlifemanagement.info/files/forestry\\_mgt\\_17.pdf](http://www.wildlifemanagement.info/files/forestry_mgt_17.pdf) (accessed May 2010).
- Howard, J.L. 2004. *Ailanthus altissima*. *In* Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available at <http://www.fs.fed.us/database/feis/plants/tree/ailalt/all.html> (accessed in May 2010).
- Hunter, J. 2000. Tree-of-heaven (*Ailanthus altissima*). *In* Bossard, C.C., J.M. Randall, M.C. Hoshovsky (eds.) *Invasive Plants of California's Wildlands*. University of California Press. Available at <http://www.cal-ipc.org/ip/management/ipcw/online.php> (accessed May 2010).

Kelly, M. 2001. Results of Basal Bark Application of Garlon 4 on *Ailanthus altissima* (Tree-of-Heaven). In M. Kelly (ed.) Proceedings of the California Exotic Pest Plant Council Symposium. Vol. 6:2000–2002. pp. 105. Available at <http://www.cal-ipc.org/symposia/archive/pdf/18602.pdf> (accessed May 2010).

Miller, J.H. 2003. Nonnative invasive plants of southern forests: a field guide for identification and control. Gen. Tech. Rep. SRS–62. USDA Forest Service, Southern Research Station. Asheville, NC. 93 pp.

Miller, J.H., S.T. Manning, and S.F. Enloe. 2010. A Management Guide for Invasive Plants in Southern Forests. General Technical Report SRS–131. USDA Forest Service, Southern Research Station. Asheville, NC. 120 pp.

Northam, E. and W. Meyer et al. 2009. Non-Native Invasive Plants of Arizona. Produced by Conservation Districts and RC & D Areas of Arizona and the University of Arizona Cooperative Extension. AZ1482. pp. 8–9. Available at <http://cals.arizona.edu/pubs/natresources/az1482.pdf> (accessed May 2010).

Pannill, P.D. and J.M. Swearingen. 2009. Least Wanted: Tree-of-Heaven Fact Sheet. Plant Conservation Alliance. Available at <http://www.nps.gov/plants/alien/fact/aial1.htm> (accessed May 2010).

Salom, S. M. and L.T. Kok et al. 2009. *Ailanthus*, Tree-of-Heaven Update: A Northeast Regional Biological Control Project. In K.A. McManus and K.W. Gottschalk (eds.) Proc. 20th USDA interagency research forum on invasive species 2009; Gen. Tech. Rep. NRS-P-51. Pp. 52–53. Available at <http://www.nrs.fs.fed.us/pubs/gtr/gtr-nrs-p-51papers/30salom-p-51.pdf> (accessed May 2010).

## Suggested Web Sites

For information about calibrating spray equipment: NMSU Cooperative Extension Service Guide A-613, *Sprayer Calibration*. Available at [http://aces.nmsu.edu/pubs/\\_a/A-613.pdf](http://aces.nmsu.edu/pubs/_a/A-613.pdf)

Herbicide labels online: <http://www.cdms.net/>

Invasive Plant Atlas of the United States: <http://www.invasive.org/weedus/index.html>

USDA Plants Database: <http://plants.usda.gov/index.html>

---

**For more information or  
other field guides, contact:**

USDA Forest Service  
Southwestern Region  
Forest Health  
333 Broadway Blvd., SE  
Albuquerque, NM 87102

**Or visit the Southwestern Region's  
website for invasive species:**

*<http://www.fs.usda.gov/goto/r3/invasivespecies>*



---

The use of trade or firm names in this publication is for reader information only and does not imply endorsement of any product or service by the U.S. Department of Agriculture. Recommendations made here for pesticide use are not obligatory, nor do they imply that discussed uses have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be applied.



**CAUTION:** Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides carefully and lawfully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.