ELEMENT STEWARDSHIP ABSTRACT
for
Ailanthus altissima
Tree-of-Heaven

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Authors of this Abstract: Marc C. Hoshovsky

I. IDENTIFIERS
Common Name: TREE-OF-HEAVEN Global Rank: G?
General Description: Deciduous trees in the family Simaroubaceae, native to China.

II. STEWARDSHIP SUMMARY
Ailanthus is a fast growing tree, a prolific seed producer, a persistant stump and root sprouter and an aggressive competitor with respect to the surrounding vegetation. It occurs primarily in disturbed areas, though it may invade undisturbed habitats. It was brought into California mainly by the Chinese who came to California during the goldrush in the 1890's, and frequently occurs in abandoned mining sites. Little work has been done on developing biological or chemical control methods. The most effective means of control may be to pull seedlings by hand before the tap root develops.

III. NATURAL HISTORY
Range:
In the Americas, Ailanthus occurs from Canada to Argentina. Native to China. Also escaped in Europe.

Habitat:

Ailanthus is native to central China, where its history is as old as the written language of the country (Hu 1979). Little information is available on its ecology in China, although Hu (1979) reviews its cultural importance and value for wood products and medicine.

The species was apparently introduced into America by two different routes. The first route began with Pierre d'Incarville mistaking it for the lacquer tree in China and sending seeds to England around 1751 (Feret and Bryant 1974, Hu 1979). It was then introduced to America by a Philadelphia gardener in 1784 (Hu 1979). Because of its rapid growth and ability to grow in unfavorable conditions with little care, it became a common stock in eastern nurseries by 1840. The second route was through Chinese miners. During the days of the California gold rush, many Chinese miners brought ailanthus seeds with them as they settled in California, probably because of its medicinal and cultural importance to them.

Escaping from cultivation and quickly becoming established on both coasts, ailanthus has expanded its range considerably since its initial introductions. Specimens from the Harvard University Herbarium indicate that it "runs wild from Massachusetts...to Oregon ... and from Toronto, Canada ... to Argentina ..." (Hu 1979). In some localities ailanthus is so well established that it appears to be a part of the native flora (Little 1974).

In the eastern United States, the frequency of ailanthus occurrences increases as one nears the cities. In neglected urban areas, ailanthus grows "as trees close to buildings, as hedges, or as bushy aggregates along railroad tracks, highway embankments, walls at the ends of bridges and overpasses, or in cracks of sidewalks and along fences" (Hu 1979). Although it is usually found in disturbed areas, it occasionally spreads to undisturbed areas. Kowarik (1983) views human settlements as centers of its distribution and roads as migration routes.

In California ailanthus is widely naturalized in cismontane areas, especially around old dwellings and mining settlements (Munz and Keck 1973). It has become established in Pleasants Valley, Solano and Marin counties, Berkeley, Vacaville, Petaluma, San Andreas, Angel's Camp, Columbia, and in various places in the Sacramento Valley (Robbins et al. 1951).

Ecology:

Although ailanthus is sensitive to frost damage during its early years (Adamik and Brauns 1957), 6-year-old trees have survived winters of -33 centigrades accompanied by high winds (Zelenin 1976). Although Koffer (1895) suggested that ailanthus was unable to withstand the prolonged dry seasons of the Midwest, Dubroca and Bory (1981) commented on the "drought resistance" of the species. Dry soils are probably more suitable for its growth than wet soils (Adamik and Brauns 1957).

Ailanthus does well on very poor soils. Adamik and Brauns (1957) cultivated the species on rather thin topsoil and it "thrives even on stony ground." The tree has been used in revegetating acid mine spoils, tolerating a pH of less than 4.1, soluble salt concentrations up to 0.25 mmhos/cm and phosphorus levels as low as 1.8 ppm (Plass 1975). The tolerance of ailanthus to soil salinity is a disputed point in the literature. Opinions range from "salty soils not suitable for growth" (Adamik and Brauns 1957) to ailanthus "growing well on very saline shell sands (Lavrinenko and Volkov 1973). Intermediate views are expressed by Brogowski et al. (1977), Semoradova and Materna (1982) and Zelenin (1976).

Ailanthus has been planted widely in urban areas because of its ability to tolerate atmospheric pollution. Its ability to adapt to "the dirt and smoke, the dust and drought of cities" was recognized nearly 100 years ago (Sargent 1888). More recently ailanthus has been observed to survive cement dust near cement and lime works (Klincsek 1976); it is moderately resistant to fumes produced by the coke and coal-tar industry (Kozyukina and Obraztsova 1971); its leaves absorb significant amounts of sulfur in areas of high traffic flow (Kim 1975); it can accumulate high levels of mercury in its tissues (Smith 1972); and it is somewhat resistant to ozone exposure (Davis et al. 1978).

Although ailanthus may suffer from root competition by other trees already established in an area (Cozzo 1972), usually it competes successfully with other plants (Cozzo 1972, Hu 1979) and is considered a "dangerous weed" in forest plantations (Magic 1974). A high degree of shade tolerance gives ailanthus a competitive edge over other plant species (Grime 1965). The production of toxic chemicals by ailanthus may also explain the success of this plant. An aqueous extract of ailanthus leaves has been shown to be toxic to 35 species of gymnosperms and 10 species of angiosperms (Mergen 1959). This may be important in limiting natural succession in ailanthus stands. The toxicity levels are highest in the leaves during the early part of the growing season and are maintained at high levels at least until October (Voigt and Mergen 1962).

Reproduction:

Ailanthus reproduces both sexually and asexually. Asexual reproduction is by vegetative sprouting from stumps or root portions (Hu 1979). Flowering occurs rather late in the spring (June). Ailanthus has the longest winter dormancy of all the trees in its native Chinese habitat (Hu 1979). Precocious flowering is not a rare occurrence in this species and has been observed in seedlings only 6 weeks after germination (Feret 1973).

Seeds ripen in large crowded clusters from September to October of the same year and may persist on the tree through the following winter (Little 1974, Hu 1979). An individual tree can produce 325,000 seeds per year which are easily wind-dispersed (Bory and ClairMaczulajtys 1980). These seeds average over 30,000 per kilogram. This amount yields up to 6-7000 "usable plants" (Little 1974). Limited testing of ailanthus seeds indicate that they have dormant embryos, and that germination is benefited by stratification on moist sand for 60 days at 41 F (Little 1974). Seedlings establish themselves rapidly by producing a well formed tap root in less than three months (Adamik and Brauns 1957). In more compacted soils these seedlings put forth long rope-like lateral roots to exploit a greater soil volume (Rabe and Bassuk 1984). Ailanthus grows quickly in full sunlight and averages a meter of growth in height per year for at least the first 4 years (Adamik and Brauns 1957). The trees may grow to 15-20 meters tall but have a rather short lifespan of less than 50 years (Adamik 1955).

Impacts:
Although only occasionally found in nondisturbed areas (Kowarik 1983), Ailanthus is a prolific seed producer, grows rapidly and can successfully compete with the native vegetation. It produces toxins which prevent the establishment of other species (Mergen 1959). The root system is aggressive enough to cause damage to sewers and foundations (Hu 1979).
Ailanthus was not nominated by any specific preserve manager, but is recognized by TNC staff as an important exotic weed. A recent survey (2 March 1985) of CNPS members showed a wide distribution of this tree throughout California. Members of both the Mt. Lassen and Sequoia chapters consider it a major pest at low elevations. There are also reports of it growing in Santa Cruz, Riverside, San Bernardino, Los Angeles and San Diego counties.

IV. CONDITION

Threats:
Although only occasionally found in nondisturbed areas (Kowarik 1983), ailanthus is a prolific seed producer, grows rapidly and can successfully compete with the native vegetation. It produces toxins which prevent the establishment of other species (Mergen 1959). The root system is aggressive enough to cause damage to sewers and foundations (Hu 1979).
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Trend:
Trend in native range in China not known, but the species has become much more abundant globally in the past century.

V. MANAGEMENT/MONITORING

Management Requirements:
Weed control involves three fundamental objectives: prevention, eradication and control. From a practical viewpoint, methods of weed management are commonly categorized under the following categories: physical, thermal, managerial, biological, and chemical (Watson 1977). Physical methods include both manual and mechanical methods. Thermal methods include both broadcast burning or spot treatment with a flame thrower. Managerial methods include the encouragement of competitive displacement by native plants and prescribed grazing. Biological control is usually interpreted as the introduction of insects or pathogens which are highly selective for a particular weed species. Chemical control includes both broadcast and spot application.

The most desirable approach is that of an integrated pest management plan. This involves the optimum use of all control strategies to control weeds. This approach is generally accepted as the most effective, economical, and environmentally sound long-term pest control strategy (Watson 1977). In cases where more than one control technique is used, the various techniques should be compatible with one another. Broadcast herbicide application, for example, may not work well with certain managerial techniques (i.e., plant competition).

PHYSICAL CONTROL. The two types of physical control methods discussed below, manual and mechanical, produce slash (i.e., cutting debris) that can be disposed of by several techniques. If cut before seeds are produced it may be piled and left for enhancement of wildlife habitat (i.e., cover for small mammals). Debris may be fed through a mechanical chipper and used as mulch during revegetation procedures. Care should be taken to prevent vegetative reproduction from cuttings. Burning the slash piles is also effective in disposing of slash.

MANUAL CONTROL. Manual methods use hand labor to remove undesirable vegetation. These methods are highly selective and permit weeds to be removed without damage to surrounding native vegetation.

Hand Pulling: Ailanthus is probably best controlled by manual removal of young seedlings. Seedlings are best pulled after a rain when the soil is loose. This facilitates removal of the rooting system, which may resprout if left in the ground. After the tap root has developed, this would be extremely difficult. Plants should be pulled as soon as they are large enough to grasp but before they produce seeds.

The Bradley Method is one sensible approach to manual control of weeds (Fuller and Barbe 1985). This method consists of hand weeding selected small areas of infestation in a specific sequence, starting with the best stands of native vegetation (those with the least extent of weed infestation) and working towards those stands with the worst weed infestation. Initially, weeds that occur singly or in small groups should be eliminated from the extreme edges of the infestation. The next areas to work on are those with a ratio of at least two natives to every weed. As the native plant stabilizes in each cleared area, work deeper into the center of the most dense weed patches. This method has great promise on nature reserves with low budgets and with sensitive plant populations. More detailed information is contained in Fuller and Barbe (1985).

Cutting: Manually operated tools such as brush cutters, power saws, axes, machetes, loppers and clippers can be used to cut ailanthus. This is an important step before many other methods are tried, as it removes the above-ground portion of the plant. For thickly growing, multi-stemmed shrubs and trees, access to the base of the plant may not only be difficult but dangerous where footing is uncertain.

Hand Digging: The removal of rootstocks by hand digging is a slow but sure way of destroying weeds which resprout from their roots. The work must be thorough to be effective as every piece of root that breaks off and remains in the soil may produce a new plant. Such a technique is only suitable for small infestations and around trees and shrubs where other methods are not practical.

Girdling: Girdling involves manually cutting away bark and cambial tissues around the trunks of undesirable trees such as ailanthus. This is a relatively inexpensive method and is done with an ordinary ax in the spring when the trees are actively growing. Hardwoods are known to resprout below the girdle unless the cut is treated with herbicides. Although it may be undesirable to leave standing dead trees in an area, this technique has been shown to reduce stump sprouting in live oaks, and may be a useful technique for controlling ailanthus.

MECHANICAL CONTROL. Mechanical methods use mechanized equipment to remove above ground vegetation. These methods are often non-selective in that all vegetation on a treated site is affected. Mechanical control is highly effective at controlling woody vegetation on gentle topography with few site obstacles such as rocks, stumps or logs. Most mechanical equipment is not safe to operate on slopes over 30 percent. It is also of limited use where soils are highly susceptible to compaction or erosion or where excessive soil moisture is present. Site obstacles such as rocks, stumps or logs also reduce efficiency.

Chopping, Cutting or Mowing: Saplings may be trimmed back by tractor-mounted mowers on even ground or by scythes on rough or stony ground. Unwanted vegetation can be removed faster and more economically in these ways than by manual means and with less soil disturbance than with scarification. However, these methods are nonselective weed eradication techniques. They reduce the potential for biological control through plant competition and open up new niches for undesirable vegetation. In addition, wildlife forage is eliminated.

Saplings usually require several cuttings before the underground parts exhaust their reserve food supply. If only a single cutting can be made, the best time is when the plants begin to flower. At this stage the reserve food supply in the roots has been nearly exhausted, and new seeds have not yet been produced. After cutting or chopping with mechanical equipment, ailanthus resprouts from root crowns in greater density if not treated with herbicides.

PRESCRIBED BURNING. A flame thrower or weed burner device can be used as a spot treatment to heat-girdle the lower stems of small trees. This technique has advantages of being less costly than basal and stem herbicide treatments and is suitable for use during wet weather and snow cover. Ailanthus resprouts after heat-girdling (Cozzo 1972).

MANAGERIAL CONTROL. In most cases ailanthus prevents the establishment of other native plants and must be initially removed. Following physical or thermal removal of mature plants, root crowns must be treated to prevent resprouting. Seedlings of native plant species usually cannot establish fast enough to compete with sprout growth from untreated stumps. Ailanthus is shade tolerant, so presumably can and will sprout under other plants.

Prescribed grazing: The continued removal of the tops of seedlings and resprouts by grazing animals prevents seed formation and also gradually weakens the underground parts. Grazing must be continued until the seedbank is eliminated, as the suppressed plants return quickly after livestock is removed and begin to dominate pastures again.

BIOLOGICAL CONTROL.

The term "biological control" is used here to refer to the use of insects or pathogens to control weeds. The introduction of exotic natural enemies to control plants is a complex process and must be thoroughly researched before implementation to prevent biological disasters. Such tools are not normally suitable for preserve managers to implement.

Biological control of ailanthus has not been addressed to any extent beyond the anecdotal stage. No susceptibilty of ailanthus to parasites was found or noticed in Austrian nurseries (Adamik and Brauns 1957). French (1972) notes that the zonate leafspot (Cristulariella pyramidalis) causes defoliation of ailanthus in Florida. In India, Atteva fabricella is considered an ailanthus defoliator (Misra 1978) and Italian seedlings, weakened by cold, were weakly parasitized by the fungus Placosphaeria spp. (Magnani 1975).

Please notify the California Field office of The Nature Conservancy of any field observations in which a native insect or pathogen is seen to have detrimental effects on ailanthus. These reports will be used to update this Element Stewardship Abstract. Management techniques which may encourage the spread of species-specific agents may be desirable in controlling ailanthus.

CHEMICAL CONTROL.

Methods of chemical control of ailanthus are poorly explored in the literature. Detailed information on herbicides in general is available in such publications as Weed Science Society of America (1983). The Weed Science Society reference gives specific or USDA (1984) information on nomenclature, chemical and physical properties of the pure chemical, use recommendations and precautions, physiological and biochemical behavior, behavior in or on soils and toxological properties for several hundred chemicals. Comprehensive coverage of this information will not be presented in this Element Stewardship Abstract. In applying herbicides it is recommended that a dye be used in the chemical mixture to mark the treated plants and thus minimize waste.

The following discussion highlights herbicide application methods which may be useful in controlling ailanthus. Herbicides may be applied non-selectively (i.e., broadcast applications) or selectively (i.e., spot applications). Both types of applications have advantages and disadvantages and will be discussed separately.

Broadcast Herbicide Application: In general, when using broadcast application methods, plants should be sprayed only when in full leaf. Results are poor prior to full leaf development. The best results have been obtained when plants are in the fruiting stage in late summer or early autumn (Mathews 1960).

Kolarvskij (1967) reports that 2,4-D can stop seedling growth in alianthus, and Sterrett et al. (1971) found that a mixture of 2- chloroethyl phosphoric acid and potassium iodide gives 80-100% defoliation of ailanthus within 3 weeks.

Spot Chemical Methods: Spot chemical methods consist of various techniques for manually applying herbicides to individual plants or small clumps of plants (such as stump resprouts).

These methods are highly selective as only specific plants are treated. They are most efficient when the density of stems to be treated is low.

Jones and Stokes Associates (1984) reviewed a variety of spot chemical techniques. The following is an excerpt from this report, listing techniques in order of increasing possibility of herbicide exposure to the environment or to humans in the vicinity of treated plants.

1) Stem injection: Herbicides are injected into wounds or cuts in the stems or trunks of plants to be killed. The herbicide must penetrate to the cambial tissue and be water-soluble to be effective. The chemical is then translocated throughout the tree and can provide good root-kill, and thus prevents resprouting.

2) Cut stump treatment: Herbicides are directly applied to the cambial area around the edges of freshly cut stumps. Application must occur within 5-20 minutes of cutting to ensure effectiveness. McHenry (1985) suggests late spring as the best season to do this. In early spring sap may flow to the surface of the cut and rinse the chemical off. At other times of the year translocation is too poor to adequately distribute the chemical. Applications may be made with backpack sprayers, sprinkling cans, brush and pail, or squeeze bottles. This treatment is effective in killing root systems of sprouting hardwoods. Picloram should not be used for this technique as it is known to "flashback" through root grafts between treated and untreated plants and may damage the untreated individuals. Tre-Hold, an asphalt based formulation containing 1% NAA ethylester has been used as a sprout retardant on ailanthus with varying degrees of effectiveness (Amchem Products 1967).

3) Basal/Stem sprays: High concentrations of herbicides in oil or other penetrating carriers are applied, using backpack sprayers, to the basal portion of stems to be killed. The oil carrier is necessary for the mixture to penetrate bark and enter the vascular system. This method gives good root kill, especially in the fall when vascular fluids are moving toward the roots. This method may be easier to use with small diameter stems than the two previous techniques.

4) Herbicide pellets: Pelletized or granular herbicides are scattered at the bases of unwanted plants. Subsequent rainfall dissolves the pellets and leaches the herbicide down to the root system. Optimal time for treatment is towards the end of the rainy season to prevent leaching beyond the root zone.

Management Programs:

Tim Thomas (1985) has removed a small stand of ailanthus in the Santa Monica Mountains National Recreation Area, by pulling up young saplings and is currently monitoring the site to see if it resprouts.

Contact: Tim Thomas, Park Ranger, Santa Monica Mountains National Recreation Area 22900 Ventura Blvd. Woodland Hills, CA 91364, (213) 888-3440.

Monitoring Requirements: Monitoring is needed to determine the presence of ailanthus on or near preserves.

VI. RESEARCH

Management Research Needs: What types of undisturbed habitats does it invade? How do native species respond to ailanthus toxins, and how is recovery potential of an area previously occupied by ailanthus affected by these toxins? What is the chemical make-up of these toxins? What can be used to buffer the effects of the toxins so that understory native seedling growth is encouraged? At what age is the tap root so long that it precludes ailanthus removal by hand?

VII. ADDITIONAL TOPICS

VIII. INFORMATION SOURCES

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IX. DOCUMENT PREPARATION & MAINTENANCE

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