WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
August 29, 2011

Scientific name:	*Ailanthus altissima* (Mill.) Swingle
Synonyms:	*Ailanthus cacodendron* (Ehrh.) Schinz & Thell., *Ailanthus glandulosa* Desf., *Rhus cacodendron* Ehrh., *Toxicodendron altissimum* Mill.
Common name:	tree of heaven, stinking quassia, copal-tree
Family:	Simaroubaceae
Legal Status:	proposed as a Class B; listed as a Class C noxious weed in 2012

Description and Variation:

Overall Habit:
Ailanthus altissima is a rapidly-growing, medium-sized, deciduous tree that can grow to heights of 30 meters in temperate climates (Hegi 1906, Lauche 1936 *both in* Kowarik and Säumel 2007). With its ability to send up root sprouts, trees are commonly found growing in dense thickets. The following characteristics are described for a typical *Ailanthus altissima* specimen. Plant traits of root sprouts can vary from the typical growth form.

Roots/Rhizomes:
Ailanthus altissima has a deep taproot and many shallow spreading lateral roots that may grow up to 15 meters or more in length (DiTomaso and Healy 2007). Lateral roots can exploit a greater soil volume than some other tree species (Pan and Bassuk 1986). Pan and Bassuk (1986), found lateral roots from two year old *A. altissima* trees to be 3 to 4 times longer than the two species it was compared to, *Acer platanoides* and *Liquidambar styraciflua*. Roots near the soil surface, up to 100 cm deep, have several primordia that easily form root suckers (Kowarik and Säumel 2007).

Stem:
Young branches have a pith center, are yellow or yellow-brown to chestnut brown in color and are pubescent when young and then glabrescent as they age (Hu 1979, Peng and Thomas 2008). Branches have heart-shaped leaf scars with bundle scars along the margin and a roundish bud at the sinus (Hu 1979). Bark on older stems is smooth and gray, and has shallow diamond-shaped fissures as it ages (Hu 1979, Hunter, 2000).

Figure 2. *Ailanthus altissima* bark (left) Grant County Noxious Weed Board 2010; glands on leaflets (right).

Leaves:

Leaves are pinnately compound, alternate and spirally arranged on stems (Kowarik and Säumel 2007). They have a strong peanut-butter or popcorn-like smell when crushed (Uva et al. 1997). Leaves are glabrous or puberulent and can reach 1 meter or more in length (Hitchcock et al. 1961), though length can be highly variable. Leaves generally have 10-27 leaflets and the terminal leaflet is often absent (Hitchcock et al. 1961, Peng and Thomas 2008). Leaflets are ovate-lanceolate in shape with a rounded base, generally 4-15 cm long. Near the leaflet base on each side, there are 1 to 3 rounded teeth, each bearing a conspicuous gland on the lower surface (Hitchcock et al. 1961, Hu 1979) (Figure 2). The terminal leaflet may have 1 to 2 enlarged lobes (Heidenhain 1932 *in* Kowarik and Säumel 2007). Leaf petioles are 7 to 13 cm long, enlarged at the base and often have a red tint (Hitchcock et al. 1961, Hu 1979).

Leaves of root sprouts, especially from trees subjected to physical disturbance, can produce much larger leaves with many more leaflets (Kowarik and Säumel 2007).

Flowers:

Plants are primarily dioecious, with male and female flowers on separate plants, but do have a few bisexual flowers that develop (Hu 1979). Flowers are arranged in large, terminal panicles that are 10-30 cm wide (Hu 1979, Peng and Thomas 2008). Male inflorescences are larger and typically produce 3-4 times more flowers than female inflorescences (Hu, 1979). Flowers are light green, 6-8 mm wide and occur on short pedicels, 1-2.5 mm long (Hitchcock et al. 1961, Peng and Thomas 2008). Each flower has 5 imbricate sepals (0.5-1 mm long), 5 petals (2-2.5 mm long) with hispid bases and an annular 10-lobed glandular disc (Hitchcock et al. 1961, Kowarik and Säumel 2007). Male flowers have 10 spreading stamens that are longer than the petals and have a glandular green disc. Male flowers also have an unpleasant odor similar to that of the foliage (DiTomaso and Healy 2007). Female flowers have 10, or sometimes 5, sterile stamens that are shorter than petals (Hu 1979). Female and perfect flowers have green glandular discs, 5 carpels, connate styles and 5 lobed stigmas (Kowarik and Säumel 2007, Peng and Thomas 2008).

Fruits and Seeds:

Flower carpels develop into oblong samaras that are 3-5cm long by 1-1.5 cm wide (Peng and Thomas 2008, DiTomaso and Healy 2007). The samaras are loosely twisted and have one centrally placed seed (Kowarik and Säumel 2007) (Figure 3). Their mature color varies from greenish yellow to reddish brown (Hu 1979).

Figure 3. Panicle of samara (left) and an individual samara (right) of *Ailanthus altissima*.

Habitat:

Ailanthus altissima can grow in temperate to subtropical and humid to arid climates (Miller 1990). It also grows in a wide variety of habitats. It is commonly found along forest edges and disturbed habitats including fence rows, roadsides, railroad embankments, old fields, abandoned lots and urban parks (Hu

1979, Pan and Bassuk 1986, Kowarik and Säumel 2007). It can survive extreme urban conditions, growing next to foundations, in cement cracks and in rubble (Uva et al. 1997) (Figure 4.).

Figure 4. *Alianthus altissima* growing through a cement crack (left) and along a dry bank (right). Grant County Noxious Weed Control Board 2010.

Ailanthus altissima also grows in natural communities such as old growth forest canopy gaps, mature second growth forests, riparian areas and grasslands (Espenschied-Reilly and Runkle 2008, Knapp and Canham 2000, Kowarik 1995, DiTomaso and Healy 2007).

Plants primarily establish in open conditions (Knapp and Canham 2000), but they can also tolerate shade (DiTomaso and Healy 2007). Kowarik and Säumel (2007) note a study by Hamerlynck (2001) that highlights *A. altissima*'s capacity to couple high shade-plant-like photosynthetic efficiency with high photosynthetic capacity in high irradiance. It can then maintain stomatal attributes that optimize water-use efficiency in shade. It grows best in loamy, moist soils but tolerates a wide range of soil types and pH (Miller 1990). It grows on soils from barren rocky substrates to sandy or clayey loams, to calcareous dry and shallow soils as well as being able to tolerate compacted and nutrient poor soils (Kowarik 1995, Howard 2004, Kowarik and Säumel 2007).

Ailanthus altissima is also pollution and drought tolerant, allowing it to survive in harsh environmental conditions (DiTomaso and Healy 2007, Kowarik and Säumel 2007). In areas of high air pollution, *A. altissima* is one of the most tolerant tree species (Kovacs et al. 1982 in Kowarik and Säumel 2007) and it is highly resistant to sulfur dioxide (Ranft and Dässler 1970 in Kowarik and Säumel 2007). Trifilò et al. (2004) studied two year old seedlings' ability to withstand drought and found they employ a highly effective water-saving mechanism that involves reduced water loss by leaves and reduced root hydraulic conductance. This mechanism allows plants to maintain high water leaf status and preserve the functional integrity of the photosynthetic process in drought conditions (Trifilò et al. 2004). Kowarik and Säumel (2007) report that higher temperatures caused a switch in biomass allocation from aboveground plant parts to the root system and an increased stem volume, suggesting an enhanced uptake of water from soil and vascular movement from a larger cross-sectional area.

<u>Geographic Distribution:</u>
Ailanthus altissima is considered an invasive plant on every continent but Antarctica (Kowarik and Säumel (2007). Native and secondary ranges of *A. ailanthus* have similar climatic conditions characterized by a long and warm growing season, regular winter frost and annual precipitation of mostly greater than 500 mm (Kowarik and Säumel (2007).

<u>Native Distribution:</u>

Ailanthus altissima is native to Taiwan (USDA ARS 2011) and all regions of China except Hainan, Heilongjiang, Jilin, Ningxia and Qinghai (Peng and Thomas 2008). It is found in many habitats from elevations of 100-2500 meters (Peng and Thomas 2008).

Distribution in North America:
Ailanthus altissima was first introduced to the United States in 1784 as a garden introduction and it became a popular ornamental plant due to its fast growth and ability to grow in a variety of conditions (Hu 1979). Ornamental and afforestation plantings in the 1800's have led to its naturalization across the United States (Hu 1979, Miller 1990). Chinese immigrants are thought to have planted it on the West Coast for its cultural significance (Feret 1985 in Kowarik and Säumel 2007). Currently, USDA Plants (2011) documents the presence of *Ailanthus altissima* in every state in the United States except for seven: Montana, Wyoming, North Dakota, South Dakota, Minnesota, Vermont and New Hampshire. It is also documented in Ontario and Quebec provinces of Canada (USDA NRCS 2011) and in Mexico (USDA ARS 2011).

Ailanthus altissima is listed on Connecticut's invasive plant list, Massachusetts prohibited plants list, New Hampshire's invasive species list and Vermont's noxious weed list as a class B noxious weed (USDA NRCS 2011).

History and Distribution in Washington:
The earliest Washington State herbarium record from the University of Washington Burke Herbarium (WTU) was collected in 1929 in Whitman County (Jones s.n., WTU 34571). WTU Herbarium collections have also been made in Jefferson County, Grant County, Kittitas County and King County. County Noxious Weed Coordinators have also noted *Ailanthus altissima* naturalized in Okanogan County, Douglas County and Yakima County (A. Lyons, D. Whaley, and D. Jacobson pers. comm.).

In Washington, trees are found growing in a variety of habitats including roadsides, bluffs, wet meadows, riverbanks and naturalized in urban areas (WTU specimens 379297, 381046, 376450, 370689, 328386, 34571, Grant County Noxious Weed Control Board pers. comm.).

Biology:

Growth and Development:
Ailanthus altissima is typically a short-lived tree, with individual stems living about 30 to 50 (or over 100) years old, but due to its root suckering and abundant seed production, thickets can live for an indefinite period of time (Burch and Zedaker 2003).

Young saplings typically lack branching, and are generally composed of a main stem axis and leaves (Kowarik and Säumel 2007). Plants are very fast growers and are believed to be the fasting-growing trees in North America (Knapp and Canham 2000, Howard 2004 in Kowarik and Säumel 2007). One year old trees grow 1-2 meters in one year (Hu 1979). Growth in height and diameter are highest in trees 5 to 10 years old and continue to an age of 10 to 20 years, and then begin to decrease (Speranzini 1937 in Kowarik and Säumel 2007). In climate chamber experiments by Kowark and Säumel (2007), stem growth was curbed in colder conditions and increased significantly in warmer temperatures.

In North America, flowering occurs from mid-April to July, depending on latitude (Miller 1990). Arthur Lee Jacobson (2008) notes it occurs in June or July in the greater Seattle area. Pollination is performed by honeybees, beetles and other nectar and pollen feeding insects (Hegi 1906 in Kowarik and Säumel 2007, Miller 1990).

Reproduction:
Plants can reproduce by seed as well as vegetatively by roots and stump sprouts.

Seeds:
Trees typically begin flowering and producing seed at 3-5 years old and have their most abundant seed production years from age 12 to 20. (Kowarik and Säumel 2007) These trees can produce up to 325,000 seeds a year (Kowarik and Säumel 2007). Samaras typically persist on plants through winter but may disperse anytime from late fall to spring (Miller 1990). Seeds may germinate in dense patches as a result of them remaining attached to their panicle during dispersal (Pan and Bassuk 1986). Seeds can disperse long distances into fields and forests and can reach canopy gaps and other suitable habitats at least 100 m from forest edges (Landenberger et al 2007). The spirally twisted samaras are adapted for wind dispersal and can also disperse on water (Kowarik and Säumel 2008). Samaras were wind dispersed 200 m over a hay field from 18 m tall parent trees (Kowarik and Säumel 2007).

Seeds need cold stratification for germination (Miller 1990). Short lived seed banks may form with seeds being viable on top of (Hildebrand 2006 in Kowarik and Säumel 2007) and in the soil for at least one year (Kota et al. 2007). Seeds can germinate in a range of habitats and soils conditions (Hu 1979). Seedlings successfully germinate on bare soil and under leaf litter, though biomass of roots and shoots were lower in the presence of litter (Kostel-Hughes et al. 2005 in Kowarik and Säumel 2007). Germinated seedlings tend to not survive in closed forest canopies. The first seedling leaf after the cotyledons has three leaflets (DiTomaso and Healy 2007).

Figure 5. Dense thickets of growth of *Ailanthus altissima*.

Vegetative Spread:
Ailanthus altissima can spread vegetatively through clonal growth which allows it to expand into forest interiors (Kowarik 1995, Knapp and Canham 2000). It can rapidly resprout from roots and stumps (Burch and Zedaker 2003) and form dense stands after disturbance (Kowarik and Säumel, 2007) (Figure 5.). Disturbances such as frost, fire, cutting, or girdling will result in prolific sprouting (von Bartossagh 1841, Hoshovsky 1988, Bory et al. 1991 all in Kowarik and Säumel 2007). Undisturbed plants will also produce shoots (Kowarik 1995). Variable sized root fragments are able to produce adventitious shoots and roots, even fragments as small as 1 cm in length can still produce shoots (Inverso and Bellani, 1991 in Kowarik and Säumel 2007). Kowarik and Säumel (2008) also found root fragments able to produce adventitious roots after floating in water.

Control:

Ailanthus altissima can be very difficult to remove once it has established a taproot (Kowarik and Säumel 2007). Where possible, plants should be controlled when they are young seedlings. Part of any successful *A.altissima* management plan needs to include monitoring controlled areas for seedlings and root and stump resprouts (Swearingen and Pannill 2003). Regardless of method selected, treated areas should be rechecked multiple times a year if possible and new suckers and seedlings need to be removed promptly

(Swearingen and Pannill 2003). If necessary, prioritize the control of female trees to reduce the production and spread of seeds (Swearingen and Pannill 2003).

Response to Herbicide:

A number of herbicide treatments and methods of application have been found to work on *Ailanthus altissima*. Meloche and Murphy (2006) tested a number of different control options and found that cut stump and glyphosate application was most effective and efficient in controlling young *A. altissima* shoots. They note that this treatment also has acceptable operating costs and it limits site disturbance (Meloche and Murphy 2006). A wick-wand applicator was used to reduce the possibility of off-target damage. The EZJect system was also tested and found to be effective at managing mature, seed producing shoots (of stems large enough to allow use of the injection system). This treatment did have higher capital costs, so the system should be purchased for management of several invasive tree species to make it more cost effective (Meloche and Murphy 2006).

Burch and Zedaker (2003) tested different herbicide treatments and found that 2 years after treatment, optimal control was achieved with a combination of Garlon 4 and Tordon K herbicides. Garlon 4 at 20% v/v alone, Garlon 4 combined with Stalker, or Stalker herbicide alone controlled *Ailanthus altissima* better than hand cutting, but were not as effected as treatments containing picloram (Burch and Zedaker 2003).

The following herbicide control methods are excerpted from Swearingen and Pannill's (2003) 'Tree of Heaven' fact sheet from the Plant Conservation Alliance, Alien Plant Working Group.

"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."

Grant County Noxious Weed Board and Lakeland Restoration Services (pers. comm.) are working on *Ailanthus altissima* control using a combination of imazapyr (Habitat) and tryclopyr (Garlon) mixed with methylated seed oil. They are utilizing a variety of methods to apply herbicide to the trees during their growth stage that are similar to some of the previously described treatments. Their methods include a stump cut method that entails cutting the tree down and directing the herbicide mixture on the cut portion. This application includes the top and the bottom of the tree as the top can still root if not treated. The treatment should take place immediately after the tree is cut or damaged since this is the time that the product will translocate the herbicide fastest and farthest throughout the tree.

Other methods they are using include the frill cut method, where they cut around the phloem of the tree and spray the wound. There is also the hack and squirt method which is taking a hatchet, damaging the tree and injecting herbicides. And also the basal bark method which consists of spraying the outside of the tree and allowing the mix to enter. This method is typically done with small trees. Small trees are also being controlled with a foliar spray where possible.

Please refer to the PNW Weed Management Handbook, available online at http://weeds.ippc.orst.edu/pnw/weeds for specific herbicide instructions, as herbicide recommendations may have changed since the time of this writing.

Response to Cultural Methods:
It may be possible to shade out and discourage establishment of *Ailanthus altissima* seedlings by establishing a thick canopy of trees or a by growing a dense grass sod (Swearingen and Pannill 2003).

Response to Mechanical Methods:
Hand pulling can be done on very young seedlings, but it is important to remove all of the roots as root fragments left in the soil may resprout. As seedlings age, they develop extended root systems that make hand pulling difficult and ineffective (Kowarik and Säumel 2007). Other mechanical treatments such as burning or girdling may kill the stems but do not address the roots that will heavily resprout (Burch and Zedaker 2003).

Cut stump treatments alone are also not recommended and can in fact favor the plant due to its ability to resprout (Meloche and Murphy 2006). Burch and Zedaker (2003) found cutting alone does not work and actually stimulates resprouting and increases overall stand density. Constán-Nava et al. (2010) conducted a study comparing treatments of cutting stems one time, cutting stems twice (in July and September) and cutting stems once followed by an herbicide application to the cut stem. They found the combined cut stump and herbicide treatment reduced biomass, root collar diameter and height by about 90% one year after application and over the following 3 years. The cutting alone treatments did not differ from the control. Long-term control of *A. altissima* resprouts was efficient when using the combined herbicide and cutting treatment, mainly because of its reduction on aboveground growth. But this treatment did not reduce resprout density; though repeating this treatment did reduce plant height and biomass and may result in total control though further studies are needed.

Cut stems left in contact with moist soil can resprout roots and shoots from nodes (DiTomaso and Healy 2007), so it is important to remove or treat cut stems that are left on site.

<u>Biological Control Potential</u>:
Grazing can be used to kill *Ailanthus altissima* stems and weaken the roots, but it isn't a long-term solution to the continuous resprouting since it does not kill the roots (Burch and Zedaker 2003).

There are currently no approved biological controls for *Ailanthus altissima*. There are have been surveys done in China where two weevils (*Eucryptorrhynchus brandti*, *E. chinensis*), one heteropteran (*Orthopagus lunulifer*), and three fungal pathogens *(Alternaria ailanthi*, *Aecidium ailanthi* and a *Coleosporium* sp.) have been selected for further study (Zheng et al., 2004 *in* Kowarik and Säumel (2007). Swearingen and Pannill (2003) report that two fungal pathogens, *Verticillium dahliae* and *Fusarium oxysporum*, have been isolated from dead and dying *A.altissima* trees in New York and in southern and western Virginia and are being investigated. A disease affecting *A. altissima* in Pennsylvania, *Verticillium albo-atrum*, is also being studied as a potential biocontrol agent (Swearingen and Pannill 2003).

<u>Economic</u> <u>Importance</u>:

<u>Detrimental:</u> *Ailanthus altissima* leaches a variety of allelochemicals (for example ailanthone) that have demonstrated inhibitory or toxic effects on neighboring plants (Small et al. 2010). Negative effects of these chemicals have been repeatedly found in laboratory and greenhouse studies (Mergen 1959, Heisey 1990a, Heisey 1990b, Lawrence et al 1991, Gòmez-Aparicio and Canham 2008, *all in* Small et al. 2010). The root bark, bark of other plant parts, leaves, samaras and wood of *A. altissima* contain, with decreasing intensity, allelopathic compounds that are toxic to numerous woody and herbaceous species (Kowarik and Säumel 2007). One study found a native herbaceous plant, *Verbesina occidentalis,* was negatively affected by growth in *A. altissima* soils, whereas common teasel, *Dipsacus fullonum*, a non-native weed, saw no influence of allelopathic soils from *A. altissima* on germination rates, or seedling growth (Small et al. 2010).

Along with its allelopathic effects, *Ailanthus altissima* is believed to also suppress native vegetation by competition, as it can rapidly form clonal thickets. Kowarik and Säumel (2007) note that the establishment of pure stands implies strong community effects that have however not been studied in detail. They do reference one study (Vila et al. 2006) that found a decrease in species richness in invaded plots compared to non-invaded plots on Mediterranean islands. DiTomaso and Healy (2007) also state that these clonal thickets displace native vegetation as well as wildlife.

Ailanthus altissima trees require a lot of maintenance in urban green spaces and along roadsides due to their vegetative regeneration and fast growth. Stands may obstruct roadside vistas and become a safety hazard by blocking the view of drivers (Burch and Zedaker 2003). Also, tree roots may break asphalt surfaces (Danin 2000) and grow into wells and sewer lines (Hu 1979). Root suckers may sprout up into fields or other areas where trees are unwanted (Miller 1990).

The smell of the leaves and the male flowers may make it undesirable in a landscape planting and has caused, at times, for this plant to be called the 'stink tree' (Hu 1979).

Contact with this plant can cause dermatitis in sensitive individuals and pollen from the male flowers can be an allergen (DiTomaso and Healy 2007). There is also a rare case report where contact with the sap caused myocarditis (Bisognano et al. 2005 *in* Kowarik and Säumel 2007).

<u>Beneficial:</u>
In China, *Ailanthus altissima* is a native tree that has traditionally been used for a variety of purposes. Its leaves have been used in the silk industry to feed silk worms (Hu 1979). The bark, roots, leaves and fruits of

the trees are used to make a vast array of different traditional medicines (Hu 1979). The wood is also used for a variety of purposes such as construction, fuel and for making tools (Hu 1979).

With its ability to survive in harsh environmental conditions, *Ailanthus altissima* can grow in strongly altered urban-industrial sites that many other plants could not survive in (Kowarik and Säumel 2007).

Honeybees that feed on Ailanthus make good-tasting honey though it may smell bad and have an unpleasant aftertaste at first (Melville 1944 *in* Hu 1979).

Rationale for Listing:
Tree of heaven, *Ailanthus altissima*, has naturalized and spread in areas throughout Washington State. This fast growing tree spreads by suckering roots as well as by producing an abundance of seed--up to 325,000 per tree. *A. altissima* leaches a variety of allelochemicals into the soil that have demonstrated inhibitory or toxic effects on neighboring plants (Small et al 2010). Along with its allelopathic effects, *Ailanthus altissima* is believed to also suppress native vegetation by competition, as it can rapidly form clonal thickets. Trees can also be a nuisance in urban areas with roots breaking asphalt surfaces, growing by building foundation and into wells and sewer lines.

References:

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