

Questions and Answers about Thousand Cankers Disease of Walnut

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What is thousand cankers disease of walnut? Thousand caners disease (TCD) is a newly recognized disease (2008) of certain walnut species (*Juglans*) caused by a fungus (*Geosmithia morbida*) that is vectored by a bark beetle (*Pityophthorus juglandis*, the “walnut twig beetle”). Thousand cankers disease has produced widespread death of walnuts in many western states during the past decade. In recent years it has been confirmed from several eastern states including areas around Knoxville, TN (2010), Richmond, VA and Bucks County, PA (2011).

Is thousand cankers disease a problem confined to the western United States? No. Although the original reports of this disease did occur in the western US, outside the native range of black walnut (*Juglans nigra*), observations of the recently discovered infestations in Tennessee, Virginia and Pennsylvania demonstrate that this disease can be a serious problem in urban and natural forests of the eastern US. In that area the infestation appears well established and of considerable duration, given the affected area, which encompasses several counties.

There may be some regional differences in the progress of the disease and in symptoms development but the walnut twig beetle and *Geosmithia morbida* appear to be adapted to black walnut in the eastern United States and tree mortality has occurred. It appears that ultimately thousand cankers disease can be lethal to susceptible host trees where ever it becomes established.

What are symptoms of the disease? The *Geosmithia* fungus kills an area under the bark in the twigs and branches where it is introduced when the walnut twig beetle tunnels into the limb. These dead areas are called cankers and numerous cankers are formed when the walnut twig beetles are abundant. Although the cankers are superficial and are originally confined to areas just under the bark they can extend into the cambium. Further the growth of cankers and the production of new cankers coalesce to girdle twigs and branches. This likely results in restricted movement of nutrients and perhaps interferes with production and storage of energy.

However, the cankers produced in TCD rarely show any of the external symptoms that are associated with most canker-producing fungi that affect trees. The affected area is shallow and can easily be missed if inspection cuts are made too deeply into the sapwood. In some infections minor weeping may occur at points where walnut twig beetles enter the bark, but often there are no external symptoms associated with the beetle entry and tunneling. Minute entry or exit wounds and sometimes star shaped cracks are observed on affected limbs with smooth bark.

Often the first symptom of TCD infection involve yellowing of leaves on individual branches (flagging) and a general foliage thinning of the tree crown. As the disease progresses larger limbs

are killed and branches dying in summer may have areas where leaves rapidly wilt. In end stages the fungus may be introduced into the trunk and large cankered areas develop in the trunk. In highly susceptible hosts, such as black walnut (*Juglans nigra*), trees in the Rocky Mountain states have almost invariably died within three years after initial symptoms (leaf flagging and noticeable crown thinning) were observed.

Symptom progression may vary. For example, many black walnut trees affected by thousand cankers disease in the Knoxville area currently show broad crown dieback but have a lush growing lower canopy during the end stages of the disease. In the western states dieback may be more scattered through the canopy throughout the progress of external symptoms expression. Furthermore, there is often very little, if any, sprouting from black walnut that die from thousand cankers in Colorado; somewhat more sprouting appears to occur in Tennessee. These may be due to differences in growing conditions, initial tree health, and the presence of other pathogens that enter TCD-compromised trees.

What is the insect vector? The walnut twig beetle, *Pityophthorus juglandis*, is the only insect presently known to transmit the fungus from tree to tree. Investigations are currently underway to see if other species that tunnel into walnut (e.g., various borers, ambrosia beetles) may also be incidental vectors. However, since TCD requires repeated reinfestation by an insect that consistently carries the *Geosmithia* fungus (as does the walnut twig beetle), other significant vectors are unlikely.

The walnut twig beetle is a native species to North America. It was first described in 1928 from beetles collected in 1896 in Grant's County in southwestern New Mexico, where the presumed host was Arizona walnut (*Juglans major*). Prior to 1992 it was reported from Arizona, New Mexico, and northern Mexico (Chihuahua) areas that coincide with the native range of Arizona walnut. Also, there were two 1959 California reports of the beetle from walnut collected in Los Angeles County. Subsequent records of the insect in California between 1973-1982 include Riverside, Butte Lassen, San Mateo, Solano, and Sacramento Counties and the insect is now broadly distributed in the state. These records suggest that the insect also was native to southern California, where the native host would be *Juglans californica* (southern California walnut).

Within the past couple of decades, the walnut twig beetle has substantially expanded its range. New state records for the insect have recently been determined from Colorado, Utah, Idaho, Nevada, Oregon, and Washington. Within California the beetle is widespread throughout central areas of the state and in some coastal counties. In July 2010 the walnut twig beetle was found in Knox County, TN in association with a detected outbreak of thousand cankers disease that appears to have originated from an introduction that occurred at least a decade earlier. Increased surveillance in 2011 identified the most recent infestations, in Pennsylvania and Virginia.

What is the fungus? The fungus identified in 2008 that is capable of producing thousand cankers is a previously undescribed species of *Geosmithia*. The fungus is consistently recovered from the walnut twig beetles and cankers that form around the beetle galleries in the bark.

Research into the genetics and biology of this fungus are underway. The origin of the fungus is not yet known but is likely also native to the same *Juglans* that serve as native hosts of the

walnut twig beetle. Limited data indicate the population of the fungus in the West is complex and diverse. This type of diversity would be expected from a long established species rather than a recent introduction from Asia or Europe.

What is the association of the twig beetle and the fungus? The *Geosmithia* fungus can consistently be recovered from the body of beetles, from their galleries and their frass. It appears that the fungus is essentially always found in association with the walnut twig beetle. This includes its occurrence in native hosts (*Juglans major* in AZ and NM, *J. californica* in CA) as well as all other *Juglans* in all other sites where walnut twig beetle has been observed.

Because of this consistent association of the beetle with *Geosmithia morbida*, the detection of the walnut twig beetle in a walnut tree can be considered equivalent to detection of thousand cankers (walnut twig beetle = *Geosmithia morbida* = thousand cankers disease).

Whether there is some mutualistic association of the two species remains a subject for further study. The walnut twig beetle does not possess mycangia for transport of the fungus but beetles are heavily contaminated externally by *Geosmithia* spores when they emerge from trees.

What species of trees are susceptible to this disease? This disease was first recognized on black walnut (*Juglans nigra*), a common woodland species distributed throughout much of the eastern US. Black walnut is extremely susceptible to thousand cankers, is the most commercially valuable *Juglans* species, and is the species of greatest TCD concern.

Evaluating other species is a major focus of ongoing research. Arizona walnut (*Juglans major*), the native host of the walnut twig beetle, apparently is quite resistant. The insect is commonly found associated with this species in New Mexico and Arizona yet in Arizona walnut beetle attacks are limited largely to small diameter branches that are overshadowed or injured. Galleries typically occur at leaf scars. The *Geosmithia* fungus colonizes around these galleries, but does not progress aggressively as in black walnut and does not result in tree mortality.

Interestingly, walnut twig beetle has never been found in native stands of little walnut (*Juglans microcarpa*), a species that occurs between the native range of Arizona walnut and black walnut and overlaps both at the extremes of its range. (It has been found damaging *J. microcarpa* in plantings at Davis, CA.) Further surveys for walnut twig beetle and its *Geosmithia* associate in little walnut is a current research priority. Some tree colonization was noted in little walnut grown in a *Juglans* research planting in Davis, CA.

Tentatively, it appears that northern California walnut (*Juglans hindsii*) and southern California walnut (*Juglans californica*) show degrees of intermediate susceptibility to thousand cankers disease. Dieback and even some tree mortality (particularly in *J. hindsii*) have recently been observed in California, although more limited die-back has been more commonly noted. It is also likely that there is a range in resistance to thousand cankers in different populations of the trees.

Thousand cankers disease was recently observed on a butternut (*J. cinerea*) in Oregon. This disease could potentially threaten this species in its native range in the eastern United States and

Canada.

The commercial nut-producing Persian (English) walnut (*Juglans regia*) appears to have fairly high resistance to thousand cankers, although it has been observed to be attacked in sites where large numbers of walnut twig beetles are present. However, most Persian walnut is grafted onto rootstock of other *Juglans* that may be more susceptible.

Walnut twig beetle and *Geosmithia morbida* do not colonize pecan and other hickories (*Carya*) are similarly immune.

Are other fungi involved? *Fusarium solani* (as well as other *Fusarium* species) often are associated with long, vertical trunk cankers in advanced stages of the disease. *Fusarium solani* is widespread in North America and has previously been reported to cause cankers on drought-stressed or freeze-damaged walnut trees. However, this fungus is not commonly found in cankers surrounding walnut twig beetle galleries. Nevertheless, it may contribute to canker development on the main trunk .

As thousand cankers causes a depletion of energy reserves, other secondary pathogens may invade trees weakened by this disease. *Armillaria* root rot, an organism well know to be favored in trees with reduced root starch reserves, has been noted to develop in thousand cankers-affected trees in Oregon.

In the advanced stages of the disease, the bark on the main trunk becomes macerated by walnut twig beetle attacks and subsequent colonization and canker formation by the *Geosmithia* fungus. This macerated bark and surrounding weakened tissue may serve as a food source for a number of opportunistic microorganisms.

Are other insect vectors important in thousand cankers disease? It is unlikely that any insect aside from the walnut twig beetle is important in the course of this disease. Other species of insects, notably various longhorned beetles and ambrosia beetles, are frequently recovered from declining walnut, including TCD-affected walnut. These species may incidentally carry spores and possibly could initiate a point of infection with the *Geosmithia* fungus. However, thousand cankers disease requires sustained attacks by a vector that can produce thousands of entry courts for *Geosmithia* infection and lives within the cambium of the tree. The habits of the walnut twig beetle, but not the other wood boring insects, are particularly suited for this type of spread.

Can trees survive this disease? Thousand cankers disease kills trees from the cumulative effects of numerous coalescing cankers (and tunneling) that develop around individual entry wounds made by walnut twig beetles. (Canker development can occur following entry wounds either associated with mating/egg laying or during the more numerous wounds made as beetles apparently tunnel briefly for feeding but do not establish egg galleries.) Although the fungus does grow within the tree, the area infected is limited; it *does not* move systemically in the plant as do some other insect vectored fungi, such as the species involved in Dutch elm disease (*Ophiostoma novo-ulmi*). Instead, tree death results from disruption of phloem tissues transporting nutrients resulting in a progressive depletion of energy.

It is unknown how long it takes to kill a tree once it has been initially colonized by *Geosmithia*-bearing walnut twig beetles and the subject is one of debate. It is possible it may take many years – possibly sometimes a decade or more – to kill even a highly susceptible black walnut (*Juglans nigra*) following the initial colonization event by walnut twig beetles. Symptoms only appear after there have been considerable amounts of canker formation produced by large numbers of walnut twig beetle entry wounds. Whether sufficient colonization to produce external symptoms can require 5 years, 10 years, or even 20 years is not known and will vary due to many factors. However, observations of black walnut in the western states indicate that TCD is ultimately fatal to essentially all trees of this species.

Trees that are well-sited, provided adequate water and have been able to produce vigorous growth may show substantially slower progress of thousand cankers than in trees growing more slowly. Thousand cankers disease appears to be a disease of energy depletion caused by disruption of the tree's ability to produce and store energy due to canker formation. Trees with large energy reserves will thus likely survive longer than more stressed trees.

Furthermore, some *Juglans* species and hybrids appear to be more resistant to thousand cankers than is *Juglans nigra* (black walnut). The course of disease may be substantially slowed in such trees or even halted. In highly resistant hosts (e.g., Arizona walnut) thousand cankers disease will rarely, if ever, progress to kill trees or even major limbs. In species or hybrids with more intermediate resistance the effects of thousand cankers may ultimately be limited to scattered dieback rather than death of the tree.

Theoretically, thousand cankers disease progress could be arrested if colonization of *Geosmithia*-bearing walnut twig beetles were prevented from producing new tunnels in trees. No methods that can adequately achieve this have been identified. In susceptible hosts, such as black walnut, trees can always be expected to die within a few years after external symptoms have been observed.

Where does thousand cankers presently occur? In the western US, die-offs of walnuts suspected or confirmed to have been caused by this insect-fungal complex have been recorded during the past decade from northern New Mexico, Colorado, Utah, Idaho, Oregon, California, Washington and, most recently (2010), Nevada. The walnut twig beetle and *Geosmithia* are also present in *Juglans major* in southwestern New Mexico, Arizona and northern Mexico. Within California, collections have been made throughout the Central Valley and as far north as Davis, where it can be found in the northern California walnut (*Juglans hindsii*). This is considerably further north than the 1959 Los Angeles County collections that were likely associated with southern California walnut (*J. californica*).

The July 2010 discovery of walnut twig beetle and thousand cankers disease in Tennessee was the first east of the Mississippi. Unfortunately, this infestation was also located near the geographic center of the native range of its most susceptible host, black walnut. The Pennsylvania and Virginia have established additional areas of TCD establishment within this range. Geographic/ecological barriers to spread of thousand cankers disease within the native range have now been breached it can be expected that TCD will ultimately work its way throughout most if not all of the native range of black walnut over the next century.

Does thousand cankers disease harm walnut wood? No. Beetle tunneling is primarily limited to the tree bark and extends very shallowly into sapwood causing no injury to marketed wood. Similarly the *Geosmithia* fungus grows in the phloem and does not produce any deep staining. Neither of the two species associated with thousand cankers will affect the quality of the wood in any manner.

Where did this disease come from? The origin of the disease is currently in debate and further research will be needed to better develop and test hypotheses on this subject.

The leading hypothesis is that the disease resulted from the movement of the walnut twig beetle and its associated *Geosmithia* fungus from native hosts (Arizona walnut, southern California walnut) into other *Juglans* species that are more susceptible to thousand cankers disease. Somehow infective beetles dispersed throughout much of the western US during the past couple of decades where they found and colonized susceptible black walnut and other *Juglans* that had been introduced and planted by humans within the past century. No *Juglans* species are native to most of the states where thousand cankers was first recognized (e.g., Colorado, Utah, Idaho, Washington, Oregon). Black walnut and some hybrid walnuts are the *Juglans* species that have been most often planted in these areas over the past century and these provided susceptible hosts into which the beetle (and fungus) were able to disperse.

If the above scenario is correct, dispersal may have occurred by natural dispersal event or by human transfer. The former would have involved a wind-blown dispersal event where an immense flight of walnut twig beetles was pushed northward on favorable weather patterns at some period in the past few decades. Human transfer, through movement of walnut wood pieces that contain living walnut twig beetles is also, always, a means of further spread. The isolated infestations in Tennessee, Virginia, and Pennsylvania are clearly due to human transfer, possibly on a piece of wood carried for woodworking that had been collected from some site where the walnut twig beetle was present.

Regardless, once established there is a lag time for the beetle populations and *Geosmithia* canker production to build to the point where symptoms of the disease became evident. The earliest known suspected cluster of black walnut die-off from this disease probably occurred in Utah and western Colorado in the early to mid-1990s. Often, these early black walnut die-offs associated with this disease were diagnosed as being drought related or of unknown cause.

There are some other alternative hypotheses on the origin of the disease. The fungus may have been introduced into North America from Central America or some other exotic location. Or there may somehow been a shift in the pathogenicity of the fungus and this new strain was acquired by walnut twig beetles where it was widely spread.

Studies of the genetics of *Geosmithia morbida* and its present distribution in various *Juglans* populations should provide information that will resolve this question. Preliminary information on the genetics of fungal strains collected across the western US indicates that it is genetically diverse. This argues against a single event introduction in to the West; there is no evidence of a “genetic bottleneck” that might be expected to occur following an introduction. Genetics

studies on the various populations of walnut twig beetles will also be illustrative of how this disease originated and spread.

Are there any traps for this insect? Walnut twig beetle has been trapped in Lindgren funnels and yellow sticky panels hung from walnut trees and on sticky clear panels stapled to walnut trunks. However, there is no evidence that any of these designs are attractive and that they effect more than incidental walnut twig beetle captures. Attempts to increase capture by use of walnut wood, pityol and other compounds useful in trapping some bark beetle do not increase capture of walnut twig beetle in these traps.

Sex pheromones produced by the walnut twig beetle appear to be present, based on observations of beetle behavior by USDA Forest Service researchers in California. Most active are male produced compounds released when beetles first colonize a walnut tree; evidence of a female-produced compound also has observed. These studies in identifying attractants has led to the first walnut twig beetle attractant (Compound X) being made available in 2012. This lure is being distributed by Contech, which recommends its use with a small Lindgren funnel. In 2012 the contact person with whom you may wish to communicate with is Bruce Thomson at: Bruce.Thomson@contech-inc.com . The web site for Contech is; www.contech-inc.com

This lure should allow for improved detection of walnut twig beetle in survey activities and will also be useful in establishing activity patterns of the insect.

Does drought have an effect on this disease? The effect of drought on thousand cankers disease is probably minimal and indirect. Well watered, well maintained black walnut has been killed by the disease almost as rapidly as trees in poorer condition. Drought stress perhaps could have some effect on progression of canker development and the relative ability of the twig beetle to successfully reproduce in trees. These effects have not been documented but drought is probably of minor importance in the overall epidemiology of this disease.

How will temperature affect this disease? Since thousand cankers disease apparently was originally associated with host plants located in the southwestern US and Mexico it is well adapted to warm conditions. This is further indicated by *Geosmithia morbida* in laboratory culture favorably growing under warm temperatures.

Cold temperatures may affect the course of thousand cankers disease in a couple of ways. Cooler weather can be expected to slow beetle development, resulting in slower generation times and perhaps slower population increase. Very extreme cold may also kill some beetles. However, observations made during the winter of 2011 indicated that at least some beetles were able to survive following a period of temperature ranging from -10F to -15F over the course of several days.

What is the life cycle of the walnut twig beetle? Recent observations can provide the broad outlines for the life history of this insect, but even basic life history information is presently lacking. This insect has previously received no study because of its negligible importance in native hosts.

The life history is imperfectly understood. Even in areas with cold winters, such as Colorado, both adults and larvae can be observed in logs during the winter months, suggesting continuously breeding overlapping generations. Adults emerge to resume activity spring and have been observed first in late-April in Colorado.

Mating occurs within an excavated chamber under the bark. Initial colonization of trees is done by males, who excavate a small chamber under the bark and release pheromones attractive to females. One or two females typically join the male and they create egg galleries under the bark, along which eggs are laid.

With warm weather, larvae feed for 4-6 weeks under the bark in meandering tunnels that run roughly perpendicular to the egg gallery. Pupation occurs at the end of the tunnel and the adults emerge through minute, round exit holes. Most galleries are formed in the phloem and bark and do not extend to the cambium and sapwood until very late in disease development. Therefore, the larval galleries do not score the sapwood as is found with beetles such as the emerald ash borer or mountain pine beetle.

Adults emerge to produce a second generation, beginning in early summer. Peak flight activity of adults in Colorado occurs from mid-July through late August and declines by early fall. However, more limited breeding may extend well into autumn and larvae as well as adults can be found throughout winter. Normally 2-3 generations are likely produced, which overlap considerably.

This life history may be considerably different in warmer climates. For example, in California overwintering stages also include larvae in various stages of development and adult flights may begin in March.

What treatments are available for thousand cankers disease? Currently there are no known means of reliably controlling this disease. Some techniques directed at the vector ultimately may prove to be useful in suppressing the rate of disease spread. However, it may be unlikely that effective treatments will be found that can control walnut twig beetles once tree attacks have begun.

Theoretically, methods that can prevent tunneling by walnut twig beetles (e.g., certain insecticides) can prevent further spread of this disease. However, to date, effective techniques to control the walnut twig beetle have not been identified. Control of walnut twig beetle by use of drenching trunk/branch sprays of insecticides (permethrin, bifenthrin, carbaryl) is a technique used successfully against some other bark beetles (e.g., mountain pine beetle, Ips beetles). Laboratory bioassays indicate that these insecticides are lethal to beetles. However, maintaining effective coverage with sprays is a huge challenge and infested black walnut trees that have received repeated insecticide spray treatments by arborists in Colorado are observed to continue to decline and die. This method appears to have only limited effectiveness, at most.

The use of soil applied systemic neonicotinoid insecticides (e.g., imidacloprid, dinotefuran, clothianidin) is a possibility for bark beetle control and there has been some attempts to use these products for this purpose. Anecdotally these treatments seem to have had negligible

effectiveness, at most. Some informal observations suggest that the disease may be suppressed for a few years by soil applications of imidacloprid if they are applied before the disease has become well established in the tree; treatments made after symptoms begin to appear are ineffective.

However, complicating the issue of pesticide use on black walnut are significant regulatory issues. Black walnut is a plant material that produces edible nuts that sometimes are collected and eaten. As a result, these trees may be considered to be “nut crops” and thus pesticide uses made to black walnut need to comply with those used on edible nut crops. This currently greatly restricts available insecticide (and fungicide) options. Insecticides that appear to have adequate labeling for use on black walnut appear to include certain brands containing imidacloprid, chlothianidan, permethrin, and carbaryl. However, pesticide uses often are interpreted differently by different state regulatory agencies and any pesticide application must conform to local laws.

Trunk injected pesticides have not been evaluated for managing this disease. Macrocytic lactones (e.g., abamectin, emamectin benzoate) and possibly certain fungicides may be useful materials for further testing. Opportunities for such evaluations may become available in the future. However, there are similar regulatory and pesticide registration issues with all trunk injection systemic pesticides that can be considered for possible use on black walnut.

Can the walnut twig beetle and thousand cankers be spread on nuts or nut meat? There is no evidence that the walnut twig beetle is attracted to or spends any time in association with walnut fruit and does not tunnel into hulls. Furthermore it is very unlikely that the *Geosmithia* fungus would colonize the hull or meat of any walnut species. Even if this were the case, the fungus would be unable to effectively colonize the tree without the presence of the beetle.

Can the walnut twig beetle survive in bark mulch? In a recent test some developing bark beetles were observed to survive in relatively large diameter chips that were collected following the chipping of a diseased tree. Therefore, it is likely that beetles could be spread on freshly chipped bark mulch.

On the other hand chipping is likely one of the best ways to disinfest wood material from TCD-affected trees. Although some walnut twig beetles and the *Geosmithia* fungus can survive normal chipping and later emergence, chips will likely unsuitable host material in a much shorter time (i.e., weeks-months) than are whole logs (i.e., years).

If I have a tree that has thousand cankers how should I handle the wood? Most important is all wood from a TCD-affected tree should be retained locally to prevent further spread of the disease. Whether the wood is consumed (e.g., firewood, woodworking) or whether it is destroyed (e.g., chipped, landfilled) is a decision that will be determined locally, but no wood material from TCD-killed trees should ever be moved to a location where the disease is not already present.

Logs and standing trees affected with thousand cankers can support development of tremendous numbers of walnut twig beetles. As long as live beetles remain associated with this wood it

remains extremely infectious and can easily allow the disease to spread. Because of this it is critically important that logs or pieces of wood with bark intact from walnut harvested in any area where TCD is known to be present (e.g., all western states and the limited areas in the 3 eastern states) never be allowed to move outside the area where thousand cankers currently is present. Movement of a single log with live beetles can be the initial source of an outbreak that could ultimately devastate black walnut in previously uninfested areas.

Walnut twig beetles will readily reinvade fresh logs with any bark remaining. These reinvasion cycles may continue until the bark is completely consumed and/or becomes so dry that larval development can no longer be completed. It is unknown how long this process will take if logs are stored under normal conditions outdoors. Logs are known to remain extremely infectious (i.e., support live beetles) for at least 15 months after being cut. Possibly, logs that have been stored for 3 or more years will no longer support beetles – but this has not been conclusively established. Furthermore the suitability of wood for continued walnut twig beetle breeding will also be affected by storage conditions such as humidity, temperature and whether cut ends are sealed. Work is in progress to better define how wood storage affects its suitability for continued walnut twig beetle breeding.

Milled wood that produces bark-free lumber will not support walnut twig beetles. Kiln drying or exposure of the cambium area to suitably high temperatures undoubtedly will kill beetles and likely accelerate drying so that wood becomes less suitable for development. However, it is still unknown if heated logs or slabs with bark intact can be reinfested by walnut twig beetles for some period.

Treatment of logs with insecticide sprays (e.g., permethrin, bifenthrin, dinotefuran) or biodiesel will not kill all beetles. Insecticide spray applications are ineffective for eliminating walnut twig beetles.

Immersion treatments are under investigation. Results to date indicate limited submersion in water (one week) does not kill all beetles. Submersion in ethanol appears more effective.

Research into methods that can reliably disinfest walnut products are a high priority of research and better answers should be available within a year or two. In the interim it is strongly recommended that all walnut wood from thousand cankers affect trees be milled and used locally to prevent accidental spread of walnut twig beetles that can move the disease into new areas.

Are there regulations affecting thousand cankers disease and movement of walnut wood?

Several states have enacted state quarantines that prohibit the movement of any walnut item that may harbor live walnut twig beetles and that originate from a state/region where thousand cankers disease is known to be present. Missouri led the way with a state quarantine in spring 2010. Since then several states have followed their lead. As of August 2010 state quarantines have been enacted or are in advanced development in Arkansas, Indiana, Iowa, Illinois, Kansas, Michigan, Nebraska, North Carolina, Oklahoma, and Wisconsin. The eastern states with known infestations (Pennsylvania, Tennessee, Virginia) have also developed ordinances for regulating walnut wood products into and around the state. Other states likely will soon have quarantines and regulations restricting introduction of walnut products that may allow spread of thousand

cankers disease.

At present there are no federally coordinated national quarantines, such as exist for emerald ash borer, Asian longhorned beetle, gypsy moth, sudden oak death, light brown apple moth, and many other pest problems that originated from outside the borders of the United States.

How should one go about surveying for thousand cankers disease? Surveys should be done in a manner that allows detection of symptomatic trees with follow-up examination to determine if walnut twig beetles and/or *Geosmithia morbida* is present in samples from suspect trees.

In initial surveys, detection of walnut trees with crown dieback or abnormally thin crowns may be indicators of thousand cankers disease. However, crown dieback may have many other causes (e.g., freeze injury, root damage, colonization by tree rotting fungi). Similarly, various biotic (e.g., aphids, mites) and abiotic causes (e.g., drought) may cause premature leaf shed broadly across a walnut canopy.

In closer inspection look for individual limbs that show flagging, either in the form of branches with clumps of yellowing leaves, or branches with leaves that have wilted and remained on the branch. These limbs are often sites where new cankers and current activity of walnut twig beetles can be most readily found.

For confirmation cut and exam dying or recently dead limbs. The most easily observed symptom of thousand cankers presence is the occurrence of minute exit holes in the bark made by walnut twig beetles. In areas where these are present the galleries of the bark beetles can usually be exposed easily when the bark is peeled away with a knife. These exit holes are most easily found in limbs with relatively smooth bark that are at least $\frac{3}{4}$ -inch diameter. Despite the name “twig beetle”, walnut twig beetles are not found in the smallest diameter twigs. Branches of 1-2 inch diameter are probably easiest to exam for the presence of the beetle.

Also indicative of thousand cankers is the occurrence of multiple trees at a site with potential symptoms.

Surveys of thousand cankers are most productively done during July and August. Early in the season symptoms of flagging may not yet express and will go undetected. Late in the season flagging may occur on limbs due to many causes (e.g., mechanical injuries, overshadowing) and normal senescence, making detection of symptomatic limbs more difficult.

If I am growing black walnut in an area where thousand cankers does not occur yet do I need to change any growing practices or marketing plans? No. Despite the eastern US infestations it remains reasonable to expect that spread of thousand cankers will only slowly move through the native range of black walnut, *if spread is not accelerated by human transfers of infected wood.*

Consider the following theoretical example. Assume that, unaided by humans, the walnut twig beetle is capable of spreading about 2 miles/year. (The ability of the beetles to move is unknown, but they are small and likely dispersal flights are normally of short distance,

particularly through forested areas.) If that is the case, then it will take about 240 years to move from Knoxville to Columbia, MO; 145 years to get to Indianapolis. Even if it moves twice as quickly natural spread may take 120 years to move deep into Missouri and 70 years into Indiana, the major US producers of black walnut wood products.

Furthermore, once established at a site there will be a lag time before it destroys all the black walnut trees. Depending on what assumptions one makes it may take 15-30 years before black walnuts will be largely destroyed in a city following its initial introduction. (Assumption based on the first detected symptoms in a tree appearing 5-15 years after initial infestation and 10-20 years for TCD to fully progress across a municipality following the appearance of the first symptomatic tree.)

This potentially gives the United States a very long time to help prepare for and absorb the effects of thousand cankers and the premature cutting of black walnut that it entails. Furthermore, over time improved means of management and development of TCD-resistant black walnut can be expected to be developed.

However, the distance between a location where thousand cankers occurs and any uninfested site is only a day trip away via pick-up load of walnut wood. The extent that humans move TCD-infected walnut wood will determine the progress and ultimate economic and ecological effects of thousand cankers disease in the US.

The establishment of effective regulations to prevent further spread of walnut twig beetle infested material can have tremendous effect in reducing risk of thousand cankers spread in the upcoming decades. Furthermore, as public awareness of thousand cankers increases it is hoped that movement of infested walnut wood originating from western states will largely cease. Woodworkers, lumber yards, tree removal services and firewood distributors are among the key groups that need to be provided information on this new disease.

At this point in time there is no need for walnut producers in the eastern US to alter any production practices or marketing plans. However, they should be engaged in the public relations work needed to restrict movement of walnut products that can support live walnut twig beetles and thus reduce the possibility of its spread into eastern production areas.

On the other hand, in areas where thousand cankers disease is known to already be present further planting of black walnut is not currently recommended. If future research and breeding allow identification of thousand cankers resistant cultivars production may prove viable. However, at this point in time the absence of effective controls and the extreme susceptibility of *Juglans nigra* to thousand cankers makes its further culture in the western US, eastern Tennessee and other areas with recent TCD detection to be highly problematic.

What should be done to help prevent further damage by thousand cankers disease? *It is extremely important that from this point on that no infested walnut twig beetles are ever allowed to move beyond the current known range of thousand cankers disease. Salvaged trees with bark intact will very likely contain these beetles. A recent observation indicated that over 30 beetles could develop under a square inch of bark, making recently killed trees potentially highly*

infectious.

Due to the high value of black walnut for woodworking purposes, the movement of such wood is most likely to occur by wood workers and wood turners; walnut originating from the western US is rarely used as firewood. Therefore it is very important that woodworkers, mills and companies involved in lumber movement, foresters and arborists understand the serious nature of this threat and never allow movement of infective walnut wood into areas where this disease does not occur.

In communities where thousand cankers has been established, there is some evidence that an aggressive sanitation program can slow the progression of the disease within an area. This primarily involves prompt detection and removal of TCD-affected trees. Enormous numbers of *Geosmithia*-bearing walnut twig beetles are produced within and emerge from the trees in end stages of infection (i.e., after showing foliar symptoms).

Where can I get more information on this situation? A fact sheet on this disease has been developed by Colorado State University and will be regularly updated as new information is learned. It and other materials related to detection and diagnosis of thousand cankers disease is located at the web site established within the Department of Bioagricultural Sciences and Pest Management at:

<http://www.colostate.edu/Depts/bspm/extension%20and%20outreach/thousand%20cankers.html>

The National Walnut Council and Purdue University have also combined to produce a Thousand Cankers Home Page (<http://thousandcankers.com/>) featuring developments related to Thousand Cankers Disease. Among the information available at this site are updates on regulations (e.g., state quarantines) related to thousand cankers disease and links to fact sheets produced by the USDA Forest Service. Many states (e.g., Missouri, Tennessee) have web sites with TCD information, typically maintained through the Department of Agriculture.