National Park Service
U.S. Department of the Interior

Northeast Region


Eastern Rivers and Mountains Network

# Early Detection of Invasive Species

# Surveillance Monitoring Field Guide

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**Purpose of this Field Guide:**
This guide was designed as part of the Eastern Rivers and Mountains (ERMN) and Northeast Temperate (NETN) Networks Early Detection of Invasive Species Surveillance Monitoring and Rapid Response monitoring protocol. The purpose is to assist National Park Service (NPS) employees, contractors, and citizen scientists to detect incipient populations of targeted invasive species before they become widely established. The taxa presented in this guide are a subset of larger target species lists that were produced for each park in the above mentioned networks. Taxa already present in the USDA Forest Service "Invasive Plants Field and Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands Field Guide" were not duplicated. The overall format of this guide follows that of the USDA Forest Service Guide and allows for supplementation with individual taxon cards from the Forest Service guide. As new park species threats arise, new species cards will be produced.

**This work is in progress; information and comments from the users of this guide are welcome.**

**Species List**
**By Scientific Name**

**Pests**
*Adelges tsugae* -- hemlock woolly adelgid
*Agrilus planipennis* -- emerald ash borer
*Anoplophora glabripennis* -- Asian longhorned beetle
*Sirex noctilio* -- sirex woodwasp

**Herbs**
*Cardamine impatiens* -- narrowleaf bittercress
*Lythrum salicaria* -- purple loosestrife
*Oplismenus hirtellus* ssp. *undulatifolius* -- wavyleaf basketgrass

**Vines**
*Dioscorea oppositiifolia* -- Chinese yam

**Shrubs**
*Frangula alnus* -- glossy buckthorn

## Species List
### By Common Name

**Pests**

Asian longhorned beetle -- *Anoplophora glabripennis*
emerald ash borer -- *Agrilus planipennis*
hemlock woolly adelgid -- *Adelges tsugae*
sirex woodwasp -- *Sirex noctilio*

**Herbs**

narrowleaf bittercress -- *Cardamine impatiens*
purple loosestrife -- *Lythrum salicaria*
wavyleaf basketgrass -- *Oplismenus hirtellus* ssp. *undulatifolius*

**Vines**

Chinese yam -- *Dioscorea oppositiifolia*

**Shrubs**

glossy buckthorn -- *Frangula alnus*

# EMERALD ASH BORER
## [*Agrilus planipennis* Fairmaire]

Fig. 1 UGA1241011


Fig. 2 UGA 5016058

**Problem:** A native of Asia,[1,2,4] emerald ash borer (EAB) infests and kills North American ash species (*Fraxinus* sp.) including green, white, black and blue ash. Damage is caused by the larvae, which feed in the cambium between the bark and wood, producing galleries that eventually girdle and kill branches and entire trees.[1,2]

**Identification:** Adults are roughly 7.5 to 13.5 mm long (⅜ to ⅝ in)[3,5] with metallic green wing covers (Fig. 1) and a coppery red or purple abdomen (Fig 2).[2,4] Larvae reach a length of 26 to 32 mm long (1 to 1 ¼ in),[1] are white to cream-colored and dorso-ventrally flattened.[2]

**Signs and Symptoms:** Irregular holes excavated by woodpeckers feeding on pre-pupal larvae (Fig. 3) may be the first sign of infestation.[1,2] After at least one year of infestation, D-shaped exit holes (3-4 mm in diam., ~⅛ in.) in the outer bark of the branches and trunk (Fig. 4) indicate adult emergence.[1,2] Adults may be visible from late May through September,[3] but are most common in June and July.[2,3] Vertical bark fissures (Fig. 5), crown dieback (Fig. 6) and epicormic


Fig. 3 UGA 1372003


Fig. 4 USDA Forest Service, Deborah McCullough, MSU

# EMERALD ASH BORER

*Agrilus planipennis* Fairmaire

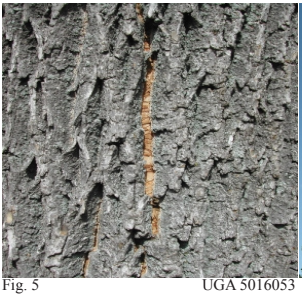

Fig. 5 UGA 5016053

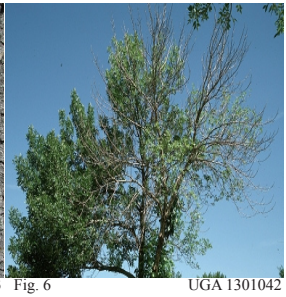

Fig. 6 UGA 1301042

sprouting and suckering are also prevalent.[1,2]

When the bark is removed from infested trees, distinct, larval tunnels or galleries that etch the outer sapwood and phloem are readily visible on the trunk and branches (Fig. 7).[2]

Fig. 7 UGA 5147090

**Similar Species:** Adult EAB beetles are generally larger and a brighter green than native North American species' of *Agrilus*,[4] like the bronze birch borer.[3] The six-spotted tiger beetle and caterpillar hunter are larger in size, are both predators of other insects, and are ground dwelling.[3]

Fig. 9 UGA 5016041

Fig. 8 UGA 2133022

Fig. 10 UGA 5022085

**Above (Fig. 8):**
six-spotted tiger beetle
*Cicindela sexguttata* Fabricius

**Upper left (Fig. 9):**
bronze birch borer
*Argrilus anxius Gory*

**Lower left (Fig. 10):**
caterpillar hunter
*Calosoma scrutator* Fabricius

# ASIAN LONGHORNED BEETLE
## [*Anoplophora glabripennis* (Motschulsky)]


Fig. 1 UGA 2159062

**Problem:** Native to China,[1,3,6] Asian longhorned beetle (ALB) (Fig. 1) infests and kills native hardwood trees including all species of maple, birch, poplar, willow, elm, ash, hackberry, sycamore and others.[1,3,6] It has the potential to cause more destruction than Dutch elm disease, chestnut blight and the gypsy moth combined.[1] Damage is caused by larvae that feed in the outer sapwood and deep into the tree's heartwood, forming tunnels or galleries in the trunk and branches.[3,6] This damage weakens the integrity of the tree and will eventually kill it if the infestation is severe enough.[1,3]

**Identification:** Adults are roughly 20 to 35 mm long (1 to 1 ½ in),[1,2,3] shiny black with long antennae, and have small white markings on the body and antennae.[2,3]

**Signs and Symptoms**: Oviposition niches/egg sites are oval or round wounds in the bark, ~13 mm in diameter (½ in), that are created when females chew through the bark and inject a single egg into the tree (Fig. 2).[1,2,3] Adult beetles emerge one year later through the bark creating round exit holes that are ~6-12 mm in diameter (⅜ to ½ in)[3,6] (Fig.

Fig. 2 UGA 1393011

Fig. 3 UGA 1393002

PEST

# ASIAN LONGHORNED BEETLE

*Anoplophora glabripennis* (Motschulsky)

Fig. 4 UGA 3225081

Fig. 5 UGA 5016094

3). Exit holes appear clean and round like they have been drilled and can be found anywhere on the tree including branches, trunk and exposed roots.[1,3] Adult emergence occurs from May through October.[1,6] In addition, large piles of coarse sawdust around the base of trees or where branches meet the main stem (Fig. 4),[1,3,6] crown dieback, epicormic branching, and holes on leaf veins where feeding has occurred (Fig. 5) may be visible.[1,3]

**Similar species**: The whitespotted pine sawyer [*Monochamus scutellatus* (Say)] (Fig. 6) is most commonly misidentified as ALB. Males are metallic black with one white dot at the base of the wing covers.[5] Females are brown with speckles and also have a white dot at the base of the wing covers.[5] ALB lacks this white dot, though it has many white spots on its wing covers.[2,5] The cottonwood borer [*Plectrodera scalator* (Fabricius)] (CB) can be distinguished from ALB by the black antennae.[2,4] ALB antennae have white bands.[1,2,4] Also, the CB has white stripes around the neck.[4] The ALB neck is black.[2] Figure 7 shows a comparison between the CB on the left and the female (middle) and male (right) ALB.

Fig. 6 UGA 5203071

Fig. 7 UGA 0014056

# SIREX WOODWASP
## [*Sirex noctilio* Fabricius]

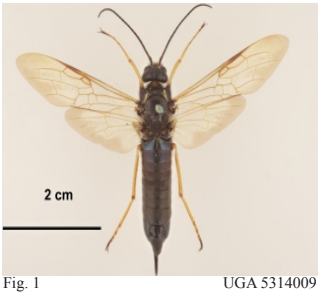

Fig. 1 UGA 5314009

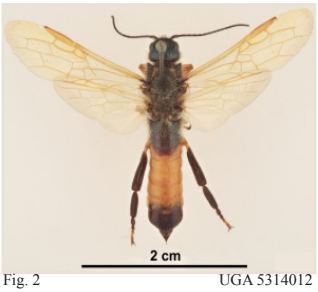

Fig. 2 UGA 5314012

**Problem:** A native of Europe, Asia, and northern Africa, sirex woodwasp (SWW) has devasted pine species in its introduced range.[2,3,5,6] Here in the U.S., SWW has the potential to threaten and kill native and exotic pines from coast-to-coast. Loblolly, scotch, shortleaf and other hard pine species are known to be susceptible.[2,5] Pine plantations are particularly vulnerable. The damage process begins when females drill their ovipositors into the outer sapwood to inject a symbiotic fungus [*Amylostereum areolatum* (Fr.) Boid.] toxic mucus, and eggs.[2,3,6] The fungus and mucus then act together to kill the tree and create a suitable environment for larval development.[2,3,6]

**Identification:** Adults are generally 25 to 38 mm long (1 to 1 ½ in)[2] with black antennae.[2,5] Females generally have dark metallic blue or black bodies and yellow to red legs (Fig. 1).[2,3] Males have orange middle segments on the abdomen and thickened black hind legs (Fig. 2).[2,3,5] Larvae are creamy white, legless, and have a distinctive dark spine at the rear of the abdomen.[2]

**Signs and Symptoms**: SWW can attack living pines, while native woodwasps attack only dead and dying trees.[2] At low populations, SSW selects stressed and injured trees for egg laying.[2,3] Foliage of infested trees initially wilts, and then changes color from dark green to yellow (Fig. 3), and finally to red during the 3-6 months following attack.[2,3,6] Infested trees may have resin beads or seeps at the egg laying sites (Fig. 4), which are more common at the mid-bole level.[2,3,6] As adults emerge, they chew round exit holes

# SIREX WOODWASP

*Sirex noctilio* Fabricius

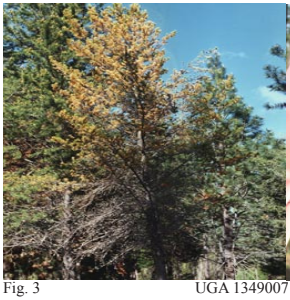

Fig. 3 UGA 1349007

Fig. 4 UGA 2166052

that vary from roughly 3 to 8 mm in diameter (⅛ to ⅜ in) (Fig. 5).[2,3,6]

Fig. 5 UGA 1231229

**Similar Species:** There are more than a dozen species of native woodwasps (horntails) that occur in North America.[4] One of them, pigeon tremex [*Tremex columba* (L.)] (Fig. 6), is a native horntail, but prefers deciduous trees.[1] The paper wasp (*Polistes* spp.) (Fig. 7) and cicada killer [*Sphecius speciosus* (Drury)] (Fig 8.), have various yellow abdominal markings and have a constricted body shape.[1] Paperwasps feed on nectar and insects and cicada killers kill and feed on cicadas.


Fig. 6 © 2006 K. Walker

Fig. 7 UGA 5006017

Fig. 8 UGA 5007028

# HEMLOCK WOOLLY ADELGID
## [*Adelges tsugae* (Annand)]

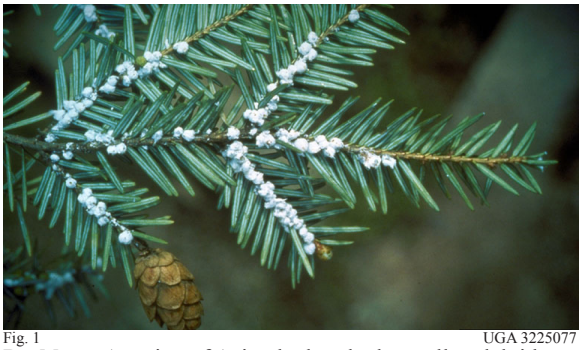

Fig. 1 UGA 3225077

**Problem:** A native of Asia, the hemlock woolly adelgid (HWA) (Fig 1.) damages and kills native eastern and Carolina hemlocks [*Tsuga canadensis (*L.) Carr., *T. caroliniana* Engelm.].[1,3] Injury is caused when immature nymphs and adults feed on young twig tissue and starch reserves.[1] Starch reserves are critical to tree growth and long-term survival. Other stressors such as elongate hemlock scale (*Fiorinia externa* Ferris), drought, needlerust [*Melampsora farlowii* (Arthur) Davis] and hemlock borer [*Melanophila fulvogutta* (Harris)] can exacerbate the damage caused by HWA, resulting in little or no chance of tree survival.[1]

**Identification:** HWA is parthenogenetic (all individuals are female with asexual reproduction) and has six stages of development: the egg, four nymphal instars, and the adult.[1,4] It also completes two generations per year on hemlock. The aphid-like, oval-shaped insect is less than 1.5 mm ($^1/_{16}$ in) long, and varies in color from dark reddish-brown to purplish-black.[1] Adults and nymphs are hard to distinguish without a hand lens. Most notably, the egg sacs (ovisacs) are covered in cotton-like wax filaments for protection[1] and are generally 3 mm (⅛ in) or more in diameter.[4]

**Signs and Symptoms:** Crawler stage nymphs (Fig.2) produce "wool," which cover their bodies and ovisacs and are most visible from late fall to early summer. The white masses generally occur on twigs at the base of needles.[1,3,4] Other symptoms include premature needle drop and discoloration (Fig. 3), twig and crown dieback (Fig. 4), and eventually complete defoliation and death.[3,4]

# HEMLOCK WOOLLY ADELGID

*Adelges tsugae* (Annand)

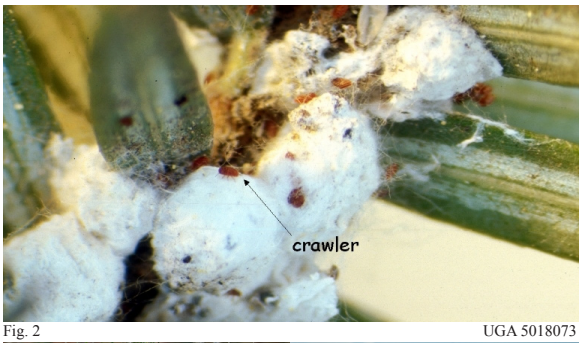


Fig. 2 UGA 5018073

Fig. 3 UGA 5125062

Fig. 4 UGA 2167012

**Similar Species:** Frequently, elongate hemlock scale (Figs. 5 and 6) is present alongside HWA.[2,5] The waxy cover of this species occurs on the lower needle surface as well as on new cones.[2,5] The flattened, elongate, light yellow to brownish orange waxy cover of the adult female is about 1.5 mm ($^{1}/_{16}$ in) long.[2,5] Spider egg sacs and oak skeletonizer (*Bucculatrix ainsliella* Murtf.) can also be confused at first glance with HWA, but do not produce the same signs and symptoms as HWA. Spider sacs are also usually associated with webbing.

Fig. 5 UGA 1122010

Fig. 6 UGA 1122011

# NARROWLEAF BITTERCRESS
## [*Cardamine impatiens* L.]
## CAIM

Fig. 1 © 2005 L. J. Mehrhoff

Fig. 2 © 2002 L. J. Mehrhoff

**Problem:** Native to Eurasia,[3] narrowleaf bittercress has the ability to rapidly spread and colonize a variety of habitats,[6] creating dense stands that outcompete native species.[5]

**Habit:** Erect, shade tolerant, annual or biennial (Fig. 1).[1,2,3,5,6]

**Reproduction:** Prolific seeder; may self pollinate.[4]

Fig. 3 © 2003 M. Storey

**Leaves:** Numerous, 6-20[1] narrow, sharply toothed, sparsely ciliate leaflets;[6] basal leaves (Fig. 2) can reach 10 cm (~4 in) and can have 3 to 11 leaflets along the rachis; leaflets are generally 3-lobed and lobes are rounded[3]; leaf bases sagittate to auriculate[1, 2, 3, 6] or clasping (Figs. 3 and 4).

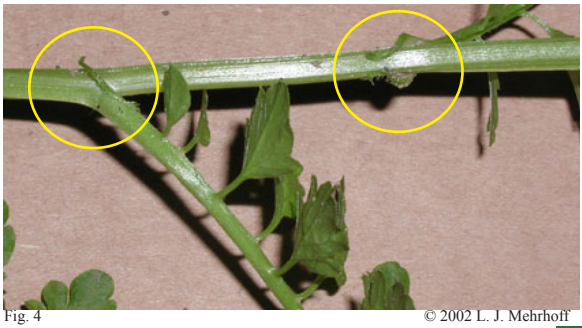

Fig. 4 © 2002 L. J. Mehrhoff

# NARROWLEAF BITTERCRESS

*Cardamine impatiens* L.

Fig. 5 © 2002 L. J. Mehrhoff

Fig. 6 © 2002 L. J. Mehrhoff

**Stems:** 1.5 to 8 dm tall (6 to 30 in);[1,6] glabrous; stems do not branch near the base of the plant, only above in the inflorescence.[3]

**Flowers:** May to September;[3] Petals white or lacking,[1,3,6] up to 2.5 mm (less than 1/10 in);[1,6] short-lived[3] (Fig. 5).

**Fruits/Seeds:** 10-24+ seeds per fruit;[1,3] seeds orange to brown,[3] enclosed in long (1½ to 2 cm; ~⅝ to ¾ in) slender capsules (siliques);[1,3,6] ascending or borne upright on short pedicels[1,3,6] (Fig. 6); mechanical dispersal where seeds are cast short distances from the plant;[3,4] flowing water is also a primary means of seed dispersal.[3,4]

**Habitat:** Mesic woods,[5,6] floodplains, roadsides, trails and lawns.[3]

**Similar Species:** Pennsylvania bittercress (*Cardamine pensylvanica* Muhl. ex Willd.),[3,5] sand bittercress (*C. parviflora* L.), and hairy bittercress (*C. hirsuta* L.) are all most commonly confused with narrowleaf bittercress.[5] Narrowleaf bittercress is the only species that exhibits sagittate to auriculate or clasping leaf bases (Figs. 3 and 4).[5] Figure 7 shows the leaf base of Pennsylvania bittercress.

Fig. 7 K. Tenaglia

# PURPLE LOOSESTRIFE

## [*Lythrum salicaria* L.]

## LYSA2

Fig. 1 UGA 1459323

**Problem:** Native to Eurasia,[2] purple loosestrife was introduced to the United States in the early 1800s via ballast and cargo.[5] It is an aggressive weed that has displaced > 50% of native vegetation in some wetlands.[6] Infestations lead to severe wildlife habitat degredation, loss of species diversity, decreased water flow and increased maintence costs.[3]

**Habit:** Erect, perennial herb (Fig. 2).[2,3,4]

**Reproduction:** Prolific seeder; produces > 2 million seeds per season;[3,6] Wind and water dispersed.[3]

**Leaves:** Opposite or whorles in threes, sessile, lanceolate to linear 3 to 10 cm long (~1 ¼ to 4 in) (Fig. 2 and 3); larger leaf bases cordate.[1,2,4]

**Stems:** Glabrous or more often pubescent;[1,2] persistent woody base;[4] to 2 m (6 ½ ft) (Fig. 2).[1,2,4]

**Flowers:** July to September[2,4] or October;[3] Purple to pink and on dense terminal spike-like inflorescence. Individual flowers have 6 petals (Fig 4 and 5).[2]

**Fruits/Seeds:** Capsule containing many angular seeds; persist through

Fig. 2 UGA 1459315

Fig. 3 UGA 1552184

HERB

# PURPLE LOOSESTRIFE

*Lythrum salicaria* L.

Fig. 4 UGA 0022075

Fig. 5 UGA 0024065

winter on plant stalk.[3]

**Habitat:** Swamps, wet meadows, shores[4] and floodplains.[1]
**Similar Species:** Fireweed [*Chamerion angustifolium* (L.) Holub ssp. *circumvagum* (Mosquin) Hoch], blue vervain (*Verbena hastata* L.) and swamp loosestrife [*Decodon verticillatus* (L.) Elliott] are commonly confused with purple loosestrife. Fireweed has 4-petaled and stalked flowers and generally occurs in dryer habitats (Fig 6).[1,4] Blue vervain has coarsley serrated leaves and much smaller flowers on spikes or heads (Fig. 7).[1,4] Swamp Loosestrife has flowers bunched at the axils (junction of leaf and stem) (Fig. 8).[1,4] These species do not form dense and uniform stands in wetland areas like purple loosestrife.

Fig. 6 © 2008 Thomas Stoughton

Fig. 7 © 2005 Louis-M. Landry

Fig.8 © 1999 Eleanor S. Saulys

# WAVYLEAF BASKETGRASS

## *Oplismenus hirtellus* ssp. *undulatifolius* (Ard.) U. Scholz

## OPHIU2

Fig. 1 UGA 5389748

**Problem**: Native to southern Europe and southeastern Asia,[4] wavyleaf basketgrass (WLBG)(Fig. 1) was first detected in Maryland in 1996[3,4] and has been spreading since.[3] This species has the potential to become an aggressive invader in eastern forests (Fig.2). Although much is not known about this new invader, an effective seed dispersal mechanism[3,4] as well as vegetative reproduction,[4] seasonal advantage of staying green longer than native plants,[3] and competitive ability are traits that have been observed since its initial discovery.

**Habit**: Shade tolerant,[4] low-trailing perennial grass.[3,6]

**Reproduction**: Efficient seeder;[2] stoloniferous.[3]

**Leaves/Blades**: Flat, ovate to elongate; sheath and culm (stems) noticeably pilose or hairy (Fig. 1);[4,5,6] wavy ripple-like appearance (Fig.1).

**Flowers**: Mid-September through November; 3 - 7 spikelets[4,5] have glumes (lower bracts) with awns or long bristle-like appendages (Fig. 3).

Fig. 2 UGA 5389747

HERB

# WAVYLEAF BASKETGRASS

*Oplismenus hirtellus* ssp. *undulatifolius* **(Ard.) U. Scholz**

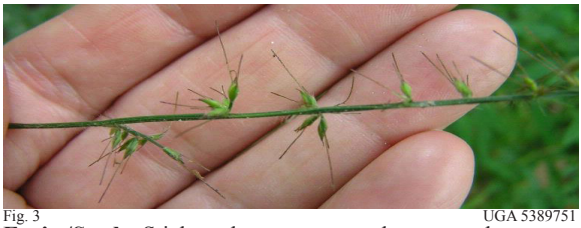

Fig. 3 UGA 5389751

**Fruits/Seeds**: Sticky substance secreted on awns that enable seeds to attach to anything they come in contact with.[1,3,4]

**Habitat**: Forest interior and edges,[3,4] shaded riparian areas and trails.[2]

**Similar Species**: Japanese stiltgrass [*Microstegium vimineum* (Trin.) A. Camus] (JSG) occurs in similar habitats, but the leaves are not wavy, culms are glabrous (smooth), and mid-veins of the leaves are offset. Deertongue grass


Fig. 4 © 2007 John Snitzer

[*Dichanthelium clandestinum (L.*) Gould] (DTG), a native species, also has hairy stems like WLBG, but grows upright and lacks wavy leaves. Figures 4 (JSG and WLBG) and 5 (all three) provide a good visual comparison between the three taxa.


Fig. 5 © 2008 K. L. Kyde

# CHINESE YAM
## [*Dioscorea oppositifolia* L.]
## DIOP

Fig. 1 UGA 2120016

Fig. 2 UGA 1237002

**Problem:** A native of China,[2,6] Chinese yam or cinnamon vine, was introduced to the United States in the 1800s as an ornamental and edible food crop.[6] It is a fast growing, twining vine[6] that has the ability to rapidly invade pristine habitats and decrease native species richness and abundance by outcompeting and eliminating native plant species.[5,6] Chinese yam's rapid mat-forming habit (Fig. 1) thickly blankets and weighs down all adjacent vegetation, breaking branches of large trees and shrubs as well as competitively excluding light.[6]

**Habit:** Perennial,[2] twining vine.[3,4,6]

**Reproduction:** Axillary tubers[2] or bulbils that resemble small potatoes (Figs. 3 and 4).[1] It has a fast rate of vegetative growth and a prolific rate of asexual reproduction via bulbils.[3,5,6]

**Leaves:** Usually opposite, but can be alternate or in whorls of 3 along the upper stem.[2] Leaves are simple, heart-shaped with 7-9 prominent, parallel veins[2,4] and are generally 4 to 8 cm long (1 ½ to 3 in) (Fig. 2).[6]

**Stems:** Slender, round stem; twines clockwise.[2,6]

**Flowers:** May-August[3]; small, greenish-white;[2] unisexual and arise from the leaf axils in spikes;[2] inconspicuous; cinnamon scented.[3,4]

**Fruits/Seeds:** In native range, a flat, 3-winged, papery capsule;[2,4] sexual reproduction by seed has not been

VINE

# CHINESE YAM

*Dioscorea oppositifolia* L.

Fig. 3 UGA 5330032

Fig. 4 UGA 1237053

documented in North America.[6]

**Habitat:** Most common on streambanks and floodplain forests; also found along roadsides, fencerows and drainage ditches.[6] Tolerates full sun to full shade, but prefers nutrient rich soils.[3,6]

**Similar Species:** The native wild yam (*Dioscorea villosa* L.) (Fig. 5) twines counter-clockwise,[2] exhibits pubescence on the upper leaf surfaces[3] and does not produce axial bulbils. It also produces seeds (Fig, 6). Greenbriar species such as roundleaf greenbriar (*Smilax rotundifolia* L.) (Fig. 7), have a similar leaf shape, but exhibit blue to black berries, do not produce axial bulbils, have and bear stipules or tendrils for climbing.[2] In addition, most *Smilax* species are armed with thorns.[2]

Fig. 5 © 2004 S. J. Baskauf

Fig. 6UGA 1342077

Fig. 7 © 2003 S. J. Baskauf

# GLOSSY BUCKTHORN
## [*Frangula alnus* Mill.]
## FRAL4

Fig. 1 UGA 5274031

**Problem:** Native to Europe,[4,6,7] Asia and North Africa,[1,3] glossy buckthorn (Fig. 1) was introduced as an ornamental pre 1800s.[2] This species invades wetlands in its non-native range creating dense thickets that out-compete and exclude native woody and herbaceous plant species (Fig. 2).[5]

**Habit:** Deciduous shrub or small tree, to 7 m (23 ft) tall.[6]

**Reproduction:** Sexually by seed.[4]

**Leaves:** Mostly alternate, oblong to obovate, entire, 5-8 cm (2 to 3 in) long; [4,6,7] glossy above, glabrous to pubescent below.[3]

**Stems:** Slender, reddish-brown, with gray pubescence on newer growth; 3 bundle scars; on older bark, prominent lenticels on older growth; naked or scaleless hairy buds (Fig. 3);[8] side twigs often sharp and pointed.[8]

**Flowers:** May-June;[7] small, greenish-white, perfect, 5 parts, clustered in flat-topped umbels.[4,6,7]

Fig. 2 UGA 5274033

SHRUB

# GLOSSY BUCKTHORN

*Frangula alnus* Mill.

Fig. 3 Chris Mattrick, USFS

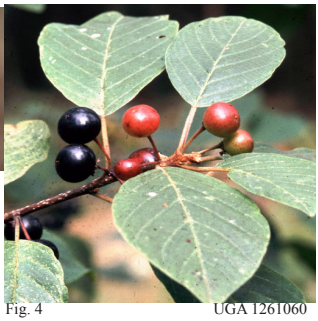

Fig. 4 UGA 1261060

**Fruits/Seeds:** Ripen July-September;[7] fruits turn from red to black[6,7] (Fig. 4) and contain 2 ungrooved seeds.[4]

**Habitat:** Aggressively colonizes wet habitats, roadsides, fencrerows, and fields.[3,7]

**Similar Species:** Common buckthorn (*Rhamnus cathartica* L.) has sub-opposite branching (Fig. 5), leaves have serrated margins unlike glossy buckthorn,[3,7] and more notably, twigs may be tipped with a sharp stout thorn. Buds are dark brown to black, scaled and in many cases, appear to sandwich the thorn at the terminal tip of the twig (Fig. 6). Similar native buckthorn species can also cause confusion.

Fig. 5 UGA 0008306

Lance-leaf buckthorn (*R. lanceolata* Pursh) has lanceolate leaves, scaled buds, and reaches heights of 1 to 2 m tall (3 to 6 ft).[6,7] Alderleaf buckthorn (*R. alnifolia* L'Hér.) generally occurs in swamps and bogs,[4,6,7] only reaches heights of 1 m (3 ft), and has scaled buds.[6,7] Carolina buckthorn (*R. caroliniana* Walter) has serrated leaves that are glabrous on both sides and has a more southern distribution.[4,6]

Fig. 6 UGA 1334007

## *Agrilus planipennis* (emerald ash borer)

**Text Citations:**


1. Kimoto, T. and M. Duthie-Holt. 2006. Exotic Forest Insect Guidebook. Canadian Food Inspection Agency, Canada. 120 pp.
2. McCullough, D. G. and S. A. Katovich. 2004. Pest Alert: Emerald Ash Borer. USDA Forest Service: Northeastern Area, Newtown Square, PA. NA-PR-02-04.
3. Rebek, K. A., E. J. Rebek and D. McCullough. 2005. Don't be Fooled by Look-Alikes! Michigan State University Extension Extension Bulletin E-2944.
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Additional comments and expertise provided by Wayne Millington, Northeast Regional Integrated Pest Management Coordinator, National Park Service.


**Photograph Information:**

Figure 1 (photographer: Howard Russell, Michigan State University).

Figures 2, 5, 9 and 10 (photographer: Pennsylvania Department of Conservation and Natural Resources-Forestry Archive).

Figures 3 and 8 (photographer: David Cappaert, Michigan State University).

Figure 6 (photographer: Joseph O'Brien, USDA Forest Service).

Figure 7 (photographer: Art Wagner, USDA APHIS PPQ).

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Figure 4 (photographer: Deborah McCullough, Michigan State University). Photograph reproduced from USDA Forest Service, http://www.na.fs.fed.us/fhp/eab/img/img.shtm.

***Anoplophora glabripennis* (Asian longhorned beetle)**
**Text Citations:**


1. APHIS PPQ. 2005. Factsheet: Asian Longhorned Beetle (*Anoplophora glabripennis*). USDA Animal and Plant Health Inspection Service (APHIS). http://www.aphis.usda.gov/publications/plant_health/content/printable_version/fs_phalb.pdf (accessed 4/29/2009).
2. Hoebeke, Richard E. nd. Asian Longhorned Beetle or Whitespotted Sawyer? USDA Forest Service. NA-PR-01-98. http://www.na.fs.fed.us/fhp/alb/pubs/alb_wss/alb_wss.htm (accessed on 4/29/2009).
3. Kimoto, T. and M. Duthie-Holt. 2006. Exotic Forest Insect Guidebook. Canadian Food Inspection Angency, Canada. 120 pp.
4. Mckinney, R., D. Duerr, and D. Haugen. nd. Asian Longhorned Beetle vs. Cottonwood Borer. USDA Forest Service. NA-PR-04-00. http://na.fs.fed.us/fhp/alb/pubs/alb_cb/alb_cb.htm. Accessed on 4/29/2009.
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Additional comments and expertise provided by Wayne Millington, Northeast Regional Integrated Pest Management Coordinator, National Park Service.


**Photograph Information:**

Figure 1 (photographer: Pest and Diseases Image Library, Australia).

Figures 2 and 3 (photographer: Dennis Haugen, USDA Forest Service).

Figure 4 (photographer: Robert Haack, USDA Forest Service).

Figure 5 (photographer: Pennsylvania Department of Conservation and Natural Resources-Forestry Archive).

Figure 6 (photographer: Natasha Wright, Florida Department of Agriculture and Consumer Services).

Figure 7 (photographer: Gerald J. Lenhard).

Photographs reproduced from www.bugwood.org.

## *Sirex noctilio* (sirex woodwasp)

**Text Citations:**


1. Borror, D. J., D. M. DeLong, and C. A. Triplehorn. 1976. An Introduction to the Study of Insects, 4th ed. Holt, Rinehart and Winston, United States of America.
2. Haugen, D. A. and E. R. Hoebeke. 2005. Pest Alert: Sirex woodwasp--*Sirex noctilio* F. (Hymenoptera: Siricidae). USDA Forest Service: Northeastern Area, Newtown Square, PA. NA-PR-07-05.
3. Kimoto, T. and M. Duthie-Holt. 2006. Exotic Forest Insect Guidebook. Canadian Food Inspection Angency, Canada. 120 pp.
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Additional comments and expertise provided by Wayne Millington, Northeast Regional Integrated Pest Management Coordinator, National Park Service.


**Photograph Information:**

Figures 1 and 2 (photographer: Pest and Diseases Image Library, Australia).

Figure 3 (photographer: Paul Klasmer, Instituto Nacional de Technologia Agropecuaria).

Figure 4 (photographer: Kevin Dodds, USDA Forest Service).

Figure 5 (photographer: Gyorgy Csoka, Hungary Forest Research Institute).

Figure 7 (photographer: David Cappaert, Michigan State University).

Figure 8 (photographer: Nancy Hinkle, University of Georgia).

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Figure 6 (photographer: Ken Walker, Pest and Diseases Image Library). Photograph reproduced from www.padil.gov.au.

## *Adelges tsugae* (hemlock woolly adelgid)

**Text Citations:**


1. Day, E. 1996. Hemlock Woolly Adelgid. Entomology Publication 444-244. Virginia Cooperative Extension. http://www.ext.vt.edu/departments/entomology/factsheets/hewoadel.html (accessed on May 5, 2009).
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3. McClure, M. S. 2002. Pest Alert: Elongate Hemlock Scale. USDA Forest Service: Northeastern Area, Newtown Square, PA. NA-PR-01-02
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Additional comments and expertise provided by Wayne Millington, Northeast Regional Integrated Pest Management Coordinator, National Park Service.


**Photograph Information:**

Figure 1 (photographer: Connecticut Agricultural Experiment Station Archive, Connecticut Agricultural Experiment Station).

Figure 2 (photographer: Pennsylvania Department of Conservation and Natural Resources--Forestry Archive).

Figure 3 (photographer: Chris Evans, River to River CWMA).

Figure 4 (photographer: William M. Ciesla, Forest Health Management International).

Figures 5 and 6 (photographer: Eric R. Day, Virginia Polytechnic Institute and State University).

Photographs reproduced from www.bugwood.org.

## *Cardamine impatiens* (narrowleaf bittercress)

**Text Citations:**


1. Fernald, M.L. 1950. Gray's Manual of Botany, 8th ed. American Book Company, New York., NY
2. Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. The New York Botanical Garden, Bronx, NY.
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**Photograph Information:**

Figures 1, 2, 4, 5, and 6: Habit, basal rosette, stem morphology, inflorescence, and infructescence (photographer: Leslie J. Mehrhoff, University of Connecticut). Photographs reproduced from http://www.ipane.org.

Figure 3: Stipules-enlarged (photographer: © 2003 Malcom Storey, www.bioimages.org.uk). Photograph reproduced from www.bioimages.org.uk.

Figure 7: Lower stem (photographer: Karen Tenaglia; photo credit: Dan Tenaglia - Missouriplants.com). Photograph reproduced from http://www.missouriplants.com.

## *Lythrum salicaria* (purple loosestrife)

**Text Citations:**


1. Fernald, M.L. 1950. Gray's Manual of Botany, 8th ed. American Book Company, New York., NY.
2. Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. The New York Botanical Garden, Bronx, NY.
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**Photograph Information:**

Figures 1 and 2 (photographer: Steve Dewey, Utah State University).

Figure 3 (photographer: Theodore Webster, USDA Agricultural Research Service).

Figure 4 (photographer: Eric Coombs, Oregon Department of Agriculture).

Figure 5 (photographer: Norman E. Rees, USDA Agricultural Research Service).

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Photo reproduced from the http://www.ct-botanical-society.org/index.html).

## *Oplismenus hirtellus ssp. undulatifolius* (wavyleaf basketgrass)

**Text Citations:**


1. Davidse, G. 1987. Fruit dispersal in the Poaceae. In: Soderstrom, T. R., K. W. Hilu, C. S. Campbell and M. E. Barkworth (eds.). Grass systematics and evolution. Smithsonian Institution Press, Washington, D.C.
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6. Weakley, Alan S. 2007. Working draft: Flora of the Carolinas, Virginia, Georgia, and surrounding areas. University of North Carolina Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at Chapel Hill.



Additional comments and expertise provided by Kerrie L. Kyde, Habitat Ecologist/ Invasive Plant Specialist, Maryland Department of Natural Resources.


**Photograph Information:**

Figures 1, 2 and 3 (photographer: Kerrie L. Kyde, Maryland Department of Natural Resources, United States).

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Figure 4 (photographer: © 2007 John Snitzer, Hood College).

Figure 5 (photographer: © 2008 Kerrie L. Kyde, Maryland Department of Natural Resources, United States).

## *Dioscorea oppositifolia* (Chinese yam)

**Text Citations:**


1. Beyerl, T. 2001. Habitat and life history characteristics of *Dioscorea oppositifolia*, an invasive plant species in southern Illinois. MS Thesis, Southern Illinois University, 104 pp.
2. Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. The New York Botanical Garden, Bronx, NY.
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**Photograph Information:**

Figures 1, 3, and 6 (photographer: Chris Evans, River to River CWMA).

Figure 2 (photographer: James H. Miller, USDA Forest Service).

Figure 4 (photographer: Jack Ranney, University of Tennessee).

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Figures 5 and 7: *Dioscorea villosa* leaf and *Smilax rotundifolia* leaf (photographer: © 2004 and © 2003 Steven J. Baskauf, http://bioimages.vanderbilt.edu).

Photographs reproduced from http://www.bioimages.org.uk.

## *Frangula alnus* (glossy buckthorn)

**Text Citations:**


1. Bailey, L. H. 1949. Manual of Cultivated Plants. Macmillan, New York.
2. Catling and Porebski, 1994 P.M. Catling and Z.S. Porebski, The history of invasion and current status of glossy buckthorn (*Rhamnus frangula*) in Southern Ontario, Canadian Field Naturalist 108. pp. 305–310.
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**Photograph Information:**

Figures 1 and 2 (photographer: Leslie J. Mehrhoff, University of Connecticut).

Figure 4 (photographer: Gil Wojciech, Polish Forest Research Institute).

Figure 5 (photographer: Paul Wray, Iowa State University).
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