United States Department of Agriculture

FIELD GUIDE TO DISEASES AND INSECTS OF QUAKING ASPEN IN THE WEST

Part I: WOOD AND BARK BORING INSECTS

Brytten E. Steed and David A. Burton

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AUTHORS

Brytten E. Steed, PhD
Forest Entomologist
USFS Forest Health Protection
Missoula, MT

David A. Burton
Project Director
Aspen Delineation Project
Penryn, CA

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WOOD & BARK BORING INSECTS

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photo by B. Steed

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INTRODUCTION TO WOOD & BARK BORING INSECTS OF ASPEN

THE TREE

Quaking aspen (*Populus tremuloides* Michx) is the most widely distributed tree species in North America. Additional common names include trembling aspen, golden aspen, mountain aspen, popple, poplar, trembling poplar, and in Spanish, álamo blanco and álamo temblón.

Quaking aspen occurs across Canada in all provinces and territories, including Nunavut (Akimiski Island). In the United States, it can be found as far north as the southern slopes of the Brooks Range in Alaska, and as far south as Arizona and New Mexico (Fig. 1). In the western United States, this tree is generally found at 5,000–12,000 feet (1,500–3,700 m), rarely below 1,500 feet (460 m). It also grows in isolated patches as far south as Guanajuato, Mexico.

Figure 1. *Current range of quaking aspen (green) in North America (E. L. Little, Jr. [1971])*

WOOD & BARK BORING INSECTS

Other *Populus* species native to North America include bigtooth aspen (*P. grandidentata* Michaux) and several cottonwood and poplar species (see Index – plant common and scientific names for partial listing). Although some damage agents are specific to quaking aspen, many use numerous *Populus* species. Some agents also include on their menu trees and shrubs in the closely related *Salix* (willow) genera, and others feed on a wide range of hardwood trees and shrubs. This guide focuses on agents damaging to quaking aspen, although other hosts are noted.

The various parts of a tree serve different functions in feeding, protecting, and stabilizing a tree. Damage to a tree that compromises these functions can result in reduced tree vigor (fewer defenses and ability to grow) or when severe or in concert with other agents, in tree death.

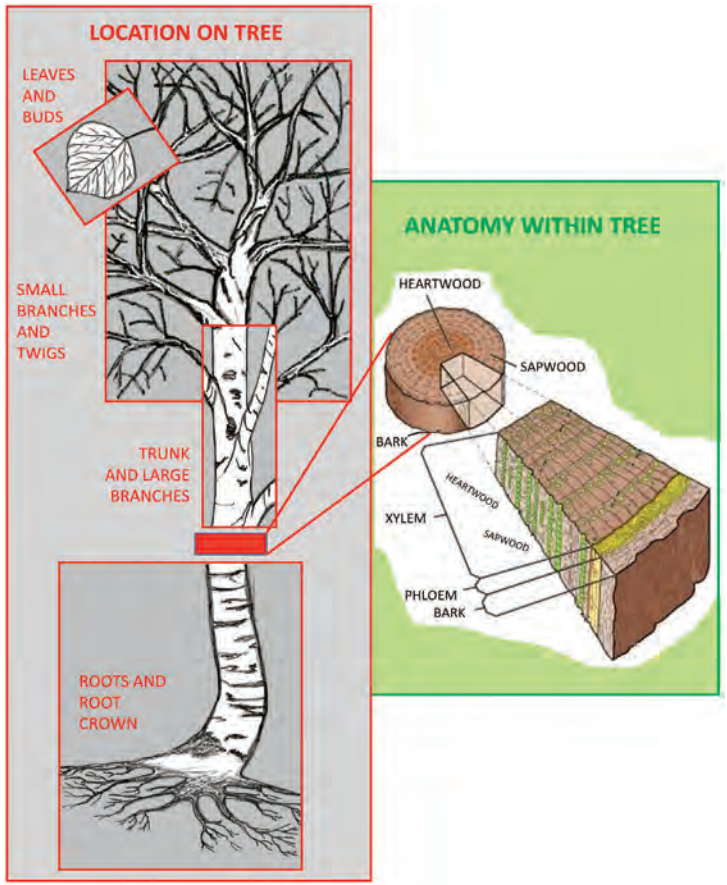


Figure 2. *Locations on and within an aspen where damage may occur*

Location of damage may be described using terms found in Figure 2, including where on a tree damage is most likely to occur and the anatomy most likely affected.

Distribution of individual insect damage agents are described using zones. In Canada, three zones are used: west, east and north. In the U.S. three zones are used: west, east, south. Alaska is lumped with the Canadian north zone (Fig. 3). These divisions are based on past geo-political convention and genetics of aspen. The U.S. "south" zone is not within aspen's native range although some agents may be present within these areas on other host tree species.

Figure 3. *Zones used in Canada and U.S. for descriptions of agent distribution*

A key to the codes used throughout the text for U.S. states and Canadian provinces is given in Table 1.

Table 1. Abbreviations of States and Provinces

STATE	CODE	ZONE
Alabama	AL	sU.S.
Alaska	AK	nCan.
Alberta	AB	wCan.
Arizona	AZ	wU.S.
Arkansas	AR	sU.S.
British Columbia	BC	wCan.
California	CA	wU.S.
Colorado	CO	wU.S.
Connecticut	CT	eU.S.
Delaware	DE	sU.S.
Florida	FL	sU.S.
Georgia	GA	sU.S.
Hawaii	HI	n/a
Idaho	ID	wU.S.
Illinois	IL	eU.S.
Indiana	IN	eU.S.
Iowa	IA	eU.S.
Kansas	KS	eU.S.
Kentucky	KY	sU.S.
Louisiana	LA	sU.S.
Maine	ME	eU.S.
Manitoba	MB	wCan.
Maryland	MD	sU.S.
Massachusetts	MA	eU.S.
Michigan	MI	eU.S.
Minnesota	MN	eU.S.
Mississippi	MS	sU.S.
Missouri	MO	eU.S.
Montana	MT	wU.S.
Nebraska	NE	eU.S.
Nevada	NV	wU.S.

STATE	CODE	ZONE
New Brunswick	NB	eCan.
New Hampshire	NH	eU.S.
New Jersey	NJ	eU.S.
New Mexico	NM	wU.S.
New York	NY	eU.S.
Newfoundland/Labrador	NL	eCan.
North Carolina	NC	sU.S.
North Dakota	ND	eU.S.
Northwest Territories	NT	nCan.
Nova Scotia	NS	eCan.
Nunavut	NU	nCan.
Ohio	OH	eU.S.
Oklahoma	OK	sU.S.
Ontario	ON	eCan.
Oregon	OR	wU.S.
Pennsylvania	PA	eU.S.
Prince Edward Island	PE	eCan.
Quebec	QU	eCan.
Rhode Island	RI	eU.S.
Saskatchewan	SK	wCan.
South Carolina	SC	sU.S.
South Dakota	SD	eU.S.
Tennessee	TN	sU.S.
Texas	TX	sU.S.
Utah	UT	wU.S.
Vermont	VT	eU.S.
Virginia	VA	sU.S.
Washington	WA	wU.S.
West Virginia	WV	sU.S.
Wisconsin	WI	eU.S.
Wyoming	WY	wU.S.
Yukon	YT	nCan.

THE INSECTS

Wood and bark boring insects come from several orders. Typically the larval stage of these insects cause most damage and are the longest-lived. Being able to differentiate taxonomic groups of borers based on basic larval traits can be helpful in identifying the damage agent. Table 2 illustrates and describes larval forms of insects included in this guide.

Table 3 lists wood and bark boring insects that have been found damaging quaking aspen in western U.S. and Canada. Many of these may be found in other parts of quaking aspen's range. A comparison of important characteristics of these agents is provided although information on some species is limited.

Table 2. Adult and larval forms of wood boring insects covered in this guide

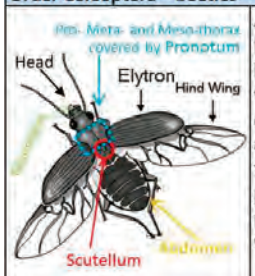
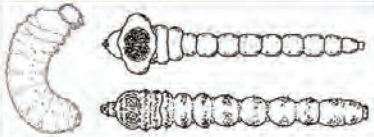
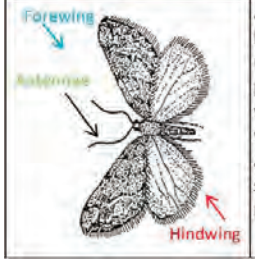
Order Coleoptera = beetles		
	Adult beetles have one pair of hardened outer wings (plural: elytra) that act as a protective cover for the second pair of membranous wings.	 Larval forms variable. However, most species whose larvae live under the bark are legless (bark beetles and weevils [left], flatheaded woodborer [top right] and roundheaded wood borer [bottom right]).
Order Diptera = flies, midges		
	Adult flies have one pair of membranous wings with the second set of wings reduced to small stubs (halters).	 Larvae are soft, white, without true legs (usually legless) or distinct head (above)
Order Hymenoptera = sawflies, ants, wasps, bees		
	Adults have two pairs of membranous wings, one pair of antennae, a pair of compound eyes, and chewing/lapping mouthparts.	 Larvae of bees, wasps, woodwasps, ants and other Hymenoptera are usually legless. However, sawfly larvae have three pair of thoracic legs, and six or more pairs of prolegs without crochets (hooks) (above).
Order Lepidoptera = moths, butterflies		
	Adult moths and butterflies usually have two pairs of large wings covered with scales. Adults have straw-like sucking mouthparts.	 Most larvae (caterpillars) have three pairs of thoracic legs, five or fewer pairs of prolegs with small hooks on the end (crochets), and chewing mouthparts (above).

Table 3. Host and range details of principal wood and bark boring insects

Location	Order	Scientific / Common Names	Distribution[1]	Likelihood of occurring in QA forest	Hosts[2]	Attack traits	Emergence hole traits	Larva (mature) traits	Adult traits
ROOT / ROOT COLLAR / LOWER STEM									
	LEPIDOPTERA-MOTH BORERS								
		Sesia tibialis American hornet moth	wCan., eCan., wU.S., eU.S.	occasional to common	cottonwoods and poplars most common; QA favored in some areas; willow occasionally	attacks trees of all sizes, feeding at or below soil line	6 mm wide, round hole at base of tree oozing sap and boring dust; pupal case protruding from exit hole	moth borer with legs and prolegs up to 40 mm long	30-40 mm wingspan, ~25 mm body length; yellow and black like a hornet
		Sthenopis purpurascens four spotted ghost moth	nCan., wCan., eCan., wU.S., eU.S.	common	*Populus* species with QA preferred in some areas; also willow and alder	attacks trees of all sizes at or below soil line	round exit hole open or loosely plugged, often below soil line; frass and chips bound by webbing into 1-2 cm clumps and ejected	moth borer with legs and prolegs, 50-60 mm long (range 30-100); cream colored with brown spots at base of hairs; wart-like swellings on some segments	66-100 mm (to 35 mm?) wingspan, purple-gray or yellow-brown with two silver spots on each forewing
	COLEOPTERA-BEETLE BORERS								
		Agrilus horni aspen root girdler	wCan., eCan., wU.S., eU.S.	common	QA preferred; other aspens and poplars also used	lower trunk, collar, roots; prefers stems <12 cm but will use up to 18 cm diameter	D-shaped exit hole likely 3-4 mm in diameter	flatheaded woodborer, legless, white, ~25 mm long	narrow, green to copper colored beetle, 6.5-11.5 mm long
		Xylotrechus obliterates poplar-butt borer	wCan., wU.S., eU.S.	common	QA principally; other poplars and aspens	root collar; roots (esp. at or just below ground line)	round exit hole; wood riddled with galleries packed with frass	roundheaded woodborer, legless cream colored	brown to gray longhorned beetle with three curved, yellow lines; 10-18 mm long, 3.5-5.0 mm wide
	HYMENOPTERA - ANTS, ETC.								
		Camponotus species carpenter ants	nCan., wCan., eCan., wU.S., eU.S., sU.S.	common	generalist on hardwoods and conifers	lower trunk, often in large trees with heart rot or with galleries from other wood borers	often several irregular holes where piles of white boring dust are ejected	small, cream colored and often attended by adults	3-16 mm long ant with elbowed antennae, black to reddish
TRUNK / LARGER BRANCHES									
	LEPIDOPTERA-MOTH BORERS								
		Acossus centerensis poplar carpenterworm	wCan., eCan., eU.S.	common	QA preferred; balsam poplar reported	trunks and branches <31 cm but occasionally trunks >41 cm; pupal case protruding after emergence	round exit hole often plugged with frass; associated with bark scars; pupal case protruding from exit hole	moth borer with legs and prolegs, hairless, 32-45 mm long	heavy gray moth with 2-tone wings (dark by body, light on outer half) spanning 40-64 mm; hind wing translucent
		Acossus populi aspen carpenterworm	wCan., eCan., wU.S., eU.S.	occasional (common locally, but widely scattered)	QA noted; other *Populus* species used (cottonwoods and poplars)	likely similar to *A. centerensis*	likely similar to *A. centerensis*	moth borer with legs and prolegs, hairless, 35-40 mm long	heavy gray moth with gray, mottled wings spanning 50-80 mm long; hind wing gray
		Prionoxystus robiniae carpenterworm	wCan., eCan., wU.S., eU.S., sU.S.	rare	QA not specified but wide host list including oak, ash, elm and poplar; preference varies by location	trunks and branches of any size down to 5 cm diameter	round exit hole open or loosely plugged; wood chips and frass up to 7-8 mm; large excavation just under bark ; pupal case protruding after emergence	moth borer with legs and prolegs; pinkish to greenish with brown spots along sides and short, stout hairs on each body segment, 50-75 mm long	stout gray moths from <50 mm to 75 mm wingspan; males have bright orange spot on hind wing

[1]Distribution: see Figure 3 for map of west/east/south United States (U.S.) and north/west/east Canada (Can)

[2]Hosts: QA=quaking aspen; for scientific names see Tree Common and Scientific Names

WOOD & BARK BORING INSECTS

Location	Order	Scientific / Common Names	Distribution[1]	Likelihood of occurring in QA forest	Hosts[2]	Attack traits	Emergence hole traits	Larva (mature) traits	Adult traits
TRUNK / LARGER BRANCHES (cont.)									
	COLEOPTERA-BEETLE BORERS *(reordered to facilitate comparisons)*								
		Agrilus granulatus liragus bronze poplar borer	wCan., eCan., wU.S., eU.S.	common	QA, bigtooth aspen, balsam and Russian poplar, black and eastern cottonwood common	larger trunks and branches of over mature or stressed trees especially but may use nearly any sized stem	D-shaped exit hole 3-4 mm in diameter with little to no expelled boring dust; new attacks look like wet spots on bark	flatheaded woodborer, legless, cream colored, 30-40 mm long, 2-3.5 mm wide	black beetle with green iridescence, 6.8-11.5 mm long
		Chrysobothris mali Pacific flathead borer	wCan., wU.S.,	uncommon	>70 species in >40 genera used; *Populus* included but not preferred; QA not commonly used	trees of any size but most damaging to young stems	oval shaped hole ~6.3 mm diameter; white frothy, oozing sap with minimal boring dust	flatheaded woodborer, legless, cream colored,15-18 mm long	bronze to copper colored beetle with distinct copper spots, 6-11 mm long
		Chrysobothris femorata flatheaded appletree borer	wCan., eCan., wU.S., eU.S., sU.S.	occasional	maple, apple, and poplar preferred; QA noted in Alberta	young stems =<5 cm	likely an oval hole 5-7 mm width of adult beetle	flatheaded woodborer, legless, cream colored, 25 mm long	gray-brown mottled beetle with bright green forehead; 7-16 mm long (ave. 12), 5-7 mm wide
		Poecilonota cyanipes eastern poplar buprestid	nCan., wCan., eCan., wU.S., eU.S., sU.S.	common	QA common, bigtooth aspen and several cottonwoods and willows used	small trunks or branches 12-32 mm, sometimes up to 75mm	oval hole 2-5 mm packed tight with boring dust; little to no boring dust ejected; new attacks look like wet spots on bark	flatheaded woodborer, legless, cream colored, 17-25 mm long	bluish-bronze beetle with coppery bronze tones on grooved elytra; 9-18 mm long, 3-7 mm wide
		Poecilonota californica western poplar buprestid	wU.S., sU.S.	occasional	QA and cottonwood; other *Populus* species may be used	trunk and branches, especially on young trees at higher elevations	likely an oval hole 4-8 mm width of adult beetle	flatheaded woodborer, legless, cream colored, likely about 17-25 mm long	black to gray-brown to bronze beetle with coppery green highlights on grooved elytra; 9-18 mm long, 4-8 mm wide
		Poecilonota ferrea iron flathead	wCan., eCan., wU.S., eU.S., sU.S.	uncommon to rare	aspen and willow presumed	likely trunk and large branches	likely an oval hole 5-8 mm width of adult beetle	flatheaded woodborer, legless, cream colored, 17-25 mm long	brassy-greenish beetle looks gray due to short hairs; 13-20 mm long, 5-8 mm wide
		Buprestis confluenta gold dust buprestid	wCan., eCan., wU.S., eU.S., sU.S.	uncommon	QA, eastern cottonwood and balsam poplar noted	trunk and branches, especially decadent and dying	likely an oval hole 5-7 mm width of adult beetle	flatheaded woodborer, legless, cream colored, likely 25+ mm long	brilliant green beetle covered with yellow spots, 12-20 mm long, 5-7mm wide
		Dicerca callosa (a flatheaded woodborer)	nCan., wCan., eCan., wU.S., eU.S.	occasional	most commonly collected on QA; other hosts possible	unknown	likely an oval hole 4-8 mm width of adult beetle	flatheaded woodborer, legless, cream colored, likely 20-30 mm long	bronze to coppery-black beetle; 12.3 to 20.7mm long (16.5 ave), 4.2-7.7mm wide (6.0 ave)
		Dicerca tenebrica flatheaded poplar borer	nCan., wCan., eCan., wU.S., eU.S., sU.S.	common	QA, bigtooth aspen, balsam poplar and cottonwoods used	trunk and branches on recently dead, dying or downed trees; likely trees must be larger than 5 cm	likely an oval hole 4.5-9 mm width of adult beetle	flatheaded woodborer, legless, cream colored, likely 20-30 mm long	black mottled beetle with pointed, grooved elytra; 14.5-26 mm long (19.5 ave), 4.5-9 mm wide (6.5 ave)
		Saperda calcarata poplar borer	nCan., wCan., eCan., wU.S., eU.S., sU.S.	common	QA preferred; other *Populus* species used, in southern range prefers eastern cottonwood	trunks and branches 7-18 cm diameter but down to 4 cm; likes open-grown trees	large, round hole to 10 mm diameter; boring shavings long and slender (ribbon-like)	roundheaded woodborer, legless, cream colored, >40 mm long	large, bluish-gray, longhorned beetle up to 40 mm long; elytra with faint yellow blotches and brown stippling
		Cryptorhynchus lapathi poplar-and-willow borer	wCan., eCan., wU.S., eU.S.	uncommon (common in some urban settings)	QA, birch and alder rarely attacked; willow preferred; other *Populus* species used	young stems 2.5-10 cm diameter attacked at trunk base or branch union	round exit hole 3-4 mm diameter	"C" shaped and grub like; legless, cream colored ~6 mm long	8-10 mm long weevil resembling a bird dropping

WOOD & BARK BORING INSECTS

Location	Order	Scientific / Common Names	Distribution[1]	Likelihood of occurring in QA forest	Hosts[2]	Attack traits	Emergence hole traits	Larva (mature) traits	Adult traits
SMALL BRANCHES / TWIGS									
	LEPIDOPTERA-MOTH BORERS								
		Paranthrene tabaniformis dusky clearwing	nCan., wCan., eCan., wU.S., eU.S., sU.S.	uncommon	QA used but cottonwoods preferred in north; willows in south; alder, birch and hawthorn noted in Europe	small stems and branches; especially lower portions of young stems; often uses galls formed by *Saperda* branch borers	exit hole not described but likely 4-5 mm diameter of similar species; frass is expelled; pupal case protruding after emergence	moth borer with legs and prolegs; cream with yellow-brown head and two brown lines along back; spots on side of each body segment; 24-32 mm long	wasp-like moth with yellow and black stripes and brown wings; 24-32 mm wingspan
	COLEOPTERA-BEETLE BORERS								
		Oberea schaumii poplar branch borer	wCan., eCan., wU.S., eU.S., sU.S.	occasional (south) to common (north)	many *Populus* species used; QA preferred in north and eastern cottonwood in south	small stems 1-6 years old and 5-15 mm (up to 38-50mm); less densely stocked regeneration stands preferred	round hole 3-4 mm wide; gall may have additional holes for ejecting tight clumps of pulverized wood; oviposition scar an elongate rectangle	roundheaded woodborer, legless yellowish, and slender with no distinct taper, 12-25 mm long	longhorned beetle usually rust colored but varying from yellowish to black; 4 black spots on prothorax; 12-16 mm long, 3 mm wide
		Saperda inornata poplar gall saperda	wCan., eCan., wU.S., eU.S., sU.S.	common	many *Populus* species and willows; QA favored in north and central U.S.	small stems 3-15 mm (1-3 to 5 years old) preferred but may use stems 50 mm or larger	3-4 mm round to oval shaped hole bored into side of gall; oviposition scar U-shaped	roundheaded woodborer; slender and legless, shiny white, 10-16 mm long	black longhorned beetle with dense hairs that make it appear gray, 8-13 mm long
		Saperda populnea small poplar borer	wCan., eCan., wU.S., eU.S.	occasional	many *Populus* species; QA not preferred but used in West; balsam poplar & black cottonwood preferred	can occur on trees of any age but uses small stems or branches =< 3 years (5-11 mm)	round exit hole 2.4-4.2 mm; oviposition scar U-shaped; galls smooth and spindle-shaped	roundheaded woodborer, legless, cream colored with pale streak down back, 11 mm long	slender black longhorned beetle 9.5 mm long and 2.7 mm wide with reddish gray patches on sides of pronotum and possible yellow spots on back
	DIPTERA - FLIES, MIDGES								
		Hexomyza schineri poplar twiggall fly	wU.S., eU.S.	common	prefers QA but will use other *Populus* species	attacks current year growth but gall may become incorporated and continue growing as stem ages	globose swelling may have several small emergence holes <2 mm; no oviposition scar	small, pale yellow-green maggot, <3 mm long	stout, dark, shiny fly with 2-3 mm wing span
	HYMENOPTERA - SAWFLIES, ETC.								
		Janas abbreviates willow shoot sawfly	wCan., eCan., wU.S., eU.S., sU.S.	rare	QA noted in MN but black willow preferred; also bigtooth aspen, eastern cottonwood and several poplars	current years elongating stems; look for 5-16 punctures girdling wilting terminal	1.5-2.5 diameter, likely round	S-shaped, cream colored with short, fleshy, clawless abdominal prolegs; yellow head and brown mandibles and terminal abdominal prong; 8-11 mm long	wasp-like in shape, brown; 10-16 mm wing span, 7-10 mm body length
BARK BEETLES AND OTHER BARK INSECTS									
	COLEOPTERA-BARK BEETLES								
		Procraphalus mucronatus (an aspen bark beetle)	nCan., wCan., wU.S.	occasional	only known from QA	recently dead or dying bark, especially sunny sides	0.8-1.0 mm round hole; galleries up to 7 mm below bark surface; gallery walls dark but not black	probably like *T. populi*	1.8 to 2.2 mm long, dark brown to black bark beetle
		Tryphloeus populi (an aspen bark beetle)	wCan., eCan., wU.S.	occasional	QA and some cottonwoods	live bark on stressed trees; 30-50 cm in diameter down to 10 cm	gallery shallow with wide, black-stained tunnels; holes likely 0.8-1.0 mm	curved, cream to brown colored, legless, C-shaped larva, likely ~2 mm long	1.7 to 2.1 mm long, dark brown to black bark beetle
		Tryphloeus thatcheri (an aspen bark beetle)	wCan., wU.S.	occasional	QA and black cottonwood	like *T. populi*	like *T. populi*	like *T. populi*	1.5 to 1.9 mm long, dark brown to black bark beetle
		Trypodendron retusum poplar ambrosia beetle	nCan., wCan., eCan., wU.S., eU.S., sU.S.	common	QA and bigtooth aspen, eastern cottonwood	prefers newly dead or dying trees or parts of trees, often on larger trees	holes ~2 mm wide, drilling into sapwood; unique tunnel is stained black	curved, white, legless, C-shaped larva 3.6-5.0 mm long,	3.6 to 4.9 mm long, dark brown to black bark beetle

WOOD & BARK BORING INSECTS

Location	Order	Scientific / Common Names	Distribution[1]	Likelihood of occurring in QA forest	Hosts[2]	Attack traits	Emergence hole traits	Larva (mature) traits	Adult traits
	LEPIDOPTERA & DIPTERA-BARK MINING MOTHS & FLIES								
		Phytobia spp. (a bark fly)	wU.S., likely further	common	unknown	superficial, star-shaped, raised pattern	n/a	unknown but possibly 15-30 mm long, 1 mm wide, white and legless, typical of genus	unknown but likely a small, black fly approximately 3-4.5 mm long, typical of genus
		Cydia populana (a bark moth)	wCan., eCan., wU.S., eU.S., (maybe further)	unknown	QA and black cottonwood	unknown	n/a	unknown	moth with wingspan of 13-14 mm typical of genus
		Marmata spp. (a bark moth)	wU.S., likely further	unknown	unknown	unknown	n/a	unknown	unknown but likely a small moth with possible wingspan of 6.5-8.5 mm, and black and white designs typical of genus

Individual Agent Descriptions

photo by H. Keams

WOOD & BARK BORING INSECTS

AMERICAN HORNET MOTH
(COTTONWOOD CROWN BORER)

Sesia tibials (Harris) Lepidoptera: Sesiidae
[=*Sesia tibiale* (Harris); =*Aegeria tibialis pacifica* (Hy. Edwards)]

Distribution: Widespread from North Atlantic coast, through northern U.S. and southern Canada, south into the Rocky Mountains (to AZ) and west to the Pacific Coast (CA)

Hosts: Cottonwoods (including eastern, white, Fremont and black) and poplars (including balsam and white) common; willows and aspen occasional

Identification: Adults are about 25 mm long and look very much like yellow-jacket wasps. They are black with bright yellow stripes and accents, and long legs. Wings are 30-40 mm long, transparent, and without scales except for along veins and fringes which are lined with brown scales. Female antennae are wider toward head but pointed at tip; male antennae have comb-like projections on each segment (unipectinate). Head is black on top and front with yellow on either side. Abdominal segments 1, 2, 4 are usually brownish black, and segments 3 and 5-7 yellow with brown-black on back (posterior) margins. Larvae have off-white bodies, red-brown to black heads, tan thoracic shields, and grow to 40 mm. Abdominal legs (prolegs) are very short with small, poorly developed hooks at the ends (crochets). Eggs are oval and light to medium brown, with a net-like patterned surface. Pupae are brown and about 5 cm long and 12 mm wide.

Figure 1. *Adult American hornet moth*

Life History: Adults emerge from infested trees in late spring through early summer by boring a 6 mm hole near the tree's base. Adults only live 4-10 days during which females deposit 200-600 eggs in cracks and crevices of bark around base of host tree. After three weeks eggs hatch and 1.3 mm-long larvae crawl down to soil line to bore into root collar of tree. Larvae initially feed in tunnels in cambial area, later developing galleries into sapwood. When larvae mature they form cocoons from wood chips and pupate. Larvae overwinter twice in their 2-year life cycle, emerging their 3rd summer. Larvae in basal stem tunnel to edge of bark to pupate; larvae in roots often enter the soil, construct a silk-lined

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Key:
- *Holes at base of tree, ~ 6 mm in diameter, often with pupal case protruding half-way out*
- *Larvae tunnel in cambium and sapwood of trees, above or at soil line, in lower trunk, root crown, or exposed roots*
- *Larvae with very short prolegs, tipped with a series of small, poorly developed hooks*
- *Adult moth that looks wasp-like: yellow and black stripes, and transparent wings*

pupal chamber out of excavated wood chips, and finally wriggle to the surface before emerging as adults.

Figure 2. *American hornet moth larvae*

Damage: Larvae feed at or below soil line (e.g. lower trunk, root crown, and roots), mostly in the cambial layer, occasionally boring into solid wood. Oozing sap and fine frass/boring dust at base of tree are indicators of infestation. Larval tunnels, varying in shape and mostly free of frass/boring dust, are about 9 mm diameter and 7-12 cm long. Upon emerging, adults leave pupal cases partially protruding from ~6mm wide exit holes. Trees of all sizes are infested, with an apparent preference for stressed or damaged trees. Tunneling structurally weakens trees, increasing their susceptibility to wind and snow breakage—especially if repeatedly attacked. Small trees can be killed outright by girdling. Holes also provide entry for disease agents.

Similar Damage: Clearwing moths, a common name for the Sessidae family of moths, are easily confused with other insects. Adults resemble wasps and hornets, and larvae resemble a number of other pests. Larvae cannot be separated easily from those of other aspen-boring moths of similar size such as aspen carpenterworm (*Acossus populi*), poplar carpenterworm (*A. centerensis*), four spotted ghost moth (*Sthenopis purpurascens* and carpenterworm (*Prionoxystus robiniae*), although full grown larvae of four spotted

Figure 3. *American hornet moth pupae in chip cocoon*

Figure 4. *American hornet moth pair*

ghost moth and carpenterworm tend to be larger in size. Of the moth borer, only the larger four spotted ghost moth also attacks stems at or below soil line. Wood borer beetle larvae that attack at or below soil line such as poplar-butt borer (*Xylotrechus obliterates*) and aspen root girdler (*Agrilus horni*) are smaller in size and do not have legs or prolegs.

A second clearwing moth, the (European) hornet moth (*Sesia apiformes* [Clerck]) was introduced into North America in the mid-1800's, also attacks *Populus* species (although aspen is not listed as a host), and looks very similar to *S. tibialis*. Its distribution overlaps in northeast U.S. and NL, but overlap in other areas is unclear due to confusion in identification with native species. However, it is reportedly established in CA. It is possible that *S. apiformis* tunnels are longer, reported to be 20-50 cm versus 7-12 cm for *S. tibialis*. Body segment color on adults differ by species, and larvae of *S. tibialis* have a distinctly more wrinkled head surface.

Remarks:

- Nursery stocks of poplar species often attacked
- Day-flying moths rarely seen except if pheromone-baited traps are used

References: 1, 10, 12, 13, 18, 20, 26, 28, 37, 55, 56, 58, 75, 91, 95, 98

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FOUR SPOTTED GHOST MOTH
(POPLAR GHOST MOTH)

Sthenopis purpurascens (Packard) Lepidoptera: Hepialidae
[=*Sthenopis quadriguttatus* (Grote)]

Distribution: NL and NY north and west to BC and NT, possibly south in mountains to AZ; common in AB in boreal forest and aspen parklands – less common in foothills and mountains or along wooded parts of grassland

Hosts: *Populus* species: when described as two species, quaking aspen and willow considered primary hosts for *S. quadriguttatus*; alder and perhaps balsam poplar for *S. purpurascens*

Identification: Adults are large moths (66-100 mm wingspan; perhaps as small as 35 mm) with two color forms; purple-gray and yellow-brown. Previously, the yellow-brown form (with quaking aspen as a preferred host) was considered a separate species – *S. quadriguttatus* (Grote). Forewings have two small silver spots near base, dark band running obliquely through mid-wing front to back, and darker wing ends. Hindwings are solid purple-brown or salmon-pink, depending on color form, with two spots along front edge. Antennae of both males and females are thread-like, unlike most large northern moths. Eggs are round, smooth and unornamented. Mature larvae are cream white, (35 to) 50 to 60 mm long with reddish brown heads and prothoracic shields, and brown at bases of setae (hairs); abdominal segments 3-7 have wart-like protuberances (dorsal pinaclule). Pupae are slender and brown.

Life History: Adults fly mid- to late-summer, often peaking in July, and seen most just after dawn or dusk (crepuscular). Females with eggs may be too heavy to fly well until complement of eggs are laid. Otherwise, flight is described as swift and close to ground. Eggs are deposited indiscriminately in vicinity of host trees. Larvae bore into roots of aspen or, to a lesser extent, into other hosts. In late spring larvae pupate within galleries. It is likely that pupae wriggle up their gallery to soil line when adults are ready to emerge. Life cycle is 1-2 years.

Figure 1. *Adult four spotted ghost moth*

Key:

- *Frass and wood chips on ground at base of host trees; some perhaps as loosely woven 1-2 cm balls*
- *Tunnels into soil around root system of host trees*
- *Large moth with patterned forewing and mostly solid-colored hind wing ranging in color from salmon-pink to purple-brown; swift flying and crepuscular.*

Figure 2. *Adult ghost moth with wings spread*

Damage: Attacks occur at ground line or below, often making infestation difficult to identify. Larvae excavate extensively at root collar and in large roots; galleries are typically 10-15 cm long and 10-12 mm wide but multiple chambers within galleries may be 25-30 mm in diameter. In smaller roots galleries are usually narrower but may be up to 70 cm long. Frass and wood-chips from root excavation are loosely bound with fine webbing into 1-2 cm diameter clumps and ejected from galleries. Gallery entrances may be loosely plugged but are usually open. Similar species also have silk-lined galleries extending up through soil. Root feeding can create entry points for numerous pathogens and can result in high levels of rot fungi that further damage root systems and exacerbate loss of structural integrity.

Similar Damage: Hornet moths (*Sesia* species), aspen root girdler (*Agrilus horni*), and poplar-butt borer (*Xylotrechus obliteratus*) also bore at tree base, root collar, or upper roots. However, mature larvae of four spotted ghost moth are larger than hornet moth larvae, and differ in shape from that of the wood boring beetles aspen root girdler and poplar-butt borer. Borers not listed may use lower portions of host trees but will likely have additional attacks further up trunk. Adult moths are very similar to *S. argenteomaculatus* (silver spotted ghost moth, also called alder root borer moth) which feeds on alder roots largely in northeast U.S. and into Canada.

Remarks:

- Ghost moths are not considered of particular management importance
- Adults are poorly attracted to light although specimens have been obtained this way

References: 31, 37, 55, 56, 59, 81, 91, 98

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ASPEN ROOT GIRDLER

Agrilus horni Kerremans
[=*Agrilus blanchardi* Horn]

Coleoptera: Buprestidae

Distribution: Found in Northeast (MA, NY), Midwest (WI, MI, SD, IA), Southwest (AZ), and east and central Canada (southern ON and MB)

Figure 1. *Adult aspen root girdler*

Hosts: Quaking aspen principal host but also uses bigtooth aspen, balsam poplar, and some aspen hybrids

Identification: Adult aspen root girdlers are narrow, black beetles with green-to-copper iridescence and are 6.5-11.5 mm long. Females are somewhat larger than males. Eggs are creamy-white, flattened ovals, 1.2 mm long and 0.8 mm wide. Egg membranes darken as embryos develop. Mature larvae are typical flathead borers, 25 mm long, white except for black mandibles and brownish pincher-like projections at tail end (anal forceps). Pupae are creamy-white and darken with age.

Life History: Adults, present in May and June, feed on foliage for about 3 weeks before females begin egg laying. Eggs are laid singly or in small groups at base of aspen suckers, within 3 cm of the ground. Natural egg mortality is high; eggs that survive hatch after 2 weeks. Larvae tunnel through the bark of these lower stems, then straight down into the large lateral roots. These straight galleries may become 20-50 cm long. Larvae then move to cambium, and begin tunneling in tight spirals around roots back up to main stem. Spiraling tunnels, flattened and frass-filled, continue until they are 5-25 cm above ground. Larvae bore to stem's center, carve out pupal chambers with exit holes, then overwinter in chambers. At the completion of pupation, adults emerge through D-shaped exit holes that will produce oval bark scars if stem has not been killed. Life cycle is likely 2 years.

Figure 2. *Bark swellings are often visible over aspen root girdler galleries*

Damage: Aspen root borers tend to infest roots and stems of healthy aspen suckers less than 18 cm diameter, although attacks are most common

Key:

- *Dying and dead girdled sprouts, usually 18 cm or less in diameter, sometimes maintaining dead leaves in winter after death*
- *Spiral swellings around the base of shoots with frass-packed galleries found just under bark*
- *Enlarged pupal chamber in stem, visible when stem is split open*
- *D-shaped emergence holes or oval bark scars*

on stems less than 12 cm. Borers do not seem to prefer weakened suckers. Larvae girdle main roots and lower stems of aspen suckers. As they do, spiral swellings around base of stems may reveal borers' presence. Occasionally galleries also wander back and forth. Girdled suckers die before normal leaf abscission and in winter suckers with dead leaves still attached will be visible. Stands with high numbers of sprouts are not greatly affected by root girdlers; but clones with sparse regeneration may suffer disproportionately more damage.

Figure 3. Spiral galleries of aspen root girdler with bark removed

Similar Damage: Beetles and larvae of aspen root girdler look very similar to bronze poplar borer (*Agrilus granulatus liragus*) and bronze birch borer (*A. anxius* Gory) but can be distinguished by their presence in sucker stems and roots rather than main stems of aspen or birch. Aspen root girdler's sinuate galleries on larger stems may resemble bronze poplar borer but are generally located lower on stem near base. Poplar-and-willow borer also prefers stems less than 12 cm diameter but does not create spiral galleries or bore into roots; it also creates copious amounts of frass and is rarely found in aspen. Poplar-butt borer (*Xylotrechus obliterates*), cottonwood crown borer (*Sesia tibialis*), and four spotted ghost moth (*Sthenopis purpurascens*) also bore at tree bases, collar, and roots but leave round holes rather than D-shaped, and are larger in size. Aspen root girdler is a buprestid with larvae and adults that differ in shape from cerambycid or moth larvae and adults.

Remarks:

- Maintain healthy trees in dense stands to minimize damage
- Cut and destroy infested trees; insecticide may be an option
- *Agrilus horni* (Kerremans) has been proposed as a junior subjective synonym of *A. acastus* Kerremans

References: 3, 13, 27, 37, 54, 55, 57, 68, 74, 75, 78, 91

WOOD & BARK BORING INSECTS

POPLAR-BUTT BORER

Xylotrechus obliteratus LeConte — Coleoptera: Cerambycidae

Distribution: Abundant in Rocky Mountain (including Waterton Lakes park in Canada); also found in some parts of eastern U.S.

Hosts: Quaking aspen primary host, but other aspens and *Populus* may also be attacked

Identification: Adults are robust, elongate, longhorned beetles, 10-18 mm long and 3.5-5.0 mm wide. They have cinnamon brown to dark gray elytra covered with sparse white hairs and three, curved yellow bands; the first one oblique, middle one curved (sometimes running up the central margin), last one transverse. Yellow bands may also exit on front and back edges of pronotum. Antennae are relatively short, reaching just past front edge of elytra. Eggs are not described. Larvae are dull-white, moderately robust, and typical of roundheaded woodborers. They also have fine velvety hairs on pronotum and blister-like structures (ampullae) on abdominal segments. Pupae are not described but those of similar species are dull white, often with stiff, slender points on sides of the pronotum.

Figure 1. *Poplar-butt borer adult*

Life History: Adults are present in late summer (July-Aug.). Females deposit eggs in bark crevices or exposed wood on lower part of trunk. Larvae produce tunnels in wood around tree's base, mostly at or just below ground level. Larvae feed beneath bark the first season, then overwinter in galleries. In spring, larvae tunnel into wood, extending galleries downward so that most of their feeding occurs at or below ground surface. They continue feeding for several years. When mature, larvae tunnel upward towards outer bark where they create pupal chambers. New adults bore through bark to emerge.

Damage: Poplar-butt borer is a serious pest of aspen in the Rocky Mountain regions, especially in higher altitudes where it may be more prevalent than poplar borer (*Saperda calcarata*). Larval tunnels can be found in lower portions of tree stems that are weakened, dying, or broken. Because of repeated poplar-butt

Key:

- *Tunnels in wood around base of tree*
- *Wind broken trees*
- *Larvae typical of roundheaded woodborers*
- *Adult longhorned beetles with antennae only about half as long as body, dark gray to brown elytra with three, curved yellow bands, and sparse white hairs.*

borer attacks, base of tree can become honey-combed with tunnels, especially at or just below ground surface but may include upper roots. Tree structure is compromised so trees often break during wind or snow storms. Females tend to return to infested trees for oviposition so that trees are attacked repeatedly until they finally succumb. Outright mortality can be common.

Similar Damage: Aspen root girdler (*Agrilus horni*), American hornet moths (*Sesia tibialis*), and four spotted ghost moth (*Sthenopis purpurascens*) also focus boring damage at tree base, root collar, or upper roots, and are commonly found in aspen. Larvae of this cerambycid beetle, however, differ in shape and size from that of the buprestid or moth borers. Poplar-butt borer adults are striking with bright yellow stripes on dark, hard wing covers (elytra). Other aspen boring insects may use lower portions of host trees but will likely focus attacks further up trunk.

Figure 2. Xylotrechus annosus *adult*

Xylotrechus annosus (Say) is less brightly striped with 3 wavy lines on the elytra. Its size is similar at 10.5-15 mm in length, 3-4.5 mm in width. Noted originally from black cottonwood, it has been found in other dead or dying *Populus* and willow species, although quaking aspen is not specifically noted. In Canada, it has been found in aspen-hardwood forests. Little is known about the biology of this beetle although it is likely saproxylic (found in dead or dying wood). Although it is listed as being found in eastern U.S. and eastern Canada, it has been trapped in many areas of the U.S. (WA, MI, NH) and Canada (BC, AB, MB, ON and QU).

Xylotrechus mormonus (LeConte) (not to be confused with *X. mormonus* Hopping, now called *X. bowditchi hoppingi* Linsley found in spruce) is another species noted for attacking willow. However, it was found emerging from a *Poplulus* (likely quaking aspen) stump in MT. Little is known about this transcontinental

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Figure 3. Xylotrechus mormonus *damage in* Populus *stump*

species. Adults are 12-17 mm long and 3.7-5.5mm wide, gray beetles covered with sparse, gray hairs (pubescence). Elytra are marked by 2 or 3 sets of narrow, yellowish, broken transverse lines or "dashes". In Canada this species is also called the popular butt borer.

Figure 4. Xylotrechus mormonus *adult*

Remarks:

- Trees at high elevations in Rocky Mountain States susceptible to attack; extensive areas at elevations of 2,100 m (7,000 ft) and above in UT and CO affected with as many as 90% of stems attacked each year
- Direct control impractical, since stumps and roots of infested trees would have to be treated or removed

References: 1, 37, 40, 41, 48, 52, 53, 55, 59, 60, 83, 91, 95

CARPENTER ANT

Camponotus species

Hymenoptera: Formicidae

Distribution: Transcontinental

Hosts: other hardwoods and conifers

Identification: Carpenter ants most often seen are black to reddish- or yellowish-black adult workers. These adults vary in size within a colony and among species but are generally 3-16 mm long. Ants have bent (elbowed), clubbed antennae and a constricted waist. When wings are present, front wings are larger than hind. Queen ants are rarely seen and considerably larger. Worker ants in *Camponotus* have an evenly rounded (convex) back (thoracic dorsum) when viewed from the side; other ants that may be confused with *Camponotus* have a notch or depression present. Egg, larval and pupal stages are found within excavated galleries and tend to be cream colored; larvae are legless.

Figure 1. *Adult carpenter ant (Camponotus sp.)*

Figure 2. *Carpenter ant larvae*

Life History: Carpenter ants start new colonies by swarming in mass flights of winged individuals, usually in spring to mid-summer. After a female ant has successfully mated, she breaks off her wings and begins her search for a suitable site to colonize and begin laying eggs. When larvae hatch, the queen will feed them from energy reserves stored within her body. Ant larvae go through four developmental stages (instars) and then form a cocoon in which they pupate. Once new adults (workers) emerge from pupal cases, the queen will lay more eggs and the new workers will take over raising the brood. It can take 3 to 4 years before an ant colony can build large enough numbers to be readily noticed. Full colony size can range from a few hundred to tens of thousands depending on the maturity of the colony and ant species.

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Key:

- *Black to reddish-black ants 3-16 mm long in frass-free, honey-combed chamber system*
- *Piles of light colored "sawdust" at base of tree*

Figure 3. *Frass from carpenter ants excavating wood borer galleries*

Damage: Carpenter ants in a live tree can indicate presence of heart or butt rot. They can also use galleries of wood boring insects that have attacked lower trunks of large trees. In both cases, carpenter ant excavations can further weaken the tree's structural integrity if sound wood is removed. Although carpenter ants prefer softened wood for initial excavations, they can move into more solid wood as gallery creation progresses. Infested trees are subject to wind breakage and the wood is usually useless for lumber or pulpwood. They do not, however, kill trees directly.

Early indications of infestation are worker ants coming and going from openings at the surface of wood. Carpenter ants do not actually eat wood but they chew through it to construct chambers. Inside, the ant galleries follow the softer springwood with numerous connections through the harder/darkened summerwood. Active galleries are kept clean of debris by adults pushing small fragments of boring dust out of

Figure 4. *Mound of frass located below carpenter ant chamber opening*

the internal chambers; accumulation of such debris below holes is a good indication of an infestation. Gallery walls are smooth, with a sand-papered appearance.

Figure 5. *Carpenter ant galleries established in existing weakened wood*

Similar damage: Excavation of wood can also be indicative of termites which superficially resemble ants and also live in large colonies. However, termites have straight antenna (not elbowed), do not have constricted waists, and their galleries are lined with moist soil (not clean). Some larger, wood boring insects that attack larger tree trunks will also produce frass and extensive galleries. If wood borer galleries are used by carpenter ants, differentiation may be difficult. However, careful watch at holes with fresh frass will often afford glimpes of worker ants ejecting fresh shavings; further disturbance may also bring a number of individuals to the surface. In addition, galleries of most wood borers are not kept as clean as those of carpenter ants. Earwigs (order Dermaptera), which may be found hiding in damaged wood, have prominent "pincers" at the end of the abdomen.

Remarks:

- Carpenter ants are important predators and scavengers, assist in decomposition of woody debris, and are important sources of food for other animals
- Control may be very difficult but not usually necessary in a forest setting; populations can be high where trees have significant rot

References: 10, 12, 19, 24, 37, 46, 56, 79, 89

WOOD & BARK BORING INSECTS

POPLAR CARPENTERWORM

Acossus centerensis (Lintner) Lepidoptera: Cossidae

Distribution: Primarily eastern – in U.S. from NY and NJ west to IL and ND; in Canada from QU and ON west to SK and AB

***Hosts*:** Quaking aspen preferred; balsam poplar occasional host

Figure 1. *Poplar carpenterworm adult*

Identification: Adult moths have blackish head, thorax, and abdomen, edged and shaded with gray. A transverse row of white hairs (setae) on the thorax is highly visible on live specimens. Forewings are two-toned - black-gray near body and lighter gray on outer half - and are covered with a network of irregular black lines. Hindwings are rounded and translucent with indistinct black lines. Wingspan of male is 40-50 mm; female is more robust with a wingspan of 50-64 mm. Females have thread-like antennae, while males have feathery antennae. Larvae are creamy-white with dark brown heads, strong black mandibles, and small brown spots (at setal bases). Thoracic shield is pale-yellow to blackish-brown. Anal shield is yellowish. Thoracic legs (three front pair) are well developed with black claws. Mature larvae are 32-45 mm long. Pupae are narrow, shiny, wrinkled, brownish-black, and around 30 mm long.

Life History: Adults emerge during the day in early summer. However, they are most active at night, often resting on roughened areas of bark, bark scars, or broken limbs during the day. Females deposit 50 or more eggs, singly or in small groups, on bark, in tunnels, or in other bark openings. Larvae bore into bark and heartwood, often feeding in groups. Gallery openings are typically kept partly closed with packed frass and debris, with fine chips and thin slivers of wood loosely packed behind that. It is believed the poplar carpenterworm goes through a 2- or 3-year life cycle. Mature larvae pupate in innermost part of galleries with their heads toward openings. After slightly less than 1 month, pupae work their way to gallery entrance, and through chip and frass plugs. Moths emerge, often leaving an empty brown pupal case protruding from the exit hole.

Damage: Larvae mostly attack stems (up to 41 cm diameter) and branches (smaller than 31 cm diameter). Bark scars often occur around open entry points and heavily infested trunks may have multiple entry points. Larvae make galleries

Key:

- *Debris-filled (plugged) entrance holes with frass and boring-dust in bark crevices and around base of tree*
- *Bark scars around entry points*
- *Brown pupal case protruding from exit hole*
- *Adults gray with dark gray bodies, front wings distinctly two-tone - darker by the body and light toward outer end with irregular dark lines throughout*

Figure 2. *Adult popular carpenterworm on finger*

up to 15 mm diameter running in diverse directions deep within the wood. Chambers up to 90 cm long have been found. Galleries end in smooth pupal cells about 40 mm long. Heavy infestations weaken trees structurally, make them susceptible to wind and snow breakage, and may ultimately cause mortality.

Similar Damage: Damage by aspen carpenter worm (*Acossus populi*) is similar, making distinction between the two difficult where distributions overlap. Carpenterworm (*Prionoxystus robiniae*) also creates similar damage and boring debris, although holes are generally kept open. In addition, *Prionoxystus* larvae create an inner chamber at entry point up to 6 cm in diameter and leave behind webbing at bark surfaces or within exit tunnel. If adult moths are available, coloring of fore- and hind- wings can be used to readily differentiate species. Other moth borers in *Sesia* and *Sthenopis* are more likely to be found at or below soil line.

Poplar borer (*Saperda calcarata*) will also create bark calluses around gallery openings and produce large boring debris, but no pupal case will exist at the exit hole. Adults and larvae of poplar borer (beetle) are also readily distinguishable from the moth borers mentioned. Most other aspen-stem boring beetles are buprestids whose larvae and adults tend to be smaller in size and create D-shaped or oval exit holes and galleries. Poplar-and-willow borer (*Cryptorhynchus lapathi*), a weevil, creates round holes and ejects copious amounts of frass but is much smaller in size.

Remarks:

- Natural control agents include an unidentified ichneumonid parasite (found in pupae), woodpeckers (eat larva), and ants (eat eggs)
- Males are easily attracted to traps baited with synthetic sex pheromone

References: 1, 12, 18, 37, 56, 91, 97, 98

WOOD & BARK BORING INSECTS

ASPEN CARPENTERWORM

Acossus populi (Walker) Lepidoptera: Cossidae

Distribution: Reportedly coast to coast; known from NV, CO, CA, and northern Rocky Mountains, as well as BC and ON

Hosts: Cottonwoods and poplars, especially quaking aspen; most *Populus* species

Identification: Adult moths are large (50-80 mm wingspan), heavy-bodied, and light-gray. Thorax is gray, with a broken narrow white band bordered on either side by black. Abdomen is dull gray. Forewings are dirty white, crossed by a network of fine dark-gray broken lines. Two or more of these lines at wing center are usually darker, more prominent, and often partly joined. Hindwings are gray with a similar net of fine black lines. Females, distinguishable from males by slightly heavier bodies, are lighter gray color, have less distinct lines (reticulation) on hindwings, and possess thread-like antennae (serrate). Male antennae are somewhat feathery (narrowly bipectinate). Larvae are cream-colored, shiny, hairless, and have dark-brown head and thoracic shield. At maturity they are 35-40 mm long.

Life History: Adults emerge in July. Soon after, females deposit eggs in bark crevices of host trees, flying principally at night. Young larvae tunnel under bark initially and then excavate extensive galleries into wood. It is likely 2-3 years are required to complete their life cycle although little is actually know about these borers. They are considered similar to poplar carpenterworm (*A. centerensis*) but are more common in western North America.

Figure 1. *Adult aspen carpenterworm (male upper and female lower)*

Damage: Bark scars often develop around entry points and frass can be found in bark crevices of actively infested trees. Multiple frass-filled entrance holes indicate degree of infestation. Galleries with blackened walls, up to 13 mm diameter, may extend deep into wood. Heavily infested boles may become so riddled with tunnels they break in wind or from snow loading. Populations

Key:

- *Debris-filled (plugged) entrance holes with frass and boring dust in bark crevices and around base of tree*
- *Bark scars around entry points*
- *Brown pupal case protruding from an exit hole*
- *Cream-colored, shiny, hairless larvae up to 4 cm long with dark brown heads and thoracic shields*
- *Adults light gray with distinct white and black patches on thorax; wing span 5-8 cm; front wing with a net of black lines and hind wing light gray with net of faint black lines*

Figure 2. *Adult aspen carpenterworm at rest*

appear to be localized but widely scattered.

Similar Damage: Damage by poplar carpenter worm (*A. centerensis*) is similar, making distinction between the two difficult where distributions overlap. Carpenterworm (*Prionoxystus robiniae*) also creates similar damage and boring debris, although entrance holes are generally kept open and free of frass. In addition, *Prionoxystus* larvae create a chamber under bark at entry point up to 6 cm in diameter, and leave behind webbing at bark surfaces or within exit tunnel. If adult moths are available, coloring of fore- and hind-wings can be used to differentiate species. Other moth borers such as *Sesia* and *Sthenopis* are more likely to be found at or below soil line.

Poplar borer (*Saperda calcarata*) will also create bark calluses around gallery openings and produce large boring debris, but no pupal case will exist at the exit hole. Adults and larvae of poplar borer (beetle) are also readily distinguishable from the moth borers mentioned. Most other aspen-stem boring beetles are buprestids whose larvae and adults tend to be smaller in size and create D-shaped or oval exit holes and galleries. Poplar-and-willow borer (C*ryptorhynchus lapathi*), a weevil, creates round holes and ejects copious amounts of frass but is much smaller in size.

Remarks:

- Adults are attracted to light, so can be collected at night
- Natural control agents are likely similar to those of poplar carpenterworm (*A. centerensis*) including parasitic wasps, woodpeckers and ants
- In CO found in conjunction with poplar borer (*Saperda calcarata*) where it appeared to preferentially lay eggs in old poplar borer egg scars

References: 1, 4, 12, 18, 37, 52, 56, 91

WOOD & BARK BORING INSECTS

CARPENTERWORM

Prionoxystus robiniae (Peck) Lepidoptera: Cossidae

Distribution: Transcontinental

Hosts: Quaking aspen noted as host, especially in Canadian literature; host preferences differ by area and include oaks (especially in East, South, and CA), green ash and elm (especially Prairie regions), poplars (especially in Rocky Mountain region) and other hardwoods such as willows, maples, black locust, and various fruit and ornamental trees and shrubs

Figure 1. *Adult arpenterworm on tree trunk*

Identification: Adults are large, grayish, stout-bodied moths, with uniform mottling of gray and black scales over body and wings. Females with 60-75 mm wingspans are much larger than males with less than 50 mm wingspans. Males have bright yellow-orange spot on hindwings. Both sexes have feathery (bipectinate) antennae. Eggs are 2.3 mm long by 1.5 mm wide ovals with a hard dark-olive brown shell and a net-like pattern of ridges. Young larvae are pinkish to dark brown, up to 7.5 cm long, with brown spots (at spiracles), and reddish-brown heads and thoracic shields. As larvae mature they gradually become greenish- or pinkish-white, with shiny dark-brown heads, black mandibles, and short, stout hairs on each body segment. Pupae are 30-50 mm long, torpedo shaped, dark-shiny brown with circular bands of backward-pointing dark spines. Males and females have differing spine arrangement.

Figure 2. *Female (left) and male(right) carpenterworm moths*

Life History: Moths emerge from early spring to mid-summer (late April to early July) depending on region (latitude). Once mated, females deposit 200-1,000 eggs singly or often as small groups of 2-6 under bark crevices or other sheltered site (especially scabbed-over, old

Key:

- *Gallery open to outside or loosely plugged*
- *Frass and boring dust caught in bark crevices and around base of tree*
- *Presence of webbing either on bark or within gallery*
- *Cave-like feeding gallery just under bark up to 6 cm diameter*
- *Large, purplish-brown pupal case protruding from exit hole*
- *Reddish-pink larvae with dark head when young, greenish- or pinkish-white larvae with dark-brown head when mature; stout hairs on each body segment*
- *Adults with uniform mottling of gray and black; males differing greatly from female with bright yellow-orange patches on hind wing*

Figure 3. *Young (top) and mature (bottom) carpenterworm larvae*

wound sites). After 10-16 days larvae hatch, construct loose webbed frass and bark shelters, and begin boring into the tree. Initially, young larvae feed just under bark in phloem, hollowing out irregularly shaped chambers up to 6 cm in diameter. Occasionally larvae wander out onto bark surfaces. After feeding, larvae move into sapwood and heartwood, creating 12-16 mm diameter, 12-22 cm long galleries that slant upward before angling straight up. Gallery entrance remains open to the outside or loosely plugged with frass and boring debris. Larvae regularly return to area around entrance hole to feed on phloem and cambium, and to eject frass/boring dust. During spring of last year of development, full-grown larvae chew away sides of innermost part of galleries to facilitate exit of pupae. Tunnels are partially lined with yellowish-brown silken threads before pupating. Three to six weeks later, pupae wriggle to exits where moths emerge. Empty purplish-brown pupal cases often remain. Life cycle requires 1-4 years for completion depending on location; 1-2 years in south, three years in central and western U.S., and four years in southeast Canada. Overlapping larval generations often occur.

Damage: In fall or spring following initial entry, spots of sap mixed with fine frass/boring dust begin to appear. Frass and boring debris can be found in bark crevices, and around bases of infested trees, becoming profuse. Irregular shaped chambers roughly 5 cm in diameter are formed just under bark by larvae

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returning to feed near gallery entrance. Inner surface of galleries is stained dark with stain moving into surrounding wood. Wounds heal in 1-2 years, leaving oval to irregular callused bark scars that remain for 10-20 years. Entry points around old scars are often re-infested.

Trees are seldom killed, but severe infestations decrease rate of growth, compromise wood quality, provide entrance for decay organisms, and weaken structural integrity necessary to withstand strong winds.

Figure 4. *Damage in* Populus *species*

No tree size preference has been noted (found down to 5 cm diameter stems) but more open grown trees, especially ornamentals and those along shelterbelts, are often attacked. Carpenterworm is not known to attack dead trees, but it can complete its lifecycle in a tree after it has died.

Similar Damage: Unlike most other wood borers, carpenterworm maintains tunnel opening clear of frass and boring dust. Other cossid moths, aspen carpenter worm (*Acossus populi*) and poplar carpenter worm (*A. centerensis*), create very similar damage and leave pupal cases behind, but do not create a large feeding chamber at entry point, or create webbing at bark surfaces (as small larvae) or within exit tunnel (before pupation). If adults are available, species can be separated by differences in wing coloring and pattern; females can be separated from similar aspen carpenterworm by the blotchy gray on forewings, and from poplar carpenterworm by gray hindwings. Other moth borers such as *Sesia* and *Sthenopis* are more likely to be found lower on stem at or below soil line.

Poplar borer (*Saperda calcarata*) will also create bark calluses around gallery openings and produce large boring debris, but no pupal case will exist at the exit hole. Adults and larvae of poplar borer (beetle) are also readily distinguishable from the moth borers mentioned. Most other aspen-stem boring beetles are buprestids whose larvae and adults tend to be smaller in size and create D-shaped or oval exit holes and galleries. Poplar-and-willow borer (*Cryptorhynchus lapathi*), a weevil, creates round holes and ejects copious amounts of frass but is much smaller in size.

Remarks:

- Damage in sawn lumber appears as pockets of ingrown bark and oval-to-irregular holes, 12 mm or larger diameter, surrounded by stained wood that can extend 60 cm up and down from the burrow
- Frass characteristics useful for identification against other species include:
  - o Excrement pellets and wood chips constitute equal proportions (>40%) of ejected frass; overall color light to dark brown; pieces may be loose or clumped
  - o Wood chips irregular in size and shape (max size 8 mm)
  - o Excrement pellets are cylindrical (max size 7 mm long by 3 mm wide) and usually darker than chips
  - o Silken thread occasionally present
  - o Gallery entrances open or loosely plugged with frass
- Carpenter ants may inhabit and further hollow out galleries
- Newly emerged female moths may be so heavy with eggs they are unable to fly, resulting in many eggs being laid on the same tree from which females emerged
- Females produce attractant pheromones able to lure males from long distances
- Woodpeckers, predatory insects, parasitic wasps and other natural enemies suppress populations but not often below acceptable levels
- Control measures include removal of brood trees, wrapping of small trees in May to prevent emergence of moths, probing holes with wire to kill larvae, pheromone attractants, and proper use of insecticides (e.g. on bark to prevent entry, or applied through gallery hole to kill larvae); because of long life cycle any treatment must be carried out over 3 or more years

Figure 6. *Typical gallery of carpenterworm with chamber just below bark*

References: 1, 12, 13, 18, 20, 27, 37, 49, 56, 58, 84, 90, 91, 92, 95, 98, 105

BRONZE POPLAR BORER

Agrilus granulatus liragus Barter & Brown Coleoptera: Buprestidae
[=*Agrilus liragus* Barter & Brown; =*A. granulatus* (Say)]

Distribution: From BC, east to NL and NB, south to PA and northern CA and NV, possibly as far south as AZ

Hosts: In addition to quaking aspen, common hosts include bigtooth aspen, balsam poplar, Russian poplar, black cottonwood and eastern cottonwood

Figure 1. *Bronze poplar borer adult next to dime*

Identification*:* Adult beetles are 6.8-11.5 mm long, flattened, and black with green iridescence. Males have a greenish head. Coppery reflections common in *A. anxinus* Gory (bronze birch borer, which it closely resembles) are nearly always lacking or never distinct. Eggs are oval (about 1.2 by 0.8 mm), flattened, and creamy-white in color. Larvae are 30-40 mm long and 2-3.5 mm wide, flattened, with a whitish body, dark mandibles, and brown pincher-like projections at tail end (anal forceps). The prothorax also has a darker, median I-shaped line. Pupae are shorter and fatter than larvae, but are similar in color and begin to show vestiges of wings.

Figure 2. *Bronze poplar borer larva in galleries; note tightly packed frass in chambers*

Life History: Adults can emerge throughout summer, depending on weather. Adults feed for a week on foliage before females start to lay eggs in bark crevices. Normally 5-8 eggs are laid at a time (up to 18). Oviposition continues throughout summer, often on trees' sunny side during warm days (27° C/ 80° F; rarely when below 21° C/ 70° F). After two weeks, emerging larvae tunnel into the phloem of branches and stems. Forays into sapwood may occur for each molt before larvae return to feeding in the phloem. Pupal chambers are formed in spring in either sapwood or in thick bark. Most larvae overwinter before pupating in

Figure 3. *Bronze poplar borer attacks are often visible as small pitch spots (left) until bark is peeled back to reveal the gallery (right)*

spring. Adult emergence holes from the bark are D-shaped; 3-4 mm diameter. Life cycle usually takes two years in vigorous trees and in northern climates; but may be completed in one year in weakened stems or warmer conditions.

Damage: Larvae mine downward in a meandering course. Tightness of zigzag pattern is likely indicative of food quality with less compact (almost random) galleries found in more rapidly degrading tree tissues. Galleries are about 30-60 cm long (up to 150 cm), widening from 0.6 mm to 3.0 mm as larvae mature, and are packed with frass. First instar larvae bore directly to the cambial layer. Occasionally, larvae will mine into the xylem to molt but return to phloem to continue feeding, lengthening the tunnel. In decadent trees, molting excursions are rarer. Larvae create pupal cells in outer xylem or bark, if bark is thick enough, and create partial exit holes for adult emergence the following spring.

There can be leaf discoloration and some defoliation after initial attack. In sufficient numbers, boring can girdle branches and stems. Boring also introduces or makes conditions conducive to a variety of canker disease, and can make trees attractive to other insects such as poplar borer (*Saperda calcarata*).

This species is an early colonizer of weakened and dead wood, and can become very abundant in the first year after a tree's death. It contributes to wood decay processes and provides food for wildlife such as woodpeckers. Vigorously growing trees are likely unsuitable for larva development and survival, although if populations become high, more healthy trees may be attacked. Stressed trees

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Key:

- *Spot of sap on bark surface with little to no other early signs of attack; no ejected frass from entry hole*
- *D-shaped, 3-4 mm diameter adult emergence holes in bark on dead stem or branch*
- *Zig zag gallery in phloem ranging from tight to nearly random pattern, 30 to 60 cm long, with or without holes into wood*

Figure 4. *Bronze poplar borer larval galleries created in weakened trees are widely spaced and random (left); in healthy trees, galleries are closely spaced, tight zigzags (right)*

are preferred with known predisposing factors including defoliation, cankers, ungulate bark damage, wind breakage and drought.

Similar Damage: *Poecilonota* species and, to some extent, flatheaded poplar borer (*Dicerca tenebrica*) are most similar in gallery pattern, exit hole shape, and host material used. Unlike some other aspen wood borers, there is no external frass or sap flow due to bronze poplar borer activity. However, eastern poplar buprestid (*P. cyanipes*) and likely other *Poecilonota* species also eject little to no frass. A tight zigzag gallery is often indicative of bronze poplar borer although in degraded hosts the more open, random pattern can resemble those of several other buprestid wood borers. Smaller size of D-shaped holes made in bark during emergence and in wood during larval molting excursions may be useful.

Remarks:

- *Agrilus granulatus* has been divided into numerous subspecies based on color, morphology of genitalia, and preferred host plants: subspecies *A. g.*

granulatus (Say) (granulate poplar borer) and *A. g. populi* Fisher (western poplar agrilus) are found in eastern and western North America, respectively, with both found in MT. *Agrilus granulatus mohavei* Knull has been noted in southern CA in fremont cottonwood; although all subspecies attack *Populus* species, only *A. g. liragus* is in aspen

- Recent studies suggest bronze poplar borer is more important in aspen stem health than previously expected, partly due to its cryptic entrance hole and common association with cankers; was associated with rapid aspen mortality (sudden aspen decline or SAD), observed in the central Rocky Mountains, 2008-2010
- Host quality effects length of life cycle, gallery shape and size, frequency of excursions into wood, and survival of larvae and emerging adults
- Natural enemies include numerous egg and larvae parasites as well as woodpeckers; reportedly woodpeckers can consume up to 40% of pupating and emerging adults on individual, standing trees
- Control includes maintaining healthy trees, cutting and destroying infested trees or limbs, and applying a pesticide recommended for wood-boring insects in early summer

References: 1, 3, 9, 10, 12, 13, 17, 18, 20, 37, 47, 52, 54, 55, 56, 58, 59, 64, 69, 78, 87, 91, 94, 95, 98, 104

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GOLD DUST BUPRESTID
(YELLOW SPOTTED JEWEL BEETLE)

Buprestis confluenta Say
[=*B. tesselata* Casey]

Coleoptera: Buprestidae

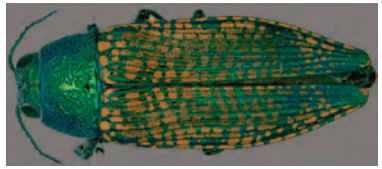

Figure 1. *Adult gold dust buprestid*

Distribution: Found from BC east to QU, south to AR, TX and CA; in U.S. collections noted from CA, CO, NE, KS, TX, MO and AR

Hosts: *Populus* species noted, with eastern cottonwood, balsam poplar and quaking aspen identified specifically; in KS and Canada found in trees along river sides

Identification: Adults are metallic wood-boring beetles ("jewel beetles") easily identified by yellow spots covering brilliant-green elytra, although elytra are occasionally coppery-brown or purplish-blue. Yellow flecks may be widely separated to almost confluent. Head and pronotum are usually solid metallic green, tips of elytra are usually coppery. Beetles range in length from 12-20 mm and width 5-7 mm—males about 15 mm long and 5-6 mm wide, females about 17 mm long and 7 mm wide. Eggs are not described but likely are small, white and oval as with other buprestids. Larvae are typical of other flathead borers. Pupae are not described but are likely similar to those of other buprestids, somewhat smaller than adult beetles, soft, creamy white, with signs of wing development.

Life History: Little is known about this woodborer, although it is likely they have life histories similar to other buprestids (e.g. two-year life cycle or greater). Adults are active from late June through August; often found sunning themselves on the south facing side of stems.

Damage: Beetles appear to prefer decadent and dying trees. In Canada they've been found using logs drifting in water. Galleries are made in phloem and sapwood, typically winding and flattened.

Similar Damage: This beetle is relatively uncommon, suggesting that if damage to aspen appears to have been caused by a buprestid-like woodborer, it is likely

Key:
- *Beetle with metallic green elytra covered in yellow spots*
- *D-shaped exit hole similar to other buprestids*

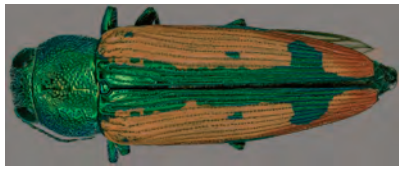

Figure 2. *Adult* Buprestis viridisuturalis

to be from a different beetle. Most other buprestid wood borers in aspen stems, especially flatheaded poplar borer (*Dicerca tenebrica*) and poplar buprestids (*Poecilonota* spp.) are likely to create similar damage, choose similar host material, and create similar galleries and frass. However, adult beetles of *B. confluenta* are unmistakable.

Although most *Buprestis* species attack conifers, another "jewel beetle", *Buprestis viridisuturalis* Nicolay and Weiss [=*B. lesnei* Garnett], reportedly attacks *Populus* and Alder species in the western U.S. (WA, OR, CA and UT noted). However, it has not been reported to attack quaking aspen and adult beetles are distinctly different in appearance.

Remarks:

References: 9, 13, 20, 37, 39, 54, 55, 61, 69, 71, 96, 98

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FLATHEADED APPLETREE BORER

Chrysobothris femorata (Olivier) Coleoptera: Buprestidae
[=*Buprestis femorata* Olivier]

Distribution: Found from BC to NB, south to Mexico; is more common east of Rocky Mountains, while similar Pacific flatheaded borer (*C. mali*) predominates in Rocky Mountains and west

Hosts: Maple and apple preferred but a wide range of shrubs, and deciduous fruit, forest and shade trees may be used including many *Populus* species; adults noted on aspen in AB and other areas

Figure 1. *Adult flatheaded appletree borer*

Identification*:* Adults are metallic olive-gray to brown beetles with a broad oval shape, measuring 7-16 mm long (average 12 mm) and up to 5-7 mm wide. They are marked with dull gray spots or bands. Elytra are black with coppery-bronze luster, but beneath the beetle's wings its body is a metallic greenish-blue. Most striking is the vivid green front of the head. Eggs are pale yellow, flattened, disk-like, wrinkled and 1.5 mm in diameter. Larvae are yellowish-white, legless and 18-25 mm long. Heads are brown with first thoracic segment broad, flattened, and hardened. The next two segments are also flattened—resulting in the characteristic "horseshoe nail" shape of flatheaded wood borers. Pale yellow pupae, 7-19 mm long, resemble adults in shape and size.

Life History: Adult beetles can be found from early spring through late fall but are most abundant in late-May through June. After exiting host, females mate, begin ovipositing in 4-8 days, and live about a month. Females lay approximately 100 eggs, singly, in cracks or crevices of bark. Eggs hatch in 8-16 days. First-instar larvae chew directly into bark and feed in phloem and surface of sapwood. As soon as larvae are fully developed, they tunnel from cambium deeper into sapwood. Later instar larvae prepare pupal chambers by plugging burrows tightly with frass. Larvae become dormant in cold weather, overwinter in these chambers, pupating in the spring for 8-14 days. Adults emerge by cutting D-shape exit holes through bark. Beetles typically have a one-year life cycle although 2-3 years may be necessary in some northern areas.

Key:
- *White, frothy sap oozing from cracks in bark*
- *Broad, metallic olive-gray to brown beetle with dull gray spots*
- *Larvae and D-shaped exit hole similar to other flatheaded woodborers*

Figure 2. *White oozing spot at point of entry of flatheaded appletree borer*

Damage: White, frothy sap oozes from cracks in bark of infested trees. Bark gradually becomes darkened, wet, and greasy appearing. Galleries, packed tightly with fine, sawdust-like frass, are broad and have many curves and bends. Little to no boring dust is ejected except at bark cracks. Areas of larval feeding often become depressed, and bark may eventually split at injured sites. Burrows in older trees with thick bark may be confined to a circular area. Wounds may be enlarged by succeeding generations.

Trunks and branches are attacked, most commonly on sunny aspects, often concentrating on trees suffering from sunscald, drought stress, transplanting or wounding. In young trees 5 cm diameter or less with thin bark, tunnels sometimes encircle and girdle stem. In weakened trees, larvae develop rapidly and produce long burrows; but in vigorous trees, larvae tend to develop slowly, and many do not survive. Old woodlands or declining orchards can harbor high numbers, causing significant damage to new plantings made in close proximity.

Similar Damage: Where species ranges overlap, type of damage and size of galleries may be very similar to other buprestid wood borers such as *Poecilonota*, *Chrysobothris*, *Dicerca* and *Buprestis* species. Adult beetles may be needed to separate these damage agents. These buprestids leave oval or D-shaped holes slightly smaller than the large (~10mm wide), perfectly round holes of the cerambycid, poplar borer (*Saperda calcarata*) or the oval to irregularly shaped, large holes (9-15mm wide) of some moth borers (e.g. carpenterworms). Bronze poplar borer (*Agrilus granulates liragus*) is a much smaller buprestid with an oval or D-shaped exit hole only 3-4 mm in diameter.

Remarks:
- Beetles move rapidly, running quickly over trunk surfaces or taking flight when disturbed; at rest, adults prefer sunny sides of trunks and larger branches

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- Control: Hymenopterous parasites and insect predators help reduce infestations, however, maintaining healthy trees is most important practice; removal of infested material will help reduce populations but unnecessary cutting and damage should be avoided; because young transplants are particularly susceptible, additional precautions such as wrapping trunks or protecting from sun may be helpful; chemical controls may occasionally be required in nursery settings

Figure 3. *Flatheaded appletree borer larva*

References: 1, 3, 9, 10, 17, 18, 20, 22, 37, 56, 58, 59, 81, 91, 98

PACIFIC FLATHEADED BORER

Chrysobothris mali Horn — Coleoptera: Buprestidae

Distribution: Occurs along West Coast into Rocky Mountain states and provinces including southern BC, AB and southern MB

Hosts: lder, birch, ash, oak, willow, poplar, elm, sycamore and over 60 other species, in over 40 genera in 21 plant families; *Populus* species not preferred and quaking aspen not commonly used

Figure 1. *Pacific flatheaded borer adult*

Identification: Adults are flattened, dark-bronze to reddish-copper beetles, 6-11 mm long, with distinct copper spots and short inconspicuous white hairs covering elytra. Eggs, about 1 mm diameter, are disk-shaped, yellowish-white, and deposited within bark crevices or depressions. Larvae vary from yellowish-white to yellow and are 15-18 mm long when mature. Thoracic segments are greatly enlarged and flattened. Larvae curve their abdomen and appear hook-like or U-shaped when exposed in feeding chambers. Pupae, 6-11 mm long, are translucent-white when first formed, then darken to bronze until adult emergence.

Life History: Adults emerge from pupation sites from April through August, but are most commonly seen in June and July. Soon after emergence, mating and egg-laying begin. Females lay up to 100 eggs, deposited singly, but may be adjacent enough to form clusters. Once hatched, larvae bore directly into bark. Larval mining tends to occur in cambium until fall when larvae tunnel into sapwood to overwinter. Before molting into last larval instar, mature larvae construct pupal chambers in tree's heartwood. Larvae overwinter as prepupae—pupating the following spring for 8-14 days. Adults emerge from pupal cells, chewing their way to the outside through a 6.3 mm oval-shaped hole. Usually, there is one generation per year; but life cycle may be longer at higher elevations and northern portions of beetles' range.

Figure 2. *Bark loosens and drops away above tunnels of Pacific flatheaded borer galleries.*

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Key:
- *Similar in most traits to flatheaded appletree borer but more common in the West*
- *Uncommon on aspen*

Damage: Quaking aspen is not commonly attacked, although Pacific flatheaded borer has a wide host range. Feeding results in unusually dark, wet spots appearing on tree's bark that may later crack slightly to expose boring chambers. White, frothy sap can ooze from bark cracks. Tunnels under bark are broad, oval-shaped, follow a very irregular pattern, and are packed with powdery boring dust and frass. Very little frass is ejected from the tree. Spiraling galleries can girdle branches or trunks of small trees. Infestations can occur over any part of a mature tree although attacks on young trees are generally limited to the larger trunk. As galleries grow, bark cracks and loosens above them. As bark drops away, ugly canker-like spots often result. Bark of infested trees may become heavily scarred. It is considered one of the most injurious enemies of newly planted trees and shrubs; young-stem girdling and branch mortality is common. However, boring activity rarely kills older trees.

Figure 3. *Bark often cracks, above tunnels of Pacific flatheaded borer galleries (on sycamore)*

Similar damage: Where species ranges overlap, type of damage and size of galleries may be very similar to other buprestid wood borers such as *Poecilonota*, *Chrysobothris, Dicerca*, and *Buprestis* species. Adult beetles may be needed to separate these damage agents. These buprestids leave oval or D-shaped holes slightly smaller than the large (~10mm wide), perfectly round holes of the cerambycid, poplar borer (*Saperda calcarata*), or the oval to irregularly shaped, large holes (9-15mm wide) of some moth borers (e.g. carpenterworms). Bronze poplar borer (*Agrilus granulates liragus*) is a much smaller buprestid with an oval or D-shaped exit hole only 3-4 mm in diameter.

Remarks:
- Field observations suggest birds remove immature stages of the borer from infested trees, and larval parasites can affect larval populations; the mite *Pyemotes bentricosus* (Newport) predates on larvae in their tunnels

References: 3, 9, 10, 18, 20, 37, 58, 59, 91, 98

POPLAR-AND-WILLOW BORER

Cryptorhynchus lapathi (L.) Coleoptera: Curculionidae
[=*Sternochetus lapathi* (L.)]

Distribution: Found throughout southern Canada and northern U.S.

Hosts: Willow preferred; *Populus* species (mainly black cottonwood, balsam poplar, and hybrid poplars) also used; quaking aspen, paper birch and alder rarely attacked in forest setting

Identification: Both male and female adults are rough-surfaced, snout-nosed weevils, about 8-10 mm long. They are mostly dull, dark brown to black, and mottled with light brown and gray scales. The hind third of their elytra are usually gray; sides of thorax and parts of legs may be whitish or pinkish. Eggs are 1.1 mm by 0.8 mm, white, found in groups of 1-4. Larvae are creamy-white, C-shaped, legless grubs with reddish-brown heads and a full-grown length of approximately 1 cm. Pupae are likely whitish and about 1 cm in length.

Figure 1. *Adult poplar-and-willow borer*

Life History: The poplar-and-willow borer can require up to 2-3 years to complete its life cycle. Oviposition takes place in summer when females make small punctures in bark, usually around the base of shoots, favoring scars, wounds, or lenticels. When the puncture is as deep as her beak can reach, the female lays 1-4 eggs in each puncture, covering them with fine wood chips. Once eggs have hatched, larvae feed under the bark then move upward into the sapwood. Larvae pupate within wood chip-filled chambers. In northern climates, both adults and larvae overwinter in galleries, but in more temperate climates adults emerge from their pupal cells in autumn and

Figure 2. *Poplar-and-willow borer larvae found in chambers constructed within young aspen stems*

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hibernate on the ground during winter. Adults are found in the trees in spring and early summer but do not lay eggs until July or August. These adults may live through two summers.

Figure 3. *Frass pushed out of chamber by poplar-and-willow borer larvae is often mixed with sap*

Damage: Larvae initially expel frass, which is found mixed with oozing sap on bark outside of holes. Later, frass is found in tunnels. Young stems, 2.5-10 cm diameter, are infested primarily around the base, and are killed by larvae mining or by breakage of weakened stems. Adult weevils may also cause injury by feeding on succulent bark of branches or main stem before mating.

The most pronounced injuries are old bark scars that are horizontal and deep, and often have right angle extensions and exposed stained wood. Stems that have been repeatedly attacked are often honeycombed with tunnels making them susceptible to decreased wood quality, breakage, and mortality. Stems in moist areas along streams and ponds are frequently attacked.

Similar Damage: Aspen root girdler (*Agrilus horni*) is the wood borer most similar in host size preference (<18 cm) and location of attack near ground. However, it is more commonly found in aspen and attacks lower on the stem, at or below soil line. The spiraling damage by aspen root girdler is diagnostic, and adults and larvae differ greatly in conformation. Poplar-and-willow borer is not likely to be confused with other insects more common in aspen stems due to its smaller larval size, smaller round exit hole, and adult/larva conformation. Callusing around entry hole and large amounts of boring dust may appear similar to poplar borer (*Saperda calcarata*). Attacks in the crown may be more difficult to differentiate from other frass-ejecting wood borers. Stem swelling resulting from poplar-and-willow borer feeding may be rougher with more frass than swellings from other gall forming insects that use young stems.

Figure 4. *Poplar-and-willow borer damage*

Key:

- *Attacks stems 2-8 cm diameter near ground line or at branch junctions*
- *Frass on ground or clinging to bark at hole entrance, often with sap oozing from bark*
- *Old bark scars that are horizontal and deep, often with extensions at right angles and stained wood*
- *Uncommon in wild stands of quaking aspen; may be common in ornamental trees*

Remarks:

- Common in ornamental aspen in northern ID
- Native to Europe and Asia, introduced into northeastern U.S. before 1882
- Weevils seldom fly and poplar-and-willow borer is no exception; if alarmed, they play dead, falling to the ground and lying motionless
- When held, adults of both sexes squeak by rubbing their abdomens with the inside of their elytra
- Adults inactive during the day if temperatures are greater than 26° C (79° F)
- Adult coloring make them look somewhat like a bird dropping

Figure 5. *Poplar-and-willow borer damage in young stem*

Figure 6. *Branch swellings and damage from poplar-and-willow borer*

References: 1, 3, 10, 12, 13, 18, 20, 35, 36, 37, 38, 50, 58, 77, 78, 84, 91, 95, 99

(A FLATHEADED BORER)

Dicerca callosa Casey — Coleoptera: Buprestidae
D. callosa callosa Casey
D. callosa frosti Nelson
[=*D. rigida* Casey; *D. tetrica* Casey; *D. frosti* Nelson]

Distribution: Subspecies *D. c. callosa* widespread throughout Canada, AK and northern portions of central and eastern U.S. while *D. c. frosti* is found throughout western U.S. and southern end of BC and AB

Hosts: *D. c. frosti* is found on aspen; *D. c. callosa* most commonly collected on quaking aspen which is its suspected host; also found on birch, willow, jack pine, and eastern white pine although these are not likely hosts

Figure 1. *Adult* Dicerca callosa callosa

Identification: Adults are robust, elongate, and moderately convex beetles. Both subspecies are bronzy to coppery-black above, and coppery below. Size averages 16.5 mm long and 6.0 mm wide, but can range from 12.3-20.7 mm long and 4.2-7.7 mm wide with *D. c. frosti* of larger average size. Likely, eggs are small, round, and off-white; larvae are cream-colored, legless, with a shape typical of buprestids (flatheaded borers), and pupae are creamy white and about the size of an adult beetle.

Life History: Little information is available on the life cycle of this beetle but *D.c. callosa* has been collected from May to September, and *D. c. frosti* from April to August.

Damage: Information on this species is lacking but it appears to be of limited impact on aspen forests. It may have habits somewhat like those of other *Dicerca* species, selecting stressed trees and contributing to introduction of pathogens.

Figure 2. *Close-up of smooth areas on pronotum of adult* Dicerca callosa callosa

Similar Damage: This woodborer is similar in size and damage to other *Dicerca*, *Chrysobothris*, *Poecilonota* and *Buprestis* buprestid wood boring beetle species but does not appear to be very common. These buprestids leave oval or D-shaped holes slightly smaller than the large

Key:

- *Difficult to differentiate from other buprestid woodborers of similar size; adults are likely necessary for species identification*

(~10mm wide), perfectly round holes of the cerambycid poplar borer (*Saperda calcarata*), or the oval to irregularly shaped, large holes (9-15 mm wide) of some moth borers (e.g. carpenterworms). Bronze poplar borer (*Agrilus granulates liragus*) is a much smaller buprestid with an oval or D-shaped exit hole only 3-4 mm in diameter.

Remarks:

References: 3, 20, 54, 70, 98, 101

WOOD & BARK BORING INSECTS

FLATHEADED POPLAR BORER
(POPLAR DICERCA)

Dicerca tenebrica (Kirby) Coleoptera: Buprestidae
[= *D. prolongata* LeConte; *D. longipennis* Casey; *D. pertinax* Casey; *D. severa* Casey; *D. subargentea* Casey; *D subcuprea* Casey, *D. sulcatula* Casey]

Distribution: Transcontinental

Hosts: Common in quaking aspen; other commonly recorded hosts include bigtooth aspen, black cottonwood, narrowleaf cottonwood, and balsam poplar; boxelder and willow listed but unlikely

Identification: Adults are robust, elongate and moderately convex beetles approximately 19.5 mm long and 6.5 mm wide (range of 14.5-26 mm long and 4.5-9 mm wide). Their elytra have small, inconspicuous, black raised areas and prolonged narrow tips. Narrow, sometimes shallow grooves (striae) run the complete length of elytra to apex. Color is brassy-to-black with a bluish tint. Underside of beetle is coppery. Eggs are small, round, and off-white. Larvae are cream-colored, legless, with a shape typical of buprestid borers. Pupae are creamy white and about the size of an adult beetle.

Figure 1. *Adult flateheaded poplar borer and its oval-shaped exit hole*

Life History: Adults are present from March to November. Females lay eggs during mid- to late-summer (July-Aug.) mostly around branch stubs and branches, and on rough bark. Sun-loving adults prefer to oviposit on trunks exposed to sunlight. Life cycle may be 2-5 years.

Damage: Larvae bore down through bark into sapwood. Tunnels are elliptical in cross section and packed with granular frass and boring dust. Adults make rather large oval openings in bark as they emerge (likely same 4.5-9 mm width of the beetle). Wounded, sickly, and recently dead trees are most likely to be attacked. Beetles are also attracted to fire-killed aspen. Beetles boring in downed logs have also been reported. Flatheaded poplar borer has been directly associated with presence of hypoxlyon canker (*Entoleuca mammata* [Wahlenb.] J.D. Rogers & Y.M. Ju) and increased decadence of poplar stands.

Key:
- *Fine granular sawdust in and around exit holes*
- *Large (maybe up to 9 mm wide), oval hole in wood and bark*
- *Difficult to differentiate from other buprestid woodborers of similar size; adults are likely necessary for species identification; common*

Similar Damage: This woodborer is similar in size and damage to several other *Dicerca, Chrysobothris*, *Poecilonota* and *Buprestis* buprestid wood boring beetle species but appears to be more common in aspen than most other species. These buprestids leave oval or D-shaped holes often slightly smaller than the large (~10mm wide), perfectly round holes of the cerambycid, poplar borer (*Saperda calcarata*), or the oval to irregularly shaped, large holes (9-15mm wide) of some moth borers (e.g. carpenterworms). Bronze poplar borer (*Agrilus granulatus liragus*) is a much smaller buprestid with an oval or D-shaped exit hole only 3-4 mm in diameter.

Figure 2. *Adult flatheaded poplar borer (right) is larger than bronze poplar borer (left)*

Remarks:
- These beetles breed in quaking aspen trees but can often be found sitting on trunks of other tree species within an aspen stand
- In CO found in conjunction with poplar borer (*Saperda calcarata*) where it will lay eggs in old poplar borer egg scars
- The species *D. divaricata* (Say) (flatheaded hardwood borer) , nearly identical in size and coloration (also found throughout U.S. and Canada), does not use quaking aspen; however, *D. callosa* Casey, a bit smaller in size, does
- *Dicerca* and *Poecilonota* adults look similar except *Dicerca* are wider, more stout, with smooth linear patches on pronotum on either side of, but not on, the centerline

References: 1, 3, 9, 10, 13, 20, 23, 37, 41, 47, 52, 54, 59, 63, 70, 94, 91, 95, 98

WESTERN POPLAR BUPRESTID

Poecilonota californica (Chamberlin) Coleoptera: Buprestidae
[=*Descarpentriesina californica* (Chamberlin)]

Distribution: In the western U.S. from OR, south to CA, east to ID, NV and TX (from West coast into Rocky Mountains)

Hosts: Quaking aspen and cottonwood recorded; other *Populus* species probably also used

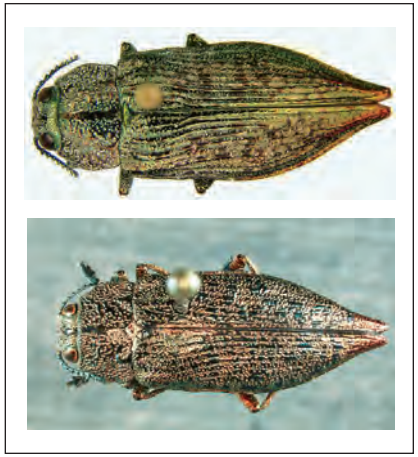

Figure 1. *Western poplar buprestid adult; note the smooth patch down centerline of pronotum*

Identification: Adults are moderately broad, robust beetles; 9-18 mm long and 4-8 mm wide. Females are typically slightly larger, more robust and darker than males. Coloring ranges from gray-brown to dark bronze to almost black. Heads are coppery green and dark coppery; antennae are blue green. Elytra are usually coppery bronze with elongate raised greenish areas. Although not described, based on similar species it is likely eggs are small, round, off-white, and laid individually in bark crevices, larvae are cream-colored, legless, with a shape typical of buprestids, and pupae are creamy white and about the size of an adult beetle.

Life History: Adults emerge during mid-summer. Larvae mine under the bark and into sapwood and heartwood extending galleries much more horizontally than vertically, sometimes venturing to the center of the tree. Frass is found packed tightly in the oval-shaped galleries. Lifecycle is likely 1-2 years.

Damage: Tree trunks and large branches may be attacked. Attacks are much more likely to be found in young trees than older ones, and at higher elevations than at lower ones. Burrowing regularly results in small patches of bark turning black and peeling away although swelling sometimes develops over tunnels. Oval exit holes are left in the bark by emerging beetles (likely the 4-8 mm width of adult beetles). Infested trees commonly remain thrifty despite the burrowing; however, small trees can be girdled. Tunneling can also result in weakening of

Key:
- *Oval exit holes 4-8 mm wide*
- *Club-like larvae, with flattened heads and thoraxes tunneling in oval shaped, frass packed chambers of younger stems*

stems so that breakage occurs at point of injury.

Similar Damage: Where species ranges overlap, type of damage and size of galleries may be very similar to other *Poecilonota* species, including the common eastern poplar buprestid (*P. cyanipes*). Also similar is damage by *Dicerca*, *Chrysobothris*, and *Buprestis* species, buprestid wood borers of similar size. Adult beetles may be needed to differentiate these damage agents. These buprestids leave oval or D-shaped holes slightly smaller than the large (~10mm wide), perfectly round holes of the cerambycid, poplar borer (*Saperda calcarata*), or the oval to irregularly shaped, large holes (9-15mm wide) of some moth borers (e.g. carpenterworms). Bronze poplar borer (*Agrilus granulatus liragus*) is a somewhat smaller buprestid with an oval or D-shaped exit hole only 3-4 mm in diameter.

Remarks:
- Western popular buprestid and other *Poecilonota* species are more narrow than *Dicerca* and *Chrysobothris* species in aspen, and have a smooth linear patch running from front to back on their pronotum; *Dicerca* species in aspen have smooth patches on either side of, but not on, the centerline

References: 14, 54, 55, 69, 91

WOOD & BARK BORING INSECTS

EASTERN POPLAR BUPRESTID
(BLUE FOOTED POPLAR BUPRESTID)

Poecilonota cyanipes (Say) Coleoptera: Buprestidae
[=*Descarpentriesina cyanipes* (Say)]

Distribution: YT south along Rocky Mountains to southern AZ, eastward along the Gulf coast, north to NB; not along Pacific Coast (*P. californica* is present along Coast, overlapping in Rocky Mountains)

Hosts: Eastern cottonwood, black cottonwood, bigtooth and quaking aspen, and willows

Figure 1. *Eastern poplar buprestid adult*

Identification: Adults are elongate to moderately slender, somewhat oval, dark bronze beetles (9-18 mm long, 3-7 mm wide). Head and pronotum are slightly flattened and have relatively little hair. Elytra are dark-bluish bronze, with abbreviated, elevated, irregular lines tinged with coppery bronze. Females are slightly broader and darker than males. Eggs are likely small, white, and laid individually in bark crevices. Larvae are yellowish-white with dark-brown heads, 17-25 mm long, and moderately flattened as is typical for buprestid larvae. Pupae are likely creamy white and nearly the size of an adult beetle.

Life History: Adults emerge from pupation sites between May and September, depending on latitude and/or elevation. On sunny days, adults are frequently found resting, crawling, and ovipositing on aspen bark. Females prefer weakened stems as oviposition sites. Larvae initially excavate small cavities just under bark, then extend galleries into sapwood. In larger stems, larvae burrow to about 12 mm deep within stem, then continue longitudinally. Larvae overwinter in their galleries. Mature larvae eventually prepare chambers in which to pupate. New adults gnaw 2-5 mm wide, oval exit holes. A generation is completed in 1-2 years.

Damage: This beetle commonly attacks stems 12-32 mm diameter, but can be found in stems up to 75 mm diameter. Galleries are oval to irregular in cross-section, 6.4 mm diameter, and extend 6-13 mm into sapwood before running 5-30 cm longitudinally within stems. Earliest evidence of infestation is small

Key:

- *Inconspicuous spot of sap on bark at entry point, sometimes developing into a round or oval sunken area, or with bark cracking to expose cavities*
- *Little or no frass ejected from galleries*
- *Frass-packed oval shaped gallery extending into wood; exit hole 2-5 mm elongate, oval*
- *Club-like shaped larvae with thoracic segments and head moderately flattened*

Figure 2. *While occasionally found in aspen boles, eastern poplar buprestid larvae are often found in smaller branches*

wet or stained spots on bark. Also, irregularly shaped scars can be found at entry points and small oval-to-round scars around oval-shaped, 2-5 mm, exit holes. Galleries are almost entirely filled with a tightly packed frass/wood mixture of fine particles and short fibers; little or none of which is ejected. Bark sometimes cracks open, exposing residue-packed cavities. Beetles usually attack branches that are weakened, injured, or decadent; sometimes using other insect exit holes and galls as access sites. Weakened lower limbs that become infested are naturally pruned; so healthy part of tree is not affected.

Similar Damage: Where species ranges overlap, type of damage and size of galleries may be very similar to other *Poecilonota* species. Also similar is damage by *Dicerca*, *Chrysobothris*, and *Buprestis* species, buprestid wood borers of similar size. Adult beetles may be needed to differentiate these damage agents. These buprestids leave oval or D-shaped holes smaller than the large (~10mm wide), perfectly round holes of the cerambycid, poplar borer (*Saperda calcarata*), or the oval to irregularly shaped, large holes (9-15 mm wide) of some moth borers (e.g. carpenterworms). Bronze poplar borer (*Agrilus granulatus liragus*) is a somewhat smaller buprestid that leaves an oval or D-shaped exit hole 3-4 mm in diameter.

Figure 3. *Multiple eastern poplar buprestid larvae in branches*

Remarks:

- Found to sometimes breed in stem galls formed by poplar gall saperda (*Saperda inornata*) on willow and bigtooth aspen; unsure if same occurs in quaking aspen
- In CO found in conjunction with poplar borer (*Saperda calcarata*) where it will lay eggs in old poplar borer egg scars
- Western popular buprestid and other *Poecilonota* species are more narrow than *Dicerca* and *Chrysobothris* species in aspen, and have a smooth linear patch running from front to back on their pronotum; *Dicerca* species in aspen have smooth patches on either side of, but not on, the centerline

Figure 4. *Bark removed to show entrance galleries of eastern poplar buprestid larvae in cottonwood branches*

References: 1, 3, 9, 10, 14, 37, 54, 52, 55, 56, 59, 58, 63, 91, 95, 98, 101

WOOD & BARK BORING INSECTS

IRON FLATHEAD

Poecilonota ferrea (Melsheimer) Coleoptera: Buprestidae
[=*Descarpentriesina ferrea* (Melsheimer)]

Distribution: From southeast BC to QU, south to FL and TX; overlaps with *P. cyanipes* but minimally with *P. californica*

Hosts: entatively described as using aspen, willow, or planted willows or poplars

Identification: Little information is available on this species, but it is likely all stages are similar to that of other *Poecilonota* species. Adults are very similar to the eastern poplar buprestid (*P. cyanipes*) but with a more angular pronotum (less sinuate at the base), a somewhat shorter elytra apex (point) and more hair on the body. Brassy-greenish elytra often look light gray due to short bristle-like hairs (more toward ends) and downy-like substance stuck in elytra punctures. Visible color may range from a dull black to a mottled iron gray with a faint tint of brown. Beetles are 13-20 mm long and 5-8 mm wide. Although not described, based on similar species it is likely eggs are small, round, off-white, and laid individually in bark crevices, larvae are cream-colored, legless, with a shape typical of buprestids, and pupae are creamy white and about the size of an adult beetle.

Figure 1. *Iron flathead adult (18 mm)*

Life History: Life history likely similar to that of other *Poecilonota* species. Flight has been noted as occurring June through August (or July through September in CA).

Damage: Has been found mining bark and wood of injured aspen and nuttal willow but actual host use is tentative. Tree trunks and large branches may be attacked. Exit hole likely to be the 5-8 mm width of adult beetles. Possible that little to no frass is ejected if it acts like eastern poplar buprestid (*P. cyanipes*).

Similar Damage: Where species' ranges overlap, type of damage and size of galleries may be very similar to other, more common *Poecilonota* species. Also similar is damage by *Dicerca*, *Chrysobothris*, and *Buprestis* species, buprestid

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Key:
- *Oval exit holes, probably 5-8 mm wide*
- *Fine frass, likely very little is ejected*
- *Club-like larvae, with flattened heads and thoraxes*

wood borers of similar size. Adult beetles may be needed to differentiate these damage agents. These buprestids leave oval or D-shaped holes slightly smaller than the large (~10mm wide), perfectly round holes of the cerambycid, poplar borer (*Saperda calcarata*), or the oval to irregularly shaped, large holes (9-15mm wide) of some moth borers (e.g. carpenterworms). Bronze poplar borer (*Agrilus granulates liragus*) is a somewhat smaller buprestid with an oval or D-shaped exit hole only 3-4 mm in diameter.

Remarks:
- This species of *Poecilonota* considered uncommon; *P. cyanipies* is more likely to be encountered

References: 9, 14, 54, 55, 91, 98, 101

POPLAR BORER

Saperda calcarata Say [=*Anaerea calcarata* Haldeman]

Coleoptera: Cerambycidae

Distribution: Found throughout most of the U.S. and Canada

Hosts: Quaking aspen preferred but uses other *Populus* species and hybrids, particularly eastern cottonwood in southern part of range; rarely uses willow

Figure 1. *Poplar borer adult*

Identification: Adults are moderately robust, elongate, longhorned beetles ranging from 20-30 mm long; females are somewhat stouter than males. Body is grayish-blue with faint yellow blotches on the elytra, all densely stippled with fine brown dots. Antennae are nearly as long as body. Eggs are creamy white and 3-4 mm long. Larvae are legless, elongate, cylindrical, yellowish-white, and up to 40 mm long or larger when mature; shape typcal of other cerambycids. Pupae are yellow-white and 20-35 mm long.

Life History: Adults emerge in summer (May-June in south; July-August in north), feeding on foliage and bark from new shoots on host trees. Mating begins shortly after emergence. Normally, individual eggs are laid in small crescent-shaped holes gnawed in bark by the female. Eggs hatch after two weeks and larvae begin feeding just under the bark where they spend their first winter. Larvae resume feeding in spring, enlarging and extending their tunnels into tree's sapwood and heartwood. Larvae can take 2-5 years to mature with life cycles shorter in the south and longer in the north. Throughout their developmental period larvae create and maintain gallery openings to the outside (unlike most other wood borers) through which they push coarse boring dust and

Figure 2. *Poplar borer larva*

WOOD & BARK BORING INSECTS

Key:

- *Presence of coarse, fibrous boring material at gallery entrance, in bark crevices, or at base of tree*
- *Oozing and reddish, shellac-like staining on bark*
- *Split bark, often heavily callused, at gallery entrance*
- *Large, round exit holes*
- *Honey combed tunnels in sapwood and heartwood*

frass. Pupation occurs in the stem from April to July, depending on location, and lasts 2-3 weeks. Adults emerge through a gallery opening.

Figure 3. *Frass/boring dust expelled out of entrance hole by poplar borer*

Damage: Considered one of the most important borers, high tree mortality has been attributed to its activity in many areas. Wet spots on trunk with oozing sap and fine boring dust on trunk are earliest signs of poplar borer presence with increased amounts of oozing, red sap and sawdust appearing as time progresses. Although attacks may occur singly, they can be clustered with new attacks often occurring on previously infested trees. Frass—fibrous-like wood shavings mixed with excrement—appear as larvae develop. Large amounts of this coarse material may be seen at tunnel entrances, in bark crevices, and in piles around base of infested trees. Bark may crack and grow rough calluses around openings. Completed galleries, 10-20 mm diameter, typically extend obliquely upward into sapwood for 5-8 cm, then straight upward for another 10-18 cm. Galleries are often crooked because they intersect or avoid galleries of other larvae. Multiple galleries create a honey-combed appearance of wood within stems.

Figure 4. *Poplar borer gallery exposed*

Although trees as small as 4 cm diameter may be attacked, most infestations occur in stems 7-18 cm diameter. Damage is more common in open stands or along stand edges owing to beetles' apparent preference for ovipositioning on trees exposed to light. Small trees are occasionally killed by larvae girdling beneath the bark, especially around root

Figure 5. *Multiple galleries and stages of poplar borer*

collar or lower stem. Large trees may be attacked on any portion of the bole and are seldom killed outright. However, multiple tunnels weaken trees structurally, causing them to break in strong winds; woodpecker feeding and opportunistic decay fungi may contribute to this weakening. Egg niches and tunnels can provide favorable infection courts for various pathogens.

Similar Damage: Other wood borers, both cerambycids and buprestids, also produce boring dust/frass mixtures and may cause brown sap flow from gallery entrance. However, such material produced by other species is usually less coarse than the shredded wood pieces created by poplar borer. Carpenter ants (*Camponotus* spp.) will produce fine, white boring dust while tunneling in holes or cavities made by this or other borers. Holes created in wood by this and other cerambycids are round compared to oval or D-shaped holes of the buprestids, or oval to irregularly shaped holes of moth borers. Holes are large (~10 mm or more in diameter) compared to other cerambycids.

Remarks:

- Active in tree trunks or large branches (if damage noted in root collar or main roots of other poplar species, especially in southeast U.S., consider *Plectrodera scalator* [Fabricius])
- Poplar borer attacks are reported to be heavier in poorly-stocked stands and open-grown trees; maintain thick stands until harvest
- Frass characteristics useful for identifying poplar borer include:
  - Mostly coarse fibrous or excelsior-like shreds (max 30 mm long by 1 mm wide but mostly less than 15 mm long) with some finely pulverized wood dust
  - Excrement pellets constitute less than 40% of ejected frass; intact excrement pellets uncommon but would be relatively short (1.5 mm long by 1.0 mm wide)
  - Frass extruded from holes in clumps or ribbon-like pieces, separate or loosely clumped; silken threads absent; yellowish-white to grayish-white in color
- Cultural practices that promote healthy trees are generally recommended; trees weakened by drought, defoliation, or poor growing conditions may be preferred although others have noted a preference for fast growing trees

References: 1, 3, 12, 8, 10, 13, 17, 18, 19, 20, 22, 25, 27, 29, 37, 50, 52, 56, 58, 59, 78, 81, 84, 87, 88, 90, 91, 95, 104, 105

Figure 6. *Poplar borer exit hole below the occupied exit hole of flatheaded poplar borer*

DUSKY CLEARWING
(POPLAR TWIG CLEARWING)

Paranthrene tabaniformis (Rottemburg) Lepidoptera: Sesiidae
[=*Sphinx tabaniformis* (Rottemburg); =*P. tricincta* (Harris) and
=*Aegeria tricincta* (Harris) as North American form]

Distribution: From NL south to FL, west to Rocky Mountain region, northwest to AK; also widespread in Europe, North Africa and Asia

Figure 1. *Adult dusky clearwing from U.S. (CO)*

Hosts: In North America, shrubby-form willows are preferred in its southern range and cottonwoods in its northern range; quaking aspen is mentioned specifically as a host in association with *Saperda* branch borer galls. In Europe, a wide range of *Populus* are noted including European aspen; alder, birch and hawthorn are also mentioned but not confirmed as hosts in North America

Identification: Adult moths are bluish-black with yellow bands on various abdominal segments (arrangement and number depending on subspecies and gender) and fuzzy tufts at the posterior end. Additional yellow spots occur on the head and legs. Forewings are opaque with reddish brown to violet-black tone; hind wings are a bit larger and bordered with dull coppery brown scales. Wingspans of males are 24-28 mm; females are slightly larger at 26-32 mm. Antennae are comb-like in males but smooth with enlarged end on females. Oval eggs are dark brown to dull black and about 0.6-1.0 mm long. Two sides are somewhat depressed and the surface has raised polygonal sculpturing. Larvae may reach 24-32 mm in length at maturity. Cream colored at maturity, their backs are marked with two brown furrows that converge toward the head. Head and jointed thoracic legs are yellowish brown, with prominent oval spiracles visible on sides of each body segment. The last abdominal segment has two brown spines. Pupae are 13-21 mm long, 4-6 mm wide, changing from light to dark brown with age, and have spines on the abdomen useful in wriggling to the bark surface before emergence.

Life History: Adults may be active from mid-April to early November, but individuals only live 8-10 days on average. Females lay 50-100 eggs on branch tips, glued singly to bark, often near damage from previous generations of dusky

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Key:

- *Swelling visible as symmetrical gall to slight swelling in 1-3 year-old stems, possibly in conjunction with damage by other gall forming stem borers, often with stem breakage*
- *Round exit hole, maybe 4-5 mm wide, with pupal case partially extruding*
- *Black, wasp-like adult moth with opaque, purplish wings, 3-4 abdominal yellow bands, yellow spots on head and legs*

clearwing larvae. Newly hatched larvae create irregular feeding chambers near the oviposition site. More mature larvae tunnel into stem pith, ejecting frass and debris from the entrance hole as galleries are extended and enlarged to a final size of about 10 cm in length (up to 15 cm). A short gallery that extends to just below the bark surface is created as the larva nears pupation. Larvae overwinter in chambers of silk and woody debris, pupating for 2-3 or more weeks in the spring before emerging through a hole in the bark surface. The pupal skin is left behind at the circular exit hole.

Figure 2. *Granular frass ejected from entry hole of larval dusky clearwing (from Hungary)*

Damage: Feeding and gallery creation causes stem swellings while tunnels weaken stems. In young (1 year) stems, swelling may create a spherical gall. In older trees, swelling may not be visible. Large infestations can cause significant growth deformation of 1-3 year old *Populus* terminals and branches, most notable in cottonwoods in the Southeast. In aspen, it has been found in northern regions using galls created by *Saperda* species where it likely contributes to breakage and death of stems and branches. Look for galls on stems and branches, stem breakage, frass expelled from entrance holes, and adult exit holes with pupal skins. No size is given for the exit hole but similar sized larvae in this genus run 4-5 mm wide which may be indicative of the minimum hole diameter that might be expected. Successive generations feeding in one location can result in large openings at points of infection. European literature also notes feeding in roots but few details are given. Life cycle is two years although in some locations in Europe a single year is more typical.

Figure 3. *Larvae of dusky clearwing feeding in stem pith (from Hungary)*

Similar Damage: Association with *Saperda* species can make differentiation difficult. However, an empty pupal skin will often be left behind in the exit hole which doesn't occur with *Saperda* or *Oberea* beetle borers. No oviposition mark is created but use of scars from other agents as oviposition sites may make it difficult to rule out its presence. Swellings caused by poplar twiggall fly (*Hexomyza schinerie*) are initiated on current-year growth (although can persist in older stems), but do not have oviposition scars and may have multiple small exit holes (<2 mm diameter) after adults have emerged. *Sesia* adults, also clearwing moths, are similar in appearance but species that use aspen apparently attack larger stems and roots.

Native *Paranthrene* species *P. dolli* (Neumoegen) (cottonwood [or poplar] clearwing borer) in eastern U.S. and Canada (pushing west to edge of Great Plains states), and *P. robiniae* (Hy. Edwards) (western poplar clearwing) west of the Rocky Mountains (pushing east into KS and ND) have similar looking adult moths that also attack *Populus* and *Salix* host species. Although not noted in aspen, they have a wide host range that would suggest aspen should not be excluded as a possible host. As such, short descriptions of both species are included.

Adults of *P. dolli* are reddish, with opaque dark brown forewings (violet or coppery reflections) and semitransparent reddish-brown hindwings. Wingspans are 30-40 mm. Adults of *P. robiniae* are yellow and black with opaque orange-brown forewings (veins may be darker) and transparent hindwings with deep yellow marks toward the outer edge. Antennae of both species are feathery in males and thread-like in females. In both species eggs are brown and oval, 1.0-1.2 mm long with sculptured surfaces; larvae are whitish, and approximately 23-32 mm long when mature. Pupae are brown and shiny; 18-20 mm long in *P. robiniae*, 20-25 mm long with two rows of spines in *P. dolli*. Life cycles are generally completed in one year for *P. dolli* and two years for *P. robiniae*.

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Damage by *P. dolli* can occur anywhere on the stem but tend to be around the base; stems may be one year or older with galls developing on stems less than 4 cm in diameter. Trunks and larger limbs of young trees are preferred by *P. robiniae* (listed as a trunk/limb borer). Entry wounds of both tend to ooze brown sap and contain granular frass expelled by excavating larvae. Larger stems with multiple attacks by *P. robiniae* have multiple entrance and exit holes, often expanded over time, and can appear galled and cankered.

Figure 4. *Pupal case left behind in exit hole when dusky clearwing emerged (from Hungary)*

Remarks:

- Three subspecies have been described across its international range *P.t. tabaniformis* (Rottemburg) (=*P.t. rhingiaeformis*), *P.t. synagiformis* (Rambur), and *P.t. kungessana* (Alpheraky); the one described for North America is *P.t. tabaniformis* [=*P. tricincta* (Harris); =*Aegeria tricincta* (Harris)]; yellow abdominal segment bands for this North American subspecies are on segments 2, 4, and 6, also on segment 7 in males
- Management recommendations include 1) maintain tree health and minimize damage (including pruning) during moth flight periods that might attract adults, 2) remove and destroy infested material - specialists suggest containing infested material in mesh with 5x5 mm openings that prevent adult moths from escaping but provide opportunities for parasitoids, and 3) some biological controls and insecticides have been used in Europe
- Desiccation of newly hatched larvae due to dry climate and difficulty in entering bark may cause up to 90% mortality

References: 1, 5, 11, 25, 55, 56, 58, 75, 78, 91, 97

POPLAR BRANCH BORER

Oberea schaumii LeConte [=*O. papleri* Chevrolat] — Coleoptera: Cerambycidae

Distribution: eastern North America west to BC, CO and TX

Hosts: Many poplar species are hosts including quaking aspen, bigtoothed aspen, Lombardy poplar, Carolina poplar, eastern cottonwood and plains cottonwood; eastern cottonwood is preferred in the south with quaking aspen preferred in the north

Identification: Adults are elongate, longhorned beetles 12-16 mm long and about 3 mm wide. High variability in coloring has led to descriptions of various species or subspecies. Head can vary in color from orange to nearly black; prothorax tends to be yellowish to orange with 4 dark, smooth spots. Elytra coloration ranges from black to brownish-yellow to yellow-orange with a covering of short, silvery hairs. The underside is often orange. Males are mostly black while females account for the lighter colors. Eggs are 2.5 mm long, yellow-white, elongate and occasionally flattened on one end. Larvae, 12-25 mm long and yellow-white, are roundheaded with dark mandibles, legless, and slender with no distinctive taper to the body. Pupae are yellow-white.

Figure 1. *Adult poplar branch borer*

Life History: Adults emerge in spring (April-June) and feed on young leaves for a few days before females lay eggs in rectangular niches gnawed in young branches or stems. Eggs hatch in two weeks, and larvae, after initially boring in cambium tissues, move towards the center of the stem and downward. They tunnel about 2.5 cm the first year, although larvae expand tunnels throughout the lifecycle with completed tunnels up to 30 cm long (17 cm average) and 4 mm wide. Initially, frass is ejected through entrance holes, later through secondary and tertiary ports (~4mm in diameter) created off the elongated central tunnel. Mature larvae eventually tunnel outward to just below the bark, first packing granular frass behind them and then fashioning loose plugs of long, fibrous frass in the upper part of the tunnel. They pupate behind the frass plug. The adult chews through the plug bark to exit. Life cycles are 1-2 years in warmer climates and 2-4 (three average) in colder areas.

WOOD & BARK BORING INSECTS

Key:

- *Elongate longhorn beetle 12-16 mm long with 4 black spots on the pronotum*
- *Swollen, crooked, or callused branches, especially in the 5-15 mm diameter class*
- *Frass protruding from entry and ejection ports (diameter ~4 mm)*

Damage: Old branches or stems 1-6 years and 5-15 mm in diameter are preferred, although stems up to 4-5 cm may be used. Preference for stands with fewer than 5,000 suckers per acre are either attractive or denser stands are avoided. Long, rectangular-shaped egg niches 5-11 mm long and 3 mm wide in the bark, usually as two parallel lines to the stems axis (top sides of branches), are the earliest sign of infestation. With time these look more like two parallel splits in the bark. Later signs of infestation include swollen or crooked branches and stems, and frass protruding from entrance and ejection ports. Callus tissue that develops around exterior openings gives stem a swollen appearance. Breakage is uncommon but happens when there are multiple tunnels in the stem. Poplar branch borer does not normally cause serious loss. However, up to a third of canker fungi in aspen have been associated with this borer. Woodpeckers excavating for beetle larvae may cause additional damage.

Figure 2. *Woodpecker holes in poplar branch borer infested stem*

Similar Damage: *Saperda inornata* (poplar-gall Saperda) and *S. populnea moesta* (poplar gall borer) also create swellings in young stems, often larger and more gall-like. Adults of these *Saperda* species are smaller (generally <12 mm), more uniformly gray, and do not have four spots on the prothorax; their egg niches are horseshoe shaped, and larvae do not construct secondary and tertiary ports for frass extraction. Their final galleries are usually shorter (up to 2.5 cm and largely within the gall). Swellings caused by poplar twiggall fly (*Hexomyza schineri*) are created on smaller twigs but can grow larger as the tree grows around them making differentiation harder; no egg niche scars are created and exit holes are smaller (<2 mm diameter).

Remarks:

- Avoid confusion with the similar species name *O. schaumii* Garnett (different author) now called *O. quadricallosa* LeConte or "western poplar branch borer". This species uses poplars and willows west of the Rocky Mountains (including Vancouver Island), although aspen does not appear to be a recorded host. Adults are similar in coloration and


Figure 3. *Possible entrance hole (A) and gallery (B) of poplar branch borer*

size (8-14 mm long) but are separated by *O. quadricallosa* having more grayish brown elytra with only a narrow basal band of yellow, head and scutellum are always black, and the basal spots on the pronotum are larger. Also avoid confusion with *O. schaumi* Linsley & Chemsak (one "i" and different author) which has been renamed in part as *O. pruinosa* Casey and part as *O. caseyi* Plavilstshikov, both found in eastern North America; *O. pruinosa* on *Populus deltoides*.

- The "poplar twig borer", *O. delongi* Knull, also attacks *Populus* species but in not noted in aspen and is found in northeastern U.S.; similar in size to *O. schaumii* and *O. quadricallosa* at 7-14 mm long, *O. delongi* differs in 1) four spots on the pronotum lacking, 2) coloration mostly black with some yellow along outer margin of elytra; head, prothorax, and underside of body can range from yellowish to black, 3) legs yellow, and 4) may use smaller material [if 1.2-5.0 cm diameter look for *O.schaumii*; if less than 1.2 mm look for *O.delongi*]
- Frass characteristics of *O. schuamii* and *O. delongii* described as pale yellow to light brown with excrement pellets <40% of frass ejected and rarely intact; primarily finely pulverized wood, some fibrous or excelsior-like shreds, usually extruded in tight clumps; silken threads absent; gallery entrance usually plugged (sometimes tightly) with frass
- In plantation or nursery settings, removal and destruction of infested branches or stems, or use of insecticides intended for wood borers can reduce infestation levels; natural controls (parasites, woodpeckers, unidentified diseases) destroy up to 98% of some populations)


Figure 4. *Adult* Oberea quadricallosa *(top) and* O. delongi *(bottom)*

References: 1, 3, 10, 17, 18, 37, 42, 44, 51, 56, 58, 59, 67, 72, 78, 80, 90, 91

WOOD & BARK BORING INSECTS

POPLAR GALL SAPERDA
(WILLOW GALL SAPERDA)

Saperda inornata (Say) Coleoptera: Cerambycidae
[=*S. concolor* LeConte; =*S. concolor unicolor* Felt & Joutel; =*S. mecasoides* Casey]

Distribution: From northern MB and SK, east to southern ON and QU, south to CO, AZ, TX to southern IL; in its Southeast range (AZ, NM, TX), much of the literature on *S. inornata* is under *S. concolor* LeConte (willow gall saperda)

Hosts: Several species in *Populus* and *Salix* (willow) are hosts; willow appears to be a preferred host in some areas with quaking aspen favored in north central U.S.; susceptibility of quaking aspen to damage varies by clone

Figure 1. *Adult poplar gall saperda (on a hybrid poplar leaf)*

Identification: Adults are 8-13 mm long, black, longhorn beetles, covered with dense hairs which makes them appear dark gray. Antennae also have hairs and are slightly shorter than the body. Eggs are creamy white, elongate, sometimes flattened on one end and 2.5 mm long. In early summer horseshoe-shaped egg niches are visible, often in a ring around the stem. Mature larvae are 10-16 mm long, white, slender and smooth or shiny with sparse white hairs. Pupae are shaped like adults, white and 8-13 mm long.

Life History: Adults emerge in early summer (mid-May to July) and feed on edges of leaves or leaf midribs, and on outer tissues of new shoots or twigs. Female beetles cut a horseshoe- or shield-shaped slit in the soft bark (3mm wide with open end up) into which one egg is laid. Usually 2-3 but up to nine of these oviposition sites may be created in a ring around the stem. Eggs hatch in 12-15 days with young larvae feeding in necrotic tissue that develops around the oviposition site.

As larvae mature, feeding creates flat, irregular galleries, extending in one direction around the stem; reaching halfway around on large stems, further on smaller stems. Galleries are kept clean with frass ejected from holes gnawed near the oviposition site. In response to oviposition and feeding damage, the tree creates callous tissue resulting in a gall; look for these as early as late June. Toward end of the first summer, larvae bore a round or oval hole into the center

Key:

- *Dark gray beetle, without spots, 8-13mm long*
- *Shield or horseshoe-shaped scar where eggs laid*
- *Spherical, scabby galls on 5-15mm diameter stems and branches; callous tissue present where feeding has occurred just under bark, bark sometimes sloughing off to expose black feeding scars*
- *Broken branch stubs at a gall or dead branches above a gall, with larval gallery 2-4 cm long running lengthwise up and down center of stem*
- *White larvae or pupae in woody tissue inside gall; galls with one 3-4 mm diameter exit hole gnawed in the side will be empty*

Figure 2. *U- or shield-shaped oviposition scar made by poplar gall saperda*

of stem, then upward or downward along the stem's axis. This central gallery is expanded as larvae develop but appears to reach about 2.5 cm long in aspen (2-4 cm); lengths of over 11 cm have been noted in willow.

Before pupating and overwintering, larvae pack their feeding gallery and the first 1/3 of their central gallery with frass. At the far end of their central gallery, larvae chew a portion of their future exit tunnel. High mortality of early stage larvae result in few (often one) larvae pupating and overwintering in a gall, each in their own, non-intersecting gallery. Adults emerge from a 3-4 mm round to oval shaped hole bored in the side of the gall. Life cycles last 1-3 years depending on climate and timing of oviposition with one year more common in the south and two years in the north.

Damage: Suckers (3-15 mm in diameter) and 1-3 to 5 year old trees are most susceptible, although stems 5 cm in diameter or larger may be used. As young larvae begin feeding in the phloem, the aspen forms callus tissue around the site creating a warty or scabby globose or spindle-like gall up to twice stem diameter, sometimes more swollen along one side. Oviposition scars are U-shaped, visible for several years as the outer bark sloughs off creating dark brown, half-moon shaped scabby patches. Stems and branches sometimes die or break off at the gall; if not, tree can overgrow the gall. Galls also can often provide an entry point for *Hypoxylon* canker (*Entoleuca mammata*), *Cytospora* (*Valsa sordida* Nitschke [= *Cytospora chrysosperma* (pers.) Fr.]), and other canker fungi. Girdling of the main stem or branches results in lost growth, although trees can recover height growth in 2-3 years. Damage to young trees can reduce overall reproduction levels in well-stocked stands. However, attacks rarely result in significant mortality.

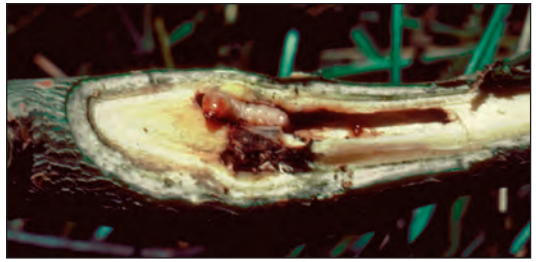

Figure 3. *Poplar gall saperda adult, larva and gallery*

WOOD & BARK BORING INSECTS

Figure 4. *Gall-like swellings from poplar gall saperda*

Similar Damage: Gall-like or callus swellings created by *Saperda populnea* are very similar but may be smoother looking**.** Poplar branch borer (*Oberea schaumii*) caused swellings are less gall-like, egg niches are elongate rectangles rather than U-shaped, several additional holes created to eject frass may be present, and feeding is more parallel to the stem with a longer (>2.5 cm) central tunnel when completed. Swellings caused by poplar twiggall fly (*Hexomyza schineri*) are generally on smaller, current-growth stems with several small holes; however, old galls may enlarge as tree grows. In addition, no egg oviposition scars are present.

Remarks

- In nurseries management techniques include maintaining vigorous stands, sanitation through removing and destroying infested branches and trees, and chemical; older stands rarely need treatment
- *S. inornata* attacks increased with stand density up to 3500 stems per acre then leveled off (no decreased attacks with increased density as with *O. schaumii*)
- Eastern poplar buprestid (*Poecilonota cyanipes*) and dusky clearwing (*Paranthrene tabaniformis*) may use stem galls formed by *S. inornata*
- *S. inornata* Say is not synonymous with *Mecas inornata* Townsend (now *M. confusa* Chemsak & Lindsley) or *M. inornata* Packard (now *M. cana saturnine* [LeConte]); as far as is currently known, *Mecas* species do not make galls

References: 1, 3, 10, 18, 20, 37, 43, 44, 45, 58, 66, 67, 72, 78, 91, 102

SMALL POPLAR BORER
(POPLAR GALL BORER)

Saperda populnea (L.) Coleoptera: Cerambycidae

Three subspecies are recognized by some:

S. p. moesta LeConte EASTERN GALL SAPERDA
S. p. populnea (L.)
S. p. tulari Felt & Joutel WESTERN GALL SAPERDA

Distribution: Of the three subspecies, only *S.p. moesta* and *S.p. tulari* are listed as being in the West with the first ranging across southern Canada and northern U.S. from the east coast to the Rocky Mountains, and the latter ranging along the West Coast from BC south into CA, east to AZ

Hosts: All subspecies are noted as attacking *Populus* species but only *S.p. moesta* has been noted specifically in aspen with balsam poplar as the principal host; *S.p. tulari* is mentioned from black cottonwood specifically

Figure 1. *Small poplar borer adult*

Identification: Adults are black-bodied, slender longhorned beetles 9.5 mm long and 2.7 mm wide. Adults appear gray colored due to uniform gray (*S.p. moesta*) to reddish gray (*S.p. tulari*) hairs, mostly concentrated in patches on each side of the pronotum. Each tapered, rounded elytra has 4-5 round punctures filled with golden-yellow hair although these golden dots are not obvious on the male (per European literature). Female antennae are shorter than the body; male antennae are longer. Prothorax is not spined but two yellow bands may be visible along the sides. Eggs are oval, approximately 2.4mm long and 0.7mm wide, with a curved middle and somewhat pointed end. Mature larvae are 11 mm long, legless, smooth, shiny cream-yellow, with some fine long whitish hairs. Heads are small and reddish brown in front, pale behind, with a pale streak along the top running front to back. Pale yellow pupae (12.5 mm long) have a few short spines on back side of the abdomen.

Life History: Adults emerge from round exit holes about 3 mm in diameter in early summer to mid-summer. After feeding on foliage and tender bark of twigs, females deposit eggs (about 50) singly in slits cut in the bark. Larvae initially mine under the bark around the twig; later, they bore into the wood, forming short (~3cm) frass-packed galleries parallel to the twig axis. Larvae overwinter in the gall. Its one-year life cycle is completed when larvae pupate the following spring.

WOOD & BARK BORING INSECTS

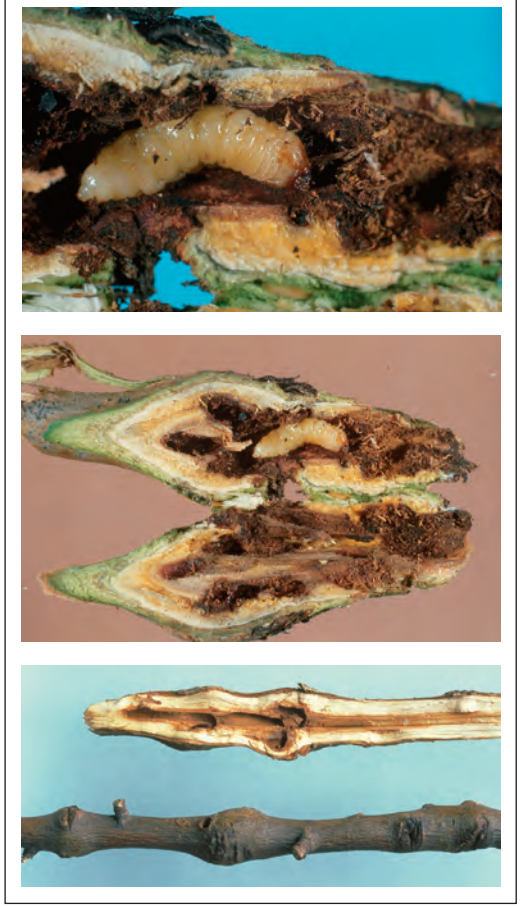

Figure 2. *Small poplar borer larvae typically located in twigs, small branches or young stems*

Damage: Galls are found mostly on twigs, branches, or stems three years or younger, but can occur on trees of any age; in Europe and Asia, young main stems are preferred with 97% of attacks found on stems 5-11 mm diameter. Adults like open forest or forest edges so trees in these conditions and branches in upper crowns are more susceptible. U-shaped oviposition scars, and gall-like or callus swellings are the most easily detected indicators of infestation. Galls are smooth and spindle-shaped in appearance, slightly flattened, and ~30 mm long and up to 19 mm wide. Formation of the gall can alter the oviposition scar from U-shaped to a narrow slit at an oblique angle. Galleries (up to 25 mm long) are mostly filled with yellowish-orange frass. Exit holes are circular with a diameter of 2.4-4.2 mm. Branches that become weakened at swelling points can break during high winds. Trees survive since infections are localized, although significant, repeated attacks can stunt growth or cause mortality of young stems. *Hypoxylon* canker (*Entoleuca mammata*) is often established in the infected twigs.

Similar Damage: Similar gall-like or callus swellings appear on poplar gall *Saperda* (*S. inornata*) infected stems and branches but small poplar borer galls may look smoother. Unlike *S. inornata*, small poplar borer larval activity is confined within the gall and stem breakage is more likely due to the generally smaller stems it infests. Poplar branch borer (*Oberea schaumii*) produces stem swellings that are not as gall-like and may have several exit ports (about 4

Key:

- *Smooth, spindle-shaped galls or callus swellings on new twigs, small branches or young stems.*
- *U-shaped oviposition scars that may change to a narrow slit at an oblique angle as gall swells*
- *All boring activity confined within the gall; galleries up to 25 mm long mostly filled with yellowish orange frass*
- *Circular exit holes 2.4-4.2 mm in diameter*

mm diameter) used for frass removal; oviposition scars are rectangular versus U-shaped. Swellings caused by poplar twiggall fly (*Hexomyza schineri*) are created on smaller twigs but can grow larger as the tree grows around them making differentiation harder; no egg niche scars are created and multiple small holes (<2 mm diameter) are probable.

Figure 3. *Smooth ovoid swellings of small poplar borer showing oviposition scars (left and center) and exit hole (right) (examples from Europe)*

Remarks:

- Several fungi have been used with success as biological control agents against small poplar borer for localized outbreaks in high value stands in Europe and Asia

References: 10, 11, 25, 37, 56, 58, 59, 91, 102

WOOD & BARK BORING INSECTS

POPLAR TWIGGALL FLY

Hexomyza schineri (Giraud) Diptera: Agromyzidae
[=*Agromyza schineri* Giraud; =*Melanagromyza schineri* (Giraud)]

Distribution: Noted in the Rocky Mountain and Midwest regions of the U.S. with possible expanding range

Hosts: Best known for serious galling on quaking aspen but will also use some other *Populus* species

Figure 1. *Adult poplar twiggall fly*

Identification: Adults are stout-bodied, shiny dark flies, about 2-3 mm long. Eggs are not described but are injected into the stem. Larvae are small, pale yellow-green maggots found within galls. Pupae are greenish with a darkened head area and 2-3 mm in length like adults.

Life History: Poplar twiggall fly overwinters within a gall as a mature, yellow-green maggot. Pupation occurs in late winter or early spring. Most pupae work their way out of galls in March and early April, and drop to the ground leaving small round exit holes less than 2 mm wide. Some pupae, however, may remain in the gall. As new shoot and branch growth is starting in spring, adult flies emerge and become active. During daylight hours, they can be found sunning themselves on leaves. After mating, females move to developing twigs and insert eggs into stems. After maggots hatch, and in response

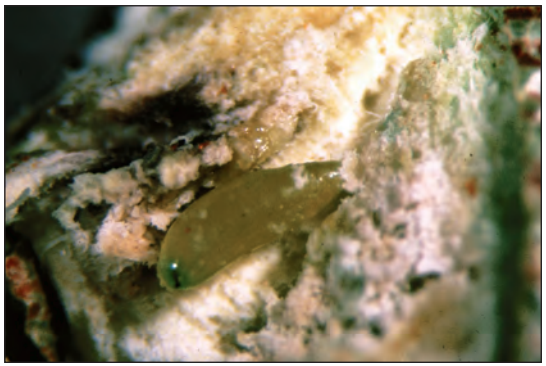

Figure 2. *Poplar twiggall fly larva exposed on gall*

Key:

- *Smooth knot-like gall on twigs of aspen*
- *Small, green-yellow maggots inside of gall or small holes in older galls*

Figure 3. *Early swelling symptom of poplar twiggall fly and adult leaf damage*

to their feeding activity, distinctive twig swellings begin. At first, swelling involves a fairly indistinct enlargement. However, within two months a full-size gall is usually present. Developing maggots grow slowly within galls during summer, and are difficult to find until late summer when growth becomes more rapid. Soon, 1-3 larvae will fill a small cavity (gall) within swollen area of twig. In early spring, larvae tunnel towards the surface of the gall leaving a thin flap of bark (operculum) covering the tunnel. Pupae work out through a small hole in the gall, falling to the ground. Adults later emerge coincident with the development of new growth. There is typically one generation per year, but unusually warm seasons may produce a second generation.

Damage: Poplar twiggall flies produce smooth, spherical gall swellings (average 13 mm long and 8.5 mm wide) on current-season, elongating twigs. Areas below buds appear to be favored sites for galls and there may be multiple galls on one twig. These galls remain in place and continue to grow and enlarge even after maggots are gone. Galls persist, become incorporated into growing twigs and branches, ultimately resulting in large swollen bands on trunks and branches that produce a gnarled and knobby appearance. While bud growth adjacent to galls is inhibited, galls do not appear to significantly weaken plants. Occasionally, *Cytospora* canker may develop around a gall, likely using the exit hole wound for entry.

Figure 4. *Branch nodes are preferred oviposition sites for poplar twiggall fly*

WOOD & BARK BORING INSECTS

Figure 5. *Pupae of poplar twiggall fly emerging from galls*

Similar Damage: Poplar gall saperda (*Saperda inornata*), poplar gall borer (*S. populnea*), and poplar branch borer (*Oberea schaumii*) also cause galls on young stems. However, branches they select are slightly larger, oviposition scars are often visible, and exit holes are larger.

Remarks:

- Some genetic variation in resistance by trees to twiggall fly is apparent
- One of the few species of Agromyzidae leaf miners that do not mine leaves; although it forms galls it is not a true gall midge
- A small wasp, *Eurytoma contractura*, parasitizes and commonly kills large numbers of poplar twiggall fly maggots; predation of pupae by chickadees and other birds also occurs
- Control with chemical has had poor results, as has trapping
- Has become a common pest of ornamental trees in some areas

References: 13, 18, 20, 21, 30, 54, 55, 58, 95

Figure 6. *Old twiggall fly injury incorporated into new wood as tree grows*

WILLOW SHOOT SAWFLY

Janus abbreviatus (Say) Hymenoptera: Cephidae

Distribution: Considered an eastern species it ranges across southern Canada from NB to AB; in east and central U.S. from ME to MN and SD, south to VA, AR and MS; however, also was noted in OR

Hosts: Preferred host is black willow with quaking aspen rare except perhaps MN; other recorded hosts include other willows, eastern cottonwood, balsam and black poplar, and bigtooth aspen

Figure 1. *Willow shoot sawfly larvae and frass in central tunnel of young stem*

Identification: Adults are delicate, wasp-like sawflies 7-10 mm long and brown in color. Translucent wings span 10-12 mm in males and 12-16 mm in females. Head and thorax are glossy black with small white to yellow markings. Female abdomens are black with body segments 2-3 (sometimes 4) red to reddish brown; in males, only the underside is colored. Female abdomens are flattened vertically and have a sharp saw-like ovipositor (looks like a stinger). Eggs are translucent to whitish, oval to elongate, and 0.8-1.0 mm long and 0.3-0.5 mm wide. Larvae are white, except for pale yellow head, brownish mandibles, and a short, round, brown prong at the tip of the abdomen. Cylindrical larvae are normally S-shaped and 8-11 mm long when fully grown. Thoracic legs are short, fleshy, without claws, and abdominal prolegs typical of sawflies are absent. Pupae are 8-10 mm long, white initially but darkening with maturity, and enclosed in a brownish, partially transparent cocoon.

Life History: Flight of willow shoot sawfly varies with the number of generations; the first flight likely timed with the period of shoot elongation in its host trees.

WOOD & BARK BORING INSECTS

Key:

- *Wilted terminal or lateral leaders with a ring of small punctures ringing the tender shoot*
- *Dead or stunted stems with hollow, frass filled tunnels and round 1.5-2.5 mm diameter exit holes*
- *Whitish, S-shaped larvae or brownish, partly-transparent cocoons within tunnels*

The female girdles new shoots with a series of 5-16 punctures made with its ovipositor. She then lays one or two eggs in additional punctures made below the girdle. The shoot wilts quickly in response to the circle of punctures and within a few days leaves will turn black. Upon hatching the larva tunnels and feeds toward the girdle for a few millimeters, then turns downward and tunnels for 7-10 cm - often the entire length of the shoot. As it feeds, frass is packed into older parts of the tunnel. Each tunnel is occupied by a single larva. When fully grown, larvae chew a short passage into the wall of the tunnel toward the outer bark, leaving intact a thin layer of bark to hide the opening. This point will later become the adult sawfly's exit hole. Prior to emerging from the 1.5-2.5 mm diameter hole, the thin layer of bark may appear as a dark, round circle. Within the tunnel, larvae construct a thin, slightly membranous cocoon in which they overwinter. They pupate and emerge as adults in spring or early summer. There is one generation per year in the northern range with up to three generations in southeastern states.

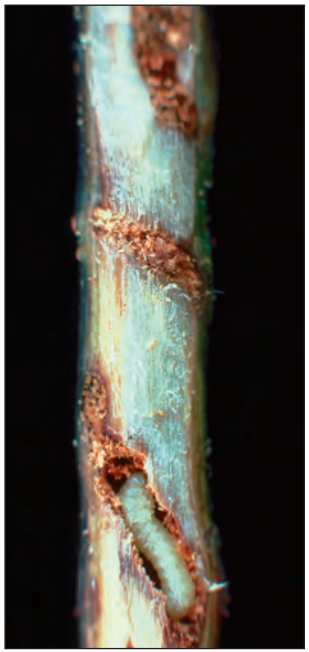

Figure 2. *The spiral girdling of a stem by a willow shoot sawfly with frass packed in the tunnel*

Figure 3. *Round exit hole of willow shoot sawfly*

Damage: The earliest evidence of injury is a wilting and shepherd's crook-like drooping of terminals above the circle of oviposition punctures. Larvae tunneling will also kill the remaining branch tip. Winds can snap the weakened shoots. Bush-like growth often occurs below dead shoot tips.

Similar Damage: The shepherd's crook-like wilting separates this borer from others that attack small shoots and branches. Larvae of willow shoot sawfly also have prolegs that are lacking in larvae of other insects creating similar damage. The fungus *Venturia macularis* (Fr.) E. Mull & Arx (shepherd's crook) may create similar wilting but without signs of perforations or boring in the stem.

Figure 4. *Willow shoot sawfly can cause shoot dieback that takes on a shepherd's crook appearance*

Remarks:

- Natural mortality is high due to fall/winter desiccation (especially in smaller, less vigorous shoots), and to natural parasitoids
- Management is limited although removal and destruction of infested branches can lower population levels

References: 1, 2, 3, 10, 13, 17, 25, 58, 78, 91, 93, 95

WOOD & BARK BORING INSECTS

[AN ASPEN BARK BEETLE]

Procryphalus mucronatus (LeConte) Coleoptera: Scolytidae

Distribution: From AK to east NV, MT, ID, CO and NM

Hosts: Only known from quaking aspen

Identification: Adult beetles are dark brown to black and about 2.2 mm long (1.8-2.2 mm) with identifying features visible under a microscope. Eggs are approximately 0.4 mm wide and 0.7 mm long, translucent white ovals with a sticky surface. Cream-colored larvae are legless. Pupae are likely cream colored and the size of adult beetles.

Life History: The female *P. mucronatus* initiates gallery construction and is soon joined by a male who will work to maintain sole access to her. Following gallery construction and mating a series of eggs are deposited along the gallery walls – perhaps no more than 14 eggs total. After a period of more than three weeks new larvae begin feeding on phloem tissues in both the main gallery and galleries they excavate into dead phloem tissue. Larval development time is about 60 days or longer when overwintering; *P. mucronatus* can overwinter as larvae, pupae, or pre-emergent adults. With this asynchronous life cycle, emerging adults may begin attacks as early as late April that continue through summer. Likely 1.5 to 2 generations are produced annually.

Figure 1: *Adult* Procryphalus mucronatus *beetle and close-up of antennal club*

Damage: *Procryphalus mucronatus* is found on dead, often fermenting, bark of stressed or dying quaking aspen. The attack accelerates decomposition of the dead parts of the tree without accelerating tree death itself. Sunny sides of tree boles and larger limbs may be preferred, the increased heat possibly accelerating beetle development and phloem decomposition.

Galleries have entrance holes nearly perpendicular to bark surface that tend to become plugged with frass as beetles extend their tunnels. Egg galleries

Key:

- *Entrance holes on dead bark 0.8–1.0 mm in diameter and perpendicular to bark surface; may be plugged with frass*
- *Galleries somewhat deep into the bark, up to 7 mm from bark surface*
- *Oxidized tissue dark but not black on larval gallery walls*
- *Bark above galleries not normally cracked*
- *Sunny sides of tree boles and larger limbs preferred*

Figure 2. Procryphalus mucronatus *galleries in bark of weakened aspen tree*

are 1-3 mm wide and around 14 mm long and look more tunnel- than cave-like. They may be straight or crooked, branched or un-branched, trend upward, are largely free of frass and are not stained black. Eggs are laid randomly along tunnel walls with larvae feeding in and widening this main gallery. Short tunnels created by older larvae often end in a pupal chamber 0.25 mm wide. Bark above these tunnels does not usually crack after beetle emergence.

Similar Damage: *Trypophloeus populi* (Hopkins) and *T. thacheri* (Wood) are two other small bark beetles attacking quaking aspen in the West. *Trypophloeus populi* differs from *P. mucronatus* in its later emergence and attack date, its use of healthier trees and live bark, its shallower, wider egg galleries with black-stained larval tunnels, clustered egg deposition, and tendency of bark to split over gallery areas. Little is known about *T. thacheri* although its biology is likely similar. These species of beetles are difficult to differentiate in the field due to their small size, but can be distinguished with the use of a microscope (see remarks below).

Remarks:

- Morphological differences between *T. populi* and *P. mucronatus* include (respectively): 5 versus 4 segmented antennae funnicle; pointed-oval versus elongate-oval antennal club; 3 straight antennal club sutures versus 2-3 procurved sutures (the 1st septate); pronotum with setae over entire surface versus anterior portion only; also *P. mucronatus*'s pronotum has a distinct raised line (rounded) on basal and lateral margins.

References: 46, 54, 64, 65, 82, 86, 103, 104

WOOD & BARK BORING INSECTS

[AN ASPEN BARK BEETLE]

Trypophloeus populi Hopkins — Coleoptera: Scolytidae

Distribution: Samples identified from MT, ID, UT, CO, NV, AZ, SK, MB, and NB

Hosts: Also found in lanceleaf, narrowleaf, and black cottonwoods

Identification*: Trypophloeus populi* adults are dark brown to black beetles between 1.7 and 2.1 mm in length, small enough to require a microscope for species identification. Eggs laid under bark are translucent white colored, oblong, approximately 0.3 mm wide and 0.6 mm long with slightly sticky surfaces. Larvae are legless and initially white, turning brownish after feeding on the dark phloem. Pupae are likely cream colored and the size of adult beetles.

Figure 1: *Adult* Trypophloeus populi *beetle (left) and close-up of antennal club (right)*

Life History: Attack is initiated by the female beetle, usually in July. Males are quickly attracted to these attacks suggesting existence of pheromones in the mass attack process. Females are often watched over by a single male who prevents entry of rival males and possibly predators to the cave-like main egg gallery. Females lay 10-25 eggs, most in a single cluster, within this gallery, although smaller groups or individual eggs may be laid on other parts of this irregularly shaped chamber. In approximately three weeks eggs begin to hatch. Larvae feed outward into unused phloem, overwintering as larvae before pupating the following spring. Adults emerge during mid-summer and into fall. In some cases 1.5 generations may be completed in a year; larva is still the most common overwintering stage.

Key:

- *Entry holes 0.8–1.0 mm diameter on live, smooth green bark, especially of stems 30-50 cm in diameter*
- *Oddly shaped, cave-like, shallow galleries just under bark surrounded by areas of lightly brown-stained bark about 2–4 cm in diameter*
- *Black staining on walls of larval galleries*
- *Cracked bark above galleries, numerous exit holes, and browning leaves later in the season*

Figure 2: *Entrance and exit holes of* Trypophloeus populi

Damage: Attacks are made in smooth, green bark of standing trees and can hasten decline and mortality of stressed trees; occasionally broken limbs may be used. Stands of 30-50 cm diameter trees, especially those infected with *Ganoderma* root and butt rot (*Ganoderma applanatum* [Pers.] Pat.), have shown high incidence of attack, although smaller material may be used. Unhealthy or diseased trees are preferred. Shortly after attack, infested trees show signs of smaller leaf size and yellowish coloring; 3-10 weeks later crowns turn brown. In addition to multiple 0.8-1.0 mm wide entrance/exit holes, 2-4 cm diameter bark patches may turn light brown, often cracking above the primary gallery as it desiccates.

Attacked trees are often infested over all suitable bole and branch surfaces. Entrance galleries angle inward and upward, running about 2.5 mm in length, and ending in a primary egg chamber where most eggs are laid. The female may then create a feeding gallery approximately 1 cm long, frass packed, and radiating out from the main chamber. At the gallery end she may excavate a secondary chamber where she lays more eggs, dies and/or exits. Larval galleries 26-42 mm long radiate from where eggs were laid. These galleries are packed with dark frass and stained brownish-black with a symbiotic fungi. In later stages the necrosis associated with the gallery often results in dense patches of dead cambium.

Similar Damage: *Procryphalus mucronatus* is another very small bark beetle attacking quaking aspen in the West. However, *P. mucronatus* tends to feed on already-dead bark patches, sometimes attacking trees several weeks after *T. populi*. *Procryphalus mucronatus* can overwinter as pupae or adult as well as larvae, and emerges earlier.

WOOD & BARK BORING INSECTS

Figure 3: *Galleries of* Trypophloeus populi

Galleries of *P. mucronatus* are further below the bark surface with individual eggs laid apart from each other rather than in cluster. Bark over *P. mucronatus* galleries does not split, and staining along galleries is not as apparent.

Three additional species of *Trypophleous* are identified in North America, two that attack elms and willow and another, *T. thatcheri* (Wood) recorded from quaking aspen and black cottonwood. Adult beetles of *T. thatcheri* are also black but slightly smaller (1.5-1.9 mm) and distributed from BC to CA; biology is likely same as *T. populi*. These species of beetles are difficult to differentiate in the field due to their small size, but can be distinguished with the use of a microscope (see remarks below).

Remarks:

- Morphological differences between *T. populi* and *P. mucronatus* include (respectively): 5 versus 4 segmented antennae funnicle; elongated, pointed oval versus more circular, flattened oval antennal club; 3 straight antennal club sutures versus 2-3 procurved sutures (the 1st septate); pronotum with setae over entire surface versus anterior portion only; also *P. mucronatus*'s pronotum has a distinct raised line (rounded) on basal and lateral margins
- *T. populi* was associated with the 2005-2009 sudden aspen decline in CO and UT

References: 54, 64, 65, 82, 86, 103, 104

POPLAR AMBROSIA BEETLE

Trypodendron retusum (LeConte) Coleoptera: Scolytidae

Distribution: From AK to NB, south through CA, NM and WV

Other Hosts: Quaking aspen, bigtooth aspen and eastern cottonwood; may attack paper birch but doesn't reproduce in it

Identification: Adult poplar ambrosia beetles are 3.6-4.6 mm long and stubby looking. Coloration is uniformly shiny dark brown to black when mature but when young, elytra may appear light brown with pale yellowish-brown patches running front to back through the center of each wing cover. Curved, white, legless larvae are 3.6-5.0 mm long. Eggs and pupae are not described but are likely white or cream colored, with pupae the size of adult beetles.

Figure 1. *Young poplar ambrosia beetle*

Life History: Female beetles initiate attack with mating taking place either on the bark surface or at tunnel entrance. Initially, female excavates a main tunnel 2.6-5.5 cm into the sapwood. She then angles off to make a peripheral, horizontal gallery following a sapwood ring; 2-5 (average of 3) such peripheral galleries are constructed. Toward the end of these peripheral tunnels 2-7 very short, horizontal galleries (cradles) are created (up and down within the sapwood ring). A single egg is oviposited in a cradle and surrounded with boring material. Beetles are monogamous with the female excavating tunnels and the male near the entrance hole removing boring dust and frass. Females also inoculate tunnels with ambrosia fungus from a special gland (mycangia). Gallery systems are usually created and used by one pair of beetles; if additional mated pairs are present they use separate gallery branches.

Larvae hatch within a week, feeding on fungus and enlarging cradles until they are slightly bigger than the size of an adult beetle. After 3-4 weeks pupation occurs and lasts for just over a week. In mid-summer (July) new adults collect fungus spores and emerge from the tunnels. By early fall, adults move to forest litter to overwinter. Overwintered beetles emerge and become active again in early spring. A one-year life cycle is typical.

WOOD & BARK BORING INSECTS

Key:

- *Fine texture boring dust and frass – off-white - on bark around small entrance holes or at base of tree; usually origination from dead or nearly dead wood*
- *Small horizontal galleries and vertical chambers surrounded by a dark brown or black stain*

Figure 2. *Entry hole of poplar ambrosia beetle in recently killed stem*

Damage: Poplar ambrosia beetles are attracted to dying or newly dead aspen snags, stumps and logs so are not important in causing tree mortality. Ambrosia beetle larvae feed exclusively on symbiotic fungi (e.g. *Ambrosiella ferruginea* [L.R. Batra]) introduced by the female. The fungus produces a dark brown or black stain which lines the tunnels.

Similar Damage: The small, round dark brown or black stained tunnels that run several centimeters deep into sapwood are unique. Adult aspen bark beetles (*Procryphalus* and *Trypophloeus* species) are significantly smaller beetles that feed in bark and phloem rather than sapwood.

Figure 3. *Poplar ambrosia beetle's stained, horizontal tunnel with secondary lateral chambers (cradles)*

Remarks:

- *Ptilinus basalis* LeConte also uses dead wood of aspen and other hardwoods. Adults are 3.0-5.5 mm long, chestnut brown with short yellowish hairs, cylindrical in shape. Males are smaller than females and have comb-like rather than serrated antennae. Found from BC to CA, into UT. It uses dead and cured wood, damaging stored hardwoods used for crafts, furniture, siding, etc.
- At least one species of Anobiidae has been found using dead, dry quaking aspen. The female creates a short tunnel, lays eggs, then dies, plugging the entrance hole with her abdomen sticking out. The larvae hatch, excavating long, winding, frass packed tunnels. Symbiotic microbs help generate nutrients needed to survive.

Figure 4. Ptilinus basalis *male adult*

References: 7, 37, 46, 91, 98, 103

EPIDERMAL BARK-MINING INSECTS

[a bark-mining fly] Diptera: Agromyzidae
possibly *Phytobia* sp.

[bark-feeding micro-moths] Lepidoptera:Tortricidae/Olethreutidae
Cydia populana (Busck)
[=*Laspeyresia populana* Busck]
Marmata spp.

Although not of economic significance, several forms of unidentified bark feeding and mining have been noted. Most common is a spider-like bark etching, but feeding just under the bark with frass visible has also been found. The agent responsible for the spider-like mining has not been identified but may be a fly species; *Phytobia* is one genus with species that feed under bark in the cambium of trees. *Cydia populana* has been noted as feeding on aspen bark but the damage has not been described. The following are details on some of the damages found and possible species responsible.

Figure 1: *Close-up of superficial damage of an epidermal bark-mining insect (fresh top left, recently dried bottom left, and old scars right)*

WOOD & BARK BORING INSECTS

Key:

- *Superficial etching into bark surface*
- *Fine frass not associated with wood borers or bark beetles*

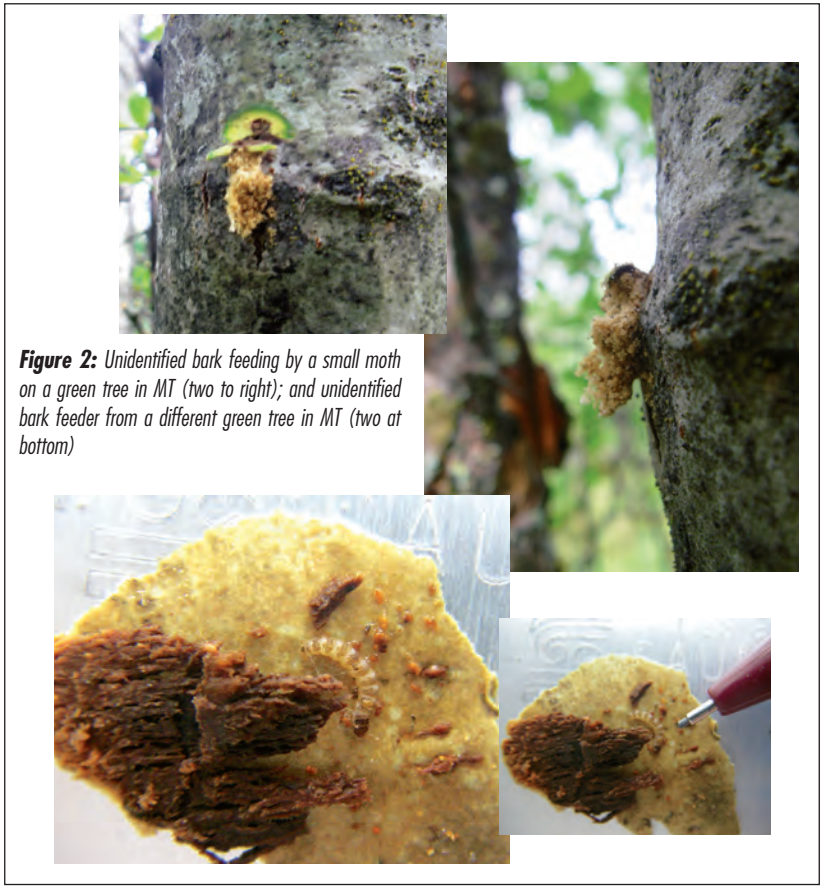

Figure 2: *Unidentified bark feeding by a small moth on a green tree in MT (two to right); and unidentified bark feeder from a different green tree in MT (two at bottom)*

Phytobia species

Distribution and Host: The spider-like etching noted on aspen possibly due to a small fly such as *Phytobia* has been found in WA, MT, NV, UT, CO, WY and AZ, and is likely in other areas; other hosts unknown.

Life History: Around 15 or so species of *Phytobia* are recognized in North America. Adults are a small (3-4.5 mm long, likely), mostly black fly with short antennae and covered with bristly hairs. Larvae are white, legless, headless and soft with a pair of hook-like mouthparts; many species are 20-25 mm long (15-30 mm range) and approximately 1 mm in diameter. The anterior spiracle is very characteristic for the family.

Figure 3: *Adult fly likely of Phytobia genus (above); larvae likely of* Phytobia *genus showing characteristic anterior spiracle of the Agromyzidae family (three to right side)*

Cydia populana

Distribution and Host: Cydia populana has been described from MT, CO and AB on aspen and black cottonwood, but sightings (photographs) exist for other locations in western U.S as well as northern areas of central and eastern U.S. In Canada sightings include southern portions of western, central and eastern Canada.

Life History: Adult moths of *Cydia populana* are described as having blackish brown forewings with brownish-yellow (ocher) markings spanning 13-14 mm and light brownish-gray colored hind wings with white cilia. The body is a dark brownish-gray with a light, brownish-yellow underside. No information is available on life history or immature life stages, nor on damage done.

Figure 4: *Adult moths of* Cydia populana *at rest (left) and with wings spread (right)*

WOOD & BARK BORING INSECTS

***Marmata* species**

Distribution and Host: Bark mining micro-moths also exist within the genus *Marmata*. Species have been described as mining in smooth bark of ash trees, as well as other hardwoods and conifers in the U.S. No species has been identified as feeding on quaking aspen although aspen seems a plausible host. Many species in this genus have not been described, making identifications difficult; many species are leaf miners.

Life History: From *Marmata* species currently described, the small adult moths of this genus have fringed wings spanning approximately 6.5-8.5 mm with black and white designs, and bodies about 2.5-3.5 mm long. Live adults of one species are described as having a "tripod" stance with the body held at a 30-45° angle, first pair of legs together in front with the end of the abdomen touching the ground. Eggs may be flattened, oval, with a glassy, iridescent cover. Larvae of some species have been described as cream colored when feeding, turning to orange or red when they mature to web-spinning stages. Pupae may darken from yellow to pale brown.

Damage:

- The spider-shaped mining by the possible fly species is superficial and does not appear to affect the tree, not even as an infection court for pathogens
- No description of the damage done by Cydia populana has been found; some species within this genus damage cones and branch tips
- No description of the damage done by *Marmata* species is readily available

Similar damage: The spider-like etchings of the bark fly appear unique but it is unknown if more than one species is responsible. It is possible some types of bark feeding may have superficial resemblance to mild roughbark diseases.

References: 4, 6, 15, 16, 32, 33, 34, 37, 62, 75, 76, 85, 91, 94, 100

Index - Agent Scientific Names

SPECIES NAME	CORRECTION	ORDER	FAMILY
Acossus centerensis (Lintner)		Lepidoptera	Cossidae
Acossus populi (Walker)		Lepidoptera	Cossidae
Aegeria tibialis pacifica (Hy. Edwards)	see: *Sesia tibialus* (Harris)	Lepidoptera	Sesiidae
Agrilus acastus Kerremans	see: *Agrilus horni* Kerremans	Coleoptera	Buprestidae
Agrilus blanchardi Horn	see: *Agrilus horni* Kerremans	Coleoptera	Buprestidae
Agrilus granulatus (Say)	see: *Agrilus granulatus liragus* B.&B.	Coleoptera	Buprestidae
Agrilus granulatus liragus Barter & Brown		Coleoptera	Buprestidae
Agrilus horni Kerremans		Coleoptera	Buprestidae
Agrilus liragus Barter & Brown	see: *Agrilus granulatus liragus* B.&B.	Coleoptera	Buprestidae
Agromyza schineri Giraud	see: *Hexomyza schineri* (Giraud)	Diptera	Agromyzidae
Anaerea calcarata Haldeman	see: *Saperda calcarata* Say	Coleoptera	Cerambycidae
Buprestis confluenta Say		Coleoptera	Buprestidae
Buprestis femorata Olivier	see: *Chrysobothris femorata* (Olivier)	Coleoptera	Buprestidae
Buprestis lesnei Garnett	see: *Buprestis viridisuturalis* N.&W.	Coleoptera	Buprestidae
Buprestis tesselata Casey	see: *Buprestis confluenta* Say	Coleoptera	Buprestidae
Buprestis viridisuturalis Nicolay & Weiss		Coleoptera	Buprestidae
Camponotus species		Hymenoptera	Formicidae
Chrysobothris femorata (Olivier)		Coleoptera	Buprestidae
Chrysobothris mali Horn		Coleoptera	Buprestidae
Cryptorhynchus lapathi (L.)		Coleoptera	Curculionidae
Cydia populana (Busck)		Lepidoptera	Tortricidae / Olethreutidae
Descarpentriesina californica (Chamberlin)	see: *Poecilonota californica* (Chamberlin)	Coleoptera	Buprestidae
Descarpentriesina cyanipes (Say)	see: *Poecilonota cyanipes* (Say)	Coleoptera	Buprestidae
Descarpentriesina ferrea (Melsheimer)	see: *Poecilonota ferrea* (Melsheimer)	Coleoptera	Buprestidae
Dicerca callosa Casey		Coleoptera	Buprestidae
Dicerca callosa callosa Casey		Coleoptera	Buprestidae
Dicerca callosa frosti Nelson		Coleoptera	Buprestidae
Dicerca divaricata (Say)		Coleoptera	Buprestidae
Dicerca frosti Nelson	see: *Dicerca callosa* Casey	Coleoptera	Buprestidae
Dicerca longipennis Casey	see: *Dicerca tenebrica* (Kirby)	Coleoptera	Buprestidae
Dicerca pertinax Casey	see: *Dicerca tenebrica* (Kirby)	Coleoptera	Buprestidae
Dicerca prolongata LeConte	see: *Dicerca tenebrica* (Kirby)	Coleoptera	Buprestidae
Dicerca rigida Casey	see: *Dicerca callosa* Casey	Coleoptera	Buprestidae
Dicerca severa Casey	see: *Dicerca tenebrica* (Kirby)	Coleoptera	Buprestidae
Dicerca subargentea Casey	see: *Dicerca tenebrica* (Kirby)	Coleoptera	Buprestidae
Dicerca subcuprea Casey	see: *Dicerca tenebrica* (Kirby)	Coleoptera	Buprestidae
Dicerca sulcatula Casey	see: *Dicerca tenebrica* (Kirby)	Coleoptera	Buprestidae
Dicerca tenebrica (Kirby)		Coleoptera	Buprestidae
Dicerca tetrica Casey	see: *Dicerca callosa* Casey	Coleoptera	Buprestidae
Hexomyza schineri (Giraud)		Diptera	Agromyzidae
Janas abbreviatus (Say)		Hymenoptera	Cephidae
Laspeyresia populana Busck	see: *Cydia populana* (Busck)	Lepidoptera	Tortricidae / Olethreutidae

SPECIES NAME	CORRECTION	ORDER	FAMILY
Marmata species		Lepidopters	Tortricidae / Olethreutidae
Mecas cana saturnine (LeConte)		Coleoptera	Cerambycidae
Mecas confusa Chemsak & Lindsley		Coleoptera	Cerambycidae
Mecas inornata Packard	see: *Mecas cana saturnine* (LeConte)	Coleoptera	Cerambycidae
Mecas inornata Townsend	see: *Mecas confusa* Chemsak & Lindsley	Coleoptera	Cerambycidae
Melanagromyza schineri (Giraud)	see: *Hexomyza schineri* (Giraud)	Diptera	Agromyzidae
Oberea delongi Knull		Coleoptera	Cerambycidae
Oberea papleri Chevrolat	see: *Oberea schaumii* LeConte	Coleoptera	Cerambycidae
Oberea quadricallosa LeConte		Coleoptera	Cerambycidae
Oberea schaumi Linsley & Chemsak	(now part *O. pruinosa* Casey and part *O. caseyi* Plavilstshikov)	Coleoptera	Cerambycidae
Oberea schaumii Garnett	see: *Oberea quadricallosa* LeConte	Coleoptera	Cerambycidae
Oberea schaumii LeConte		Coleoptera	Cerambycidae
Paranthrene dolli (Neumoegen)		Lepidoptera	Sesiidae
Paranthrene robiniae (Hy. Edwards)		Lepidoptera	Sesiidae
Paranthrene tabaniformis (Rottemburg)		Lepidoptera	Sesiidae
Paranthrene tabaniformis kungessana (Alpheraky)	see: *Paranthrene tabaniformis* (R.)	Lepidoptera	Sesiidae
Paranthrene tabaniformis synagiformis (Rambur)	see: *Paranthrene tabaniformis* (R.)	Lepidoptera	Sesiidae
Paranthrene tabaniformis tabaniformis (Rottemburg)	see: *Paranthrene tabaniformis* (R.)	Lepidoptera	Sesiidae
Paranthrene tricincta (Harris)	see: *Paranthrene tabaniformis* (R.)	Lepidoptera	Sesiidae
Phytobia species		Diptera	Agromyzidae
Poecilonota californica (Chamberlin)		Coleoptera	Buprestidae
Poecilonota cyanipes (Say)		Coleoptera	Buprestidae
Poecilonota ferrea (Melsheimer)		Coleoptera	Buprestidae
Prionoxystus robiniae (Peck)		Lepidoptera	Cossidae
Procryphalus mucronatus (LeConte)		Coleoptera	Scolytidae
Ptilinus basalis LeConte		Coleoptera	Anobiidae
Saperda calcarata Say		Coleoptera	Cerambycidae
Saperda concolor LeConte	see: *Saperda inornata* (Say)	Coleoptera	Cerambycidae
Saperda concolor unicolor Felt & Joutel	see: *Saperda inornata* (Say)	Coleoptera	Cerambycidae
Saperda inornata (Say)		Coleoptera	Cerambycidae
Saperda mecasoides Casey	see: *Saperda inornata* (Say)	Coleoptera	Cerambycidae
Saperda populnea (L.)		Coleoptera	Cerambycidae
Saperda populnea moesta LeConte		Coleoptera	Cerambycidae
Saperda populnea populnea (L.)		Coleoptera	Cerambycidae
Saperda populnea tulari Felt & Joutel		Coleoptera	Cerambycidae
Sesia apiformis (Clerck)		Lepidoptera	Sesiidae
Sesia tibiale (Harris)	see: *Sesia tibialis* (Harris)	Lepidoptera	Sesiidae
Sesia tibialis (Harris)		Lepidoptera	Sesiidae
Sphinx tabaniformis (Rottemburg)	see: *Paranthrene tabaniformis* (R.)	Lepidoptera	Sesiidae
Sternochetus lapathi (Linnaeus)	see: *Cryptorhynchus lapathi* (Linnaeus)	Coleoptera	Curculionidae
Sthenopis purpurascens (Packard)		Lepidoptera	Hepialidae
Sthenopis quadriguttatus (Grote)	see: *Sthenopis purpurascens* (Packard)	Lepidoptera	Hepialidae

SPECIES NAME	CORRECTION	ORDER	FAMILY
Trypodendron retusum (LeConte)		Coleoptera	Scolytidae
Trypophloeus populi Hopkins		Coleoptera	Scolytidae
Trypophloeus thatcheri (Wood)		Coleoptera	Scolytidae
Xylotrechus annosus (Say)		Coleoptera	Cerambycidae
Xylotrechus mormonus Hopping	see: *Xylotrechus bowditchi hoppingi* Linsley (in *X. annosus* write-up)	Coleoptera	Cerambycidae
Xylotrechus mormonus (LeConte)		Coleoptera	Cerambycidae
Xylotrechus obliteratus LeConte		Coleoptera	Cerambycidae

WOOD & BARK BORING INSECTS

Index - Agent Common Names

*common name approved by Entomological Society of America (accessed 15 May, 2014)
[0] common name approved by Entomological Society of Canada (accessed 15 May, 2014)
(-) secondary common name given in this guide

List of Tree Common and Scientific Names

COMMON NAME	SCIENTIFIC NAME
alder	***Alnus*** Mill.
apple	***Malus*** Mill.
ash	***Fraxinus*** L.
ash, green	*Fraxinus pennsylvanica* Marshall
aspen	***Populus*** L.
aspen, bigtooth	*Populus grandidentata* Michx.
aspen, European	*Populus tremula* L.
aspen, quaking / trembling	*Populus tremuloides* Michx.
birch	***Betula*** L.
birch, paper	*Betula papyrifera* Marshall
	Betula papyrifera Marshall var *papyrifera*
cottonwood	***Populus*** L.
cottonwood, black	*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw
cottonwood, eastern	*Populus deltoides* W. Bartram ex Marshall
	Populus deltoides W. Bartram ex Marshall ssp. deltoides
cottonwood, Fremont	*Populus fremontii* S. Watson
	Populus fremontii S. Watson ssp. Fremontii
	Populus fremontii S. Watson ssp. mesetae Eckenwalder
cottonwood, lanceleaf	*Populus ×acuminata* Rydb. [from *angustifolia x deltoides*]
cottonwood, narrowleaf	*Populus angustifolia* James
cottonwood, plains	*Populus deltoides* W. Bartram ex Marshall ssp. *monilifera* (Aiton) Eckenwalder
cottonwood, Rio Grande	*Populus deltoides* W. Bartram ex Marshall ssp. *wislizeni* (S.Watson) Eckenwalder
elm	***Ulmus*** L.
hawthorn	***Crataegus*** L.
locust	***Robinia*** L.
locust, black	*Robinia pseudoacacia* L.
maple	***Acer*** L.
box elder	Acer negundo L.
oak	***Quercus*** L.
poplar	***Populus*** L.
poplar, balsam	*Populus balsamifera* L.
	Populus balsamifera L. ssp. *balsamifera*
poplar, Carolina	*Populus ×canadensis* Moench [from *P. deltoides x P. nigra*]
poplar, black	*Populus nigra* L.
poplar, Lombardy	*Populus nigra* L.
poplar, Russian	*Populus ×petrowskiana* R.I. Schrod. ex Regel
sycamore	***Platanus*** L.
willow	***Salix*** L.
willow, black	*Salix nigra* Marshall
willow, nuttall / Scouler's	*Salix scouleriana* Barratt ex Hook

WOOD & BARK BORING INSECTS

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INTRODUCTION	1	USGS digital representation of aspen range as found in Little Jr, E. L. 1971. Atlas of United States trees. Volume 1. Conifers and important hardwoods. Miscellaneous publication 1146. USDA Forest Service, Washington, DC.
	2	Brytten Steed, USDA Forest Service
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INDIVIDUAL DAMAGE AGENTS		
root, root crown, lower stem		
Lepidoptera (moths)		
American hornet moth	1	© Mike McIvor (from North American Moth Photographers Group)
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Coleoptera (beetles)		
aspen root girdler	1	© Robert L. Otto (BugGuide.net)
	2	Mike Ostry, USDA Forest Service, Bugwood.org
	3	Mike Ostry, USDA Forest Service, Bugwood.org
poplar butt borer	1	L.G. Bezark, L.G. A photographic catalog of the Cerambycidae of the World. Available from: https://apps2.cdfa.ca.gov/publicApps/plant/bycidDB/wdefault.asp (accessed 28 January 2014)
	2	© Jeff Gruber, University of Wisconsin Entomology Depart. (BugGuide.net)
	3a-c	Brytten Steed, USDA Forest Service
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carpenter ants	1	Jim Baker, North Carolina State University, Bugwood.org
	2	Whitney Cranshaw, Colorado State University, Bugwood.org
	3	Brytten Steed, USDA Forest Service
	4	Brytten Steed, USDA Forest Service
	5	Joseph O'Brien, USDA Forest Service, Bugwood.org
trunk and large branches		
Lepidoptera (moths/butterflies)		
poplar carpenter worm	1	James Solomon, USDA Forest Service, Bugwood.org
	2	© Cindy Mead (BugGuide.net)
aspen carpenter worm	1a&b	© Tom Dimock (from North American Moth Photographers Group)
	2	© John Davis
carpenterworm	1	James Solomon, USDA Forest Service, Bugwood.org
	2	James Solomon, USDA Forest Service, Bugwood.org
	3a	James Solomon, USDA Forest Service, Bugwood.org
	3b	Whitney Cranshaw, Colorado State University, Bugwood.org
	4	Bob Hammon, Colorado State University, Bugwood.org
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	4a	Tom Zegler, USDA Forest Service
	4b	James Solomon, USDA Forest Service, Bugwood.org
gold-dust buprestid	1a	Steven Valley, Oregon Department of Agriculture, Bugwood.org
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	2b&c	Steven Valley, Oregon Department of Agriculture, Bugwood.org
flathead appletree borer	1	Joseph Berger, Bugwood.org
	2	James Solomon, USDA Forest Service, Bugwood.org
	3	James Solomon, USDA Forest Service, Bugwood.org
Pacific flathead borer	1	© Tom Murray (BugGuide.net; licensed under a Creative Commons License at http://creativecommons.org/licenses/by-nd-nc/1.0/ and http://creativecommons.org/licenses/by-nd-nc/1.0/legalcode)
	2	James Solomon, USDA Forest Service, Bugwood.org
	3	James Solomon, USDA Forest Service, Bugwood.org
poplar and willow borer	1	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
	2	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
	3	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
	4	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
	5	Fabio Stergulc, Università di Udine, Bugwood.org
	6	Bill Zanze, Portland OR parks
Dicerca callosa	1	© G.J. Hilchie, Museums and Collections Services, University of Alberta, E.H. Strickland Entomological Museum, accessed 2014 (http://entomology.museums.ualberta.ca/index.html)
	2	© G.J. Hilchie, Museums and Collections Services, University of Alberta, E.H. Strickland Entomological Museum, accessed 2014 (http://entomology.museums.ualberta.ca/index.html)
flathead poplar borer	1	Brytten Steed, USDA Forest Service
	2	Brytten Steed, USDA Forest Service
western poplar buprestid	1a	© Joshua P. Basham (Bugguide.net)
	1b	© Dennis Haines (Bugguide.net)
eastern poplar buprestid	1	© Mike Quinn (BugGuide.net; licensed under a Creative Commons License at http://creativecommons.org/licenses/by-nd-nc/1.0/ and http://creativecommons.org/licenses/by-nd-nc/1.0/legalcode)
	2	James Solomon, USDA Forest Service, Bugwood.org
	3	James Solomon, USDA Forest Service, Bugwood.org
	4	James Solomon, USDA Forest Service, Bugwood.org
iron flatheaded borer	1	© Tim Loh (BugGuide.net)

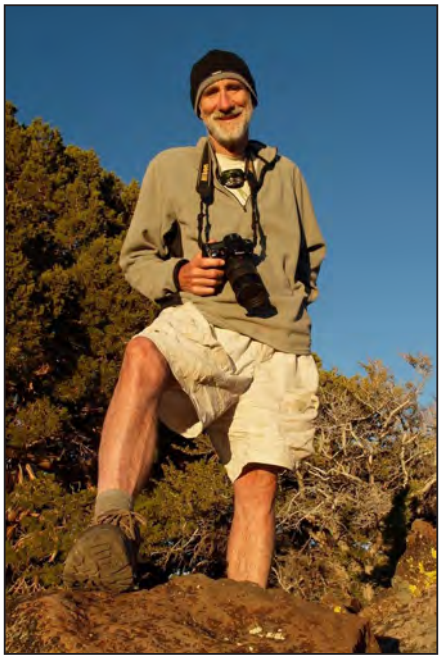
WOOD & BARK BORING INSECTS

AGENT SECTION	FIGURE#	IMAGE CREDIT
poplar borer	1	Tom Zegler, USDA Forest Service
	2	Natural Resources Canada, Canadian Forest Service, accessed Feb. 2014 (http://tidcf.nrcan.gc.ca/en/home)
	3	Tom Zegler, USDA Forest Service
	4	Lindsey Myers, USDA Forest Service
	5	James Solomon, USDA Forest Service, Bugwood.org
	6	Brytten Steed, USDA Forest Service
small branches and twigs		
Lepidoptera (moths/butterflies)		
dusky clearwing	1	© DianeWilson (BugGuide.net; licensed under a Creative Commons License at http://creativecommons.org/licenses/by-nd-nc/1.0/ and http://creativecommons.org/licenses/by-nd-nc/1.0/legalcode)
	2	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
	3	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
	4	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
Coleoptera (beetles)		
poplar branch borer	1	James Solomon, USDA Forest Service, Bugwood.org
	2	James Solomon, USDA Forest Service, Bugwood.org
	3a	Brytten Steed, USDA Forest Service
	4a	S. Heydon, accessed through L.G. Bezark. A photographic catalog of the Cerambycidae of the World. Available from: https://apps2.cdfa.ca.gov/publicApps/plant/bycidDB/wdefault.asp (accessed January 2014)
	4b	© Andy Daun (BugGuide.net; licensed under a Creative Commons License at http://creativecommons.org/licenses/by-nd-nc/1.0/ and http://creativecommons.org/licenses/by-nd-nc/1.0/legalcode)
poplar gall saperda	1	© Stephen Luk (BugGuide.net; licensed under a Creative Commons License at http://creativecommons.org/licenses/by-nd-nc/1.0/ and http://creativecommons.org/licenses/by-nd-nc/1.0/legalcode)
	2	Mike Ostry, USDA Forest Service, Bugwood.org
	3	Mike Ostry, USDA Forest Service, Bugwood.org
	4	Mike Ostry, USDA Forest Service, Bugwood.org
small poplar borer	1	© Joyce Gross (joycegross.com; Bugguide.net)
	2a&b	Natural Resources Canada, Canadian Forest Service, accessed Feb. 2014 (http://tidcf.nrcan.gc.ca/en/home)
	2c	Petr Kapitola, State Phytosanitary Administration, Bugwood.org
	3a-c	Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
Diptera (flies)		
poplar twiggall fly	1	Whitney Cranshaw, Colorado State University, Bugwood.org
	2	Whitney Cranshaw, Colorado State University, Bugwood.org
	3	Whitney Cranshaw, Colorado State University, Bugwood.org
	4	Whitney Cranshaw, Colorado State University, Bugwood.org
	5	Whitney Cranshaw, Colorado State University, Bugwood.org
	6	Whitney Cranshaw, Colorado State University, Bugwood.org

AGENT SECTION	FIGURE#	IMAGE CREDIT
Hymenoptera (sawflies, wasps, ants)		
willow shoot sawfly	1	James Solomon, USDA Forest Service, Bugwood.org
	2	James Solomon, USDA Forest Service, Bugwood.org
	3	James Solomon, USDA Forest Service, Bugwood.org
	4	James Solomon, USDA Forest Service, Bugwood.org
bark beetles and other bark insects - trunk or branches		
Coleoptera (beetles)		
Procryphalus mucronatus	1a&b	Mercado, J.E. 2010. Bark Beetle Genera of the United States. Colorado State Univ., USDA-APHIS-PPQ Center for Plant Health Science and Technology, and USDA-FS Rocky Mountain Research Station. January 2014.
	2	Brytten Steed, USDA Forest Service
Trypophloeus populi	1a&b	Mercado, J.E. 2010. Bark Beetle Genera of the United States. Colorado State Univ., USDA-APHIS-PPQ Center for Plant Health Science and Technology, and USDA-FS Rocky Mountain Research Station. January 2014.
	2	Brytten Steed, USDA Forest Service
	3a&b	Brytten Steed, USDA Forest Service
poplar ambrosia beetle	1	Steven Valley, Oregon Department of Agriculture, Bugwood.org
	2	Brytten Steed, USDA Forest Service
	3	Tom Zegler, USDA Forest Service
	4	© M.S. Caterino/SBMNH (BugGuide.net)
Epidermal bark-mining insects		
	1a&b	Tom Zegler, USDA Forest Service
	1c	Brytten Steed, USDA Forest Service
	2a-d	Lindsey Myers, USDA Forest Service
	3a	© Bo Zaremba (BugGuide.net)
	3b-d	© Pierre-Marc Brousseau (BugGuide.net)
	4a	© Nolie Schneider (from North American Moth Photographers Group)
	4b	Jerry Powell, Essig Museum of Entomology (CalPhoto and North American Moth Photographers Group)

Dedication

This work is dedicated to David A. Burton without whom this work, and many other aspen-related projects, would not have been possible. His dedication to this guide, his entrepreneurial spirit, and his love of aspen made him invaluable. His friendship made him irreplaceable.



David A. Burton
1943-2014