FINAL PROJECT REPORT
WTFRC Project Number: AE-04-426

Project Title: Alternate Hosts of Apple Maggot as a Threat to Apples

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Cooperators: WSU personnel, various growers and homeowners in western and central Washington

Budget History:

Item	**Year 1:** 2004	**Year 2:** 2005	**Year 3:** 2006
Salaries	19,500[1]	19,500[1]	19,500[1]
Benefits	2,000	2,000	2,000
Wages	0	0	0
Benefits	0	0	0
Equipment	0	0	0
Supplies	2,500[2]	2,500[2]	2,500[2]
Travel	2,000[3]	2,000[3]	2,000[3]
Miscellaneous	0	0	0
Total	26,000	26,000	26,000

[1]Two-three GS-3 to GS-5 for 3-6 months; Traps, tubs, screening, and shrubs and trees from nurseries.
[3]Gasoline for travel to and from field sites.

Objectives (2004-2006):
1) Determine apple maggot abundance and prevalence on alternate and normal host trees, including hawthorn, in different regions in Washington, with emphasis in central Washington.
2) Determine effects of fruit maturity and spatial relationships between alternate host trees on apple maggot infestations.
3) Determine conditions under which ornamental shrubs and alternate hosts are used by apple maggot through manipulative host studies in apple or hawthorn.
4) Determine frequency of infestations of hawthorn species and apple varieties.
5) Determine abundance of hawthorns and alternate hosts near representative commercial orchards.
6) Determine acceptance of apple varieties by apple maggots reared from hawthorns and alternate hosts.

Significant Findings:
● Feral apple and black hawthorn fruit were infested by apple maggot larvae in central Washington in Yakima, Nile Valley, Wenas, and Ellensburg, but at low and manageable densities.
● Other than hawthorns, no alternate hosts of apple maggot flies were found in central Washington
● Apple maggot flies infested black hawthorn more frequently than apples in central Washington; whether this suggests a host preference is unclear, but hawthorns should still be considered a threat to apples for now.
● In western Washington, apple maggot flies infested previously unrecorded hosts, including pear, Asian pear, garden plum, Japanese plum, cherry plum, apricot, bitter cherry, mountain ashes, and cotoneasters, indicating flies in Washington have the genetics to utilize a fairly wide range of hosts.
● Flies from black hawthorns are abundant when earlier developing apples are ripening; these apples may be more likely to be attacked by flies from black hawthorn than are later apples.
● Shrubs such as cotoneasters are infested, but are not a threat unless near infested apple/haw trees
● Black and English hawthorns are equally infested, but English hawthorns ripen later; combined, both may contribute flies to early and late developing apples.
● In the Yakima area, black hawthorns are abundant near some apple orchards, but there are few other alternate hosts; removing these hawthorns may further reduce the threat of the flies infesting apples.
● Flies reared from English hawthorn and other alternate hosts accepted apples, suggesting flies from hawthorn trees also can attack apples in the field.

Results and Discussion:
1) Determine apple maggot abundance and prevalence on alternate and normal host trees. In Yakima/vicinity (Table 1) from 2004-2006, only one pupa (presumably an apple maggot) was found in many apples sampled. None was found in black hawthorn in 2004 and 2005, but 8 were found in this host in 2006. No other plants produced apple maggot pupae, although they produced other species of fruit flies. In the Nile Valley (Table 2) from 2004-2006, none of the apples produced pupae, but black hawthorns from 2003-2006 produced apple maggot pupae and adults in low numbers. None of the other plants produced apple maggot, although again they produced other fly species. In Wenas (Table 3), the relatively few apples found were not infested. However, as in Yakima and the Nile Valley, black hawthorn was infested. Also similar to the Nile Valley, apple maggot populations were low despite the high abundance of native black hawthorn at the collection site. It was estimated that the 49 trees sampled in Wenas represented only about 10% of the available trees, as most were inaccessible along deep ravines. In Ellensburg (Table 4), three pupae were found in apple, but only in the last of the three years of sampling. None of the other plants was infested by apple maggots. In Goldendale, where sampling was limited to late season in 2006, no apple maggots were detected in apple, crabapple, or other sampled plants (data not shown).

In general, then, in central Washington, breeding apple maggot populations are low, but they are widespread, as they were found in every area sampled (except in Goldendale where sampling was less extensive than in other areas). Results suggest that at present apple maggots can be contained or

managed well and kept out of commercial orchards in central Washington because of the low densities. Likely because of the low numbers, apple maggots have not utilized alternative hosts in central Washington. Therefore, in central Washington, alternate hosts do not appear to be a threat to the apple industry, although this could change if fly populations are left unmanaged in the long term in the future, because fly populations in Washington undoubtedly have the ability to exploit alternate hosts (see below).

The low infestations of apple maggots in both apple and black hawthorn in central Washington suggest a recent introduction of the fly or that some environmental factor in this area, such as low moisture, has prevented the population from increasing to higher levels. Alternatively, with respect to black hawthorn, the variety in central Washington may not allow for high larval survival (compared with the variety in western Washington, *C. douglasii suksdorfii*, see below). The high abundance of black hawthorn trees with heavy fruit loads in the Nile Valley and Wenas suggest the population is not limited by breeding sources. An interesting and potentially important result in central Washington was that black hawthorns were more frequently infested than apples. Several possible explanations can account for this. One, the apple maggots here are a race that prefers black hawthorns. Two, the varieties of apples found along roadsides or feral settings are those less preferred by the flies. Three, black hawthorns are more abundant than unmanaged apples, and the numbers of flies finding them correspondingly are higher than those finding the less abundant apples.

In western Washington in Puyallup (Table 5) there were clear differences in patterns from those at the central Washington sites. Nearly all apple and English hawthorns (*Crataegus monogyna*) were infested with apple maggot. Significantly, alternate hosts were found, as Asian pear and European mountain ash and milkflower cotoneaster were infested. In Vancouver, its vicinity, and Portland (Table 6), again there were clear differences from results in central Washington. Similarly high percentages of apples and black and English hawthorns were infested. Smooth and cockspur hawthorns were also infested. Also, there were several alternate hosts in this area - apricot, European pear, Asian pear, garden plum, Japanese plum, cherry plum, western mountain ash, cranberry cotoneaster, milkflower cotoneaster, and possibly Japanese honeysuckle (depending on the outcome of fly rearing in 2007).

The western Washington results are important because they show that Washington apple maggots are able to exploit a fairly wide range of hosts (Table 7) under some conditions. The possibility that flies from western Washington have been (and will be) transported by humans from western to central Washington is real. It can be assumed, unless evidence to the contrary is found, that flies in central Washington potentially can also attack alternate hosts, for example, apricot or pear.

2) Effects of fruit maturity and spatial relationships between alternate host trees and normal trees on maggot infestations. In western Washington, black hawthorn generally matured in July and August and had highest fly populations during this period. Thus flies from this host most likely would attack earlier developing apple varieties (assuming these flies live on average about 30 days). There was about a one-month period between peak ripeness of black hawthorn and English hawthorn, keeping the fly populations on the two hosts somewhat separated. Early apples such as "Early Transparent' in general were more frequently infested than late, firmer varieties (e.g., 'Gravenstein'), although exceptions to this were seen in 2006, which made generalizations difficult. Early-developing plums were less frequently attacked than later-developing plums, but their relationship to apple was not clear. The cotoneasters and ashes seem to mature too late to make them a real threat to most apples (see below).

3) Determine conditions under which ornamental shrubs and alternate hosts are used by apple maggot through manipulative host studies. The distance that ornamental shrubs (between rows of infested apples or 20 ft outside orchards), in this case cotoneasters (*Cotoneaster dammeri*), were from an infested apple orchard had no bearing on infestation by apple maggots. No cotoneaster fruit produced pupae. Earlier developing species or varieties of cotoneaster may have led to different results. However, cotoneasters in the field surveys were found to be infested by apple maggot,

although at relatively low levels (Tables 5 and 6). Cotoneasters likely do not represent a threat to apples unless unmanaged, heavily infested apples or hawthorns are nearby.

4) Determine frequency of infestations of hawthorn species and apple varieties. In central Washington, black hawthorn appeared to be more infested than English and other ornamental hawthorns, but numbers were too low to draw strong conclusions. If true, however, black hawthorns are a larger threat to early-mid season apples than English hawthorns in central Washington. In western Washington, black hawthorn and English hawthorn appear to be infested at equal frequencies (Tables 5 and 6) despite the large differences in their fruiting phonologies. English hawthorns may be a threat to later apples.

5) Determine abundance of hawthorns and alternate hosts near representative commercial orchards. Black hawthorns were found in abundance close (≤1/2 mile) to some commercial orchards in western Yakima. These were mostly roadside trees, although some were in residential yards. The fly-infested hawthorns in 2006 were found in a back yard with a small planting of apples about 3-4 miles from a commercial orchard. However, despite extensive searches around 10 orchards here and in the Naches area, few hawthorns or other alternate hosts (as determined in western Washington) were found. The major plants found around orchards were roses, which, up to this point, have not been found to be infested by apple maggot in Washington (although it is/was a host in the eastern U.S.).

6) Determine acceptance of apple varieties by apple maggots reared from hawthorns and alternate hosts. Flies reared from English hawthorn did not accept 'Fuji' apples that had been cold stored. However, of 20 female flies (9-14 days old) reared from this hawthorn, 50% accepted 'Early Transparent' apples within 30 min. Flies probed (a series of short stings) or stung the fruit and dragged their ovipositors over the fruit. This indicated that flies reared from hawthorn do accept apples. Other observations indicated flies reared from pear also accepted apple. More data using larger fly sample sizes are needed to determine the frequencies of acceptance.

Significance to the Industry and Potential Economic Benefits. The research is significant for the apple industry because it helps identify which plants are used by apple maggots and how prevalent infestations are in major apple-growing regions. Apple maggot establishment on apples is the major problem, but its establishment on alternate hosts near commercial orchards would also be a major problem because this would increase the fly trapping and detection efforts, potentially at a high labor cost. Also, if the flies need to be controlled around the orchards, spray applications need to be made at additional costs to growers. Results reported here suggest that black hawthorns may be a threat to apples if they occur close to orchards (unclear how far, but possibly ½ -1 mile away), but that other alternative hosts are not likely to threaten apples in central Washington. This is probably because of the relatively low numbers of flies in this region at present. The fact that apple maggots attack both apples and black hawthorns here indicates we need to continue to monitoring for the fly. It is unknown whether the situation represents the beginning of one similar to that postulated to have occurred in western Washington prior to 1979, when apple maggot populations apparently were too low to be easily detected. Our results from western Washington also indicate apple maggots in Washington have the ability to exploit several abundant plants such as pear in central Washington, assuming the genetics of the flies in the two regions are similar. This is a real possibility because it is likely western Washington was a source of at least some populations in central Washington. If so, even small populations left unmanaged to reproduce in central Washington may increase and eventually utilize alternate hosts such as pear, plum, and others.

Table 1. Plants sampled and numbers of *Rhagoletis* pupae and adults from various fruit collected in Yakima and vicinity, Yakima County, WA, June to October 2002-2006

Plant Species	Sample Year	No. Plants	No. Fruit	No. Pupae	% Plants Infested	No. Adults
Apple	2004	12	233	0	0	---
	2005	30	1,446	0	0	---

	2006	127	8,592	1	0.8	__, AM
Crabapple	2005	74	12,499	0	0	---
	2006	122	26,207	0	0	---
Black Hawthorn	2004	41	6,741	0	0	---
	2005	39	4,643	0	0	---
	2006	77	24,237	8	2.6	__, AM
Ornamental Hawthorns[a]	2005	25	9,667	0	0	---
English Hawthorn	2006	11	5,691	0	0	---
Smooth Hawthorn	2006	26	12,606	0	0	---
Washington Hawthorn	2005	3	120	0	0	---
	2006	42	45,457	0	0	---
European Pear	2004	5	70	0	0	---
	2005	2	6	0	0	---
	2006	20	965	0	0	---
Ornamental Pear	2006	22	4,882	0	0	---
Garden Plum	2005	6	381	0	0	---
	2006	18	1,266	0	0	---
Apricot	2006	23	1,184	0	0	---
Peach	2006	1	10	0	---	---
Sweet/Sour Cherry	2002	32	6,026	1,679	71.9	672[a], CFF
	2003	12	3,249	1,136	100.0	454[a], CFF
	2004	9	1,800	1,338	100.0	535[a], CFF
	2005	20	3,025	2,428	95.0	324, CFF
	2006	11	4,059	60	81.8	___, CFF
Choke Cherry	2002	3	596	0	0	---
	2003	44	27,354	0	0	---
	2004	4	520	0	0	---
	2005	16	3,608	0	0	---
	2006	10	3,942	0	0	---
Roses[c]	2004	15	1,316	65	73.3	30, RM
	2005	29	2,900	130	31.0	3, RM
	2006	97	18,178	726	87.6	__, RM
Japanese Quince	2004	1	21	0	---	---
	2005	3	32	0	0	---
	2006	1	31	0	---	---
Firethorn	2004	4	582	0	0	---
	2006	26	26,152	0	0	---
Serviceberry	2005	4	384	0	0	---
European Mountain Ash	2005	13	2,644	0	0	---
	2006	30	20,212	0	0	---
Korean Mountain Ash	2006	1	359	0	---	---
Cotoneaster sp.	2005	1	400	0	0	---
Rockspray Cotoneaster	2006	21	3,814	0	0	---
Common Snowberry	2004	5	619	13	60.0	4, SBM
	2005	10	600	77	100.0	10, SBM
	2006	31	5,667	425	80.6	__, SBM
Blue Elderberry	2004	6	1,070	0	0	---
	2005	9	1,800[b]	0	0	---
	2006	6	17,900[b]	0	0	---

Red Osier Dogwood	2005	6	2,892	0	0	---
	2006	13	4,411	3	15.4	__, DF
Flowering Dogwood	2004	1	140	0	0	---
	2006	43	10,786	0	0	---
Gooseberry	2004	2	244	0	0	---
Russian Olive	2004	1	157	0	0	---
	2006	17	4,554	0	0	---
Golden Currant	2005	14	2,953	2	14.3	0
Tall Oregon-Grape	2005	34	10,520	60	20.6	36, OG
	2006	4	978	0	0	---
English Walnut	2005	36	1,080	7,835	97.2	432, WHF
	2006	3	45	119	100.0	___, WHF
Holly	2004	2	200	0	0	---
	2005	1	145	0	---	---
	2006	4	1,052	0	0	---
Juniper	2005	1	25	0	---	---
	2006	2	363	0	0	---
European Cranberry Bush	2005	1	145	0	---	---
Viburnum species	2006	5	2,301	0	0	---
Common Buckthorn	2006	6	761	0	0	---
English Yew	2006	24	3,280	0	0	---
Virginia Creeper	2006	15	3,997	0	0	---
Bittersweet Nightshade	2006	16	1,866	0	0	---
Garden Asparagus	2006	3	399	0	0	---
Netleaf Hackberry	2006	2	290	0	0	---
Barberry	2006	3	825	0	0	---
Tartarian Honeysuckle	2006	2	442	0	0	---
Euonymus	2006	2	414	0	0	---

[a]Combined English and smooth hawthorns; [b]Estimated; [c]Nootka and Woods' roses combined.
AM, *R. pomonella*; CFF, *R. indifferens*; RM, *R. basiola*; SBM, *R. zephyria*; OG, *R. berberis*; WHF, *R. completa* (Note: the same abbreviations for fly species are used in all tables); ___, not emerged yet.

Table 2. Plants sampled and numbers of *Rhagoletis* pupae and adults from various fruit collected in the Nile Valley, Yakima County, WA, June to September 2004-2006

Plant Species	Sample Year	No. Plants	No. Fruit	No. Pupae	% Plants Infested	No. Adults
Apple	2004	23	1,030	0	0	---
	2005	73	2,905	0	0	---
	2006	27	1,323	0	0	---
Crabapple	2005	4	642	0	0	---
Black Hawthorn	2003	12	926	1	8.3	1, AM
	2004	40	10,402	15	22.5	11, AM
	2005	46	18,425	1	2.2	1, AM
	2006	60	21,907	4	5.0	2, AM
European Pear	2004	6	320	0	0	---
	2005	5	125	0	0	---
	2006	5	209	0	0	---
Garden Plum	2004	4	319	0	0	---
	2005	6	350	0	0	---

	2006	4	387	0	0	---
Apricot	2006	1	47	0	---	---
Sweet/Sour Cherry	2005	6	1,161	0	0	---
Bitter Cherry	2003	30	10,954	373	73.3	88, CFF
	2004	20	3,784	308	65.5	51, CFF
	2005	23	3,947	76	21.7	11, CFF
	2006	41	8,819	560	68.3	__, CFF
Choke Cherry	2003	23	9,751	0	0	---
	2004	20	5,592	0	0	---
	2005	41	8,200	73	12.2	3, CFF
	2006	17	5,378	0	0	---
Roses[a]	2004	45	4,223	585	84.4	129, RM
	2005	52	5,200	548	69.2	96, RM
	2006	21	1,845	489	100.0	__, RM
Serviceberry	2005	22	3,293	0	0	---
Common Snowberry	2004	32	5,343	178	50.0	61, SBM
	2005	23	1,557	522	100.0	30, SBM
	2006	37	4,640	644	97.3	__, SBM
Blue Elderberry	2004	18	3,103	0	0	---
	2005	41	8,200[a]	0	0	---
	2006	14	35,698[a]	0	0	---
Golden Currant	2005	12	2,985	28	50.0	0
Red Osier Dogwood	2005	20	7,959	4	20.0	1, DF
	2006	23	6,221	38	73.9	_, DF
Tall Oregon-Grape	2005	2	254	0	0	---

[a]Estimated; [b]Nootka and Woods' roses combined.

Table 3. Plants sampled and numbers of *Rhagoletis* pupae and adults from various fruit collected in Wenas, Yakima County, WA, August to September 2006

Plant Species	No. Plants	No. Fruit	No. Pupae	% Plants Infested	No. Adults
Apple	9	450	0	0	---
Black Hawthorn	49	18,195	21	20.4	__, AM
Choke Cherry	12	2,194	0	0	---
Roses[a]	21	1,469	32	71.4	__, RM
Common Snowberry	21	2,349	186	61.9	__, SBM

[a]Nootka and Woods' roses combined.

Table 4. Plants sampled and numbers of *Rhagoletis* pupae and adults from various fruit collected in Ellensburg, Kittitas County, WA, June to September 2004-2006

Plant Species	Sample Year	No. Plants	No. Fruit	No. Pupae	% Plants Infested	No. Adults
Apple	2004	194	4,850	0	0	---
	2005	139	6,950	0	0	---
	2006	64	2,496	3	1.6	__, AM
Crabapple	2004	151	15,700	0	0	---
	2005	108	13,800	0	0	---
	2006	35	4,916	0	0	---
Black Hawthorn	2004	19	3,800	0	0	---

	2005	15	1,450	0	0	---
	2006	27	4,198	0	0	---
Ornamental Hawthorns[a]	2005	30	5,580	0	0	---
English Hawthorn	2006	4	1,936	0	0	---
Smooth Hawthorn	2006	18	5,610	0	0	---
Washington Hawthorn	2006	9	7,419	0	0	---
European Pear	2004	96	2,400	0	0	---
	2005	48	1,645	0	0	---
	2006	2	27	0	0	---
Garden Plum	2004	55	2,612	0	0	---
	2005	32	960	0	0	---
	2006	14	1,239	0	0	---
Peach	2006	1	33	0	0	---
Sweet Cherry	2005	1	500	103	---	59, CFF
Choke Cherry	2005	14	5,300	0	0	---
	2006	10	2,026	0	0	---
Bitter Cherry	2006	10	2,265	32	70.0	__, CFF
Apricot	2004	11	300	0	0	---
	2005	6	180	0	0	---
Roses[c]	2004	12	2,400	10	25.0	1, RM
	2005	53	8,000	179	43.4	18, RM
	2006	30	3,020	122	53.3	__, RM
Quince	2006	1	189	0	---	---
Firethorn	2006	11	6,662	0	0	---
Serviceberry	2005	3	300	0	0	---
Red Osier Dogwood	2006	2	553	0	0	---
European Mountain Ash	2006	21	13,590	0	0	---
Rockspray Cotoneaster	2006	8	2,069	0	0	---
Peking Cotoneaster	2006	21	3,729	0	0	---
Peach	2005	4	110	0	0	---
Common Snowberry	2004	3	600	0	0	---
	2005	9	1,520	88	55.6	2, SBM
	2006	26	5,098	519	96.2	_, SBM
Blue Elderberry	2004	10	>2,000[b]	0	0	---
	2005	11	>2,200[b]	0	0	---
	2006	11	30,000[b]	0	0	---
Tall Oregon-Grape	2005	10	1,000	93	80.0	8, OG
	2006	4	613	0	0	---
Juniper	2005	3	225	0	0	---
English Yew	2006	5	204	0	0	---
Virginia Creeper	2006	5	1,969	0	0	---
Tartarian Honeysuckle	2006	3	48	0	0	---

[a]Combined English and smooth hawthorns; [b]Estimated; [c]Nootka and Woods' roses combined.

Table 5. Plants sampled and numbers of *Rhagoletis* pupae and adults from various fruit collected in Puyallup, Pierce County, WA, June to October 2004-2006

Plant Species	Sample Year	No. Plants	No. Fruit	No. Pupae	% Plants Infested	No. Adults
Apple	2004	7	345	208	100.0	>23, AM

	2005	13	820	816	100.0	297, AM
	2006	13	1,150	1,221	100.0	__, AM
English Hawthorn	2004	2	400	125	100.0	>8, AM
	2005	6	1,200	290	100.0	235, AM
	2006	8	3,200	271	87.5	__, AM
Asian Pear	2004	1	8	12	---	7, AM
	2005	2	35	24	100.0	11, AM
	2006	1	20	3	---	__, AM
Garden Plum	2004	2	60	0	0	---
	2005	2	100	0	0	---
	2006	3	150	0	0	---
Roses[a]	2005	3	70	0	0	---
European Mountain Ash[b]	2005	1	100	13	---	1, AM[a]
	2006	10	4,000	20	20.0	_, AM
Black Berry	2004	2	100	0	0	---
Salal	2005	2	200	0	0	---
Blue Elderberry	2006	2	100	0	0	---
Milkflower Cotoneaster	2006	2	800	17	50.0	_, AM
Rockspray Cotoneaster	2006	3	1,200	0	0	---
English Holly	2006	1	400	0	0	---
Oregon Grape	2006	2	800	0	0	---

[a]Unidentified species; [b]New host record.

Table 6. Plants sampled and numbers of *Rhagoletis* pupae and adults from various fruit collected in Vancouver, Clark County, WA, Skamania, Skamania County, WA, and Portland, Multnomah County, OR, June to October 2005-2006

Plant Species	Sample Year	No. Plants	No. Fruit	No. Pupae	% Plants Infested	No. Adults
Apple	2005	47	1,733	1,032	93.6	43, AM
	2006	62	2,876	1,384	72.6	__, AM
Crabapple	2005	1	189	6	---	3, AM
	2006	10	950	169	60.0	__, AM
Flowering Crabapple	2006	10	4,543	9	20.0	__, AM
Black Hawthorn	2005	17	6,558	331	70.6	81, AM
	2006	22	11,170	293	68.2	__, AM
English Hawthorn	2005	54	33,165	2,393	87.0	847, AM
	2006	45	37,221	788	88.9	__, AM
Smooth Hawthorn[a]	2005	1	272	188	---	57, AM[a]
	2006	1	1,339	112	---	__, AM
Washington Hawthorn	2006	5	6,174	0	0	---
Cockspur Hawthorn	2006	6	831	4	≤50.0[b]	__, AM
Chinese Hawthorn	2006	1	123	0	---	---
Apricot[c]	2005	4	146	44	100.0	20, AM[c]
European Pear	2005	7	268	0	0	---
	2006	22	936	3	9.1	__, AM
Asian Pear	2006	8	314	100	37.5	__, AM
Garden Plum	2005	6	367	35	16.7	12, AM
	2006	20	1,095	107	40.0	__, AM
Japanese Plum[a]	2005	1	51	5	---	2, AM[a]

Sweet/Sour Cherry	2005	3	625	203	100.0	52, CFF
	2006	5	1,085	121	60.0	__, CFF
Bird Cherry	2006	10	5,632	451	20.0	__, CFF
Bitter Cherry	2006	12	2,287	264	≥41.7	__, CFF
Cherry Plum[c, a]	2005	3	201	28	66.7	9 AM[c], 1 CFF[a]
Cherry Laurel	2005	6	696	75	50.0	34, CFF
	2006	2	665	0	---	---
Portugal Laurel	2006	1	421	0	---	---
Roses[d]	2005	3	827	279	63.2	218, RM
	2006	5	726	102	80.0	__, RM
Firethorn	2006	5	3,495	0	0	---
Western Mountain Ash[a]	2005	1	552	8	---	8, AM[a]
	2006	41	47,046	2	4.9	__, AM
European Mountain Ash	2005	1	643	0	---	---
Cranberry Cotoneaster	2005	3	132	5	---	4, AM
	2006	1	475	0	---	---
Milkflower Cotoneaster[a]	2005	2	1,078	3	50.0	1, AM[a]
	2006	2	1,790	0	---	---
Rockspray Cotoneaster	2006	33	4,148	0	0	---
Littleleaf Cotoneaster	2006	6	1,816	0	---	---
Aronia Species	2006	5	1,547	0	---	---
Common Snowberry	2005	18	5,151	574	94.4	279, SBM
	2006	23	13,678	596	100.0	__, SBM
Blue Elderberry	2005	5	5,045	0	0	---
	2006	8	13,044	0	0	---
Orange Honeysuckle	2005	1	38	0	---	---
Honeysuckle[e]	2006	10	438	0	0	---
Twinberry	2006	1	368	0	---	---
Red-Flowering Currant	2006	4	4,614	0	0	---
Japanese Honeysuckle	2006	1	74	12	---	__, AM?
Highbush-Cranberry	2005	1	372	0	---	---
	2006	10	6,659	0	0	---
Western Viburnum	2006	4	561	0	0	---
Cornelian Cherry	2005	1	541	0	---	---
Pacific Dogwood	2005	2	2,875	0	0	---
	2006	4	1,319	0	0	---
Red Osier Dogwood	2005	1	694	0	---	---
	2006	18	15,100	25	22.2	__, DF
Japanese Dogwood	2006	7	450	0	0	---
Flowering Dogwood	2006	11	696	0	0	---
Cherry Olive	2005	1	446	0	---	---
	2006	2	665	0	0	---
Tall Oregon-Grape	2005	1	547	0	---	---
	2006	29	4,641	53	17.2	__, OGF
Dull Oregon-Grape	2005	1	252	82	---	56, OGF
	2006	9	899	0	----	---
English Walnut	2005	1	62	454	---	---[f], WHF
	2006	6	422	491	100.0	__, WHF
Black Walnut	2005	2	116	370	100.0	163, WHF[f]

	2006	6	273	110	16.7	__, WHF
Blueberry	2005	3	1,663	0	0	---
Grape	2005	2	1,060	0	0	---
	2006	8	6,497	0	0	---
Porcelainberry	2006	1	113	0	0	---
Cascara	2005	4	1,352	4	50.0	0
	2006	6	3,391	55	33.3	__, CFF
Bittersweet Night Shade	2005	1	571	0	---	---
	2006	13	3,968	0	0	---
English Yew	2005	1	228	0	---	---
	2006	8	419	0	0	---
Strawberry Madrone	2005	1	57	0	---	---
Pacific Madrone	2005	1	1,320	0	---	---
Camellia	2006	4	79	0	---	---
Salal	2006	18	4,649	0	0	---
Burning Bush	2006	1	411	0	---	---
Western Burning Bush	2006	1	63	0	---	---
Purple Beauty	2006	1	475	0	---	---

[a]New host record; [b]Tree samples pooled; [c]New Washington State record; [d]Nootka and Woods' roses combined; [e]Several unidentified species. [f]Combined for both walnut species.

Table 7. Complete updated list of 18 confirmed apple maggot developmental hosts in nature in Washington, 2002-2006

Common Name	Scientific Name	Family	WA Nativity
Apple	*Malus domestica* (Borkh.) Borkh.	Rosaceae	Introduced
Black Hawthorn	*Crataegus douglasii* Lindl.[b]	Rosaceae	Native
Black Hawthorn	*Crataegus suksdorfii* (Sarg.) Kruscke[b]	Rosaceae	Native
English Hawthorn	*Crataegus monogyna* Jacq.	Rosaceae	Introduced
Smooth Hawthorn	*Crataegus laevigata* (Poiret) DC.[c]	Rosaceae	Introduced
Cockspur Hawthorn	*Crataegus crus-galli* L.	Rosaceae	Introduced
Crabapples	*Malus* spp.	Rosaceae	Introduced
European Pear	*Pyrus communis* L.	Rosaceae	Introduced
Asian Pear	*Pyrus serotina* L.	Rosaceae	Introduced
Garden Plum	*Prunus domestica* L.	Rosaceae	Introduced
Japanese Plum	*Prunus salicina* Lindl.	Rosaceae	Introduced
Cherry Plum	*Prunus cerasifera* Ehrh.	Rosaceae	Introduced
Apricot	*Prunus armeniaca* L.	Rosaceae	Introduced
Bitter Cherry	*Prunus emarginata* (Dougl. ex Hook.) D. Dietr.	Rosaceae	Native
Western Mountain Ash	*Sorbus scopulina* Greene	Rosaceae	Native
European Mountain Ash	*Sorbus aucuparia* L.	Rosaceae	Introduced
Cranberry Cotoneaster	*Cotoneaster apiculatus* Rehd. & Wils.	Rosaceae	Introduced
Milkflower Cotoneaster[d]	*Cotoneaster lacteus* W. W. Smith	Rosaceae	Introduced

Aults were reared from all hosts; [a]Termed 'native' if in our Washington collection sites, but not exclusive to Washington; [b]Some authorities consider black hawthorns west of the Cascade Mountains to be *C. suksdorfii* (Sarg.) Kruscke (Love 1999); [c]Also known previously as *Crataegus oxyacantha* L.
[d]Still need confirmation, even though identified as this species.
Note: only apple and black hawthorn were infested in central Washington.