FINAL REPORT
WTFRC Project # AE-03-328 **Organization Project # 5352 22000 015 13T**

Project Title: Identification of extra-orchard host plants and habitats for key natural enemies of pome fruit pests suitable for manipulation or conservation

PI: Eugene Miliczky
Organization: USDA-ARS, Wapato, WA

CO-PI: David Horton, USDA-ARS, Wapato, WA

Contract Administrator: Janet Tsukahira, jtsukahira@pw.ars.usda.gov, (510) 559-6019

Objectives:

1. Assess the arthropod inhabitants of alder (*Alnus* spp.) leafrolls, especially with regard to beneficial insects that also occur in Washington orchards or may be of value in orchard biological control. Evaluate the potential of *Clubiona* spiders, common occupants of alder leafrolls, as predators of orchard pest leafrollers: PLR and OBLR.
2. Conduct a survey of native plant species for leafrolling caterpillars that may serve as alternate hosts for *Colpoclypeus florus*, an important parasite of orchard pest leafrollers; determine if non-pest leafrollers on native host plants harbor parasitoids of potential value in biological control of orchard pest leafrollers; test suitability of non-pest leafrollers from native host plants as hosts for *C. florus*.
3. Conclude western flower thrips/extra-orchard host plant survey by sampling a series of important WFT host plants that spans the season; assess numbers and occurrence of WFT and its predators on the plants.
4. Determine if the density of western flower thrips in apple blossoms varies as distance from adjacent extra-orchard habitat increases; does the level of WFT damage (pansy spot) vary as distance from extra-orchard habitat increases; assess the efficacy of field sampling for WFT by the blossom flick method to determine thrips densities in apple bloom.
5. Determine if psyllid species found on extra-orchard host plants are attacked by *Trechnites insidiosus*, a parasitoid of the pear psylla, or other parasitoid species.

Significant findings:

- Alders are heavily infested with leafrolling caterpillars and the leafrolls are occupied by a variety of beneficial arthropods. These include species of known importance in orchard biological control and species that may be of potential value to orchard biological control. Sac spiders in the genus *Clubiona* are frequently found in alder leafrolls. In laboratory trials *C. pacifica* was an effective predator of PLR and OBLR larvae on apple seedlings. Pupae and adults were also attacked and the spiders may occasionally feed on eggs. The alder leafrollers are parasitized by several kinds of wasps and flies.
- Western Flower Thrips density in apple blossoms showed a significant decline as distance from adjacent extra-orchard habitat increased. The decline was most marked between the orchard border and 30 feet into the orchard from the border. Incidence of thrips damage also showed a significant decline as distance into the orchard from the orchard border increased. Flick sampling for WFT was less than 100% effective at removing all thrips from the blossoms. Efficiency was poorest with pink stage blossoms but improved at each subsequent stage of bloom development – open king bloom, full bloom, and petal fall.

- Extra-orchard habitats rich in flowering plant species may allow the western flower thrips to pass through a continuous series of generations on native plant species as they successively come into flower. Thrips populations can in turn support important predators such as the minute pirate bug, *Orius*, and the small immatures of several kinds of spider.
- Many species of native plants found in extra-orchard habitats are hosts for leafrolling type caterpillars. Many of these caterpillars are attacked by parasitoid wasps and flies, some of which may be of potential value against orchard pest leafrollers. *Colpoclypeus florus* successfully parasitized 2 tortricid leafrollers from alder and one from dogwood in preliminary laboratory trials.
- Several species of psyllid found on extra-orchard host plants were found to be hosts for parasitoid wasps, although none yielded *Trechnites*.

Results and Discussion:

<u>Determine how the density of western flower thrips changes within the orchard as distance from adjacent native habitat increases, especially within 100' of the orchard border</u>: This study was conducted in collaboration with Steve Cockfield and Elizabeth Beers who sampled the 4 Wenatchee area orchards. The Western Flower Thrips, *Frankliniella occidentalis*, was the most abundant species by far in our samples, based on adult specimens. For example, other species comprised less than 2% of the 1,754 adult thrips taken in the 4 Yakima Valley orchards. WFT abundance varied widely among the 8 orchards with a 60-fold difference between the least and most densely populated blocks (Table 1). Immature thrips were detected in all orchards and tended to be more abundant in samples taken later in the bloom period. While not certain, it is likely that most immature thrips were *F. occidentalis*.

Table 1. Numbers of adult WFT taken at 4 Yakima and 4 Wenatchee area orchards in flower clusters at 6 distances from adjacent, non-orchard habitat. Thrips numbers at each distance are the totals for the collections made at pink, king bloom, full bloom, and 100% petal fall.

	Yak 1	**Yak 2**	**Yak 3**	**Yak 4**	**Wen 1**	**Wen 2**	**Wen 3**	**Wen 4**	**Totals**
Border	30	92	116	164	10	59	77	2	**550**
30'	13	79	92	141	5	43	34	8	**415**
60'	3	55	88	160	8	44	21	0	**379**
100'	2	31	66	178	5	29	19	2	**332**
200'	7	12	59	117	9	41	9	2	**256**
300'	4	16	58	146	11	15	30	1	**281**
Totals	**59**	**285**	**479**	**906**	**48**	**231**	**190**	**15**	**2213**

Western flower thrips density declined significantly as distance from non-orchard habitat increased for the full bloom samples (repeated measures ANOVA; P = 0.007) and the overall summed samples (P = 0.007). Furthermore, the density decline was most marked near the orchard border. Profile contrast analysis showed that a significant decline in thrips density occurred between the orchard border and 30' from the border for the full bloom sample (P = 0.035) and the overall summed sample (P = 0.013). A significant decline was also noted in the full bloom sample for the 60' vs. 100' comparison (P = 0.05).

Thrips damage due to pansy-spotting (Table 2) showed a significant decline with distance effect (repeated measures ANOVA: P = 0.013). The decline was most marked near the edge of the orchard (profile contrast analysis: border vs. 30'; P = 0.018). There was not always, however, a close correspondence between thrips density during bloom and the level of thrips damage observed in an orchard (Tables 3a and 3b). Damage in orchards with high thrips densities did not always exceed damage in orchards with considerably lower thrips densities, while, on the other hand, the orchard with the lowest thrips density had the 5th highest level of damage. Thrips density in an orchard during bloom appears to be a less than optimal predictor of damage. A possible contributing factor is that thrips activity in the orchard is not restricted to the immediate bloom period. Thrips are active outside the orchard throughout the season and they pass through numerous generations. Within the orchard, they are found on many of the flowering plants that occur as weeds or deliberately planted species such as dandelions, clovers, and mustards. Thrips are present in and around an orchard well after bloom and may continue to visit apples and perhaps cause damage by continued egg laying in the young fruit. Beers et al. (1993: Orchard pest management: a resource book for the Pacific Northwest) noted the poor correlation between thrips density and oviposition damage, as well.

Table 2. Number of apples showing thrips damage (pansy spot) in 4 Yakima and 4 Wenatchee area orchards at 6 distances from adjacent, non-orchard habitat. Sample size: 250 apples @ each distance.

	Yak 1	**Yak 2**	**Yak 3**	**Yak 4**	**Wen 1**	**Wen 2**	**Wen 3**	**Wen 4**	**Totals**
Border	15	12	34	22	12	10	17	16	**138**
30’	7	7	40	17	5	3	11	8	**98**
60’	7	11	38	10	10	0	7	11	**94**
100’	6	3	35	13	5	4	11	6	**83**
200’	4	4	42	20	12	0	12	7	**101**
300’	4	2	40	8	12	3	8	7	**84**
Totals	**43**	**39**	**229**	**90**	**56**	**20**	**66**	**55**	**598**

Table 3a. Total number of WFT collected per orchard ranked from highest to lowest with corresponding number of pansy spot damaged fruit.

Orchard	**Yak 4**	**Yak 3**	**Yak 2**	**Wen 2**	**Wen 3**	**Yak 1**	**Wen 1**	**Wen 4**
No. of Thrips	906	479	285	231	188	59	48	15
No. of damaged fruit	90	229	39	20	66	43	56	55

Table 3b. Orchards ranked from highest to lowest thrips density and corresponding ranking with regard to number of pansy spot damaged fruit.

Orchard	**Yak 4**	**Yak 3**	**Yak 2**	**Wen 2**	**Wen 3**	**Yak 1**	**Wen 1**	**Wen 4**
Thrips ranking	1	2	3	4	5	6	7	8
Damage ranking	2	1	7	8	3	6	4	5

<u>Efficacy of the “blossom flick” method of field sampling for Western Flower Thrips</u>: Flick sampling to determine thrips densities in apple flower clusters in the field was less than 100% effective in dislodging thrips from the bloom in our trials (Table 4). Efficiency of thrips dislodgement from flower clusters was lowest for clusters in the pink stage and a mean of only 43% (N = 4) of the thrips present in pink stage clusters was dislodged by flicking. However, flicking efficiency improved at each subsequent stage of flower cluster development and a mean of 91% (N = 6) of the thrips present in 100% petal fall clusters was dislodged by flicking.

Table 4. Number (%) of Western Flower Thrips removed from flower clusters (N = 25) in the field by the flick sampling technique and the number (%) undetected by flick sampling but removed from the same flower clusters by detergent sampling in the laboratory. One set of samples was taken along the orchard border and a second set was taken in the orchard interior, about 300’ from the border.

		BORDER				INTERIOR		
Orchard –stage		**Flick**	**Detergent**	**Total**		**Flick**	**Detergent**	**Total**
Yak 2 – king		12 (60%)	8 (40%)	20		3 (60%)	2 (40%)	5
Yak 2 – full		7 (70%)	3 (30%)	10		1 (25%)	3 (75%)	4
Yak 2 – petal		29 (94%)	2 (6%)	31		21 (95%)	1 (5%)	22
Yak 3 – pink		1 (20%)	4 (80%)	5		3 (43%)	4 (57%)	7
Yak 3 – king		4 (50%)	4 (50%)	8		0 (0%)	3 (100%)	3
Yak 3 – full		80 (77%)	24 (23%)	104		21 (72%)	8 (28%)	29
Yak 3 – petal		52 (95%)	3 (5%)	55		19 (90%)	2 (10%)	21
Yak 4 – pink		7 (50%)	7 (50%)	14		3 (50%)	3 (50%)	6
Yak 4 – king		13 (37%)	22 (63%)	35		5 (36%)	9 (64%)	14
Yak 4 – full		89 (86%)	14 (14%)	103		48 (84%)	9 (16%)	57
Yak 4 - petal		78 (87%)	12 (13%)	90		42 (93%)	3 (7%)	45

Arthropods associated with rolled leaves on alders (*Alnus* spp.): Thirty-two samples of rolled alder leaves were collected at 16 sites between 23 June and 9 September, 2004. Thirteen sites were in Yakima Co. along Highway 410 or subsidiary roads; 1 site, Cascade Park, was near the border between Yakima and Kittitas Counties; and 2 sites were in Chelan Co. along Highway 20 near Rainy Pass. Nine sites had not been sampled in previous years. Individual sites were sampled 1 to 5 times and the number of rolled leaves examined per sample ranged from 23 to 135.

Several types of predatory, parasitic, and plant-feeding arthropods were found at all or nearly all sample sites as shown in Table 5. Many of the gaps in the table could probably be filled in with additional sampling.

Table 5. Presence (+) or absence of plant feeding (upper half of table) and predatory and parasitic (lower half of table) arthropods in rolled alder leaves at 16 sites sampled in 2004.

Sample site[1]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Gelechiid LR	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tortricid LR	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Plant-feeding mites	+	+	+	+	+	+	+	+	+	+	+	+	+	+		
Thrips	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Aphids	+	+	+	+		+	+	+	+	+		+			+	+
Psyllid[2]	+	+	+	+	+	+	+	+	+	+		+	+	+		
Springtail		+	+	+	+		+	+	+	+	+	+	+	+		
Rust? mite		+	+	+	+	+	+	+	+	+	+	+	+	+		
Gelechiid parasitoids	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tortricid parasitoids		+	+				+									
***Clubiona* spiders**	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
other spiders	+	+	+	+	+	+	+	+		+	+	+		+		
Brown lacewing	+	+	+	+			+	+	+	+		+	+	+		
Green lacewing		+	+			+				+				+		+
***Anthocoris* bugs**	+	+	+	+	+		+	+		+	+	+	+			
***Deraeocoris* bugs**	+	+	+				+	+					+			
Predatory mites		+	+		+	+	+	+		+			+	+		+

[1] Site 1 – Cascade Park; Sites 2 through 14 located along Highway 410 and subsidiary roads all of which paralleled rivers or streams; Sites 15 and 16 along Highway 20 near Rainy Pass.
[2] By the time most samples were collected this single generation psyllid was evidenced primarily by cast skins and waxy deposits.

Alders were heavily infested with a number of species of leafrolling caterpillars at all sites. Two species in the family Gelechiidae were recognized, 1 of which was found on all 3 species of alder that were sampled – *Alnus incana*, *A. rubra*, and *A. sinuata*. The second gelechiid was largely restricted to *A. sinuata*, a species that we found most abundantly at our higher elevation sites. In addition, several species of leafrollers in the family Tortricidae occurred on the alder, one of which was quite common. This species was tested as a host for *Colpoclypeus florus* (see below) and is the subject of a new research proposal.

Plant-feeding mites were found on the vast majority of rolled leaves at most sites and more than 1 species was probably represented. Rust(?) mites were found on many rolled leaves especially later in the season when their numbers seemed to build up.

Thrips were found on nearly as many rolled leaves as phytophagous mites early in the season, but while the percentage of mite infested leaves remained high through August, thrips infestation declined in that month. More than one species of thrips was present, including probable predatory types, and both suborders of thrips were represented although the terebrantia (the group that includes the western flower thrips) was far more common.

Aphids were found on a low percentage of rolled leaves at most sites. Springtails were seen occasionally in the early part of the season but the number of infested leafrolls increased late in the season. Perhaps the senescing leaves were more attractive to these insects, many of which feed on decaying plant material.

Alder is of particular interest because of the large number of beneficial arthropods that colonize the plants some of which occurred in high numbers in some of our samples. Included in this group are a number of generalist predators that are also found in orchards where they prey on pest insects.

Brown and green lacewings were found in a small percentage of leafrolls at most sites. The former included *Hemerobius neadelphus* and the latter included *Chrysoperla plorabunda* (*carnea*) and *Chrysopa coloradensis*, all 3 of which occur in orchards as generalist predators of soft-bodied insects.

Predatory bugs found on the alders that also colonize orchards, where they prey on pest insects, included *Deraeocoris brevis* and *Anthocoris antevolens*. *D. brevis* occurred in low abundance at several of the sites but *A. antevolens* was more abundant and in several of our samples individuals were found in 5% to 10% of the leafrolls examined (19 of 45 leafrolls in 1 sample). We assume that an important prey item for both predators is the native psyllid found on the alders as both bugs are important predators of pear psylla in orchards.

Spiders were well represented in alder leafrolls with sac spiders in the genus *Clubiona* the most numerous. *Clubiona* have potential as leafroller predators (see below) and 2 species have been identified on alder. *C. pacifica* was the most commonly encountered but *C. moesta* was also found, and it has been taken in Washington orchards. Other spiders found on alder that also occur in Washington orchards include the jumping spiders *Pelegrina aeneola* (a dominant member of the spider fauna in some organic orchards) and *Eris militaris, Misumena vatia* (a crab spider), the cobweb weaver, *Enoplognatha ovata*, the line weaver, *Spirembolus mundus*, and the philodromid, *Philodromus rufus*.

The predatory mites included as the last item in Table 5 belong to the family Anystidae. They are distinctive rather large, long-legged, red mites that run swiftly and were observed preying on plant-feeding mites and their eggs. Other predatory mites of more typical appearance were probably present in the leafrolls but I did not distinguish them from the similar appearing phytophagous species.

Both the gelechiid and tortricid leafrollers served as hosts for a number of species of insect parasitoids and parasitism rates exceeded 10% in some samples. Ichneumonid, braconid, and chalcidoid wasps and tachinid flies were reared from the leafrollers and various stages of the leafrollers were attacked by different parasitoids. Some of the parasitoids, especially those that attack the alder tortricids, may potentially utilize orchard pest leafrollers as alternate hosts.

The importance of rolled leaves to a number of the plant-feeding and predatory arthropods was shown by collecting samples of rolled and unrolled leaves at 3 sites on 31 August. Similar numbers of both types of leaves were collected at the 3 sites and examined in the laboratory. Results of the comparison are shown in Table 6.

Table 6. Number of rolled and unrolled alder leaves on which various arthropod groups were found at 3 sites on 31 August 2004.

Site #	**1**	**1**		**2**	**2**		**3**	**3**
Type of leaf	**rolled**	**unrolled**		**rolled**	**unrolled**		**rolled**	**Unrolled**
# of leaves examined	**43**	**42**		**57**	**57**		**63**	**50**
# of leaves w/*Clubiona*	17	0		4	0		2	2
# w/other spiders	4	0		1	2		9	0
# w/spider spin-ups	14	0		26	0		13	0
# w/*Anthocoris*	2	0		5	0		0	0
# w/phytophagous mites	39	9		55	9		51	2
# w/thrips	4	1		6	0		9	3
# w/springtails	10	0		18	2		7	0
Rust (?) mites	11	18		7	54		45	42

Rolled alder leaves were colonized in greater numbers by most arthropod groups in Table 6 than were nearby unrolled leaves. Rolled leaves may offer certain advantages over unrolled leaves such as more constant and higher humidity, protection from direct sun, protection from wind and rain and perhaps protection from some predators (leafrolls are quite visible, however, and visually oriented predators may well cue in on rolled leaves). Rolled leaves are probably used by all these groups as protected sites for molting as evidenced by the large number of rolled leaves that contained cast spider skins. Shed *Anthocoris* skins were also frequently found in rolled leaves. Egg sacs of various spiders were found in rolled leaves, including *Clubiona*, and *Anthocoris* may used rolled leaves as a mating site as males and females were found in the same roll on a number of occasions. The rust (?) mite was one group that showed the opposite trend in 2 of the 3 samples and unrolled leaves colonized by the mites heavily outnumbered rolled leaves that were colonized.

Three species of alder were sampled in 2004: mountain or thin-leaf alder (*A. incana*), red alder (*A. rubra*), and sitka or wavy-leaved alder (*A. sinuata*). A fourth species, white alder (*A. rhombifolia*) also occurs in eastern Washington. The 3 sampled species occurred together at some sites but mountain alder was the most common species overall. Sitka alder was the dominant species at higher elevations according to our samples and red alder is the dominant species west of the Cascades. All three were infested with both tortricid and gelechiid leafrollers and most of the other arthropod groups listed in Table 5 were found on all 3 species as well. Sitka alder, however, was much less heavily infested with plant-feeding mites than the other 2 species.

<u>Preliminary screening of leafrollers from native plant species as possible alternate hosts for *Colpoclypeus florus*</u>: Seven species of leafrolling caterpillars from four native plants were exposed to *C. florus*, an important parasitoid of our pest leafrollers, in laboratory trials. The plants were among those known to usually be infested with leafrollers based on sampling in previous years. Results of the tests are summarized in Table 7

Table 7. Summary of acceptability tests of native leafrolling caterpillars as alternative hosts for the leafroller parasitoid, *Colpoclypeus florus*.

Host plant	**Leafroller family**	**# larvae exposed**	**# larvae parasitized**	**# *C. florus* adults/host**
Lupine	Unknown	7	0	--
Dogwood	Tortricidae sp.1	16	3	3-13
Dogwood	Tortricidae sp. 2	2	0	--
Alder	Gelechiidae	10	0	--
Alder	Tortricidae sp. 1	8	6	8-15
Alder	Tortricidae sp. 2	1	1	8
Strawberry	Tortricidae[1]	25	20	1-11

[1]Tentatively identified as the strawberry leafroller, *Ancylis comptana*.

The alder gelechiid and the lupine leafroller, also not a tortricid, were not accepted as hosts by *C. florus* in these tests whereas four of the tortricid species were parasitized. In the case of the leafroller from strawberry this would not be surprising if the species is, as it appears to be, the strawberry leafroller.

One additional similar test was run with a small, unidentified parasitoid wasp that attacks a small leafroller on rose. The leafroller, also unidentified, has been found at a couple of sites, may be quite abundant, and rate of parasitism is fairly high. Multiple adult parasitoids develop from a single host, as in *C. florus*. Adult parasitoids reared from the small rose leafroller were tested against PLR and tortricid leafrollers from alder, cottonwood, and dogwood. However, none of the leafrollers was parasitized.

<u>Tests of *Clubiona* spiders as predators of oblique-banded and pandemis leafroller larvae</u>: Four tests were conducted to evaluate the efficacy of *Clubiona* spiders as predators of pandemis and oblique-banded leafroller larvae. All adult spiders used in these tests were *C. pacifica* Banks, which is the species we have collected most frequently. Since conditions varied somewhat among the 4 tests each is described briefly and the results are summarized in the table below.

Test #1. This test utilized potted pear seedlings, 14” to 16” tall, inoculated with OBLR larvae and placed in cylindrical, clear plastic cages. There were 5 cages and one *Clubiona* spider was introduced into each cage. Two medium size immatures, 1 sub-male, and 2 females were used. A confounding factor in this test was that OBLR fared poorly on the pear plants. Some larvae appeared sickly, fed little, and died or became moribund before the end of the experiment. Also, the 3 immature *Clubiona* molted during the experiment and as a result would not have been actively hunting for at least a portion of the time during which the experiment was running. No definite predation could be attributed to these 3 spiders. One of the female spiders died during the experiment. The second female *Clubiona*, however, consumed all 4 OBLR larvae available to her. The only leafrollers alive at the end of the test were a large larva and a pupa, both in the cage occupied by the female spider that died.

Test #2. This test was run in a similar fashion to the first, except that apple seedlings inoculated with 5 pandemis larvae each, were used. There were 6 cages and each received 1 adult female *Clubiona*. All spiders had reached adulthood in the laboratory and were unmated. Only 2 PLR did not fall victim to spiders and they could not be accounted for at the end of the test. Two PLR reached the pupal stage but they also were located and consumed by spiders.

Test#3. For this test, a 3 ½ ‘ tall apple tree in a 5 gallon pot was inoculated with 24 OBLR larvae (4^{th} and 5^{th} instar). Nineteen larvae established on the plant, which was then enclosed in a large, organdy screen cage and 3 medium to large immature *Clubiona* added. The test was run for 19 days after which the cage was checked for surviving and dead OBLR. Twelve pupae and 1 large larva survived. Five larvae were definitely killed by the spiders and a 6th was a probable victim, thus accounting for all 19 OBLR. Only 1 *Clubiona* survived. This was a female which molted to the adult stage during the test. Two shed *Clubiona* skins were found as were several spider parts, the former indicating 2 spider molting events and the latter probably indicating that the surviving spider cannibalized 1 or both of the other 2 spiders.

Test #4. Five branches of a small apple tree in a 5 gallon pot were inoculated with 5 or 6 medium to large OBLR larvae apiece. The next day each branch was covered with a small screen cage and a female *Clubiona* introduced. The test was run for 14 days and the cages checked for predation. One spider died during the test and one failed to kill any OBLR. The other 3 spiders killed 1 or 2 OBLR apiece.

Table summarizing the results of the 4 *Clubiona* predation on leafroller experiments in 2004.

Test	**Host**	**# of Spiders**	**# of available LR's**	**# LR's predated (%)**	**# LR's surviving**
1	Pear	5	18	4 (22%)	2
2	Apple	6	27	25 (93%)	0
3	Apple	3	19	5 or 6 (26% or 32%)	13
4	Apple	5	17	5 (29%)	12
Totals	**--**	**19**	**81**	**39 or 40 (48% or 49%)**	**27**

Eighteen *Clubiona*, 6 females and 12 immatures of various sizes, were exposed to PLR egg masses to determine if the spiders showed any propensity to feed on eggs. One female *C. pacifica* completely consumed an egg mass that had been deposited on wax paper and a second female fed on a mass that had been deposited on the side of a plastic vial and consumed about 10% of the eggs. None of the other 16 spiders fed on the egg masses although most fed on newly eclosed neonate larvae.

Host plant suitability studies:

1) Apple as a host for the alder tortricid leafroller. Six medium to large, field collected alder tortricid leafroller larvae were placed on foliage of a small potted apple tree in the greenhouse on 29 July 2004. Six similar alder tortricid larvae were placed on a small potted alder tree to serve as an alder control. Finally, 6 PLR larvae from a laboratory colony, also of similar size, were placed on a small potted apple tree to serve as an apple control. Leafroller survival was evaluated on 10 August. None of the 6 alder tortricid larvae placed on apple was recovered and there had been very little feeding or leafrolling activity by the alder leafrollers. In contrast, 6 leafrolls were found on the alder plant that had been infested with alder leafrollers and there was feeding damage, some quite extensive, associated with each leafroll. One large larva and one pupa were recovered from the plant. Three large PLR larvae and 2 pupae were recovered from rolled leaves on the apple tree and at least 13 leaves were found that had feeding damage. These results, while preliminary, indicate that apple is probably not a suitable host plant for the alder tortricid leafroller.

2) Pear as a host for the alder tortricid leafroller. Three, small, potted, pear plants were each inoculated with 2 field-collected alder tortricid larvae and 2 OBLR larvae of comparable size from a laboratory colony for comparison. Larvae were small to medium sized, the latter being somewhat less than half grown. Larvae were preferentially placed on young, developing leaves of the plants on 21 July. A check on leafroller establishment the following day indicated some leafrolling activity on the young, terminal leaves of each of the 3 plants. On 6 October each plant and the cage in which they were kept were carefully examined for leafrollers, feeding damage, leafrolling activity, and frass. The oldest developmental stage recovered in this test was a dead, abnormally developed OBLR pupa in the spun-together, heavily fed-upon, terminal leaves of the plant. Other than this, individual examination of all leaves on the 3 test plants showed only 6 of 84 leaves with feeding damage, the largest of which was a rectangular area of 8mm x 10mm. A few leaves had a small amount of webbing present. Three, dead, OBLR larvae were also found but they had developed little. No alder

leafroller larvae were recovered. Again these results are preliminary but they indicate the unsuitability of pear as a host for the alder tortricid.

3) Alder as a host for PLR and OBLR. Fifteen small OBLR larvae (probable 2^{nd} and 3^{rd} instars) were placed on young, developing leaves of a potted mountain alder (*Alnus incana*) plant on 14 July 2004. Ten PLR of similar size were likewise placed on a second alder plant (fewer PLR were used because I had fewer available). Equal numbers of OBLR and PLR were placed on apple cuttings in vials of water as controls. The apple cuttings did not prove suitable for the leafrollers and none of them survived for more than a few days. The first check on leafroller survival on alder was made on 30 July. One OBLR pupa and 5 feeding larvae in leafrolls were found as well as extensive feeding damage and frass. No PLR larvae or pupae were found, however, and there was little evidence of feeding and very little frass. Final evaluation of leafroller survival on alder was made on 6 August when 4 normal OBLR pupae were found in leafrolls but no PLR of any stage were present. These results, while preliminary, indicate the probable suitability of *Alnus incana* as a host for OBLR. While PLR did poorly on alder in this test, *A. incana* and *A. rubra* have been listed as host plants for this species (Miller, J. C. 2003. Lepidoptera of the Pacific Northwest: caterpillars and adults. FHTET-2003-03, USDA-Forest Service).

<u>Survey of extra-orchard host plants for leaf-rolling caterpillars</u>: The leafroller on extra-orchard host plant survey was completed in 2004 when 145 samples of foliage apparently infested with leafrolling caterpillars were collected and reared. Collections were made from 29 plant species and moths were obtained from 24 species. Some of the moths are tortricids. Parasitoids were reared from the leafroller material from 8 host plants: lupine, willow, paintbrush, tall buckwheat, chokecherry, dogwood, cottonwood, and Ceanothus. Most parasitoids were wasps, but wasps and a tachinid fly were obtained from leafroller material found on tall buckwheat. Insects obtained from stinging nettle proved to be butterflies and a web-spinning sawfly was obtained from rose. Overall, 102 moths or their parasitoids were obtained from the 145 specimens that were collected in 2004, a rearing success rate of 70%. In addition to this material many specimens from the alder work were reared. Parasitoids of both the tortricid and gelechiid leafrollers were obtained and some hyperparasitoids as well. Several species, including wasps and tachinid flies, were found to attack the alder leafrollers.

Budget

Project title: Identification of extra-orchard host plants and habitats for key natural enemies of pome fruit pests suitable for manipulation or conservation

PI: Eugene Miliczky

Project Duration: 2003-2004

Project Total (2 years): $66,700

Item	Year 1 (2003)	Year 2 (2004)
Salaries[1]	$23,407	$25,790
Benefits (35.7%)[2]	$8,293	$9,210
Total	$31,700	$35,000

[1]Post-doc, Eugene Miliczky, 0.51 FTE (12 months)
[2]Benefits, Eugene Miliczky, 0.51 FTE (12 months)