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Animal and Plant
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Plant Protection
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Rhagoletis cerasi (Linnaeus)

European cherry fruit fly

Diptera: Tephritidae

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Synonyms: None. While there are some historical names listed as synonyms, none have been considered to be of importance or in regular use since at least 1900 (CABI, 2016).

In Europe, *Rhagoletis cerasi* was thought to have two geographic races, referred to as northern and southern races. The southern race is found in Italy, Switzerland, southern Germany, southwestern France, and southern parts of Austria; the northern race ranges north of those parts from the Atlantic Ocean to the Black Sea (White and Elson-Harris, 1992). However, it was determined that these "races" were actually differences in the *Wolbachia* bacterium carried by the fruit fly. Boller et al. (1976) found unidirectional mating incompatibility between the two races. This causes southern females and northern males to be interfertile and crosses between southern males and northern females to be sterile (Riegler and Stauffer, 2002; Schuler et al., 2016).

Prevalence and global distribution: Asia – Georgia (Republic of) (CABI, 2016), Iran (CABI, 2016), Kazakhstan (CABI, 2016), Kyrgyzstan (CABI, 2016), Tajikistan (CABI, 2016), Turkey (Kovanci and Kovanci, 2006b), Turkmenistan (CABI, 2016),Uzbekistan (CABI, 2016); **Europe –** Austria (Boller et al., 1976), Belgium (CABI, 2016), Bulgaria (Boller et al., 1976), Croatia (Riegler and Stauffer, 2002), Czech Republic (Riegler and Stauffer, 2002), Czechoslovakia (former) (Baker and Miller, 1978), Denmark (CABI, 2016), Estonia (CABI, 2016), France (Boller et al., 1976), Germany (Boller et al., 1976), Greece (Boller et al., 1976), Hungary (Boller et al., 1976), Italy (Boller et al., 1976), Latvia (Stalažs, 2012), Lithuania (White and Elson-Harris, 1992), Moldova (CABI, 2016), Netherlands (Boller et al., 1976), Norway (Jaastad, 1994), Poland (Boller et al., 1976), Portugal (CABI, 2016), Romania (Boller et al., 1976), Russia (White and Elson-Harris, 1992) (Eastern Siberia, Russia (Europe), Siberia, Western Siberia [CABI, 2016]), Serbia (Stamenković et al., 2012), Slovakia (Boller et al., 1976), Slovenia (Riegler and Stauffer, 2002), Spain (Boller et al., 1976), Sweden (White and Elson-Harris, 1992), Switzerland (Jaastad, 1998), Ukraine (Riegler and Stauffer, 2002), Yugoslavia (Boller et al., 1976).

Host range: Caprifoliaceae – *Lonicera tatarica* (Boller and Prokopy, 1976; Daniel and Grunder, 2012), *Lonicera xylosteum* (honeysuckle) (Boller et al., 1998; Jaastad, 1998); **Rosaceae** - *Prunus avium* (sweet cherry) (Daniel and Grunder, 2012; Kovanci and Kovanci, 2006b), *Prunus cerasus* (sour cherry) (Boller and Bush, 1974; Daniel and Grunder, 2012), *Prunus mahaleb* (mahaleb cherry) (Boller and Bush, 1974; Daniel and Grunder, 2012), *Prunus serotina* (black cherry) (Daniel and Grunder, 2012).

Higher population levels are generally observed in sweet cherry orchards, and sour cherry orchards generally do not incur as high infestation levels (Daniel and Grunder, 2012). Sour cherries may provide an alternative oviposition site when sweet cherries are harvested or highly infested (Kovanci and Kovanci, 2006a). *Rhagoletis cerasi* may also move on to *Lonicera* berries after cherries have been exhausted for oviposition or harvested (Boller et al., 1998; Daniel and Grunder, 2012). Flies that emerge from *Lonicera* berries show a strong preference for ovipositioning in *Lonicera* (Boller et al., 1998) and are less likely to serve as a secondary source for reinfestation (Daniel and Grunder, 2012). *Rhagoletis cerasi* has also been reported infesting *Berberis vulgaris* (Hendel, 1927 as referenced by CABI, 2016), *Lycium barbarum*, and *Vaccinium myrtillus* (Phillips, 1947 as referenced by CABI, 2016), though these appear to be misidentifications or casual observations (CABI, 2016; White and Elson-Harris, 1992) and are not considered host plants.

Biology: *Rhagoletis cerasi* has one generation per year and a narrow host range (Boller et al., 1976; Daniel and Grunder, 2012). Overwintering is obligatory and occurs in the soil near host plants as pupae (Daniel and Grunder, 2012). Single eggs are deposited in each fruit, which are then marked with a pheromone that repels other ovipositing females to maximize use of the host resources (Daniel and Grunder, 2012). Adult emergence is based on spring soil temperatures, overwintering temperatures, host plants the pupae originated from, and geographic location (Daniel and Grunder, 2012). The lifespan under field conditions is likely between four to seven weeks (Daniel and Grunder, 2012). A mating pheromone is used, though it does not appear to have attraction properties over longer distances (Daniel and Grunder, 2012). Cherry fruit that is changing from green to yellow, with a hardened pit and at least 5 mm pulp-thickness, is preferred for oviposition (Daniel and Grunder, 2012). Egg laying begins as soon as fruit begins to change color and continues until harvest (Höhn et al., 2012). In the field, fecundity ranges from 30 to 200 eggs per female (Daniel and Grunder, 2012). Larvae tunnel through the cherry fruit, consuming the pulp (Daniel and Grunder, 2012). Mature larvae exit fruit, generally near the stem, around harvest time, to pupate in the soil (Daniel and Grunder, 2012). A chilling period of approximately 180 days below 5 °C is required for maximum adult emergence (Daniel and Grunder, 2012). Some pupae may remain in diapause for an additional year or more (Daniel and Grunder, 2012). Population densities in Europe cycle, with four to five year periods of high densities followed by a period of very low density (Daniel and Grunder, 2012).

Rhagoletis cerasi populations are infected with multiple strains of *Wolbachia*, a bacterium that is maternally inherited (Arthofer et al., 2009). The wCer2 strain of *Wolbachia* is widespread in the southern European population and causes unidirectional cytoplasmic incompatibility with the northern population. Southern females produce viable offspring with northern males, but progeny of southern males and northern females are sterile (Arthofer et al., 2009; Riegler and Stauffer, 2002).

Rhagoletis cerasi occurs on two host plants, *Prunus* and *Lonicera* (Boller et al., 1998; Boller and Bush, 1974), which have been described as potential host races due to the populations having different emergence times that could be the result of an adaptation to the host plants (Boller and Bush, 1974). Experiments in crossing the *Prunus* and *Lonicera* races have demonstrated no evidence of incompatibility (Boller and Bush, 1974), and a genetic study has found no allele patterns suggestive of host races (Schwarz et al., 2003). Adults show a strong preference to oviposition in the same host (cherry or *Lonicera* berries) from which they emerged (Boller et al., 1998; Daniel and Grunder, 2012), though adult *R. cerasi* move to neighboring trees of later-ripening varieties or *Lonicera* spp. bushes in search of suitable oviposition sites (Daniel and Grunder, 2012). Populations growing on *Lonicera* spp. in the shady forest edge have later emergence, flight, and oviposition periods than populations growing in cherry orchards (Boller et al., 1998).

Similar species in the United States: We have several other *Rhagoletis* species that also infest sweet and sour cherries already present and requiring control measures in the United States. *Rhagoletis cingulata* (eastern United States and Canada to central Mexico) and *R. indifferens* (northwestern United States and southwestern Canada) are already established in the North American Plant Protection Organization (NAPPO) region as significant pests of sweet and sour cherry production (Yee et al., 2013). *Rhagoletis cingulata* was first detected in Europe in 1983 and can be found in some of the same European regions as *R. cerasi* (Egartner et al., 2010; Lampe et al., 2005). *Rhagoletis indifferens* has not been detected outside of North America (Egartner et al., 2010; Yee et al., 2013). *Rhagoletis fausta* also infests sweet and sour cherries and is present in North America (Yee et al., 2013). It is not, however, closely related to *R. cingulata* and *R. indifferens*, and does not appear to be as economically significant in cherry production (Yee et al., 2013). If *R. cerasi* were to establish in the United States, it is uncertain whether control measures already in place for other *Rhagoletis* species would be as effective for mitigating impacts, or if additional actions would be required.

Known pest status: *Rhagoletis cerasi* is considered the most important pest of sweet cherries in Europe. Without effective control measures, up to 100 percent of sweet cherry fruit may be infested (Daniel and Grunder, 2012). Sour cherries may also be damaged, though unprotected infestation rates are closer to 30 percent (Olszak and Maciesiak, 2004). Backyard cherry orchards are more likely to be impacted by *R. cerasi* infestations than larger commercial orchards due to fewer control measures being implemented. In Serbia, up to 10 percent of cherries in commercial production are damaged, and up to 100 percent in orchards or solitary trees without conventional control measures in place (Stamenković et al., 2012). Damage thresholds related to infestations of *R. cerasi* may vary based on market order. Based on reports in the literature, they typically range from 2 to 4 percent of marketable fruit for consumption and up to 6 percent for industrial processing (UNECE, 2010; Stamenković et al., 2012). It is unclear where rejected cherries are diverted to, but it is reported that this results in significant economic impacts for growers (Stamenković et al., 2012).

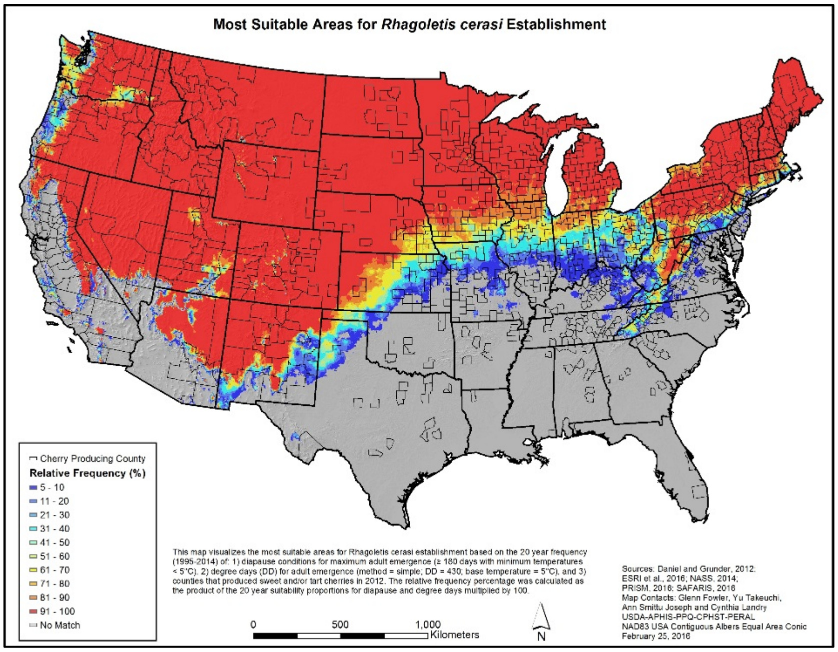
Potential pathways of introduction: At this time, there are no clear open pathways for introduction of *R. cerasi* into the United States. The most likely pathway for introduction of *R. cerasi* into the United States is through the importation of infested cherry fruit; however, there is no indication of an open commercial pathway of commercial cherry fruit imported from regions where *R. cerasi* is known to be established. Cherries (*Prunus avium*) may be imported into all U.S. ports from Argentina, Australia (including Tasmania), Canada, Chile, and New Zealand (APHIS, 2016a). The Republic of Korea and Japan (except for Amami, Bonin, Ryukyu, Tokara, and Volcano Islands) may export to Guam and the Northern Mariana Islands, and South Africa may export to ports within the continental United States (APHIS, 2016a). Cherries grown in fruit fly free areas of Mexico may export to all U.S. ports; cherries grown outside of fruit fly free areas may export to North Atlantic ports only, with cold treatment (APHIS, 2016a). *Rhagoletis cerasi* is not known to be established in any of these regions from which cherry imports are permitted. Between 1988 and 2015, *R. cerasi* immatures have been intercepted 113 times in fruit in baggage at U.S. ports of entry (PestID, 2016). The risk of establishment based on larvae in baggage is likely to be low; larvae would have to emerge from the cherries, mature, and find suitable mates and host plants (i.e., infested cherries would need to be placed near host plants).

It is also possible that pupae within the soil accompanying plants for planting could transport *Rhagoletis* spp. long distances (CABI and EPPO, 2004). However, given the limited mobility of larvae prior to pupation in the soil, trees would have to be fruit bearing prior to shipment and accompanied by soil in order for pupae to be in the soil beneath. Some *Prunus* propagative material is imported from European countries, though under strict regulations that would prevent an introduction of *R. cerasi* (among other pests) into the United States (Podleckis, 2016). Most *Prunus* material that enters the United States is imported as dormant bud stick or as bare root trees, and is subject to size regulations for Asian longhorned beetle and citrus longhorned beetle (Podleckis, 2016; PPQ, 2016). It is therefore highly unlikely that *R. cerasi* would be introduced into the United States with propagative material.

The potential for an open pathway for introduction would increase if *R. cerasi* were confirmed in Canada. In 2015, Canada exported $25.8 million worth of fresh cherries for consumption into the United States (FAS, 2016). Inspection may not be sufficient for detecting infested cherries, as only fruits with a fully grown larva will show clear symptoms of being less firm (Caruso and Cera, 2004). Additionally, while likely a limited risk, there is also the possibility of a slow natural spread of *R. cerasi* from Canada into the United States, particularly if there are cherry production fields near the border.

If *R. cerasi* is confirmed to be present in Canada, it is possible that it was imported with fresh cherry fruit from areas in Europe where it is known to occur. Based on available information regarding the import regulations for Canada, at this time fresh cherry fruit is allowed from Belgium, France, Greece, Hungary, Italy, Switzerland, Turkey, and former Yugoslavia with no specific plant protection requirements (CFIA, 2016). However, we do not know whether or not fresh cherry fruit is currently being imported from these areas.

Potential distribution in the United States and spread: *Rhagoletis cerasi* requires 430 degree days above a base developmental temperature of 5 °C for adult emergence (Daniel and Grunder, 2012). Additionally, multiple studies regarding the obligatory winter diapause indicate that maximum emergence of adults occurred in association with 180 days below 5 °C (Daniel and Grunder, 2012). The above data were combined in order to develop the predictive map of the most suitable areas for *R. cerasi* establishment shown below (Fowler et al., 2016). The potential for establishment of *R. cerasi* is highest in the red regions, and considered very low to negligible for the gray. Counties in the conterminous United States that produce cherries are most at risk and are outlined below.



Adults rarely move far from their host plants, though some dispersive flights do occur when nearby host resources are depleted (Boller et al., 1976). Dispersal flights are likely to only occur when fruits suitable for oviposition are not available (e.g., cherries destroyed by frost or early harvest, or already marked with host-marking pheromone) (Daniel and Grunder, 2012). Within orchards, adult *R. cerasi* may move to neighboring trees of later-ripening varieties or *Lonicera* spp. bushes in search of suitable oviposition sites (Daniel and Grunder, 2012). Daniel and Baker (2013) reviewed the current knowledge of *R. cerasi* spread and reported that while it can fly more than one kilometer in 24 hours in the laboratory, the majority of flies in the field move less than 100 meters, and none more than 600 meters. Wind may also play a role in the local spread of *R. cerasi* adults (Daniel and Baker, 2013). The spread of *R. cerasi* in the United States would likely be slowed by both the lack of self-motility and also the current domestic restrictions on movement of cherry fruit due to the presence of *R. indifferens* and *R. cingulata* (Yee et al., 2013). Within the United States, Florida, Idaho, and California have implemented regulations for importation of host commodities associated with *R. cingulata*, *R. indifferens*, and *R. fausta* (Yee et al., 2013).

Detection: The timing of the infestation and subsequent harvest of cherries can make detection of infested fruit difficult. The initial emergence of adult flies can vary significantly depending on climate, altitude, latitude, slope, and other environmental factors (Daniel and Grunder, 2012). Damaged fruits are not always easily detectable, as only fruits with a fully grown larva will show clear symptoms of being less firm (Caruso and Cera, 2004). Yellow sticky traps are commonly used and are the recommended type of trap for monitoring adults of *R. cerasi* (Daniel and Baker, 2013; Kovanci and Kovanci, 2006a; Russ et al., 1973), though they are unreliable for detecting first adult emergence where populations are low (Kovanci and Kovanci, 2006b). Lampe et al. (2005) noted that in areas where both species are present in Europe, Pherocon ® AM Traps widely used in the United States are more effective for monitoring adult flight of *R. cingulata*; Rebell ® Yellow Traps as used in Europe are more effective for monitoring *R. cerasi.* Researchers in Europe continue to work to develop the most effective trap size, shape, and color for monitoring adult emergence and presence/absence of *R. cerasi* (Daniel et al., 2014). While trap shape appears to be minimally important to fly capture rates, a cylinder shape with a height of 20 cm and circumference of 54 cm was shown to have the best economic and practical considerations (Daniel et al., 2014). Updated trap densities for *Rhagoletis* spp. are included on page 18 of the FAO IAEA Trapping Manual for Area-Wide Fruit Fly Programs (FAO and IAEA, 2013), indicating both trap types and densities and attractant recommendations for a variety of monitoring, detection, and control scenarios. A mating pheromone is used, though it does not appear to have attraction properties over longer distances. Additional research may result in more effective traps (Daniel and Grunder, 2012). *Rhagoletis cerasi* can be differentiated from other fruit flies morphologically (Daniel and Grunder, 2012).

Rhagoletis cerasi is listed in the CAPS Stone Fruit Survey Guidelines (CAPS, 2012). The current CAPS-approved survey method includes the use of a yellow sticky card baited with ammonium acetate and protein hydrolysate embedded in the adhesive (CAPS, 2012).

Control: The establishment of *R. cerasi* in the United States would likely require additional control measures beyond those already in place in cherry production. The *Rhagoletis* species already present in the United States are controlled through rigorous IPM processes, and conventionally produced sweet cherries are rarely infested (Smith and Kupferman, 2002). In Europe, *R. cerasi* is the only insect pest of cherry that requires treatment of fruit (Daniel and Baker, 2013). Timing of measures is critical to obtain sufficient control to reduce impacts in the fruit. Peak activity of the American cherry fruit fly (*Rhagoletis cingulata*) occurs two weeks later than the peak activity of *R. cerasi* (Daniel and Grunder, 2012). Peak activity of *R. indifferens* may also vary from these species. Additionally, the American cherry fruit fly tends to more frequently infest sour cherry species, while the European cherry fruit fly infests sweeter cherry species (Lampe et al., 2005). However, chemical control measures do appear highly effective when properly timed and applied. In European commercial orchards where conventional insecticides were used, damage attributed to *R. cerasi* infestations was less than 0.1 percent (Kovanci and Kovanci, 2006b). The commercial orchards received six to seven applications of malathion throughout the season (Kovanci and Kovanci, 2006b). In Europe, neonicotinoids and pyrethroids were noted as the most commonly used chemical control measure against *R. cerasi* in cherry production (Daniel and Grunder, 2012). In the United States, careful planning and monitoring is required to sufficiently manage the *Rhagoletis* species already present (Smith and Kupferman, 2002). Additional measures are likely to be required to continue to be able to meet various infestation thresholds, such as the zero tolerance level seen in Washington for fruit fly infestations (Smith and Kupferman, 2002).

The application of an entomopathogenic fungi, *Beauveria bassiana*, is an effective control measure used in organic cherry production during the flight period of *R. cerasi* (Daniel and Wyss, 2010). Netting to cover the soil in smaller-scale organic cherry production was found to significantly reduce flight activity and fruit infestation by *R. cerasi* (Daniel and Baker, 2013). Exclusion netting (1.3 mm net) placed on the cherry trees has also shown to be as effective as some chemical control measures (Brand et al., 2013; Grassi et al., 2010; Höhn et al., 2012; Ughini et al., 2010). Nets must be placed as early as possible after the first adult capture or when the fruit color changes, and remain in place until harvest (Höhn et al., 2012; Ughini et al., 2010). Early and complete harvest of cherries was the most effective control before insecticides were available (Daniel and Grunder, 2012). Mass trapping using yellow sticky traps and/or baits have also shown to be economically prohibitive in commercial cherry production (Daniel and Grunder, 2012) but are widely used in organic cherry production (Daniel and Grunder, 2012; Daniel and Wyss, 2010).

Orchard management is also important to minimize impacts from *R. cerasi* infestations. This may include pruning of trees to 10 m in order to improve spray coverage and facilitate the early and complete harvest of fruit; choosing varieties that further facilitate early harvest, including varieties that are suitable for mechanical harvest; and not dropping infested fruit on the ground. Allowing grass under trees to grow may further delay adult emergence by 10 days (Daniel and Grunder, 2012).

Chemical management used in Europe to control *R. cerasi* in commercial orchards includes acetamiprid, alpha-cypermethrin, bifenthrin, cypermethrin, deltamethrin, dimethoate, etofenprox, fosmet, gamma-cyhalothrin, lambda-cyhalothrin (bait sprays), lambda-cyhalothrin, malathion, methomyl, pyrethroids, thiacloprid, thiamethoxam, and zeta-cypermethrin. In organic orchards, management includes azadirachtin, *Beauveria bassiana*, pyrethrum, and spinosad (Daniel and Grunder, 2012). From these measures, acetamiprid, dimethoate, gamma-cyhalothrin, lambda-cyhalothrin, malathion, thiamethoxam, zeta-cypermethrin, azadirachtin, *Beauveria bassiana*, and spinosad are currently labeled for use in sweet and/or sour cherry production in the United States (CDMS, 2016). A study comparing efficacy of thiamethoxam and acetamiprid against the former standard dimethoate, which is no longer registered for use in some countries due to ecotoxicity and residues on fruit, found all three were effective (Höhn et al., 2012).

Some biological control measures such as viruses, bacteria, entomopathogenic nematodes, parasitoids, and predators have either not been shown to be effective or not been researched enough to determine effectiveness against *R. cerasi* (Daniel and Grunder, 2012). Sterile insect technique was researched, developed, and found to be an effective control measure between 1960 and 1980 (Daniel and Grunder, 2012). However, the life cycle of *R. cerasi* (e.g., univoltine, obligatory diapause) complicated rearing and inhibited commercial use (Daniel and Grunder, 2012). Bait sprays are more effective in isolated orchards where risk of reinfestation from surrounding areas is minimal, or as part of an area-wide treatment (Böckmann et al., 2013).

Potential economic impacts: A predictive pest impact assessment conducted and reviewed by analysts within PPQ-CPHST-PERAL determined that *R. cerasi* would be a high-impact pest in both unmitigated and mitigated systems (PERAL, 2016). This pest is difficult to control and can cause significant damage to the value of the fruit. It is a well-studied species and is considered a serious pest in the scientific literature (PERAL, 2016). After consideration of current U.S. conditions, the predicted impact for this pest remains high in mitigated systems. While control measures for American cherry fruit fly species (*R. cingulata* and *R. indifferens*) are currently in place, phenological differences will likely necessitate additional control measures for *R. cerasi*. Additionally, the potential phase-out of broad-spectrum insecticides may ultimately increase the cost and difficulty of controlling both American and European species (PERAL, 2016). Typically, *R. cerasi* has been controlled with broad-spectrum insecticides such as Dimethoate. However, as these insecticides are being phased out of use due to ecotoxicity and residual persistence concerns, control is likely to become more difficult and more expensive. If *R. cerasi* became established in the United States, it would likely require additional controls beyond what is already in place in U.S. cherry production. Phenological differences between American cherry fruit fly species and the European cherry fruit fly will likely require growers to spray insecticides more often in order to control all pests (PERAL, 2016).

The value of fresh sweet cherry production in the United States in 2014 totaled $705.5 million, and fresh sour cherry production totaled $2.4 million (NASS, 2016). Even in conventional commercial production of cherries in Europe, up to 10 percent of the fruit has been damaged (Stamenković et al., 2012). Although infestation rates normally remain below 20 percent in Europe, the market is reported to reject the whole lot if infestation exceeds 2 percent (Daniel and Grunder, 2012). After being rejected as fresh cherries for consumption, the lot is likely sold as distilling cherries at a significant reduction in price (Daniel and Grunder, 2012). The United States also has very low tolerance levels for *Rhagoletis* infestations in fresh cherry fruit, as can be seen in the zero tolerance level in fruit produced in Washington State for export to California or foreign countries (Smith and Kupferman, 2002). When a single *R. indifferens* larvae is found (reportedly five to twenty times per season), the entire shipment is rejected and inspection efforts are increased (Smith and Kupferman, 2002).

Trade implications: *Rhagoletis cerasi* is considered a regulated organism by Algeria, Argentina, Canada, Honduras, India, Indonesia, Japan, Jordan, Republic of Korea, Madagascar, Mauritius, Morocco, Namibia, Nigeria, South Africa, Taiwan, Thailand, and Timor-Leste (PExD, 2016). In 2015, the United States exported fresh cherry fruit valued at $431 million (FAS, 2016) to many different countries. Table 1 includes exports that exceeded $1 million in 2015, the full list of exports are included in table form in the Appendix. Notably, significant amounts of cherry fruit were exported to multiple countries in which *R. cerasi* is considered a regulated organism including Canada (valued at $109 million in 2015), South Korea ($108 million), Japan ($32 million), Taiwan ($31 million), and Thailand ($5.5 million) (FAS, 2016).

Table 1. Value of fresh cherry exports from the United States that exceed $1 million (FAS, 2016; queried February 17, 2016). These values may include fresh organically produced cherries, conventionally produced sweet cherries, and/or conventionally produced sour cherries.

Trading Partner	Total Cherry Exports Value	Regulated organism
Canada	2015: $109 million	Yes
South Korea	2015: $108 million	Yes
China	2015: $65 million	
Hong Kong	2015: $43 million	
Japan	2015: $32 million	Yes
Taiwan	2015: $31 million	Yes
Australia	2015: $22 million	
Mexico	2015: $6.3 million	
Thailand	2015: $5.5 million	Yes
Singapore	2015: $3.3 million	
United Kingdom	2015: $2.8 million	
Vietnam	2015: $2.7 million	
Netherlands	2015: $2.3 million	*R. cerasi* is present in country
Malaysia	2015: $1.5 million	
Norway	2015: $1.3 million	*R. cerasi* is present in country

A search of the Phytosanitary Certificate Issuance and Tracking System (APHIS, 2016b) indicates that several of the countries to which the United States exports fresh cherry fruit already require a systems approach and phytosanitary declaration of freedom from the *Rhagoletis* species already present here (e.g., South Korea, Taiwan). However, based on the presence of *R. indifferens* and *R. cingulata* in cherry production areas in the United States, the introduction of *R. cerasi* is not likely to significantly affect international export of cherry fruit unless it is found in the United States prior to being confirmed in Canada. *Rhagoletis indifferens* and *R. cingulata* are both already present in both the United States and Canada. The establishment of *R. cerasi* in the United States without being present in Canada may significantly affect the export of fresh fruit.

Domestic movement of cherry fruit could be impacted, based on the presence of *R. indifferens* and *R. cingulata* (Yee et al., 2013). Florida regulates all host fruit or articles that may be infested by *Rhagoletis* spp. (FDACS, 2016). The California Department of Food and Agriculture also maintains exterior and interior quarantines for cherry fruit flies in the United States (CDFA, 2016). The introduction of *R. cerasi*, which could result in a need for additional cherry fruit fly control measures in the United States, may initiate additional state quarantines in attempt to reduce the spread.

Potential environmental impacts: Similarly to *R. cingulata*, ecological impacts associated with establishment of *R. cerasi* in the United States are considered unlikely. The viability of the seed within the fruit is not affected by infestation, and the fruit remains suitable for consumption by animals (EFSA, 2014). Trees grown for ornamental purposes are also unlikely to be significantly affected, as they are not grown for fruit. However, the addition of specific control measures for *R. cerasi* may impact the environment. Control measures are necessary to achieve marketable fruit with very little to no larval infestation rates, and timing with annual emergence of the adults is critical in obtaining sufficient control (Daniel and Grunder, 2012). Given that *R. cerasi* emerges two weeks earlier than *R. cingulata*, there may therefore be additional control needs, including chemical sprays on the fruit. Control measures used in organic cherry production are less likely to affect the environment.

Uncertainty: It is uncertain whether control measures already in place for *R. indifferens* and *R. cingulata* in both conventional and organic cherry production would also be effective if *R. cerasi* were introduced into the United States. Additional measures and adjustment to the timing of the measures would likely need to be implemented. It is uncertain whether the trapping and monitoring methods already in place for *Rhagoletis* species in the United States would be as effective as those methods used in Europe for *R. cerasi*. If *R. cerasi* were to become established in the United States, hybridization with the American cherry fruit fly (*R. cingulata*) could occur, thereby potentially facilitating new pest dynamics, including host preferences, flight periods, and life cycle (Johannesen et al., 2013). *Lonicera* spp. growing on forest edges in close proximity to cherry orchards can support large populations of *R. cerasi* and could serve as a potential reservoir for reinfestations of cherry orchards after a successful eradication initiative (Boller and Bush, 1974), though there is no research confirming the *R. cerasi* populations on *Lonicera* switch to *Prunus* host plants.

The level of interspecific competition that may occur should *R. cerasi* be introduced into the native ranges of *R. cingulata* and *R. indifferens* in North America is unclear. The earlier oviposition and subsequent pheromone deterrent fruit marking of *R. cerasi* over *R. cingulata* suggests that *R. cerasi* may be able to infest more fruit and develop larger populations more quickly than *R. cingulata* (Egartner et al., 2010); however, earlier studies indicated that different species did not recognize other marking pheromones (Prokopy et al., 1976). Furthermore, *R. cingulata* produces more eggs and has a faster larval development period than *R. cerasi*, which would likely minimize advantages of *R. cerasi* over *R. cingulata* (Egartner et al., 2010). *Rhagoletis cingulata* and *R. indifferens* also emerge at different times than *R. cerasi*, potentially complicating control measures and the need for additional sprays (Egartner et al., 2010). *Rhagoletis cerasi* requires 430 degree days above 5 °C (Daniel and Grunder, 2012), while *R. cingulata* requires 950 degree days above 4.4 °C and *R. indifferens* requires 462 degree days above 5 °C (Egartner et al., 2010). Timing of control measures for *R. indifferens* and *R. cerasi* may therefore be similar. Egartner et al. (2010) noted that European flight period of *R. cingulata* occurred mid-June to mid-August while the American flight period of *R. indifferens* occurred mid-May through July.

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Appendix. Value of fresh cherry exports from the United States worldwide (FAS, 2016; queried February 17, 2016). These values may include fresh organically produced cherries, conventionally produced sweet cherries, and/or conventionally produced sour cherries.

Trading Partner	**Total Cherry Exports Value***	**Regulated organism?****
Canada	2015: $109 million	Yes
South Korea	2015: $108 million	Yes
China	2015: $65 million	
Hong Kong	2015: $43 million	
Japan	2015: $32 million	Yes
Taiwan	2015: $31 million	Yes
Australia	2015: $22 million	
Mexico	2015: $6.3 million	
Thailand	2015: $5.5 million	Yes
Singapore	2015: $3.3 million	
United Kingdom	2015: $2.8 million	
Vietnam	2015: $2.7 million	
Netherlands	2015: $2.3 million	*R. cerasi* is present in country
Malaysia	2015: $1.5 million	
Norway	2015: $1.3 million	*R. cerasi* is present in country
France	2015: $483,000	*R. cerasi* is present in country
Philippines	2015: $472,000	
Germany	2015: $440,000	*R. cerasi* is present in country
United Arab Emirates	2015: $244,000	
Indonesia	2015: $205,000	Yes
New Zealand	2015: $166,000	
Bahamas	2015: $106,000	
Trinidad and Tobago	2015: $89,000	
Denmark	2015: $87,000	*R. cerasi* is present in country
India	2015: $80,000	Yes
Cambodia	2015: $69,000	
Colombia	2015: $45,000	
Spain	2015: $43,000	*R. cerasi* is present in country
Netherlands Antilles	2015: $42,000	*R. cerasi* is present in country
Panama	2015: $32,000	
Aruba	2015: $28,000	
Cayman Islands	2015: $26,000	
Honduras	2015: $25,000	Yes
Burma	2015: $18,000	
Barbados	2015: $17,000	
Curacao	2015: $5,000	
Dominican Republic	2015: $10,000	
Botswana	2015: $9,000	
Bermuda	2015: $6,000	
Guatemala	2015: $5,000	
Iceland	2015: $5,000	
Costa Rica	2015: $5,000	
Ecuador	2015: $5,000	
Saudi Arabia	2015: $4,000	
Guyana	2015: $4,000	
Belgium	2015: $0 / 2014: $262,000	*R. cerasi* is present in country

Bahrain	2015: $0 / 2014: $7,000	
Belgium-Luxembourg	2015: $0 / 2014: $262,000	
Bangladesh	2015: $0 / 2014: $0	
Brazil	2015: $0 / 2014: $387,000	
Chile	2015: $0 / 2014: $49,000	
Italy	2015: $0 / 2014: $10,000	*R. cerasi* is present in country
Jamaica	2015: $0 / 2014: $0	
Kuwait	2015: $0 / 2014: $0	
Malawi	2015: $0 / 2014: $3,000	
Qatar	2015: $0 / 2014: $45,000	
Russia	2015: $0 / 2014: $14,000	*R. cerasi* is present in country
Senegal	2015: $0 / 2014: $0	
Sweden	2015: $0 / 2014: $41,000	*R. cerasi* is present in country
Venezuela	2015: $0 / 2014: $14,000	
Wallis and Futuna	2015: $0 / 2014: $0	
French Pacific Islands	2015: $0 / 2014: $0	

*Value of fresh fruit exported from the United States to the corresponding trading partner
**Based on information available in the Phytosanitary Export Database (PExD)