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Asian Citrus Psyllid Control Program in the Continental United States and Puerto Rico

Environmental Assessment
August 2010

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I. Introduction

Asian citrus psyllids (ACP), *Diaphorina citri* Kuwayama, were first found in the United States in 1998. The psyllids are known to transmit a bacterium named *Candidatus* Liberibacter asiaticus (*Ca.* L. asiaticus). Although not harmful to humans and animals, *Ca.* L. asiaticus causes Huanglongbing (HLB), or citrus greening (CG) in citrus and its close relatives (e.g., limeberry and trifoliate orange).

CG has resulted in extensive economic losses to the citrus production worldwide (NAS, 2010; Gottwald and Graham, 2008; and Norberg, 2008). Infected citrus orchards are usually destroyed or become unproductive in 5 to 8 years (Bové, 2006). In order to prevent the introduction and spread of CG into other citrus-growing areas, the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) has determined the need to control ACP. This environmental assessment (EA) will analyze the potential environmental impact of the proposed ACP control program.

A. Asian Citrus Psyllids

ACPs are small insects, 3 to 4 millimeters (1/8 to 1/6 inch) in length with brown mottled bodies and light brown heads. Their bodies are covered with a whitish, waxy secretion that makes them appear dusty (see figure 1). Adults may live for several months. Psyllids are most active when a plant has new growth. Adult psyllids commonly aggregate on young, tender plant tissue where they feed and mate.

Fig. 1. Adult Asian citrus psyllid on a young citrus leaf. (Photo credit USDA–ARS–National Invasive Species Information Center, D. Hall. http://www.invasivespeciesinfo.gov/animals/acp_child.shtml)

After mating, female psyllids feed on flush (new, tender terminal branches) to produce mature eggs. Females may produce up to a maximum of 520 to 1,900 eggs (Husain and Nath, 1926; Pande, 1971; Liu and Tsai, 2000; Tsai and Liu, 2000). Eggs are inserted into the leaf tissue inside the folds of unexpanded leaves, on the edges of young leaves, or at the base of leaf buds. There can be as many as 9 to 10 generations of psyllids a year. The immature stage of the psyllid, or nymph, is found on new growth and move in a slow, steady manner when disturbed. The adults leap when disturbed and may fly a short distance (Mead, 1977).

Even without transmitting *Ca.* L. asiaticus, ACP can cause damage to host plants (see appendix A for a list of host plants). While feeding on plant fluids, toxins present in the ACPs' saliva are injected into the plant. The toxins cause curling and distortion of young leaves; however, this damage is minimal compared to the damage caused by transmitting *Ca.* L. asiaticus. ACP can acquire *Ca.* L. asiaticus while feeding on host plants infected with the bacterium. After a latent period,[1] the psyllid is able to transmit the pathogen to other host plants. Transmission of the pathogen is thought to occur through salivary secretions. ACP can carry and transmit *Ca.* L. asiaticus to host plants throughout its entire life. ACP can also transmit *Ca.* L. asiaticus to its offspring.

B. Citrus Greening

CG is considered to be one of the most serious citrus diseases in the world. The disease has been found in Africa, Asia, Mexico, the Caribbean, Central America, South America, North America, and the Saudi Arabian Peninsula. CG attacks the vascular system of host plants. The pathogen is phloem-limited, inhibiting the food-conducting tissues of the host plant, and causes yellow shoots, asymmetrical chlorosis[2] (referred to as blotchy mottle) (see figure 2), reduced foliage, small misshaped (see figure 3), bitter tasting fruit, fruit that remains green at one end after maturity (see figure 4) and tip dieback in citrus plants and their close relatives.

Fig. 2. Sweet orange tree exhibiting blotchy mottle. (Photo credit Hilda Gomez, USDA)

[1] An interval of time between exposure to the infection and subsequent consequences of infection.
[2] Abnormal yellowing (or whitening) of green leaves.

Fig. 3. Misshaped mandarin fruit infected with CG disease. (Photo credit J.M. Bové, INRA Centre de Recherches de Bordeauz, National Invasive Species Information Center. http://www.invasive.org/species/subject.cfm?sub=4695.)

Fig. 4. Mature tangelo fruit infected with CG disease. (Photo credit Hung Shih-Cheng, Taiwan Agricultural Research Institute)

Ca. L. asiaticus, the pathogen that causes CG, is transmitted by two vectors, ACP and the African citrus psyllid (*Trioza erytreae* (del Guercio)). The African citrus psyllid is not known to be present in the United States. *Ca.* L. asiaticus can also be transmitted by grafting and, under laboratory conditions, by dodder.[3]

Once infected, there is no cure for a tree with CG. In areas of the world where CG occurs, citrus trees decline and die within a few years and may never produce usable fruit. CG greatly reduces production, destroys the economic value of the fruit and juice, and can kill trees. While ACP can cause economic damage to citrus groves and nurseries by direct feeding, APHIS considers this damage to be minimal compared to the damage and subsequent economic impacts caused by CG.

The severity of the disease in Asia has been well substantiated in literature. In 1966, Fraser et al. stated that the catastrophic losses of citrus trees in India were likely due to CG (as cited by da Graça, 1991). In the

[3] A parasitic plant of the morning glory family that lacks leaves, roots, and chlorophyll, but have special suckers for drawing nourishment from its host.

Philippines, a significant loss in the area of land planted with citrus from 1961 to 1974 was primarily attributed to leaf mottling or CG (Altamirano et al., 1976). The Food & Fertilizer Technology Center for the Asian and Pacific Regions indicate that as a result of infection by CG, average citrus yields in Asia have been falling. For example, the average citrus yield in Vietnam's Nghe An Province during the 1960s was 18 to 20 million tons per hectare (mt/ha) (2.47 acres). In 2003, average yields were reduced to around 6 to 9 mt/ha. The life span of citrus groves fell from 17 to 18 years in the 1960s to less than one third of that in 2003 (FFTC, 2003). Economic losses are directly related to the life span of the citrus trees. The longer the trees live, the greater the return to farmers. For example, if a citrus grove in Thailand lives for only 6 years, a farmer would suffer a loss of $8,292 per ha (2.47 acres) of citrus. If a grove lives for 8 years, a farmer would suffer a loss of $3,660 per ha. Only if a grove survives for 10 years will there be a profit of $3,383 per ha (Roistacher, 1996).

C. Range of ACP and CG in the United States

ACP was first discovered in the United States in Palm Beach County, Florida, in 1998. Subsequently, CG was detected in Miami-Dade County, Florida, in 2005. Currently, ACP is present in Alabama, Florida, Georgia, Hawaii, Louisiana, Mississippi, Texas, Guam, Puerto Rico, U.S. Virgin Islands, and portions of Arizona, California, and South Carolina. CG is currently known to be present in Florida, Georgia, Puerto Rico, U.S. Virgin Islands, and portions of Louisiana and South Carolina.

ACP is restricted by the range of its host and is more prevalent in the United States in hot coastal areas (Sullivan and Zink, 2007). Under laboratory conditions, the optimal range of temperatures for population growth in growth chambers is 77 to 82 °F (Liu and Tsai, 2000). Adults can live for 1 to 2 months at temperatures below 68 °F (Sullivan and Zink, 2007). (See appendix B for a map of U.S. counties where there has been a positive detection of ACP, as well as areas that are suitable for ACP establishment based upon cold temperature mortality.) There is little information available on whether rainfall or irrigation influences vector survival or establishment (Sullivan and Zink, 2007). It is known that ACP populations reach high levels in arid regions of the world where citrus is produced, including Saudi Arabia (Bové and Garnier, 1984), Yemen (Bové and Garnier, 1984), and Iran (Bové et al., 2000).

Ca. L. asiaticus is well adapted for temperatures occurring across the citrus belt of the United States (Sullivan and Zink, 2007). The traditional citrus climate extends from northern California through southern California and into the low Arizona desert. There is a break in New Mexico because of the State's high elevation and cold winters, thus causing an absence of host plants. The citrus belt picks up again in southern Texas and extends along the Gulf Coast and into Florida

(Sullivan and Zink, 2007). As previously mentioned, CG is known to be present in Florida, Georgia, Louisiana, Puerto Rico, U.S. Virgin Islands, and as far north as Charleston, South Carolina. Symptoms of CG are influenced by the temperatures at which affected trees grow (Bové, 2006).

D. Current ACP and CG Management Actions

The goal of ACP management programs is to reduce the level of populations. By reducing the number of ACPs populating an area, it is generally accepted that the chance of *Ca.* L. asiaticus being introduced or spread throughout an area is lowered. However, due to the number of psyllids present and their ability to disperse, management programs have never completely eliminated ACP from an area. Because the vector (ACP) can never be fully eradicated, the control of CG is dependent upon areas infected with CG being quickly identified and eliminating any host plants infected with CG. However, the elimination of CG from an area has also never been successful (Rogers et al., 2009a). This is due partly to the fact that trees can be infected and contagious with CG yet not show symptoms for several years. In addition, there are currently no antimicrobials effective against *Ca.* L. asiaticus.

A pest management program for ACP could include chemical and biological control measures. In areas of the world where citrus is grown and CG is present, the use of insecticides to control ACP has been a major component of CG management strategy (Rogers et al., 2009a). No scientific data has been collected in the countries where insecticides were used against ACP to demonstrate that insecticides slowed the spread of CG; however, "…anecdotal evidence suggests that reducing psyllid populations via insecticide application does help to slow the rate of spread of the disease" (Rogers et al., 2009a). Management programs should, whenever possible, optimize an affordable ACP control program (e.g., reduce the number of pesticide applications used) while minimizing negative impacts on important natural predators (Stansly et al., 2008). However, any reductions in pesticide usage must be tempered by the need to achieve a high rate of control of ACP, which, in turn, are expected to result in effective control of CG.

In addition to insecticides, some areas are using biological control agents[4] to decrease ACP populations and control CG. CG and its two vectors, ACP and African citrus psyllid, have threatened citrus crops of Reunion, an island located in the Indian Ocean east of Madagascar. A control strategy implemented in the mid-1970s consisted of setting up disease-free nurseries using healthy trees and promoting the biological control of both psyllids by importing exotic natural enemies. The approach was effective

[4] Biological control agents are organisms that are natural predators, parasites, or pathogens of a pest that work to decrease a pest's populations to a more desirable level.

in reestablishing profitable domestic citrus production within this tropical island ecosystem (Aubert et al., 1996). There are also predators of ACP naturally present which may assist in controlling ACP populations, such as lacewings and ladybeetles. In addition to reducing ACP populations, the use of insecticides has reduced populations of natural predators of ACP (Qureshi and Stansly, 2007).

Routine scouting for infected trees is necessary to control for CG (Brlansky et al., 2010). Leaves with yellowing veins and blotchy mottle are the most diagnostic symptom of the disease; however, nonspecific foliar symptoms are sometimes difficult to distinguish from nutritional deficiencies and other plant diseases (Irey et al., 2006a and 2006b). There are laboratory tests that can be done if confirmation of the disease is necessary (Irey et al., 2006; Li et al., 2006). Any infected trees should be removed from the area and destroyed. Prior to removing the tree, the tree should be treated with a foliar insecticide. The foliar insecticide should kill any adult psyllids that would have dispersed from the tree during removal, thereby minimizing the risk of spreading CG to any healthy host trees in the area. Trees may be physically removed by pulling or pushing them out of the ground with heavy equipment, or cutting the trunk at or near the soil line. Regardless of the technique used, herbicides should be used on any sprouts that grow from roots left in the ground or from a freshly cut stump as these sprouts would still be infected with CG.

APHIS' 2006 CG disease guidelines indicate that any methods for disposing of infected trees that kill vectors, prevent further access to foliage by vectors, and prevent the use of removed trees as budwood sources are appropriate (Floyd and Krass, 2006). Suitable disposal methods include burning, chipping (only smaller diameter branches and foliage would need to be chipped; large diameter wood could be disposed of by other means), or burial in a landfill (Floyd and Krass, 2006).

APHIS has undertaken measures to control the artificial spread[5] of ACP to noninfested areas of the United States in order to slow the spread of CG since the introduction of the disease into the country 2005. APHIS issued numerous Federal Orders designating all or parts of affected counties and States as areas quarantined for ACP and/or CG, and imposed restrictions on the interstate movement of all ACP and CG host plant material from those areas. On June 17, 2010, APHIS published an interim rule which codified most of the provisions of the Federal Orders into regulation. Under the interim rule, a State, or a portion of a State, is quarantined when ACP and/or CG is found. The interstate movement of ACP and CG host plants and plant material from quarantined areas is regulated. ACP and CG host plants and plant material that are to be moved interstate or

[5] Humans moving ACP host plant material have been responsible for the long-distance spread of ACP and CG; this is often referred to as "artificial" spread.

immediately exported from the United States from an area quarantined for ACP but not CG must be treated with methyl bromide, some other approved treatment, or processed in a manner to eliminate the risk of spreading ACP and CG. Nursery stock that is to be moved interstate that is not treated with methyl bromide must be treated with a soil drench or an in-ground granular application of dinotefuran or imidacloprid followed by a foliar spray containing either bifenthrin, chlorpyrifos, deltamethrin, fenpropathrin, or an imidacloprid and cyfluthrin mixture. ACP and CG host plants and plant material intended for consumption, for use as apparel, or for decorative purposes that are not treated with methyl bromide must be treated with irradiation or processed in a manner to eliminate the risk of spreading ACP and CG. Nursery stock from an area quarantined for CG cannot be moved interstate unless it is treated for ACP and is immediately exported from the United States.

The Federal Orders and interim rule focused on controlling the artificial spread of ACP and CG. The regulations, which established quarantines and regulated movement of host plants, primarily affect nursery stock producers (nurseries), as well as commercial retailers and distributors.

In addition to spreading artificially, ACP and CG can spread naturally. The natural spread of pests is usually considered to be an increase in distribution that occurs without human assistance. The spread tends to occur via flight, wind dispersal, or transport by vectors such as insects or birds. While the artificial movement of ACP on host plants from nurseries is one concern, the natural movement of ACP within and between abandoned citrus groves, producing citrus groves, residential and other private properties, and public areas is of concern because they serve as potential reservoirs for infected psyllids. Therefore, in addition to the Federal actions taken to control the spread of psyllids from nurseries, some States have implemented their own additional ACP control programs to decrease the natural spread of ACP and CG.

The California Department of Food and Agriculture (CDFA) issued a State quarantine in areas where ACP has been found. CDFA is working to increase surveying and trapping, and is cooperating with counties on ACP trapping programs. CDFA is attempting to educate the public by providing informational materials, including mailing of postcards, posters, pamphlets, and Web sites. CDFA has been inspecting cargo at the State border for ACP and treating the cargo with insecticides if ACP is found.

CDFA is also conducting insecticide treatments in urban and rural residential areas on a voluntary basis if ACP is found. Treatments may extend up to 400 meters around each detection site. Only ACP host plants are treated. Both foliar insecticides (applied to plant leaves) and systemic insecticides (applied to the soil, taken up by the plant’s roots, and moved throughout the plant’s system) are applied. Foliar treatments include

PyGanic® (an organic formulation of a pyrethrin), Tempo® SC Ultra (cyfluthrin is the active ingredient), or Sevin® SL (carbaryl is the active ingredient). Soil treatments are conducted with Merit® 2F (imidacloprid is the active ingredient). Properties that are treated receive written notification at least 24 hours prior to treatment. Following treatments, CDFA leaves completion notices with homeowners, detailing precautions that they should take to minimize exposure (CDFA, 2010).

The University of California (UC) Integrated Pest Management Program (IPM) has provided treatment guidelines to citrus growers in California's ACP quarantine zones. UC IPM recommends that growers treat with both a foliar insecticide for immediate control and a systemic insecticide for long-term control. A foliar treatment may be made using Danitol® 2.4 EC (fenpropathrin), Baythroid® XL (cyfluthrin), Delegate® (spinetoram), Lorsban® 4E (chlorpyrifos), Dimethoate® 400 (dimethoate), Sevin® 80S or Sevin® XLR Plus (carbaryl), Carzol® SP (formetanate), or Micromite® 80 WGS (diflubenzuron). Systemic insecticides may be applied using Movento® (spirotetramat) (while it is still available), Admire® Pro (imidacloprid), dinotefuran, or another registered systemic imidacloprid product, such as Alias™ 2F, Nuprid® 2F, or Couraze™ 2F (UC IPM, 2009).

ACP and CG infestations are present in citrus-producing areas of Mexico that are in close proximity to the U.S. border. In addition, infestations in other citrus-producing areas within Mexico may result in movement of ACP into the United States via fruit shipment. Mexican infestations represent an additional threat to citrus-producing areas, especially those located near the U.S.-Mexico border. CDFA, in cooperation with APHIS and the Mexican government, Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentacíon (SAGARPA), have implemented a coordinated program to control the ACP infestation and reduce the threat of spreading CG. Interstate or export movement of regulated commodities require a certificate or permit, contingent upon the treatment of the commodity. Control methods that are being used within Mexico include (1) regulatory chemicals, (2) cold treatment, (3) vapor heat treatment, and (4) irradiation treatment. Regulatory chemical treatments include fumigation with methyl bromide and foliar pesticide applications using carbaryl, pyrethrins, cyfluthrin, bifenthrin, chlorpyrifos, deltamethrin, fenpropathrin, or an imidacloprid/cyfluthrin mixture. Soil drenches with a formulation of imidacloprid or dinotefuran could be applied to provide systemic control of ACP. Nurseries, citrus groves, and residential properties are being treated. Cold treatment, vapor heat treatment, or irradiation treatment of certain produce, as a requirement for certification and shipping, must be conducted in facilities that are inspected and approved. APHIS is assisting SAGARPA with funding, staffing, and/or expertise, as necessary, to ensure that all measures are implemented and sustained.

The State of Florida uses insecticides and biological control agents to control ACP and the spread of CG. The University of Florida's Institute of Food and Agriculture Sciences (IFAS) recommends the use of the following chemicals in citrus groves to treat for ACP: chlorpyrifos, dimethoate, fenpropathrin, imidacloprid (foliar and soil drench), phosmet, spinetoram, spirotetramat, thiamethoxam (foliar and soil drench), and zeta-cypermethrin (Rogers et al., 2009a; and Rogers et al., 2009b). No sprays are recommended during bloom to protect bees and other beneficial insects (Stansly et al., 2008). The post-bloom period is also critical for many natural predators of ACP and, therefore, only select insecticides should be used if necessary (Stansly et al., 2008).

In 1999, the Florida Department of Agriculture and Consumer Services released Tamarixia radiata (T. radiata) (imported from Taiwan and Vietnam) as a biological control agent of ACP. T. radiata is a small, stingless wasp ectoparasite (an external parasitic organism) of ACPs. Parasitism rates have been low, averaging below 20 percent during the spring and summer (Qureshi et al., 2009). A wasp, *Diaphorencyrtus aligarhensis,* has also been introduced for the biological control of ACP in Florida; however, it has not become established in the State.

IFAS' CG management recommendations include treating all citrus groves as though they already have CG. They recommend propagation of disease-free nursery stock, removing trees infected with CG, controlling ACP populations, and, if possible, removing host plants from around commercial citrus groves. IFAS recommends that citrus growers scout for CG four times a year, and more frequently if surrounding groves have CG. During the spring, flush scouting becomes more difficult, and IFAS recommends that scouts should look further into the tree canopy (IFAS, 2009). Certain areas of Florida are treating both abandoned and producing citrus groves.

Texas is in the process of implementing an ACP and CG action plan that would include all locations where citrus is grown (e.g., citrus groves, abandoned citrus groves, residential citrus and public lands) (TCGTF, 2009). Chemical treatment, monitoring, and an education and public outreach program are proposed in the action plan. Citrus growers would treat for ACP based on information acquired from traps deployed in their groves. Growers would test for CG and would remove any diseased trees (TCGTF, 2009). In addition to the U.S. Environmental Protection Agency (EPA)-registered insecticides, Danitol 2.4-EC (fenpropathrin) may be used for low volume ground application against ACP in Texas. The product has been approved by the Texas Department of Agriculture under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), section 24(c).

In 2009, the Texas A&M University–Kingsville Citrus Center, in cooperation with APHIS, implemented an ACP control research project in citrus groves and residential properties within Hidalgo County, Texas. The objective of the study was to demonstrate that ACP populations may be controlled in a coordinated fashion and at a regional level in managed and abandoned citrus groves and residential properties to lower the potential risk posed by CG. The research included chemical treatments of chlorpyrifos, citrus oil, fenpropathrin, imidacloprid, kaolin clay, neem oil, pyrethrin, and/or zeta-cypermethrin on citrus trees in approximately 1,400 acres in Hidalgo, Texas, from mid-February 2009 until September 2009. Treatments were applied via aerial applications and ground applications. Researchers concluded that: 1) aerial applications of pesticides were as effective as ground applications at controlling ACP; and 2) covering a large area with pesticides in a coordinated fashion was much more effective at controlling ACP than a patchwork of pesticide applications (Sétamou et al., 2009). These studies are continuing in 2010 on approximately 4,700 acres in the same area; the chemicals being studied are the same.

In Plaquemines Parish, Louisiana, the Plaquemines Parish Council and citrus producers are conducting ACP suppression efforts that consist of two aerial applications of insecticides per year over commercial citrus groves. The Plaquemines Parish government has funded helicopter spraying in conventional commercial citrus groves (LSUAG, 2009; Bennett, 2009). The Louisiana Citrus Spray Schedule indicates that the following chemicals may be utilized, depending on time of the year and whether the trees have bloomed: Danitol® 2.4 EC (fenpropathrin), Lorsban® 4E (chlorpyrifos), Sevin® XLR Plus (carbaryl), Provado® (imidacloprid), Mustang Max™ (zeta-cypermethrin), and horticultural oils (LSUAG, 2010). The parish also treats residential properties on a voluntary basis with CoreTect tablets (LSUAG, 2009; Bennett, 2009) and Merit 2F (Bennett, 2009), which contain the active ingredient imidacloprid.

The Arizona Department of Agriculture maintains ACP traps and conducts visual inspections for the pest. The State has not published formal recommendations for the use of treatments against ACP; however, a CG task force has been formed. The Arizona Cooperative Extension (ACE) recommends homeowners use water or soap solutions or an insecticide to control ACP, and to contact ACE if symptoms of ACP occur (Begeman and Wright, 2009).

E. Previous Environmental Documentation

In September 2005, APHIS prepared an EA to analyze and evaluate potential environmental effects resulting from a Federal Order which would implement a CG control program in Florida nurseries (USDA–

APHIS, 2005a). The EA was subsequently revised and finalized in January 2006 (USDA–APHIS, 2006). APHIS prepared a second EA in October 2007 (USDA–APHIS, 2007). This EA evaluated the possible environmental impacts associated with revising the CG Federal Order, and, in particular, the treatment schedules specified within it. APHIS prepared a third EA in January 2009 (USDA–APHIS, 2009a) which evaluated the environmental impacts of implementing an ACP control research project in citrus groves and residential properties in Hidalgo County, Texas. The finding of no significant impact was amended in 2010 (USDA–APHIS, 2010a) to discuss the 2010 research program in Hidalgo County, Texas.

APHIS prepared a fourth EA in July 2009 (USDA–APHIS, 2009b). This EA analyzed the environmental impacts anticipated from chemically treating ACP and CG host plants and plant material that are to be moved interstate or immediately exported from the United States from an area quarantined for ACP but not CG. The chemical treatments that were analyzed were methyl bromide, dinotefuran, imidacloprid, bifenthrin, chlorpyrifos, deltamethrin, fenpropathrin, and an imidacloprid and cyfluthrin mixture. Irradiation of ACP and CG host plants and plant material intended for consumption, for use as apparel, or for decorative purposes that are not treated with methyl bromide was also analyzed.

II. Purpose and Need

APHIS is responsible for taking actions to exclude, prevent, eradicate, and/or control plant pests, such as ACP and CG, under the Plant Protection Act (7 United States Code (U.S.C.) 7701 et seq.). As such, it is important that APHIS take the steps necessary to control CG and its vector, ACP, to prevent their introduction and spread into uninfested citrus growing areas of the country.

The purpose of a national ACP control management program is to prevent the introduction and further spread of CG in the U.S. citrus industry. The current Federal ACP and CG interim rule established the quarantine areas for ACP and CG, and also placed restrictions on the interstate movement of host plants and plant parts from the quarantined areas. The proposed ACP control program in citrus groves would address the risk of the natural spread of ACP and CG in and around commercial citrus groves.

There is a need for the program to protect the U.S. citrus industry from the economic damage of CG, one of the worst citrus pests in the world. The United States is one of the top citrus exporters in the world, ranking first in grapefruit, third in oranges, fifth in lemons and limes, and seventh in tangerines (USDA–FAS, 2010). The resources potentially at risk in the four largest commercial citrus-producing States (Arizona, California, Florida, and Texas) if CG were to become established in the United States are summarized in table 1.

Table 1. Acreage and Value of Citrus Production in the Four Largest Producing States.

State	Bearing Acres[1]	Production Value[1]	Employment[2]	Other Revenues[2]
Florida	530,900	$1.5 billion	110,500 jobs	$7.5 billion
California	269,600	$1.2 billion	22,000 jobs	$1.2 billion
Texas	27,300	$46.5 million	1,911 jobs	$121 million
Arizona	17,900	$36.6 million	n/d	n/d

[1] USDA–NASS Citrus Fruits 2009 Summary
[2] Industry estimates based on CNAS (2007), R. Norberg (2008), Spreen et al. (2006).

In addition to the direct loss of citrus production, impacts to other businesses could occur from CG infestations. An economic assessment was conducted by the Center for North American Studies (CNAS), Texas A&M University, on the potential economic impacts of CG in Texas. The assessment not only considered the effects of CG on the citrus industry, but also how a change to the citrus industry could affect business activity, income, and employment in other sectors of the economy that are associated with the citrus industry. CNAS reported that farm and related sector income generated by citrus production in Texas was an annual average of $50.9 million for crop years 2004–05 and 2005–06. Another $24.5 million was generated off-farm in transportation, handling, processing, and marketing. Total employment associated with the Texas citrus industry was estimated to be 1,911 jobs (farm jobs represented the majority, but sorting, grading, cleaning, and packing, etc., were included). After 2 years of CG infestation, CNAS predicts a total income loss of $14.7 million and total job losses at 373. After 5 years of infestation, income losses were predicted to total an additional $42.6 million and job losses to reach 1,080. Losses in real estate, farm machinery and equipment, food services, medical sectors, and banking and insurance businesses were averaged after 2 and 5 years and were expected to reach hundreds of thousands of dollar losses for each sector (CNAS, 2007).

The purpose of this EA is to analyze the environmental impact of an ACP control program throughout the continental United States and Puerto Rico. This EA has been prepared consistent with the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321 et seq.) and APHIS' NEPA implementing procedures (7 CFR part 372). APHIS provided a 30-day public comment period for this EA. The comment period ended on September 26, 2010. APHIS received three comments. As a result, minor editorial revisions were made to this EA.

III. Affected Environment

The area that could be affected by the proposed action, USDA participation in a cooperative Federal, State, and industry ACP and CG management program, includes all the counties with commercial citrus production in Arizona, California, Florida, Louisiana, and Texas (see appendix C for a map of the counties). In addition, the Commonwealth of Puerto Rico produces citrus commercially and has both ACP and CG and, therefore, is included in the affected area. Theoretically, ACP can survive in a larger area than that in which citrus is grown commercially. Indeed, ACP has been found in nonagricultural areas in Alabama, Georgia, Mississippi, and South Carolina. However, some areas that could harbor populations of ACP are not of interest to the cooperative management efforts because, even if infested with ACP, it is unlikely that they would host CG and potentially affect commercial citrus. This may be because these areas are many miles away from the nearest commercial citrus, or they are separated from commercial citrus by unsuitable desert habitat which effectively isolates the ACP population from areas where ACP or CG could become an economic issue. Therefore, to insure that all areas that could reasonably harbor ACP and host CG and be expected to serve as reservoirs of ACP (which could spill into commercial areas) are included within the program area; the affected area has been identified to be larger than the sum of the areas in which commercial citrus is grown. The area that is considered to be the affected environment is displayed in a map in appendix D.

IV. Alternatives

A. No Action

Under the no action alternative, APHIS would not participate with the citrus-producing States or industry to implement a coordinated and cooperative program to control ACP or prevent CG. There would be no Federal funding, staffing, or other assistance to combat ACP and CG. The result would likely be that each State implements a separate program. This will result in a fragmented approach that lacks national coordination and leveraging of resources across States and, therefore, reduced effectiveness and efficiency. APHIS' only involvement would be to maintain the current quarantine for ACP and CG. Under this scenario, ACP would spread unchecked to all areas of the United States where hosts are present, thus increasing the likelihood that CG would be introduced, spread and, perhaps, become established throughout the United States.

B. Cooperative Federal, State, and Industry ACP and CG Management Program

Under this alternative, APHIS, States, the citrus industry, and other stakeholders would implement a cooperative program designed to suppress ACP and, hence, prevent or slow the spread of CG into citrus-producing areas. APHIS will provide the overall national coordination and technical support to cooperating States and stakeholders. The goal is to leverage resources of Federal and State agencies and industry organizations to optimize the overall effectiveness of program delivery. APHIS has assembled a number of working groups consisting of representatives from Federal and State agencies and industry organizations, to coordinate the overall implementation of the program, including research, communication and outreach, and regulatory issues. The U.S. citrus industry has also created the National Citrus Health Response Program Council (National CHRP Council) which consists of representatives from citrus-producing organizations from each State. The National CHRP Council serves as the liaison for the citrus industry, and provides leadership and coordination of industry resources in support of the program.

In addition to the technical support and the overall coordination of the program, USDA will provide funding and other resources to cooperating States in support of program implementation. These resources would be used in support of field operations, including survey, diagnostics, control, and public education and outreach.

1. Strategy

The strategy is to contain, control, and suppress ACP populations where they are known to be present through timely, targeted, and coordinated treatments. While the majority of the treatments would be confined to commercial citrus groves, some treatments may also occur in non-commercial citrus sites. Treatments in noncommercial sites are designed to prevent ACP populations from spreading into commercial citrus-producing groves and are implemented under the supervision of State and local authorities. Treatments in the commercial citrus-producing groves would be applied in accordance with pesticide label requirements and would be paid for and conducted by the growers in a well-coordinated fashion and timed prior to tree flush cycles. Growers in the affected areas have or are in the process of establishing pest management districts/regions that would be responsible for coordinating all treatments in commercial settings. All program activities would be implemented in cooperation with State and local authorities, as well as growers. This will help contain, control, and suppress ACP populations in a coordinated fashion and, therefore, prevent or slow the spread of CG into healthy commercial citrus-producing areas and groves.

2. Surveys

Surveillance activities would be carried out by Federal, State, and local personnel in order to detect the presence of ACP and CG. A number of survey methods and tools have been identified, including visual inspection of host plants, mechanical suction devices (P-vac), sweepnets, tap sampling, and traps. Trapping is be the most common method as it is used for early detection in areas where ACP has yet to be detected or to delimit newly discovered infestations. In areas where ACP is known to be present, traps would be used to evaluate the effectiveness of the control actions. Traps are serviced by Federal, State, or local agricultural inspectors. The trap used for ACP detection is a two-sided board coated with Stickum™. ACPs are caught on the sticky surface. Detection and delimitation surveys would be conducted in residential, urban, and rural areas. USDA–APHIS has established survey protocols that will provide guidelines and standards to be implemented across all program areas.

3. Diagnostics

Accurate and timely identification of ACP and diagnostics of CG is essential. Critical programmatic activities and decisions, including determining survey and timely control measures, are based on accurate identification. Identification of ACP is especially important in a new area where the disease is not known to occur. Increased surveillance for CG may be undertaken in these areas once ACP is confirmed. APHIS has established a network of laboratories strategically located to provide the identification and diagnostic support for the program. (Identification and diagnostics include confirmation of ACP, and testing of psyllid and plant tissue samples for the possible presence of CG.) In areas where ACP or CG is detected for the first time, confirmatory diagnostics must be conducted through the APHIS National Identification Services.

4. Public Education and Outreach

USDA–APHIS has established the Communication and Outreach Working Group, which consists of representatives of communication professionals from APHIS, cooperating States, industry, and stakeholders. The group is responsible for coordinating timely and accurate information about the program and the threat that ACP and CG can impose on the U.S. citrus production. The working group has developed a communication plan in an effort to prevent the further spread of citrus pests and diseases. The primary goal of the plan is to increase public awareness (particularly among travelers and online consumers) of the potential risks associated with moving citrus plants and products. In addition, each State task force convenes routine meetings to inform members of the citrus and nursery industries and local communities about pests and diseases of concern, requirements associated with the quarantines that are in place to ensure compliance, and the activities that are ongoing to limit the spread of citrus pests and diseases. In addition, the communication plan includes providing the information through various communication channels, including prints (pamphlets), online (Web sites), and targeted TV public announcements and advertisements.

5. Chemical Treatment for ACP

Two application strategies will be used for chemical control of ACP. Foliar sprays will be used for immediate reduction of ACP populations. Soil applications will also be used to provide longer lasting, systemic ACP control. Commercial citrus groves may be treated with a soil drench or in-ground granular pesticide application followed by a foliar spray. Table 2 provides a list of pesticides that may be recommended for use in the program. All formulations of insecticides used in the program must be registered by EPA under FIFRA. In commercial treatments, all chemical treatments would be conducted by the commercial growers or certified applicators and paid by the growers.

Treatments in settings other than nurseries or citrus groves, such as residential and public properties, would occur under State authority upon the detection of one or more ACP. Indications from potential State cooperators are that residential and other noncommercial insecticide applications are likely to take place in Arizona, California, Louisiana, and Texas. At the present time, Florida and Puerto Rico have no plans to treat noncommercial sites; however, this may change in the future depending upon the needs of the cooperators, and expert advice and opinions. If residential treatments are made, they are likely to be on a voluntary basis—that is, the resident would agree to allow the State or their cooperators to conduct the treatment. The treatment area may extend up to 400 meters around each find of ACP. The current ACP programs in California and Mexico apply an insecticide to ACP host plants within 400 meters around each ACP find. Only ACP host plants would be treated. Noncommercial site treatment options, under State authority, include both foliar and systemic insecticides.

a. Foliar Treatments

Foliar treatment may commence upon the detection of ACP to target the adult life stage of the pest using one or more of the following insecticides—

1) Carbaryl - may be applied to all host plants within an area up to a 400-meter radius of the find sites using hydraulic-spray or hand- spray equipment. According to label directions, treatments may be repeated every 10 to 14 days; or

2) Cyfluthrin - would be applied a minimum of one time to the foliage of host plants at designated residential and noncommercial properties. The chemical may be applied to all host plants in an area up to a 400-meter radius of the find sites using hydraulic-spray or hand-spray equipment; or

3) Pyrethrin - an organic formulation of the chemical may be applied according to label instructions to all host plants in an area up to a

400-meter radius of the find sites, using hydraulic spray or hand spray equipment. Treatments may be repeated according to label directions.

Table 2. Potential Insecticides and Use Sites.

Potential Chemical	Potential Use Site	
	Commercial and Abandoned Groves	Noncommercial Sites
	SOIL DRENCH or IN-GROUND GRANULAR	
Dinotefuran	X	X
Imidacloprid	X	X
Thiamethoxam	X	----
	FOLIAR (AIR OR GROUND)	
Abamectin	X	----
Azadirachtin	X	----
Bifenthrin	X	----
Carbaryl	X	X
Chlorpyrifos	X	----
Citrus Oils	X	----
β-Cyfluthrin	X	X
Deltamethrin	X	----
Diflubenzuron	X	----
Dimethoate	X	----
Fenpropathrin	X	----
Formetanate	X	----
Imidacloprid/Cyfluthrin	X	----
Kaolin Clay	X	----
Malathion	X	----
Petroleum Oils	X	----
Phosmet	X	----
Pyrethrin	X	X
Spinetoram	X	----
Spirotetramat	X	----
Thiamethoxan	X	----
Zeta-Cypermethrin	X	----

b. Systemic Treatments

Soil treatments are also conducted upon the detection of ACP to target the immature life stages, such as eggs and nymphs, using the insecticide imidacloprid or dinotefuran. These treatments are applied to soil beneath the drip line of host plants a minimum of one time and a maximum of twice a year.

Affected residential and noncommercial properties would be notified in writing at least 24 hours prior to treatment. Following treatment, completion notices would be left with homeowners detailing precautions to take and postharvest intervals applicable to any fruit on the property. Treatments may be repeated at intervals prescribed on the label if live psyllids are found upon reinspection.

6. Biological Control of ACP

Biological control organisms of ACP (including insect-attacking mites, insects, and pathogens) would be incorporated into the program as they become available to reduce the severity of infestations of ACP in the United States. Biological control organisms would be targeted for use in urban and natural settings and certified organic farms where insecticides are not feasible to apply. They might also be used in infested abandoned groves where industry or State cooperators cannot spray due to funding, logistical reasons, or other issues.

7. Quarantine

As required by the interim rule published in the *Federal Register* on June 17, 2010, a quarantine would be established under APHIS and State authority if one or more ACP is found in an area. All articles capable of harboring ACP would be regulated in accordance with the recently published interim rule (available under *Federal Regulations* at http://www.aphis.usda.gov/citrusgreening). Prior to movement out of quarantined areas, nursery stock may also be treated with methyl bromide in accordance with 7 CFR part 305. A technical working group recommended that areas quarantined for ACP remain so for a minimum of four flush cycles (approximately 18 months to 2 years) before deregulating the area.

V. Environmental Consequences

A. No Action

Under the no action alternative, APHIS would not participate with the citrus-producing States or industry to implement a coordinated and cooperative program to control ACP or prevent CG. There would be no Federal funding, staffing, or other assistance to combat ACP or CG. The result would likely be that each State would implement a separate program. This will result in a fragmented approach that lacks national coordination and leveraging of resources across States and, therefore, reduced effectiveness and efficiency.

APHIS' only involvement would be to maintain the current quarantine for ACP and CG. Under this scenario, it is doubtful that a successful ACP control program could be instituted or sustained in all of the affected States, thus increasing the likelihood that CG would be introduced and, perhaps, become established throughout the United States. This would first occur in areas where CG has been determined to be present (Florida, Georgia, Louisiana, Puerto Rico, U.S. Virgin Islands, and South Carolina). Depending upon the degree of success of the efforts of individual States and individual farmers, CG will likely spread throughout the remainder of the citrus belt negatively affecting U.S. citrus production (including fruit, juice, and citrus byproducts) and the ability to market citrus in the world marketplace. APHIS staff estimates show revenues of $3 billion (packinghouse door equivalents) generated by citrus fruit production could rapidly decrease, along with the potential loss of more than 30,000 jobs associated with planting, grove maintenance, and crop harvest. Another 220,000 jobs and lost revenue could result from infection of nursery stock, closure of fruit processing and packaging facilities, and halting production of cartons and containers, transportation, marketing, shipping/distribution, and retail sales currently valued at more than $13 billion per year.

B. Cooperative Federal, State, and Industry ACP and CG Management Program

1. Survey, Identification and Diagnostics, Public Education and Outreach, and Strategy

The environmental impacts of the survey, identification and diagnostics, public education and outreach, and strategy aspects of the proposed cooperative ACP management and control program are expected to be minimal. Survey will involve an increased physical presence in the field to place and monitor traps; however, the increased effort will not provide a discernible increase in environmental impacts to either commercial areas or noncommercial and residential areas because human activity is more or less constant in these areas, and no lasting pollutants are distributed throughout the potential impact area.

Diagnostics and public education will not result in a discernible impact to the environment, although, in a cumulative sense, an increase in public education could raise public awareness of the problems and issues surrounding ACP control and CG eradication efforts.

Impacts that could be associated with the implementation of the ACP control strategy are likely to be minimal. The strategy will result in a regionally coordinated approach to ACP control. The coordinated approach is likely to result in local shifts in pesticide usage, with use of some insecticides increasing and some decreasing. The coordinated approach, however, should result in a more effective and efficient way to control ACP than individual and independent controls by growers would offer. From that standpoint, over the long term an effective, coordinated control program for ACP and CG is likely to result in reduced impact to natural resources and to the economic health of the citrus industry. In the short term, nonagricultural properties that may be included in the program may receive insecticide treatments that they would otherwise not have received. Some properties that may receive treatments under this program would not ordinarily be treated. If left untreated, these properties could then serve as reservoirs for repopulating the surrounding areas after they have been treated, thus reducing the effectiveness of the treatments. For those properties that would have received treatments with or without this program, their treatments will be coordinated with those of surrounding properties and, thus, are likely to be more effective at reducing local ACP populations.

2. Chemical Treatments for ACP Control

Most insecticide treatments will be conducted and funded by the growers in commercial citrus groves. APHIS' involvement with insecticide application is primarily one of providing advice to growers and cooperators. Where the State cooperators have determined it to be important to the ACP control efforts, they may apply chemical treatments to host plants in residential and noncommercial areas, and possibly to abandoned orchards in close proximity to commercial production areas. Any insecticides used by State cooperators, and those recommended for use by APHIS and State cooperators for commercial citrus grove applications, will be determined on a regional basis after consideration of typical pesticide use in the area, advice of ACP control experts, other agricultural experts, and review of EPA-approved insecticides and uses. All uses will be in accordance with EPA-approved pesticide labels. Experts within each of the potential cooperating States regularly provide their recommendations to State departments of agriculture and to APHIS. Each of the insecticides proposed for use has distinct characteristics that will be considered prior to making any recommendations. The insecticides listed in table 2 are those that may be recommended for use. A summary of their potential for environmental and human health impact follows.

Human Health, Nontarget Toxicity, and Risk of Program Insecticides

For program insecticides restricted to applications in citrus groves, potential human-related exposure during applications would be restricted to workers and applicators at the time of application. Protective gear, safety precautions required on the label, State law, and standard program operating procedures are designed to ensure that no adverse effects to applicators are expected (USDA–APHIS, 2005b).

All insecticides that are recommended in the proposed program are currently registered by EPA for use on citrus. As long as they are used in accordance with their labels, the legal residue tolerances established by EPA are not expected to be exceeded. However, the area-wide coordination established by the proposed program could result in more effective ACP control and, ultimately, result in reducing the total number of applications and their associated residues. EPA sets residue tolerances at levels where they are confident that they pose minimal, if any, risk to people. Applications made in accordance with the label directions, including harvest and reentry intervals, and washing and disinfection of fruit at packinghouses reduces public exposure so that it is below tolerance limits and is unlikely to be harmful to the public. In addition, during treatments of residential areas, human exposure to program insecticides is minimized through adherence to recommended practices at the time of program control applications.

For all insecticide applications in citrus groves, there is the potential for indirect risk to wild mammals and birds from the loss of available invertebrate prey that would occur after treatment. Risks from these types of effects are reduced for those birds and mammals that can forage outside of the treatment area and recovery of most invertebrate populations that will occur within the citrus groves after treatment will ensure that any impacts to mammals and birds are short-term in nature. The extent and time for recovery would be based on how persistent and broad spectrum a selected insecticide may be in its nontarget effects.

a. Dinotefuran (Citrus Groves)

(1) Human Health Toxicity and Risk

Dinotefuran is a systemic insecticide belonging to the neonicitinoid class but within the nitroguanidine subclass. Dinotefuran has moderate acute toxicity to mammals, and low inhalation and dermal toxicity. It is not considered a skin irritant based on skin sensitization and irritation studies; however, it is considered an eye irritant. Based on sublethal study results, dinotefuran is not considered a carcinogen or mutagen; developmental effects only occur at doses that are maternally toxic. Immune- and endocrine-related effects have been observed in multiple studies (EPA, 2004a). These effects were observed during prolonged exposures and are not anticipated in this program. The primary immune system-related effect observed in the studies was altered thymus weights which may not be related to direct immune toxicity of dinotefuran. However, this may be a secondary effect due to overall reduced body size and weight gain during exposures that were 13 weeks or greater, depending on the type of study. Based upon EPA's evaluation of risk to different human population subgroups, including occupational exposures, it was determined that the dinotefuran risk alone, as well as aggregate risk when including other neonicitinoid insecticides, did not exceed agency levels of concern (EPA, 2004a).

Due to the mobility and persistence of dinotefuran, there is the potential for surface and ground water residues to occur in areas that are vulnerable to runoff and leaching. Adherence to label requirements and avoidance of dinotefuran applications to permeable soils will reduce the possibility of contamination of any drinking water resources. Due to the systemic nature of dinotefuran, there is the possibility of residues in citrus harvested for human consumption. The low residues that have been observed with similar insecticides in citrus, and the low toxicity to mammals suggest that adverse effects would not be expected for people that would consume citrus from groves treated with dinotefuran.

(2) Nontarget Toxicity and Risk

Dinotefuran has low to moderate acute and chronic toxicity to nontarget wildlife, such as mammals and birds. Direct risk is not expected based on conservative estimates of exposure and the available toxicity data. Indirect impacts to wildlife populations through the loss of invertebrate prey are also not expected to be significant because only sensitive terrestrial invertebrates that feed on treated trees will be impacted while other insects would be available as prey items. Dinotefuran toxicity is high for honey bees and, similar to other neonicotinoid insecticides, there is uncertainty regarding the impacts of residues from this class of systemic insecticides in pollen and nectar. Studies measuring pollen and nectar residues in other crops with imidacloprid, a neonicotinoid insecticide, have shown that sublethal effects occur above residues measured in the field. However, there is uncertainty regarding dinotefuran residue levels in pollen and nectar from citrus trees and potential impacts to honey bees.

Dinotefuran has low toxicity to fish and most aquatic invertebrates with the exception of some marine invertebrates where it is considered highly toxic. Available toxicity data indicate that degradates of dinotefuran are less toxic to aquatic organisms. Dinotefuran is susceptible to runoff which could occur in aquatic areas adjacent to citrus groves. Significant drift to sensitive aquatic habitats is not expected based on the method of application. Exposure and risk to aquatic organisms will be minimized by adherence to label requirements regarding applications near water. Risk is expected to be minimal to fish, although there is a possibility of risk to some sensitive aquatic invertebrates in very shallow water bodies adjacent to treated citrus groves.

The solubility and soil adsorption characteristics of dinotefuran suggest that it is highly mobile. Dinotefuran does not break down in water, but is somewhat susceptible to microbial degradation and is very sensitive to photolysis. Because of the high mobility and solubility of dinotefuran, there is the potential for leaching into ground water; however, avoiding application to permeable soils and areas where the water table is high will mitigate the potential for contamination. Dinotefuran is not expected to impact air quality based on the method of application and chemical properties which suggest a low potential for volatilization.

b. Imidacloprid (Residential/Citrus Groves)

(1) Human Health Toxicity and Risk

Imidacloprid belongs to a class of insecticides, called neonicotinoids, which act by binding directly to the acetylcholine binding receptor. Imidacloprid is a chemical that has systemic transport qualities in plants which make it efficacious against psyllids and other sucking insects when it is applied as a soil drench or tablet treatment to soil. The acute oral median lethal toxicity of imidacloprid is considered to be moderate to mammals. Inhalation and acute dermal toxicity are considered to be low. The formulation of imidacloprid to be used in the program is of comparable or lower toxicity than the active ingredient. The program applications pose no evident dermal irritation or sensitization, and only mild eye irritation. The acute reference dose (RfD)[6] was set at 0.14 mg/kg/day based on results from an acute neurotoxicity study in rats (EPA, 2003a). The primary metabolites and degradation products of imidacloprid are of lower toxicity than the parent compound, based on available data. Imidacloprid is rapidly excreted by mammals. Synergism of the toxicity of imidacloprid from program use is not expected due to its unique mechanism of toxic action which differs from other chemicals likely to be applied in the program area.

Chronic studies of oral exposures to the rat were found to have a NOEL of 5.7 mg/kg/day and a LOEL of 17 mg/kg/day. Uncertainty factors were applied to this NOEL to determine a chronic RfD[7] for imidacloprid of 0.057 mg/kg/day (EPA, 2003a). An acute population-adjusted RfD of 0.14 mg/kg/day was determined, based upon a rat neurotoxicity study. Reproductive and developmental toxicity studies in rats found a NOEL of 13 mg/kg/day based upon decreased body weights in both genders before mating, and in pups from two litters in a two-generation study. Based upon several in vitro[8] and in vivo studies, imidacloprid is not considered to be mutagenic or genotoxic.[9] EPA has classified imidacloprid in Group E in regard to carcinogenic potential. This indicates that the submitted studies provide evidence of noncarcinogenicity to humans.

In this program, imidacloprid is applied as a soil drench. Exposure of applicators via inhalation, dermal contact, and oral intake to the active ingredient in these formulations is minimal due to the method of application, large droplet size, personal protective equipment, and the

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[6] The acute reference dose is defined by EPA as an estimate of a daily oral exposure for an acute duration (24 hours or less) to humans that is likely to be without risk of adverse health effects over a lifetime.

[7] The chronic reference dose is defined by EPA as an estimate of a daily oral exposure for a chronic duration (up to a lifetime) to humans that is likely to be without risk of adverse health effects over a lifetime.

[8] An artificial environment outside the living organism.

[9] Chemicals capable of causing damage to DNA.

environmental fate of imidacloprid. Potential acute and chronic exposure scenarios indicate minimal risk to workers (USDA–APHIS, 2008). Notifications to residents include recommendations to avoid exposure to pesticide residues. All calculated risks for children and adults exposed to contaminated water and fruit residues were at least two orders of magnitude below those of concern for both acute and chronic exposures (USDA–APHIS, 2008). In addition, risks to the general population that would consume treated citrus from orchards that received applications of insecticides would be low due to the timing of application relative to harvest and the low residues that have been detected in citrus after applications of a systemic insecticide, such as imidacloprid (Ortelli et al., 2005; Blasco et al., 2006). Any residues that would be detected in citrus harvested from these orchards are expected to be well below levels of concern for both adults and children and within the tolerances set by EPA.

(2) Nontarget Toxicity and Risk

Imidacloprid is considered to have moderate toxicity to mammals but is considered toxic to birds, with acute oral median lethal toxicity values ranging from 41 to 152 mg/kg. The limited applications to specific citrus host plants will result in potential effects to invertebrates that are likely to be localized. Concerns have been raised about potential lethal and sublethal effects to honey bees and other pollinators. Median lethal toxicity values of imidacloprid have been based upon oral or contact exposure. Laboratory and field studies of honey bees indicate a lack of adverse effects at test concentrations comparable to realistic exposure scenarios, and adverse health impacts to hives only with greater exposures (USDA–APHIS, 2008).

Exposure to wild mammals and birds from applications of imidacloprid and associated residues is not expected to occur at levels that could result in significant risk in residential applications (USDA–APHIS, 2008). The terrestrial insects that feed upon vegetation of those host plants that have been treated with soil drench applications are likely to be impacted, but the effects would be restricted to the areas of treatment. Any predatory or parasitic insects that depend upon ACP would also be affected due to loss of prey. In residential applications, mammals and birds that feed on insects would not depend exclusively upon the affected insects and would be expected to expand their foraging range to ensure adequate consumption. In citrus grove applications, the potential impacts to wildlife from loss of invertebrate prey would be greater than those in residential applications due to a larger treatment area.

Aquatic vertebrates and invertebrates can be exposed through runoff or drift from the site of application. Significant drift is not expected from soil drench applications. Soil drench applications are not expected to result in toxic effects to aquatic vertebrates, but could pose a risk to the most sensitive aquatic invertebrates under conservative exposures (USDA–APHIS, 2008). Adherence to label requirements will minimize the risks to aquatic resources from these types of applications.

The half-life of imidacloprid in soil under field conditions ranges from 7 to 107 days. Imidacloprid does not adsorb strongly to soil particles. Imidacloprid is soluble in water and has a half-life under natural light of less than 5 hours in water. Based on the chemical properties of imidacloprid, there is the potential for leaching into ground water resources. Adherence to label requirements, as well as the avoidance of applications to permeable soils and/or areas where the water table is high, will ensure the protection of ground water. Imidacloprid is not expected to impact air quality because the method of application will not result in significant drift. Volatilization to the atmosphere is also not anticipated, based on the chemical properties of imidacloprid.

c. Thiamethoxam (Citrus Groves)

(1) Human Health Toxicity and Risk

Thiamethoxam is a neonicotinoid insecticide that has activity against chewing and sucking insects on a variety of crops. Thiamethoxam acts by inhibiting nicotinic acetylcholine receptors in the insect nervous system. The primary metabolite of thiamethoxam is another neonicotinoid insecticide, clothianidin. Thiamethoxam has low to moderate acute toxicity to mammals in oral exposures, and has low dermal and inhalation toxicity. The technical material is not irritating to the skin and is a mild irritant to the eye (EPA, 2010b). Formulations proposed for soil and foliar applications have low oral, dermal, and inhalation toxicity, and are considered mild eye and skin irritants. Available mammalian studies suggest that effects occur primarily to the liver, kidney, testes, and blood in different test animals and exposures. Developmental effects have been observed in rat studies; however, effects were observed at doses that are maternally toxic. Thiamethoxam is not considered mutagenic and is not considered to be carcinogenic (EPA, 2010b).

Applications will be restricted to either foliar or soil applications in commercial citrus groves. Workers and applicators will be the population segment at greatest risk of exposure to thiamethoxam applications. Precautionary label language and personal protective equipment requirements will reduce exposure and risk to this group of the population. Thiamethoxam exhibits chemical properties that could result in the contamination of surface and ground water resources that may be used for drinking water. The potential for this type of exposure is reduced by following label recommendations regarding avoiding applications to soils that are highly permeable or poorly drained, and the use of vegetative filter strips between areas of application and aquatic resources.

(2) Nontarget Toxicity and Risk

Thiamethoxam has low to moderate toxicity to nontarget wildlife, such as birds and mammals (EPA, 2010a, and 2010b). Thiamethoxam is toxic to honey bees based on available toxicity data resulting in label language designed to reduce exposure and risk to these types of pollinators (EPA, 2010b). Thiamethoxam is also expected to impact other sensitive nontarget terrestrial invertebrates; however, these impacts will typically be confined to areas within the orchard. Impacts to nontarget terrestrial invertebrates adjacent to the orchard are not expected for soil treatments, and foliar application exposure will be reduced by avoiding drift into nontarget areas.

Thiamethoxam toxicity to fish is considered low, while toxicity to aquatic invertebrates ranges from low to highly toxic, depending on the test organism (EPA, 2010b; Barbee and Stout, 2009). Toxicity to aquatic invertebrates, such as freshwater cladocerans, is low, while toxicity to aquatic insects is high with median lethality and sublethal effect values in the low parts per billion range (EPA, 2010b). Exposure and risk to aquatic organisms from thimethoxam, and the associated metabolite clothianidin, can be reduced by avoiding applications under conditions that would allow for runoff and drift.

Thiamethoxam degradation in soil is slow with half-lives ranging from approximately 30 days to greater than 100 days (Mainfisch et al., 2001). In areas where soil treatments occur within citrus orchards, there could be some impacts to soil quality, particularly to organisms that may be sensitive to thiamethoxam. For foliar treatments, potential soil-related impacts will be minimized by making applications that reduce the possibility of off-site movement. Thiamethoxam is highly water soluble and exhibits chemical properties that suggest it could move off-site (Mainfisch et al., 2001). Precautionary language on the label, as well as avoiding applications to soils that are poorly drained, sloping towards aquatic areas, or where there is a high water table, will reduce the potential for impacting surface and ground water quality. Impacts to air quality are not expected from thiamethoxam soil applications, based on the method of application, and foliar applications are only expected to impact air quality during application. Thiamethoxam does not readily volatilize into the atmosphere, suggesting that any impacts to air quality would be primarily confined to treated areas during foliar applications.

d. Abamectin (Citrus Groves)

(1) Human Health Toxicity and Risk

Abamectin is a mixture of two avermectin compounds that are derived from the bacterium *Streptomyces avermitilis*. These products have insecticidal properties that are used to control a variety of pests in agricultural and nonagricultural applications. As a technical material, abamectin is considered highly toxic to mammals from ingestion with median lethality values ranging from 4.4 to 14.9 mg/kg (EPA, 2004b). Comparable studies with the formulated material show lower toxicity from oral exposures. Inhalation and dermal toxicity is much lower with median lethality values typically higher than the highest concentration tested. Depending on the formulation, or whether testing the technical material, skin and eye irritation is considered mild to moderate. Abamectin is not considered mutagenic or carcinogenic based on long-term laboratory studies with the mouse and dog. In studies using the rat, abamectin has been shown to be teratogenic at doses that also result in maternal toxicity. Reproductive effects, such as decreased pup weight, increased stillbirths, and decreased lactation have also been noted in studies at dose levels of 0.40 mg/kg/day (EPA, 2004b).

Abamectin will be applied in citrus groves using aerial or ground equipment where significant exposure to the public is not expected. Exposure and risk will be greatest for workers and applicators during the time of application. Impacts to drinking water resources are not expected. Abamectin has very low solubility in water and adheres strongly to soil and sediment and, therefore, it would not be expected to leach to ground water or be present in surface water. Adherence to label requirements (such as spray drift management requirements and buffer zones from aquatic areas) will further reduce the threats to surface water that may be used as a source of drinking water.

(2) Nontarget Toxicity and Risk

Abamectin acute oral toxicity is high to wild mammals based on laboratory data using the technical material. However, the various formulations available for use against ACP in citrus demonstrate an approximate ten-fold reduction in acute oral toxicity. Available data for the technical and formulated material indicate that dermal and inhalation toxicity to wild mammals is low. Developmental and reproductive effects have been noted in longer term studies at concentrations greater than 1 mg/kg/day. Toxicity to birds is low with median lethal dietary toxicity values of 383 and 3,102 ppm for the bobwhite quail and mallard, respectively (EPA, 2010a). Indirect impacts to mammals and birds that depend on invertebrate prey items could occur after abamectin treatment in citrus groves. Abamectin is considered highly toxic to honey bees and other nontarget terrestrial invertebrates (EPA, 2010a). Adherence to label requirements regarding the protection of honey bees will reduce the impact.

Abamectin is highly toxic to fish and aquatic invertebrates. The range of concentrations that cause direct mortality to fish from abamectin exposure is in the low-ppb range, while the range of sensitivities to aquatic invertebrates is greater because of a larger number of tested species. Toxicity values for aquatic invertebrates vary from the high-ppt range, with freshwater crustaceans being the most sensitive, to the least tolerant species (eastern oyster) with effect concentrations in the mid-ppb range (EPA, 2010a). Abamectin exposure in aquatic systems would be expected in situations where aquatic invertebrates occur in proximity to citrus groves. Low application rates and the environmental fate of abamectin, such as low water solubility and a strong affinity to soil and sediment, would result in low residues in water, and reduce the potential for adverse impacts to fish and aquatic invertebrates. Required application buffers and other drift reducing measures listed on the labels for this insecticide will further reduce the risk to aquatic resources.

Impacts to air quality from abamectin treatments will be limited to the time of application within the citrus grove. Abamectin does not exhibit environmental fate or chemical properties that suggest that it would volatilize into the atmosphere. Impacts to soil quality would be limited to those areas of treatment within the groves. Abamectin has a variable half-life in soil, depending on the degradation process, and can range from a few hours in the presence of light to approximately 60 days under dark, aerobic conditions. Abamectin is not expected to impact ground or surface water because of label restrictions for each formulation near surface water and the environmental fate for this class of insecticides. Due to the very low solubility and strong tendency to bind to soil, abamectin is not considered mobile and would not move to ground water resources. Its presence in surface water would be short lived because it would bind to sediment, and it is also sensitive to photodegradation in water with a reported half-life of less than a day. Degradation in sediment is slightly slower with half-lives ranging from 2 to 4 weeks.

e. Azadirachtin (Citrus Groves)

(1) Human Health Toxicity and Risk

Neem oil is an extract from the neem plant that contains azadirachtin, which has insecticidal properties by disrupting insect molting by acting as an ecdysone antagonist. The formulated material has very low acute oral, dermal, and inhalation toxicity, with all median lethality values greater than the highest concentration tested. It is considered a mild skin irritant but is not an eye irritant or a skin sensitizer. Azadirachtin is not considered mutagenic or carcinogenic, according to the data provided on the material safety data sheet.

Exposure and risk to humans from neem applications are expected to be minimal. An aerial or ground application would occur within established citrus groves where exposure would be greatest for workers and applicators. The low toxicity and adherence to label requirements would minimize risk to this segment of the population. Azadirachtin is not expected to be a threat to surface drinking water or ground water based on its low solubility and binding to soil which would suggest that leaching into ground water is not likely, and any surface water residues would dissipate quickly.

(2) Nontarget Toxicity and Risk

Azadirachtin is considered practically nontoxic to birds, with reported median lethality values greater than the highest test concentration. It is considered moderately toxic to some terrestrial invertebrates, including honey bees. Significant exposure and risk to terrestrial vertebrates are not expected from the use of azadirachtin because of its low toxicity and low exposure to treated vegetation or invertebrates. Indirect risk to vertebrates that use invertebrate prey as a food source would be low because azadirachtin is selective in its impacts to terrestrial invertebrates.

Azadirachtin is considered toxic to aquatic organisms, with median lethality toxicity values ranging from the low ppb to low ppm (EPA, 2009a). Azadirachtin exposure in aquatic habitats could occur where they are in close proximity to citrus groves. The potential for these types of impacts to aquatic resources will be greatest in shallow, static water bodies, although adherence to label requirements and the use of measures to reduce drift will reduce exposure and risk.

Azadirachtin use in this program is not expected to cause adverse impacts to soil, water, or air quality. Degradation in soil appears to be microbially mediated, with a half-life of approximately 20 days at 25 °C (Stark and Walter, 1995). Persistence in water varies, with reported dissipation half-lives as short as a day up to 30 days (Thompson et al., 2004). Azadirachtin is not expected to bind strongly to soil and is very susceptible to photolysis with a half-life of less than 1 hour (Johnson and Dureja, 2002). Azadirachtin is not expected to volatilize into the atmosphere and would only occur as drift from ground or aerial applications. Photolytic instability and the use pattern in this program will minimize any potential off-site impacts to air quality.

f. Bifenthrin (Citrus Groves)

(1) Human Health Toxicity and Risk

Bifenthrin is a synthetic pyrethroid insecticide with a mode of action similar to other pyrethroids, such as cyfluthrin, which was previously discussed. Bifenthrin has moderate acute oral toxicity but low dermal toxicity. It is not considered to be a dermal sensitizer or an eye or skin irritant (EPA, 2007a). Bifenthrin is not considered to be a reproductive or developmental toxicant. However, it is considered a potential carcinogen based on the formation of urinary bladder tumors when administered at high doses to mice.

The application of this insecticide is limited to treatments of citrus groves. The potential for bifenthrin exposure would be restricted to applicators and no adverse effects are expected with adherence to label requirements and other standard operating procedures. Ground and surface drinking water resources are not expected to be impacted based on label restrictions regarding the protection of surface water and the environmental fate properties for bifenthrin which demonstrate low solubility and a high affinity for binding to soil. Risks to the general population that would consume treated citrus from orchards that received foliar applications of insecticides would be low due to the short persistence of bifenthrin in the environment, and the timing of application relative to harvest which would allow for significant degradation.

(2) Nontarget Toxicity and Risk

Bifenthrin has low to slight toxicity to birds and moderate acute toxicity to wild mammals. Significant exposure and risk to nontarget terrestrial vertebrates is not expected due to low toxicity and low residue levels expected on plant and insect food items. Impacts to terrestrial invertebrates from bifenthrin treatments within the citrus groves are expected. Bifenthrin is considered highly toxic to honey bees by oral and contact exposure.

Similar to other pyrethroid insecticides, bifenthrin is considered highly toxic to fish and aquatic invertebrates. Toxicity values for both groups of organisms ranges from the low parts per trillion (ppt) to the low parts per billion (ppb), depending on the test species and conditions (Solomon et al., 2001; EPA, 2009). The greatest risk of exposure to aquatic resources is through drift from bifenthrin applications in citrus groves. Bifenthrin runoff is not expected to be a significant route of exposure to aquatic resources because this type of insecticide binds tightly to soil and has very low solubility, reducing the potential for transport and exposure to most aquatic organisms.

Bifenthrin has extremely low solubility and mobility in soil, suggesting that it would not be a threat to ground water. Threats to surface water quality would be primarily from drift which is reduced by the implementation of spray drift mitigation measures and any label-required application buffers from aquatic resources. Impacts to air are not expected because of the low vapor pressure for bifenthrin.

g. Carbaryl (Residential/Citrus Groves)

(1) Human Health Toxicity and Risk

Carbaryl is a carbamate[10] insecticide with a mode of action that occurs primarily through acetylcholinesterase (AChE) inhibition[11] (Klaassen et al., 1986). Carbaryl is a broad-spectrum insecticide that is effective as a foliar treatment against psyllids and other leaf-dwelling insects.

The acute oral median lethal toxicity of carbaryl is considered to be moderate to mammals. Inhalation and acute dermal toxicity are considered to be low. The formulations of carbaryl that may be used in the program are of comparable or lower acute toxicity than the active ingredient. The program applications pose minimal dermal irritation and no dermal sensitization. The formulations that may be used in the program may result in mild eye irritation. Carbaryl is readily metabolized and largely excreted from humans within 24 hours. The primary metabolite of carbaryl, 1-naphthol, is considerably less toxic than the parent compound.

The toxicity of carbaryl may be increased by exposure to some other carbamates and organophosphates (Knaak and O'Brien, 1960; Keplinger and Deichmann, 1967; Segal and Fedoroff, 1989). Although this is possible in the program area, it is unlikely that the timing of program applications of carbaryl will occur at an interval close enough to result in this effect on toxicity.

A chronic feeding study of dogs determined a no observed effect level (NOEL)[12] of 3.83 milligrams per kilograms per day (mg/kg/day) for carbaryl based upon significant decreases in plasma and brain cholinesterase activity at higher doses (EPA, OPPTS, 1994). A subchronic rat neurotoxicity study found a NOEL of 1 mg/kg/day based upon decreased blood and brain cholinesterase[13] at higher doses (EPA, 2007b). Reproductive and developmental toxicity studies in rats found a maternal NOEL of 1 mg/kg/day and a teratologic[14] NOEL of 3.15 mg/kg/day. Carbaryl has been classified as a likely carcinogen based upon vascular tumors and hepatic and kidney adenomas (a type of benign tumor) found in a chronic carcinogenicity study. Chromosomal damage

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10 Carbamates are organic compounds derived from carbamic acid (NH_2COOH).
11 Inhibitors of acetylcholinesterase act by disrupting the transmission of nerve impulses across the nerve synapses in animals. Depending on the degree of acetylcholinesterase inhibition, effects can include anything from headaches, mental confusion, blurred vision, and muscle twitching to muscle paralysis.
12 The highest tested dose of a substance that has been reported to have no harmful health effects.
13 An enzyme that is widely distributed throughout the muscles, glands, and nerves of the body that converts acetylcholine into choline and acetic acid.
14 Causing malformations of an embryo or fetus.

has been reported with high doses of carbaryl, but no in vivo[15] mutagenic effects have been observed (EPA, 2007b).

Carbaryl is applied as a foliar treatment in the program either to residential citrus or in citrus groves. Due to higher application rates, exposure was greater for applicators than other residential foliar treatments; however, due to its low toxicity it was shown to have wide margins of safety (USDA–APHIS, 2008).

Ingestion of contaminated drinking water and treated citrus fruit were exposure scenarios analyzed for the use of carbaryl. All calculated risks for children and adults indicate minimal risk to the public for residential applications (USDA–APHIS, 2008).

(2) Nontarget Toxicity and Risk

The acute oral median lethal toxicity of carbaryl is considered to be moderate for mammals, while toxicity to birds ranges from toxic to practically nontoxic, with acute oral median lethal toxicity values from 16 mg/kg to greater than 2,000 mg/kg. Exposures to carbaryl of mammals and birds from residential program applications were determined to result in doses that pose minimal acute or chronic risks (USDA–APHIS, 2008). Indirect impacts to insectivores[16] (e.g., loss of terrestrial invertebrate prey) are not expected to be of concern in residential applications. Any effects will be localized based on the method of application and the selective treatment of individual host trees. There is the potential for indirect impacts to birds and mammals that forage for terrestrial invertebrate prey items in carbaryl treated citrus groves. Carbaryl has a short half-life in the environment; therefore, recovery of nontarget terrestrial invertebrates would be expected to occur for most invertebrates.

The broad-spectrum activity of carbaryl results in high toxicity to most insects, including pollinators. The 48-hour contact median lethal dose for honey bees is 0.001 microgram per bee (µg/bee). Adherence to carbaryl label requirements regarding the protection of honey bees will reduce exposure and risk to honey bees and other pollinators.

Carbaryl is moderately to highly toxic to fish, and very highly toxic to all aquatic insects and to most aquatic crustaceans. Carbaryl is not subject to significant bioaccumulation[17] due to its low water solubility and lack of uptake in plant and animal tissues. Aquatic vertebrates and invertebrates may be exposed to carbaryl through runoff or drift adjacent to the site of application. Exposure to aquatic resources from residential applications is

[15] Experiments done in or on living tissue or a whole, living organism.
[16] Species whose diet consists primarily of insects.
[17] The accumulation of substances, such as pesticides, or other organic chemicals in an organism.

expected to be less than those from citrus grove applications. Applications in residential treatment areas are to individual trees using ground equipment, compared to broadcast aerial and ground applications in citrus orchards. Aquatic resources adjacent to citrus groves may receive exposure from carbaryl applications. Sensitive sites, such as shallow, static bodies of water, may be impacted by carbaryl applications. Risk is greatest for aquatic invertebrates because they are more sensitive to carbaryl, potentially resulting in indirect impacts to aquatic vertebrates that depend on these resources as prey. Exposure and risk to aquatic sites can be reduced by adherence to label requirements for each carbaryl formulation that may be used in either residential or citrus grove applications.

Carbaryl is not expected to persist in the environment under the proposed use patterns. Carbaryl degrades rapidly in soil and water with half-lives in laboratory and field studies ranging from less than 1 day to approximately 20 days (FS, 2008a). Carbaryl is not considered to be a threat to ground water resources because it is not considered to be mobile and susceptible to leaching. Carbaryl could impact surface water quality in situations where aquatic resources are adjacent to treatment sites. Water quality impacts will be minimized by following adherence to label requirements for ground and aerial treatments. Carbaryl is not expected to have impacts to air quality from volatilization[18] after application. Carbaryl will occur in the atmosphere during application as spray droplets; however, this will occur in the immediate area of application and will dissipate quickly after treatment.

h. Chlorpyrifos (Citrus Groves)

(1) Human Health Toxicity and Risk

Chlorpyrifos is an organophosphate insecticide with a mode of action that occurs primarily through the inhibition of cholinesterase enzyme. Signs and symptoms of low doses include localized effects (such as nosebleeds, blurred vision, and bronchial constriction) and systemic effects (such as nausea, sweating, dizziness, and muscular weakness). At higher doses, the signs and symptoms include irregular heartbeat, elevated blood pressure, cramps, and convulsions. Acute oral toxicity is moderate based on median lethality values ranging from 60 to 1,000 mg/kg, depending on the test species. Dermal toxicity is considered low, and the formulated material can cause moderate eye and skin irritation. Chlorpyrifos is not considered mutagenic, teratogenic, or carcinogenic by EPA (USDA–APHIS, 2005b).

The application of this pesticide would be limited to one application by either ground or air in areas that are established citrus groves.

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[18] The conversion of a chemical substance from a liquid or solid state to a gaseous or vapor state.

Contamination of ground water resources is not expected based on the environmental fate for chlorpyrifos. Application buffers and spray drift mitigation language on chlorpyrifos labels will reduce surface water contamination, and, based on the fate of chlorpyrifos in aquatic environments, any residues that may occur would be expected to partition to sediment. Exposure to the general population that may consume treated citrus from these types of applications would be low due to the timing of application relative to harvest, adherence to preharvest intervals, and the low levels of chlorpyrifos residues that may occur in edible portions of citrus (Iwata et al., 1983; Montemurro et al., 2002).

(2) Nontarget Toxicity and Risk

Chlorpyrifos is considered to be moderately to highly toxic to birds, depending on the test species (EPA, 2009a; USDA–APHIS, 2005b). Symptoms of nonfatal exposure to birds include cholinesterase depression (ChE), weight loss, reduced egg production, and reduced hatchling survival. There is the possibility of some direct impacts to wildlife that would forage exclusively on plant and insects within treated citrus groves. Risk is reduced for those wildlife species that may also forage outside treated groves. Indirect impacts to mammals and birds that depend on insects as part of their diet could occur for those species that forage exclusively in citrus groves. The ability of wild mammals and birds to forage in areas outside of the groves, as well as recovery of impacted invertebrates in treated groves, will reduce those types of potential impacts to wildlife populations. Impacts to terrestrial invertebrates, such as worker honey bees, are expected; however this effect would be restricted primarily to areas within and adjacent to citrus groves. Precautionary language prohibiting applications to blooming plants when bees are actively foraging would further reduce impacts to pollinators.

Chlorpyrifos is highly toxic to fish and aquatic invertebrates with acute median lethality values ranging from the low ppt to low ppb range, depending on the test species (EPA, 2009a; USDA–APHIS, 2005b). Exposure and risk to aquatic species would be reduced by adherence to label requirements to reduce drift, and by applying buffers of 25 feet for ground applications and 150 feet for aerial applications from all aquatic resources.

Potential effects of chlorpyrifos on air, soil, or water quality would be restricted to areas near the site of application. Chlorpyrifos can persist in soil and water for several months under certain conditions; however, the persistence is generally only for a month or less. This is dependent on the organic content of the soil. Chlorpyrifos degrades quickly in the presence of light, with a half-life of approximately 2.7 hours. In water, it will bind readily with sediment with aqueous half-lives ranging from 7 to 28 days. Chlorpyrifos can volatilize into the atmosphere; however, its persistence is expected to be short, with a half-life of only a few hours because of its photolytic sensitivity (USDA–APHIS, 2005b). Chlorpyrifos can impact air quality through drift from ground or aerial applications. These impacts would be restricted to areas within established citrus groves with off-site transport reduced by strict adherence to label requirements regarding the minimization of drift.

i. Citrus Oils (Citrus Groves)

(1) Human Health Toxicity and Risk

Citrus oil is a biological insecticide derived from the extraction of oils from citrus that can be used to control certain insect pests. These oils are a proprietary mixture of different materials, with limonene being one of the components with insecticidal activity. Constituents of citrus oil have been shown to have low mammalian toxicity (EPA, 1994). Prolonged inhalation of mist or vapors of the formulated material can cause adverse effects, and contact with the eye can cause substantial irritation.

Citrus oil use in this program would be as a foliar application in citrus groves. In citrus groves, exposure would be restricted to workers and applicators. Based on available toxicity data and the requirements for personal protective equipment, risk is expected to be minimal. Threats to ground or surface water resources are not expected based on the chemical fate of citrus oil which suggests low solubility and mobility.

(2) Nontarget Toxicity and Risk

Nontarget toxicity data for citrus oils is limited; however, data for some constituents contained within these types of materials, such as limonene, demonstrate that acute and subacute toxicity to birds is extremely low. The low toxicity to terrestrial vertebrates suggests minimal direct risk to wild mammals and birds. Indirect impacts through the loss of insect prey to this group of organisms are not expected because citrus oils are not considered broad-spectrum insecticides and would only have impacts to a small group of terrestrial invertebrates. Toxicity to terrestrial invertebrates, such as honey bees, is unknown.

Aquatic toxicity is low, with median lethality values in the low-ppm range for invertebrates and fish, based on limited available data (Kassir, et al., 1989; EPA, 1994). Exposure to aquatic habitats adjacent to citrus groves may occur during aerial applications, although adherence to label requirements, the environmental fate of these types of oils, and low toxicity suggest that adverse impacts would not be expected in these types of environments.

Citrus oil impacts to soil, water, and air quality are expected to be negligible. All treatments would be made in a manner to minimize off-site transport, thereby minimizing impacts to water quality. Impacts to ground water are not expected because citrus oil is not considered soluble or mobile. Citrus oil can occur in the atmosphere as drift from ground and aerial applications; however, this impact would be short in duration and occur primarily within the treatment block.

j. β-Cyfluthrin (Residential/Citrus Groves)

(1) Human Health Toxicity and Risk

Cyfluthrin is a synthetic pyrethroid insecticide[19] with broad-spectrum activity. The mode of toxic action occurs by causing the sodium channels to stimulate nerves to produce repetitive discharges. Muscle contractions are sustained until a block of the contractions occurs. Nerve paralysis can occur at high levels of exposure (Walker and Keith, 1992). Cyfluthrin is effective against psyllids and other sucking insects when applied as a foliar treatment.

The acute oral median lethal toxicity of cyfluthrin is considered to be low to moderate in mammals. Inhalation and acute dermal toxicity are considered to be low. The formulation of cyfluthrin to be used in the program is of comparable or lower acute toxicity than the active ingredient. The program applications pose no evident dermal irritation or sensitization, but may result in mild eye irritation. An acute neurotoxicity study using the rat resulted in a decrease in motor activity at 10 mg/kg/day with a resulting NOEL of 2 mg/kg/day. Based on this study, the acute RfD was set at 0.02 mg/kg/day (EPA, 2005a). Cyfluthrin is rapidly absorbed and largely excreted as conjugated (joined) metabolites within 48 hours.

Synergism of the toxicity of organophosphates and synthetic pyrethroids, such as cyfluthrin, has been shown in laboratory and field tests (Keil and Parrella, 1990; Horowitz et al., 1987). Although this is possible in the program area, it is unlikely that the timing of applications of organophosphates will occur at intervals close enough to program applications of cyfluthrin to result in this effect.

Chronic studies of oral exposures were found to have a NOEL of 2.5 mg/kg/day and a lowest observed effect level (LOEL)[20] of 6.2 mg/kg/day based upon decreased body weights and other effects. Uncertainty factors were applied to the NOEL to determine the chronic

[19] Pyrethroids are synthetic chemical compounds similar to the natural chemical pyrethrins produced by the flowers of pyrethrums.

[20] LOEL is the lowest tested dose of a substance that has been reported to cause harmful health effects.

RfD for cyfluthrin of 0.025 mg/kg/day (EPA, 1997a). An acute RfD of 0.02 mg/kg/day was determined based upon a rat neurotoxicity study (EPA, 2005a). Reproductive and developmental toxicity studies in rats found a maternal NOEL of 3 mg/kg/day, and a developmental NOEL of 10 mg/kg/day. Cyfluthrin is not considered to pose mutagenic or carcinogenic risks (EPA, 1997a).

Cyfluthrin will be applied as a foliar treatment. The potential exposure to applicators was determined to be two to four orders of magnitude lower than the RfD, so there is minimal risk for workers (USDA–APHIS, 2008). Ingestion of contaminated drinking water and treated citrus fruit were exposure scenarios analyzed for the use of cyfluthrin. All calculated risks for children and adults indicate minimal risk to the public (USDA–APHIS, 2008).

(2) Nontarget Toxicity and Risk

The acute oral median lethal toxicity of cyfluthrin is considered to be low to moderate for mammals. Inhalation and acute dermal toxicity are considered to be low. The formulation of cyfluthrin to be used in the program is of comparable or lower toxicity than the active ingredient. Cyfluthrin is considered to be practically nontoxic to birds with acute oral median lethal toxicity values greater than 2,000 mg/kg (EPA, 2010a). Exposure to nontarget terrestrial animals from residential treatments is expected to be lower because applications are made to individual trees, compared to citrus groves where broadcast applications over a larger area will occur. Residential treatments will only be made to individual citrus trees and not other vegetation present in these areas.

Mammals and birds and other wildife that may forage for invertebrate prey will have other available food items from plants that have not been treated; treated citrus is expected to be recolonized by terrestrial invertebrates after treatment. The potential for indirect risk is greater in citrus orchards because applications are broadcast over groves which will occupy a larger area when compared to the residential treatments. Direct risk to wild mammals and birds that may feed on contaminated prey is expected to be low for both proposed use patterns (based on the available toxicity data) and conservative estimates of residues that can occur on prey items. There is the potential for indirect risk to terrestrial vertebrates that depend on insects as a food source. This type of risk is greater in citrus groves compared to residential treatments. Cyfluthrin is expected to impact some nontarget terrestrial invertebrates, resulting in a temporary depression in invertebrate populations in treated citrus groves. The potential for indirect impacts will be greater in larger groves due to the larger area of application relative to the foraging range for small mammals and birds; however, their ability to forage outside the range of the groves and the recovery of invertebrate populations will help to minimize the potential for these types of impacts.

The broad-spectrum activity of cyfluthrin results in high toxicity to most insects, including pollinators. The 48-hour contact median lethal dose for honey bees is 0.037 µg/bee (EPA, 2010a). Adherence to cyfluthrin label requirements regarding the protection of honey bees will reduce exposure and risk to honey bees and other pollinators.

Cyfluthrin is highly toxic to fish and very highly toxic to most aquatic invertebrates (EPA, 2010a). The greatest risk to aquatic resources is through drift from cyfluthrin applications. Cyfluthrin runoff is not expected to be significant to aquatic resources because this type of insecticide binds tightly to soil and has very low solubility, thereby reducing the potential for transport and exposure to most aquatic organisms. Drift from residential applications to aquatic areas is expected to be less than from applications to citrus groves. Residential applications are made to individual trees using hand-held spray equipment which helps to reduce potential drift. Larger broadcast applications to citrus groves will increase the chance of off-site transport from drift to aquatic resources. Adherence to label requirements for cyfluthrin formulations registered for use in citrus groves provide multiple measures to reduce the potential for drift from areas of application. Spray drift restrictions, as well as other measures such as buffer zones from aquatic sites, that are stated on the labels will reduce exposure and risk to aquatic organisms.

Cyfluthrin impacts to soil, water, and air quality are expected to be minimal based on the environmental fate and label requirements for application. Cyfluthrin half-lives in soil are variable depending on pH and organic matter. Laboratory and field dissipation half-lives range from approximately 30 to 94 days. Once cyfluthrin reaches the soil, it binds very tightly to soil particles and is not considered to be water soluble. The high affinity for soil and low solubility suggest that any cyfluthrin that reaches an aquatic resource will be soil bound or partition very rapidly to the sediment. The lack of mobility suggests that ground water contamination will not be a concern. Surface water quality could be impacted from drift during applications; however, several mitigation measures are stated on the label to protect surface water quality. Cyfluthrin will only occur in the atmosphere during application; however, it will dissipate rapidly and is not expected to volatilize back into the atmosphere, based on its chemical properties.

k. Deltamethrin (Citrus Groves)

(1) Human Health Toxicity and Risk

Deltamethrin is a pyrethroid insecticide that has both contact and ingestion activity to several pest insects. It is widely used on a variety of crops and ornamentals to control sucking insects, as well as some lepidopteran[21] pests.

Based on the test conditions and species, acute mammalian toxicity for deltamethrin is variable, with oral toxicity values ranging from toxic to practically nontoxic (CA DPR, 2000; Barlow et al., 2001). Dermal toxicity is considered to be low, as is the inhalation toxicity for most formulations, with the exception of one emulsifiable concentrate formulation which demonstrates moderate inhalation toxicity (CA DPR, 2000). Several studies have shown that deltamethrin is not a carcinogen, mutagen, or teratogen (Barlow et al., 2001; EPA, 2004c).

The potential for exposure to deltamethrin would be restricted to applicators during application; however, by adhering to label requirements and other standard operating procedures, no adverse effects to applicators are expected. The environmental fate of deltamethrin, as well as adherence to label requirements regarding applications near surface water, suggest that ground and surface drinking water resources would not be impacted. Deltamethrin exhibits a strong binding affinity to soil and sediment and has low water solubility, suggesting that it would not leach to ground water, and any surface water residues would partition rapidly to sediment. Risks to the general population that would consume treated citrus from orchards that received foliar applications would be low due to the relatively short half-life of deltamethrin in the environment and the timing of application relative to harvest.

(2) Nontarget Toxicity and Risk

Deltamethrin toxicity to nontarget birds and mammals suggests effects at lower concentrations for mammals when compared to birds, where deltamethrin is considered practically nontoxic (EPA, 2008). Direct risk to birds and mammals is not expected based on conservative assumptions of exposure and available toxicity data. There is the possibility of indirect impacts through the loss of invertebrate prey after treatment. This type of impact is only expected to occur for those terrestrial vertebrates that rely exclusively on deltamethrin-sensitive invertebrates within treated groves. Other invertebrates that are more tolerant of deltamethrin, as well as recolonization of the area from areas outside the citrus groves, would help to minimize indirect impacts. Deltamethrin is considered highly toxic to

[21] Large order of scaly-winged insects, including butterflies and moths.

honey bees. Adherence to label requirements will help to minimize exposure and risk to honey bees that may forage in citrus groves.

Deltamethrin is considered highly toxic to fish and aquatic invertebrates, with fish being less sensitive than aquatic invertebrates (EPA, 2008; Solomon et al., 2001). Acute fish toxicity values vary based on test species and conditions, but range from the mid-ppt to low-ppb range (EPA, 2008). Acute aquatic invertebrate toxicity is also dependent on the test species and condition, with toxicity values that range from low-ppt to the low-ppb range (EPA, 2008). Aquatic chronic toxicity is also high for fish and aquatic invertebrates, with no effect concentrations in the low-ppt range. Exposure to aquatic habitats adjacent to citrus groves could result in adverse impacts to these types of habitats. Adherence to label requirements regarding the minimization of drift and any other restrictions will reduce off-site transport to these areas and reduce risk.

Deltamethrin has low solubility and a strong binding affinity for soil and sediment. In aquatic environments, deltamethrin is stable to degradation at a neutral pH, but will degrade quickly in more alkaline environments. Deltamethrin is susceptible to photolysis and microbial degradation in water and soil (Laskowski, 2002). Deltamethrin has a low vapor pressure and is not expected to have adverse impacts to air quality.

I. Diflubenzuron (Citrus Groves)

(1) Human Health Toxicity and Risk

Diflubenzuron is an insecticide that inhibits chitin production in invertebrates, and has a variety of agricultural and nonagricultural uses. The technical active ingredient and proposed formulation exhibit low acute toxicity to mammals with oral, dermal, and inhalation median lethality values greater than the highest test concentration (FS, 2004; Chemtura, 2008). Diflubenzuron is not considered to be mutagenic, carcinogenic, or teratogenic based on available laboratory toxicity studies. However, a primary environmental metabolite of diflubenzuron, 4-chloroaniline is considered a probable carcinogen. Based on available mammalian studies that measured sublethal effects, the most sensitive endpoint appears to be impacts to hemoglobin which is involved in oxygen transport in blood. Diflubenzuron causes the formation of excessive methoglobin which is unable to transport oxygen.

Diflubenzuron use in this program is restricted to ground or aerial applications in commercial citrus groves where exposure would be greatest for applicators. The low acute and chronic toxicity of diflubenzuron and adherence to label requirements regarding protective personal equipment suggest that the risk to this segment of the population would be low. Diflubenzuron has low solubility and partitions to soil and sediment suggesting that it would not leach to ground water that may serve as a drinking water source. The low mammalian toxicity and environmental fate properties suggest risk to surface water used as a drinking water source would also be low based on labeled use of diflubenzuron.

(2) Nontarget Toxicity and Risk

Diflubenzuron toxicity to wild mammals and birds is low based on available toxicity data (FS, 2004; USDA–APHIS, 2010c). Toxicity values, based on acute exposures in birds, demonstrate median toxicity lethality values greater than the highest test concentration, and no observable effect concentrations of 250 ppm or greater in chronic exposures (EPA, 1997b; Kubena, 1981; Kubena, 1982). Exposure to diflubenzuron residues from program applications on wild mammal and avian food items is not expected to result in adverse effects (USDA–APHIS, 2010c). There is the potential for indirect effects to mammals and birds because of the loss of invertebrate prey items after diflubenzuron treatment in citrus orchards. Field studies evaluating these types of effects in wild mammals have shown some shifts in diet after treatment with diflubenzuron, although no impacts were noted to wild mammal populations (Seidel and Whitmore, 1995; FS, 2004). Similar studies of different songbirds in forested areas treated with diflubenzuron have noted shifts in their insect diet after treatment (Stribling and Smith, 1987; Sample et al., 1993; FS, 2004).

Laboratory and field studies assessing nontarget impacts to terrestrial invertebrates have demonstrated minimal to no impacts on most terrestrial invertebrates, including honey bees. Evaluation of impacts to honey bees in field studies, including those conducted in citrus groves, have demonstrated safety to bees when using diflubenzuron (Emmett and Archer, 1980; Atkins et al., 1976; Schroeder et al., 1980; Robinson, 1979). Field studies assessing the impact of diflubenzuron on other nontarget terrestrial invertebrates has shown minimal impacts in a range of diflubenzuron applications (Sample et al., 1993; Catangui et al., 1996; FS, 2004).

Diflubenzuron has low to moderate acute toxicity to fish with median lethal concentrations ranging from the low-ppm range to greater than 600 ppm for some species (USDA–APHIS, 2010c). Sublethal and chronic toxicity is also considered to be low based on available data. Diflubenzuron is considered highly toxic to most aquatic invertebrates. Acute toxicity can range from below 1 ppb for some freshwater crustaceans to greater than 125 ppm for the most tolerant aquatic invertebrates species (USDA–APHIS, 2010c). Available data for metabolites of diflubenzuron in aquatic environments demonstrates equal or lower toxicity when compared to the parent material. Direct risk to aquatic vertebrates is not expected when considering conservative exposure estimates in shallow water bodies. There is the potential for direct toxicity of diflubenzuron to aquatic invertebrates in water bodies adjacent to commercial citrus groves. Depending on the aquatic resource and the level of exposure, aquatic invertebrate losses could result in indirect effects to organisms dependent on these resources as food; however, in some cases, recovery of invertebrate populations would make these types of effects temporary.

Diflubenzuron impacts to air quality are not expected beyond the period of application where off-site drift could occur. Diflubenzuron has chemical and physical properties that suggest it will not volatilize into the atmosphere after application (USDA–APHIS, 2010c). Diflubenzuron has very low water solubility and preferentially adheres to soil particles; therefore, it is not considered to be mobile and is not a threat to ground water resources. Diflubenzuron could impact surface water quality via drift and runoff at the time of application, although this will be reduced by adherence to label requirements. Diflubenzuron persistence in sediment and water is expected to be short with half-lives of less than 35 days. Half-lives in soil are similar to those in aquatic systems. Dissipation half-lives in citrus and apple orchards report values of 68 to 78 days, respectively.

m. Dimethoate (Citrus Groves)

(1) Human Health Toxicity and Risk

Dimethoate is a systemic organosphosphate insecticide whose primary mode of action is through inhibition of cholinesterase. Acute exposure through oral, dermal, and inhalation routes demonstrate moderate oral toxicity and low dermal and inhalation toxicity (EPA, 2006a). Dimethoate is considered a slight to moderate eye and skin irritant, and available data for the proposed formulation for use in this program suggests comparable acute toxicity. Similar to other organophosphate insecticides, the most sensitive endpoint in short- and long-term exposures to dimethoate and its associated metabolite, omethoate, is cholinesterase inhibition (EPA, 2006a). Dimethoate is considered a possible human carcinogen based on the formation of lymph and spleen tumors in laboratory test animals.

Dimethoate applications are limited to ground or aerial foliar treatments in citrus groves. Dimethoate exposure and risk during application is restricted primarily to applicators. Adherence to label requirements regarding the use of personal protective equipment and other standard operating procedures will reduce exposure and risk to applicators. Exposure to the general population that would consume dimethoate-treated citrus from orchards that received applications would be low based on the timing of application relative to harvest, which would allow for significant degradation, and adherence to preharvest interval restrictions.

(2) Nontarget Toxicity and Risk

Dimethoate has moderate acute toxicity to wild mammals, based on median lethality values of 120 and 420 mg/kg in the mouse and rat, respectively (EPA, 2006a). Mammalian dermal and inhalation toxicity is considered low for the technical and proposed formulation material. Sublethal and chronic toxicity endpoints demonstrate cholinesterase inhibition, based on NOELs of less than 1.0 mg/kg/day (EPA, 2006a). Dimethoate is considered highly toxic to birds with acute oral median lethality values ranging 5.4 mg/kg for the red-winged blackbird to 63.5 mg/kg for the mallard (EPA, 2010a). Chronic toxicity to birds was measured in reproduction studies with multiple sublethal impacts at 10.1 ppm (EPA, 2006a). Because of the potential for exposure to food items that terrestrial vertebrates may consume in treated citrus groves, there is a greater risk to avian species compared to wild mammals. Direct acute risk to mammals is not expected but conservative assumptions regarding exposure, as well as a more sensitive acute lethality value, indicate that there may be risks to birds. Sublethal impacts may occur from exposure to organophospate insecticides, such as dimethoate, that act to inhibit cholinesterase. Sublethal impacts, such as changes in nesting behavior and predator avoidance, can result in effects on reproduction and populations after exposure to organophospate and carbamate insecticides. The risks from these types of impacts will be reduced for those wild mammals and birds that do not feed exclusively in treated citrus groves, and for those chemicals that have short residual half-lives. Chronic exposure to contaminated plant material from program applications are not expected due to the short half-life on plant surfaces that ranges from 0.9 to 16.3 days (EPA, 2006b; Antonious et al., 2007). Due to the broad-spectrum nature of the organophosphate insecticides, nontarget terrestrial invertebrate impacts would be expected in citrus groves immediately after application. For those terrestrial vertebrates foraging for terrestrial invertebrates in citrus groves, the amount of prey items would decrease after treatment. Significant population impacts to wildlife are not expected to occur because not all invertebrates would be impacted, and there would be recovery of most invertebrates within the citrus grove.

Toxicity to pollinators, such as the honey bee, is high in acute and contact toxicity studies from exposure to dimethoate. Toxicity has also been shown to be high to other terrestrial invertebrates, such as parasitic wasps (EPA, 2006a). Risk to honey bees is reduced to some extent by adherence to label requirements for dimethoate applications in citrus. Restrictions on dimethoate application during the daytime (when bees are most active or when citrus trees are blooming) will reduce the exposure of honey bees and other pollinators.

Dimethoate acute toxicity to fish is considered moderate, while toxicity to aquatic invertebrates ranges from moderate to very highly toxic (EPA, 2006a). The primary metabolite, omethoate, is more acutely toxic to aquatic invertebrates than dimethoate; however, it appears to be similar in toxicity to dimethoate, based on acute fish and chronic aquatic invertebrate data. Chronic and sublethal impacts to fish and aquatic invertebrates range from the low to upper ppb with aquatic invertebrates being the more sensitive taxa. Dimethoate exposure to aquatic biota in shallow aquatic habitats could result in adverse impacts; however, risk is reduced by adherence to label requirements regarding the prevention of drift and runoff.

Dimethoate does not exhibit properties that indicate volatilization into the atmosphere. Air quality would be impacted at the time of application in the citrus grove due to spray applications, although this would be localized and of short duration. Under aerobic conditions, dimethoate breaks down rapidly with soil half-lives ranging from 2.0 to 3.7 days (EPA, 2006b). Dimethoate is mobile in soil, thus, it could move off-site via runoff or leaching. Adherence to label requirements and avoidance of applications to permeable soils or areas where a high water table is present will reduce the probability of off-site transport to ground and surface water.

n. Fenpropathrin (Citrus Groves)

(1) Human Health Toxicity and Risk

Fenpropathrin is a synthetic pyrethroid insecticide which affects the nervous system. It is a moderate skin and eye irritant. Signs and symptoms can include muscle contractions, tremors, loss of muscle coordination, and nerve paralysis at moderate to high levels of exposure. Fenpropathrin is not considered carcinogenic by EPA (USDA–APHIS, 2005b).

The application of this pesticide would be limited to ground or aerial foliar treatments within established citrus groves. The environmental fate of fenpropathrin, as well as adherence to label requirements regarding applications near surface water, suggests that ground and surface drinking water resources would not be impacted. Fenpropathrin binds strongly to soil and sediment and has low water solubility, suggesting that it would not leach to ground water, and any surface water residues would partition rapidly to sediment. Risks to the general population that would consume treated citrus in orchard applications would be low due to the short half-life of fenpropathrin in the environment and the timing of application relative to harvest which would allow for significant degradation.

(2) Nontarget Toxicity and Risk

The program use of fenpropathrin is unlikely to impact most nontarget wildlife. The toxicity of fenpropathrin is moderate to mammals and has a slight oral toxicity to birds. Direct risk to terrestrial vertebrates is not expected due to the moderate toxicity of fenpropathrin and expected low exposure from ground or aerial applications. Terrestrial invertebrates would be impacted in areas of treatment; however, these effects would be restricted to treated areas within the citrus grove, and would be temporary due to the recolonization of invertebrates from untreated areas (USDA–APHIS, 2005b). Impacts to honey bees would be reduced by adherence to label requirements for use.

Fenpropathrin is highly toxic to aquatic organisms with median lethality values ranging from the low ppt to low ppb range for fish and aquatic invertebrates. Exposure and risk to these habitats will be reduced with adherence to label requirements, as well as label requirements for application buffers of 25 feet for ground applications and 250 feet for aerial applications, which will minimize drift to adjacent bodies of water.

Impacts to air, water, and soil from the proposed fenpropathrin applications are expected to be minimal because of its use pattern and environmental fate properties. Fenpropathrin is persistent in water at a neutral pH; however, it degrades more quickly at alkaline pH values and has a hydrolysis half-life of 14 days. Photolytic degradation in soil is much faster when compared to water with reported half-lives in water greater than a year and 14 days in soil. Potential mobility is low, based on low water solubility and a high binding affinity for soil, reducing the potential for runoff. Residues on treated vegetation are also of short persistence (USDA–APHIS, 2005b).

o. Formetanate Hydrochloride (Citrus Groves)

(1) Human Health Toxicity and Risk

Formetanate hydrochloride (HCL) is a carbamate insecticide with a primary mode of action resulting in the inhibition of cholinesterase. Formetanate HCL is highly toxic to mammals when ingested but has moderate toxicity when inhaled and low dermal toxicity (EPA, 2007c). The formulated material is considered toxic from ingestion and inhalation but has a low dermal toxicity similar to the active ingredient. The formulated product is considered harmful to the eyes when exposure occurs and may be a skin sensitizer (Gowan, 2007). In acute and chronic studies, the most sensitive endpoint in most studies was cholinesterase inhibition. Formetanate HCL is not considered to be carcinogenic, teratogenic, or mutagenic in laboratory studies, and no immune- or endocrine-related impacts have been observed (EPA, 2007c).

Applications will be restricted to ground applications in commercial citrus groves. Workers and applicators will be the population segment at greatest risk of exposure to formetanate HCL applications. Precautionary label language and personal protective equipment requirements will reduce exposure and risk to this group of the population. Formetanate HCL is considered to be highly water soluble so there is the potential for surface water contamination from runoff after treatment. Label language regarding the management of drift and runoff to water resources that may be used for drinking water will reduce exposure and risk to the general population. In addition, the rapid degradation of formetanate HCL in water, especially in neutral and alkaline conditions, will further reduce exposure in drinking water sources.

(2) Nontarget Toxicity and Risk

Formetanate HCL is highly toxic to wild mammals and birds based on surrogate laboratory toxicity testing. Oral median lethality values were typically below 50 mg/kg for both groups (EPA, 2003b). Toxicity to pollinators is low to moderate in acute laboratory and field residue studies. Other nontarget terrestrial invertebrates may be impacted within and adjacent to commercial citrus orchards when applications of formetanate HCL occur. These impacts will typically be confined to areas within the orchard, and effects to terrestrial invertebrates adjacent to the orchard will be reduced by making ground applications and adhering to spray drift language on the label designed to minimize insecticide movement to nontarget habitats.

Formetanate HCL toxicity to aquatic organisms is variable with cold and warm freshwater fish species having moderate toxicity (EPA, 2003b). Limited freshwater invertebrate toxicity data demonstrates high toxicity to freshwater cladocerans, and moderate toxicity to estuarine and marine aquatic invertebrates. Exposure and risk to aquatic organisms can be reduced by avoiding applications under conditions that would allow for runoff and adhering to label recommendations to reduce drift.

Formetanate HCL is not expected to persist in soil under aerobic or anerobic conditions. Laboratory and field studies that measured the degradation and dissipation of formetanate HCL reported half-lives ranging from approximately 6 to 30 days. Formetanate HCL is extremely water soluble and does not adhere to soil and sediment suggesting it could impact water quality in aquatic sites adjacent to commercial citrus orchards where applications would occur. Precautionary label language, as well as avoiding applications to soils that are poorly drained, sloping towards aquatic areas, or where there is a high water table will reduce the potential for contamination.

p. Imidacloprid/Cyflythrin (Citrus Groves)

(1) Human Health Toxicity and Risk

Imidacloprid is a systemic, chloro-nicotinyl insecticide whose mode of toxic action and toxicity has been described in section V.B.2.c., above. Cyfluthrin is a synthetic pyrethroid insecticide that affects the sodium channels which are responsible for nerve stimulation. Cyfluthrin is not considered to be an eye irritant or skin sensitizer. At moderate to high levels of exposure, signs and symptoms can include muscle contractions, tremors, loss of muscular coordination, and nerve paralysis. Cyfluthrin is not considered to be carcinogenic, mutagenic, or teratogenic by EPA. The difference in the mechanism of toxic action ensures that this mixture does not pose increased toxicity through synergistic action. Although synergistic effects on toxicity are possible with simultaneous exposure to organophosphates (such as chlorpyrifos) and cyfluthrin, this type of combined exposure is unlikely with the safety precautions required of this program and the lack of concurrent applications expected using organophosphate and pyrethroid insecticides. The application of this insecticide mixture is limited to a ground or aerial foliar treatment in production citrus groves. None of the routine or extreme exposure scenarios from this mixture pose unacceptable risks to workers or applicators. Moreover, required protective gear and safety precautions further ensure that no adverse effects to program workers are expected.

Imidacloprid applied with cyfluthrin is not expected to impact ground water resources. Adherence to label requirements (such as application buffers and drift mitigation requirements) will reduce the possibility of surface water residues for either insecticide. In addition, cyfluthrin is expected to bind tightly with soil or sediment, and would only occur in surface water for a very short duration. The low mobility and solubility of cyfluthrin suggest it would not leach into ground water. Imidacloprid is considered to be more mobile and soluble; however, avoiding applications to soils where leaching is more likely, as well as areas where there is a high water table, will reduce the potential for ground water contamination. Risks to the general population that would consume treated citrus from commercial groves that received applications of insecticides would be low due to the timing of application relative to harvest, which would allow for significant degradation of the insecticides.

(2) Nontarget Toxicity and Risk

Direct risk to wild mammals and birds from foliar applications of cyfluthrin and imidacloprid is not expected, based on available effects data and conservative assumptions of exposure. However, there is the possibility of indirect impacts to wildlife from the loss of invertebrate food items that would be affected by the insecticide treatment. Adherence to label requirements regarding treatment in areas when bees are actively foraging, or when blooms are present, will reduce exposure and risk to pollinators.

This mixture is considered highly toxic to fish and most aquatic organisms, based on previous discussions regarding the individual use of each insecticide. Adherence to label requirements to reduce drift, as well as application buffers of 25 feet for ground applications and 150 feet for aerial applications from all aquatic resources, will reduce exposure and risk to aquatic vertebrates and invertebrates.

q. Kaolin Clay (Citrus Groves)

(1) Human Health Toxicity and Risk

Kaolin is a naturally occurring aluminosilicate material that has a nontoxic mode of action by acting as a repellant or by providing a protective barrier from insects and disease. In addition to its use for insect and disease control, kaolin is widely used in health products and toiletries, and as an indirect food additive (EPA, 2000).

Based on available toxicity data, kaolin has low acute toxicity via oral, dermal, and inhalation routes. Kaolin is a minor eye irritant and is not considered a dermal irritant. The formulated product proposed for use in this program, which is a dust, may cause irritation to the throat, eye, and skin to workers; however, adherence to the label requirements and recommended personal protective equipment would reduce exposure. Due to the low toxicity of kaolin and similar clays, little chronic toxicity data exists. Some impacts to lung function, called kaolinosis, can occur in long-term exposure to kaolin particles; however, this would not be expected in this program because the material is not applied as a dust (WHO, 2005).

Kaolin is proposed for use in commercial citrus groves where exposure would be greatest for workers and applicators. Based on the low toxicity of kaolin, its prevalence in the environment, and its low solubility, it is not expected to be a significant risk to ground or ground water resources.

(2) Nontarget Toxicity and Risk

Available toxicity data for kaolin and other clay materials suggest low toxicity to nontarget terrestrial vertebrates. Toxicity to terrestrial invertebrates, such as pollinators, is also considered low, based on available data where acute median lethality values were greater than the highest concentration tested (EPA, 2000). Based on the low toxicity of kaolin clay and its repellent activity to some terrestrial invertebrates, direct and indirect effects to wild mammal and bird populations are not expected.

Available toxicity data for related clay materials to nontarget aquatic organisms demonstrate very low toxicity to aquatic invertebrates and vertebrates, with toxicity values typically above 100 ppm (WHO, 2005). Exposure and risk to nontarget organisms are expected to be minimal, based on the low toxicity of kaolin and expected aquatic residues that could occur near citrus groves where applications may occur.

Kaolin use in this program is not expected to cause adverse impacts to soil, water, or air. Impacts to soil are not expected. In addition, significant volatilization or drift is not expected into the atmosphere, based on the physical properties of kaolin once it is mixed and applied to the foliage of host plants.

r. Malathion (Citrus Groves)

(1) Human Health Toxicity and Risk

Malathion is a broad-spectrum organophospate insecticide that when metabolized to malaoxon can inhibit cholinesterase. Acute exposure through oral, inhalation, and dermal routes demonstrates low toxicity to mammals (FS, 2008b). In most cases, median lethality values are greater than the highest test concentration, or are at levels that would not be expected to occur in actual application scenarios. It is considered a slight eye and skin irritant but is not a skin sensitizer (EPA, 2009b). In acute and chronic studies, the more sensitive endpoint tends to be cholinesterase inhibition. Malathion is not considered to be a mammalian reproductive or a teratogenic insecticide; however, there is information that suggests carcinogenicity is possible (EPA, 2009b). Other studies have shown enhancement or suppression of different immune functions in various studies over a range of doses (FS, 2008b). Recent studies also have suggested a link between attention deficit hyperactivity disorder (ADHD) and exposure to metabolic degradates of certain organosphophate insecticides (including malathion) that may occur on certain fruits and vegetables (Bouchard et al., 2010). While no residue levels are anticipated to exceed EPA tolerance levels, the presence of any residues would be mitigated because citrus fruits are typically washed and disinfected with sodium hypochlorite, sodium orthophenyl-phenate (SOPP), or peracetic acid (PAA), brushed, rinsed, and waxed prior to packing. Fruits entering processing facilities also are washed with disinfectants.

The application of malathion is limited to ground or aerial treatments in commercial citrus groves. The potential for malathion exposure and risk during application would be restricted primarily to applicators. Current and recently proposed labeling to protect applicators, as well as adherence to other standard operating procedures, make it unlikely that the use of malathion would result in adverse impacts to applicators. Malathion does exhibit some properties that suggest it could move to ground water.

EPA's ground water database reveals that approximately 1 percent of wells sampled over a 20-year period had detectable levels of malathion (EPA, 2009b). Malathion, as well as the more toxic metabolite, malaoxon, has a very short half-life in water, suggesting that occurrence in either ground or surface water would be short lived. Implementation of label requirements designed to protect ground and surface water will reduce the risk to these resources. Risks to the general population that would consume treated citrus from orchards that have received applications would be very low due to the short persistence of malathion in the environment, the timing of application relative to harvest (which would allow for significant degradation), and adherence to preharvest interval restrictions.

(2) Nontarget Toxicity and Risk

Malathion is slightly to moderately toxic to mammals and birds in acute oral exposure studies. Cholinesterase inhibition appears to be the most sensitive endpoint for measuring exposure in mammals and birds. Significant inhibition of cholinesterase by organophosphate insecticides can lead to several sublethal impacts in exposed terrestrial organisms. Malathion is considered moderately to highly toxic to a wide range of terrestrial invertebrates. The range of contact median lethality values in honey bees ranges from 0.20 to 0.70 µg/bee. The alkali and alfalfa leafcutter bee appear to be similar in sensitivity with contact median lethality values of 0.31 and 0.47 µg/bee, respectively (FS, 2008b). Citrus groves treated with malathion would be expected to see some reductions in terrestrial invertebrates. The residual activity of malathion is short; therefore, invertebrates outside of the groves would be expected to move back into treated areas and reestablish populations. These reductions in invertebrate populations could lead to indirect impacts to wild mammals and birds that depend on these items as a food source.

Malathion toxicity to fish ranges from highly toxic with a median lethality value of 4 ppb to greater than 15 parts per million (ppm) for the bonytail chub (USDA–APHIS, 2010c). Sublethal acute and chronic effects to fish have been noted in the low-ppb range based on cholinesterase inhibition and behavioral effects. Malathion is also considered highly toxic to aquatic invertebrates with median lethality toxicity values ranging from less than 1 ppb to greater than 100 ppm, depending on the test species. Direct risk to fish and aquatic invertebrates could occur in sensitive aquatic habitats that are adjacent to citrus groves. Indirect impacts to fish through the loss of invertebrate prey could occur in aquatic habitats where direct impacts to fish and amphibians would not be anticipated. Field studies designed to assess these types of impacts have observed indirect impacts in aquatic systems that were treated with multiple applications of malathion over time (Relyea and Dieks, 2008; FS, 2008b).

Malathion impacts to air quality will be limited to citrus groves and adjacent areas during the time of application. Malathion is not expected to volatilize from terrestrial or aquatic environments based on chemical and physical properties (USDA–APHIS 2010c). Impacts to soil and associated microorganisms would only be expected to occur in the areas of treatment, and would be short lived based on the environmental fate properties of malathion. Persistence of malathion and its metabolite malaoxon in soil is expected to be short with half-lives generally less than a week. Malathion degradation in water is also short with half-lives in natural water bodies ranging from less than a day to approximately 10 days. The short half-life of malathion and its ability to bind to organic matter suggest that leaching to ground water is not expected. Surface water contamination can occur via drift and runoff. Adherence to label requirements regarding the protection of surface water will reduce potential residues for surface water adjacent to citrus groves.

s. Petroleum Oils (Citrus Groves)

(1) Human Health Toxicity and Risk

Petroleum oils are a blend of hydrocarbons that may be mixed with other pesticides, or can be used alone, to control some insect pests. Acute oral, dermal, and inhalation toxicity is very low for mammals; subchronic and chronic studies have also demonstrated low toxicity (EPA, 2007d). Petroleum oils can cause mild eye, skin, and throat irritation under prolonged exposure. Components of these oils have not been shown to be mutagenic or reproductive toxicants. Carcinogenicity has not been established based on a lack of conclusive evidence in experimental animals (EPA, 2007d).

Petroleum oils are proposed for ground or aerial application in commercial citrus groves. The greatest potential for exposure is to workers and applicators during application. Ground and surface water resources that could be used for drinking water are not expected to be significantly impacted due to the properties of petroleum oils which suggest low mobility, solubility, and binding affinity to soil and sediment (EPA, 2007d).

(2) Nontarget Toxicity and Risk

The acute effects of hydrocarbon solvents, including mineral oils and aliphatic or open-chained petroleum hydrocarbons, indicate low mammalian toxicity from ingestion, inhalation, or dermal exposures (Ebbon, 2000; EPA, 2007d). Chronic studies also indicate low toxicity to mammals based on several studies. Avian toxicity data is limited, although oral toxicity studies and dietary studies indicate that oils are considered practically nontoxic to birds (EPA, 2007d). There is the potential for impacts to eggs when direct treatment to bird nests occurs within citrus groves. Adverse impacts to wild mammals and birds are not expected based on conservative assumptions regarding petroleum oil concentrations on food items for wild mammals and birds, and the available toxicity data. Indirect effects through the reduction in invertebrate prey items could occur for those vertebrates foraging in the groves, although the impacts are expected to be less than with conventional insecticide use. Dilling et al. (2009) observed a reduction in the abundance of insects collected from eastern hemlock sites treated with horticultural petroleum oils compared to controls; however, no effects in species richness were observed.

Available aquatic toxicity data indicate that the toxicity of oils is low for aquatic organisms and would only occur above solubility limits (Ebbon, 2000). Median lethality values and no observable effect concentrations for fish and aquatic invertebrates exposed to various mineral oils were well above 100 ppm. EPA (2007d) reported low toxicity to fish, although for two oils freshwater crustacean effects were reported at approximately 1.0 mg/L. Impacts to aquatic invertebrates could occur in situations where they become trapped at the surface of bodies of water where oil has formed a layer. This would only occur in static bodies of water where wave action would not break up the layer of oil, and with significant drift during application.

Petroleum oils will occur in the atmosphere during the time of application; however, they will dissipate quickly and are not expected to volatilize once they reach the site of application. Based on low solubility and adherence to soil particles, threats to ground and surface water are not expected.

t. Phosmet (Citrus Groves)

(1) Human Health Toxicity and Risk

Phosmet is a broad-spectrum organophosphate insecticide that is registered for use to control several pests in agricultural and nonagricultural applications. Acute oral mammalian toxicity to the technical material is considered moderate with an oral median lethality value of 113 mg/kg. Inhalation and dermal toxicity is comparatively lower with median lethality values greater than the highest test concentration for the technical and formulated material (EPA, 2006c; Gowan, 2007). Phosmet is not considered to be a skin irritant but can cause mild eye irritation. As with other organophosphate insecticides, the most sensitive endpoint in short- and long-term exposures is cholinesterase inhibition. Phosmet is not considered mutagenic, and carcinogenicity has not been shown in rat studies; however, in a study using mice, there was an increase in liver tumors in males and mammary tumors in females (EPA, 2006c).

Phosmet applications will only occur in commercial citrus groves using ground or aerial equipment. Workers and applicators are the population segment that has the greatest potential for exposure and risk. Adherence to proposed mitigation measures for occupational exposures will reduce the risk to this population group (EPA, 2006c). Threats to drinking water resources will be minimized by adherence to label requirements regarding spray drift management to reduce surface water exposure, and avoiding applications to permeable soils or in areas where a high water table is present which could increase the likelihood of ground water contamination.

(2) Nontarget Toxicity and Risk

Phosmet has moderate acute toxicity to mammals for both the technical and formulated material. Dermal toxicity is low; the inhalation median toxicity is higher than the highest test concentrations reported in studies for the technical and formulated material. Sublethal and chronic toxicity effect thresholds are based primarily on the inhibition of cholinesterase in various test organisms (EPA, 2006c). Phosmet acute toxicity to birds varies with acute median lethality values ranging from 18 mg/kg in the red-winged blackbird to 1,830 mg/kg for the mallard. Reproductive impacts have been noted in chronic phosmet exposure to birds at concentrations greater than 60 ppm (EPA, 2010a). Direct risk to wild mammals and birds that may consume contaminated food items in citrus groves is expected to be low when factoring availability of food items outside of citrus groves where phosmet applications have not occurred. Indirect impacts to mammals and birds that depend on terrestrial invertebrates will also be minimized by foraging in areas where treatments have not occurred, as well as recovery of nontarget invertebrates in areas of treatment. Impacts to terrestrial invertebrates are expected in treatment areas because of the broad spectrum of activity of the organophosphate class of insecticides. Acute contact and residue studies indicate that phosmet is considered highly toxic to honey bees (EPA, 2010a). Adherence to label requirements regarding the protection of honey bees will reduce exposure and reduce adverse impacts.

Phosmet acute median toxicity values for fish are variable depending on species, ranging from the low ppb for the coldwater species, rainbow trout, to the low ppm for the fathead minnow (EPA, 2010a). Phosmet is highly toxic to most aquatic invertebrates with acute median lethality or effect values ranging from approximately 2 ppb for aquatic crustaceans to greater than 90 ppm for mollusks. Phosmet exposure and risk to aquatic biota in habitats adjacent to treated citrus groves may occur, although adherence to label requirements designed to reduce the potential for off-site drift and run-off will reduce risk.

Phosmet is not expected to have adverse impacts to air quality once applications are completed because it is not considered to be a volatile insecticide. Phosmet does not persist in soils, with half-lives of 3 days under aerobic conditions and 15 days under anaerobic conditions. Degradation in soil is microbially mediated (EPA, 2006c). In water, phosmet degradation is pH dependent. Half-lives range from 9 days at a pH of 5 to 16 hours at more alkaline conditions. Phosmet and its primary metabolite, phosmet oxon, demonstrate properties that could result in leaching to ground water or runoff into surface water. The likelihood of this type of transport is reduced by its rapid degradation in soil and avoidance of applications to sites that could result in off-site movement in water.

u. Pyrethrin (Residential/Citrus Groves)

(1) Human Health Toxicity and Risk

Pyrethrins are naturally derived extracts from certain species of chrysanthemum plants that have insecticidal properties. The mode of toxic action occurs through effects on the sodium channels to stimulate nerves to produce repetitive discharges. This results in muscle contractions that are sustained until a block of the contractions occurs. Nerve paralysis can occur at high levels of exposure (Walker and Keith, 1992). Pyrethrins have certain properties that serve to both intoxicate and repel certain insects. The control activity occurs through direct contact of the insecticide with the insect; therefore, thorough coverage of the host plants is important to the successful control of ACP.

The acute oral toxicity of pyrethrin to mammals is considered to be low to moderate. Acute dermal and inhalation toxicity are low. The formulation of pyrethrin to be used in the program has comparable acute toxicity to the active ingredient. This formulation poses slight dermal irritation, some dermal sensitization, and eye irritation. These effects are avoided by the use of proper protective gear by pesticide applicators. An acute RfD of 0.07 mg/kg/day was established based on uncertainty and safety factors applied to the results of an acute neurotoxicity study (EPA, 2006d). The primary metabolites and degradation products of pyrethrin are considered to be of lower toxicity than the parent compound (EPA, 2005b). Pyrethrin is rapidly metabolized by mammals through oxidation and/or conjugation before excretion.

Synergism of the toxicity of organophosphates when combined with pyrethroids (such as pyrethrin) has been shown in laboratory and field tests (Keil and Parrella, 1990; Horowitz et al., 1987). Although this is possible in the program area, it is unlikely that applications of organophosphates will be made to treatment sites at an interval close enough to program applications of pyrethrin to result in this effect. Tank mix applications of pyrethrin and organophosphate insecticides are not anticipated, and applications at intervals that would allow for residues of both chemistry classes to result in simultaneous exposure are not expected based on typical insecticide application intervals.

Chronic oral studies of the rat found a NOEL of 4.37 mg/kg/day which was used by EPA to derive the chronic RfD of 0.044 mg/kg/day (EPA, 2006d). Developmental toxicity studies of rabbits demonstrate a maternal NOEL of 25 mg/kg/day. A reproductive study of rats indicates a reproductive NOEL of 196 mg/kg/day, and an offspring NOEL of 6.4mg/kg/day, based on decreased pup weights. A neurotoxicity study in rats determined a NOEL of 20 mg/kg/day, based upon the occurrence of tremors in female rats at higher concentrations. Carcinogenicity studies of pyrethrin have equivocal data based upon a reported treatment-related increase in hepatocellular (liver cells) adenomas. Pyrethrin does not appear to be mutagenic or teratogenic, based upon available data (EPA, 2005b).

In this program, pyrethrin is applied as a foliar treatment. The potential exposure to applicators was determined to be from one to three orders of magnitude lower than the reference dose, so there is minimal risk for workers (USDA–APHIS, 2008).

Ingestion of contaminated drinking water and treated citrus fruit were exposure scenarios analyzed for the use of pyrethrin in residential applications. All potential risks for children and adults were determined to be negligible (USDA–APHIS, 2008). Risks to the general population that would consume treated citrus from orchards that received applications of this insecticide would be low due to the short half-life of pyrethrin and the timing of application relative to harvest.

(2) Nontarget Toxicity and Risk

The acute oral median lethal toxicity of pyrethrin is considered to be low for mammals and birds. Available data indicate that inhalation and acute dermal toxicity are also low. The formulation of pyrethrin to be used in the program is of comparable toxicity to the active ingredient. Exposures of mammals and birds to pyrethrin from residential applications are unlikely to pose any acute or chronic risks (USDA–APHIS, 2008). Indirect impacts to insectivores (i.e., loss of terrestrial invertebrate prey) are not expected to be of concern in residential applications because the effects will be localized based on the method of application and the selective treatment of individual host trees. Adverse effects from residential applications to terrestrial invertebrates on untreated trees are minimized by the lack of substantial drift of the large droplet size of the pesticide formulation applied to host plants. In situations where pyrethrin would be used over large areas in citrus groves, there is the potential for some terrestrial invertebrate impacts that could result in temporary reductions in prey items. Not all terrestrial invertebrates would be expected to be affected, and there would be rapid recovery of the more sensitive terrestrial invertebrates because of the short residual half-life of pyrethrin.

The broad-spectrum activity of pyrethrin results in high toxicity to most insects, including pollinators. The 48-hour contact median lethal dose for honey bees is 0.022 µg/bee. Risk to pollinators in treated residential areas will be less than for comparable treatments in citrus groves. Treating individual trees in residential settings will reduce the potential for drift. In addition, other nontreated flowering vegetation would be available for pollinator foraging. Adherence to label requirements designed to reduce exposure to honey bees will reduce exposure and risk in treated groves.

Pyrethrin is highly toxic to fish and to most aquatic invertebrates (EPA, 2006d). The greatest risk to aquatic resources is through drift from pyrethrin applications in citrus groves. Pyrethrin runoff is not expected to be significant to aquatic resources because this type of insecticide binds tightly to soil and has very low solubility, reducing the potential for transport and exposure to most aquatic organisms. Drift from residential applications to aquatic areas is expected to be less than from applications to citrus groves. Residential applications are made to individual trees using hand-held spray equipment which helps to reduce potential drift.

The use of pyrethrins in this program is not expected to have adverse impacts to soil, water, or air due to their environmental fate profile. Half-lives in soil and water are very short thereby reducing the time for any potential impacts to soil and water quality. The half-life of pyrethrin in soil ranges from 3.2 to 10.5 days. Pyrethrins bind tightly to soil particles, reducing their bioavailability in terrestrial and aquatic systems. Pyrethrins are light sensitive and have a photolysis[22] half-life of less than 4 hours. Pyrethrins have low water solubility and short half-lives of 14 to 17 hours in alkaline water. The low mobility and solubility for pyrethrin suggest that leaching into ground water resources is not expected. Impacts to air quality are also not expected, based on the chemical characteristics of pyrethrin that indicate low volatility. Pyrethrin could occur in the atmosphere as drift from ground and aerial applications; however, adherence to label requirements will minimize the potential for off-site drift.

[22] Chemical decomposition induced by light or other radiant energy.

v. Spinetoram (Citrus Groves)

(1) Human Health Toxicity and Risk

Spinetoram is an analogue of the insecticide, spinosad, a fermentation byproduct of the bacterium *Saccharopolyspora spinosa*. The insecticide has low oral, inhalation, and dermal mammalian toxicity in acute exposures to the technical and formulated material proposed for use in this program (EPA, 2009c; Dow, 2008). The formulation (Delegate™ WG) is a slight eye irritant but is considered nonirritating to skin. Spinetoram is not mutagenic, carcinogenic, or neurotoxic to laboratory test mammals at relevant test concentrations (EPA, 2009c). Parental reproductive effects have been noted at doses above those expected from use in this program; however, no impacts have been noted in offspring, suggesting low developmental and reproductive toxicity. No developmental effects were noted in studies conducted with the rat and rabbit. Immune effects were noted in multiple test species represented by aggregation of macrophages[23] in the spleen, lymph node, thymus, and bone marrow. The lowest reported NOEL was 2.49 mg/kg/day in the dog in long-term chronic exposures (EPA, 2009c).

Spinetoram is proposed for use in citrus groves to be applied by air or as a ground orchard application. Because use is limited to production orchard groves, the highest potential for exposure is to applicators. Adherence to recommendations for personal protective equipment and the favorable toxicity profile for spinetoram result in low a probability of adverse impacts to applicators. Exposure to the public from contaminated drinking water or drift at levels that could pose significant risk is not expected. Adherence to label requirements regarding best management practices to reduce off-site transport from drift will reduce the potential for exposure. In addition, spinetoram has low water solubility and preferentially binds to soil which would further reduce exposure via contaminated surface or ground water.

(2) Nontarget Toxicity and Risk

Available toxicity data indicate that spinetoram has low acute and chronic toxicity to wild mammals and birds (EPA, 2010a). The risk of spinetoram treatments in citrus groves is expected to be low for wild mammals and birds that may feed on contaminated food items. Indirect risks to terrestrial wildlife from the loss of invertebrate prey items could occur for those species that only forage within commercial citrus groves and rely on spinetoram-susceptible terrestrial invertebrates. These types of impacts are not anticipated for most terrestrial vertebrates because they would typically forage inside and outside of the groves, and other terrestrial

[23] Macrophages are large, white blood cells found primarily in the bloodstream and connective tissues that help the body to fight off infections by ingesting the disease-causing organisms.

invertebrates that are not sensitive to spinetoram would be available. Spinetoram is toxic to some terrestrial invertebrates, including the honey bee, and impacts are expected in citrus groves where treatments would occur. Adherence to label requirements regarding the protection of honey bees will minimize risk to that group of insects.

Spinetoram and its associated metabolites are highly toxic to fish and aquatic invertebrates. Aquatic invertebrate toxicity values range from the upper ppt in chronic studies to low ppb in acute studies, while available fish toxicity data demonstrate toxicity values in the upper-ppb to low-ppm range (EPA, 2010a). Direct risk to aquatic invertebrates is expected for those aquatic resources immediately adjacent to commercial citrus groves. These impacts would also result in indirect risk to fish and other aquatic biota, such as amphibians, that depend on invertebrate prey items as a food source. Adherence to label requirements regarding the protection of aquatic resources from spray drift and runoff will reduce the risk to aquatic fauna present adjacent to commercial citrus groves.

Spinetoram has low water solubility and adheres to soil; therefore, its impact to surface water quality is expected to be minimized because of preferential binding to soil and sediment. Spinetoram mobility in soil is considered to be low because of its chemical and environmental fate properties and, thus, the risk of ground water contamination is also low. Degradation of spinetoram in soil under aerobic conditions varies with half-lives ranging from 3 to 31 days, while persistence in aquatic systems can be much greater with water and sediment half-lives ranging from approximately 100 days to greater than 1 year (EPA, 2010a). Spinetoram is not expected to impact air quality through volatilization because its known chemical properties indicate that it would only occur in the atmosphere during times of application.

w. Spirotetramat (Citrus Groves)

(1) Human Health Toxicity and Risk

Spirotetramat is a ketoenole insecticide that acts primarily by preventing lipid metabolism in certain invertebrates. Spirotetramat was registered for control of sucking insects, such as psyllids and whiteflies, as well as mites, on a variety of crops. Registration was recently cancelled due to a court case in which the U.S. District Court for the Southern District of New York vacated all registrations issued by EPA for pesticide products containing spirotetramat. The court decision was based on EPA’s failure to provide an opportunity for public comment on the applications for those registrations before they were granted (EPA, 2010a). Evaluation and approval of the registration by EPA in the future, and the use of section 18 emergency use exemptions will be required before its use in the proposed ACP program.

Spirotetramat has low toxicity to mammals via oral, dermal, and inhalation exposures. Reported acute toxicity values demonstrate that median lethality occurs at values greater than the highest test concentration used in the study (EPA, 2008a). The formulation proposed for use in this program is not considered a skin irritant; however, it is a mild eye irritant and a skin sensitizer. Spirotetramat is not considered mutagenic, carcinogenic, or neurotoxic; however, reproductive and developmental effects have been observed at high doses. Developmental effects were only seen at levels that were considered maternally toxic (EPA, 2008a; Bayer CropScience, 2007).

Spirotetramat is proposed for use in commercial citrus groves by ground or aerial application. The population segment at greatest risk of exposure to spirotetramat is workers and applicators. Spirotetramat does exhibit environmental fate properties, such as high solubility and weak soil binding, which could pose a threat to drinking water near areas of application. Adherence to label requirements regarding the protection of surface water and avoidance of applications to permeable soils will reduce the probability of spirotetramat movement to ground and surface water resources.

(2) Nontarget Toxicity and Risk

Spirotetramat toxicity to mammals and birds is low based on available acute toxicity data required for pesticide registration (EPA, 2008a). Chronic toxicity is also low for mammals, although reproduction studies have shown a range of sublethal impacts to birds at all tested concentrations. Because acute exposure levels will be below effect thresholds, wild mammals and birds that are foraging in spirotetramat-treated citrus groves are not expected to be directly impacted. Chronic risk to mammals is not expected; however, there is the potential for chronic risk to avian species based on estimated residues and available toxicity data. As with other insecticides proposed for use in this program, there is the possibility of indirect impacts for those wild mammals and birds that rely on insects present in citrus groves. Spirotetramat is expected to have some impacts to nontarget terrestrial invertebrates, but most activity is against mites and sucking insects; therefore, other invertebrates that could serve as prey items would be available in citrus groves. Spirotetramat has low toxicity to honey bees, based on standard toxicity testing; however, other studies measuring sublethal brood impacts have observed effects below currently labeled rates (EPA, 2008a).

Spiroteramat aquatic toxicity is variable depending on the test species and duration of testing. Toxicity to fish is considered moderate with median lethality values in the low-ppm range, while aquatic invertebrate toxicity studies demonstrate slight to high toxicity (EPA, 2008a). Based on the use rate for spirotetramat on citrus, the direct risk to fish is expected to be low.

There is potential for some impacts to aquatic invertebrates; however, adherence to label restrictions regarding the protection of aquatic resources from drift and runoff will reduce the potential for significant impacts.

Aerial and ground applications of spirotetramat will result in the presence of material in the atmosphere immediately after application in and adjacent to the citrus groves. Adherence to label restrictions for application will reduce the potential for off-site impacts to air quality; significant volatilization into the atmosphere is not expected. Significant soil impacts are not anticipated based on the environmental fate profile for spirotetramat. Spirotetramat is not expected to persist in soils with half-lives of a few days. Dissipation half-lives in soil and water are typically less than 3 days, with hydrolysis half-lives ranging from 8.6 to 47 days, depending on pH and temperature. Spirotetramat is water soluble and has low soil adsorption properties suggesting a potential for movement into ground water. Avoiding applications to permeable soils or areas where a high water table is present will reduce the threat to ground water.

x. Thiamethoxam (Citrus Groves)

See section V.B.2.d. for information regarding thiamethoxam.

y. Zeta-Cypermethrin (Citrus Groves)

(1) Human Health Toxicity and Risk

Zeta-cypermethrin is a synthetic pyrethroid insecticide that is used to control a variety of insect pests in agricultural and structural/residential uses. The active ingredient is a combination of eight isomers[24] with four of the most insecticidally active isomers occurring at higher concentrations compared to cypermethrin. Formulated zeta-cypermethrin is moderately toxic via oral and inhalation routes of exposure to mammals, but is considered to have low dermal toxicity. The formulated material is moderately irritating to the eyes and skin, however, it is not considered a skin sensitizer. Zeta-cypermethrin is not considered mutagenic or teratogenic; however, it is considered a possible carcinogen based on results from a chronic mouse study where benign lung tumors were observed at the highest dose level. These levels are well above those expected in this program. Similar effects were not observed in other test species in chronic studies (EPA, 2008b).

Exposure of the general public to zeta-cypermethrin during applications in this program is not expected because applications would occur within

[24] An isomer is a molecule with the same number of atoms as another but arranged into a different structure.

established citrus groves. Applications are not expected to impact drinking water supplies because zeta-cypermethrin has very low solubility and a high binding affinity for soil, indicating a low probability of vertical or lateral transport into ground or surface water.

Risks to the general population that would consume treated citrus from orchards that received applications would be low due to the timing of application relative to harvest which would allow for significant degradation and adherence to preharvest interval restrictions.

(2) Nontarget Toxicity and Risk

Zeta-cypermethrin has low acute and chronic avian toxicity with reported acute median lethal doses and chronic no observable effect concentrations greater than the highest test concentration (EPA, 2005c). Toxicity is high to most terrestrial invertebrates, including honey bees, with label requirements regarding minimizing exposure in areas where bees are actively foraging.

Estimates of residues on food items for wild mammals and birds in treated citrus groves would not be expected to cause direct adverse risk. There is the potential for indirect risk to wild mammals and birds from the loss of available invertebrate prey that would occur after treatment in citrus groves.

Zeta-cypermethrin is considered highly toxic to aquatic invertebrates and vertebrates with reported median lethality values in the low-ppt to low-ppb range, depending on the test species, although fish were slightly less sensitive when compared to aquatic invertebrates (Solomon et al., 2001; EPA, 2005c and 2008b). Impacts to aquatic biota would be expected for those resources near the citrus groves. Exposure would be reduced by adherence to label requirements, such as aerial and ground application buffers, drift mitigation language, and vegetative filter strips that are required for product use.

Zeta-cypermethrin is not expected to cause adverse impacts to soil, water, or air quality because of the mitigation measures proposed on the label, as well as environmental fate and chemical properties. Zeta-cypermethrin breaks down in soil under aerobic and anaerobic conditions with half-lives of less than 65 days. Zeta-cypermerthrin has very low water solubility and a high binding affinity to soil and sediment that would result in a low probability of ground water contamination. Adherence to label restrictions regarding applications near water, and its physical and chemical properties would reduce impacts to surface water quality. Physical and chemical characteristics for zeta-cypermethrin preclude significant volatilization into the atmosphere. Zeta-cypermethrin may be present in the air as drift following ground and aerial applications, although strict adherence to label requirements, including spray drift precautionary language, will minimize off-site drift.

3. Biological Control

The APHIS–PPQ Pest Permitting Branch (PPB) has authority to regulate importation and interstate movement of biological control organisms. Before approving environmental releases of non-indigenous biological control organisms into the United States, PPB considers the impact on the environment, agriculture, threatened and endangered species, and other nontarget species. To date, PPB has only considered one biological control agent for ACP control. APHIS prepared an EA for the release of the parasitoid Tamarixia radiata (T. radiata) into the continental United States that resulted in a finding of no significant impact (USDA–APHIS, 2010b). That document and finding is incorporated by reference into this EA. It describes the environmental impacts of the release of T. radiata into the environment of the continental United States. The cooperative ACP management and control program is proposing to incorporate biological control organisms of ACP as they are approved by PPB. T. radiata would be the first ACP biological control organism incorporated into the program.

4. Quarantine

An EA was prepared to analyze the environmental impacts of the interim rule prior to its implementation. This analysis resulted in the signing of a finding of no significant impact. Both of these documents are incorporated into this EA by reference. They may be found at http://www.aphis.usda.gov/plant_health/ea/downloads/citrusgreening-ea-quarantine.pdf and http://www.aphis.usda.gov/plant_health/ea/downloads/citrusgreening-fonsi-quarantine.pdf.

C. Cumulative Effects

Under NEPA, Federal agencies are required to analyze the potential cumulative impacts of a proposed action. The Council on Environmental Quality defines cumulative impacts as impacts on the environment that result from incremental impact(s) of an action when added to other past, present, and reasonably foreseeable future actions. Actions resulting in a cumulative impact may or may not be generated by the same agency. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

All of the pesticides that would be used in the proposed program are registered for use on citrus by EPA. For commercial citrus producers, this means that any grower can legally use any one, or several, of the insecticides on their property at their discretion as long as they are used in accordance with the pesticide label. Most labels specify maximum allowable volumes, amount of active ingredient, and/or number of applications per year or cropping season which serves to restrict usage.

The use of the insecticides in noncommercial settings is also subject to all restrictions on the pesticide label. In the case of the proposed cooperative ACP program, the applicators treating on commercial citrus properties would all be commercial citrus producers. Commercial producers are not obligated to participate in the program. Their participation is voluntary, therefore, they may or may not adhere to the recommendations of the program, depending upon what they determine is best for their operations. On the other hand, the applicators treating on noncommercial properties would all be State cooperators, or their designees, who would be bound to the recommendations of the program.

In addition to the chemical treatments that would be utilized against ACP under the proposed action alternative, chemical treatments are currently required for use against ACP as part of USDA–APHIS' June 17, 2010 interim rule. As previously mentioned, this rule primarily regulates the interstate movement of nursery stock. Nursery stock that is to be moved interstate from an area quarantined for ACP must be treated with an EPA-approved insecticide that has also been approved for use by APHIS. The potential environmental impacts were analyzed in an EA in July, 2010 (USDA–APHIS, 2009b). The EA stated that the only potentially affected areas to be treated pursuant to the proposed program were within commercial nurseries. As outlined in the July EA and the Environmental Consequences section of this EA, provided that persons applying the chemical treatments follow the pesticide label, its applicable directions, and all restrictions and precautions, including statements pertaining to Worker Protection Standards and buffer zones, the effects to the environment and to humans from chemical treatments within all ACP-infested areas (e.g., nurseries, dooryard treatments, and commercial groves) are not expected to be substantial.

Citrus trees are susceptible to various pests in addition to ACP. Citrus growers currently treat their citrus trees with a variety of pesticides to kill or control these pests. For example, some major citrus diseases found within the affected environment are treated with EPA-approved fungicides—citrus canker, sooty mold, greasy spot, Alternaria brown spot, Phytophthora-induced diseases, melanose, citrus scab, and post-bloom fruit drop. Other citrus pests that require treatment include citrus tristeza virus and citrus blight. Of these citrus diseases, USDA–APHIS only regulates the treatment of citrus canker. Citrus canker, caused by the bacterium *Xanthomonas citri* subsp. C*itri*., has only been found in Florida. Under USDA–APHIS regulations, fruit moved from the citrus canker quarantine area must be treated with an EPA-approved disinfectant only at commercial packinghouses. The use of disinfectants is done within contained facilities so environmental effects would not be substantial. While USDA–APHIS may not require chemical treatment against the various other citrus pests, State agencies may require treatment or citrus growers may choose to treat their citrus trees.

New citrus pests are always a threat, and chemical treatments may need to change to fit these needs. Citrus black spot is a citrus disease caused by a fungus (*Guignardia citricarpa* Kiely) and has been found at two sites within southern Florida. Sweet orange scab, a disease caused by a fungus (*Elsinoe australis* Bitanc. & Jenkins) has been confirmed as occurring at multiple sites in eastern Texas and one residential property in Orleans Parish, Louisiana. Other fungal diseases are present and routinely treated in each of the citrus-producing States. At this time, it is not known what changes, if any, may result from these recent finds. These diseases are controlled or suppressed effectively in other countries using many of the same fungicides currently applied to commercial citrus production in the United States.

It is important to note that for every pest there is not necessarily another pesticide added to a citrus grower's treatment plan. Under the proposed program, multiple pesticides could be utilized, which may prove beneficial to growers because it increases the ability of an applicator to find products that are registered to treat multiple citrus pests. APHIS' participation in the proposed program could result, over time, in more efficient and effective uses of resources in a coordinated effort to control ACP and to protect trees from CG. Because there is no effective treatment for CG other than the destruction of the infected plants, the only logical way to protect citrus trees is to control the vector for CG. This means that control of ACP by commercial growers would occur. By assembling the country's best expertise in control of citrus pests, sharing their advice with producers, and encouraging producers to cooperate in control efforts, a reduction in total pesticide applications for CG in commercial production areas may result over time. In the near term, however, as control efforts are initiated, there is likely to be an increase in total pesticide applications for ACP control. The extension of treatments to areas beyond commercial production sites would reduce populations of ACP in adjacent areas that can serve as reservoirs of ACP which could reinfest the commercial growing areas.

Treatments in residential and other noncommercial production sites are likely to increase the total amount of insecticide used at these sites. The applications, however, would be done by highly qualified State cooperators, or their designees, and not by homeowners or other proprietors who are not proficient in pesticide applications. Therefore, the insecticide applications are likely to be done in the most efficient and effective manner. Plus, because they would be done as part of a larger, regional coordinated program, the probable result would be to reduce reservoirs of ACP that could reinfest commercial areas.

In addition, allowing multiple pesticide classes to be used against ACP may reduce the probability of pesticide resistance. Pesticide resistance is a "heritable and significant decrease in the sensitivity of a pest population to a pesticide that is shown to reduce the field performance of pesticides" (EPA, 2001). An important pesticide resistance management strategy is to avoid the repeated use of a particular pesticide (EPA, 2001). By using various chemicals with different modes of actions, applicators might reduce the ability of ACP to develop pesticide resistance.

VI. Other Environmental Considerations

A. Endangered Species

Section 7 of the Endangered Species Act and its implementing regulations require Federal agencies to ensure their actions are not likely to jeopardize the continued existence of threatened or endangered species or result in the destruction or adverse modification of critical habitat.

APHIS is preparing a biological assessment that considers the impact of the proposed program and other ACP-related activities on federally listed threatened and endangered species and designated critical habitat in the citrus-producing counties in California, Florida, Texas, Arizona, Louisiana, and Puerto Rico. Upon conclusion of the assessment, APHIS will determine if the program would affect listed species or their critical habitats. APHIS will then request concurrence with this determination from the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS).

In the meantime, APHIS recognizes its obligations under the Endangered Species Act. APHIS is working with FWS and NMFS to ensure that any regional or local actions taken under the proposed action do not affect threatened and endangered species or their designated or proposed critical habitats. If there is a possibility for adverse effects to listed species or critical habitat, the proposed action will not occur until APHIS has completed its work with FWS and NMFS, and has reached either a determination of no effect to listed species for the site or until these agencies have concurred with a may affect but not likely to adversely affect determination by APHIS.

B. Executive Orders

Consistent with Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," APHIS considered the potential for the proposed action to have any disproportionately high and adverse human health or environmental effects on any minority populations and low-income populations. Colonias[25] and farm worker housing can be located within the potential action area. Applications in residential areas are on a voluntary basis for all population subgroups where, if granted consent by the landowner, an application will be made to individual residential citrus trees. The proposed method of treatment, adherence to label language by applicators, and notification of residents prior to spraying will minimize exposure and risk to all population subgroups, including minority and low-income populations. In cases where insecticide applications are made to commercial citrus orchards, there is the potential for additional exposure to workers and applicators. Adherence to label language regarding the use of personal protective equipment and other label language designed to reduce exposure will also reduce the risk to applicators and workers who may belong to minority and low-income populations.

Consistent with EO 13045, "Protection of Children from Environmental Health Risks and Safety Risks," APHIS considered the potential for disproportionately high and adverse environmental health and safety risks to children resulting from the proposed action of making applications to residential citrus. The potential for exposure and disproportionate adverse risk to this segment of the population is expected to be low as only backpack applications to an individual residential host tree will be made, thereby minimizing exposure to the public compared to broadcast applications. In addition, adherence to label language and notification to those residents regarding treatments and precautionary measures to reduce exposure will reduce the risk to children. Residential treatments are voluntary; when consent is granted, it is the responsibility and obligation of the program pesticide applicators to ensure that the general public is not in or around areas being treated. This will reduce exposure and risk of the general public, including children, which could occur during the application process. Commercial citrus applications that are made by private applicators are not expected to result in adverse impacts to children because this subgroup of the population would not be expected to be in a commercial grove during an application. Notification of the public and posting can also reduce the possibility of exposure, as well as compliance with any application restrictions near residential areas and schools for certain insecticides. Adherence to label directions for each insecticide will also reduce exposure of children to insecticides from harvested fruit, as well as protect drinking water resources.

[25] The term "colonia" in Spanish means a community or neighborhood. The Office of the Texas Secretary of State defines a "colonia" as a residential area along the Texas-Mexico border that may lack some of the most basic living necessities, such as potable water and sewer systems, electricity, paved roads, and safe and sanitary housing.

C. National Historic Preservation Act of 1966

Consistent with the National Historic Preservation Act of 1966, APHIS has examined the proposed action in light of its impacts to national historic properties. APHIS has determined that the proposed action is a type of activity that is unlikely to have the potential to cause effects on historic properties. The proposed action will include survey, diagnostics, and public education, as well as voluntary insecticide treatments by citrus growers. In addition, USDA and its cooperators may treat residential and noncommercial citrus areas with insecticides with the consent of residential landowners. The proposed action is not anticipated to disturb historic sites because it will be mainly carried out in agricultural settings or in residential areas. In the unlikely event that historic districts, sites, buildings, structures, or objects that are included in or eligible for inclusion in the National Register of Historic sites are in or near the treatment area, the State Historic Preservation Officer will be contacted prior to initiation of treatment of the proposed site.

VII. Listing of Agencies and Persons Consulted

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Policy and Program Development
Environmental and Risk Analysis Services
4700 River Road, Unit 149
Riverdale, MD 20737

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Emergency and Domestic Programs
4700 River Road, Unit 134
Riverdale, MD 20737

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Center for Plant Health Science and Technology
22675 N. Moorefield Rd.
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U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Citrus Health Response Program
920 Main Campus Drive, Suite 200
Raleigh, NC 27606

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Appendices

Appendix A. ACP and CG (*Ca.* L. asiaticus) Host Plants

Scientific Name (Gutierrez, 2010)	**Common Name(s)**	**ACP and/or CG (*Ca.* L. asiaticus) Host Plants** (Gutierrez, 2010)
Aegle marmelos	Bael, Bengal quince, golden apple	ACP host
Aeglopsis chevalieri	Chevalier's aeglopsis	ACP and CG host
Afraegle gabonensis	Chevalier's aeglopsis, Gabon powder-flask	ACP host
Afraegle paniculata	Chevalier's aeglopsis, Nigerian powder-flask	ACP host
Amyris madrensis	Mountain torchwood	ACP host
Atalantia species (including *Atalantia monophylla)*	Chevalier's aeglopsis, Indian atalantia	ACP host
Balsamocitrus dawei	Uganda powder flask	ACP and CG host
Bergera (=*Murraya*) *koenigii*	Curry leaf	ACP host
Burkillanthus malaccensis	Malay ghost-lime	CG host
Catharanthus roseus	Vinca, Madagascar periwinkle	CG host (laboratory only)
Choisya arizonica	Arizona orange	ACP host
Choisya ternate	Mexican orange, mock orange, Mexican orange blossom	ACP host
×*Citrofortunella* species (including ×*Citrofortunella microcarpa*)	Limequat, calamondin, and Panama orange	ACP host
×*Citrofortunella microcarpa*	Calamondin, Panama orange	CG host
×*Citrofortunella floridana* ×*Fortunella crassifolia*	Limequat and hybrid oval kumquat	ACP host
×*Citroncirus webberi*	Citrange	CG host
Citropsis articulate	African cherry orange	ACP host
Citropsis gilletiana	Gillet's cherry orange	ACP host
Citrus amblycarpa	Nasnaran mandarin	ACP and CG host
Citrus assamensis	Ginger lime	ACP and CG host
Citrus aurantifolia	Key lime	ACP and CG host
Citrus aurantium	Sour orange, Seville orange, bigarde, marmalade orange	ACP and CG host
Citrus deliciosa	King orange	ACP host
Citrus depressa	Flat lemon	ACP and CG host
Citrus halimii	Papeda	CG host
Citrus hassaku	Hassaku orange	CG host
Citrus hystrix	Mauritius papeda, caffre lime, kaffir lime	ACP host
Citrus ichangensis	Ichant papeda, Ichang lime	ACP and CG host
Citrus indica	Indian wild orange	CG host

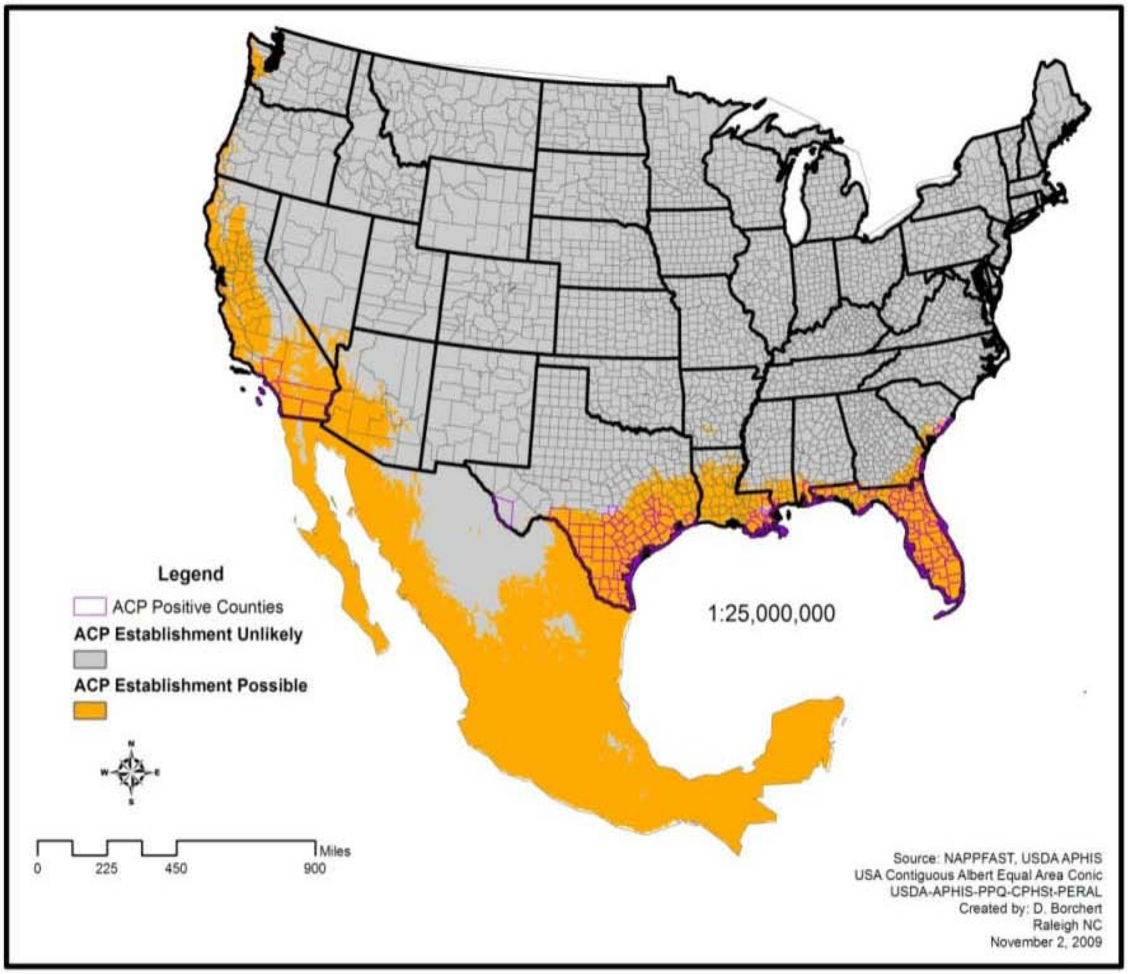
Citrus jambhiri	Jambhuri orange lime loose-jacket, rough lemon	ACP and CG host
Citrus junos	Yuzu, Japanese citron	ACP and CG host
Citrus karna	Karna, jaune orange	ACP host
Citrus keraji	Kabuchi, keraji, unzoki	CG host
Citrus latipes	Khasi papeda	ACP host
Citrus limetta	Tunisian sweet-lime, sweet-lemon, Moroccan limetta	ACP and CG host
Citrus limettioides	Sweet lime	ACP and CG host
Citrus limon	Lemon	ACP and CG host
Citrus limonia	Chinese lemon	ACP and CG host
Citrus macrophylla	Alemow	CG host
Citrus macroptera	Melanesian papeda	CG host
Citrus madurensis (=×*Citrofortunella microcarpa)*	Calamondin or Panama orange	CG host
Citrus maxima	Pummelo, pomelo, shaddock, pompelmous	ACP and CG host
Citrus medica	Citron	ACP and CG host
Citrus meyeri	Meyer lemon, dwarf lemon	ACP host
Citrus micrantha	Biasing	CG host
Citrus natsudaidai	Japanese summer grapefruit	ACP host
Citrus nobilis	Tangerine	ACP and CG host
Citrus obovoidea	Kinkoji	ACP host
Citrus oto	Mandarin	CG host
Citrus paradise	Grapefruit	ACP and CG host
Citrus pseudolimon	Galgal lemon	ACP host
Citrus reshni	Cleopatra mandarine, Spice mandarin	CG host
Citrus reticulate	Mandarin, tangerine	ACP and CG host
Citrus sinensis	Sweet orange, orange	ACP and CG host
Citrus sinesis x citrus reticulata	Tangor	ACP host
Citrus sulcata	Sanbokan	ACP host
Citrus sunki	Sour mandarin, sunki mandarin	ACP and CG host
Citrus tamurana	Hyuganatsu	ACP host
Citrus x tangelo	Tangelo, ugli	ACP and CG host
Citrus tankan	Jiaogan	ACP and CG host
Citrus unshiu	Satsuma	ACP and CG host
Clausena anisum-olens	Citrus	ACP host
Clausena excavate	Pink wampee	ACP host
Clausena harmandiana		ACP host
Clausena indica	Clausena	ACP and CG host

Clausena lansium	Wampee	CG host
Clymenia polyandra	Clymenia	ACP host
Cuscuta species (including *Cuscuta australis, Cuscuta campestris, Cuscuta pentagona, Cuscuta reflexa)*	Dodder, lovevine, strangleweed, hellbind, goldthread, devil	CG host (laboratory only)
Eremocitrus glauca	Desert lime	ACP and CG host
Eremocitrus hybrid (*Citrus glauca* x *Citrus reticulata*)		ACP host
Eremocitrus specie X *Citrus depressa*		ACP host
Esenbeckia berlandieri	Berlandier's jopoy	ACP host
Feroniella lucida	Feronia, Feroniella	ACP host
Fortunella species	Kumquat	ACP and CG host
Fortunella x crassifolia	Meiwa kumkuat	ACP and CG host
Fortunella hindsii	Hong Kong kumquat, wild kumquat	ACP host
Fortunella japonica	Marumi kumquat, Morgani kumquat	ACP host
Fortunella margarita	Oval kumquat, Nagami kumquat	ACP and CG host
Fortunella x obovata	Changshou kumquat	CG host
Fortunella polyandra	Malayan kumquat	ACP host
Glycosmis pentaphylla	Orange berry, Gin berry	ACP host
Limonia acidissima	Indian wood apple	ACP and CG host
Merope specie	Mangrove lime	CG host
Merrillia caloxylon	Flowering merrillia	ACP host
×*Microcitronella* species	Faustrimedin	ACP host
Microcitrus specie		ACP and CG host
Microcitrus australasica	Finger lime	CG host
Microcitrus australis	Australian round lime	ACP host
Microcitrus hybrid		ACP host
Microcitrus inodora	Large leaf Australian wild lime	ACP host
Microcitrus papuana	Round lime	ACP host
Micromelum minutum	Lime berry	CG host
Murraya species	Mock orange, orange-jasmine, Chinese-box	CG host
Murraya euchrestifolia	Mock orange	ACP host
Murraya paniculata	Orange-jasmine, Chinese-box	ACP and CG host
Naringi crenulata	Naringi	ACP host
Nicotiana tabacum	Tobacco	CG host (laboratory only)
Pamburus missionis	Mock orange	ACP and CG host
Poncirus trifoliate	Trifoliate orange	ACP and CG host
Poncirus trifoliate x Citrus sinensis	Citrange	CG host
Ravenia spectabilis	Lemonia, pink ravenia	ACP host

Severinia buxifolia	Chinese box orange	ACP and CG host
Solanum lycopersicum	Tomato	CG host
Swinglea glutinosa	Tabog	ACP and CG host
Tetradium ruticarpum	Evodia	ACP host
Toddalia asiatica	Orange climber plant	ACP host
Triphasia trifolia	trifoliate limeberry	ACP and CG host
Vepris (=*Toddalia*) *lanceolata*	White ironwood	ACP host
Zanthoxylum beecheyanum	Chinese pepper	CG host
Zanthoxylum clavaherculis	Hercules' club, Southern prickly-ash	ACP host
Zanthoxylum fagara	White ironwood, Lime prickly-ash, wild lime	ACP host

Appendix B. Positive ACP Counties and Temperature Suitability Map

The following is a map of U.S. counties where there has been a positive detection of ACP, as well as where ACP may or may not become established based on cold temperature mortality.

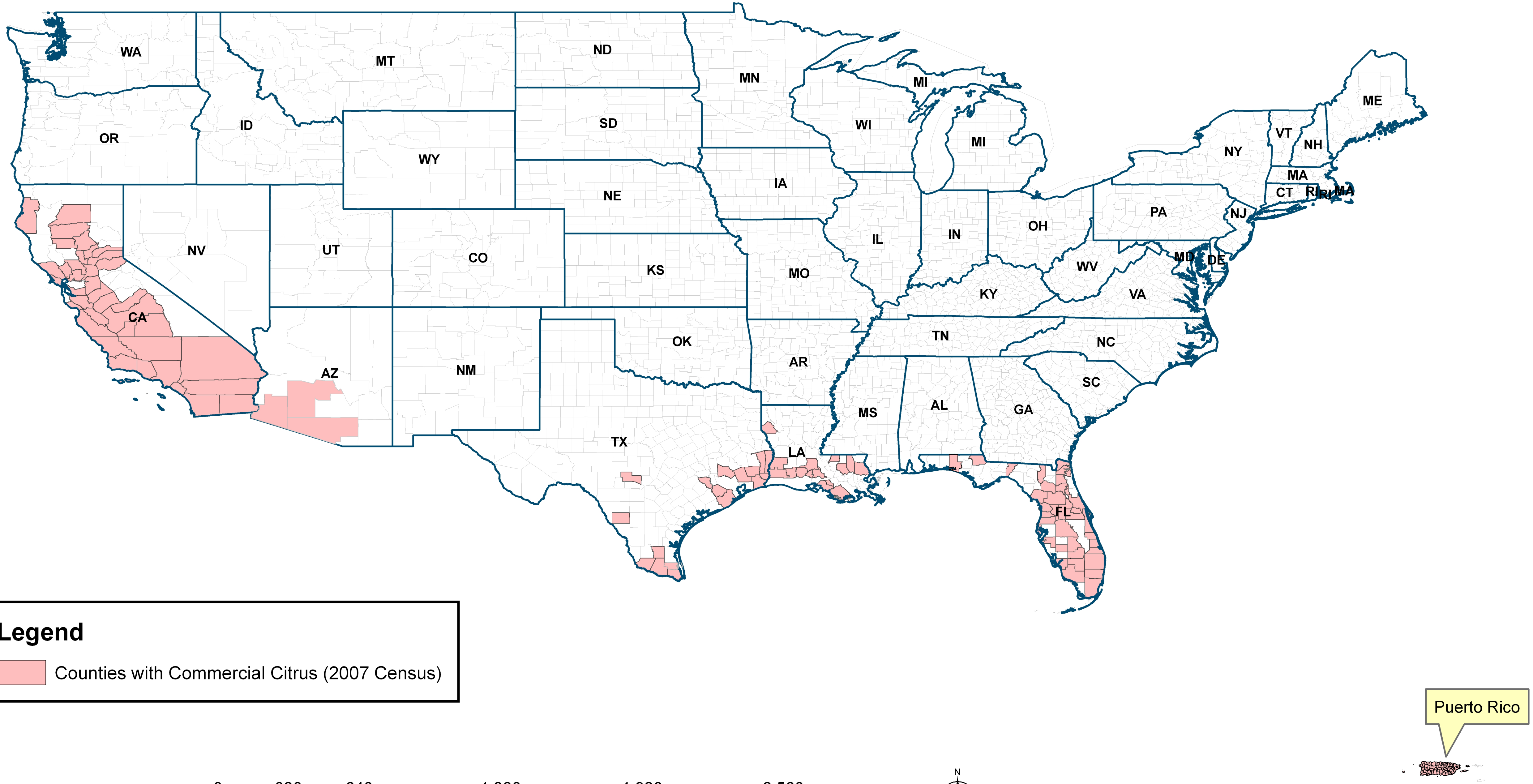


Appendix C. U.S. Counties with Commercial Citrus Production

United States Department of Agriculture

Counties with Commercial Citrus

Animal and Plant Health Inspection Service



Legend

Counties with Commercial Citrus (2007 Census)

0 320 640 1,280 1,920 2,560 Kilometers

N

USDA-APHIS-PPD
Environmental Services
4700 River Road, Unit 149
Riverdale, MD 20737

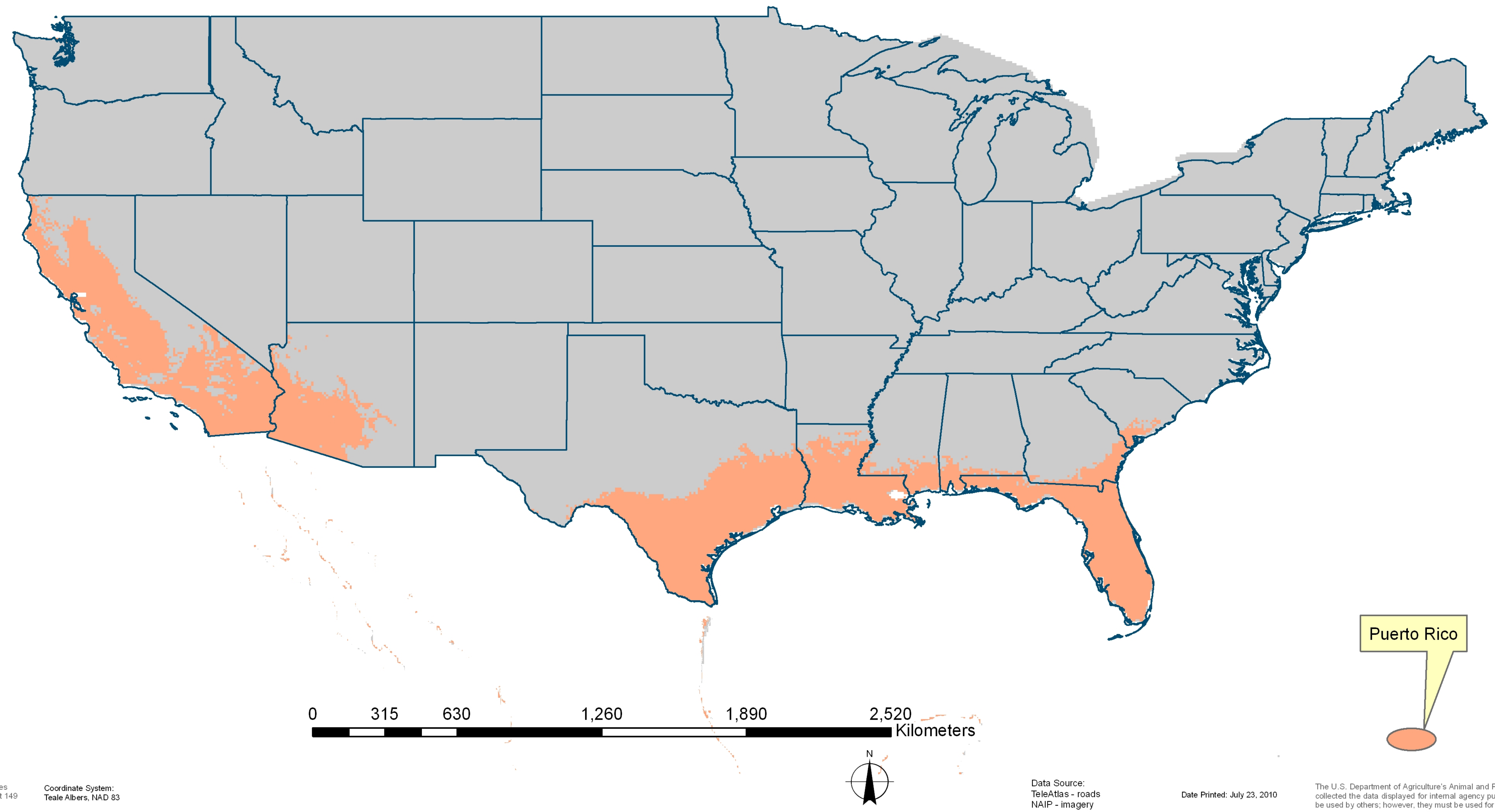
Coordinate System:
Teale Albers, NAD 83

Data Source:
TeleAtlas - roads
NAIP - imagery

Date Printed: October 14, 2010

Appendix D. Affected Environment for the Proposed ACP Control Program

Affected Environment



USDA-APHIS-PPD
Environmental Services
4700 River Road, Unit 149
Riverdale, MD 20737

Coordinate System:
Teale Albers, NAD 83

Data Source:
TeleAtlas - roads
NAIP - imagery

Date Printed: July 23, 2010