Importation of Avocado Fruit (*Persea americana* Mill. var. 'Hass') from Mexico

A Risk Assessment

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U.S. Department of Agriculture (USDA)
Animal and Plant Health Inspection Service (APHIS)
Plant Protection and Quarantine (PPQ)
Center for Plant Health Science and Technology (CPHST)

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Executive Summary

This pest risk assessment (PRA) responds to a request to remove certain restrictions on the importation of ‘Hass’ avocados (*Persea americana* Mill. var. ‘Hass’) from the state of Michoacán, Mexico. Its purpose is to analyze the likelihood of pest introduction if the Mexican ‘Hass’ avocado import program is expanded to all US states plus the District of Columbia year-round or, alternatively, to 47 states and the District of Columbia year-round; excluding California, Florida, and Hawaii for a period of two years. This assessment was thus prepared to assist APHIS in evaluating the above request to expand the scope of the existing Mexican ‘Hass’ avocado import program. APHIS phytosanitary regulations currently restrict fresh avocado imports to 31 northeastern and north central states and the District of Columbia, limiting distribution to October 15 through April 15, with the exception of Alaska receiving year-round imports.

The 47 state year-round scenario is proposed and analyzed because California, Hawaii, and Florida are the commercial avocado producing states (NASS, 2004) that would be at risk for avocado-specific pests that could enter with Mexican avocados. The risk analysis did not include buffer states because the likely buffer states, which would be Alabama, Arizona, Georgia, Nevada, and Oregon, do not produce avocados or have special quarantine regulations against avocados moving through their states or moving into the prohibited states, but California and Florida do have adequate domestic quarantine regulations against certain agricultural products moving into and within them. Because Hawaii is an island, it would not need buffer states. The avocado-growing area of Florida is confined to the southern half of the peninsula, therefore Florida's northern counties serve as buffers to the producing counties. The avocado-growing areas of California are more extensive, but they are either bordered by the Pacific Ocean on the west, large expanses of desert counties of California or desert areas of Nevada and Arizona to the east, a wide expanse of non-avocado-growing counties to the north, and Mexico to the south.

APHIS will implement a two-year period during which avocados would not be imported into California, Hawaii, and Florida . This restriction will provide APHIS an opportunity to further substantiate the effectiveness of the mitigation measures under the expanded program, specifically, to gather and analyze new pest interception and survey data acquired during year-round shipping. Because importation has been limited to the period from October 15 to April 15 annually, APHIS will now take the opportunity to collect and analyze pest interception data from Mexican avocados for the April 15 to October 15 period. A second orchard certification survey would be added to gather the additional data. It would cover the dry season period beginning in January and would be effective in sampling stem weevil larvae (Gudino-Guzman, 1990) in branches and fruit and seed moth larvae (Ventura *et al.*, 1999; Cervantes-Peredo, 2000) present during early flowering and at the decline of the peak harvesting period in Michoacan.

In the 50 state scenario, an assumption has been made that the prevalence of infestation (P1) is as measured during the current six months of inspection (of the current areas of production). However, in order for APHIS to have confidence that the prevalence will indeed be the same year round, there is a need to gather and analyze new pest interception and survey data gathered during year-round, increased growing area, and increased volume shipping.

1. The results of the 50 state scenario are correct/acceptable, contingent upon the prevalence (P1) being the same or better than it currently is.
2. APHIS does not have a measure of what the pest incidence rates would be under a proposed all year round, 47 or 50 state scenario. APHIS has assumed that the pest incidence rates will be the same as, or less than at present. (If this assumption is incorrect, then APHIS has underestimated the risk posed by the 47 & 50 state scenarios. The consequences to California, Hawaii, and Florida are significant under the 50 state scenario).
3. Because pest prevalence (as determined by pest incidence rates) is the initiator of risk, it is important that an accurate estimate be obtained.
4. A two year period is necessary to gather and analyze new pest interception and survey data in order to verify that the pest incidence under the 50 state, year round, scenario is indeed the same as under the current system..
5. During this two year period, it is prudent to implement the 47 state scenario, and exclude California, Hawaii, and Florida, since they are the commercial avocado producing states that would be at risk for avocado-specific pests that could enter with Mexican avocados.

If the pest incidence rates over the two year implementation of the 47 state scenario is found to be the same or less than the current pest incidence rates, then implementation of the 50 state scenario would be warranted (based on the results of the quantitative model). If the pest incidence rates over the two year implementation of the 47 state scenario is found to be greater than the current pest incidence rates (i.e. the assumptions in 2 above is found to be wrong), then only the 47 state scenario would provide protection against establishment of avocado-specific pests in California, Hawaii, and Florida.

On May 24, 2004 the Federal Register published a proposed rule expanding the Mexican ‘Hass’ avocado import program allowing for comments from May 24 through July 23, 2004. Supporting documents for the proposed rule were available on the APHIS website or by contacting APHIS. The present revision incorporates comments and data received during the comment period on the proposed rule and the May 2004 version of the PRA. The individual responses by APHIS to the comments appear in the final rule. Revisions to the present PRA include the following:

- A 47 state scenario was added in which the risk is calculated for all states and the District of Columbia, excluding California, Florida, and Hawaii.
- Uncertainty was added to the estimate for sensitivity of inspection in the analysis. The estimate of 50% was replaced with a uniform distribution from 17.9% to 83.5%.

- The estimate for the number of avocados imported was changed for consistency with the economic analysis.
- Statistics including mean, mode, and standard deviation were reported for all analysis output distributions in Appendix D.

Quantitative analyses were used to determine the expected number of imported program avocados that would enter infested with the three seed weevils (*Conotrachelus aguacatae, C. perseae, H. lauri*), the stem weevil (*C. aguacatae*), the seed moth (*S. catenifer*), and fruit flies (A*nastrepha* spp., *C. capitata*). One analysis focuses on the seed moth, stem weevil and the three seed weevils. A second analysis was used for fruit flies because they have a broader host range. Two import scenarios are considered for the importation of 'Hass' avocados: distribution in 47 states (excluding CA, FL, and HI) and distribution in all 50 states. The pathway extends from production, harvest, and packing in Mexico, through all of the mitigations described in the safeguards section, and ends with infested avocados distributed to, and discarded (other than landfills or incinerated) in, areas in the U.S. with susceptible hosts.

In the 50 state plus the District of Columbia scenario:

- Less than 442 infested avocados will enter the entire United States each year, with 95% confidence.
- Less than 54 avocados infested with stem weevils, seed weevils or seed moths will enter avocado producing areas each year, with 95% confidence.
- Less than 238 avocados infested with fruit flies will enter fruit fly susceptible areas each year, with 95% confidence. .
- Less than 3 avocados infested with stem weevils, seed weevils or seed moths will be discarded in avocado producing areas each year, with 95% confidence.
- Less than 12 avocados infested with fruit flies will be discarded in fruit fly susceptible areas each year, with 95% confidence.
- There is an overall low likelihood of pest entry, based on the quantitative analysis.
- There is a low likelihood of pest establishment, based on a qualitative analysis.
- When low likelihood of pest establishment and low likelihood of pest entry are considered together, then the likelihood of introduction is low.
- The consequences of introduction are medium for stem weevils, seed weevils, or seed moths and high for fruit flies, based on a qualitative analysis.
- The overall pest risk potential may be derived from considering the low likelihood of introduction and medium to high consequences of introduction for the above pests.

In the 47 state scenario (excluding CA, FL, and HI):

- Less than 393 infested avocados will enter the 47 states each year, with 95% confidence.

- Less than 7 avocados infested with stem weevils, seed weevils or seed moths will enter avocado producing areas outside of California, Florida and Hawaii each year, with 95% confidence.
- Less than 98 avocados infested with fruit flies will enter fruit fly susceptible areas outside of California, Florida and Hawaii each year, with 95% confidence. .
- Less than 1 avocado infested with stem weevils, seed weevils or seed moths will be discarded in avocado producing areas outside of California, Florida, and Hawaii each year, with 95% confidence.
- Less than 5 avocados infested with fruit flies will be discarded in fruit fly susceptible areas outside of California, Florida, and Hawaii each year, with 95% confidence.
- There is an overall low likelihood of pest entry, based on the quantitative anlysis.
- There is a low likelihood of pest establishment, based on a qualitative analysis.
- When low likelihood of pest establishment and low likelihood of pest entry are considered together, then the likelihood of introduction is low.
- The consequences of introduction are low for stem weevils, seed weevils, or seed moths and high for fruit flies, based on a qualitative analysis.
- The overall pest risk potential may be derived by considering the low likelihood of introduction and low to high consequences of introduction for the above pests. It is lower than that of the 50 state scenario.

Likelihood of establishment was determined by considering several factors. Even if some infested avocados entered the country, the likelihood of pest establishment and spread would require that: a) the infested avocados must be in close proximity to host material, b) the pests must find mates, c) the pests must successfully avoid predation, d) the adult pests must find host material, and e) the climatological and microenvironmental conditions must be suitable. The likelihood of establishment is substantially reduced by the above factors. It has been estimated that only 10% of exotic insect species entering actually become established and that plant pests entering in small numbers, such as those above, are vulnerable to demographic, environmental, and other stochastic forces that drive their small populations to extinction (National Academy of Sciences, 2002). Although information that would allow quantifying these factors for the pests of concern is not currently available, APHIS concludes that collectively they result in a low likelihood of pest establishment.

The results of the quantitative analysis are useful but they do not provide an expression of “risk” as an endpoint. The quantitative analysis estimated the probability that infested fruit enter production areas; establishment requires additional steps (identified as “a” through “e” above). Risk-reducing effects of the systems approach are evidenced in USDA’s experience with the program and fruit sampling information. Repeated surveys, inspections, and other requirements of the systems approach reduce risk substantially. Confidence in these surveys and inspections is reinforced, first, by repeated site visits by APHIS personnel; second, by the active participation of APHIS field personnel in the surveys; third, by the systems approach mitigations; and fourth, by the fact that examination of over ten million fruit has not revealed any pests.

Only those avocados discarded (not in landfills or incinerated) in susceptible areas pose a risk of establishment of the pests into the United States. This is because most purchased program avocados entering are subject to either being consumed or discarded into sanitary landfills or incinerated and do not pose a risk of establishment.

The likely number of infested avocados imported under the program may be compared to the number of smuggled or non-program avocados containing the quarantine pathway pests already entering. Approximately150 to 300 smuggled or non-program avocados enter per year. APHIS-PPQ data (PIN-309) indicate that pathway pests are routinely found in prohibited avocados intercepted in baggage and cargo at ports of entry. During the seventeen-year period from 1985 to 2002, an average of 30 avocados infested with pathway pests were intercepted and denied entry into the United States each year. Studies of port efficiency (Miller *et al*., 1996; Meissner *et al.*, 2003) at finding prohibited materials suggest that inspectors detect approximately 10-20% of what actually arrives at US borders; this suggests that an estimated average 150-300 infested non-program avocados are introduced illegally each year in baggage and cargo. During the period 1985 to 2002, 512 pathway pests were detected in prohibited intercepted avocados (specific variety or cultivar not recorded) in baggage and cargo: *Anastrepha* spp.: 10; *Conotrachelus* sp.: 242; *Copturus* sp.: 5; *Heilipus* sp.: 38; *Stenoma* sp.: 217. Prohibited avocados in baggage and cargo pose a substantially greater risk to agriculture than commercial imports of ‘Hass’ avocados from Mexico. Legalizing imports of avocados from Mexico could reduce smuggling of the commodity into the United States.

In addition to the likelihood of introduction of fruit flies from prohibited baggage and cargo, *Anastrepha ludens* has been recorded in southern Texas for the past decade. Thousands of fruit flies are trapped yearly in this area and are currently under an eradication program; however, no establishment beyond southern Texas and to other growing regions in the United States has been observed. At this time (2004), *A. ludens* continue to be present in southern Texas, suggesting that the spread of *A. ludens* to production areas to the north is unlikely.

The assessment lists all avocado pests known to occur in Mexico. After eliminating non-quarantine and non-pathway pests from the list, eight pests (three fruit flies: *Ceratitis capitata*, *Anastrepha ludens*, *A. striata*; three seed weevils: *Conotrachelus aguacatae*, *C. perseae*, and *Heilipus lauri*; one stem weevil: *Copturus aguacatae*; and one seed moth: *Stenoma catenifer* are of quarantine significance and may follow the avocado fruit pathway. Only the fruit flies would result in high-level consequences if introduced and established. The other quarantine pathway pests would result in medium level consequences. The fruit flies are generalists as far as plant species infested, whereas the other quarantine pathway pests would only infest avocados as a host in the United States.

Mitigation of the risk posed by the pests is accomplished by a systems approach. The systems approach is designed to reduce the risk of quarantine pests following the pathway and to trigger the appropriate action should pathway pests be detected during those periods or places specified in the regulation or work plan. The systems approach for ‘Hass’ avocados imported from Mexico includes a set of independent and overlapping phytosanitary measures that collectively reduce the risk of pest introduction into the United States. The first level of control aims to monitor levels of target pests in the PRA (Pest Risk Assessment) area. Mandatory survey requirements are in place to detect infestations with a high degree of confidence. Exporting municipalities and orchards in Michoacán have been surveyed annually for six years with negative results for five of the pathway pests: *Ceratitis capitata*, *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae*, and *Conotrachelus perseae*. The stem weevil, *Copturus aguacatae*, was detected in seven surveys of orchards seeking certification to export to the United States over a six year period. These seven detections were part of orchard surveys which resulted in suspension of the orchards from the program. *Anastrepha* species were detected in adult bait traps numerous times over the last six years, but were never found to be infesting fruit. Those positive surveys resulted in mandatory fruit fly bait treatments.

Part of the first level of the systems approach includes geographic and botanical restrictions. Fruits are only allowed from the PRA area which is restricted to the state of Michoacán, Mexico. The fruit is also restricted to the avocado cultivar ‘Hass’. Research has shown that *Anastrepha* spp. fruit flies have a low likelihood of being in the pathway if the fruit remains healthy and attached to the tree. Fruit that falls from the tree is not permitted to enter the pathway. Culling is done to remove damaged or otherwise atypical fruit from the pathway.

Cutting and inspection of fruit is the second level of control designed to detect fruit infested with any of the quarantine pathway pests. Samples of fruit are collected during orchard certification surveys, at packinghouses, and at ports of entry into the United States. No pests have been found in Mexican avocados in six years of fruit cutting and inspection. Over ten million fruit were examined (8.8 million in the orchards, 1.4 million in packing houses, and 117,750 at border inspection ports) for pests. If an infested avocado were to be found, a trace-back mechanism in the systems approach allows APHIS and Mexican authorities to identify the source orchard. Depending on the pest species, these orchards, or the municipalities where the orchards are, would lose their export certification until appropriate pest eradication measures are completed.

The mitigations in the systems approach are designed to reduce the number of infested avocados in the pathway and the frequency of pest entry. The success of this approach is evident from the failure to detect even one infested avocado in the pathway, despite continuous and concerted efforts. Avocado importations during the last six years have provided APHIS with valuable experience managing the systems approach and increased the Agency’s confidence in the efficacy of the safeguards.

Fruit flies (*Anastrepha* spp.) have been a major concern and a key focus of previous risk analyses. Recent research (Aluja, *et al*., 2004) prompted a re-evaluation of the potential of *Anastrepha* spp. to infest 'Hass' avocados (Appendix C). Based on this research, the USDA Agricultural Research Service (ARS) concluded that commercially produced 'Hass' avocados are a "very poor host" for the Mexican fruit fly [*Anastrepha ludens* (Loew)]. Moreover, 'Hass' avocados produced and exported using the systems approach described in this document have a low likelihood of being a pathway for *Anastrepha* spp. fruit flies as supported by six years of survey, fruit cutting, and inspection data.

Introduction

This risk assessment is in response to a request by Mexico to remove certain restrictions on the importation of fresh avocado (*Persea americana* Mill var. 'Hass') fruit from Michoacán, Mexico; its purpose is to analyze the risks of expanding the existing Mexican 'Hass' avocado import program to authorize imports to all US states year-round, and, alternatively, to 47 states excluding CA, HI, and FL (commercial avocado-producing states).

The 47 state year-round scenario is proposed and analyzed because California, Hawaii, and Florida are the commercial avocado producing states (NASS, 2004) that would be at risk for avocado-specific pests that could enter with Mexican avocados. The risk analysis did not include buffer states because the likely buffer states, which would be Alabama, Arizona, Georgia, Nevada, and Oregon, do not produce avocados or have special quarantine regulations against avocados moving through their states or moving into the prohibited states, but California and Florida do have adequate domestic quarantine regulations against certain agricultural products moving into and within them. Because Hawaii is an island, it would not need buffer states. The avocado-growing area of Florida is confined to the southern half of the peninsula, therefore Florida's northern counties serve as buffers to the producing counties. The avocado-growing areas of California are more extensive, but they are either bordered by the Pacific Ocean on the west, large expanses of desert counties of California or desert areas of Nevada and Arizona to the east, a wide expanse of non-avocado-growing counties to the north, and Mexico to the south.

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In the 50 state scenario, an assumption has been made that the prevalence of infestation (P1) is as measured during the current six months of inspection (of the current areas of production). However, in order for APHIS to have confidence that the prevalence will indeed be the same year round, there is a need to gather and analyze new pest interception and survey data gathered during year-round, increased growing area, and increased volume shipping.

1. The results of the 50 state scenario are correct/acceptable, contingent upon the prevalence (P1) being the same or better than it currently is.
2. APHIS does not have a measure of what the pest incidence rates would be under a proposed all year round, 47 or 50 state scenario. APHIS has assumed that the pest incidence rates will be the same as, or less than at present. (If this assumption is incorrect, then APHIS has underestimated the risk posed by the 47 & 50 state scenarios. The consequences to California, Hawaii, and Florida are significant under the 50 state scenario).
3. Because pest prevalence (as determined by pest incidence rates) is the initiator of risk, it is important that an accurate estimate be obtained.
4. A two year period is necessary to gather and analyze new pest interception and survey data in order to verify that the pest incidence under the 50 state, year round, scenario is indeed the same as under the current system..
5. During this two year period, it is prudent to implement the 47 state scenario, and exclude California, Hawaii, and Florida, since they are the commercial avocado producing states that would be at risk for avocado-specific pests that could enter with Mexican avocados.

If the pest incidence rates over the two year implementation of the 47 state scenario is found to be the same or less than the current pest incidence rates, then implementation of the 50 state scenario would be warranted (based on the results of the quantitative model). If the pest incidence rates over the two year implementation of the 47 state scenario is found to be greater than the current pest incidence rates (i.e. the assumptions in 2 above is found to be wrong), then only the 47 state scenario would provide protection against establishment of avocado-specific pests in California, Hawaii, and Florida.

This assessment was prepared to assist APHIS in evaluating the request to expand the scope of the existing import program. APHIS regulations currently restrict avocado imports to 31 northeastern and north central states, Alaska, and the District of Columbia. Shipment and distribution are allowed only from October 15 to April 15. This plant pest risk assessment evaluates the importation of fruit to the entire United States year-round or to 47 states excluding CA, HI, and FL. Whereas the current system is used as a reference point, this assessment focuses on the risks associated with a program that will be expanded and referred to as a modified systems approach.

This assessment first identifies and lists all pests of potential importance to the United States associated with avocados in Mexico (Appendix A). Non-quarantine and non-pathway pests are then eliminated from further consideration.

The assessment next estimates the likelihood of introduction for the remaining pathway pests. Introduction is the entry of a pest resulting in its establishment (FAO, 2002). Quantitative evidence collected by APHIS over the last six years of the import program including the quantity of the commodity imported annually, infestation rate by pathway pests, detection sensitivity of those pests, and numbers of imported fruit entering different areas of the country was available. APHIS analyzed the data to determine the likelihood of entry of pests. Likelihood of entry along with likelihood of establishment, assessed qualitatively, were used to determine likelihood of introduction.

Three quantitative endpoints of the likelihood of entry of pathway pests are estimated under both a 50 state import scenario and a 47 state import scenario: the number of infested avocados entering the United States, the number of infested avocados entering susceptible areas, and the number of infested avocados discarded in susceptible areas in the United States each year. These endpoints are estimated separately for fruit flies and for pests that only infest avocados (Appendix D).

Only those avocados discarded (other than in landfills or incinerated) in susceptible areas pose a risk of establishment of the pests in the United States. However, most program avocados that enter the country are consumed, discarded into sanitary landfills, or incinerated. All of these disposal methods are dead-end pathways and do not result in establishment. Sanitary landfills are considered a dead-end pathway for insects in commodities and a safe way to dispose of live insect pests (Auclair *et al.*, In Review; Lyon, 2000) because landfills are compacted and covered with dirt daily (Merrill, 1997) which prevents entry or escape of pests.

The additional steps leading to pest establishment are evaluated using qualitative factors (Chapter "P3-Proportion of fruit discarded"); those steps including: a) the infested avocados must be in close proximity to host material, b) the pests must find mates, c) the pests must successfully avoid predation, d) the adult pests must find host material, and e) the climatological and microenvironmental conditions must be suitable. "Only an estimated 10% of all nonindigenous insect species that are introduced into a new range become established" and plant pests entering in small numbers are vulnerable to demographic, environmental, and other factors that drive them to extinction (National Academy of Sciences, 2002). Based on the above steps and factors, APHIS estimates that the likelihood of establishment would be low.

The consequences of introduction, including economic and environmental, are considered qualitatively (Chapter "Estimates of Consequences of Introduction"). APHIS (2000) guidelines were followed for this assessment.

By stating both the undesirable outcome (consequences) and the probability that it will occur, APHIS has provided the information needed to determine the overall pest risk potential, or the likelihood that pests of concern will be introduced and cause significant negative consequences (Byrd and Cothern, 2000). Consideration of the likelihood of introduction and the consequences of introduction may be used to estimate the overall pest risk potential.

This document does not attempt to address the level of pest infestation that constitutes acceptable or negligible risk; however, information on the number of quarantine pathway pests found on other pathways (prohibited fruit in travellers' baggage and prohibited cargo) entering the United States is provided for comparison. Also, to provide context, the infestations of *Anastrepha* fruit flies in south Texas over the past decade have been cited.

APHIS has completed several risk assessments of avocados imported from Mexico (USDA 1995, 1995a, 1996, APHIS 2001b, c). This document updates and supplements evidence presented in those assessments. This assessment also considers new evidence regarding the potential for *Anastrepha* fruit flies to infest 'Hass' avocados and the results of avocado inspections completed by Mexican and APHIS officials. Key elements of previously published risk assessments and other APHIS documents are presented within the document in order to permit the reader to understand this analysis without reference to previous work. Some elements, however, are incorporated by reference; the relevant documents are available on the Internet at: http://www.aphis.usda.gov/ppq/avocados/. While the 1995 PRA (1995a) discussed risk based on importation into 19 states during a six-month period, the current PRA predicts risk for 50 states, and alternatively 47 states (except CA, FL, and HI), year-round. The conclusions in the current PRA were based on two major pieces of data unavailable when the 1995 PRA was written: six years of inspection data under the program with no detections and a 2001-2002 non-host study for fruit flies in Mexico. The six years of data included fruit-cutting data for over 10 million imported fruits cut from 1997-2002. Data from these studies provided more accurate assumptions to be made in 2004 versus 1995. Both PRAs, in general terms, concluded that the likelihood of pest introduction into the United States was low, but each expressed it differently. The 1995 model determined outbreak frequency while the current model determined the number of infested fruit discarded in a susceptible area. APHIS revised the quantitative model to enhance its credibility and incorporate additional data collected during the previous six years.

History of Avocado Importation from Mexico

Quarantine 56 (7 CFR **§** 319.56) provides general regulatory authority for the importation of fruits and vegetables. In 1973, the specific avocado quarantine was incorporated into the general nursery stock (7 CFR **§** 319.37) and fruit and vegetable quarantines (Quarantine 56, 7 CFR **§** 319.56).

USDA has restricted the importation of Mexican avocado fruit since 1914 in order to protect the phytosanitary health of U.S. avocado production. The primary justification for the 1914 restriction was the presence of an avocado seed weevil (*Heilipus lauri*) in Mexico (Table 1). Since 1914, Mexican agricultural officials and exporters, as well as U.S. importers of agricultural commodities, have repeatedly petitioned for authorization to import Mexican avocado fruit into the United States.

Table 1 - Chronology of Mexican Avocado Importation

Year	Event
1914	APHIS prohibits importation of avocados from Mexico because of seed weevils.
1993	APHIS amends rule to allow entry of Mexican avocados into Alaska under certain conditions.
1997	APHIS amends rule to allow entry of Mexican avocados from Michoacán, Mexico to 19 northeastern states from November to February, subject to certain phytosanitary requirements.
2001	APHIS amends rule to allow entry of Mexican avocados from Michoacán, Mexico to 31 northeastern and north central states from October 15 through April 15, subject to certain phytosanitary requirements.
2003	APHIS publishes draft risk analysis associated with exports of Mexican Hass avocados from Michoacán to all 50 states and during the entire year.

In 1992, Mexican authorities asked APHIS to consider allowing the importation of 'Hass' avocados from Mexico to any destination in the United States. APHIS conducted a risk assessment and concluded that Mexican avocados could be safely imported into Alaska because imported pests could not survive or establish there. That assessment used a decision sheet format (Attachments 1 and 2 of Risk Management Analysis: A Systems Approach for Mexican Avocados, APHIS, 1995b). A proposed rule was published in the Federal Register in 1992 (APHIS, 1992) and the final rule was published the following year (APHIS, 1993a). At the current time, 'Hass' avocados from Michoacán can be imported to Alaska under the conditions specified in 7CFR§319.56-2bb.

Interest in the exportation of Mexican avocado fruit to other states continued after 1993 with Mexico making repeated requests. APHIS formed an oversight group to consider Mexico's requests. The APHIS Oversight Group met several times and made three trips to the Mexican avocado growing areas in Michoacán, Mexico. APHIS developed two documents relevant to avocado imports: *Potential Economic Impacts of an Avocado Weevil Infestation in California* (APHIS, 1993b), and *Economic Impact of the Establishment of Mexican Fruit Fly in the United States* (APHIS, 1993c).

In July 1994, Sanidad Vegetal, the plant protection branch of the Mexican Ministry of Agriculture and Water Resources, requested that APHIS allow Mexico to export fresh 'Hass' avocados from approved orchards in approved municipalities in Michoacán into the northeastern United States. After reviewing Mexico's proposal, APHIS published an *Advance Notice of Proposed Rulemaking* (59 FR 59070-59071, Docket

No. 94-116-1) in the *Federal Register* (November 15, 1994) announcing APHIS' receipt of the request. APHIS officials prepared two documents as part of the risk analysis. The first document, "Risk Management Analysis: A Systems Approach for Mexican Avocado," (USDA, 1995b), is an analysis of the procedures to reduce pest risk associated with Mexican 'Hass' avocados. The second document "Importation of Avocado Fruit (*Persea americana*) from Mexico: Supplemental Pest Risk Assessment" (USDA, APHIS, 1995a) includes a quantitative assessment of the likelihood of introducing certain pests, as well as an assessment of the consequences of introduction. The assessment estimated that the risk was low with a systems approach in place (*i.e*., a systems approach as described in http://www.aphis.usda.gov/ppq/avocados/). A final rule was published in the *Federal Register* in February, 1997 to allow the importation of fresh 'Hass' avocados from Mexico under certain conditions. The 1997 rule allowed imports of avocados to nineteen northeastern states (Connecticut, Delaware, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin), and the District of Columbia, but limited shipments to the months of November through February. Climatic conditions in those states during the winter months precluded the establishment of any exotic plant pests that might accompany avocados from Michoacán, Mexico.

In September 1999, the Government of Mexico requested that APHIS further expand the importation of 'Hass' avocados into the United States in accordance with the Sanitary and Phytosanitary (SPS) Agreement and the North American Free Trade Agreement (NAFTA). APHIS considered the request and finalized the current rule for avocado importation from Mexico in 2001. Under the regulations (7CFR§319.56-2ff) avocados are currently allowed to enter 31 states and the District of Columbia from October 15 through April 15 of the subsequent year. The current importations are subject to a series of mitigations, described in "Risk Management Analysis: A Systems Approach for Mexican Avocados" (USDA, 1995b, available at: http://www.aphis.usda.gov/ppq/avocados/). Under the regulations (7CFR§319.56-2bb) avocados may be imported intoAlaska throughout the year under less restrictive conditions.

Key Safeguards on the Importation of Mexican Avocados

The importation of Mexican avocados is managed using a "systems approach." This refers to a set of independent and overlapping phytosanitary measures that collectively mitigate the risk of pest introduction into the United States (Anonymous, 2002) and is also described as the integration of different pest risk management measures, at least two of which act independently, and which reduces the risk of pest introduction (FAO, 2002). The systems approach for 'Hass' avocados has successfully protected U.S. agriculture for several years from pests potentially associated with this pathway. Avocado importations during the last six years provided APHIS with valuable experience managing the systems approach and increased the Agency's confidence in the efficacy of the safeguards.

Key safeguards in the systems approach are listed in Table 2 and described below. The expanded distribution of avocados requested by Mexico will eliminate one component (component 6, Table 2) and expand two components (Component 1 and 9, Table 2), allowing avocados to enter all fifty states, plus the District of Columbia year-round.

Table 2. Components of the Current and Modified Systems Approachs for Avocados imported from Mexico

Current Systems Approach	Modified Systems Approach
1. Field Surveys once per year (municipalities and orchards certification, pest free status, Michoacán only)	**Field Surveys twice per year (municipalities and orchards certification, pest free status, Michoacán only)**
2. Trapping Activities	Trapping Activities
3. Field Sanitation	Field Sanitation
4. Host Resistance ('Hass' cultivar only)	Host Resistance ('Hass' cultivar only)
5. Post-Harvest Safeguards (transport to packinghouse in screened trucks within three hours of harvest, shipping in sealed, refrigerated containers)	Post-Harvest Safeguards (transport to packinghouse in screened trucks within three hours of harvest, shipping in sealed, refrigerated containers)
6. Winter Shipping Only (Oct 15 – April 15)	**No restriction on shipping season**
7. Packing House Inspection, Culling, and Fruit Cutting	Packing House Inspection, Culling, and Fruit Cutting
8. Port-of-Arrival Inspection and Clearance Activities	Port-of-Arrival Inspection and Clearance Activities
9. Limited Distribution (31 states and the District of Columbia)	L**imited distribution (all states and the District of Columbia, except for CA, FL, and HI) for two years from the date of publication of the final rule and unlimited distribution thereafter.**

1. Field surveys

Current regulations (7 CFR § 319.56-2ff (c) (ii)) require annual surveys of orchards and municipalities. Under the proposed modification to the systems approach bi-annual surveys are required.

<u>Municipality Surveys</u>

Only certain municipalities of Michoacán are qualified for the export program (http://www.aphis.usda.gov/ppq/avocados/workplan_2003.pdf). Current regulations (annual survey) and the proposed systems approach (bi-annual surveys) require the Government of Mexico, along with APHIS, to conduct surveys of Michoacán municipalities for *Ceratitis capitata*, *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae* and *Contrachelus perseae* before the municipality can become certified to export fruit. Certification is dependent upon pests being absent from the municipalities. The *Ceratitis capitata* survey must include a trap every one to four square miles (7 CFR§319.56-2ff (c)(1)(iii)). For *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae* and *Conotrachelus perseae* (7 CFR§319.56-2ff (c)(1)(iii)), the surveys must cover at least 300 randomly selected hectares in each municipality and include randomly selected portions of each certified commercial orchard, wild areas and backyards with avocado trees. The surveys include foliage sampling, fruit cutting, and visual inspection. Foliage samples are collected by beating the lower branches of a tree over a white tarpaulin. Foliage and other material falling onto the tarpaulin are examined for pests. The survey must be conducted during the growing season and completed prior to the harvest of the avocado. The survey sampling method is calibrated to detect pests if they are present in one percent or more of the area surveyed at a 95% confidence level (USDA, 1995b; http://www.aphis.usda.gov/ppq/avocados/workplan_2003.pdf**.**)**.** If quarantine pests are found, the affected areas are eliminated from the export program and eradication programs initiated. Under the modified systems approach the municipality surveys will be conducted on a semiannual basis.

Six years of surveys produced no evidence of *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae* and *Conotrachelus perseae* in Michoacán municipalities certified to export to the United States (Table 5). *Stenoma catenifer*, *Conotrachelas aguacatae*, and *Heilipus lauri* have not been found in Michoacán (USDA, 2001b; see Appendix B). The seed weevil, *Conotrachelus perseae*, occurs only in one small area of Michoacán near Ziracuaretiro (see Appendix B). Mexico has quarantined this area and conducted an eradication program for the past three years during which time the quarantined area has been reduced from 600 to 140 acres (USDA, 2001b). (The municipality of Ziracuaretiro is currently not in the export program.)

Jackson traps are used to detect Cerititis capitata in each municipality.The trap density is one trap er 1 to 4 square miles. They are inspected and serviced once every 2 weeks. The traps are set and maintained according to the Mexican National Trapping program.

APHIS monitors Mexico's compliance with municipality survey procedures in Michoacán. Sanidad Vegetal is required to inform APHIS about any pest infestations. If *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae* or *Conotrachelus perseae* were detected, the affected municipality would lose its pest-free certification. Eradication measures would commence and avocado exports from the municipality involved would be suspended. Exports could resume only if and when APHIS determines that Mexico had implemented effective measures and eradicated the pest from the infected municipality (Appendix E). If *Ceratitis capitata* is detected, the finding must be reported to APHIS.

<u>Orchard surveys</u>

Certification of orchards in the export program requires participation in a multi-level pest inspection and approval process. The certification process begins when a grower petitions the Junta Local de Sanidad Vegetal (JLSV - the local equivalent to a U.S. county agricultural office) to participate in the export program. Inspectors from the JLSV office visit the prospective orchard biweekly and conduct general pest inspections. After the JLSV inspector identifies an orchard as pest-free, the Comite Estatal de Sanidad Vegetal (CESV - equivalent to a state agricultural office in the U.S.) inspects the orchards once again, and certifies that it is free from the pathway pests. Orchards that pass this inspection are approved to export the following season. APHIS and CESV inspectors conduct a third inspection the following year during the avocado growing season. Final approval to export is only given after an orchard is determined to be free of pathway pests in all three inspections (Appendix E).

Fruit are cut and inspected for pathway pests in the orchards during the surveys. A total of 8.8 million avocados from export orchards have been inspected over the past six years (an average of 1.4 million avocados per year) and no pathway pests have been detected (Table 4).

APHIS personnel monitor compliance with orchard survey requirements and APHIS personnel participate in the annual orchard surveys. The current systems approach requires Mexican authorities to conduct one annual survey of orchards for the stem weevil, *Copturus aguacatae*. If the stem weevil were detected, the affected orchard would be denied export certification for the entire shipping season. Exports could resume only when APHIS determines that Mexico has implemented effective measures and eradicated the pest from the affected orchard (Appendix E). Under the proposed modified systems approach with year-round shipping, the survey requirement will increase to two surveys per year. If the stem weevil were detected, the affected orchard would be denied export certification. Exports could resume only when APHIS determines that Mexico has implemented effective measures and eradicated the pest from the infected orchard (Appendix E). During the past six years of surveillance, stem weevils have been detected in seven orchards (Table 5a).

2. Trapping

Under the current and proposed regulation, Authorities must continuously use McPhail traps to monitor for *Anastrepha ludens*, *A. serpentina*, and *A. striata* (Appendix E) in certified orchards. If *Anastrepha* species are detected in traps, an additional 10 traps must be deployed in the surrounding 50 hectares. If another fruit fly is found, malathion bait spraying must be done every 7-10 days in the affected orchard for the orchard to remain in the program.

3. Field sanitation practices

The current and proposed modified systems approach requires orchard sanitation measures (Appendix E). Dead branches on avocado trees must be pruned. Fallen fruit must be collected and removed weekly. Fallen fruit, which are usually overripe or damaged, are more susceptible to pest infestation, including fruit flies (*Anastrepha* spp.; Enkerlin *et al*, 1993). Pruning helps to prevent infestations of the stem weevil (*Copturus aguacatae*; USDA, 1995b). Field sanitation measures are intended to maintain healthy orchards, thus reducing their susceptibility to pest infestation.

Field sanitation practices are the responsibility of the avocado grower or orchard owner. Junta Local de Sanidad Vegetal (JLSV) monitors compliance. Sanidad Vegetal and APHIS assess field sanitation practices during orchard surveys.

4. Host resistance

The natural resistance and very poor host status of 'Hass' avocados to certain *Anastrepha* spp. found in Mexico was, and will continue, to be used as a safeguard. A discussion of the effectiveness of this safeguard can be found in Appendix C. 'Hass' avocados are easily distinguishable from other varieties by their pebbly skin texture, characteristic shape and size, and black color when ripe (Other varieties are smooth and green.) Accidental or deliberate substitution of other varieties is unlikely and can be easily detected.

5. Post-harvest safeguards

The following requirements will be maintained in the proposed modified systems approach (Appendix E).

In the orchard, avocado field boxes must be marked with the registration number of the orchard (7CFR§319.56-2ff(c)(2)(v)). At the packinghouse, the identity of the orchard orchard must be maintained from field boxes to shipping boxes for traceback purposes. In addition, avocados must be packed in boxes marked with the identity of the grower, packinghouse, and exporter (7CFR§319.56-2ff(c)(3)(vii)). Prior to packing in boxes, each avocado must be labeled with the registration number of the packinghouse. If a pest were found in an avocado at any point from the packinghouse to the market, APHIS and Sanidad Vegetal can determine the orchard where it was grown. Although no pathway pests have been detected in the past six years, this trace-back mechanism is an important safeguard designed to allow APHIS and Mexican authorities to determine the cause of a breakdown in the systems approach and respond with appropriate measures.

A phytosanitary certificate issued by Sanidad Vegetal certifying that the conditions specified in the regulations have been met must accompany all shipments of avocados. Shipments are safeguarded during transit and inspected upon arrival at their port of entry. Certificates are then checked by DHS (Department of Homeland Security) inspectors. These measures ensure that the fruit shipments originate from certified orchards and certified packinghouses and are managed in accordance with the requirements generated by the systems approach.

Another post-harvest requirement is the refrigeration of trucks from the packinghouse to US markets (7 CFR§319.56-2ff (c)(3)(viii)). At the packinghouse, boxes must be placed in a refrigerated truck, or refrigerated container, and remain in that truck or container while in transit through Mexico to the United States. Prior to leaving the packinghouse, Sanidad Vegetal must secure the truck or container with a seal that will be broken if the truck or container is opened. Once sealed, the refrigerated truck or container must remain unopened until it reaches the United States. The mortality effect of refrigeration on the pathway pests has not been determined, but is expected to be a significant, additional safeguard.

The current and proposed modified systems approaches require transportation of avocados in refrigerated trucks or containers to the US border. In addition, avocados are refrigerated during storage as part of normal retail marketing and fruit distribution. Optimum storage temperatures for ‘Hass’ avocados range from 5˚ to 8˚C (www.postharvest.com.au/Avocado_Hass.pdf). Insects develop very little, if at all, from below 4 -10˚C (http://www.ento.vt.edu/Fruitfiles/Understanding_Degree_Days.html), as they commonly exhibit high mortality at the lower storage temperatures (Stinner *et al.*, 1974; Wagner *et al.*, 1984).

6. Winter Shipping

The current rule limits the shipment and distribution of Mexican avocados to the timeframe between October 15 and April 15 (7 CFR § 319.56-2ff (a) (2)). This restriction would be removed in the proposed modified systems approach.

7. Packinghouse inspection and fruit cutting

The packinghouses in Mexico that process avocados for export to the United States must be registered with Sanidad Vegetal and listed in their annual work plan provided to APHIS. The requirements for packinghouses specified in the current rule include several mitigations designed to exclude fruit flies, detect infested avocados, and allow trace-back if infested avocados are found.

Avocados must be moved from the orchard to the packinghouse within three hours of harvest or covered to exclude pests (7CFR§319.56-2ff((c)(2)(v)). During shipment to the packinghouse, the avocados must be covered or enclosed. At the packinghouse, screens are required on windows and double doors on entrances (7CFR§319.56-2ff((c)(3)(ii)).

Stems and leaves must be removed from the fruit prior to being packed in boxes. This requirement helps to ensure that pests infesting parts of the plant other than the fruit are excluded from the shipment.

Inspectors in the packinghouses inspect and cut fruit sampled from shipments for the presence of pathway pests. In practice, this is accomplished by sampling fruit from each field truck arriving at the packinghouse from the orchard that will go into a shipment. Cutting typically involves making multiple thin slices completely through the fruit, including the seed. Sanidad Vegetal inspectors have examined nearly 250,000 avocados per year this way for the past six years. A total of 1.5 million avocados were examined; no pests were found (Table 4.).

8. Port-of-arrival inspection

Mexican avocados currently enter the United States at designated locations. Department of Homeland Security (DHS) inspectors ensure that the seals on the trucks are intact upon arrival and that the shipment is accompanied with a phytosanitary certification issued by Sanidad Vegetal certifying compliance with all provisions of the rule.

At the port of first arrival DHS inspectors must inspect avocados from each shipment for pests. According to the AQIM Handbook (PPQ, 2003) sampling was devised to provide a 95% probability of detecting pests present at a 1% infestation rate per shipment. Currently, DHS inspectors sample one fruit per box from 30 boxes per shipment. DHS (formerly APHIS) inspectors have examined approximately 20,000 avocados per year, which is approximately a total of 120,000 avocados for the past six years. Biometric sampling equivalent to detecting a 1% infestation level with a 95% probability will continue under the proposed modified systems approach.

9. Limited Distribution

Existing restrictions on the distribution of imported avocados will be removed except for California, Florida, and Hawaii. The prohibition on the movement of avocados into CA, FL, and HI will be lifted after two years from the publication of the final rule. Until the distribution prohibition is lifted, export boxes will be marked, "Not for importation or distribution into CA, FL, and HI."

Under the proposed rule, avocados may enter any US port, except for CA, FL, and HI for the first two years.

Summary of Key Safeguards

Surveys for pathway pests in municipalities and orchards, municipality, orchard, and packinghouse certification, host plant resistance, protection of harvested fruit from infestation, and shipment in sealed, refrigerated trucks are the first line of defense in preventing pests from entering the import pathway. The cutting and inspection of fruit in orchards, packinghouses and at ports of entry is a secondary line of defense. If a pathway pest is detected, APHIS and Mexican officials can trace the infested fruit back to the orchard of origin to determine the cause of the breakdown and take corrective action. In six years of imports, no pathway pests have been detected in certified harvested fruit in the import pathway even with sampling of more than ten million fruit.

The systems approach is effective in part because of the overlap of the phytosanitary measures. For example, if an orchard survey were to fail (i.e. an infested orchard was not detected), other components of the systems approach (i.e. orchard fruit cutting, packing plant inspection) would still prevent the importation of infested fruit.

Summary of Risk Analysis-Related Activities

APHIS conducted a risk management analysis for Mexican 'Hass' avocados in 1995; this analysis (USDA, 1995, a, b) described the degree to which various elements of the systems approach are expected to mitigate the pest risk associated with such importations. The analysis concluded that the cumulative effects of the systems approach lowered the risk of all target pests and that even if one of the mitigation measures should completely fail, the effect of the other measures would maintain a low level of risk.

In 2001, APHIS again reviewed the Mexican ‘Hass’ avocado import program in response to a request from the California Avocado Commission (USDA, 2001b; http://www.aphis.usda.gov/ppq/avocados/#support). As part of the review, a team of APHIS officials visited avocado production areas in Michoacán, Mexico. The site visited by the team observed trapping and orchard sanitation practices in Michoacán and concluded that the program was operating in compliance with the regulations. Also, the USDA review team visited one of ten agricultural quarantine highway checkpoints on the border of one of the approved municipalities staffed by Comite Estatal de Sanidad Vegetal (CESV). All fruit trucks must stop at these checkpoints, both entering and leaving the municipalities, to verify documentation and contents of the truck. The agricultural inspectors make random checks of passenger vehicles and non-fruit trucks entering the municipalities as a phytosanitary measure to maintain freedom from avocado pests not known to occur in the municipality. The review team concluded that the surveillance activities used in Mexico for area and production site approvals complied with 7 CFR § 319.56-2ff. JLSV’s biweekly year-round surveys in export orchards, CESV’s yearly spring surveys from March through June of avocado export orchards, backyard avocado trees and wild avocado trees, and the joint APHIS/CESV summer survey from July through September have been adequate to meet the surveys required in 7 CFR § 319.56-2ff(c)(1)(ii), 7 CFR § 319.56-2ff(c)(2), and 7 CFR § 319.56-2ff(c)(2)(i).

The report of the review group may be summarized as follows (USDA 2001b):

- The stem weevil, *Copturus aguacatae*, occurs in Michoacán and in municipalities having orchards that export to the U.S.
- The seed weevil, *Conotrachelus perseae*, occurs in Michoacán, but not within exporting municipalities. In Michoacán, it occurs only in one small area near Ziracuaratiro—this area is under an eradication program and is not in the export program, and has been a quarantined area, although it has been reduced from 600 acres to 140 acres.
- The seed weevils, *Conotrachelas agaucate* and *Heilipus lauri*, are not known to be in Michoacán. [Other sources state that *Conotrachelas aguacate* does occur in Michoacan (Whitehead, 1979 a, b; Sanidad Vegetal, 1992)].
- The seed moth, *Stenoma catenifer*, has not been found in Michoacán, but if it were, it would likely be detected by current sampling systems.

Following requests from the Mexican government in 2001-2002, APHIS prepared an initial draft of the present risk analysis document (published on the APHIS website June 2003). After a 90-day public comment period (60-day comments plus a 30-day extension), APHIS updated the PRA to reflect the input received, as follows:

-Fruit flies are analyzed for their consequences of introduction, although it is not likely that they are in the pathway. This was done because comments noted that some types of avocados (not related to the commercial ’Hass’ variety) may be infested by fruit flies. Since a majority of the comments included concerns with fruit flies, APHIS decided that the fruit flies should be further analyzed, although scientific evidence has determined that ‘Hass’ avocados are a very poor host.

-The pest list was modified to include fruit flies.

-Several refinements to the quantitative analysis of the expected number of infested avocados entering are included, but the revised analysis did not change the conclusions relative to the risks associated with the quarantine pests considered.

-Interpretation of the host status of ‘Hass’ avocado and *Anastrepha* spp. fruit flies, based on a review by USDA-ARS of research, are now incorporated. This analysis was also expanded and revised to acknowledge and incorporate recommendations communicated by USDA-ARS (ARS, 2004; Appendix F).

Revisions to the present PRA incorporate responses to substantive comments on the proposed rule and the May 2004 PRA and include the following:

-A 47 state scenario was added in which the risk is calculated for all states and the District of Columbia, excluding California, Florida, and Hawaii.

-Uncertainty was added to the estimate for sensitivity of inspection in the model. The estimate of 50% was replaced with a uniform distribution from 17.9% to 83.5%.

-The estimate for the number of avocados imported was changed for consistency with the economic analysis.

-Statistics including mean, mode, and standard deviation were reported for all model output distributions in Appendix D.

Pathway Analysis

This risk assessment was pathway-initiated, meaning that the assessment was initiated in response to the request by the Mexican government to export a particular commodity, avocados.

The approach taken in this assessment was to first identify all Mexican avocado pests. From this initial list, non-quarantine pests (as defined by IPPC above) were eliminated. From the list of quarantine pests, those pests that were not normally found on the plant part proposed for export (*e.g.*, those pests that would infest only roots) were eliminated. The likelihood and consequences of introduction was then estimated for the remaining pests. These steps include the three stages of the IPPC guidelines, plus additional detail consistent with the IPPC standards (APHIS, 2000; FAO, 1995; FAO, 2002):

1. Assessment of the weed potential of avocados.
2. Development of a pest list.
3. Identification of quarantine pests.
4. Identification of pathway pests for further consideration.
5. Estimation of the likelihood of introduction of the pests that are both quarantine and pathway pests under the conditions specified.
6. Estimation of the consequences of introduction.

In this document we address each of these six steps.

Assessment of Weed Potential of Avocado

The initial step after receiving a request for the importation of a commodity is to analyze the weed potential of the commodity itself. The process of evaluating the potential of avocados to become weeds is shown in Table 3. We found that the weed potential of avocado was low and the table details the evidence used in making this determination. Avocados of many cultivars, including ‘Hass’ are currently grown in several areas of the United States for fruit production (Appendix D), in addition to being marketed as

Table 3 – Weed Potential of Avocado

Species: Avocado, *Persea americana*

To determine weed potential we followed the format below.

Is the species listed in:

NO	*Geographical Atlas of World Weeds* (Holm, 1979)
NO	*World's Worst Weeds* (Holm, 1977)
NO	*Report of the Technical Committee to Evaluate Noxious Weeds; Exotic Weeds for Federal Noxious Weed Act* (Gunn & Ritchie, 1982)
NO	*Economically Important Foreign Weeds* (Reed, 1977)
NO	Weed Science Society of America List (WSSA, 1989)
NO	Is there any literature reference indicating weed potential (*e.g.*, *AGRICOLA*, *CAB*, *Biological Abstracts*, *AGRIS*; search "avocado" combined with "weed" or “weediness”).
IF:	All of the above answers are no,

THEN: It is concluded that avocado is not a weed, and a weed risk assessment is not needed; therefore, the PRA may proceed (APHIS, 2000).

landscape plants.

Pest List

We identified all Mexican avocado pests with potential economic importance in the United States [Appendix A, Tables A-1 (pathogens) and A-2 (arthropods)]. These lists were generated through the review of the following references and resources:

- Literature reviews using the AGRICOLA and CABPEST databases.
- Previous decision sheets covering the importation of avocados from Mexico, Jamaica, and Central America.
- The United States catalogue of intercepted pests and interception records.
- C.M.I. Distribution Maps and Descriptions of Plant Pathogenic Fungi and Bacteria.
- Texts and indices of plant pests and pathogens as listed in the bibliography section at the end of this assessment.
- APHIS' files on pests not known to occur in the United States (*e.g.*, PNKTO's “Pests Not Known to Occur” and INKTO's “Insects Not Known To Occur”).
- Results kept by APHIS of annual orchard certification pest surveys in Mexico.

All pests listed in Tables A-1 and A-2 are present in Mexico. The following information is given in the tables:

- Information about pest occurance in the U.S.
- Information on the biology and regulatory history (*e.g.*, APHIS interception records); all pests intercepted at U.S. ports on avocado fruit from Mexico (including those smuggled) are included on the pest list
- Selected references on the biology/distribution of each pest

Identification of Quarantine Pests

From the list of Mexican avocado pests identified in the analysis, all those that were not “quarantine” pests were eliminated. A quarantine pest is “a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled” (FAO, 1995). The distribution of each pest was reviewed to determine if any official control programs exist. Only those pests that were absent from the US, present in the US but not widely distributed, or officially regulated fit the international standard for quarantine pests.

In Tables A-1 and A-2 of Appendix A, “MX” in the Distribution column indicates that the pest is present in Mexico and not in the United States (unless a state is identified in the same column, using the two letter state abbreviation) and is, therefore, a quarantine pest. Of the 26 pathogens listed in table A-1 (Appendix A), three do not occur in the United States (Two other pests are not identified to species and could be in the United States. If they are identified, they could be re-analyzed for quarantine significance in the future [APHIS, 2000]). Of the arthropods in table A-2 (Appendix A), 45 are quarantine pests.

Identification of Pathway Pests

From the list of quarantine pests, we eliminated those pests that are unlikely to follow the pathway prior to mitigation by the modified systems approach, including cultivar resistance. Later in the analysis, the likelihood that fruit flies and other quarantine pests listed as in the pathway will remain in the pathway after mitigation is evaluated after the biology of each pest was reviewed to determine if the pest was associated with the fruit. The pathway of those pests that could not reasonably be expected to remain with the fruit after harvesting and packinghouse processing were eliminated (APHIS, 2000).

No quarantine pathogens (Table A-1) are considered to be in the pathway.

Of the arthropod pests listed in Table A-2, fruit flies deserve special note. Previous assessments (APHIS, 1995a) considered certain *Anastrepha* species as pests likely to be associated with avocado fruit. Those earlier assessments concluded that avocados were either non-hosts or at best, poor hosts, and that the probability of association of *Anastrepha* spp. with the 'Hass' avocado imports was low (USDA,1995a). In the present document, *Anastrepha ludens, A. striata, and Ceratitis capitata* are listed in Table A-2 as being in the pathway before mitigation with the further explanation that the commodity has been designated a very poor host for *Anastrepha ludens* and *A. striata* by ARS as a result of studies by Aluja *et al.* (2004). The field survey infestation records (Liquido *et al*., 1998; Norrbom, 2004; Norrbom and Kim, 1988) were recognized as evidence for listing those fruit flies in the pathway of unspecified varieties before mitigation.

Aluja *et al*. (2004) concluded that 'Hass' avocados on the tree, or within three hours after harvest, are a "non-host" for *Anastrepha ludens, A. obliqua, A. serpentina*, and *A. striata.* The protocol developed by Cowley, *et al.*, (1992) was followed by Aluja *et al*. (2004) to determine if commercial 'Hass' avocados are natural hosts (Appendix C). that the Aluja *et al.* (2004) study was the first that followed a published protocol [Cowley, *et al.*, (1992)] designed to determine natural host status for fruit flies and the main one that supported removal of 'Hass' avocados from the pathway of concern In laboratory and field trials, 'Hass' avocados were naturally and artificially exposed to large numbers of fertile pairs of four different species of *Anastrepha*: *A. serpentina, A. ludens, A. striata, and A. obliqua*. The conditions of exposure included both choice studies and no-choice studies. The choice studies included 'Hass' avocados and other hosts. In the choice trials, fruits other than avocados had infestations that resulted in adults. The no-choice studies included 'Hass' avocados only. In the no-choice studies, no adults developed from oviposited eggs. ARS reviewed the research results and concluded that "very poor" host status was demonstrated (ARS, 2004; Appendix F).

As further evidence, APHIS analyzed export program data records. Over ten million avocados were cut over the past six years as required by the current systems approach; none were found positive for fruit flies (Table 4). Based on the findings of Aluja *et al.* (2004) and on an ARS review of the Aluja research (Appendix F), APHIS concluded that commercially produced 'Hass' avocados are very poor hosts for the *Anastrepha* species tested and that the likelihood of introducing these species into the U.S. under the systems approach is low (See Table A-2 and discussion in this PRA under "Estimates of Consequences of Introduction-Fruit Flies").

Anastrepha obliqua and *A. serpentina* were addressed in the non-host research of Aluja *et al.* (2004). Neither species has been reliably documented as infesting avocado (Norrbom, 2004; Norrbom and Kim, 1988), therefore they are not listed as pathway pests.

Anastrepha fraterculus (Mexican population) is not addressed in the research of Aluja *et al.* (2004). Genetic and host studies have indicated that cryptic species probably exist within *A. fraterculus* (Selivon and Perondini, 1998; Smith-Caldas *et al*., 2001). Other studies (Aluja *et al*., 2003; Baker *et al*., 1944; Steck, 1991, 1999; Steck & Sheppard, 1993) have indicated that the Mexican population of the complex differs in host usage from South American populations. Although South American populations may infest avocado (Norrbom, 2004; Norrbom and Kim, 1988; Ovruski *et al.*, 2003), the Mexican population does not (Aluja *et al*., 2003b). Based on this evidence, APHIS excludes the Mexican population of the nominate species from the pathway.

Ceratitis capitata can infest avocado (Liquido *et al.,*1998) and is a quarantine pathway pest. It is mitigated by official control measure and it is not found in the export region , only on the Mexico-Guatemala border (APHIS, 1999).

Conotrachelas aguacatae, C. perseae, *Heilipus lauri*, *Copturus aguacatae,* and *Stenoma catenifer* are quarantine pests that attack fruit internally; these pests are in the pathway prior to mitigation (Garcia *et al.*, 1998; Wysoki *et al.*, 2002).

The remaining listed arthropod species in Table A-2 do not follow the pathway because they are either associated with plant parts other than the mature fruit or secondary invaders that occur only in rotting fruit or are mobile and highly likely to be removed during harvest and handling (APHIS, 2000).

The following pests are analyzed (see section "Estimates of Consequences of Introduction" and Appendix D) as quarantine pathway pests:

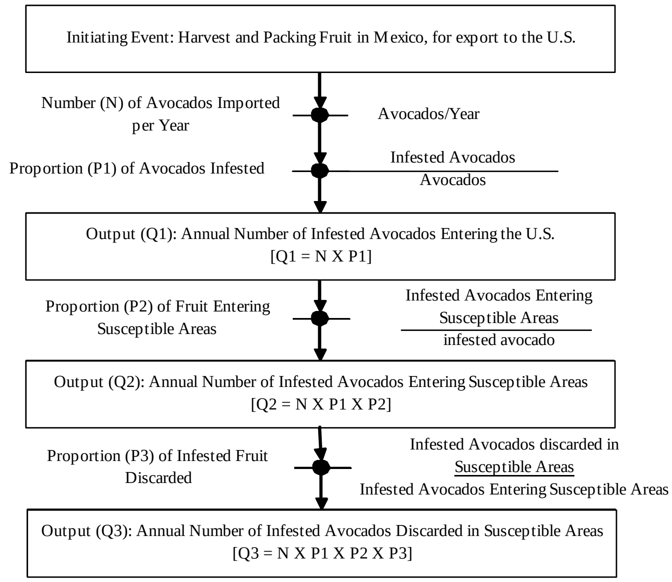
- *Conotrachelus aguacatae* - seed weevil
- *Conotrachelus perseae* - seed weevil
- *Heilipus lauri* - seed weevil
- *Copturus aguacatae* - stem weevil
- *Stenoma catenifer* - seed moth
- *Ceratitis capitata*, *Anastrepha ludens* (but see Appendices B and C)*, A. striata* (but see Appendices B and C) - fruit flies

The fruit flies, seed weevils, stem weevil, and seed moth are analyzed quantitatively to determine the number of infested avocados expected to enter (Appendix D).

Pathway Model

Quantitative analysis was used to determine the expected number of avocados that may enter infested with three seed weevils (*Conotrachelus aguacatae*, *C. perseae*, *H. lauri*), the stem weevil (*C. aguacatae*), the seed moth (*S. catenifer*), and fruit flies (A*nastrepha* spp., *C. capitata*). Two models were developed. One model focuses on the seed moth, stem weevil and the three seed weevils. Because the fruit flies have a broader host range, a second model was used for these pests.

Figure 1. Mexican Hass Avocado Pathway Scenario



Two scenarios are considered for the importation of 'Hass' avocados from Michoacán, Mexico: distribution in 47 states (excluding CA, FL, and HI) and distribution in all 50 states. The pathway extends from production, harvest and packing in Mexico, through all of the mitigations described in the safeguards section, and ends with infested avocados distributed to, and discarded (other than as landfill or incineration, see "Introduction") in areas in the U.S. with susceptible hosts (Figure 1). Outputs for both scenarios include estimates for the number of infested avocados that will enter the United States (Q1), the number of avocados that will enter susceptible areas in the United States each year (Q2), and the number of avocados that will be discarded in susceptible areas in the United States each year (Q3). The model assumes full compliance with the mitigations in the systems approach.

N – Annual Number of Fruit Imported

The quantity of Hass avocados that would be imported from Mexico if they were allowed to enter 47 states or 50 states during all seasons of the year is uncertain. A range was therefore used to express our understanding of these values (Figures 2 and 3). The quantity of imported avocados, N, is represented in the model by a distribution defined by a lower bound, most likely value, and an upper bound. The lower bound is Hass avocado imports from Mexico in 2002 (APHIS, 2004b). It is unlikely the actual number of avocados imported will be less after expansion of the program than it is currently. The most likely estimates are based on the projections of the economic analysis. The upper bound is the expected total production in certified orchards in Michoacán after five years of increasing production (see Appendix D for details).

The lower and upper bounds for the 47 and 50 state scenarios are the same but the most likely values are different. APHIS estimates that between 112 million and 1.8

billion 'Hass' avocados will be imported from Mexico annually under both the 50 state and the 47 state scenario distribution schemes. The most likely values are 402 million for the 50 state scenario and 296 million for the 47 state scenario. The maximum estimate is five to seven times the amount imported in the 2001/2002 season (see Appendix D).

The distribution for the annual number of avocados imported is represented in Figures 2 and 3 (For details of the calculations, see appendix D).

Figure 2

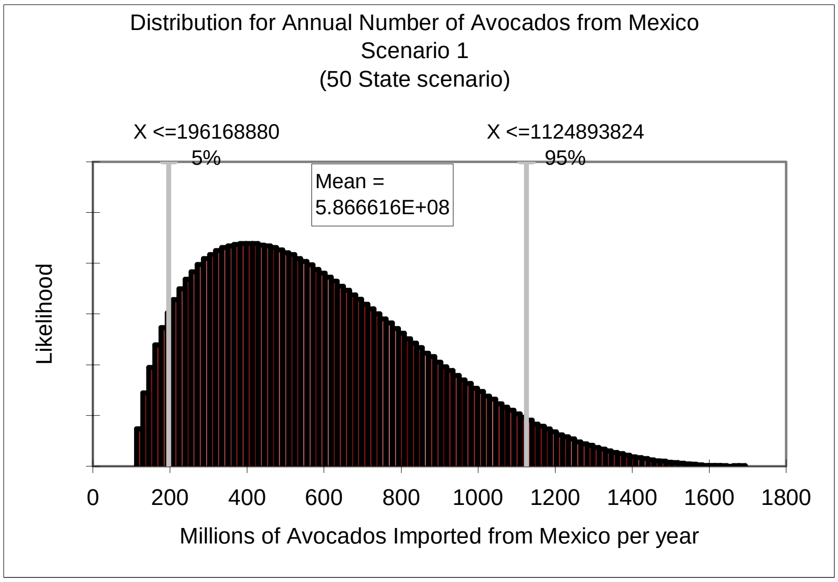
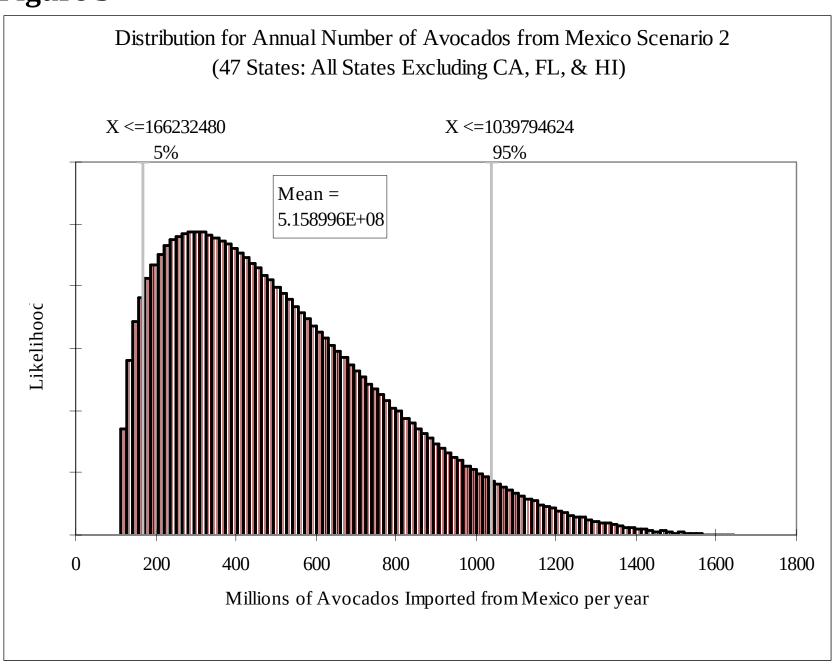


Figure 3



P1 – Proportion of Avocados Infested

Three sources of data relevant to the proportion of avocados infested were identified. First, six years of fruit cutting data for avocados imported to the United States were compiled by APHIS (Table 4). Second, Japan compiled data on avocado inspections for importation from 1992-1994 (Federal Register 60 no. 127: 34835. 1995.) as reported below. Finally, data from foliage surveys for pests in Michoacán orchards and wild and backyard tree surveys in Michoacán municipalities between 1997 and 2002 were available (Table 5a and 5b). Only the first source (U.S. fruit cutting data) is used to estimate the proportion of avocados infested. The other two data sources are not used in the quantitative estimation but the results of all three data sources are consistent. The three data sets are presented and discussed below.

Mexican and APHIS Fruit cutting data

Mexican and APHIS officials inspected more than ten million avocados over the past six years and found zero infested avocados (APHIS, 2001a, b; Table 4). The *Work Plan for the Exportation of 'Hass' Avocados from Mexico to the United States of America* (USDA, 2001b - Appendix E) details the procedures for avocado inspections. The inspectors cut the fruit, including the seed, into multiple thin slices that are visually examined for fruit flies, seed pests, and stem weevils. Fruits are inspected in the orchards during surveys, at harvest, in the packinghouses in Mexico, and on arrival in the United States. A level of sampling is done at the packinghouse on field trucks that is equivalent to sampling 300 fruit per shipment departing the packinghouse. DHS inspectors examine one avocado from each of 30 boxes on each truck arriving at ports of entry.

Table 4. Fruit sampled and cut for seed weevils, stem weevil, seed moth, and fruit flies*

Season	Orchard, Backyard, and Wild Tree	Packing house	Border Inspection	Row Total	Quarantine Pests
1997/1998	1,155,305	417,900	10,410	1,583,615	None
1998/1999	1,121,471	203,250	16,860	1,341,581	None
1999/2000	952,423	166,650	20,070	1,139,143	None
2000/2001	1,209,814	172,800	17,280	1,399,894	None
2001/2002	1,616,456	347,475	41,250	2,005,181	None
2002/2003	2,749,876	141,558	11,880	2,903,314	None
Subtotal	8,805,345	1,449,633	117,750	**10,372,728**	None

*Source: Federal Register Vol. 66, No. 135, p 36896-7 and Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentacion, Mexico. The table was updated with information from the 2001/2002 and 2002/2003 shipping seasons (APHIS, 2003b).

Earlier fruit cutting data from Mexico is consistent with these findings. From July 1992 to May 1994, Martinez *et al.* (1993) sampled and cut 153,500 kg of fruit (618,975 fruits) from packinghouses representing 257 orchards and four municipalities (Uruapan, Salvador Escalante, Tancitaro and Periban); no fruit flies were reported. A report from Enkerlin *et al.* (1994 unpublished) states that 2,300 kg of fruit was cut (12,683 fruits) from an orchard in Uruapan from November 1993 to April 1994, and again no fruit flies were found.

Gould (1995) reported that the sensitivity of detection of fruit infested with third instar Caribbean fruit fly larvae ranged between 17.9% for green guavas to 83.5% for carambolas by experienced inspectors. The study did not include avocado. The estimate for sensitivity is represented in the model by a uniform distribution ranging from 17.9% to 83.5%. All values within the range are considered equally likely.

The sensitivity of cutting and inspection procedure could vary somewhat among pathway pests. All of them can damage the fruit pulp when present in the fruit; however, the stem weevil (*Copturus aguacatae*) produces tunnels that are usually restricted to a small portion of the fruit close to the peduncle. Stem weevil larvae rarely migrate into the fruit, but when they do, they are usually localized to the area of the fruit near the peduncle (APHIS, 1997; Gudino Juarez and Garcia Guzman, 1990). Inspectors are specifically instructed and trained to examine the peduncle end of the fruit for stem weevil larvae (APHIS, 1997). Because of this training and because the location of stem weevil larvae is highly predictable and usually quite localized, APHIS has determined that the sensitivity of detection for stem weevils and other internal avocado pests could be reasonably considered to be intermediate along the range given above.

Japanese fruit cutting data

From 1992 to 1994 Mexico shipped 5,230,114 kg of 'Hass' avocados to Japan (about 14 million fruit). Japanese agricultural officials inspected 16,000 kg (or about 50,000 fruit); no target pests of concern to the US were reported, which is consistent with the results from the other two sources (Federal Register 60 no. 127: 34835. 1995).

Foliage survey data

Data from orchard surveys conducted by Mexico and APHIS is indirect evidence of the proportion of avocados infested (Tables 5a and 5b).

Table 5a - Foliage Surveys in Avocado Orchards in Michoacán, Mexico (In orchards that applied for inclusion in the export program)

		Number of Orchards Positive				
Year	**Number of Orchards**	**Stem Weevil *Copturus aguacatae***	**Seed Weevil *Heilipus lauri***	**Seed Moth *Stenoma catenifer***	**Seed Weevil *Conotrachelus aguacatae***	**Seed Weevil *Conotrachelus perseae***
1997	61	0	0	0	0	0
1998	244	0	0	0	0	0
1999	500	3	0	0	0	0
2000	790	0	0	0	0	0
2001	996	1	0	0	0	0
2002	1,469	3	0	0	0	0
Total	**4,060**	**7**	**0**	**0**	**0**	**0**

Table 5b – Wild and Backyard Tree Surveys in Michoacán, Mexico

Year	No. of backyards	No. of wild trees surveyed	Number of Sites Positive				
			Stem Weevil *Copturus aguacatae*	Seed Weevil *Heilipus lauri*	Seed Moth *Stenoma catenifer*	Seed Weevil *Conotrachelus aguacatae*	Seed Weevil *Conotrachelus perseae*
1997	42	200	0	0	0	0	0
1998	82	107	19	0	0	0	0
1999	39	379	37	0	0	0	0
2000	54	270	25	0	0	0	0
2001	54	191	24	0	0	0	0
2002	398	782	141	0	0	0	0
Total	**669**	**1,929**	**246**	**0**	**0**	**0**	**0**

Source - APHIS International Services. – NAR, 2003- Uruapan, Michoacán.

The current avocado rule requires annual surveillance of municipalities approved to export avocados to the United States for four pathway pests (*H. lauri*, *S. catenifer*, *C. aguacatae*, and *C. perseae*). These four pests, controlled at the level of the municipality, were never found in the six annual surveys of the municipalities in Michoacán (Table 5a and 5b). *Copturus aguacatae* was frequently found in orchards and other sites during surveys in Michoacán (Table 5a and 5b); however, this pest was rarely found in surveys of orchards registered to export to the United States, and never found in dissected fruit for export. In annual inspections, seven orchards were positive over six years. Data from surveys of municipalities and orchards were not used in estimating P1 (the proportion of fruit infested) because the data is an indirect measure of fruit infestation prevalence; however, orchard infestation is a necessary prerequisite for fruit infestation. The orchard survey corroborates the fruit cutting results (Table 4). Additionally, although adult fruit flies (*Anastrepha* spp.) have been frequently trapped in all of the participating municipalities over the last six years (Aluja *et al*., 2004; APHIS, 2003a), no larvae have been reported in cut fruit (Table 4).

To determine the proportion of avocados infested, we used a binomial distribution based on the number of avocados inspected and the number found with pests (zero). The implicit assumptions are that: (a) avocados are either infested or not infested; (b) every avocado has an equal probability of being infested; and (c) sampling of avocados is random. In reality, infested avocados are probably clustered because fruit from an infested orchard would likely be together in a shipment. Also, sampling in orchards is not random because fallen avocados are targeted for inspection. These potential biases are acknowledged; however, they increase the likelihood of pest detection.

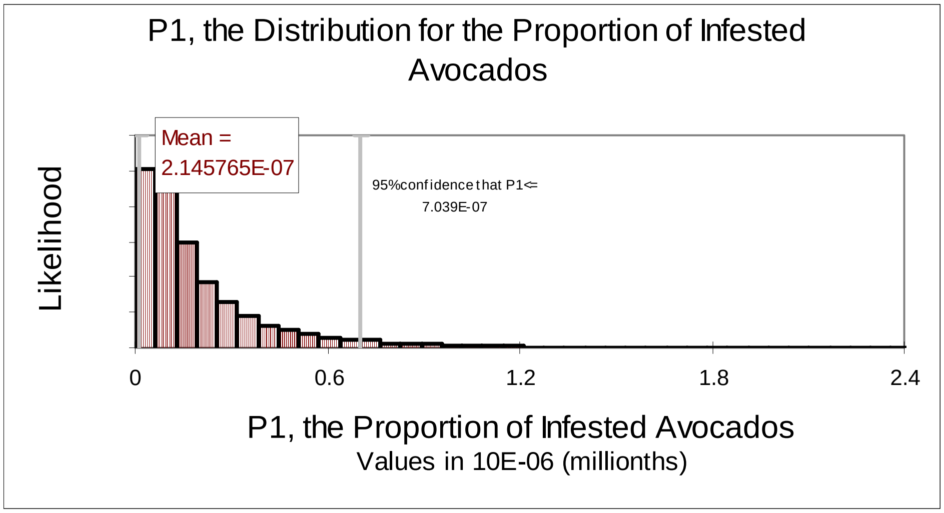


Figure 4 - Probability Distribution for P1, The Proportion of Infested Avocados

Figure 4 is a graph of the proportion of infested ‘Hass’ avocados imported annually. The most likely value of the distribution is zero; the 95% confidence interval ranges from 0 to 7.0×10^{-7} (Table 7 and Figure 4) (For details, see Appendix D).

Of the three sources of data discussed (*i.e.*, surveys, Japanese inspection results, and Mexico-APHIS fruit cutting results), only the Mexico-APHIS fruit cutting data were used to determine the proportion of avocados infested. The foliage survey data and Japanese fruit cutting data support the conclusion that the most likely level of infestation is zero.

The fruit cutting data used in this analysis was collected annually between August and April. However, studies during other months have also not detected pests in avocados. Many thousands of fruit were inspected for fruit flies over summer seasons (Aluja *et al.* 2004; Enkerlin *et al*, 1994 unpub; Martinez *et al*, 1993) with negative results. Because populations of pests occur during all times of the year, sampling at any time of year could detect pests if they are present. Under the modified systems approach, surveying will be expanded to semiannual to cover year-round harvesting and fruit cutting at the border and packinghouse will be conducted year-round. Fruit cutting rates will remain constant year-round and at a sufficiently high level to detect pests if they are present at any time of year.

Q1 – Annual number of infested avocados reaching the United States

The estimate for the annual number of infested avocados that reach the United States (Q1) is the product of the number of avocados imported (N) and the proportion infested (P1) or $Q1 = N \times P1$ (Fig. 5&6). This estimate includes avocados reaching all areas, not just locations where suitable hosts occur.

Figure 5

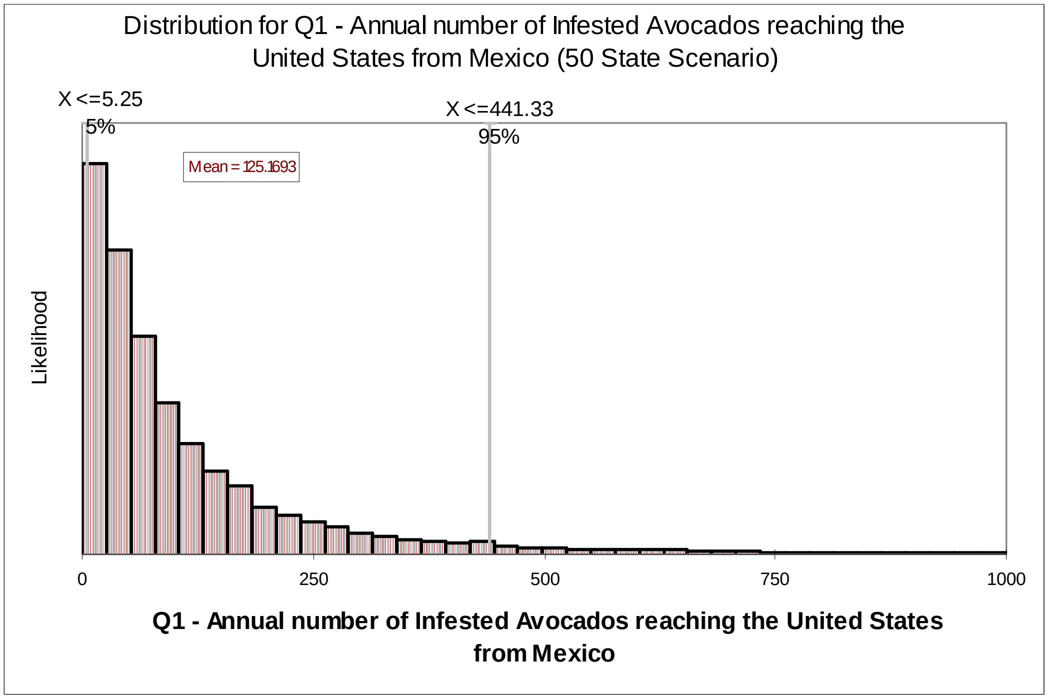
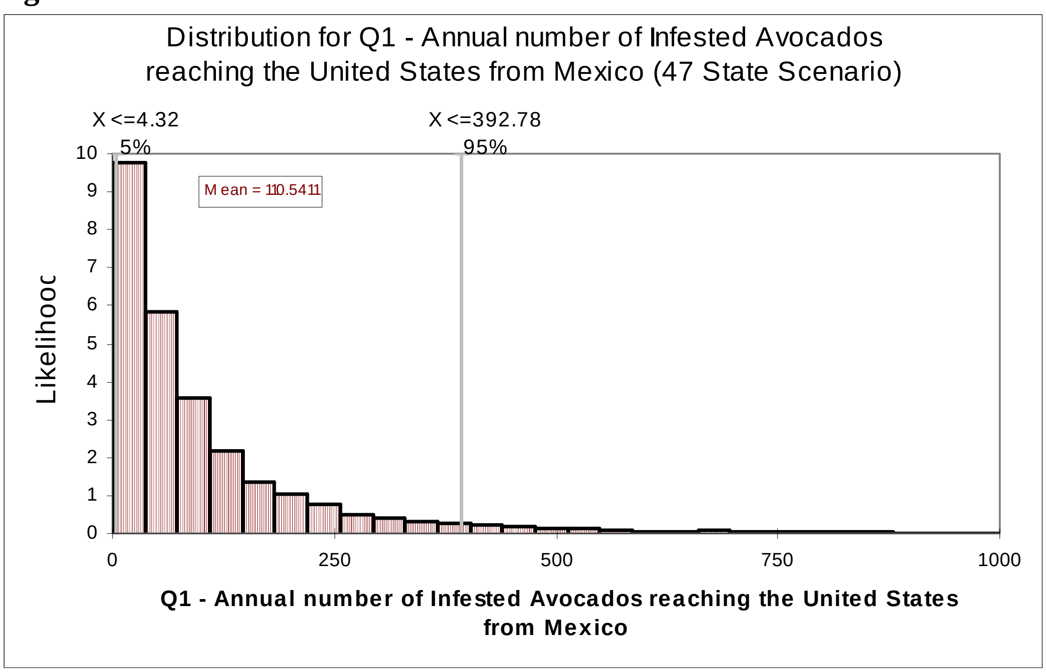


Figure 6



Monte Carlo simulation of the model using @Risk (Palisade Corporation, Newfield, New York) and Excel (Microsoft Corporation, Redmond, Washington) resulted in a distribution for Q1 (Figures 5 and 6). In the 50 state scenario the most likely value for Q1 is zero; the distribution indicates 95% confidence that the annual number of infested avocados entering the United States is less than 442 avocados (Figure 5, Table 7). In the 47 state scenario the most likely value for Q1 is also zero; the 95% confidence is less than 393 (Figure 6, Table 7).

<u>P2 – Proportion of fruit that will enter susceptible areas in the United States~~.~~</u>

Because the areas of the U.S. with susceptible hosts are different for fruit flies than for the obligate avocado pests, separate determinations of P2 were made for these two groups of pests. P2 was determined as follows:

Fruit flies
The fruit fly susceptible area is all of plant hardiness zones 8-11 in the U.S (Appendix G). Hardiness zones 8-11 includes all or portions of California, Oregon, Washington, Arizona, Florida, Louisiana, Nevada, Texas, Louisiana, Mississippi, Arkansas, Alabama, Georgia, North Carolina, South Carolina, Virginia, and Hawaii. The proportion of avocados entering fruit fly susceptible areas, P2a, is calculated at 53.7% for the 50-state scenario and 24.8% for the 47-state scenario. For calculations, see Appendix D.

Other pathway pests
Avocados are the only host in the United States for five pathway pests (*Copturus aguacatae, Conotrachelas aguacatae, Conotrachelas perseae, Heilipus lauri*, and *Stenoma catenifer*). The geographic area in the United States susceptible to the multiplication and establishment of these pests is limited to the region in and around avocado trees.

P2 for these pests is based on the land area of the U.S. allocated to avocado production, the human population within that area, and the per capita consumption of avocados. Because P2 is uncertain, a distribution with minimum, most likely, and maximum values was used. P2 was determined as follows (for additional details, see Appendix D):

The minimum susceptible area is the total area of commercial avocado orchards in the U.S. For each avocado growing area in the U.S., the number of avocado farms was multiplied by the area of each avocado farm (assumed to be 0.0314 square miles or 0.1 mile in radius). The product (square miles in avocados) was divided by the square miles in the county to determine the proportion of the county in avocados.

The most likely susceptible area is the total area of commercial avocado orchards in the United States, plus a one-mile buffer zone around each orchard. This parameter was calculated in the same manner as the minimum susceptible area except for the inclusion of a one mile buffer zone for each avocado farm. The area of each avocado farm is assumed to be 3.8 square miles (1.1 mile radius for each farm).

The maximum susceptible area is all counties in plant hardiness zones 9-11. It is possible for avocados to grow in this region, even though the actual growing area is substantially less.

The number of avocados consumed in the susceptible area is calculated from the population multiplied by the per capita avocado consumption in the area. The proportion of all avocados consumed in susceptible areas in Table 6 is calculated from the number of avocados consumed in susceptible areas divided by the number of avocados consumed in the United States.

Table 6. Avocados consumed in susceptible areas

	50 State scenario		47 State scenario*	
	Number consumed	**Proportion**	**Number consumed**	**Proportion**
Minimum	426,804	0.0006	666	0.000001
Most-likely	51,636,258	0.073	79,852	0.000113
Maximum	264,098,978	0.375	65,029,989	0.092

The proportion of is avocados consumed in susceptible areas divided by all avocados consumed in the U.S. (703,906,532)
* The 47 state scenario excludes California, Hawaii, and Florida.

The primary source of uncertainty in the estimate of P2 is the area within the United States that is susceptible to the establishment of avocado pests. Backyard and ornamental avocado trees contribute to the susceptible area, but their numbers and locations are unknown. Because of the lack of information on backyard and ornamental avocado trees, we assumed the maximum susceptible area includes all of plant hardiness zones 9-11.

Two assumptions were made in the estimation of P2. We assumed people are evenly distributed throughout the county and that imported avocados are evenly distributed within regions according to the regional per capita consumption rate. These assumptions probably resulted in over-estimation of P2 because of cities located in some of the areas. More Mexican avocados will probably be sent to areas of the country without domestic production, which would reduce the true value of P2 relative to the estimated range.

<u>Q2 – Annual number of infested avocados that enter susceptible regions of the United States</u>

Q2 is a product of the number of avocados imported (N), the proportion infested (P1), and the proportion of susceptible counties in the United States (P2) or Q2 = N × P1 × P2.

Monte Carlo simulation using @Risk® resulted in distributions for Q2 (Figure 7-10).

Figure 7

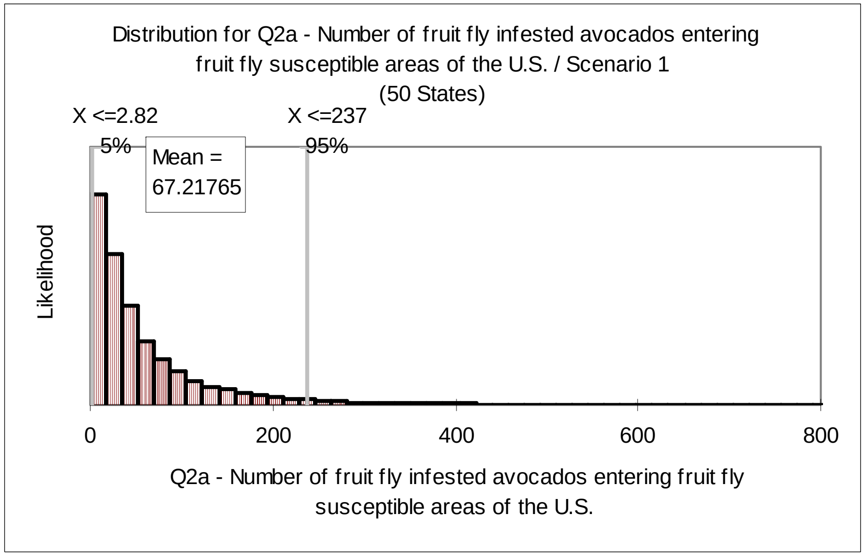


Figure 8

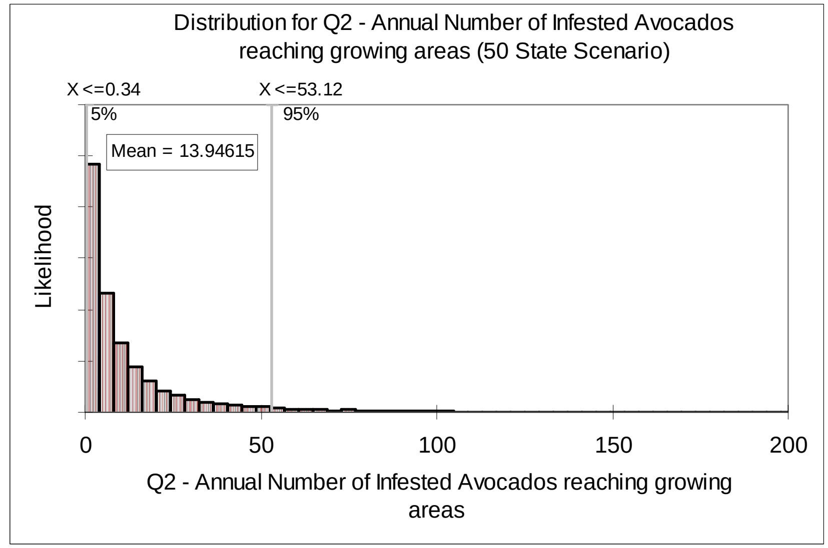


Figure 9

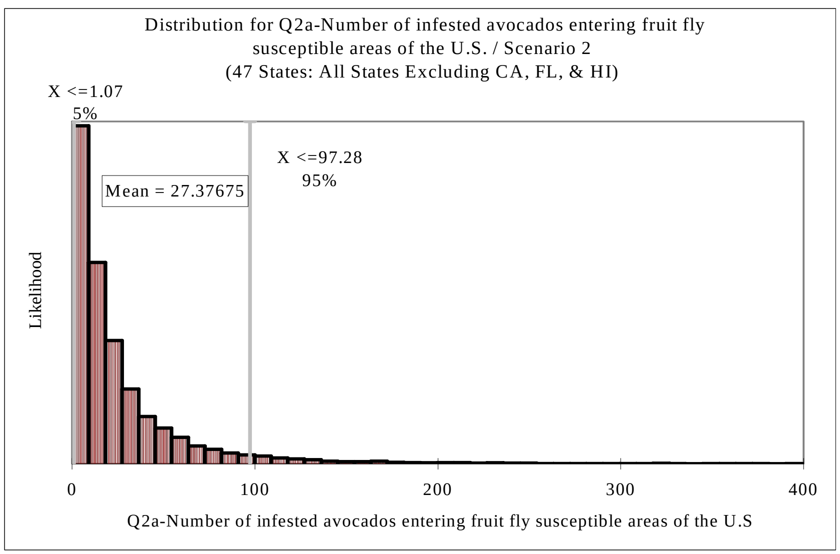
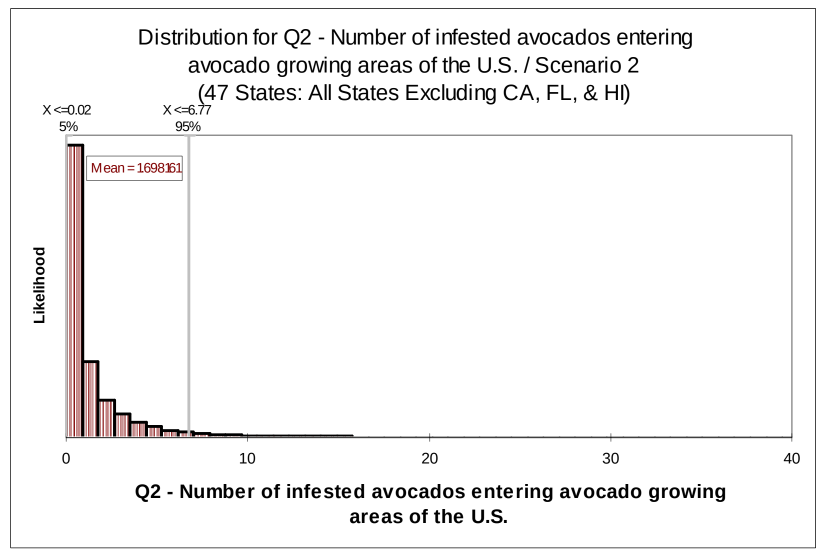


Figure 10



The 50 state scenario gives a 95% confidence that:

- No more than 238 fruit fly infested fruit will enter hardiness zone 8-11 each year (Fig 7),
- No more than 54 fruit infested with seed weevils, (*Conotrachelus aguacatae, C. perseae*, *H. lauri*) stem weevils, (*C. aguacatae*) or seed moths (*S. catenifer*) will enter avocado growing areas in the United States each year (Fig. 8).

The 47 state scenario gives a 95% confidence that:

- No more than 98 fruit fly infested fruit will enter hardiness zone 8-11 each year (Fig. 9).
- No more than 7 fruit infested with seed weevils, (*Conotrachelus aguacatae*, *C. perseae*, *H. lauri*) stem weevils, (*C. aguacatae*) or seed moths (*S. catenifer*) will enter avocado growing areas in the United States each year (Fig. 10).

<u>P3—Proportion of fruit discarded</u>.
P3 is the proportion of infested avocados that are discarded in susceptible areas. Most fruit is eaten by consumers, discarded into landfills, incinerated, or disposed of in such a way that there would be a low likelihood of any pest establishment. We based our estimate of P3 on information from two risk analyses: 1) Suburban New Zealand (5%; Wearing *et al.*, 2001) related to how much cherry fruit with codling moth might be discarded. 2) Urban Japan (0.5%; Roberts *et al.*, 1998) related to how much apple fruit with fire blight might be discarded. No studies are known for the United States. For simplicity, we used a point estimate and, in an abundance of caution, chose the higher of the two reported numbers (5%). The use of the maximum value ensures that we do not underestimate risk.

<u>Q3 – Annual number of infested avocados discarded in susceptible regions of the United States</u>

Q3 is the product of the number of avocados imported (N), the proportion infested (P1), the proportion of susceptible counties in the United States (P2), and the proportion of avocados discarded (P3) or Q3 = N × P1 × P2 × P3.

Monte Carlo simulation using @Risk® generated distributions for Q3 (Figure 11-14). In the 50 state scenario the model gives a 95% confidence that:

- No more than 12 fruit fly infested fruit will be discarded in hardiness zone 8-11 each year (Fig. 11).
- No more than 3 fruit infested with seed weevils, (*Conotrachelus aguacatae, C. perseae, H. lauri*) stem weevils, (*C. aguacatae*) or seed moths (*S. catenifer*) will be discarded in avocado growing areas in the US each year (Fig. 12).

In the 47 state scenario the model gives a 95% confidence that:

- No more than 5 fruit fly infested fruit will be discarded in hardiness zones 8-

11 (Fig. 13).

- No more than 1 fruit infested with seed weevils, (*Conotrachelus aguacatae, C. perseae, H. lauri*) stem weevils, (*C. aguacatae*) or seed moths (*S. catenifer*) will be discarded in avocado growing areas in the US each year (Fig. 14).

Table 7 - The 95% Confidence Level for Results of the Pathway Model

	Description of Parameter	50 State Scenario	47 State Scenario
P1	Proportion of Mexican avocados that are infested with a pathway arthropod pest	70/100,000,000	70/100,000,000
P2	Proportion of fruit that enters avocado growing areas	0.232	0.042
P2a	Proportion of fruit that enters fruit fly susceptible areas	0.537	0.248
P3	Proportion of infested avocados that are discarded	5%	5%
Q1	Annual number of infested avocados that enter the United States	442	393
Q2	Number of avocado pest infested avocados entering avocado growing areas of the U.S.	54	7
Q2a	Number of fruit fly infested avocados entering fruit fly susceptible areas of the U.S.	238	98
Q3	Number of arthropod pest infested avocados discarded in avocado growing areas of the U.S.	3	1
Q3a	Number of fruit fly infested avocados discarded in fruit fly susceptible areas of the U.S.	12	5

The numbers in this table may not agree with those in Appendix D. The numbers of infested avocados reported in this table were rounded up to the next whole integer.

The results of the quantitative analysis (summarized in Table 7) were used to determine the likelihood of entry. They express the likelihood of an infested avocado being discarded in a suitable location. There is an overall low likelihood of pest entry.

Even if some infested avocados entered the country, the likelihood of pest establishment and spread would require that: a) the infested avocados must be in close proximity to host material, b) the pests must find mates, c) the pests must successfully avoid predation, d) the adult pests must find host material, and e) the climatological and microenvironmental conditions must be suitable. These factors substantially reduce the likelihood of establishment. People generally consume the fruit they purchase and dispose of the waste material in a manner (such as in plastic bags that are landfilled or incinerated) that precludes the release of pests into the environment. The likelihood of establishment is substantially reduced by the above factors. It has been estimated that only 10% of exotic insect species introduced actually become established and that plant pests entering in small numbers, such as those above, are vulnerable to demographic, environmental, and other factors that drive their small populations to extinction (National Academy of Sciences, 2002). Although information that would allow quantifying these factors for the avocado pests of concern is not currently available, APHIS concludes that collectively they result in a low likelihood of pest establishment.

Figure 11

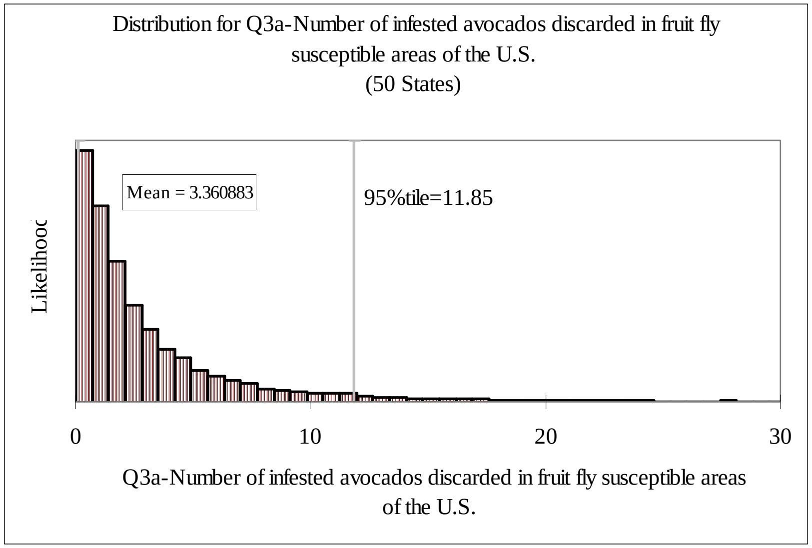


Figure 12

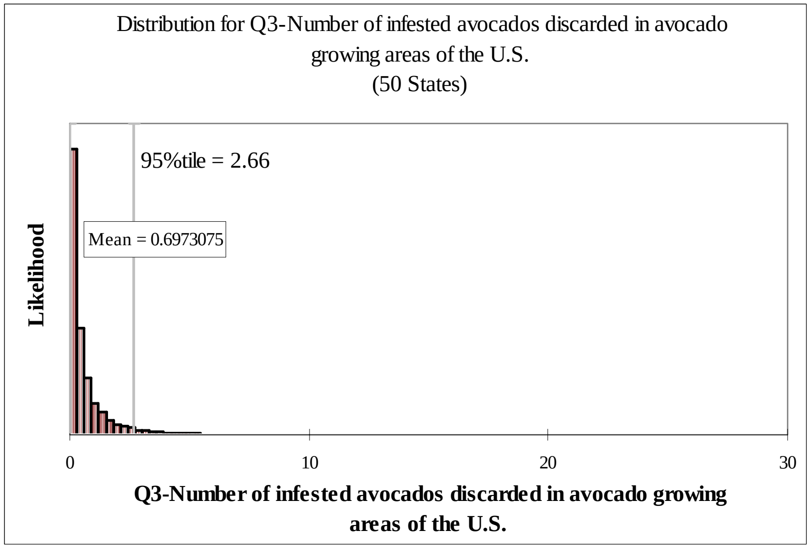


Figure 13

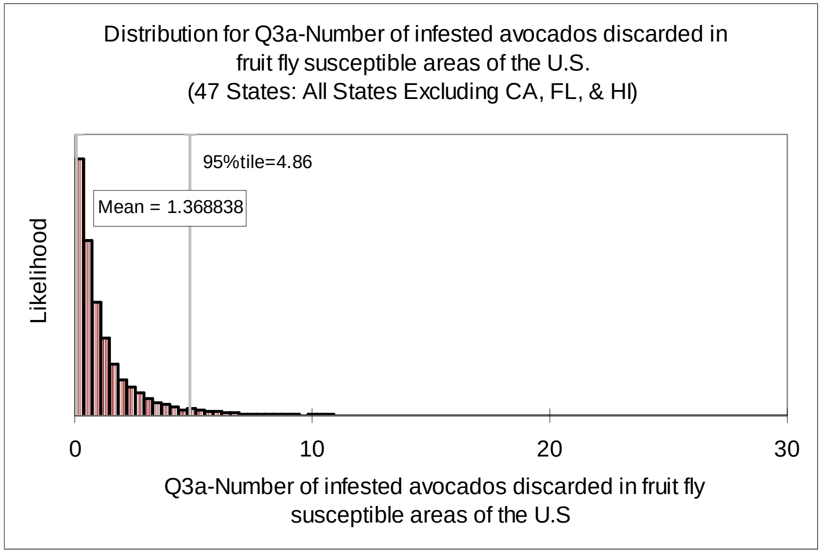
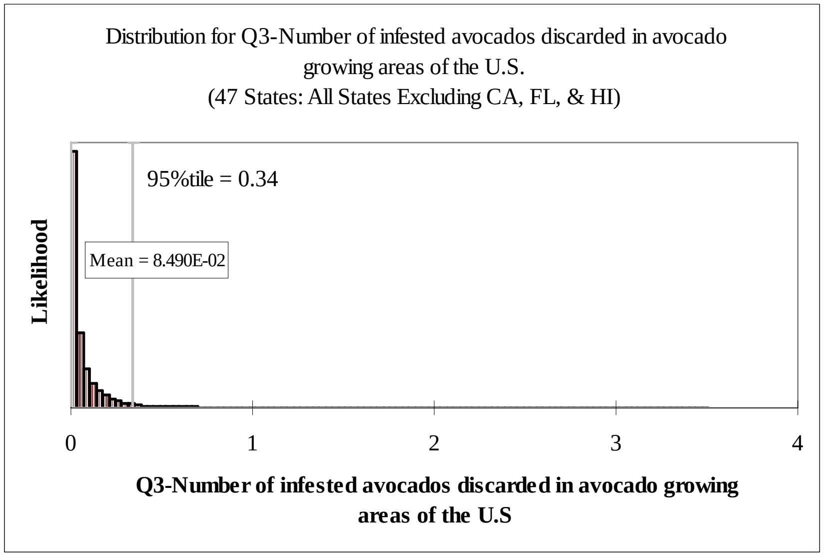


Figure 14



Estimates of Consequences of Introduction

We rated the potential consequences for each pest with respect to five different elements that follow current APHIS (2000) guidelines for commodity risk assessment. The ranking considers pest potential in the absence of specific risk mitigation activities. They were ranked for both the 47 and 50 state scenario. Criteria for estimating consequences were qualitative. Numerical values (high (3 points), medium (2 points), or low (1 point)) were assigned to each element to assist in categorization. The sum of the five individual ratings provided an estimate of the potential consequences for each pest.

APHIS estimated consequences of introduction for each of the pest categories listed in the previous section as candidates for further analysis. Low impact pests have values of 5-8, medium impact pests have values of 9-12, and high impact pests have values of 13-15.

Risk Element 1: Climate/Host Interaction

When a pest is introduced to a new area it can be expected to behave as it does in its native area if host plants are available and climatic conditions are similar. The evaluation considers ecological zones and the interaction between the geographic distribution of the pest and the host. For this element, risk values are based on the availability of both host material and suitable climate conditions. To rate this risk element, we use the United States Plant Hardiness Zones (Cathey, 1990). Risk values are assigned according to the following: the availability of suitable host plants and suitable climate and the pest's potential to establish a breeding colony:

High (3): In four or more plant hardiness zones.
Medium (2): In two or three plant hardiness zones.
Low (1): In only a single plant hardiness zone.

Risk Element 2: Host range

The risk posed by a plant pest depends on its ability to establish a viable reproductive population and its potential for causing plant damage. We assumed risk is correlated positively with host range. For pathogens, risk is more complex and depends on host range, aggressiveness, virulence and pathogenicity. APHIS rated risk primarily as a function of host range:

High (3): Pest attacks multiple species within multiple plant families.
Medium (2): Pest attacks multiple species within a single plant family.
Low (1): Pest attacks a single species|multiple

Risk Element 3: Dispersal Potential

A pest may disperse after establishment in a new area. Consider the following:

- reproductive patterns in the pest (*e.g.*, voltinism, reproductive output)
- innate dispersal capability of the pest
- natural factors (*e.g.*, wind, water, presence of vectors) facilitate dispersal.

High (3): Pest has high reproductive potential (*e.g.*, multiple generations or cohorts per year, many offspring per reproductive event, high capacity of a population for increase), *AND* individuals are highly mobile (*i.e.*, capable of moving long distances,over 10 km/year, either under their own power, or by being moved by natural forces such as wind, water or vectors).

Medium (2): Pest has either high reproductive potential *OR* the species is mobile.

Low (1): Neither high reproductive potential nor highly mobile.

Risk Element 4: Economic Impact

Introduced pests are capable of causing a variety of economic impacts. We divide these impacts into three categories: 1. Lower yield of the host crop (*e.g.*, by causing plant mortality, or by acting as a disease vector); 2. Lower value of the commodity (*e.g.*, by increasing costs of production, lowering market price, or a combination); 3. Loss of markets (foreign or domestic).

High (3): Pest causes all three types of impacts.

Medium (2): Pest causes any two of the above impacts.

Low (1): Pest causes any one of the above impacts.

Risk Element 5: Environmental Impact

The analysis considered the following four elements:

1. Establishment of the pest is expected to cause significant, direct environmental impacts (*e.g.*, ecological disruptions, reduced biodiversity).
2. Pest is expected to have direct impacts on the species listed by Federal or State agencies as endangered, threatened, or a candidate. An example of a direct impact would be feeding on a listed plant. If feeding trials with the pest have not been conducted on the listed organism (no direct negative data), a pest will be expected to feed on the plant if it feeds on other species within the genus or other genera within the family.
3. Pest is expected to have indirect impacts on the species listed by Federal or State agencies as endangered, threatened, or candidate species (*e.g.*, by disrupting sensitive, critical habitat).
4. Establishment of the pest would stimulate control programs consisting of toxic chemical pesticides, or release of non-indigenous biological control agents.

High (3): Two or more of the above.

Medium (2) One of the above.

Low (1): None of the above (it is assumed that establishment of a non-indigenous pest will usually have an environmental impact).

Seed weevils (*Conotrachelas aguacatae, C. perseae, Heilipus lauri*)

Climate/host interaction—Seed weevils infest avocado only (CPC, 2001), which has tropical or subtropical distribution in hardiness zones 9-11 in Central America (Whitehead, 1979a). Avocado has the same climatic distribution in California, Florida and Hawaii (NASS, 1997). There are some non-commercial avocado trees in southern Texas. This factor is rated medium (2) for both the 50 and 47 state scenario..

Host range—Seed weevil species infest only avocado (this includes all varieties) (CPC, 2001), thus the rating is low (1) for both the 47 and 50 state scenario.

Dispersal potential— Seed weevils have long life cycles (60-180 days), 2-3 generations per year, and adults are long-lived (about 90-120 days). Females of *Conotrachelus* spp. can lay up to 70 eggs and *H. lauri* may lay up to 144 eggs. Immature stages may remain up to 90 days in fruit. Adults are sedentary and tend to remain in the foliage of the host tree, but are capable of flying between orchards (CPC, 2001; Garcia e*t al.*, 1998; Teliz, 2000; Wysoki *et al.*, 2002). Larvae are internal and can be transported worldwide by human. Because of their sedentary nature, APHIS considered seed weevils to have a low rating; however, their long life span increases the likelihood of assisted movement and, therefore, they are given a final ranking of high (3) for this factor for both the 47 and 50 state scenario.

Economic impact—Seed weevils can cause up to 80% yield loss in the export area (Garcia, *et al.*, 1998; Wysoki *et al.*, 2002). A yield loss of 20% is expected if the pest has an outbreak in the PRA area, after which the annual production costs could increase by 41%, avocado yields could decrease by 20% (due to limited effectiveness of aerial treatments), and estimated social losses could total $123.6 million per year (Evangelou, *et al.*, 1993). Spray programs for adults are required if they are detected by surveys (Teliz, 2000). The species are regulated pests (APHIS, 2002) and are likely to trigger quarantines of exported avocados from the United States to other countries. This justified a rating of high (3) under the 50 state scenario and low (1) under the 47 state scenario.

Environmental impact— Seed weevils infest only avocado. (There are no associations with endangered or threatened species.) Spray programs could commence in commercial avocado-growing areas if an outbreak occurs (Evangelou, *et al.*, 1993). Increased sprays from eradication programs could increase impacts on endangered or threatened species beyond those impacts already caused by existing agriculture. This factor was thus rated as medium (2) under the 50 state scenario and low (1) under the 47 state scenario.

The overall cumulative risk rating for the consequences of introduction for seed weevils was considered medium (11) under the 50 state scenario or low (8) under the 47 state scenario. Generally, medium risk reflects evidence that the three species are monophagous and would, at most, be narrowly distributed with one host in the PRA area, if they should become introduced and established.

Stem weevil

Climate/host interaction. The stem weevil infests only avocado, which has tropical or subtropical distribution in hardiness zones 9-11 in Mexico (Velez, 1959). Avocados have the same climatic distribution in the United States. This factor is rated medium (2).

Host range—Avocado (including all varieties) is the only host for the stem weevil (Velez, 1959). This factor was rated low (1).

Dispersal potential—The life cycle of the stem weevil is long (>150 days) with a protracted larval stage (>115 days), which, in turn, limits the number of 1-2 generations annually (Teliz, 2000). Females only lay up to eight eggs (Velez, 1959). Stem weevil larvae rarely migrate into the fruit, but when they do, they are usually localized to the area of the fruit near the peduncle (APHIS, 1997; Gudino Juarez and Garcia Guzman, 1990). Adults are capable of short flights, but typically remain in foliage (Garcia, *et al.*, 1998) within an orchard. Larvae are internal and the main method of spread is by human activity. Because of their sedentary nature, we considered the stem weevil to have a low rating. Their long life span increases the likelihood of movement and that was the reasoning for a ranking of medium (2).

Economic impact—Sprays are recommended in the export country when the stem weevil is detected (Teliz, 2000). A yield loss of 20% is expected if the pest has an outbreak in the PRA area, annual production costs could increase by 41%, avocado yields could decrease by 20% (due to limited effectiveness of aerial treatments), and estimated social losses could total $123.6 million per year (Evangelou, *et al.*, 1993). The species is a regulated pest (APHIS, 2002) and is likely to trigger quarantines of avocados exported from the US to other countries. This justified a rating of high (3) under the 50 state scenario and low (1) under the 47 state scenario.
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Environmental impact—Stem weevils infest only avocado and there are no associations with endangered or threatened species. Spray programs will commence in commercial avocado-growing areas of the PRA area if an outbreak should occur (Evangelou, *et al.*, 1993). Increased sprays from eradication programs could increase impacts on endangered or threatened species beyond those impacts already caused by existing agriculture. This factor was rated as medium (2) under the 50 state scenario and low (1) under the 47 state scenario..

The overall impact potential for stem weevils is medium (10) under the 50 state scenario or low (7) under the 47 state scenario.

Seed moth

Climate/host interaction— The seed moth infests avocado and related species, which have tropical or subtropical distribution in hardiness zones 9-11 in Central and South

America (Cervantes-Peredo, *et al.,* 1999). Avocados have the same climatic distribution in the United States (National Agric. Statistics Service, http://www.usda.gov/nass/). The seed moth may be able to infest *Persea borbonia* (L.) Spreng. (redbay) because avocados and redbay belong to the same genus.; however, redbay is not a reported host for the seed moth. Redbay occurs along the south Atlantic and Gulf coasts (USFS, 2002). The two hosts overlap in hardiness zones 7-9. This factor is rated medium (2).

<u>Host range</u>—The seed moth infests species in several genera of Lauraceae, including greenheart, *Chlorocardium rodiei* (Schomb.) Rohwer Richter & van der Werff (Cervantes-Peredo, *et al.*, 1999). All avocados, of all varieties, are the only known host in the United States for the seed moth. This factor was rated low (1).

<u>Dispersal potential</u>—The seed moth occurs widely over Mexico, but is limited there to avocados grown below 1,000 m in elevation and, apparently, does not occur in the export program area (Cervantes-Peredo, 2000; see Appendix B). Adults can fly and females have high reproductive potential; they can lay up to 240 eggs at one time (Jaramillo *et al.*, 1972). Up to three generations per year are recorded (Garcia, *et al.*, 1998). Because larvae are internal, worldwide spread by human is possible. This factor was rated high (3).

<u>Economic impact</u>—Fruits of all sizes are infested by seed moth. Fruits that are infested when small fall off the tree before reaching harvestable size (Cervantes-Peredo, 2000). Over 80% of avocados (not 'Hass' variety) in some Brazilian orchards were infested, and over 80% of those fell before reaching their harvestable size (Ventura, *et al.*, 1999). In field reports from South America, it was noted that 'Hass' avocados were not infested, but more than 54% of other avocado cultivars received damage (Arellano-Cruz, 1998). The seed moth is a regulated pest (APHIS, 2002) and it is likely that other countries would quarantine this pest if it were to become established. This factor was rated high (3) under the 50 state scenario and low (1) under the 47 state scenario..

<u>Environmental impact</u>—If an outbreak of the seed moth should occur in United States' avocado orchards, spray programs against adults, like those described for seed and stem weevils (Evangelou, *et al.*, 1993), would begin in commercial avocado growing areas. Increased spraying from eradication programs could increase the impact on endangered or threatened species. This factor was rated as medium (2) under the 50 state scenario and low (1) under the 47 state scenario..

Following the guidelines, the overall impact potential for the seed moth was considered medium (11) under the 50 state scenario and low (8) under the 47 state scenario.

Fruit flies (*Anastrepha ludens, A. striata, Ceratitis capitata*)
Avocados are not considered a reliably documented host for *Anastrepha serpentina, A. fraterculus* (Mexico populations) or *A. obliqua* (Norrbom, 2004). Only one record

exists, for Brazil, for *A. obliqua.* Three "females" were "recovered from host fruit" which was an unknown variety, and it is listed as a "first record" (Uramoto *et al.*, 2001). Because the paper is only an abstract, has not been peer-reviewed or published in a journal, reports only "preliminary" results, reports a previously undocumented host for the fly, reports only three recovered "females" (unspecified as to whether they were based on adult identifications) from an unspecified number of fruit, it is unspecified whether the fruits were from the tree or ground or ripe or immature, and no other records are listed in the comprehensive *Anastrepha* species host database of Norrbom (2004), APHIS is provisionally not listing 'Hass' avocados as a host of the species in the present pest list. In support of this, the 'Hass' avocado host studies by Aluja *et al.* (2004) did not record any infestation by *A. obliqua.* Consequences are the same for both the 50 and 47 state scenarios.

<u>Climate/host interaction</u>— These fruit flies infest many hosts over a range that includes tropical and subtropical areas. *Anastrepha striata* occurs from Mexico to Brazil and outbreaks have occurred in Texas and California; therefore, it may be expected to inhabit hardiness zones 8-11. *Anastrepha ludens* occurs from northern Mexico to Costa Rica, and outbreaks have occurred in Texas and California; therefore, it may be expected to occur over hardiness zones 8-11 (Foote et al., 1993; Sequeira *et al*., 2001). *Ceratitis capitata* occurs over southern Europe and throughout Central and South America (CPC, 2002), it is established in Hawaii, and outbreaks have occurred in Florida and California; therefore, it may be expected to inhabit hardiness zones 8-11 (APHIS, 1999; USDA, 2001a). This factor is rated high (3) for these species.

<u>Host range</u>—*Anastrepha striata* infests *Prunus persica, Persea, Eugenia, Mangifera, Passiflora, Diospyros, Manihot*, and other genera in multiple families. *Anastrepha ludens* infests *Prunus persica, Annona, Casimiroa, Citrus, Cydonia, Mammea, Mangifera, Persea, Psidium*, *Pyrus* and other genera representing over five families (Norrbom, 2004). *Ceratitis capitata* infests over 100 crop and non-crop species, including *Opuntia*, *Persea*, *Prunus*, *Malus*, *Capsicum*, and others in over 10 families (Liquido *et al*., 1998). This factor is rated high for all species (3).

<u>Dispersal potential</u>—All of these fruit flies have been documented to have continuous generations within their ranges, females live several months and are capable of laying over 100 eggs each. The fruit fly's life cycle is less than 45 days, under optimum conditions, capability to spread naturally by flight over 20 km per year, and capability to spread worldwide in commerce (CPC, 2002; Fletcher, 1989; Foote *et al*., 1993; Liquido *et al*., 1998; Norrbom, 2004; Sequeira *et al*., 2001; White and Elson-Harris, 1994). This factor is rated high for all species (3).

<u>Economic impact</u>—All of these species are regulated pests (APHIS, 2002); as a result, their establishment in the United States could trigger quarantines against exports. *Anastrepha striata* is the primary pest of guava in Venezuela, reducing both the yield and quality of fruit (Marin Acosta, 1973). *Anastrepha ludens* infestations in citrus could cause a decrease in yield and quality in the United States valued at $70 million (1975 prices) (Andrew *et al*, 1977; Erikson *et al.*, 2000). *Ceratitis capitata* infestation

may cause high yield and quality losses requiring up to $341 million in additional production costs if it should become established in California (CDFA, 2003). This factor is rated high for all species (3).

Environmental impact—If an outbreak was detected, all species would be expected to trigger APHIS eradication programs involving area-wide spray programs that could cause ecological destruction; these programs have been previously used Florida, Texas, and California (Sequeira et al., 2001). *Anastrepha striata* may infest the listed species of *Eugenia* and *Prunus*. *A. ludens* may infest the listed species of *Prunus*. *Ceratitis capitata* may infest listed species of *Opuntia* and *Prunus* (USFWS, 2002). This factor is rated high for all species (3).

Following the guidelines, the overall consequences potential for the fruit flies is high (15) under both the 50 and 47 state scenarios.

The scores for each of the elements, as related to the pest in question, are presented in Table 8. The potential consequences associated with each pest are estimated by adding together the values (one for each element).

Table 8 - Summary of potential consequences from quarantine pathway pests (50 state scenario)

Pest	Climate/Host Interaction	Host range	Dispersal Potential	Economic Impact	Environmental Impact	Total
Seed weevils	2 Medium	1 Low	3 High	3 High	2 Medium	11 Medium
Stem weevil	2 Medium	1 Low	2 Medium	3 High	2 Medium	10 Medium
Seed moth	2 Medium	1 Low	3 High	3 High	2 Medium	11 Medium
Fruit flies	3 High	3 High	3 High	3 High	3 High	15 High
(47 state scenario)						
Seed weevils	2 Medium	1 Low	3 High	1 Low	1 Low	8 Low
Stem weevil	2 Medium	1 Low	2 Medium	1 Low	1 Low	7 Low
Seed moth	2 Medium	1 Low	3 High	1 Low	1 low	8 Low
Fruit flies	3 High	3 High	3 High	3 High	3 High	15 High

Note: Descriptions of elements and assignment of values are explained in the text. This ranking did not consider specific mitigation practices (APHIS, 2000).

Discussion

A quantitative analysis, based on the fruit cutting data over the past six years and the number of fruit forecast to be exported to the United States was used to determine the expected number of infested 'Hass' avocados imported from the state of Michoacan and entering the U. S. Only those avocados discarded (other than in landfills or incinerated) in susceptible areas pose a risk of establishment of the pests in the United States. Avocados consumed, discarded into sanitary landfills, or incinerated are dead-end pathways and would not result in pests establishing viable populations in the U.S.

The additional steps leading to pest establishment are evaluated using qualitative evidence (Chapter "P3-Proportion of fruit discarded"); those steps including: a) the infested avocados must be in close proximity to host material, b) the pests must find mates, c) the pests must successfully avoid predation, d) the adult pests must find host material, and e) the climatological and microenvironmental conditions must be suitable. "Only an estimated 10% of all nonindigenous insect species that are introduced into a new range become established" and plant pests entering in small numbers are vulnerable to demographic, environmental, and other factors that drive them to extinction (National Academy of Sciences, 2002). Based on the above, APHIS concludes that there is a low likelihood of establishment

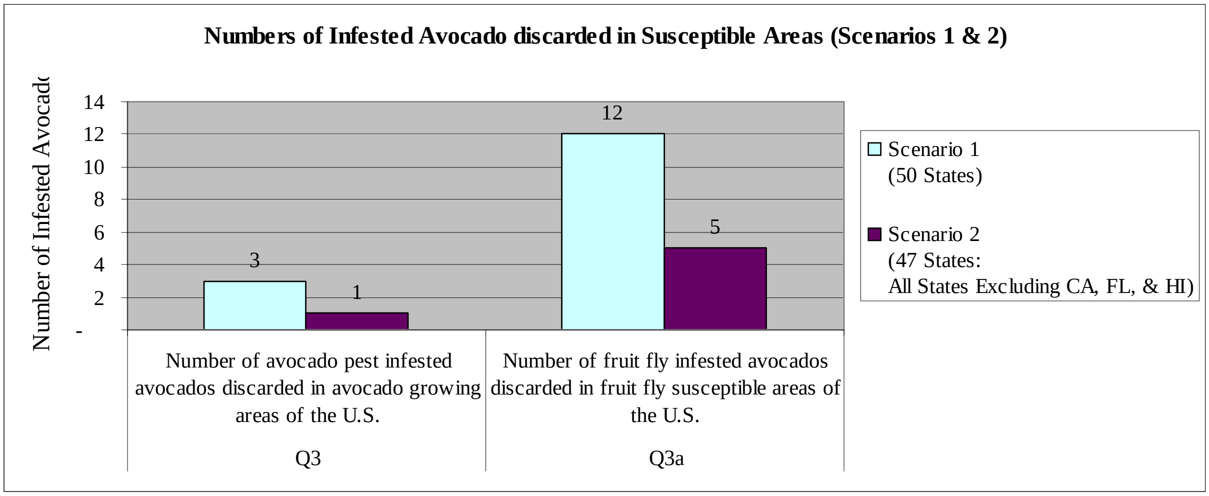
By considering both the low rate of entry and the low likelihood of establishment, APHIS concludes that there is a low likelihood of introduction.

The consequences of introduction, including economic and environmental, are also considered qualitatively (Chapter "Estimates of Consequences of Introduction"). APHIS (2000) guidelines were followed for this assessment.

By stating both the undesirable outcome and the probability that it will occur, APHIS has provided the information needed to determine the overall pest risk potential, or the likelihood that pests of concern will be introduced, become established, and cause significant negative consequences (Byrd and Cothern, 2000). Consideration of the likelihood of introduction and the consequences of introduction may be used to estimate the overall pest risk potential.

The number of Mexican avocados that will be discarded in susceptible areas in the United States is low whether the avocados are distributed in all 50 states or 47 (Figure 15). The number of fruit fly infested avocados discarded in susceptible areas under the 50 state scenario is 12; and 5 under the 47 state scenario. The number of arthropod pest infested avocados discarded in avocado growing areas of the U.S. under the 50 state scenario is 3; and 1 under the 47 state scenario. The difference of 7 for fruit flies and 2 for other arthropod pests is the number of infested avocados that would be excluded from California, Florida, and Hawaii assuming full compliance with the distribution requirement.

Figure 15



If an outbreak of a regulated quarantine pest occurs, APHIS may implement emergency domestic eradication programs as it has for fruit flies and other pests in the recent past. It is probable that the programs will involve pesticide applications. Pesticides appropriate for control of the particular pest and approved for emergency use by EPA will be used. The pesticides used would be those normally used to control pests in regular pest management systems in the United States.

The rate of avocado pests entering the United States from commercially imported ‘Hass’ avocados is far lower than the rate of pests arriving at U.S. ports of entry in prohibited avocados (‘Hass’ and other varieties) in cargo and passenger baggage. APHIS-PPQ data (APHIS, 2003c) indicate that pathway pests are routinely found in prohibited avocados intercepted in baggage and cargo at U.S. ports of entry. During the seventeen-year period from 1985 to 2002, an average of 30 avocados infested with pathway pests were intercepted and denied entry into the United States each year. Studies of port efficiency (Miller *et al*., 1996; Meissner *et al*., 2003) found that inspectors detect approximately 10-20% of what actually arrives. This suggests that an estimated average of 150 to 300 infested avocados are introduced each year through baggage and cargo. During the period 1985 to 2002, 502 pathway pests were detected in intercepted avocados (specific variety or cultivar not recorded) that were found in baggage and cargo: *Conotrachelus* sp.: 242; *Copturus* sp.: 5; *Heilipus* sp.: 38; *Stenoma* sp.: 217. During the same period, 24,283 tephritid larvae were intercepted at the Mexico border in all types of fruit, most of it from baggage (APHIS, 2004). Prohibited avocados in baggage and cargo clearly pose a substantially greater risk to U.S. agriculture than commercial imports of ‘Hass’ avocados from Mexico. To the extent that increased access to legal imports of, commercially produced avocados from Mexico could reduce the incentive for smuggling, such imports might in fact reduce the pest risk to the U.S.

In addition to the presence of fruit flies in prohibited baggage, *Anastrepha ludens* has been found in southern Texas for the past decade. Thousands of fruit flies are trapped yearly in this area and are currently under an eradication program (Texas Department of Agriculture, 2004; Dave Bartels, personal communication 2003); however, there has been no establishment of *A. ludens* beyond southern Texas to other growing regions in the United States. At this time (2004), *A. ludens* is still in southern Texas. This evidence suggests that spread of *A. ludens* to northern production areas is unlikely.

APHIS concluded that prohibited avocados in baggage and cargo pose a greater risk to United States agriculture than commercial imports of 'Hass' avocados from Mexico. The continued occurrence of *A. ludens* in southern Texas over the past ten or more years further supports the conclusion that background exposure is greater than that associated with commercial importation of 'Hass' avocados.

Conclusions

1. Avocados from Mexico are a potential pathway for the following quarantine pests: three fruit flies: *Anastrepha ludens*, *A. striata*, and *Ceratitis capitata*; three seed weevils: *Conotrachelus aguacatae, C. perseae*, and *Heilipus lauri*; one stem weevil: *Copturus aguacatae*; and one seed moth: *Stenoma catenifer.*

2. Repeated area surveys and inspections of orchards and processed fruit by Mexican and USDA-APHIS personnel for over six years have failed to find *Conotrachelus aguacatae, Heilipus lauri,* and *Stenoma catenifer* and *Conotrachelus perseae*. Over ten million fruit have been examined for pest larvae with negative results.

   The stem weevil, *Copturus aguacata*e, is known to exist in Michoacán. The pest was detected seven times in annual surveys of export-eligible orchards over six years. Those orchards were subsequently prohibited to export fruit. The pest was never found in exported fruit.

   Fruit fly adults are regularly trapped, and will continue to be monitored, in exporting orchards. The orchards are subject to mandatory controls and bait spraying when fruit flies are detected, but no larvae have been detected by fruit cutting. Experiments (Aluja *et al*., 2004) and ARS (2004, Appendix F) conclusions on fruit flies have led APHIS to conclude that *Anastrepha* spp. are of low likelihood to be in the pathway of entry and introduction in commercial 'Hass' avocado fruit. *Ceratitis capitata* is of low likelihood to be in the pathway because it is officially controlled in Mexico and does not occur in Michoacán.

3. The systems approach is effective. Six years experience, including the dissection of over ten million fruit, validates the effectiveness of the systems approach in preventing the introduction of Mexican avocado pests. The systems approach for avocado imports focuses on preventing infestation and detecting infection, if it occurs. The systems approach includes overlapping safeguards, such as surveys, orchard inspections, orchard treatments, certification, fruit inspection, and trace-back ability.

4. The number of avocados that have been inspected over the last six years allows estimation of the highest number of infested avocados that could be imported without detection with a high degree of precision. The 90% confidence interval of the proportion of infested avocados ranged from 0 to 7.0×10^{-7} [that is, from 0 to 70.0/100,000,000]. The above pertains to fruit flies, seed weevils, stem weevil, and seed moth.

In the 50 state plus the District of Columbia scenario:

- Less than 442 infested avocados will enter the entire United States each year, with 95% confidence.
- Less than 54 avocados infested with stem weevils, seed weevils or seed moths will enter avocado producing areas each year, with 95% confidence.
- Less than 238 avocados infested with fruit flies will enter fruit fly susceptible areas each year, with 95% confidence. .
- Less than 3 avocados infested with stem weevils, seed weevils or seed moths will be discarded in avocado producing areas each year, with 95% confidence.
- Less than 12 avocados infested with fruit flies will be discarded in fruit fly susceptible areas each year, with 95% confidence.
- There is an overall low likelihood of pest entry, based on the quantitative analysis.
- There is a low likelihood of pest establishment, based on a qualitative analysis.
- When low likelihood of pest establishment and low likelihood of pest entry are considered together, then the likelihood of introduction is low.
- The consequences of introduction are medium for stem weevils, seed weevils, or seed moths and high for fruit flies, based on a qualitative analysis.
- The overall pest risk potential may be derived from considering the low likelihood of introduction and medium to high consequences of introduction for the above pests.

In the 47 state scenario (excluding CA, FL, and HI):

- Less than 393 infested avocados will enter the 47 states each year, with 95% confidence.
- Less than 7 avocados infested with stem weevils, seed weevils or seed moths will enter avocado producing areas outside of California, Florida and Hawaii each year, with 95% confidence.
- Less than 98 avocados infested with fruit flies will enter fruit fly susceptible areas outside of California, Florida and Hawaii each year, with 95% confidence. .
- Less than 1 avocado infested with stem weevils, seed weevils or seed moths will be discarded in avocado producing areas outside of California, Florida, and Hawaii each year, with 95% confidence.

- Less than 5 avocados infested with fruit flies will be discarded in fruit fly susceptible areas outside of California, Florida, and Hawaii each year, with 95% confidence.
- There is an overall low likelihood of pest entry, based on the quantitative anlysis.
- There is a low likelihood of pest establishment, based on a qualitative analysis.
- When low likelihood of pest establishment and low likelihood of pest entry are considered together, then the likelihood of introduction is low.
- The consequences of introduction are low for stem weevils, seed weevils, or seed moths and high for fruit flies, based on a qualitative analysis.
- The overall pest risk potential may be derived by considering the low likelihood of introduction and low to high consequences of introduction for the above pests. It is lower than that for the 50 state scenario.

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Preparation, Consultation and Review

Agency Contacts:

Michael K. Hennessey
USDA-APHIS-PPQ
Center for Plant Health Science & Technology
Plant Epidemiology & Risk Analysis Laboratory
1730 Varsity Dr., Suite 300
Raleigh, North Carolina 27606-5202 USA
michael.k.hennessey@aphis.usda.gov
Telephone: (919)-855-7514

Authors

M. Hennessey, R. Sequeira, A. Hogue, D. Oryang, P. Evangelou, R. Fite, K. Bedigian (USDA-APHIS)

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M. Firko, T. Henry, N. Jones, T. Kalaris, J. Lightfield, C. Miller, L. Millar, S. Nakahara, D. Odermatt, J. Pakaluk, E. Podleckis, S. Redlin, and R. Stewart (USDA).

Internal Review~~:~~

H. Abuelnaga, K. Bedigian, W. Burnett, M. Dirani, L. Duffie, P. Gadh, R. Griffin, S. Hamm, L. Lewandowski, R. McDowell, C. Miller, S. Redlin (USDA-APHIS).

External Review

Numerous public and stakeholder comments on the May 2004 version of the PRA and the Proposed Rule were received from avocado growers, United States legislators, state extension scientists, consulting risk analysts, trade representatives, representatives of state departments of agriculture, scientists and government representatives from Mexico and other countries. APHIS responses to individual comments appear in the Final Rule and some responses were addressed in this PRA.

Appendix A – Pest List

Appendix A: Pest List

Table A-1: Pathogens.

Scientific Name [1] and Common Name	**Distribution [2]**	**Comment [3]**	**References**
Fungi			
Armillaria mellea (Vahl:Fr.) P. Kumm. Armillaria root rot	MX CA FL OT	a, c	Ploetz, *et al.*, 1994; CMI, 1980a
Ascochyta sp.	MX	b, y	APHIS, 2004
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. in Penz. Teleomorph: *Glomerella cingulata* (Stone.) Spauld. & H. Schrenk Anthracnose	MX CA FL HI TX OT	c, f	Ploetz, *et al.*, 1994
Diaporthe rudis (Fr:Fr) Nitschke Synonym: *Diaporthe medusaea* Nitschke Melanose	MX CA FL TX OT	c, f	Kranz, *et al.*, 1977
Ganoderma lucidum (Curtis:Fr) P. Karst. Wood rot	MX CA FL TX OT	a, f	Morales-Garcia, 1989; Farr, *et al.*, 1989; CMI, 1975
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. Stem-end rot	MX CA FL OT	c, f	Alfieri, *et al.*, 1984; CMI, 1976
Phoma sp.	MX	b, y	APHIS, 2004
Phomopsis sp.	MX	b, y	APHIS, 2004
Mycosphaerella perseae L.E. Miles Leaf spot	MX FL	a, f	Farr, *et al.*, 1989; Alfieri, *et al.*, 1984
Phyllachora gratissima Rehm. Tar spot	MX PR USVI	a, d	Cannon, 1996; Cook, 1975; Farr *et al.*, 2003; Garcia E. & Teliz Ortiz, 1984; Hodges, 1969, 2004; Lopez & Garcia, 1995; Menge & Ploetz, 2003; Otero, 1939; Pirone, 1978; Seaver, 1928; Teliz, 2000; Watson, 1971; Weber, 1973
Phymatotrichopsis omnivora (Duggar) Hennebert Texas foot rot	MX CA TX	a, c, f	Morales-Garcia, 1989
Phytophthora cinnamomi Rands Phytophthora root rot	MX CA FL TX OT	a, f	Ploetz, *et al.*, 1994; CMI, 1991
Phytophthora citricola Sawada Black fruit rot	MX CA OT	c, f	Fucikovsky & Luna, 1987; Ploetz, *et al.*, 1994; CMI, 1979
Phytophthora nicotianae Breda de Haan var. *parasitica* (Dastur) G.M. Waterhouse Collar rot	MX CA FL OT	c, f	Alfieri, *et al.*, 1984; Farr, *et al.*, 1989; CMI, 1964
Pseudocercospora purpurea (Cooke) Deighton Synonym: *Cercospora purpurea* Cooke	MX CA FL	c, f	Fucikovsky & Luna, 1987; Ploetz, *et al.*, 1994

Appendix A – Pest List

Table A-1: Pathogens.			
Scientific Name [1] and Common Name	**Distribution [2]**	**Comment [3]**	**References**
Cercospora spot, Blotch			
Pythium ultimum Trow Root rot	MX CA FL HI OT	a, c, f	French, 1989; CMI, 1981b
Rhizoctonia solani Kühn Root rot	MX CA FL TX OT	a, c, f	Alfieri, *et al.*, 1984; Farr, *et al.*, 1989; French, 1989; CMI, 1974
Rosellinia bunodes (Berk. & Br.) Sacc. Black (Rosellinia) root rot	MX	A	Ploetz, *et al.*, 1994; Watson, 1971; CMI, 1985
Rosellinia necatrix Prill. Anamorph: *Dematophora necatrix* R. Hartig White root rot	MX CA OT	a, f	Ploetz, *et al.*, 1994; CMI, 1987
Rosellinia pepo Pat. Black root rot	MX	A	Ploetz, *et al.*, 1994; CMI, 1968
Sclerotium rolfsii Sacc. Anamorph: *Corticium rolfsii* Curzi Seedling blight	MX CA FL HI TX OT	c, f	Alfieri, *et al.*, 1984; CMI, 1981a
Sphaceloma perseae Jenkins Scab, Rona	MX CA FL TX	c, y	APHIS, 2004; Ploetz, *et al.*, 1994; CMI, 1986a
Verticillium albo-atrum Reinke & Bert. Verticillium wilt	MX CA FL TX OT	a, c, f	Ploetz, *et al.*, 1994; Morales-Garcia, 1989; CMI, 1986b
Bacteria			
Agrobacterium tumefaciens (Smith & Town.) Conn Crown gall	MX CA FL TX OT	a, c, f	Bradbury, 1986; CMI, 1980b
Erwinia carotovora subsp. *carotovora* (Jones) Bergey *et al.* Soft rot	MX CA FL HI TX OT	c, f	Bradbury, 1986
Erwinia herbicola (Löhnis) Dye	MX CA FL HI TX OT	F	Bradbury, 1986; Fucikovsky & Luna, 1987
Pseudomonas syringae pv. *syringae* van Hall Fruit spot, Blossom blight, Blast	MX CA FL TX OT	c, f	Bradbury, 1986; CMI, 1988
Nematodes			
Radopholus similis (Cobb) Thorne	MX CA FL TX OT	a, d	Anonymous, 1984; APHIS, 2004; Ploetz, *et al.*, 1994; Anonymous, 1992
Virus, viroid and viruslike agents			
Avocado sunblotch viroid	MX CA FL	f	Fucikovsky & Luna, 1987; Ploetz, *et al.*, 1994

[1] Scientific names of fungi and bacteria as listed in Ploetz, *et al.*, 1994; Bradbury,1986; and Farr, *et al.*,1989.
[2] Distribution legend for Table A-1: MX = Mexico; CA = California; FL = Florida; HI = Hawaii; PR = Puerto Rico; TX = Texas; USVI = US Virgin Islands; OT = Other, occurs in states other than CA, FL,

HI, TX.

[3] Comments for Table A-1:

a = Pest associated with plant part other than commodity
b = Further analysis not possible because species not identified
c = Listed in catalogue of pest interceptions as non-reportable (APHIS, 2003c)
d = Listed in catalogue of pest interceptions as reportable (APHIS, 2004)
f = Pest occurs in the United States and is not currently subject to official restrictions and regulations (*i.e.*, not listed as reportable or non-reportable, and no official control program)
y = Multiple APHIS interceptions exist (APHIS, 2003c; APHIS, 2004).

Appendix A – Pest List

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution [1]**	**Comments [2]**	**References**
Abgrallaspis howardi (Cockerell) (Homoptera: Diaspididae)	MX, US	a, c	Teliz, 2000
Abgrallaspis perseus Davidson (Homoptera: Diaspididae)	MX	g, j, z	APHIS, 2004; Davidson, 1964
Abgrallaspis sp. (Homoptera: Diaspididae)	MX	b, g, j, x	APHIS, 2004
Acanthoscelides sp. (Coleoptera: Bruchidae)	MX	a, b	Adame, 1998
Acutaspis albopicta (Cockerell) (Homoptera: Diaspididae)	MX, US	g, j, z	APHIS, 2004; Nakahara, 1982
Acutaspis perseae (Comstock) (Homoptera: Diaspididae)	MX, US	a, j	Ebeling, 1959
Aeolothrips mexicanus Preisner (Thysanoptera: Aeolothripidae)	MX	a	Hoddle, 2002; Teliz, 2000; Yee *et al.*, 2003
Aetalion quadratum Fowler (Homoptera: Aetalionidae)	MX	a, g	Ebeling, 1959
Agromyzidae (Diptera), Unidentified species	MX	a, b	Hennessey, 2002
Aleurocanthus woglumi Ashby (Homoptera: Aleyrodidae)	MX, US	a, g	Ballou, 1922; PNKTO No.15
Aleurodicus dugesii (Cockerell) (Homoptera: Aleyrodidae)	MX	a, g	Ebeling, 1959
Aleyrodidae (Homoptera), species unidentified	MX	a	Hennessey, 2002
Amorbia emigratella Busck (Lepidoptera: Tortricidae)	MX, US	a, c	Ebeling, 1959
Anastrepha fraterculus (Wiedemann) (Mexico population) (Diptera: Tephritidae)	MX	k	Aluja et al., 2003a; Baker *et al*., 1944; Baker, 1945; Norrbom, 2004; Steck, 1991; Steck, 1999; Steck & Sheppard, 1993
Anastrepha ludens (Loew) (Diptera: Tephritidae)	MX	g, m, n	Aluja, *et al*., 2004; APHIS, 1993c; Norrbom, 2004; Norrbom & Kim, 1988; Stone, 1942; 7 CFR 301.64
Anastrepha obliqua (Loew) (Diptera: Tephritidae)	MX	g, m, y	Norrbom, 2004; Aluja *et al.*, 2004
Anastrepha serpentina (Wiedemann) (Diptera: Tephritidae)	MX	g, m, y	Norrbom, 2004; Aluja *et al.*, 2004
Anastrepha striata Schiner (Diptera: Tephritidae)	MX	g, m	Uchoa & Zucchi, 2000; Ballou, 1936; Jiron, *et al.*, 1988; Norrbom, 2004; Norrbom & Kim, 1988;

Table A-2: Arthropods

Genus species Author (Order: Family)	Distribution [1]	Comments [2]	References
			Aluja *et al.*, 2004
Anomala sp.	MX	a, b	APHIS, 2004
Anthonomus sp. (Coleoptera: Curculionidae)	MX	a, b	Adame, 1998
Apate monacha F. (Coleoptera: Bostrichidae)	MX	a, g	Pierce, 1917
Aphis gossypii Glover (Homoptera: Aphididae)	MX, US	a, c	Ebeling, 1959
Probably *Apion* sp. (Coleoptera: Curculionidae)	MX	a, b	Adame, 1998
Aspidiotis spinosus (Comstock) (Homoptera: Diaspididae)	MX, US	a, c	Teliz, 2000
Attelabus sp. (Coleoptera: Curculionidae)	MX	a, b	Adame, 1998
Brevipalpus australis (Acarina: Tenuipalpidae)	MX	a	Garcia *et al.*, 1998
Brochymena quadripustulata F. (Heteroptera: Pentatomidae)	MX, US	a, c	Alvarez *et al.*, 1967; Henry & Froeschner, 1988
Burtinus notatipennis Stal (Heteroptera: Coreidae)	MX, US	a, c	Ebeling, 1959; Henry & Froeschner, 1988
Calipitrimerus muesebecki Keifer (Acarina: Eriophyidae)	MX, US	a	Baker *et al.*, 1996; Garcia *et al.*, 1998
Capaneus humerosus Distant (Heteroptera: Coreidae)	MX	a	Ebeling, 1959
Caulophilus latinasus Say (Coleoptera: Curculionidae)	MX, US	a, c	McKenzie, 1935
Ceratitis capitata (Wiedemann) (Diptera: Tephritidae)	MX	g, l, z	Liquido, *et al.*, 1998; Metcalf & Metcalf, 1993; White & Elson-Harris, 1992; 7 CFR 301.78; 7 CFR 318.13;
Ceroplastes cirripediformis Comstock (Homoptera: Coccidae)	MX, US	a, c	Ebeling, 1959
Ceroplastes cistudiformis Townsend & Cockerell (Homoptera:Coccidae)	MX, US	a, c	Ebeling, 1959
Ceroplastes floridensis Comstock (Homoptera: Coccidae)	MX, US	a, c	Ebeling, 1959
Chrysodina sp. (Coleoptera: Chrysomelidae)	MX	b	APHIS, 2004
Chrysomphalus agavis (Townsend &	MX, US	a, j	Ebeling, 1959

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution [1]**	**Comments [2]**	**References**
Cockerell) (Homoptera:Diaspididae)			
Chrysomphalus aonidum (L) (Homoptera: Diaspididae)	MX, US	a, c, j	Metcalf & Metcalf, 1993
Chrysomphalus dictyospermi (Morgan) (Homoptera: Diaspididae)	MX, US	a, c, j	Teliz, 2000
Cicadellidae, species unidentified (Homoptera)	MX	a, b	Hennessey, 2002
Coccus hesperidum (L) (Homoptera: Coccidae)	MX, US	a, c	Ebeling, 1959
Conotrachelus aguacatae Barber (Coleoptera: Curculionidae)	MX	z, g	Arellano, 1975; Wysoki *et al.*, 2002
Conotrachelas perseae Barber (Coleoptera: Curculionidae)	MX	z, g	APHIS, 1993b; Ebeling, 1959
Conotrachelus sp. (Coleoptera: Curculionidae)	MX	z, g	Adame, 1998; APHIS, 1993b
Conotrachelus sp. probably *flavangulus* Champion (Coleoptera: Curculionidae)	MX	a	Adame, 1998; APHIS, 1993b
Copaxa multifenestrata (Herrich-Schaffer) (Lepidoptera: Saturniidae)	MX	a, g	Teliz, 2000
Possibly *Copturomimus* sp. (Coleoptera: Curculionidae)	MX	a	Adame, 1998
Copturus aguacatae Kissinger (Coleoptera: Curculionidae)	MX	z, g	APHIS, 1993b; MacGregor & Gutierrez, 1983; APHIS, 2004
Copturus constrictus Champion (Coleoptera: Curculionidae)	MX	a	Sleeper, 1978
Corthylus nudus Schedl (Coleoptera: Scolytidae)	MX	a	MacGregor & Gutierrez, 1983
Curculionidae, unidentified species (Coleoptera)	MX	a, b	Adame, 1998
Cyclocephala sp. (Coleoptera: Scarabaeidae)	MX	b	APHIS, 2004
Probably *Cylindrocopturus* sp. (Coleoptera: Curculionidae)	MX	a, b	Adame, 1998
Dallasiellus sp. (Hemiptera: Cydnidae)	MX	b, x	APHIS, 2004

Table A-2: Arthropods

Genus species **Author (Order: Family)**	**Distribution** [1]	**Comments** [2]	**References**
Deloyala guttata (Olivier) (Coleoptera: Chrysomelidae)	MX, US	a, c	APHIS, 2004; Ebeling, 1959
Diabrotica porracea Harold (Coleoptera: Chrysomelidae)	MX	a, g, x	APHIS, 2004
Diaprepes abbreviatus (L) (Coleoptera: Curculionidae)	MX, US	a, g	Bennett, 1985
Diaspidiotus perniciosus (Comstock) (Homoptera: Diaspididae)	MX, US	a, c, j	Teliz, 2000
Diaspidiotus sp. (Homoptera: Diaspididae)	MX	b, x	APHIS, 2004
Diaspididae, unidentified species (Homoptera)	MX	b	APHIS, 2004
Diaspis cocois Lichtenstein (Homoptera: Diaspididae)	MX, US	a, c, j	Teliz, 2000
Dysdercus obliquus (Herrich-Schaeffer) (Heteroptera: Pyrrhocoridae)	MX, US	a, c	Ebeling, 1959; Henry & Froeschner, 1988
Eotetranychus sexmaculatus (Riley) (Acarina: Tetranychidae)	MX, US	a, c	Bolland *et al*., 1998; Garcia *et al*., 1998
Estigmene sp. (Lepidoptera: Arctiidae)	MX, US	a, b, c	APHIS, 2004
Farinococcus olivaceus (Cockerell) (Homoptera:Pseudococcidae)	MX	a	Ebeling, 1959
Formicidae species undetermined (Hymenoptera)	MX	a	Hennessey, 2002
Frankliniella bruneri Watson (Thysanoptera: Thripidae)	MX	a, g	Hoddle, 2002; Teliz, 2000; Yee *et al*., 2003
Frankliniella cephalica Hood (Thysanoptera: Thripidae)	MX, US	a, c	Ebeling, 1959
Frankliniella chamulae Johansen (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Teliz, 2000; Yee *et al*., 2003
Frankliniella difficilis Hood (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Teliz, 2000; Yee *et al*., 2003
Frankliniella minor Moulton (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Teliz, 2000; Yee *et al*., 2003
Franklinothrips vespiformis (Crawford) (Thysanoptera: Aeolothripidae)	MX, US	a, c	CPC, 2003; Teliz, 2000
Hansenia pulverulenta (Guerin-Meneville) (Homoptera:Flatidae)	MX	a	MacGregor & Gutierrez, 1983

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution** [1]	**Comments** [2]	**References**
Heilipus albopictus Champion (Coleoptera: Curculionidae)	MX	a	MacGregor & Gutierrez, 1983
Heilipus lauri Bohemann (Coleoptera: Curculionidae)	MX	z, g	APHIS, 1993b; Ebeling, 1959
Heliothrips haemorrhoidalis (Bouche) (Thysanoptera:Thripidae)	MX, US	a, c	Ebeling, 1959
Hemiberlesia diffinis (Newstead) (Homoptera: Diaspididae)	MX	a, g, j	Nakahara, 1982; Teliz, 2000
Hemiberlesia lataniae (Signoret) (Homoptera: Diaspididae)	MX, US	a, c, j	Nakahara, 1982
Hemiberlesia rapax (Comstock) (Homoptera: Diaspididae)	MX, US	a, c, j	Nakahara, 1982
Hemiberlesia sp. (Homoptera: Diaspididae	MX	b, j, x	APHIS, 2004
Icerya montserratensis Riley & Howard (Homoptera: Margarodidae)	MX	a, g	Ebeling, 1959
Icerya purchasi Maskell (Homoptera: Margarodidae)	MX, US	a, c	Ebeling, 1959
Idona minuenda (Ball) (Homoptera: Cicadellidae)	MX, US	a, c	Teliz, 2000
Idona spp. (Homoptera: Cicadellidae)	MX, US	a	Ebeling, 1959
Largus cinctus Herrich-Schaeffer (Heteroptera: Largidae)	MX, US	a, c	Ebeling, 1959; Henry & Froeschner, 1988
Leptoglossus phyllopus (L) (Heteroptera: Coreidae)	MX US	a, c	Ebeling, 1959
Leptothrips mcconnelli (Crawford) (Thysanoptera: Phlaeothripidae)	MX	a	Hoddle, 2002; Teliz, 2000; Yee *et al.*, 2003
Ligyrus sp. (Coleoptera: Scarabaeidae)	MX	a, b, x	APHIS, 2004
Liothrips perseae (Watson) (Thysanoptera: Phlaeothripidae)	MX	a	MacGregor & Gutierrez, 1983; Nakahara, 1995
Melanaspis aliena (Newstead) (Homoptera: Diaspididae)	MX	a, j	Nakahara, 1982
Melipona testacea cupira Smith (Hymenoptera: Meliponidae)	MX	a	Ebeling, 1959
Metcalfiella monogramma (Germar) (Homoptera: Membracidae)	MX	a, g	Ebeling, 1959

Table A-2: Arthropods

Genus species **Author (Order: Family)**	**Distribution** [1]	**Comments** [2]	**References**
Mycetaspis personata (Comstock) (Homoptera: *Diaspididae*)	MX, US	a, c, j	Nakahara, 1982
Neohydatothrips signifer Priesner (Thysanoptera: Thripidae)	MX	a	Hoddle, 1999; 2002; Mound & Marullo, 1996 [synonymized *N. burungae* (Hood)]; Yee *et al*., 2003
Neosilba batesi Curran (Diptera: Lonchaeidae)	MX, US	a	Ahlmark & Steck, 1997; Aluja *et al*., 2004; Hennessey, 2002; White & Elson-Harris, 1992
Nipaecoccus nipae (Maskell) (Homoptera: Pseudococcidae)	MX, US	a, c	Ebeling, 1959
Oligonychus yothersi (McGregor) (Acarina: Tetranychidae)	MX, US	a	MacGregor & Gutierrez, 1983; McMurtry, 1985
Oligonychus perseae Tuttle, Baker & Abbatiello (Acarina: Tetranychidae)	MX, US	a, c	Teliz, 2000
Oligonychus platani (McGregor) (Acarina: Tetranychidae)	MX, US	a, c	MacGregor & Gutierrez, 1983; McMurtry, 1985
Oligonychus punicae (Hirst) (Acarina: Tetranychidae)	MX, US	a, c	McMurtry, 1985
Papilio garamas garamas Hubner (Lepidoptera: Papilionidae)	MX, US	a	Teliz, 2000, USGS, 2003
Paraleyrodes goyabae (Goeldi) (Homoptera: Aleyrodidae)	MX	a	Teliz, 2000
Paraleurodes sp. near *goyabae* (Goeldi) (Homoptera: Aleyrodidae)	MX	a	Ebeling, 1959
Phyllophaga sp. (Coleoptera: Scarabaeidae)	MX	a, b, x	APHIS, 2004
Pinnaspis strachani (Cooley) (Homoptera: Diaspididae)	MX, US	a, c, j	Teliz, 2000
Pityophthorus sp. (Coleoptera: Scolytidae)	MX	a (in pallets), b, x	APHIS, 2004
Planococcus citri (Risso) (Homoptera: Pseudococcidae)	MX, US	a, c	Ebeling, 1959
Polydrusus sp. (Coleoptera: Curculionidae)	MX	a, b	Adame, 1998
Polyphagotarsonemus latus (Acarina: Tarsonemidae)	MX, US	a, c	Garcia *et al*., 1998; Jeppson et al., 1975
Pseudacysta perseae (Heidemann) (Heteroptera: Tingidae)	MX, US	a, c	MacGregor & Gutierrez, 1983; Henry & Froeschner, 1988

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution [1]**	**Comments [2]**	**References**
Pseudobaris sp. (Coleoptera: Curculionidae)	MX	a	Adame, 1998
Pseudococcus longispinus (Targioni-Tozzetti) (Homoptera: Pseudococcidae)	MX, US	a, c	Ebeling, 1959
Pseudococcidae, unidentified species (Homoptera)	MX	a, b	Hennessey, 2002
Pseudophilothrips perseae (Watson) (Thysanoptera: Phlaeothripidae)	MX	a	Hoddle, 2002; Teliz, 2000; Yee *et al*., 2003
Psychidae species unidentified (Lepidoptera)	MX	a, b	Hennessey, 2002
Pulvinaria simulans Cockerell (Homoptera: Coccidae)	MX	a	Ebeling, 1959
Pyrrhopyge chalybea Scudder (Lepidoptera: Hesperiidae)	MX	a, g	Diaz, 1976
R*hyssematus* sp. (Coleoptera: Curculionidae) (unconfirmed)	MX	a	Adame, 1998
Saissetia coffeae (Walker) (Homoptera: Coccidae)	MX, US	a, c	Metcalf & Metcalf, 1993
Saissetia hemisphaerica (Targioni) (Homoptera: Coccidae)	MX, US	a	Ebeling, 1959
Scaphytopius sp. (Homoptera: Cicadellidae)	MX	a, g	Ebeling, 1959
Scirtothrips aceri (Moulton) (Thysanoptera: Thripidae)	MX, US	a	Hoddle, no date; 2002; Teliz, 2000; Yee *et al*., 2003
Scirtothrips aguacatae Johansen & Mojica (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Johansen & Mojica-Guzman, 1998; Teliz, 2000; Yee *et al*., 2003
Scirtothrips kupandae Johansen & Mojica (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Johansen & Mojica-Guzman, 1998; Teliz, 2000; Yee *et al*., 2003
Scirtothrips longipennis (Bagnall) (Thysanoptera: Thripidae)	MX, US	a	Hoddle, 2002; Johansen & Mojica-Guzman, 1998; Mound & Palmer, 1981; Yee *et al*., 2003
Scirtothrips manihotifloris Johansen & Mojica (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Johansen & Mojica-Guzman, 1998; Yee *et al*., 2003
Scirtothrips perseae Nakahara (Thysanoptera: Thripidae)	MX, US	a	Hoddle, 2002; Johansen & Mojica-Guzman, 1998; Nakahara, 1997; Teliz, 2000; Yee *et al*., 2003

Table A-2: Arthropods

Genus species Author (Order: Family)	Distribution [1]	Comments [2]	References
Scirtothrips tacambarensis Johansen & Mojica (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Johansen & Mojica-Guzman, 1998; Yee *et al*., 2003
Scirtothrips uruapaniensis Johansen & Mojica (Thysanoptera: Thripidae)	MX	a	Hoddle, 2002; Johansen & Mojica-Guzman, 1998; Yee *et al*., 2003
Stenoma catenifer Walsingham (Lepidoptera: Oecophoridae)	MX	z, g	Ebeling, 1959
Tegolophus perseaflorae Keifer (Acarina: Eriophyidae)	MX, US	a	Baker *et al*., 1996; Garcia *et al*., 1998
Trialeurodes floridensis (Quaintance) (Homoptera: Aleyrodidae)	MX, US	a, c	Teliz, 2000
Trialeurodes similis Russell (Homoptera: Aleyrodidae)	MX	a, c	Ebeling, 1959
Trioza anceps Tuthill (Homoptera: Psyllidae)	MX	a, g	MacGregor & Gutierrez, 1983
Umbonia crassicornis (Amyot & Serville) (Homoptera: Membracidae)	MX, US	a, c	Teliz, 2000
Velataspis dentata (Hoke) (Homoptera: Diaspididae)	MX, US	a, c, j	Teliz, 2000

[1] Distribution legend for Table A-2: MX = Mexico; US = United States.

[2] Comments for Table A-2:

a = Pest associated with plant part other than commodity, or in rotting fruit on ground.
b = Further analysis not possible because species not identified
c = Listed in catalogue of pest interceptions as non-reportable (APHIS, 2003c)
g = Listed in the catalogue (APHIS, 2003c, APHIS, 2004) of intercepted pests as reportable.
j = Armored scale insect: no quarantine action taken on fruit for consumption because "...armored scales in general have a low probability of establishment from infested shipments of commercial fruit" (ARS, 1985); also Gullan and Kosztarab (1997) state that the crawler is the dispersing stage, that other stages are immobile, and that dispersal in mainly onto the original plant or by wind, neither of which would occur with the commodity.
k = There is a taxonomic problem with the species. The Mexico population of this species does not use avocado fruit as a natural host. Some South American populations do infest avocado.
l = Pest excluded by official control from area of production and processing.
m = "Not… a natural host" based on Aluja *et al.* (2004).
n = "Not…a natural host" based on Aluja *et al.* (2004) and review of that work by ARS that concluded that 'Hass' avocados are a "very poor host".
x = Multiple APHIS interceptions exist (APHIS, 2003c; APHIS, 2004).
y = Original studies have not demonstrated that avocado is a natural host in the field, according to the references.
z = Pest is known to commonly infest fruit. It would be reasonable to expect that the pest may remain with the fruit during processing and shipping.

Appendix B: Review of the Biology of Selected Pests

This review of the biology of selected quarantine pests is an update of information in attachments 1 and 2 of the initial pest risk assessment: "Risk Management Analysis: A Systems Approach for Mexican Avocados" (USDA, 1995b). Key evidence from those documents was revised and updated.

1. *Conotrachelus perseae* and *C. aguacatae* (seed weevils)
a. Distribution -These seed weevils are reported to occur in Mexico and Central American as far south as Panama (Whitehead, 1979a, b; Ebeling, 1959). In Mexico, *C. perseae* is reported in the states of Michoacán, Puebla, Veracruz, and Jalisco. *Conotrachelas aguacatae* is reported for the states of Coahuila, Jalisco, Michoacán, Nayarit, Queretaro, Guanajuato, Puebla, and Morelos (Whitehead, 1979a, b and Sanidad Vegetal, 1992), and is prevalent at high elevations. FAO (1986) reports its occurrence in Mexico.
b. Host -The only host reported for *C. perseae* and *C. aguacatae* is *P. americana* (avocado). Interceptions of *Conotrachelus* by PPQ indicate that the "Creole type of avocado" (Mexican race) seems to be most heavily attacked (USDA, 1941). Sanidad Vegetal (1992) reports that both of these weevils prefer the Mexican race of avocado, but also attack the variety 'Hass.' Since *Conotrachelaus* is reported as a pest of avocado in Central America, it should be assumed that various varieties of the Guatemalan race of avocado could be attacked.
c. Biology -Eggs are deposited on the young undeveloped fruit and the larva feed in the seed until they are fully developed. When fully developed the larva exit the fruit and pupate in the soil. Sanidad Vegetal (1992) reports that one to four larvae of *C. perseae* develop in each infested fruit, however, Sleeper (1978) reports that up to 28 larvae can be found in one fruit. Sanidad Vegetal (1992) and Sleeper (1978) also states that the damaged fruit falls to the ground before the fruit is fully developed. PPQ has intercepted larvae in various stages of development in avocado fruits being smuggled into the United States; this indicates that at least a portion of the infested fruits developed to a marketable stage (USDA 1941). The adults are active at night and feed on the fruits, leaves, and stems of avocado trees. In Mexico, *C. perseae* is reported to have two generations per year.
d. Economic Importance -Ebeling (1959) ranked both of these weevils as minor pests of avocados. Arellano (1975) reports this pest tunnels into/through the seeds of *P. americana*. Sanidad Vegetal (1992) reported that on neglected farms the infestation rate could be between 7 and 18 percent of the fruit and as high as 66 percent on Creole trees. Field controls reported by Sanidad Veqetal include foliage and ground application of pesticides, raking of the ground to expose the pupae, and the collection and destruction of fallen fruit (Sanidad Vegetal 1992).

2. *Heilipus lauri* (a seed weevil)
a. Distribution -This pest is reported to occur in Mexico and south to (at least) Colombia. In Mexico, it is reported to be in the states of Hidalgo, Mexico, Morelos, Veracruz, Guerrero, Puebla and Tlaxcala (Garcia, 1962; Sanidad Vegetal, 1992; MacGregor, 1983). This pest is also reported at high elevations.
b. Host -Sanidad Vegetal (1992) reports that it prefers Creole avocado trees (Mexican race), but also attacks improved avocado varieties.
c. Biology -Ebe1ing (1959) reports the biology of this pest. He states that there is one generation per year. The winter is spent in the adult stage, and adults deposit eggs in the developing fruit in

May, June, and Ju1y. The larvae tunnel to the seed where they feed and pupate. After the adults leave the fruit they feed on the leaf, bud, sprout, and fruit of their host. Sometimes pupation takes place in the soil from fallen fruit. Sanidad Vegetal (1992) states that there is an average of two larvae per infested seed and that there were two generations in a 15.5-month period in Morelos, where this pest was studied.
d. Economic Importance -Ebeling (1959) ranked this pest as a major pest of avocado; larvae feed seeds, adults on leaves. In certain areas of Mexico, it can cause up to 80 percent fruit loss (Garcia, 1962). Sanidad Vegetal (1992) reported various field controls, including foliar application of pesticides directed at the adu1ts, weed control, and the destruction of fallen fruit.

3. *Copturus aguacatae* (an avocado stem weevi1)
a. Distribution -This weevil is known to be from the Mexican states of Guerrero, Puebla, Morelos, and Michoacán (Whitehead, 1979b; Kissinger, 1957; Macgregor, 1983).
b. Host- The only host reported was *P. americana* (Kissinger, 1957, Muniz, 1959). Adults reared from smuggled avocado fruit intercepted at the Mexican border were *C. aguacatae*. In recent years, larvae have been detected in smuggled ‘Hass’ avocado fruit intercepted by PPQ from Mexico, mainly El Paso, Texas.
c. Biology -The weevil bores into the small new stems and branches, but can affect the older branches or fruits near the peduncle end at high population densities. Eggs are laid in holes bored by the female in the bark of the plant (Garcia et al., 1998). A maximum of eight eggs are laid in a group by the female. Oviposition occurs mostly in April and May by the first generation and in October and November by the second generation, a1though adults emerge from May to early July and from November to February (Muniz, 1959). Stem weevil larvae rarely migrate into the fruit, but when they do, they are usually localized to the area of the fruit near the peduncle (APHIS, 1997; Gudino Juarez and Garcia Guzman, 1990).
d. Economic Importance -This species and related weevils have been reported to cause great destruction to avocado trees. The boring of this pest causes die back of the branches and uncontrolled infestations that can cause a reduction in the size of the tree. Ebeling (1959), Sleeper (1978), and Whitehead (1979b) call this a major pest. Muniz (1959) states secondary infections of viruses, bacteria and fungi may occur. *C. aguacatae* and related pests have been controlled by repeated foliar applications of contact pesticides.

4. *Stenoma catenifer* (avocado seed moth)
a. Distribution -This pest is reported to occur in Mexico south to Brazil (Acevedo, 1973), and has recently been reported in Guyana (Cervantes-Peredo *et al.*, 1999). In Mexico, it is reported in the states of Veracruz, Tamaulipas, Oaxaca, Chiapas, Nuevo Leon, Guerrero, and Colima (Acevedo, 1973; Macgregor, 1983). It is not reported from Michoacán.
b Host -This moth is reported to attack *P. scheidiana* (chinini) and *Beilschmedia* sp. (anayo) (Acevedo, 1973; USDA, 1980). It also attacks *P. americana* (cultivated avocado), and has been reported on the varieties ‘Choquette’, ‘Hall’, ‘Lula’, ‘Booth 7’, ‘Booth 8’, and ‘Carmelita’ (Acevedo 1973; Ebeling, 1959). Recently, it was reported on *Chlorocardium rodiei* (Greenheart), the most important timber tree in Guyana (Cervantes Peredo *et al.*, 1999).
c. Biology -This moth spends the winter as an adult in the soil or leaf litter. In the spring, the female mates and deposits eggs on the stem and fruit of its hosts. Adults usually remain hidden during the day and fly erratically around the host at night. The 1arvae bores in the stem and fruit. Within the fruit, *S. catenifer* feeds on the pulp for several days before moving into the seed,

where the main part of its development takes place. Pupation takes place outside of the fruit, in or on the soil. The number of generations per year varies, depending on the availability of fruit (Acevedo, 1973; Ebeling, 1959; USDA, 1980).
d. Economic Importance -This is one of the most serious avocado pests in the world. Ebeling (1959) rates it as a major pest of avocado. The larvae damage the terminal twigs and can often kill young trees. The damage on stems can also result in fruit drop. The damage occurs about one month after the fruit forms, and makes the fruit unmarketable (Acevedo, 1973). In Venezuela, it is considered one of the most important pests of avocado (Boscan and Godoy, 1982). In tropical areas of Mexico, this pest is a limiting factor for avocado production. A fruit infestation rate of 94 percent has been reported, and one larva can destroy a fruit. In one study, it required 14 treatments of pesticide per season to eliminate damage from this pest (Acevedo, 1973).

5. *Anastrepha ludens, A. striata, and Ceratitis capitata* (Fruit flies).
Avocado is not considered a host for *Anastrepha serpentina*, *A. fraterculus* (Mexico populations) and *A. obliqua* (Norrbom, 2004) that are listed in Table A-2
a. Distribution-These fruit flies have a range that includes tropical or subtropical areas. *Anastrepha striata* occurs from Mexico to Brazil and outbreaks have occurred in Texas and California. *Anastrepha ludens* occurs from northern Mexico to Costa Rica, and outbreaks have occurred in Texas and California (Foote et al., 1993; Sequeira *et al*.,2001). *Ceratitis capitata* occurs over southern Europe and throughout Central and South America (CPC, 2002), it is established in Hawaii, and outbreaks have occurred in Florida and California.
b. Hosts--*Anastrepha striata* infests *Prunus persica, Persea, Eugenia, Mangifera, Passiflora, Diospyros, Manihot*, and other genera in multiple families. *Anastrepha ludens* infests *Prunus persica, Annona, Casimiroa, Citrus, Cydonia, Mammea, Mangifera, Persea, Psidium, Pyrus* and other genera representing over five families (Norrbom, 2004). *Ceratitis capitata* infests over 100 crop and non-crop species, including *Opuntia, Persea, Prunus, Malus, Capsicum*, and others in over 10 families (Liquido *et al*., 1998). Aluja *et al.* (2004) concluded that commercial 'Hass' avocados from Mexico are "not…a natural host" for *A. ludens, A. striata, A. serpentina, and A. oblique.* Based on Aluja *et al.* (2004), ARS concluded that the commodity is a "very poor host" for *A. ludens* (Appendix F).
c. Biology- These fruit flies have been documented to have continuous generations within their ranges. Females can live for several months and are capable of laying over 100 eggs each. These fruit flies have a life cycle of less than 45 days, under optimum conditions, a capability to spread naturally by flight over 20 km per year, and a capability to spread worldwide in commerce. Eggs are laid under or within the peel of fruits of various stages of maturation; the larvae bore through the pulp until pupation, which occurs after dropping to the soil (CPC, 2002; Fletcher, 1989; Foote *et al*., 1993; Liquido *et al*., 1998; Norrbom, 2004; Sequeira *et al*., 2001; White and Elson-Harris, 1994).
d. Economic importance- These species are regulated pests (APHIS, 2002); therefore, their establishment in the United States could trigger quarantines against exports. *Anastrepha striata* is a primary pest of guava in Venezuela, reducing the yield and quality of fruit (Marin Acosta, 1973). *Anastrepha ludens* infestations in citrus could cause a decrease in yield and quality in the United States valued at $70 million (1975 prices) (Andrew *et al*, 1977). *Ceratitis capitata* infestation may cause yield and quality losses requiring up to $341 million in additional production costs if it becomes established in California (CDFA, 2003). Eradication of outbreaks is an annual expense incurred by USDA and the states, and if an outbreak is detected, all of these

species would be expected to trigger APHIS eradication programs involving area-wide spray programs, as has occurred in Florida, Texas, and California (Sequeira *et al*., 2001).

This section on the biology of selected pests was drafted by C. E. Miller, RAS, PPD, APHIS, September 1992 and revised by L. Duffie, USDA-APHIS-PPQ-CPHST, January 2003, and M. Hennessey, December, 2003 and February, 2004. References for this section may be found in the section entitled “References”.

Appendix C: Review of *Anastrepha* Species

Previous analysis and much of the focus from stakeholders (as per the Administrative Record on comments regarding proposed rules for avocado importation from Mexico) was on the potential of introduction of *Anastrepha* spp. fruit flies with 'Hass' avocados. The status of 'Hass' avocados as hosts of *Anastrepha* spp. fruit flies has been the focus of intense research. From 1992 to 1994 Martinez *et al.* (1993) dissected 153.5 tons of avocado fruit (618,975 fruit) by randomly cutting one cm slices of selected fruit from nine packinghouses in Michoacán. No fruit flies were detected to be infesting avocados even though trapping data showed that fruit flies were present in the area attacking other hosts. In a related study, Enkerlin *et al.* (1993) evaluated the host status of 'Hass' avocados before and after they were removed from the tree. They found that avocados were not naturally infested when attached to the tree. Furthermore, when fruit was still attached and artificially infested with fruit flies, oviposition did occur, but larvae did not develop. Researchers [Enkerlin *et al.* (1993); Santiago Martinez *et al.*, 1993] reported that biochemical processes were probably responsible for the lack of viabile eggs in fruit that was attached to the tree. (This resistance rapidly disappeared after harvest.) Enkerlin *et al.* (1993) were able to obtain viable larvae under laboratory conditions with artificial infestations of harvested fruit, if the fruit was mature (more than 21.5% dry matter) and at least 3 hours elapsed after harvest.

Recent research by Aluja *et al.* (2004) conducted during August-October, 2001, and April-June, 2002 combined detailed field observations and laboratory studies. Field studies were conducted in 2001 and 2002 at three different altitudes (1200-1440, 1600-1800, and 2000-2100 m above sea level) that encompassed all key production areas in the state of Michoacán, Mexico. In the field experiments, ready-to-harvest fruit of Hass' avocados randomly collected from six orchards at the three different representative altitudes (76,950 fruit) did not reveal fruit fly infestations. Additionally, field cages were used to artificially infest fruit attached to branches (5,200 fruit) in commercial orchards with large numbers of viable fruit flies (wild and lab reared flies). Fruit fly larvae were found in two fruits. These two infested fruits were observed over the following days, but viable offspring did not result (that is, underweight pupae were formed, but adults did not emerge). Finally, for the field observations, mature avocados were placed on trays on the orchard floor (3,600 fruit). Three fruits were infested by the loncheid decomposer, *Neosilba batesi* (Diptera: Lonchaeidae), but had no fruit fly infestations. This finding further supports the low likelihood of infestation by *Anastrepha,* even in fallen fruit.

As part of the observations by Aluja *et al.* (2004), fruit was sampled from packinghouses (1,620 fruit) and no infestation was detected. In laboratory trials, fruit was artificially exposed to large numbers of mated females of four different species of *Anastrepha*: *A. serpentina, A. ludens, A. striata, and A. obliqua*. The conditions of exposure varied from "choice" studies and "no-choice" studies in laboratory conditions. The no-choice studies included only 'Hass' avocados. The choice studies included 'Hass' avocados and known hosts. Whereas oviposition was attempted, infestation by the different fruit flies did not occur. In the choice trials, the known hosts were visited more frequently and had infestations that resulted in viable offspring. Observations on the physiological responses to oviposition in 'Hass' cultivar avocados suggest epicarp regeneration and callus formation that inhibits proper larval development. The latter observations on the resistance mechanisms in avocados by Aluja *et al.* (2004) were consistent with observations by Smith (1973), Armstrong *et al.* (1993), Martinez *et al.* (1993) and Enkerlin *et al.* (1993).

From the above studies, and from the rigor of the most recent study by Aluja *et al.* (2004),(all observations and design phases were overseen by USDA and independent reviewers) and based in addition to the analysis in Appendix D of this PRA, APHIS concludes that commercially produced fruit from Michoacán, Mexico are considered to be a low-likelihood pathway for *Anastrepha* spp. Previous assessments (USDA, 1995a) included *Anastrepha* spp. as part of the quarantine pests that were considered in greater detail, although avocados were considered non-hosts or at best, poor hosts., Those earlier assessments concluded that there was a very low probability of association of *Anastrepha* with the ‘Hass’ avocado imports (USDA, 1995a, b; 2001b).

Appendix D - Quantitative Risk Assessment Model

This document presents the methodology and results of the quantitative analysis.

Summary

In 1993, APHIS authorized entry of Mexican avocado fruit into Alaska. In 1997 'Hass' avocados were allowed to be shipped, from Michoacán, Mexico, to 19 states and the District of Columbia, and the allowable shipping season was November 15 to February 15. Since November 2001 (according to CFR §319.56-2ff: "Administrative instructions governing movement of 'Hass' avocados from Michoacán, Mexico, to approved States")**, 'Hass'** avocados have been allowed to be shipped to 31 states and the District of Columbia, and the allowable shipping season is October 15 to April 15.

Since 1997 approximately 300 million 'Hass' avocados have been imported from Mexico under a systems management protocol that includes packinghouse and port of entry inspections. To date, more than ten million fruit have been cut and inspected as part of the avocado export program, and no quarantine pests have been detected.

This assessment responds to a request to expand the importation of fresh 'Hass' variety avocado fruits (*Persea americana*) grown in the state of Michoacán, Mexico, into all U.S. states during all months of the year.

APHIS conducted a screening analysis on previously identified avocado pests known to occur in Mexico that may have potential economic importance in the United States. The screening involved the elimination of non-quarantine pests and non-pathway pests from the list, and resulted in the identification of the following pathway pests of quarantine significance.:

1. three seed weevils: *Conotrachelus aguacatae, Conotrachelus perseae*, and *Heilipus lauri*;
2. one stem weevil: *Copturus aguacatae*:
3. one seed moth: *Stenoma catenifer*; and
4. fruit flies: *Anastrepha ludens, A. striata,* and *Ceratitis capitata*

This quantitative risk assessment (QRA) focuses on these pests and categorizes them into two groups as follows:

1. Avocado Pests: The seed moth, stem weevil and three seed weevils are exclusively avocado pests, and are dealt with together.
2. Fruit Flies: The fruit flies can infest other fruit aside from Avocados, so they are dealt with together.

The QRA estimates the annual number of infested avocados entering the United States, the annual number of infested avocados entering susceptible areas in the United States, and the annual number of infested avocados discarded in susceptible areas.

APHIS has developed a risk assessment model that is presented in this document. The risk assessment predicts that 114 million to 1.8 billion 'Hass' avocados will be imported annually from Mexico.

This assessment does not evaluate the individual effectiveness of the systems mitigations in reducing the phytosanitary risks to the United States. It considers the individual mitigations collectively, and assumes that the current or equivalent systems mitigations will remain in place at the same level.

The following two scenarios are evaluated in the risk assessment:

Scenario 1: Importation of avocados from Mexico to all States, all year round..

Scenario 2: Importation of avocados from Mexico, to all States excluding Florida, California and Hawaii, all year round.

This assessment utilizes the results of six years of surveys to estimate the proportion of imported avocados that are infested. For each of the two scenarios the assessment estimates the following five quantitative endpoints:

1. the number of infested avocados reaching the United States each year,
2. the number of avocado pest infested avocados reaching avocado producing areas in the United States each year,
3. the number of fruit fly infested avocados reaching fruit fly susceptible areas in the United States each year,
4. the number of avocado pest infested avocados discarded in avocado growing areas, and
5. the number of fruit fly infested avocados discarded in fruit fly susceptible areas.

Following is a summary of the results of twenty thousand Monte Carlo iterations of the risk assessment model using @Risk (Palisade Corporation, Newfield, New York) and Excel (Microsoft Inc., Redmond, Washington).

		95%tile values		99%tile values	
	Description of parameter	**Scenario 1 (50 States)**	**Scenario 2 (47 States)** All States Excluding CA, FL & HI	**Scenario 1 (50 States)**	**Scenario 2 (47 States)** All States Excluding CA, FL & HI
N	Annual Number of Avocados from Mexico	1,124,808,576	1,039,780,992	1,346,052,992	1,274,103,040
P1	Proportion of infested avocados	7.04E-07	7.04E-07	1.23E-06	1.23E-06
P2	Proportion of fruit that enters avocado growing areas	0.232	0.042	0.280	0.056
P2a	Proportion of fruit that enters fruit fly susceptible areas	0.537	0.248	0.537	0.248
P3	Proportion of fruit discarded	0.050	0.050	0.050	0.050
Q1	Number of infested avocados entering the USA	442	393	874	794
Q2	Number of avocado pest infested avocados entering avocado growing areas of the U.S.	54	7	110	16
Q2a	Number of fruit fly infested avocados entering fruit fly susceptible areas of the U.S.	238	98	469	197
Q3	Number of arthropod pest infested avocados discarded in avocado growing areas of the U.S.	**3**	**1**	**6**	**1**
Q3a	Number of fruit fly infested avocados discarded in fruit fly susceptible areas of the U.S.	**12**	**5**	**24**	**10**

There is a 95 percent confidence of the parameter value not exceeding the 95 percentile value. There is a 99 percent confidence of the parameter value not exceeding the 99 percentile value.

Scenario 1: All 50 States

Parameter	Description	STDEV value	Mean value	Mode value	50%tile value	95%tile value	99%tile value
N	Annual Number of Avocados from Mexico	286,965,917	586,659,876	399,446,055	543,662,857	1,124,808,631	1,346,053,000
P1	Proportion of infested avocados	2.59E-07	2.15E-07	1.41E-08	1.30E-07	7.04E-07	1.23E-06
P2	Proportion of fruit that enters avocado growing areas	0.065	0.112	0.073	0.103	0.232	0.280
P2a	Proportion of fruit that enters fruit fly susceptible areas	0.000	0.537	0.537	0.537	0.537	0.537
P3	Proportion of fruit discarded	0.000	0.050	0.050	0.050	0.050	0.050
Q1	Number of infested avocados entering the USA	176.11	125.17	13.51	66.97	441.33	873.13
Q2	Number of infested avocados entering avocado growing areas of the U.S.	24.20	13.95	0.03	6.07	53.12	109.27
Q2a	Number of infested avocados entering fruit fly susceptible areas of the U.S.	94.57	67.22	7.25	35.97	237.00	468.88
Q3	Number of infested avocados discarded in avocado growing areas of the U.S.	1.21	0.70	0.00	0.30	2.66	5.46
Q3a	Number of infested avocados discarded in fruit fly susceptible areas of the U.S.	4.73	3.36	0.36	1.80	11.85	23.44

Scenario 2: 47 States excluding California, Florida and Hawaii

Parameter	Description	STDEV value	Mean value	Mode value	50%tile value	95%tile value	99%tile value
N	Annual Number of Avocados from Mexico	272,336,381	515,902,233	283,990,974	465,168,274	1,039,780,964	1,274,102,978
P1	Proportion of infested avocados	2.59E-07	2.15E-07	1.41E-08	1.30E-07	7.04E-07	1.23E-06
P2	Proportion of fruit that enters avocado growing areas	0.013	0.015	0.000	0.012	0.042	0.056
P2a	Proportion of fruit that enters fruit fly susceptible areas	0.000	0.248	0.248	0.248	0.248	0.248
P3	Proportion of fruit discarded	0.000	0.050	0.050	0.050	0.050	0.050
Q1	Number of infested avocados entering the USA	162.04	110.54	0.40	58.36	392.78	793.65
Q2	Number of infested avocados entering avocado growing areas of the U.S.	3.42	1.70	0.00	0.59	6.77	15.83
Q2a	Number of infested avocados entering fruit fly susceptible areas of the U.S.	40.13	27.38	0.10	14.45	97.28	196.56
Q3	Number of infested avocados discarded in avocado growing areas of the U.S.	0.17	0.08	0.00	0.03	0.34	0.79
Q3a	Number of infested avocados discarded in fruit fly susceptible areas of the U.S.	2.01	1.37	0.01	0.72	4.86	9.83

METHODOLOGY

The study is comprised of an analysis of the pathway of commercial exports from Mexico of fresh 'Hass' avocados, produced and imported in compliance with USDA regulations. The Quantitative Risk Assessment (QRA) was conducted to identify what can go wrong and how likely it is to happen.

The risk assessment provides a method for measuring phytosanitary risk and providing information to facilitate or support decision-making tasks.

Based on the probabilistic scenario analysis methodology, the risk assessment process involved:

A. Identifying the phytosanitary hazards;
B. Stating the questions to be answered;
C. Developing scenario trees (conceptual outlines), labeling the scenario trees and assigning units;
D. Stating assumptions;
E. Gathering and documenting the evidence, and Assigning values to the branches of the scenario trees;
F. Performing calculations to summarize the likelihood of the hazards occurring

A. Phytosanitary Hazards

APHIS conducted a screening analysis on previously identified avocado pests known to occur in Mexico that may have potential economic importance in the United States. The screening involved the elimination of non-quarantine pests and non-pathway pests from the list and resulted in the identification of pathway pests of quarantine significance. APHIS has identified the following quarantine pests that could pose a threat to U.S. agriculture if introduced into susceptible areas in the United States via this importation:

1. seed weevils:
    a. *Conotrachelus aguacatae,*
    b. *Conotrachelus perseae*, and
    c. *Heilipus lauri*
2. stem weevil: *Copturus aguacatae*
3. seed moth: *Stenoma catenifer*; and
4. fruit flies: *Anastrepha ludens, A. striata,* and *Ceratitis capitata*

The phytosanitary hazard (or unwanted event) is the introduction of any one of these pests into susceptible areas in the United States.

B. Questions to be answered

A quantitative risk assessment usually answers the questions: "What is the likelihood of the hazard occurring, what is its magnitude/frequency, and what are the consequences?" This risk assessment estimates the likelihood of entry of any pathway pest into susceptible areas in the US. The end point of entry was terminated at discarding for the quantitative portion. Therefore, the quantitative risk assessment estimates the likelihood of entry and discard of the avocado pests in susceptible areas. We estimate five quantitative endpoints:

a) the number of infested avocados entering the United States each year,

b) the number of infested avocados entering avocado producing areas in the United States each year,
c) the number of infested avocados entering fruit fly susceptible areas in the United States each year,
d) the number of infested avocados discarded in avocado growing areas, and
e) the number of infested avocados discarded in fruit fly susceptible areas.

Then estimates:

1) The annual number of infested fruit likely to enter the United States by computing the product of the annual number of avocados likely to be imported, and the proportion of imported avocados that are infested;
2) The annual number of infested fruit likely to enter susceptible areas (avocado growing and fruit fly susceptible areas where host material is available) in the United States by computing the product of the annual number of infested fruit likely to enter the United States, and the proportion of avocados consumed in susceptible areas.
3) The annual number of infested fruit likely to be discarded in susceptible areas in the United States by computing the product of the annual number of infested fruit likely to enter susceptible areas, and the proportion of avocados discarded (those that are not eaten, and do not go to landfills or are incinerated).

Due to the lack of quantitative data, the additional steps leading to the establishment of a pest in the United States are evaluated using qualitative evidence.

C. <u>Scenario Tree</u>

Infested 'Hass' avocados from Mexico could enter and be discarded in susceptible areas in the United States if:

A. A quantity of avocados are harvested in Mexico for export to the United States, and
B. a proportion of them are still infested after systems mitigations, and
C. some infested avocados are distributed to susceptible areas, and
D. some of those infested avocados are discarded in the susceptible areas.

A scenario tree is a pictorial representation of all possible outcomes of an initiating event. A risk pathway tree depicts that subset of pathways that lead to manifestation of a hazard. The risk pathway tree is a pictorial representation of what could go wrong where infested 'Hass' avocados from Mexico enter avocado producing and fruit fly susceptible areas.

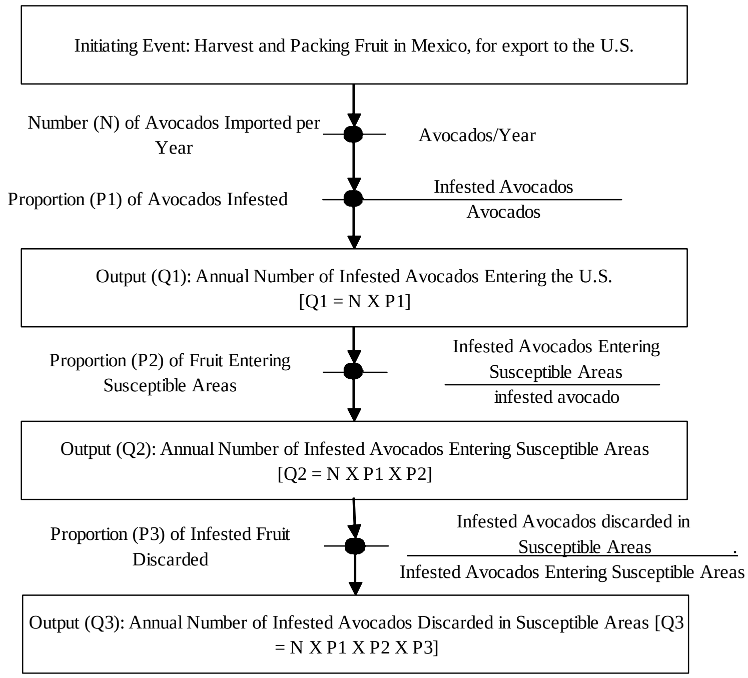
A risk pathway tree representing the generic pathway is presented on the following page.

According to the risk pathway tree (Figure 1), the annual number of infested avocados that enter and are discarded in susceptible areas is based on:

a) N, the potential quantity of avocados to be imported from Mexico, and
b) P1, the pest infestation rate (as determined by survey/inspection), and
c) P2, the fraction of avocados likely to enter susceptible areas, and

d) P3, the fraction of avocados likely to be discarded into the environment by consumers

Figure 1. Risk Pathway Tree



D. <u>Quantitative Model Assumptions:</u>

The following assumptions were made in the quantitative model:

1. Infested avocados are distributed homogeneously throughout the avocado population. In other words, each avocado is equally likely to be infested. The probability that any given avocado is infested is defined stochastically by a probability distribution.
2. The process of survey/inspection is a binomial process.
3. The proportion of avocados entering susceptible areas in the United States was estimated from the proportion of the total population represented in those areas, and the relative per-capita avocado consumption of individuals in those areas.
4. The effectiveness of specific mitigations is not considered in this quantitative model. However, it is assumed that the mitigations described in the keys safeguards sections will remain in place.
5. The prevalence of pest infestation in April to October (the proposed addition to the shipping season) is the same as the prevalence in October to April (the current shipping season).
6. The levels of inspection and fruit cutting in April to October (the proposed addition to the shipping season) is the same as the levels of inspection and fruit cutting in October to April (the current shipping season).
7. The systems approach remains in place in at least the current level of intensity.

The evidence used, and manner of estimation of each of the parameters is presented below.

E. Parameter Estimates

Parameter Estimate Node 1: Parameter: *N*

Description: Annual number of 'Hass' avocados imported from Mexico.

Units:

$$\frac{\textit{Avocados}}{\textit{Year}}$$

Evidence on N:

1. Historical records of Hass avocado importations from Mexico are documented by APHIS in the Federal Register (Vol. 66, No. 135, p 36896-7), and summarized in Table 1.

Table 1. Estimated number of Mexican 'Hass' avocado fruit entering the United States*

Season	Shipments	Boxes	Fruit
1997/1998	347	537,850	25,816,800
1998/1999	560	868,000	41,664,000
1999/2000	669	1,036,950	49,773,600
2000/2001	576	895,900	42,854,400
2001/2002	-	-	101,596,348

*Source: Federal Register Vol. 66, No. 135, p 36896-7; 2001/2002 values from J. G. Vila (USDA-APHIS-PPQ)

2. In 1997 'Hass' avocados were allowed to be shipped from Michoacán, Mexico, to 19 states and the District of Columbia, and the allowable shipping season was November 15 to February 15. Avocados to Alaska were allowed under a less restrictive program.
3. Since November 2001**,** 'Hass' avocados have been allowed to be shipped to 31 states and the District of Columbia, and the allowable shipping season is October 15 to April 15 (7CFR§319.56-2ff). Avocados to Alaska were allowed under a less restrictive program
4. It is proposed that avocados be allowed into all 50 states, plus the District of Columbia, with no seasonal restrictions.
5. In 1994 there were 23,500 hectares of avocados in Michoacán, Mexico, that were certified and produced avocados for export to the whole world.
6. The Hass avocado yield in Michoacán, Mexico, is 9 metric tons per hectare.
7. There is an annual increase in the certified growing area of 15% per year. The increase is expected to extend over the next five years.
8. On average, there are 48 avocados per 25 pound box imported from Mexico.
9. The initial quantity of avocados from Mexico is 58.247 million pounds (Table 1 & 3, APHIS 2004b)
10. For the 50 state scenario, the most likely quantity of avocados from Mexico is 209.307 million pounds (Table 3, APHIS, 2004b)

11. For the 47 state scenario, the most likely quantity of avocados from Mexico is 154.02565 million pounds (Table 1, APHIS, 2004b)

Evaluation:
The amount of avocados to be imported from Mexico will increase at least proportionately to:
a) the increased number of states that imports are allowed into (50 vs 31 and 47 vs 31), and
b) the increased time frame in which importation will occur (October to October vs October to April, 12 months vs 6 months)
The annual amount of avocados imported from Mexico will also depend on the potential increased production of avocados in Mexico into the future.

The quantity of imported avocados, N, is determined based on a lower bound (minimum value), most likely value, and an upper bound (maximum value). The minimum and maximum values represent amounts that could be imported, without reference to market expectations. Hass avocado imports from Mexico in 2002 serve as a lower bound for this range, and potential imports, based on expected total production in certified orchards after five years, is the upper bound. The most likely value represents the amount that Mexico's exporters are likely to send to the United States, based on economic assessment ptojections, for each of the two scenarios. A Pert distribution was used to define the distribution for the annual number of avocados imported from Mexico.

<u>Derivation of the minimum, maximum and most likely values of the distribution for N</u>:
To help in conversions: There is an average of 48 avocados per 25 pound box (Thus 1.92 avocados per pound). 1 Metric Ton = 2,205 pounds = 4,233 Avocados.

Minimum value of N: The minimum value for both scenarios is 58.247 million pounds per year (APHIS, 2004b). This equates to **114,286,464** avocados per year.

Most likely value of N: The most likely value is:
1. 209.307 million pounds per year, for the 50 state scenario(Mexican Hass Avocado Economic assessment, 2004). This equates to **401,869,440** avocados per year
2. 154.02565 million pounds per year, for the 47 state scenario(Mexican Hass Avocado Economic assessment, 2004). This equates to **295,729,248** avocados per year.

Maximum value of N: The maximum value is 937,841,349 pounds (**1,800,655,390** avocados) per year for both scenarios.

Derivation of this quantity is based on the expected total production in certified areas in 2004. This is calculated by determining the total production in tons in 2004, and correcting this for the annual rate of increase: 23,500 hectares with a yield of 9 metric tons per hectare gives a total production of 211,500 metric tons. An annual rate of increase in the certified area of 15 percent over five years, based on industry expectations necessitates multiplying the 211,500 metric tons by the compounded increase over five years ($2.0114 = \{1+0.15\}^5$), yields 425,402 metric tons. This is 937,841,349 pounds of avocados, and equates to **1,800,655,390** avocados.

i	Total Production in 2004 (Hectares)	23,500		
j	Yield (Metric Tons per Hectare)	9		c = (i*j)*(1+k)^L
k	Annual Percent Increase	0.15		
L	Number of years of increase	5		
c	**Maximum**	425,402	937,841,349	1,800,655,390

This maximum value assumes that all production from all certified orchards would be exported to the United States. It is unlikely that the actual number of avocados imported would exceed this level because the maximum value (937,841,349 pounds) exceeds the U.S. supply of avocados of all varieties from all sources, domestic and foreign, in 2002. The maximum estimate is five to seven times the amount imported in the 2001/2002 season

Summary of N

APHIS estimates that between 111 million and 1.8 billion ‘Hass’ avocados will be imported from Mexico annually under both the 50 state scenario, and the 47 state scenario. The most likely value is approximately 402 million for the 50 state scenario, and 296 million for the 47 state scenario. . The most likely estimates are based on projections from the Economic Analysis (APHIS, 2004b).

Description	**Minimum**	**Most likely**	**Maximum**
Annual pounds of avocados from Mexico under 50 state scenario	58,247,000	209,307,000	937,841,349
Annual pounds of avocados from Mexico under 47 state scenario	58,247,000	154,025,650	937,841,349

Description	**Minimum**	**Most likely**	**Maximum**
Annual Number of Avocados from Mexico under 50 state scenario	111,834,240	401,869,440	1,800,655,390
Annual Number of Avocados from Mexico under 47 state scenario	111,834,240	295,729,248	1,800,655,390

The probability distribution for the annual number of avocados imported is a pert distribution defined by minimum, most likely, and maximum values.

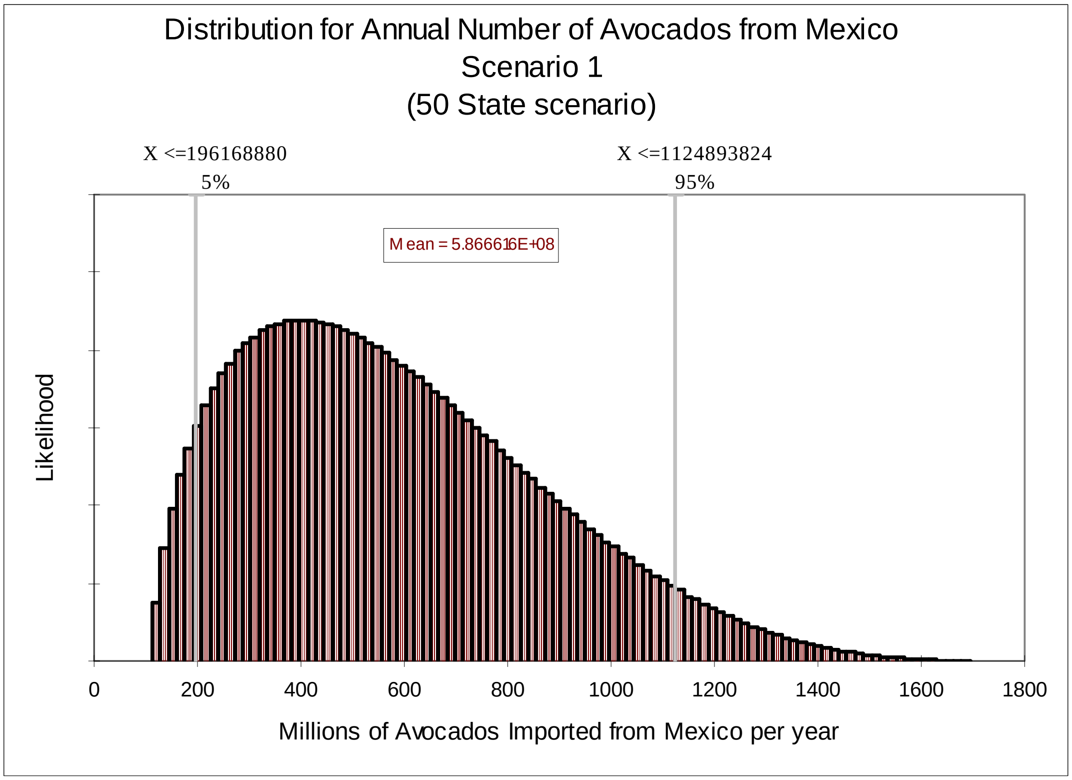
The pert distributions for the two scenarios are represented by the following equation:

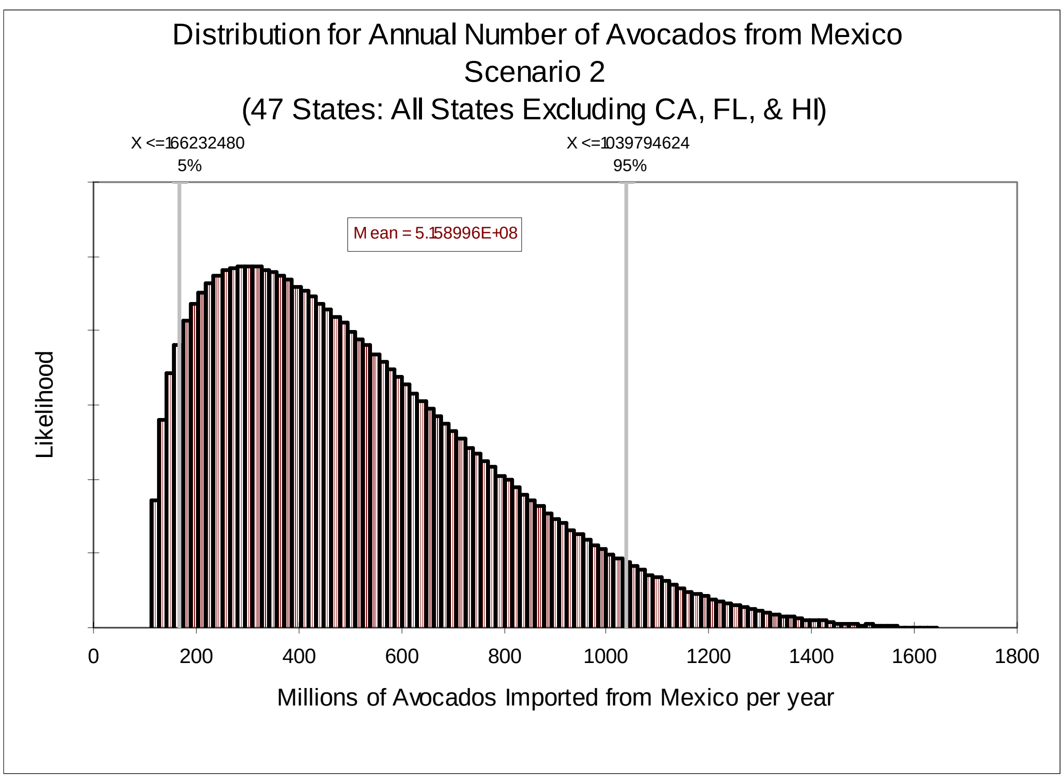
$N_{50\ state}$ = RiskPert(**111,834,240**, **401,869,440**, **1,800,655,390**)

$N_{47\ state}$ = RiskPert(**111,834,240**, **295,729,248**, **1,800,655,390)**

The probability distribution for N, are presented in Figure 2. on the following page.

Figure 2. Distributions for the annual number of 'Hass' avocados imported into the U.S.





<u>Parameter Estimate Node 2: Parameter</u>: *P1*

Description: Fraction/Proportion of Avocados entering the UNITED STATES Infested.

Units:

Infested Avocados

Avocado

Evidence on P1:

P1-1. Seed weevils (*Conotrachelus aguacatae, Conotrachelus perseae*, and *Heilipus lauri*) and the seed moth (*Stenoma catenifer*) have never been found in foliage and tree surveys in Michoacan, Mexico. In four years of surveys, the only pest detected via survey in Michoacan, Mexico is the stem weevil (*Copturus aguacatae*). Tables 3 & 4 contain data obtained from surveys in Michoacan, Mexico.

Table 3 - Foliage Surveys in Avocado Orchards in Michoacán, Mexico
(Proposed orchards to be included in the Hass avocado export program to the US)

Year	Number of Orchards	Number of Orchards Positive				
		Stem Weevil *Copturus aguacatae*	Seed Weevil *Heilipus lauri*	Seed Moth *Stenoma catenifer*	Seed Weevils *Conotrachelus aguacatae & C. perseae*	Fruit Flies *Anastrepha* spp. & *Ceratitis capitata*
1997	61	0	0	0	0	0
1998	244	0	0	0	0	0
1999	500	3	0	0	0	0
2000	790	0	0	0	0	0
2001	996	1	0	0	0	0
2002	1,469	3	0	0	0	0
Total	**4,060**	**7**	**0**	**0**	**0**	**0**

Table 4 – Wild and Backyard Tree Surveys in Michoacán, Mexico

Year	No. of backyards	No. of wild trees surveyed	Number of Sites Positive				
			Stem Weevil *Copturus aguacatae*	Seed Weevil *Heilipus lauri*	Seed Moth *Stenoma catenifer*	Seed Weevils *Conotrachelus aguacatae & C. perseae*	Fruit Flies *Anastrepha* spp. & *Ceratitis capitata*
1997	42	200	0	0	0	0	0
1998	82	107	19	0	0	0	0
1999	31	379	37	0	0	0	0
2000	54	270	25	0	0	0	0
2001	54	191	24	0	0	0	0
2002	398	762	145	0	0	0	0
Total	**661**	**1,909**	**250**	**0**	**0**	**0**	**0**
Source - USDA, APHIS, International Services. – NAR, 2003- Uruapan,Mich.							

P1-2. None of the orchards that were positive for stem weevil were permitted to export avocados to the US. They were removed from certification and the export program for the shipping season. (7CFR§319.56-2ff(e)(2))

P1-3. To date, more than ten million fruit have been cut as part of the avocado export program, and none of the five quarantine pests have been detected as shown in Table 5.

Table 5. Fruit sampled for seed weevils, stem weevils, seed moths, and fruit flies*

Season	Field Samples	Packing house	Border Inspection	Season Total	Quarantine Pests Detected
1997/1998	1,155,305	417,900	10,410	1,583,615	0
1998/1999	1,121,471	203,250	16,860	1,341,581	0
1999/2000	952,423	166,650	20,070	1,139,143	0
2000/2001	1,209,814	172,800	17,280	1,399,894	0
2001/2002	1,616,456	347,475	41,250	2,005,181	0
2002/2003	2,749,876	141,558	11,880	2,903,314	0
Subtotal	8,805,345	1,449,633	117,750	**10,372,728**	0

*Source: Federal Register Vol. 66, No. 135, p 36896-7 and Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentacion, Mexico. The table was update with numbers from the 2001/2002 and 2002/2003 shipping seasons.

Evaluation:

Examination of the survey data presented in Tables 3 & 4 can lead one to conclude that seed weevils and seed moths do not exist in Michoacan, Mexico. However, APHIS is uncertain whether the lack of detection of these pests is due to pest absence, or is due to below-detectable-levels of pest prevalence. For purposes of this risk assessment, APHIS has assumed the latter.

According to evidence P1-3, none of the orchards that were positive for stem weevil (Table 3 & 4) were permitted to export avocados to the US. They were removed from the export program. The orchards that remained in the export program have been assumed to have stem weevils at below-detectable-levels of prevalence.

Examination of the sampling data for the six import seasons, in Table 5, indicates that a total of 10,372,728 avocados were sampled, and no quarantine pests were found.

This information can be used to estimate the undetectable prevalence of pest infestation in the avocados that are imported into the United States.

The sampling data has been translated into the language of probability as follows:

- The sampling procedure is modeled as a binomial process where:
  - an avocado is either infested, or not infested, and
  - an infested avocado, when sampled and cut, is determined to be either infested or not infested. Sensitivity is a measure of likelihood that an infested avocado will be positively identified.
  - This likelihood of successful identification is the product of the prevalence of infestation and the sensitivity of the test, and does not change from trial to trial.

- The three parameters that characterize a binomial process are:

- n, the number of trials
- p, the probability of success on one trial
- x, the number of successes in n trials

- Based on the sampling data (Table 5) the values of these three parameters are:
  - n, number of binomial trials, is 10,372,728
  - x, the number of successful trials (detections), is 0
  - p, the probability of success on one trial, x, is unknown. This probability of success is the product of the prevalence and the sensitivity. It is what we desire to estimate.

- **<u>When n and x are known</u>, as is the case in hand, the question that can be answered is**:
  - What is the probability of success on a single trial if there have been x detections in n observations?

    The RiskBeta @Risk function can be used iteratively to develop a Beta probability distribution for the probability of success, p, as follows: p = RiskBeta(x+1, n-x+1)

However, because n is greater 7,000,000 the RiskBeta function in @Risk doesn't work. As a workaround the Excel BETAINV function can be used to compute p.
APHIS has used the Excel BETAINV() function to generate the probability distribution for the proportion of infested avocados, P1. P1 is represented by the equation:

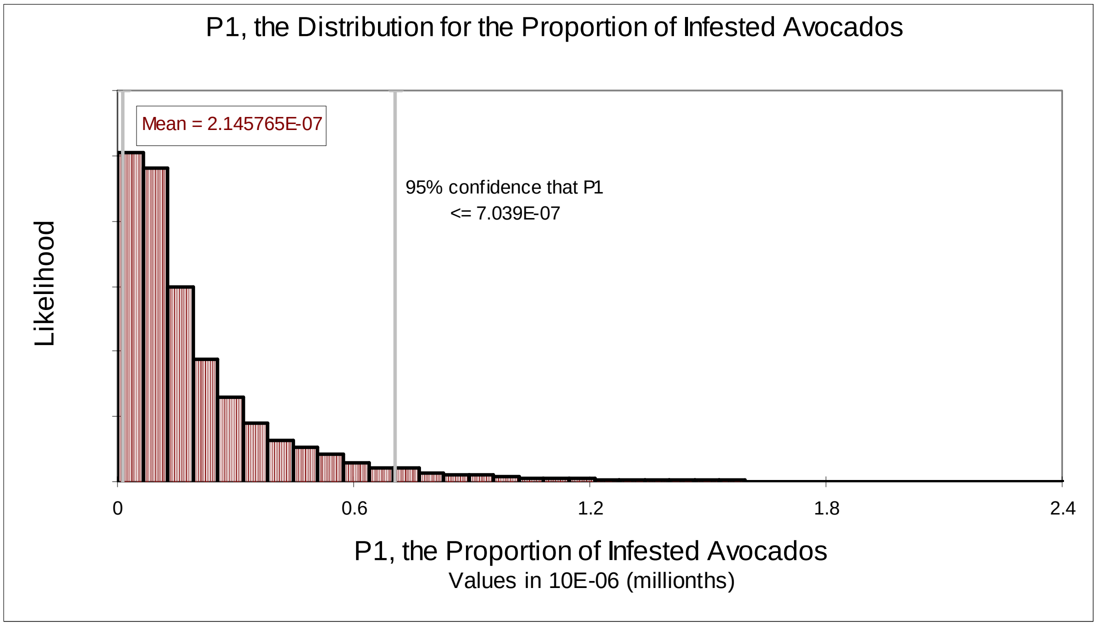
P1 = BetaInv(RiskUniform(0,1),x+1,n*sens-x+1)

where x = 0 and n = 10,372,728 and sens = RiskUniform(0.179,0.835)
sens = sensitivity of inspection

Gould (1995) reported that the sensitivity of detection of fruit infested with third instar Caribbean fruit fly larvae ranged between 17.9% for green guavas to 83.5% for carambolas by experienced inspectors. The study did not include avocado. The estimate for sensitivity is represented in the model by a uniform distribution ranging from 17.9% to 83.5%. All values within the range are considered equally likely.

The resulting distribution is represented in Figure 3.

Figure 3. Probability Distribution for P1, the Proportion of Infested Avocados



There is 95% confidence that the proportion of infested avocados is less or equal to 7.03×10^{-7}. The most likely proportion of infested avocados is zero (0).

<u>Parameter Estimate Node 3: Parameter</u>: *P2*

Description: P2 is the proportion of infested avocados entering susceptible areas.

Units:

$$P2 = \frac{\textit{Infested Avocados entering susceptible area}}{\textit{Infested Avocado}}$$

Two quantitative determinations were performed for P2 as follows:

1. **For the Avocado Pests** (seed moth, stem weevil and three seed weevils), the susceptible areas are those in which the avocado host exists (avocado growing areas).
2. **For Fruit Flies**, since fruit flies can infest other fruit aside from Avocados, it was necessary to consider that the susceptible area to fruit fly infestation is the whole of plant hardiness zones 8-11.

Evidence:

P2-1. Table 6 presents the U.S. per capita consumption of avocados by region

P2-2. Table 7 presents the population in U.S. counties that grow avocados, the number of avocado farms in those counties, and the derived population of the county living in the proportionate area of the farms, and the derived population of the county living in the proportionate area of the farms with a one mile radius buffer around them.

In the evaluation of P2 the following important factors were considered:

- An assumption is made that infested avocados are homogeneously mixed in the total avocado population entering the U.S. from Mexico.
- Based on this assumption, the proportion of infested avocados entering susceptible areas is equivalent to the proportion of avocados entering susceptible areas.
- The number of avocados entering an area is is based solely on the number of avocados consumed in an area.
- The number consumed in an area is dependent on the population in the area and the percapita consumption of the population

Therefore, the proportion of infested avocados entering an area is dependent on the population in the area, the percapita consumption of the population, and the total avocado consumption in the U.S. and can be determined as:

$$\mathbf{P2} = \frac{\textbf{Population in susceptible area} \times \textbf{Per Capita consumption of population}}{\textbf{Total avocado consumption in US}}$$

Table 6 - Approximate U.S. per Capita Consumption of Avocados, by Region, 2002

Region[1]	2002 Population[2]	California Hass and non-Hass Avocado Shipments[3]	Florida Avocado Shipments[4]	Hass Avocado Imports from Mexico[5]	Avocado Imports other than from Mexico[6]	Total Supply	Consumption per Capita
Pacific	57,882,559	196,496,750	3,206,256		92,343,798	292,046,804	5.05
Southwest	27,128,666	73,805,625	1,502,723		34,811,376	110,119,724	4.06
Southeast	58,049,092	33,883,650	27,517,768		27,341,565	88,742,983	1.53
Northeast	70,158,899	29,050,850	16,510,661	28,386,814	20,442,967	94,391,292	1.35
East Central	49,765,488	28,694,950	11,007,107	20,135,487	17,947,764	77,785,308	1.56
West Central	25,383,994	19,513,050	1,406,081	10,270,553	9,630,738	40,820,422	1.61
United States	288,368,698	381,444,875	61,150,596	58,792,854	202,518,208	703,906,533	2.4

Sources:

[1] Regions are according to California's Avocado Marketing Research and Information Center (AMRIC). Pacific: AK, AZ, CA, HI, ID, NV, OR, UT, WA; Southwest: NM, OK, TX; Southeast: AL, AR, FL, GA, LA, MS, NC, SC, TN; Northeast: CT, DC, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT, VA, WV; East Central: IL, IN, KY, MI, OH, WI; West Central: CO, IA, KS, MN, MO, MT, NE, ND, SD, WY.

[2]U.S. Department of Commerce, Bureau of the Census.

[3]AMRIC. All major California avocado handlers participate in the AMRIC system, representing about 95 percent of all California avocado production.

[4]Florida Avocado Administrative Committee (USDA Marketing Order #915). Reported production in 2002: 1,111,829 bushels, with each bushel 55 pounds. Distribution among regions based on personal communications with AMS and Florida Agricultural Extension staff.

[5]Total Hass avocado imports from Mexico based on U.S. Census Bureau data; distributed among the Northeast, East Central, and West Central regions by population.

[6]Total avocado imports other than from Mexico based on U.S. Census Bureau data; distributed among the regions in the same proportion as the California shipments for imports from Chile, New Zealand, Ecuador, and Brazil, and in the same proportion as the Florida shipments for imports from the Dominican Republic and the Bahamas.

Evaluation of P2

In calculating P2, it is necessary to a) determine the susceptible area, b) determine the population in the susceptible area, c) determine the percapita consumption of that population, and d) divide the product of the population and the percapita consumption by the total number of avocados from Mexico.

Evaluation of P2 for the other pathway pests, P2,
The proportion of avocados consumed in susceptible areas, is represented in the model as a distribution defined by minimum, most-likely, and maximum values.

The minimum proportion of avocados consumed in susceptible areas (avocado growing areas). The *minimum susceptible area* is the total area of commercial avocado orchards in the U.S. (see column

The *minimum susceptible area* (a2 in Table 7) was calculated as follows:

For each avocado growing county in the U.S., the number of avocado farms was multiplied by the area of each avocado farm (assumed to be 0.0314 square miles or 0.1 mile in radius). The product (square miles in avocados) was divided by the square miles in the county to determine the proportion of the county in avocados.

The population in the minimum susceptible area (n2 in Table 7) was determined as follows:

The proportion of area growing avocados was multiplied by the county population to determine the population in susceptible areas (assuming the population is evenly distributed). The population in avocado growing areas of each county within the Pacific, Southwest, and Southeast regions was determined from the data in Table 7 and the summed results are shown in Table 8.

The number of avocados consumed in the minimum susceptible area:

The percapita consumption of each region (from Table 6) was multiplied by the population in the susceptible area in each region (Table 7) to yield the number of avocados consumed in the susceptible area in each region (Table 8).

The Most Likely proportion of avocados consumed in susceptible areas (avocado growing areas). The *most likely susceptible area* is the total area of commercial avocado orchards in the U.S. including a one-mile buffer zone around each orchard. This parameter was calculated in the same manner as the *mimimum susceptible area* except for the inclusion of a one mile buffer zone for each avocado farm. The area of each avocado farm is assumed to be 3.8 square miles (1.1 mile radius for each farm).

Table 8 shows the calculation of the minimum and most likely proportion of avocados consumed in susceptible regions. The population in susceptible regions is multiplied by the per capita avocado consumption in each region to determine the avocados consumed in susceptible areas. The total avocados consumed in avocados growing areas divided by the total avocados consumed in the U.S. is the *proportion of avocados consumed in susceptible areas* in the U.S.

Table 7 - Population in susceptible areas of the U.S.

County	**State**	**Number of Avocado Farms in the county**	**County Population**	**County Area (miles^2)**	**Avocado growing Area (miles^2)** [Minimum Susc. Area]	**Avocado growing Area with buffer (miles^2)** [Most likely Susc. Area]	**Pop. in avocado growing areas** [Pop in Min susc area]	**Pop. in avocado growing areas with buffer** [Pop in Most likely Susc. Area]
		m	n1	a1	a2 = m**PI**$(0.1)^2$	a3 = m**PI**$(1.1)^2$	n2= n1*a2/a1	n3= n1*a3/a1
Los Angeles	CA	90	9,519,338	4,752	2.8274	342	5,664	685,344
Madera	CA	3	123,109	2,153	0.0942	11	6	653
Monterey	CA	6	401,762	3,771	0.1885	23	21	2,430
Orange	CA	37	2,846,289	948	1.1624	141	3,490	422,287
Riverside	CA	558	1,545,387	7,303	17.5301	2,121	3,710	448,855
San Benito	CA	5	53,234	1,391	0.1571	19	7	728
San Bernardino	CA	41	1,709,434	20,105	1.2881	156	110	13,252
San Diego	CA	2,757	2,813,833	4,526	86.6137	10,480	53,849	6,515,621
San Joaquin	CA	9	563,598	1,426	0.2827	34	112	13,522
San Luis Obispo	CA	122	246,681	3,616	3.8327	464	262	31,638
Santa Barbara	CA	393	399,347	3,789	12.3465	1,494	1,302	157,454
Santa Clara	CA	5	1,682,585	1,304	0.1571	19	203	24,525
Santa Cruz	CA	32	255,602	607	1.0053	122	424	51,223
Tulare	CA	50	368,021	4,839	1.5708	190	120	14,456
Ventura	CA	902	753,197	2,208	28.3372	3,429	9,667	1,169,638
Hawaii	HI	1,007	148,677	5,087	31.6358	3,828	925	111,879
Honolulu	HI	8	876,156	2,127	0.2513	30	104	12,527
Kauai	HI	13	58,463	1,266	0.4084	49	19	2,283
Maui	HI	29	128,094	2,399	0.9111	110	49	5,887
Brevard	FL	12	476,230	1,557	0.3770	46	116	13,953
Broward	FL	5	1,623,018	741,043	0.1571	19	1	42
Collier	FL	3	251,377	2,305	0.0942	11	11	1,244
Dade	FL	482	2,253,362	2,431	15.1425	1,832	14,036	1,698,355
Hillsborough	FL	4	998,948	1,266	0.1257	15	100	11,998
Palm Beach	FL	4	1,131,184	2,386	0.1257	15	60	7,209
Cameron	TX	6	335,227	1,276	0.1885	23	50	5,993
Hidalgo	TX	10	569,463	1,583	0.3142	38	114	13,675

Number of avocado farms from NASS Census of Agriculture.
County Population from U.S. Census.2002.

Table 8. Minimum and Most Likely proportion of avocados consumed in avocado growing areas

					Scenario 1 Considering 50 states		Scenario 2 Considering 47 states, excuding CA, FL and HI	
Region	**States**	**Minimum Population**	**Most Likely Population**	**Per Capita Consu mption**	**Minimum number of Avocados consumed**	**Most Likely number of Avocados consumed**	**Minimum number of Avocados consumed**	**Most Likely number of Avocados consumed**
Pacific	CA & HI	80,044	9,684,202	5.05	404,222	48,905,220	0	0
Southwest	TX	164	19,668	4.06	666	79,852	666	79852
Southeast	FL	14,324	1,732,801	1.53	21,916	2,651,186	0	0
Avocados consumed in growing areas					426,804	51,636,258	666	79,852
Avocados consumed in the U.S.					703,906,532	703,906,532	703,906,532	703,906,532
P2, Proportion of Avocados consumed in growing areas					**0.000606**	**0.073357**	**0.000001**	**0.000113**

Population values were taken from Table 7, per capita consumption rates from Table 6, and total avocados consumed in the U.S. from Table 6.

The Maximum proportion of avocados consumed in avocado growing areas
The *maximum susceptible area* is all of plant hardiness zones 9-11 in the U.S. Hardiness zones 9-11 includes portions of California, Arizona, Florida, Louisiana, Nevada, Oregon, and Texas plus all of Hawaii. It is possible for avocados to grow in this region, even though the actual growing area is substantially less. Table 9 shows the population in counties within plant hardiness zones 9-11.

Table 10 shows the calculation of the proportion of avocados consumed in plant hardiness zones 9-11. The population in plant hardiness zones 9-11 is multiplied by the per capita avocado consumption in each region to determine the avocados consumed. The total avocados consumed in this area, divided by the total avocados consumed in the U.S. is the *proportion of avocados consumed in plant hardiness zones 9-11* in the U.S.

Table 9. Population of U.S. Counties in Plant Hardiness Zones 9-11

California	**Pop.**	**California**	**Pop**	**Texas**	**Pop.**	**Florida**	**Pop.**
Alameda	1,443,741	Stanislaus	446,997	Aransas	22,695	Brevard	489,522
Amador	35,100	Sutter	78,930	Bee	32,314	Broward	1,668,560
Butte	203,171	Tehama	56,039	Brazoria	249,832	Charlotte	147,009
Calaveras	40,554	Touloumne	54,501	Brooks	7,683	Citrus	122,470
Contra Costa	948,816	Trinity	13,022	Cameron	344,782	Clay	147,542
Del Norte	27,507	Tulare	368,021	Chambers	26,859	Collier	265,769
El Dorado	156,299	Ventura	753,197	Dawson	14,838	DeSoto	32,438
Fresno	799,407	Yolo	168,660	Dimmit	10,170	Duval	792,434
Glenn	26,453	Yuba	60,219	Duval	12,996	Flagler	54,964
Humboldt	126,518		**33,771,127**	Fort Bend	381,200	Glades	10,750
Imperial	142,361	**Louisiana**		Frio	16,392	Hardee	26,759
Inyo	17,945	Ascension	79,873	Galveston	255,865	Hendry	36,562
Kern	661,645	Assumption	23,257	Harris	3,460,589	Hernando	135,751
Kings	129,461	Calcaseiu	182,842	Jackson	14,291	Highland	88,972
Lake	58,309	Cameron	9,805	Jefferson	249,640	Hillsborough	1,027,318
Los Angeles	9,519,338	Iberia	73,530	Jim Hogg	5,161	Indian River	116,488
Madera	123,109	Jefferson	451,459	Jim Wells	39,950	Lake	227,598
Marin	247,289	Jefferson Davis	31,275	Kennedy	413	Lee	462,455
Mariposa	17,130	Lafayette	190,894	Kleberg	31,015	Manatee	274,523
Mendocino	86,265	LaFourche	90,273	LaSalle	5,849	Marion	267,889
Merced	210,554	Plaquemines	27,004	Hidalgo	590,285	Martin	130,313
Monterrey	401,762	San Martin	49,181	Liberty	72,620	Miami-Dade	2,289,683
Napa	124,279	St Bernard	49,181	Live Oak	12,177	Monroe	78,556
Nevada	92,033	St Charles	48,548	Matagorda	38,157	Okeechobee	36,385
Orange	2,846,289	St James	21,224	Maverick	48,259	Orange	923,311
Placer	248,399	St John Baptist	43,798	McMullen	849	Osceola	181,932
Riverside	1,545,387	St Mary	52,833	Nueces	312,470	Palm Beach	1,165,049
Sacramento	1,223,499	Terre Bonne	105,123	Orange	84,582	Pasco	362,658
San Benito	53,234	Vermillion	53,661	Refugio	7,729	Pinellas	924,610
San Bernardino	1,709,434		1,583,761	San Patricio	67,120	Polk	492,751
San Diego	2,813,833	**Arizona**		Starr	54,671	Putnam	70,880
San Francisco	776,733	Mojave	161,788	Victoria	84,710	Sarasota	335,323
San Joachim	563,598	Yuma	164,942	Webb	201,292	Seminole	374,334
San Luis Obispo	246,681	Yavapai	175,507	Wharton	41,202	St Johns	131,684
San Mateo	707,161	Maricopa	3,194,798	Willacy	19,905	St Lucie	200,018
Santa Barbara	399,347	Pinal	188,846	Zapata	12,461	Sumpter	54,504
Santa Clara	1,682,585	Pima	863,049		6,831,023	Volusia	454,581
Santa Cruz	255,602	Cochise	119,281	**Oregon**			14,602,345
Shasta	163,256	Santa Cruz	39,590	Tillamook	24,308	**Nevada**	
Siskiyou	44,301		4,907,801	Lane	324,316	Clark	1,464,653
Solano	394,542			Douglas	100,866		
Sonoma	458,614			Coos	62,459	**Hawaii**	1,224,398
				Curry	21,118		
					533,067		

Table 10. Estimating the proportion of avocados consumed in plant hardiness zones 9-11 in the U.S.

REGION	STATE	STATE POP.	Avocado growing area REGION POP. (50 state scenario).	Avocado growing area REGION POP. (47 state scenario).	Per Capita Consumption	Avocados Consumed (50 state scenario)	Avocados Consumed (47 state scenario)
Pacific	California	33,771,127					
	Arizona	4,907,801					
	Oregon	533,067					
	Nevada	1,464,653					
	Hawaii	1,224,398					
			41,901,046	6,905,521	5.05	211,600,282	34,872,881
Southwest	Texas	6,831,023					
			6,831,023	6,831,023	4.06	27,733,953	27,733,953
Southeast	Louisiana	1,583,761					
	Florida	14,602,345					
			16,186,106	1,583,761	1.53	24,764,742	2,423,154
Avocados consumed in growing areas						264,098,978	65,029,989
Avocados consumed in the U.S.						703,906,532	703,906,532
P2, Proportion of Avocados consumed in Avocado growing areas						0.375	0.092

Population values taken from Table 9, per capita consumption rates from Table 6, and total avocados consumed in the U.S. from Table 6

Evaluation of P2 for fruit flies

The *fruit fly susceptible area* is all of plant hardiness zones 8-11. In the U.S. hardiness zones 8-11 includes parts of California, Arizona, Nevada, Oregon, New Mexico, Alabama, Mississippi, Arkansas, Washington, Georgia, North Carolina, South Carolina, Virginia, and Texas, plus all of Florida, Louisiana, and Hawaii (Appendix G).

Table 11 shows the calculation of the proportion of avocados consumed in the fruit fly susceptible regions. The population in plant hardiness zones 8-11 is multiplied by the per capita avocado consumption in each region to determine the number of avocados consumed. The total avocados consumed in the fruit fly susceptible area, divided by the total avocados consumed in the U.S. is the *proportion of avocados consumed in the fruit fly susceptible areas* in the U.S.

The proportion of avocados entering fruit fly susceptible areas, P2, is represented in the model as a point estimate, and has been determined to be 53.7% (Table 12, Appendix G). There is no distribution for P2 for fruit fly susceptible areas.

Table 11. Estimating the proportion of avocados consumed in fruit fly susceptible areas (Plant Hardiness Zones 8 to 11)

REGION	STATE	Population supplied avocados (50 state scenario)	Population supplied avocados (47 state scenario)	Avocado growing area REGION POP. (50 state scenario).	Avocado growing area REGION POP. (47 state scenario).	Per Capita Consumption	Avocados Consumed (50 state scenario)	Avocados Consumed (47 state scenario)
Pacific	ARIZONA	5,120,630	5,120,630					
	CALIFORNIA	34,132,979	0					
	HAWAII	1,224,398	0					
	NEVADA	1,509,113	1,509,113					
	OREGON	3,031,029	3,031,029					
	WASHINGTON	4,732,172	4,732,172					
	Total for Pacific region			49,750,321	14,392,944	5.05	251,239,121	72,684,367
Southwest	TEXAS	18,728,368	18,728,368					
	NEW MEXICO	314,047	314,047					
	Total for Southwest region			19,042,415	19,042,415	4.06	77,312,205	77,312,205
Southeast	ALABAMA	1,825,459	1,825,459					
	ARKANSAS	375,960	375,960					
	FLORIDA	16,419,963	0					
	GEORGIA	2,772,498	2,772,498					
	LOUISIANNA	4,081,130	4,081,130					
	MISSISSIPPI	1,983,082	1,983,082					
	NORTH CAROLINA	1,502,018	1,502,018					
	SOUTH CAROLINA	2,526,450	2,526,450					
	Total for Southeast region			31,486,560	15,066,597	1.53	48,174,437	23,051,893
Northeast	VIRGINIA	949,601	949,601					
	Total for Northeast region			949,601	949,601	1.35	1,281,961	1,281,961

Avocados consumed in fruit fly susceptible areas	378,007,724	174,330,427
Avocados consumed in the U.S.	703,906,532	703,906,532
P2a, Proportion of Avocados consumed in fruit fly susceptible areas	0.537	0.248

Population values taken from Appendix G, per capita consumption rates from Table 6, and total avocados consumed in the U.S. from Table 6

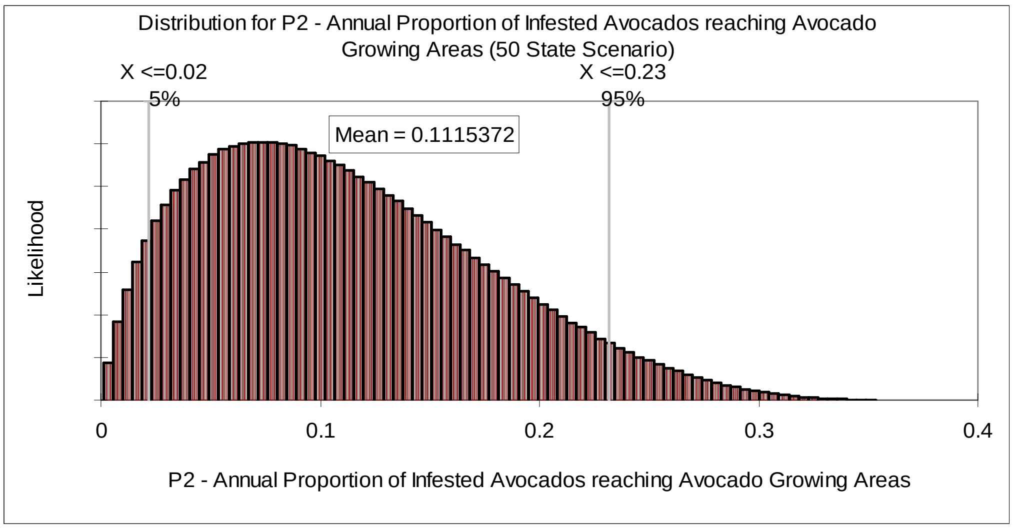
Distribution for **P2 for Avocado Pests:**

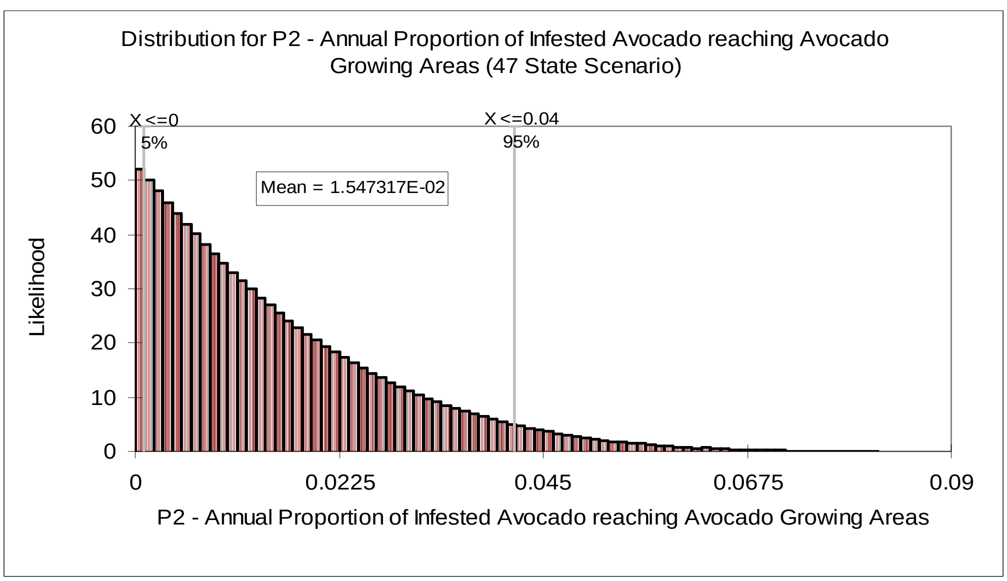
In this risk assessment an assumption has been made that the distribution of avocados in the United States depends solely on the relative consumption of avocados, and other market forces are not considered.

P2, is represented by a pert distribution that, for each of the two scenarios, is defined by a minimum, most likely, and maximum value as follows:

Parameter	Description	Minimum	Most likely	Maximum
$P2_{50\ state}$	Proportion of fruit that enters avocado growing areas (50 state scenario)	0.000606	0.073357	0.375
$P2_{47\ state}$	Proportion of fruit that enters avocado growing areas (47 state scenario)	0.000001	0.000113	0.092

The resulting probability distribution functions (PDF) for P2 are presented below.





Parameter Estimate Node 4: P3

Description: P3 is the proportion of infested avocados that are discarded in susceptible areas.

Units:

Infested Avocados discarded in susceptible area

Infested Avocados entering susceptible area

One quantitative determination was performed for P3 as follows:

Evidence:

P3-1. A maximum of 5% of fruit is routinely discarded into the environment. The other 95% is either eaten by consumers, thrown in the trash, or disposed of in such a way that any pests in it have no chance of establishing in a host population (APHIS, 2003d; Roberts *et al.*, 1998; Wearing *et al.*, 2001).

Most fruit is eaten by consumers, discarded as garbage, or disposed of in such a way that any pests would have no chance of establishment. We based our estimate of P3 on information from two risk analyses:

1) Suburban New Zealand (5%; Wearing *et al.*, 2001) related to how much cherry fruit with codling moth might be discarded.
2) Urban Japan (0.5%; Roberts *et al.*, 1998) related to how much apple fruit with fire blight might be discarded.

No studies are known for the United States. For simplicity, we used a point estimate and, in an abundance of caution, chose the higher of the two reported numbers (.05). The use of the maximum value ensures that we do not underestimate risk.

Following is a summary of the input parameters used in scenarios 1 and 2

Input Parameters

Scenario1: 50 States						
Distributed all year round to all states						
	Description	Minimum	Most likely	Maximum	Equation	Reference
	Annual pounds of avocados from Mexico	58,247,000	209,307,000	937,841,349		
N	Annual Number of Avocados from Mexico	111,834,240	401,869,440	1,800,655,390	N = RiskPert(min,ml,max)	
P1	Proportion of infested avocados	ns = 10,372,728	x = 0	Sens = RiskUniform (17.9%, 83.5%)	P1 = BetaInv(RiskUniform(0,1),x+1, ns*sens-x+1)	
P2	Proportion of fruit that enters avocado growing areas	0.000606336	0.073356696	0.375190406	P2 = RiskPert(min,ml,max)	Table 8 for MIN & ML Table 10 for MAX
P2a	Proportion of fruit that enters fruit fly susceptible areas		0.537014088		P2a = most likely value	Table 11
P3	Proportion of fruit discarded		0.05		P3 = most likely value	

Scenario1: 50 States						
Distributed all year round to all states						
	Description	Minimum	Most likely	Maximum	Equation	Reference
	Annual pounds of avocados from Mexico	58,247,000	154,025,650	937,841,349		
N	Annual Number of Avocados from Mexico	111,834,240	295,729,248	1,800,655,390	N = RiskPert(min,ml,max)	
P1	Proportion of infested avocados	ns = 10,372,728	x = 0	Sens = RiskUniform (17.9%, 83.5%)	P1 = BetaInv(RiskUniform(0,1),x+1, ns*sens-x+1)	
P2	Proportion of fruit that enters avocado growing areas	0.000000946	0.000113441	0.092384409	P2 = RiskPert(min,ml,max)	Table 8 for MIN & ML Table 10 for MAX
P2a	Proportion of fruit that enters fruit fly susceptible areas		0.247661329		P2a = most likely value	Table 11
P3	Proportion of fruit discarded		0.05		P3 = most likely value	

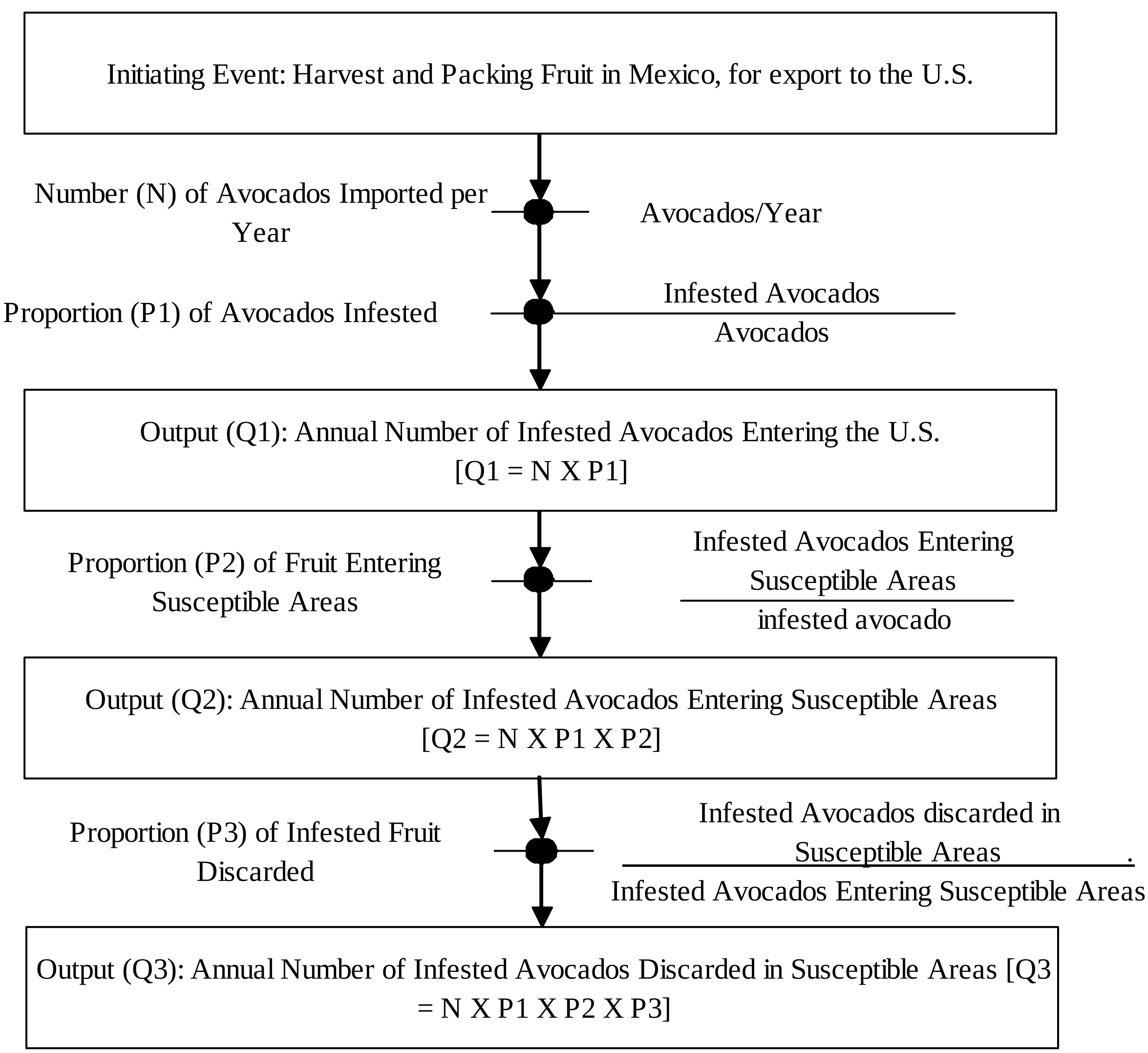
<u>**Mathematical** Model: Performing Calculations</u>

This quantitative risk assessment estimates the number of infested Mexican 'Hass' avocados that enter susceptible areas via the importation of avocados from Michoacán, Mexico.

The annual number of infested avocados entering susceptible areas in the United States is based on:

a) N, the quantity of avocados imported from Mexico per year, and
b) P1, the proportion of avocados that are still infested on importation to the United States (the pest infestation rate, as determined by inspection), and
c) P2, the fraction of avocados likely to end up in susceptible areas.
d) P3, the fraction of avocados likely to be discarded

The following risk pathway tree represents this.



As shown in the scenario tree, the annual number of infested avocados entering susceptible areas, Q2, is determined mathematically by taking the product of N, P1 and P2, as follows:

$$Q2 = N \times P1 \times P2$$

A dimensional analysis (Also shown in the scenario tree) yields the following units:

$$Q2 = \frac{Avocados}{Year} \times \frac{Infested\_Avocados}{Avocado} \times \frac{Infested\_Avocados\_reaching\_Susceptible\_Areas}{Infested\_Avocado}$$

Therefore:

$$Q2 = \frac{Infested\_Avocados\_reaching\_Susceptible\_Areas}{Year}$$

Similarly, the annual number of infested avocados discarded in susceptible areas, Q3, is determined mathematically by taking the product of N, P1, P2 and P3, as follows:

$$Q3 = N \times P1 \times P2 \times P3 \equiv Q2 \times P3$$

A dimensional analysis (Also shown in the scenario tree) yields the following units:

$$Q3 = \frac{Infested\_Avocados\_reaching\_Susceptible\_Areas}{Year} \times \frac{Infested\_Avocados\_Discarded\_in\_Susceptible\_Area}{Infested\_Avocados\_reaching\_Susceptible\_Areas}$$

Therefore:

$$Q3 = \frac{Infested\_Avocados\_Discarded\_in\_Susceptible\_Area}{Year}$$

Each of the parameters N, P1, P2 and P3 are defined by probability distributions that describe a range of possible values and their likelihood of occurrence.

In order to implement the multiplication of these distributions, APHIS has used the Monte Carlo simulation abilities of the @RISK (Palisade Corporation, Newfield, New York) software to run 20,000 iterations of this model, with a seed value of 100.

Following are the results.

Results

Between 112 million and 1.8 billion 'Hass' avocados will be imported each year from Mexico. Following is a summary of the results of conducting the twenty thousand MonteCarlo iterations of the risk assessment model using @Risk (Palisade Corporation, Newfield, New York) and Excel (Microsoft Corporation, Redmond, Washington).

The main conclusions of this risk assessment are that, as a result of trade, carried out with the appropriate systems mitigations and safeguards:

In the 50 state plus the Disctict of Columbia scenario, the risk assessment model results present a 95% confidence that:

- Less than 442 infested avocados will enter the entire United States each year
- Less than 54 avocados infested with stem weevils, seed weevils or seed moths will enter avocado producing areas each year
- Less than 238 avocados infested with fruit flies will enter fruit fly susceptible areas each year,
- Less than 3 avocados infested with stem weevils, seed weevils or seed moths will be discarded in avocado producing areas each year,
- Less than 12 avocados infested with fruit flies will be discarded in fruit fly susceptible areas each year.

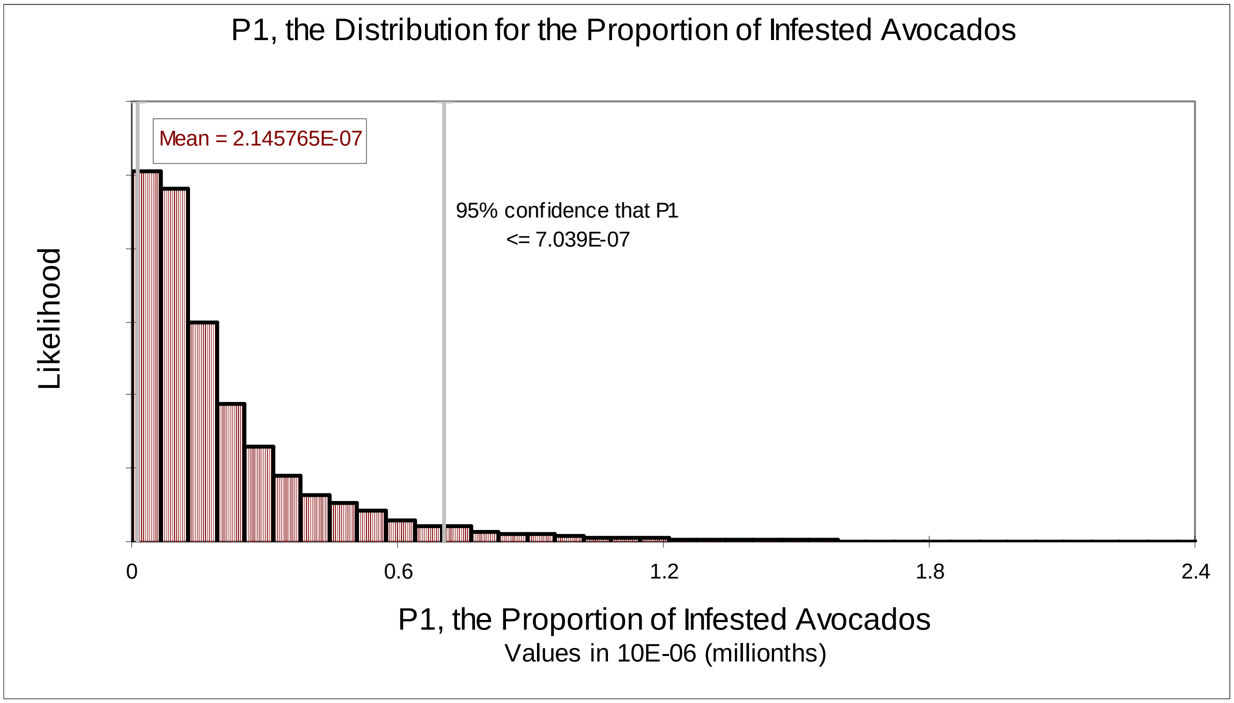
In the 47 state scenario (excluding CA, FL, and HI), the risk assessment model results present a 95% confidence that:

- Less than 393 infested avocados will enter the 47 States each year,
- Less than 7 avocados infested with stem weevils, seed weevils or seed moths will enter avocado producing areas outside of California Florida and Hawaii, each year.
- Less than 98 avocados infested with fruit flies will enter fruit fly susceptible areas outside of California Florida and Hawaii, each year.
- Less than 1 avocado infested with stem weevils, seed weevils or seed moths will be discarded in avocado producing areas outside of California, Florida, and Hawaii each year.
- Less than 5 avocados infested with fruit flies will be discarded in fruit fly susceptible areas outside of California, Florida, and Hawaii each year.

P1, Proportion of Avocados that are Infested

As determined by the sampling and fruit cutting data, the proportion of avocados infested with fruit flies is the same as the proportion of avocados infested with the seed weevils, stem weevils or seed moth. The probability distribution is presented below.

Probability Density Distribution



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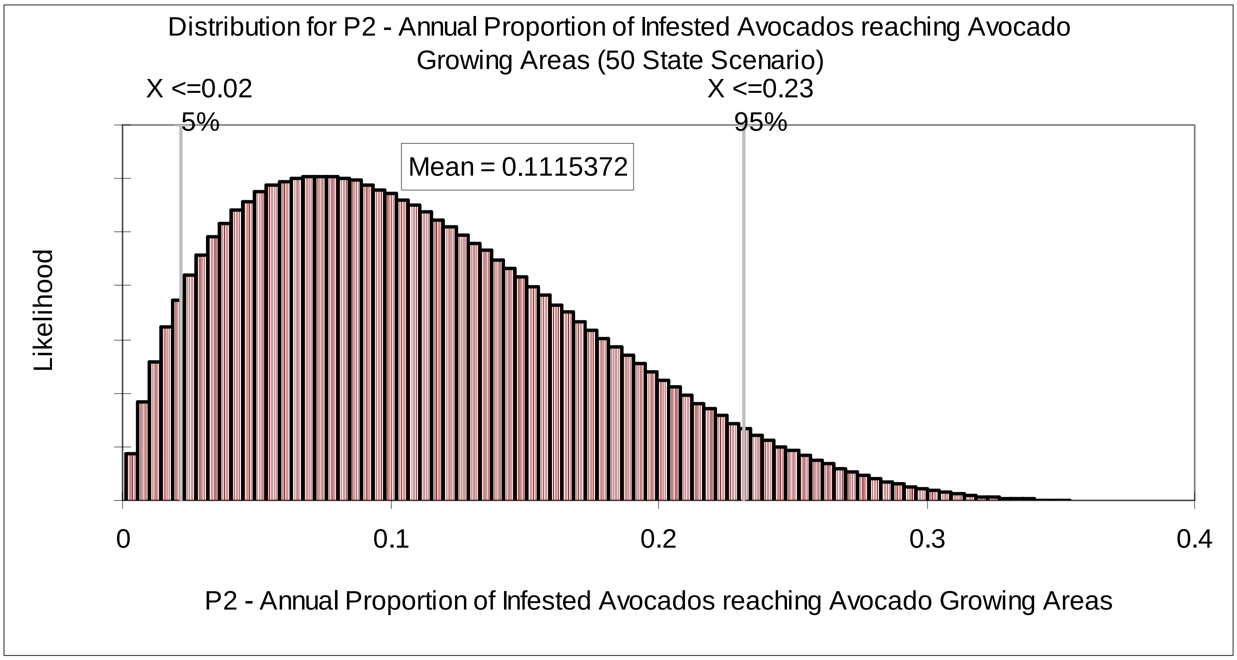
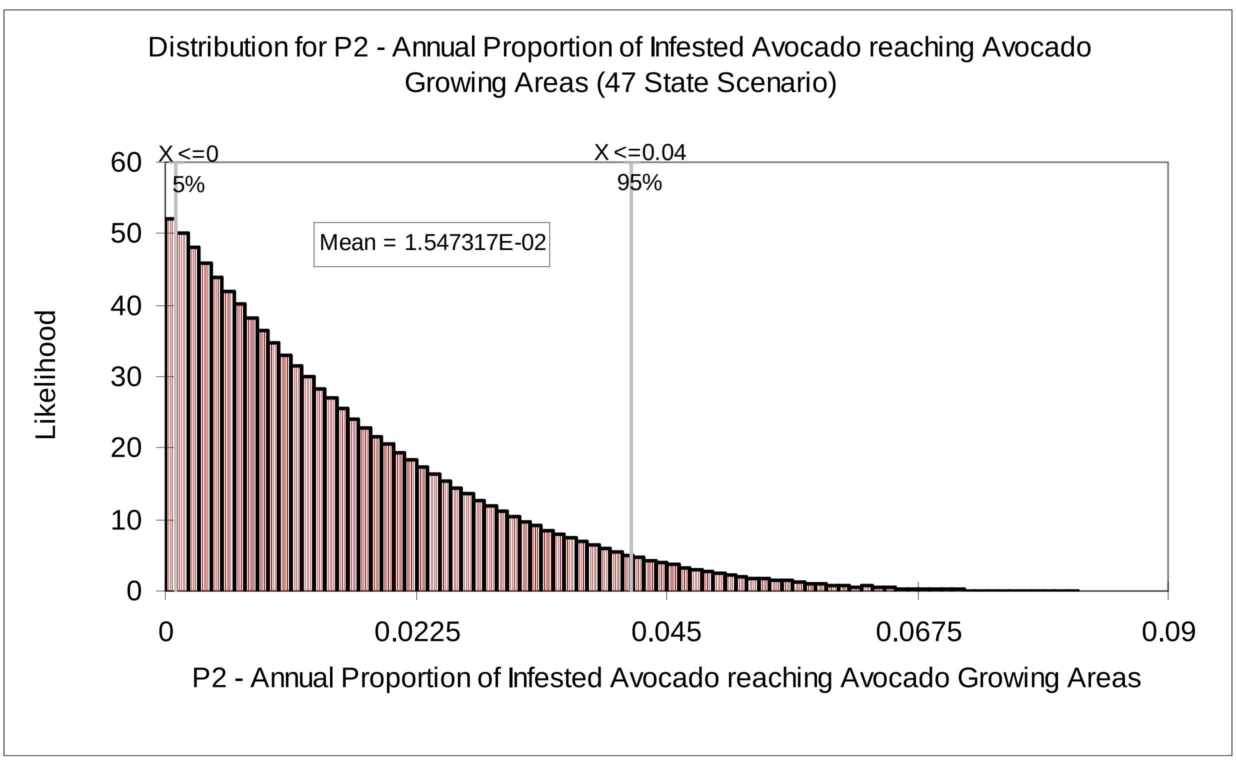
P2, Proportion of Infested Avocados entering Susceptible Areas

For the fruit flies: the annual proportion of infested avocados entering fruit fly susceptible areas is a point value of 53.7%

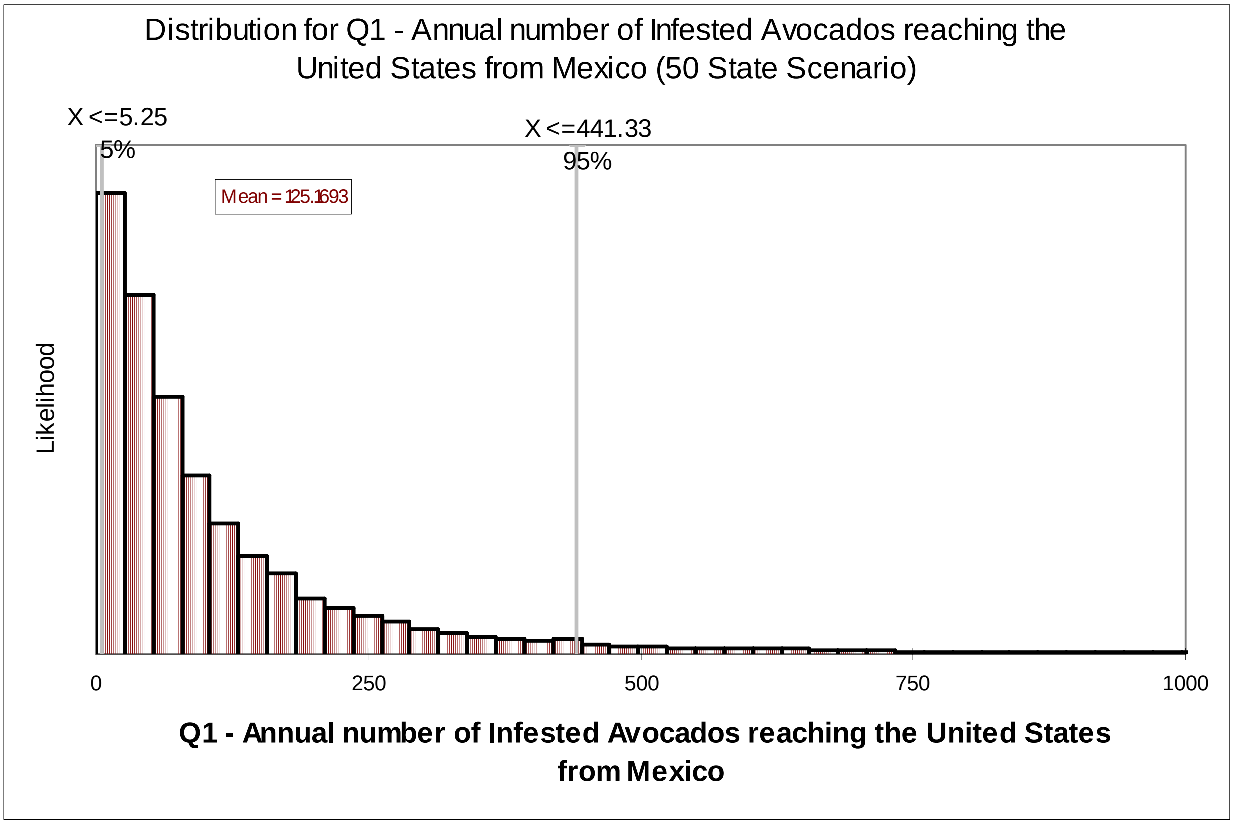
For the avocado pests: the annual proportion of infested avocados entering avocado growing areas is represented by the following distribution.

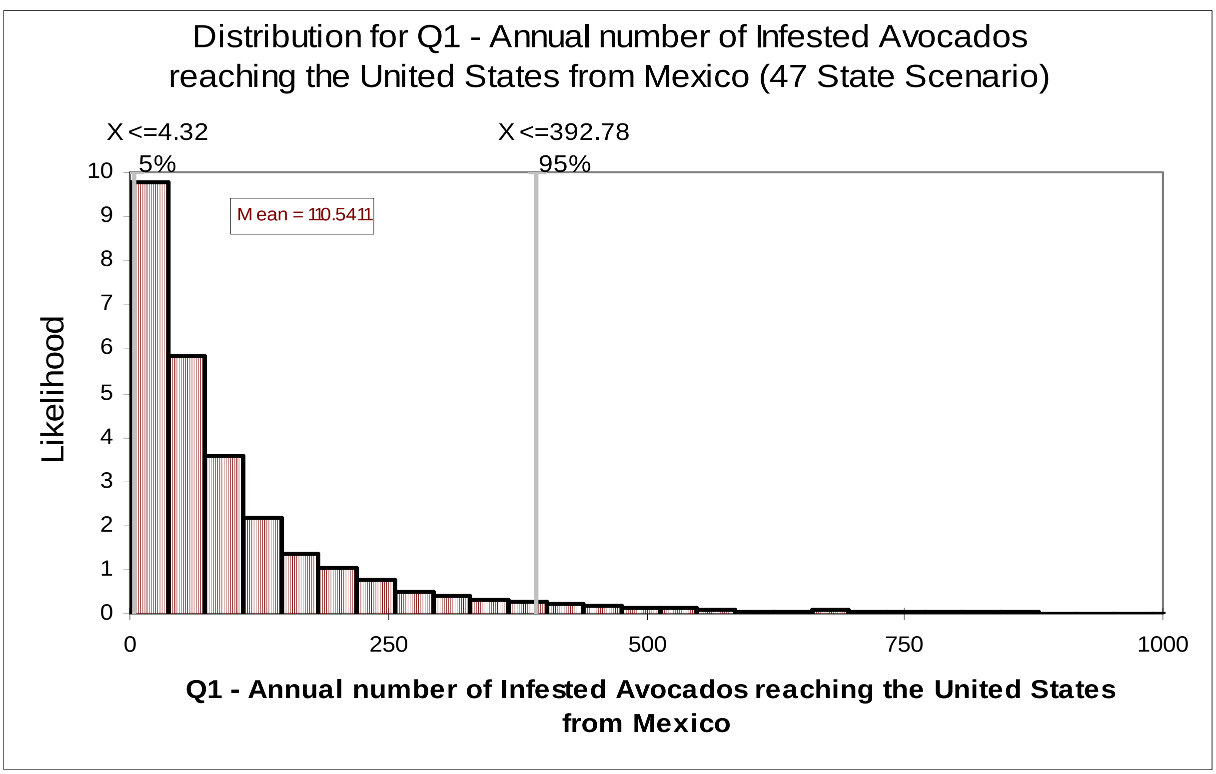
Probability Density Distribution





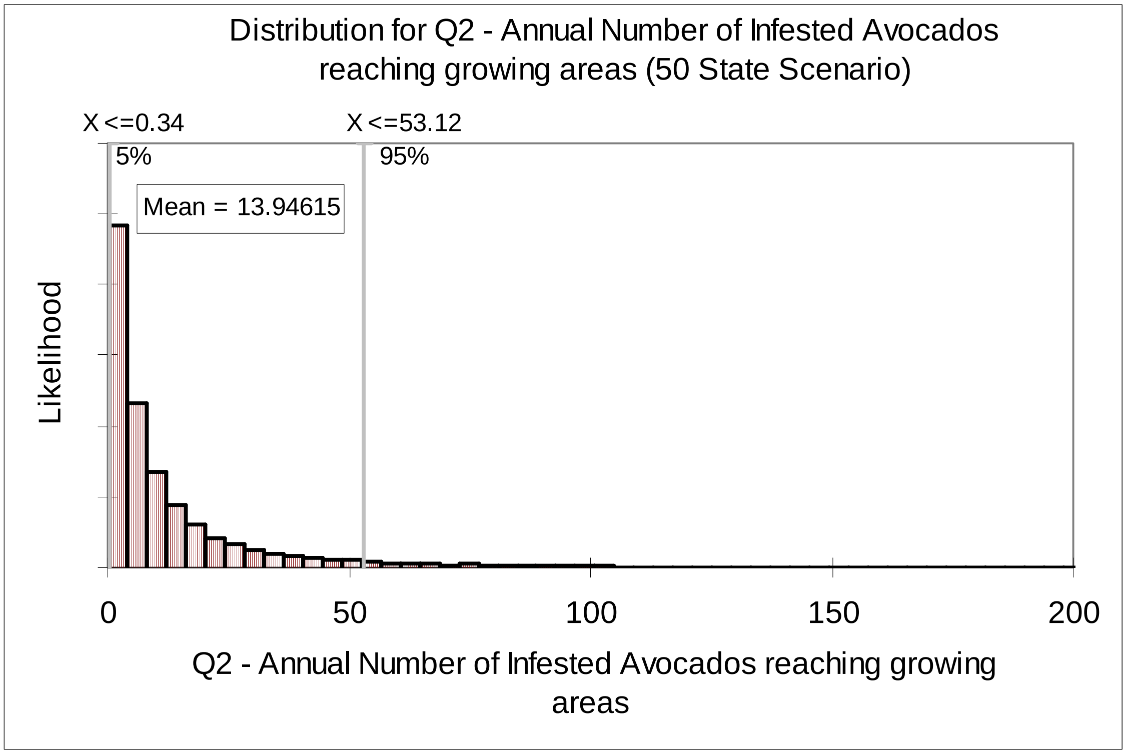
Q1, Annual number of Infested avocados entering the US Probability Density Distribution

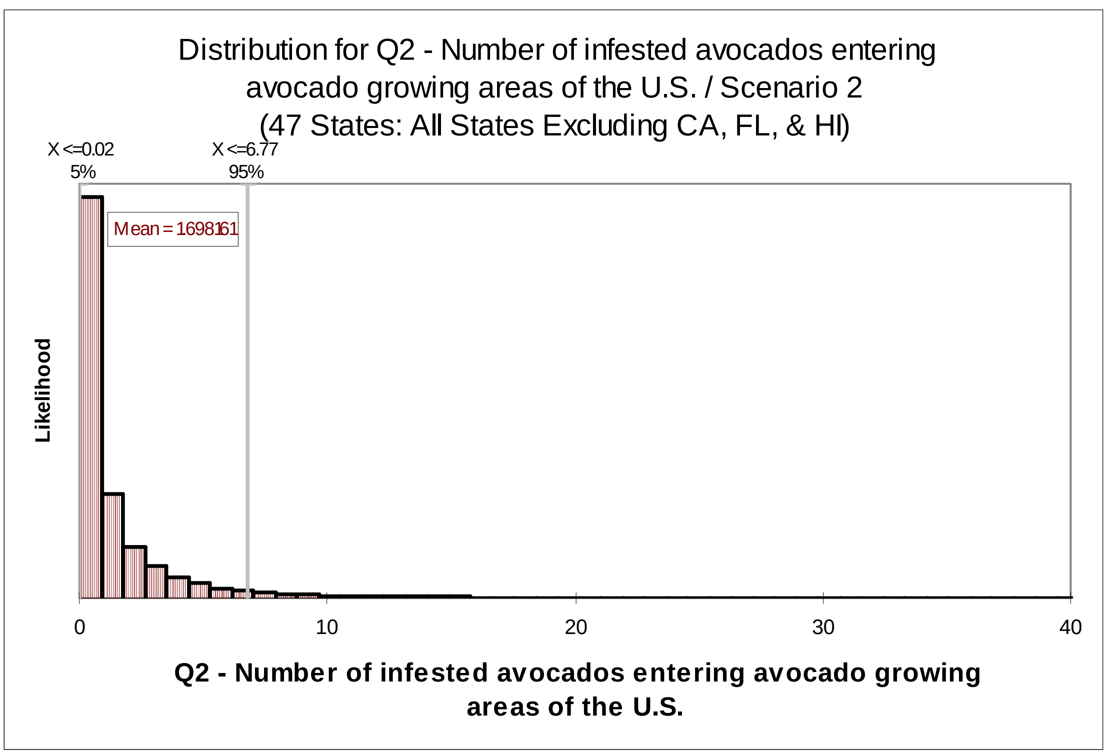


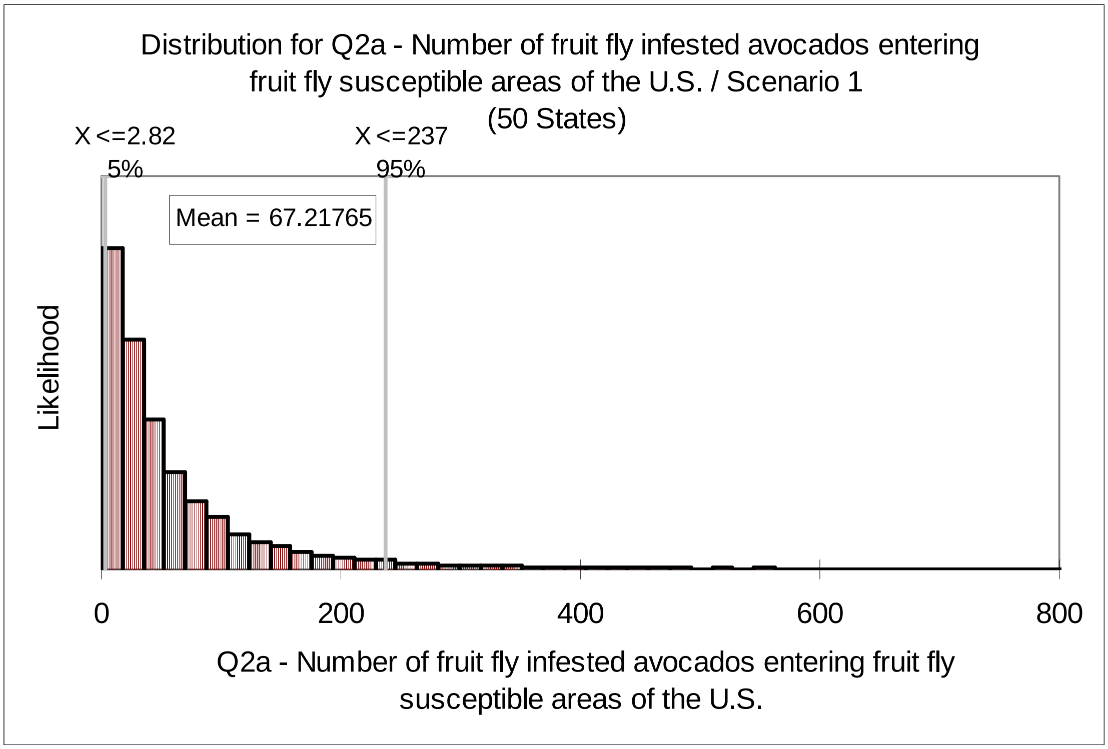


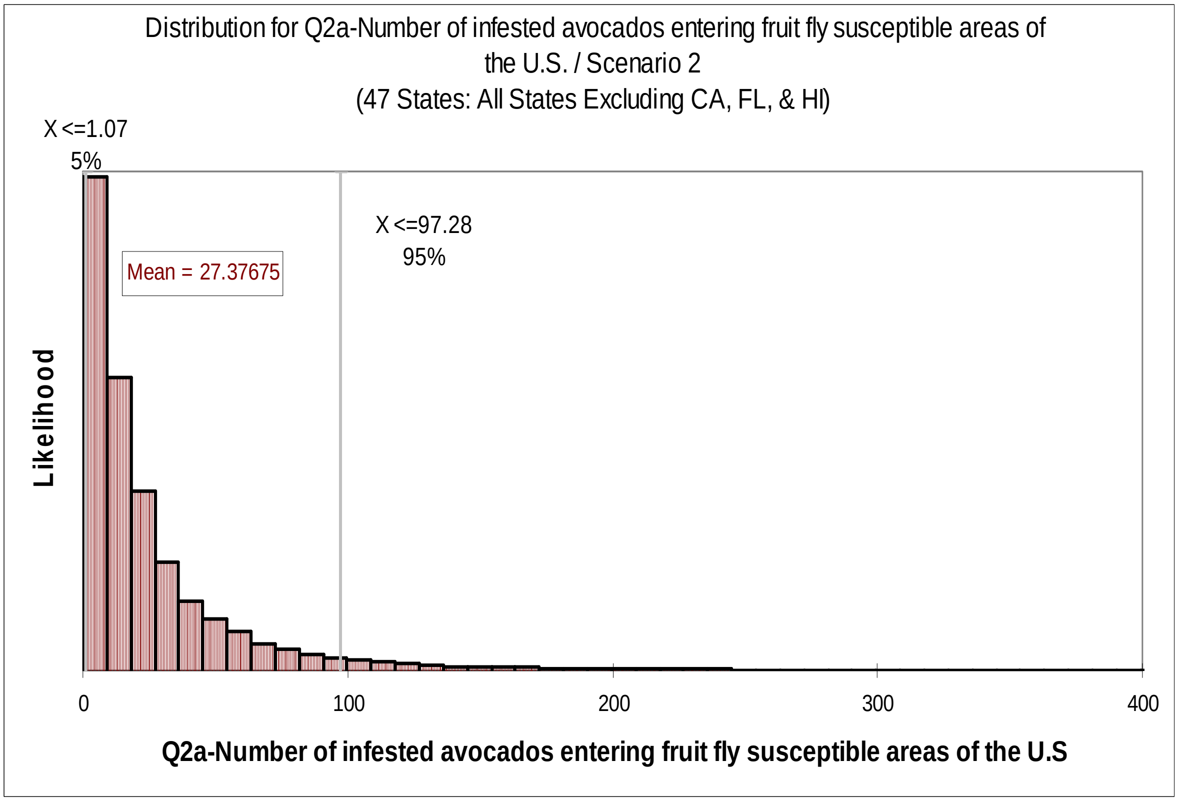
Q2, Annual number of Infested Avocados entering susceptible areas

Probability Density Distribution



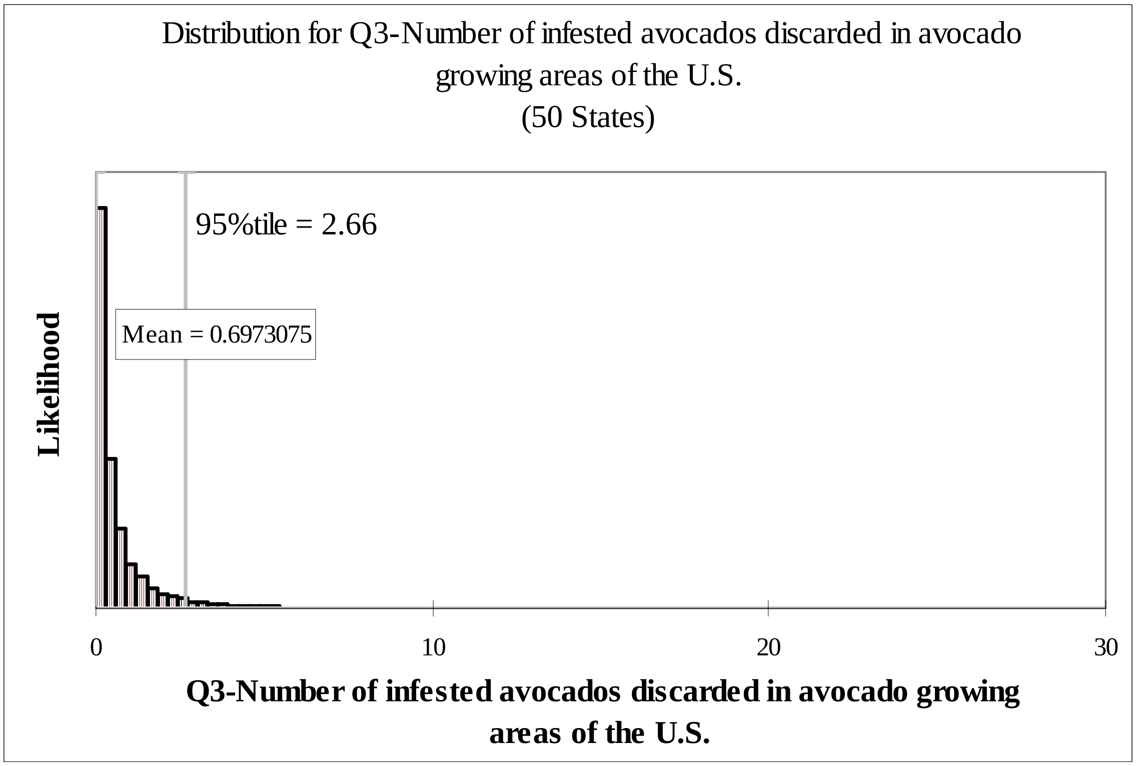


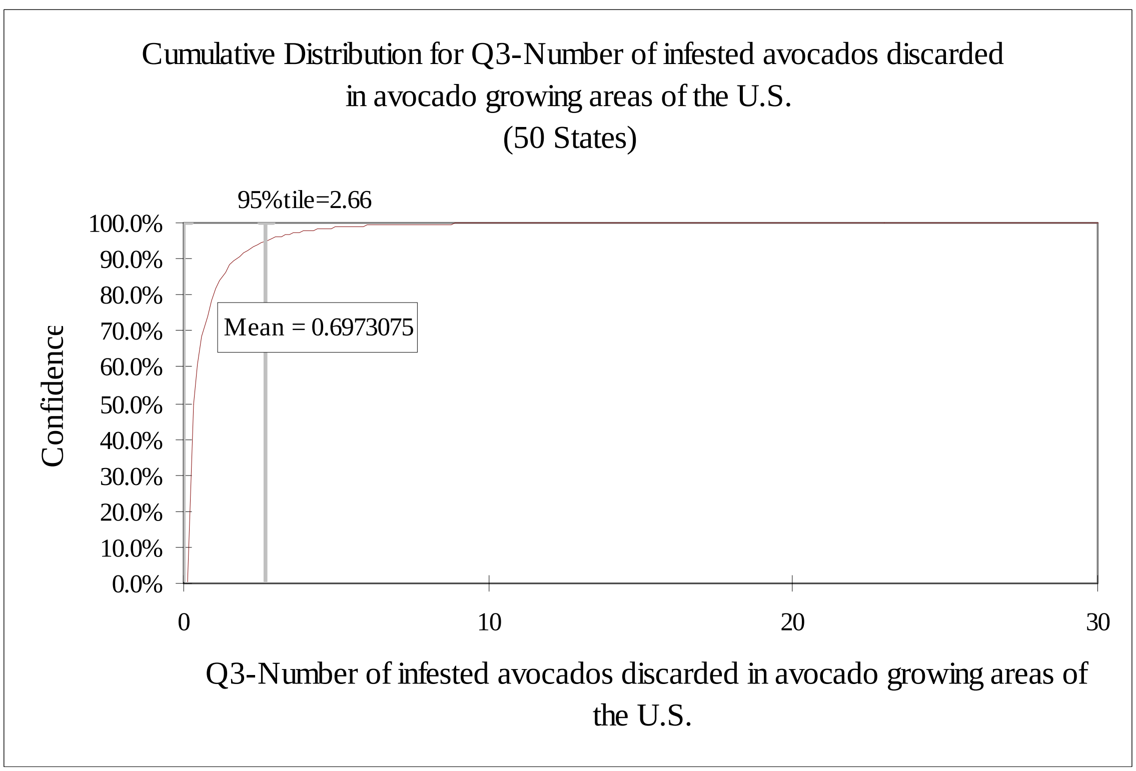

Distribution for Q2a - Number of fruit fly infested avocados entering fruit fly susceptible areas of the U.S. / Scenario 1
(50 States)
X <=2.82
5%
X <=237
95%
Mean = 67.21765
Likelihood
0
200
400
600
800
Q2a - Number of fruit fly infested avocados entering fruit fly susceptible areas of the U.S.

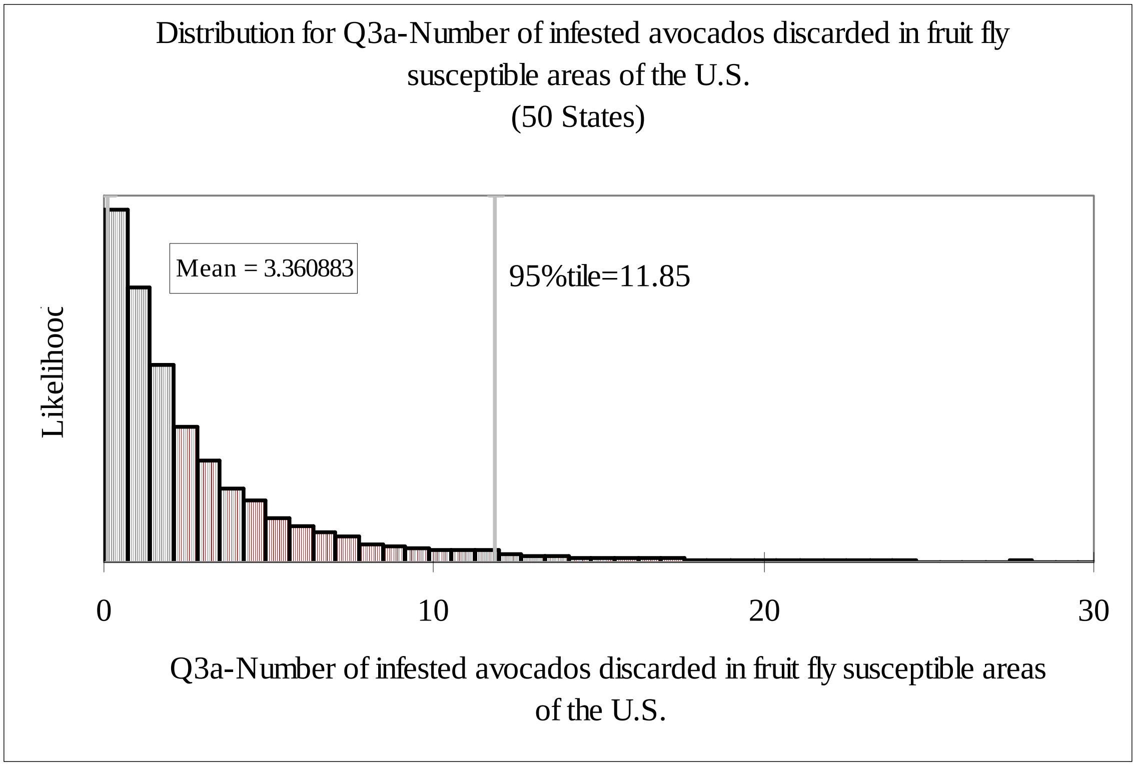

Distribution for Q2a-Number of infested avocados entering fruit fly susceptible areas of the U.S. / Scenario 2
(47 States: All States Excluding CA, FL, & HI)
X <=1.07
5%
X <=97.28
95%
Mean = 27.37675
Likelihood
0
100
200
300
400
Q2a-Number of infested avocados entering fruit fly susceptible areas of the U.S

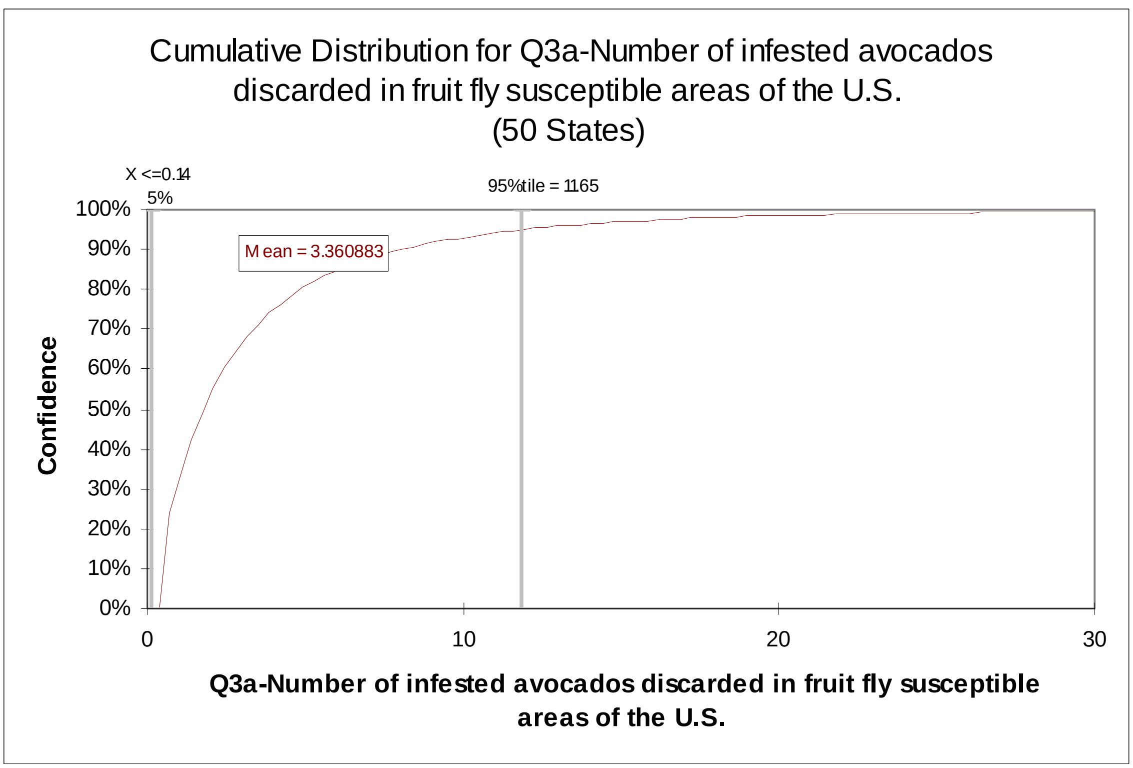
Q3, Annual number of Infested Avocados Discarded in susceptible areas

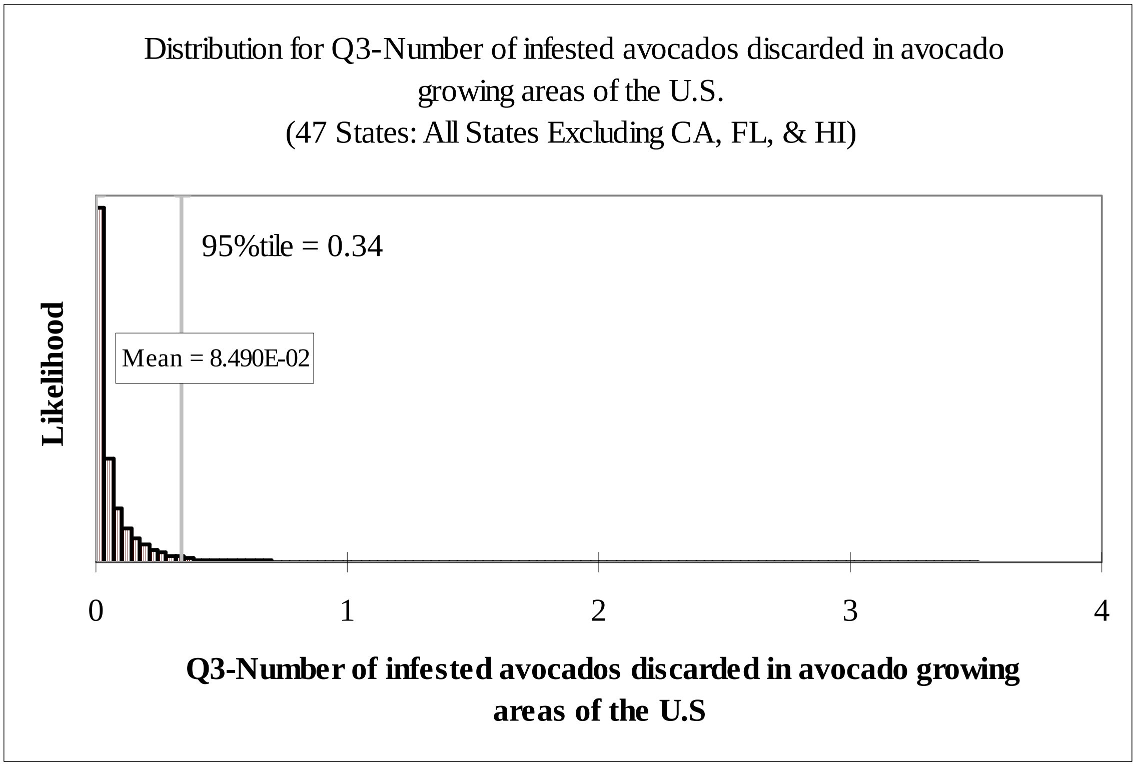
Probability Density Distribution

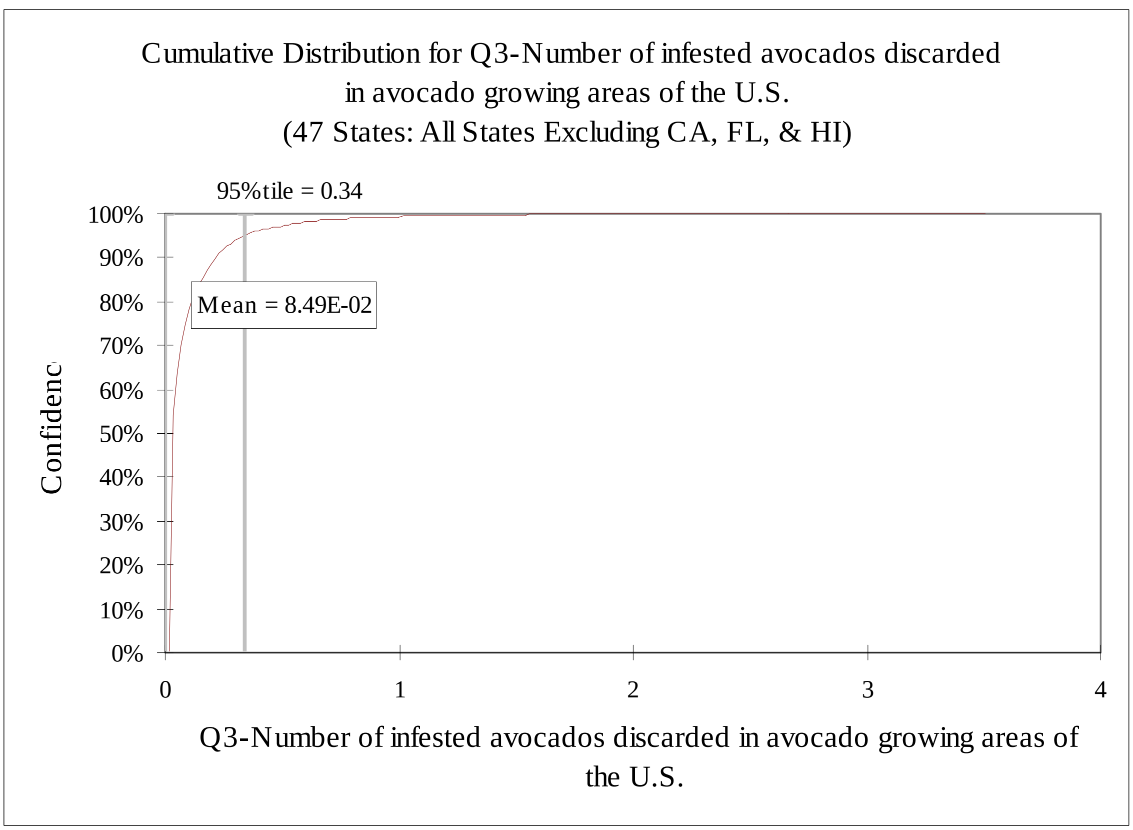


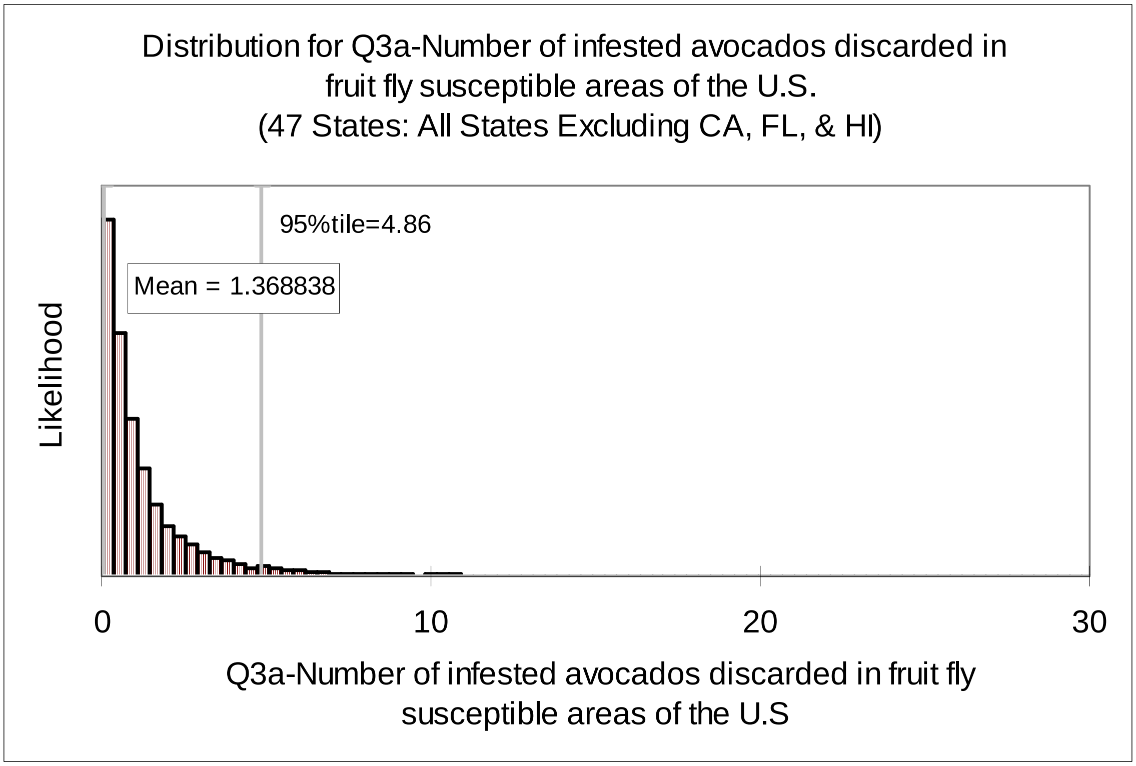


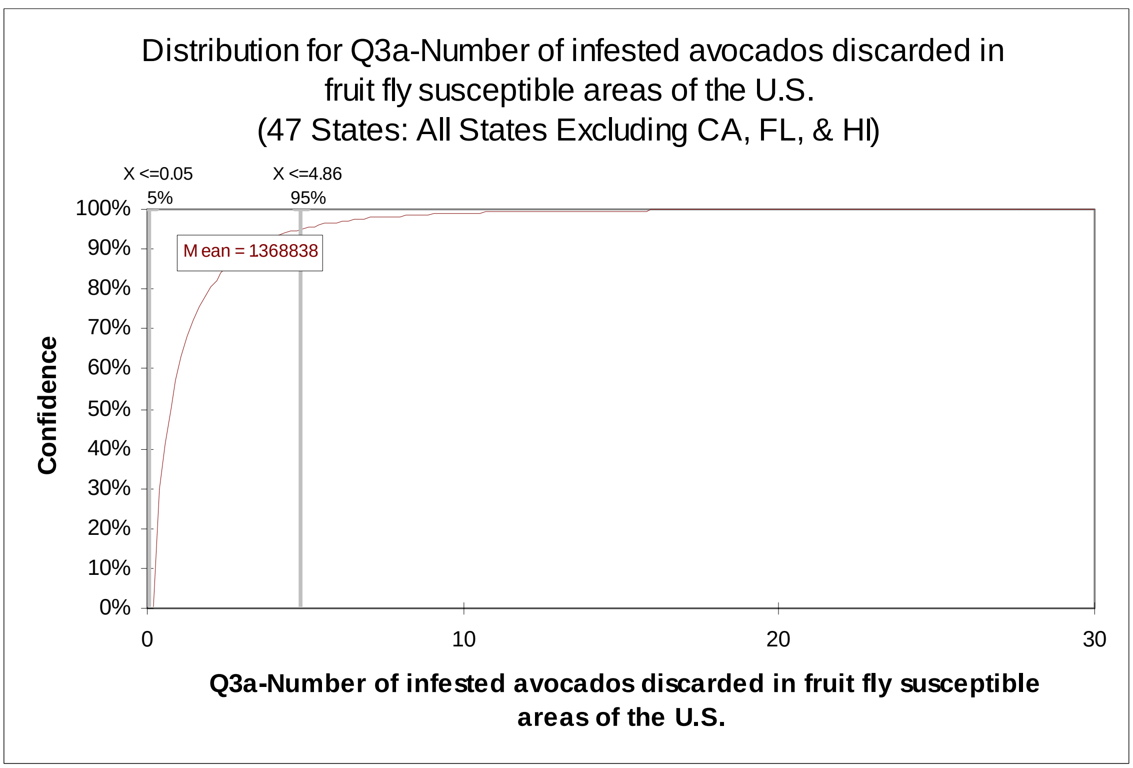

Distribution for Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S.
(50 States)
Likelihood
Mean = 3.360883
95%tile=11.85
0
10
20
30
Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S.


Cumulative Distribution for Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S.
(50 States)
X <=0.14
5%
95%tile = 11.65
Mean = 3.360883
Confidence
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S.

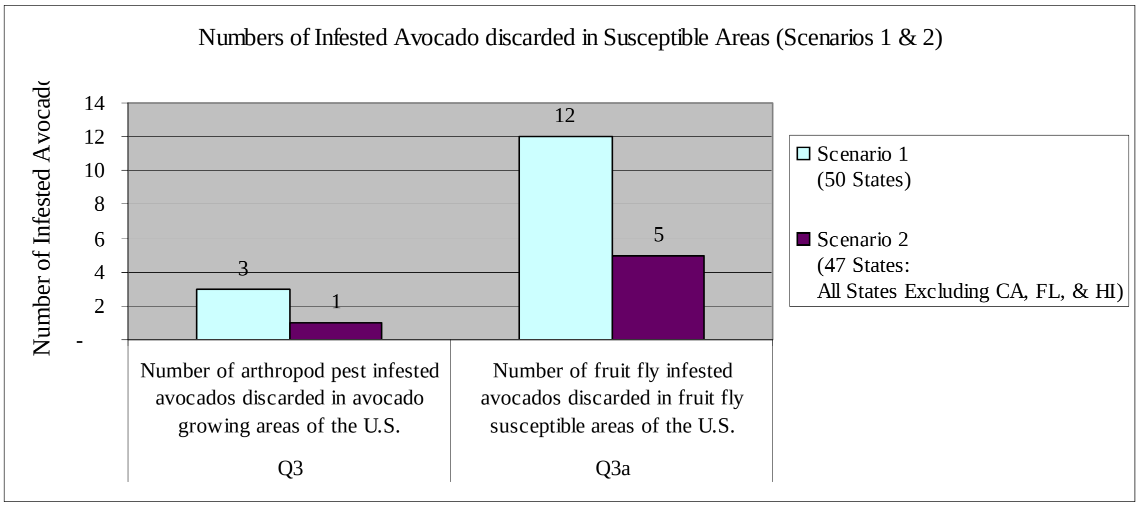

Distribution for Q3-Number of infested avocados discarded in avocado growing areas of the U.S.
(47 States: All States Excluding CA, FL, & HI)
95%tile = 0.34
Mean = 8.490E-02
Likelihood
0
1
2
3
4
Q3-Number of infested avocados discarded in avocado growing areas of the U.S


Cumulative Distribution for Q3-Number of infested avocados discarded in avocado growing areas of the U.S.
(47 States: All States Excluding CA, FL, & HI)
95%tile = 0.34
Mean = 8.49E-02
Confidenc
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
Q3-Number of infested avocados discarded in avocado growing areas of the U.S.


Distribution for Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S.
(47 States: All States Excluding CA, FL, & HI)
95%tile=4.86
Mean = 1.368838
Likelihood
0
10
20
30
Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S


Distribution for Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S.
(47 States: All States Excluding CA, FL, & HI)
X <=0.05
5%
X <=4.86
95%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Mean = 1368838
Confidence
0
10
20
30
Q3a-Number of infested avocados discarded in fruit fly susceptible areas of the U.S.

The likelihood that infested Mexican avocados will be discarded in susceptible areas in the United States is low whether the avocados are distributed in all 50 states or 47. The number of fruit fly infested avocados discarded in susceptible areas under the 50 state scenario is 12; and 5 under the 47 state scenario. The number of arthropod pest infested avocados discarded in avocado growing areas of the U.S. under the 50 state scenario is 3; and 1 under the 47 state scenario. The difference of 7 for fruit flies and 2 for other arthropod pests is the number of infested avocados that would be excluded from California, Florida, and Hawaii assuming full compliance with the distribution requirement.



Hass Avocados from Mexico Risk Assessment Simulation Results

Scenario1: 50 States (Distributed all year round to all states)							
	Parameter Description	**STDEV**	**Mean**	**Mode**	**50%tile Value**	**95%tile Value**	**99%tile Value**
N	Annual Number of Avocados from Mexico	286,965,917	586,659,876	399,446,055	543,662,857	1,124,808,631	1,346,053,000
P1	Proportion of infested avocados	2.59E-07	2.15E-07	1.41E-08	1.30E-07	7.04E-07	1.23E-06
P2	Proportion of fruit that enters avocado growing areas	0.065	0.112	0.073	0.103	0.232	0.280
P2a	Proportion of fruit that enters fruit fly susceptible areas	0.000	0.537	0.537	0.537	0.537	0.537
P3	Proportion of fruit discarded	0.000	0.050	0.050	0.050	0.050	0.050
Q1	Number of infested avocados entering the USA	176.11	125.17	13.51	66.97	441.33	873.13
Q2	Number of infested avocados entering avocado growing areas of the U.S.	24.20	13.95	0.03	6.07	53.12	109.27
Q2a	Number of infested avocados entering fruit fly susceptible areas of the U.S.	94.57	67.22	7.25	35.97	237.00	468.88
Q3	Number of infested avocados discarded in avocado growing areas of the U.S.	1.21	0.70	0.00	0.30	2.66	5.46
Q3a	Number of infested avocados discarded in fruit fly susceptible areas of the U.S.	4.73	3.36	0.36	1.80	11.85	23.44

Scenario 2: 47 States (Distributed all year round to all states except CA, FL, and Hawaii)							
	Description	**STDEV**	**Mean**	**Mode**	**50%tile Value**	**95%tile Value**	**99%tile Value**
N	Annual Number of Avocados from Mexico	272,336,381	515,902,233	283,990,974	465,168,274	1,039,780,964	1,274,102,978
P1	Proportion of infested avocados	2.59E-07	2.15E-07	1.41E-08	1.30E-07	7.04E-07	1.23E-06
P2	Proportion of fruit that enters avocado growing areas	0.013	0.015	0.000	0.012	0.042	0.056
P2a	Proportion of fruit that enters fruit fly susceptible areas	0.000	0.248	0.248	0.248	0.248	0.248
P3	Proportion of fruit discarded	0.000	0.050	0.050	0.050	0.050	0.050
Q1	Number of infested avocados entering the USA	162.04	110.54	0.40	58.36	392.78	793.65
Q2	Number of infested avocados entering avocado growing areas of the U.S.	3.42	1.70	0.00	0.59	6.77	15.83
Q2a	Number of infested avocados entering fruit fly susceptible areas of the U.S.	40.13	27.38	0.10	14.45	97.28	196.56
Q3	Number of infested avocados discarded in avocado growing areas of the U.S.	0.17	0.08	0.00	0.03	0.34	0.79
Q3a	Number of infested avocados discarded in fruit fly susceptible areas of the U.S.	2.01	1.37	0.01	0.72	4.86	9.83

Appendix E – 7CFR§319.56-2ff

Administrative instructions governing the movement of 'Hass' avocados from Michoacán, Mexico to approved states.

Fresh 'Hass' variety avocados (Persea americana) may be imported from Michoacán, Mexico, into the United States for distribution in approved States only under a permit issued in accordance with § 319.56-4, and only under the following conditions:

(a) Shipping restrictions.

(1) The avocados may be imported in commercial shipments only;

(2) The avocados may be imported only between October 15 and April 15 of the following year; and

(3) The avocados may be distributed only in the following States: Colorado, Connecticut, Delaware, the District of Columbia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming.

(b) Trust fund agreement. The avocados may be imported only if the Mexican avocado industry association representing Mexican avocado growers, packers, and exporters has entered into a trust fund agreement with the Animal and Plant Health Inspection Service (APHIS) for that shipping season. That agreement requires the Mexican avocado industry association to pay in advance all estimated costs that APHIS expects to incur through its involvement in the trapping, survey, harvest, and packinghouse operations prescribed in paragraph (c) of this section. These costs will include administrative expenses incurred in conducting the services and all salaries (including overtime and the Federal share of employee benefits), travel expenses (including per diem expenses), and other incidental expenses incurred by the inspectors in performing these services. The agreement requires the Mexican avocado industry association to deposit a certified or cashier's check with APHIS for the amount of those costs, as estimated by APHIS. If the deposit is not sufficient to meet all costs incurred by APHIS, the agreement further requires the Mexican avocado industry association to deposit with APHIS a certified or cashier's check for the amount of the remaining costs, as determined by APHIS, before the services will be completed. After a final audit at the conclusion of each shipping season, any overpayment of funds would be returned to the Mexican avocado industry association or held on account until needed.

(c) Safeguards in Mexico. The avocados must have been grown in the Mexican State of Michoacán in an orchard located in a municipality that meets the requirements of paragraph (c)(1) of this section. The orchard in which the avocados are grown must meet the requirements of paragraph (c)(2) of this section. The avocados must be packed for export to the United States in a packinghouse that meets the requirements of paragraph (c)(3) of this section. Sanidad Vegetal must provide an annual work plan to APHIS that details the activities that Sanidad Vegetal will, subject to APHIS' approval of the work plan, carry out to meet the requirements of this section; APHIS will be directly involved with Sanidad Vegetal in the monitoring and supervision of those activities. The personnel conducting the trapping and pest surveys must be hired, trained, and supervised by Sanidad Vegetal or by the Michoacán State delegate of the Secretaria de Agricultura, Ganaderia y Desarrollo Rural (SAGDR).

(1) Municipality requirements.

(i) The municipality must be listed as an approved municipality in the annual work plan provided to APHIS by Sanidad Vegetal.

(ii) The municipality must be surveyed at least annually and found to be free from the large avocado seed weevil Heilipus lauri, the avocado seed moth Stenoma catenifer, and the small avocado seed weevils Conotrachelus aguacatae and C. perseae. The survey must cover at least 300 hectares in the municipality and include randomly selected portions of each registered orchard and areas with wild or backyard avocado trees. The survey must be conducted during the growing season and completed prior to the harvest of the avocados.

(iii) Trapping must be conducted in the municipality for Mediterranean fruit fly (Medfly) (Ceratitis capitata) at the rate of 1 trap per 1 to 4 square miles. Any findings of Medfly must be reported to APHIS.

(2) Orchard and grower requirements. The orchard and the grower must be registered with Sanidad Vegetal's avocado export program and must be listed as an approved orchard or an approved grower in the annual work plan provided to APHIS by Sanidad Vegetal. The operations of the orchard must meet the following conditions:

- (i) The orchard and all contiguous orchards and properties must be surveyed annually and found to be free from the avocado stem weevil Copturus aguacatae. The survey must be conducted during the growing season and completed prior to the harvest of the avocados.
- (ii) Trapping must be conducted in the orchard for the fruit flies Anastrepha ludens, A. serpentina, and A. striata at the rate of one trap per 10 hectares. If one of those fruit flies is trapped, at least 10 additional traps must be deployed in a 50-hectare area immediately surrounding the trap in which the fruit fly was found. If within 30 days of the first finding any additional fruit flies are trapped within the 260-hectare area surrounding the first finding, malathion bait treatments must be applied in the affected orchard in order for the orchard to remain eligible to export avocados.
- (iii) Avocado fruit that has fallen from the trees must be removed from the orchard at least once every 7 days and may not be included in field boxes of fruit to be packed for export.
- (iv) Dead branches on avocado trees in the orchard must be pruned and removed from the orchard.
- (v) Harvested avocados must be placed in field boxes or containers of field boxes that are marked to show the Sanidad Vegetal registration number of the orchard. The avocados must be moved from the orchard to the packinghouse within 3 hours of harvest or they must be protected from fruit fly infestation until moved.
- (vi) The avocados must be protected from fruit fly infestation during their movement from the orchard to the packinghouse and must be accompanied by a field record indicating that the avocados originated from a certified orchard.

(3) Packinghouse requirements. The packinghouse must be registered with Sanidad Vegetal's avocado export program and must be listed as an approved packinghouse in the annual work plan provided to APHIS by Sanidad Vegetal. The operations of the packinghouse must meet the following conditions:

- (i) During the time the packinghouse is used to prepare avocados for export to the United States, the packinghouse may accept fruit only from orchards certified by Sanidad Vegetal for participation in the avocado export program.
- (ii) All openings to the outside must be covered by screening with openings of not more than 1.6 mm or by some other barrier that prevents insects from entering the packinghouse.
- (iii) The packinghouse must have double doors at the entrance to the facility and at the interior entrance to the area where the avocados are packed.
- (iv) Prior to the culling process, a sample of 300 avocados per shipment must be selected, cut, and inspected by Sanidad Vegetal and found free from pests.
- (v) The identity of the avocados must be maintained from field boxes or containers to the shipping boxes so the avocados can be traced back to the orchard in which they were grown if pests are found at the packinghouse or the port of first arrival in the United States.
- (vi) Prior to being packed in boxes, each avocado fruit must be cleaned of all stems, leaves, and other portions of plants and labeled with a sticker that bears the Sanidad Vegetal registration number of the packinghouse.

- (vii) The avocados must be packed in clean, new boxes, or clean plastic reusable crates. The boxes or crates must be clearly marked with the identity of the grower, packinghouse, and exporter, and the statement "Not for distribution in AL, AK, AZ, AR, CA, FL, GA, HI, LA, MS, NV, NM, NC, OK, OR, SC, TN, TX, WA, Puerto Rico, and all other U.S. Territories."

- (viii) The boxes must be placed in a refrigerated truck or refrigerated container and remain in that truck or container while in transit through Mexico to the port of first arrival in the United States. Prior to leaving the packinghouse, the truck or container must be secured by Sanidad Vegetal with a seal that will be broken when the truck or container is opened. Once sealed, the refrigerated truck or refrigerated container must remain unopened until it reaches the port of first arrival in the United States.
- (ix) Any avocados that have not been packed or loaded into a refrigerated truck or refrigerated container by the end of the work day must be kept in the screened packing area.

(d) Certification. All shipments of avocados must be accompanied by a phytosanitary certificate issued by Sanidad Vegetal certifying that the conditions specified in this section have been met.

(e) Pest detection.

(1) If any of the avocado seed pests Heilipus lauri, Conotrachelus aquacatae, C. perseae, or Stenoma catenifer are discovered in a municipality during an annual pest survey, orchard survey, packinghouse inspection, or other monitoring or inspection activity in the municipality, Sanidad Vegetal must immediately initiate an investigation and take measures to isolate and eradicate the pests. Sanidad Vegetal must also provide APHIS with information regarding the circumstances of the infestation and the pest risk mitigation measures taken. The municipality in which the pests are discovered will lose its pest-free certification and avocado exports from that municipality will be suspended until APHIS and Sanidad Vegetal agree that the pest eradication measures taken have been effective and that the pest risk within that municipality has been eliminated.

(2) If Sanidad Vegetal discovers the stem weevil Copturus aguacatae in an orchard during an orchard survey or other monitoring or inspection activity in the orchard, Sanidad Vegetal must provide APHIS with information regarding the circumstances of the infestation and the pest risk mitigation measures taken. The orchard in which the pest was found will lose its export certification immediately and will be denied export certification for the entire shipping season of October 15 through April 15.

(3) If Sanidad Vegetal discovers the stem weevil Copturus aguacatae in fruit at a packinghouse, Sanidad Vegetal must investigate the origin of the infested fruit and provide APHIS with information regarding the circumstances of the infestation and the pest risk mitigation measures taken. The orchard where the infested fruit originated will lose its export certification immediately and will be denied export certification for the entire shipping season of October 15 through April 15.

(f) Ports. The avocados may enter the United States at:

(1) Any port located in a State specified in paragraph (a)(3) of this section;
(2) The ports of Galveston or Houston, TX, or the border ports of Nogales, AZ, or Brownsville, Eagle Pass, El Paso, Hidalgo, or Laredo, TX; or
(3) Other ports within that area of the United States specified in paragraph (g) of this section.

(g) Shipping areas.

(1) Except as explained below in paragraph (g)(3) for avocados that enter the United States at Nogales, AZ, avocados moved by truck or rail car may transit only that area of the United States bounded as follows:

(i) On the east and south by a line extending from Brownsville, TX, to Galveston, TX, to Kinder, LA, to Memphis, TN, to Knoxville, TN, following Interstate 40 to Raleigh, NC, and due east from Raleigh, and
(ii) On the west by following Interstate 10 North from El Paso, TX, to Las Cruces, NM, and north following Interstate 25 to the Colorado border, then west along Colorado and Utah's southern borders, then north along Utah's western border, then west along Idaho's southern border and north along Idaho's western border to the border with Canada.

(2) All cities on the boundary lines described in paragraph (g)(1) are included in this shipping area. If the avocados are moved by air, the aircraft may not land outside this shipping area.
(3) Avocados that enter the United States at Nogales, AZ, must be moved to Las Cruces, NM, by the route specified on the permit, and then must remain within the shipping area described above in this paragraph.

(h) Shipping requirements. The avocados must be moved through the United States either by air or in a refrigerated truck or refrigerated rail car or in a refrigerated container on a truck or rail car. If the avocados are moved in a refrigerated container on a truck or rail car, an inspector must seal the container with a serially numbered seal at the port of first arrival in the United States. If the avocados are moved in a refrigerated truck or a refrigerated rail car, an inspector must seal the truck or rail car with a serially numbered seal at the port of first arrival in the United States. If the avocados are transferred to another vehicle or container in the United States, an inspector must be present to supervise the transfer and must apply a new serially numbered seal. The avocados must be moved through the United States under Customs bond.

(i) Inspection. The avocados are subject to inspection by an inspector at the port of first arrival, at any stops in the United States en route to an approved State, and upon arrival at the terminal market in the approved States. At the port of first arrival, an inspector will sample and cut avocados from each shipment to detect pest infestation.

(j) Repackaging. If any avocados are removed from their original shipping boxes and repackaged, the stickers required by paragraph (c)(3)(vi) of this section may not be removed or obscured and the new boxes must be clearly marked with all the information required by paragraph (c)(3)(vii) of this section.

(k) Compliance agreements.

(1) Any person, other than the permittee, who moves or distributes the avocados following their importation into the United States (i.e., a second-party or subsequent handler) must enter into a compliance agreement with APHIS. In the compliance agreement, the person must acknowledge, and agree to observe, the requirements of paragraph (a) and paragraphs (f) through (k) of this section. Compliance agreement forms are available, free of charge, from local offices of Plant Protection and Quarantine, which are listed in local telephone directories.

A compliance agreement will not be required for an individual place of business that only offers the avocados for sale directly to consumers.

(2) Before transferring the avocados to any person (i.e., a second-party handler) for movement or distribution, the permittee must confirm that the second-party handler has entered into a compliance agreement with APHIS as required by paragraph (k)(1) of this section. If the permittee transfers the avocados to a second-party handler who has not entered into a compliance agreement, APHIS may revoke the permittee's import permit for the remainder of the current shipping season.

(3) Any second-party or subsequent handler who transfers the avocados to another person for movement or distribution must confirm that the person receiving the avocados has entered into a compliance agreement with APHIS as required by paragraph (k)(1) of this section. If the second-party or subsequent handler transfers the avocados to a person who has not entered into a compliance agreement, APHIS may revoke the handler's compliance agreement for the remainder of the current shipping season.

(4) Action on repeat violators. APHIS may deny an application for an import permit from, or refuse to enter into a compliance agreement with, any person who has had his or her import permit or compliance agreement revoked under paragraph (k)(2) or (k)(3) of this section twice within any 5-year period.

(Approved by the Office of Management and Budget under control number 0579-0129)
[62 FR 5313, Feb. 5, 1997, as amended at 64 FR 68005, Dec. 6, 1999; 66 FR 55551, Nov. 1, 2001]

Appendix F – ARS Analysis of Aluja *et al* (2004) Fruit Fly Research

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USDA

United States Department of Agriculture

Research, Education, and Economics
Agricultural Research Service

February 12, 2004

SUBJECT: Hass Avocado

TO: Richard Dunkle, Deputy Administrator
Animal and Plant Health Inspection Service

FROM: Judith B.St. John
Associate Deputy Administrator

This report summarizes the ARS review of the APHIS Hass avocado pest risk analysis. The review was conducted at the request of APHIS to provide comments on an APHIS pest risk analysis concerning a request from Mexico to expand Hass avocado importation into the United States (letter from Dr. Richard Dunkle, Deputy Administrator, PPQ, to Dr. Ken Vick, National Program Leader, ARS, dated September 4, 2003). During subsequent conversations with APHIS personnel in Raleigh, North Carolina, ARS noted that its expertise lay with the Mexican fruit fly part of this issue. Therefore, ARS' review focuses on the fruit fly research project (Aluja et al, in press) submitted by Mexico in support of their request for expanded Hass avocado importation. This study concluded Hass avocado was not a host for Mexican fruit fly and was central to the Mexican fruit fly component of the avocado pest risk analysis. The non-host designation essentially removed the fruit fly from the first draft of the APHIS pest risk analysis exercise.

This is, therefore, a review of the study submitted by Dr. Martin Aluja to APHIS on host status of Hass avocado relative to Mexican fruit fly in Mexico (**Martin Aluja, Fancisco Diaz-Fleischer, and Jose Arredondo. In press. Non-host status of commercial Persea Americana cultivar "Hass" to Anastrepha ludens, A. oblique, A. serpentine, and A. striata (Diptera" Tephritidae), Journal Economic Entomology**). ARS also took into account other available pertinent information related to the avocado host status issue in forming its conclusions.

Two ARS scientists, Dr. Peter Follett, Hilo, Hawaii, and Dr. Robert Mangan, Weslaco, Texas, conducted the initial ARS review; both have considerable experience in host status issues including avocados. In particular, they are familiar with ARS work in the late 1980's and early 1990's establishing the host status of Sharwil avocados relative to fruit flies in Hawaii. Dr. Follett is an expert in quarantine research, including for fruit flies. Dr. Mangan is a recognized expert in quarantine research especially with regard to the Mexican fruit fly. He also reviewed the experimental work plan of Dr. Aluja prior to initiation of the study, and the work plan of Dr. Enkerlin who conducted similar research

ars

National Program Staff
5601 Sunnyside Avenue, George Washington Carver Center
Beltsville, Maryland 20705

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on Mexican fruit fly relative to host status for avoçado in Mexico 1993-1994. He also provided USDA oversight of Dr. Enkerlin's research over the course of that study and provided input into the ARS review of the results of that research (**"ARS Review of Research Report from Mexico on Host Status of Hass avocado for Anastrepha Fruit Flies", Ken Vick, National Program Leader, Stored Product Insects and Plant Quarantine, USDA/ARS, 7/21/1994**). Dr. Ken Vick's role in the present review was to consolidate the views and comments of Drs. Follett and Mangan and provide a second tier review of the entire subject.

Previous work on avocados, especially Enkerlin, et al., **(Status of the "Hass" avocado as host of three species of fruit flies of the Anastrepha genus (Diptera: Tephritidae) under induced laboratory and field conditions and also under natural field conditions, Secretariat of Agriculture and Water Resources; Plant Health General Directorate, Mexico National Campaign Against fruit flies, May 1994)** established that Hass avocados could become good hosts after harvest but while on the tree were poor hosts for Mexican fruit fly. Clearly there is a fruit maturation process that makes fruit more acceptable to Mexican fruit fly as the fruit ripens. The physiological nature of this switch-over, or when or how fast it happens is not known. It appears from Enkerlin, et al.'s work, however, that the threshold for avocados becoming a good host to Mexican fruit fly happens soon after harvest.

The Aluja et al. manuscript is a thorough study of fruit fly behavior relative to avocado fruit. The Journal of Economic Entomology has accepted it. The purpose of this review was for ARS to determine whether the data presented justify ARS changing its position developed after the Enkerlin et al. study showing that Hass avocado is a poor host of Mexican fruit fly while the fruit is still attached to the tree. Technical comments that follow focus on those data that were critical to making that decision. While we do not take issue with the data presented, we do disagree in some cases with the conclusions that were drawn by the authors.

Aluja et al. distinguish between infestations that occur in caged tests and those that occur in free-living fly populations. The view held by the ARS reviewers of this manuscript is that the use of caged tests are a valid and necessary host status research method. Given the infrequency of oviposition and egg survival in a poor host, the uncertain fruit fly population and the millions of avocados in an orchard, it would be almost impossible to conduct meaningful host status tests without caged tests. Oviposition is a complex and purposeful behavior, not simply a scattering of eggs by gravid females bent on releasing matured eggs. It is known that Mexican fruit fly females can hold their eggs and that even under the best of rearing conditions, many females do not oviposit. Thus, there is no evidence that Mexican fruit fly females were "forced" to oviposit during the short exposure period used by the authors in these tests.

In this study, the flies were "forced" to be in contact with avocado tree limbs and fruit, however the trapping data presented by Aluja et al. showed that this cage situation mimicked the situation in the field. In addition, the highest frequency of adult captures in the avocado orchards were during the winter months when fruit were reaching maturity. Interestingly, Oi (**Oi, D. H., 1983, The effects of ripeness and skin penetrability on the breeding of the Mediterranean fruit fly, *Ceratitis capitata* (Wied.), and oriental fruit fly, *Dacus dorsalis* Hendel, in the 'Sharwil' avocado. M.S. Thesis, University of Hawaii, Honolulu**) and Oi and Mau (**Oi, D. H. & R. F. Mau, 1989, The relationship of fruit ripeness to infestation in 'Sharwil' avocados by the Mediterranean fruit fly and the oriental fruit fly (Diptera: Tephritidae). J. Econ. Entomol. 82: 556-560.)** were also able to infest Sharwil avocados when Mediterranean fruit flies and oriental fruit flies were caged with Sharwil avocado fruit still attached to the tree (3 infested fruit of 19 with Mediterranean fruit fly and 1 of 21 with oriental fruit fly). Armstrong (1991) discounted this work and said "…forced infestations do not necessarily reflect the true host status of the 'Sharwil' avocado in nature or under commercial conditions" only a few months before fruit flies were found in Sharwil avocados being packed for export to the U.S. mainland.

It seems clear that in the present case, the vast majority of Haas avocado picked from trees and safeguarded after harvest will not be infested with Mexican fruit fly. However, Mexican fruit flies are found in the interior of Hass avocado orchards, they attempt and succeed in ovipositing in fruit on the tree, and in the Aluja et al. study 4 fruit were infested with larvae. The infested fruit were apparently normal in appearance. The reason infestation can occur in a small number of fruit is not known. It is also not known how frequently this happens, whether it is seasonal or whether conditions in some years favor increased incidence. It is the ARS view that the small infestation rate observed in Hass avocado, in the context of other avocado experience, is sufficient to classify Hass avocado as a very poor host of Mexican fruit fly. This is consistent with the decision made for Sharwil avocado in Hawaii in the early 1990's.

It is not an ARS role to take a position on whether low level infestation rate such as seen in the case of Hass avocado poses an important quarantine risk. Nor is it an ARS role to suggest whether mitigation is needed or the type of mitigation required, should APHIS decide one is needed. ARS defers to APHIS' experience and expertise in risk assessment and management and notes that APHIS successfully manages many commodities with quarantine risks (including avocados) entering the U.S. from all parts of the world.

cc:
C. Rexroad, ARS
G. Gordh, APHIS

Appendix G: Population of U.S. Counties in Plant Hardiness Zones 8-11 (Fruit Fly susceptible areas) (http://quickfacts.census.gov)

COUNTY	POPULATION
TEXAS	
Anderson	54,585
Angelina	80,582
Aransas	22,695
Atascosa	40,948
Austin	24,596
Bandera	12,645
Bastrop	63,934
Bee	32,314
Bell	244,668
Bexar	1,446,333
Bosque	17,535
Bowie	89,306
Brazoria	249,832
Brazos	156,099
Brewster	8,866
Brooks	7,683
Burleson	16,874
Burnet	36,889
Caldwell	35,050
Cameron	344,782
Camp	11,549
Cass	30,438
Chambers	26,859
Cherokee	47,450
Colorado	20,384
Comal	85,109
Comanche	14,026
Coryell	74,495
Crockett	4,099
Culberson	2,975
Dallas	2,218,899
Dawson	14,838
Denton	432,976
DeWitt	20,067
Dimmit	10,170
Duval	12,996
Edwards	2,162
El Paso	679,622
Ellis	111,360
Falls	18,091
Fayette	22,304
Fort Bend	381,200
Freestone	18,595
Frio	16,392
Galveston	255,865
Gillespie	21,607
Goliad	7,075
Gonzales	18,884
Gregg	111,379
Grimes	24,740
Guadalupe	94,215
Hamilton	8,079
Hardin	48,988
Harris	3,557,055
Harrison	62,110
Hays	109,570
Hidalgo	590,285
Hill	33,701
Hood	431,100
Hopkins	31,960
Houston	23,225
Hudspeth	3,344
Jackson	14,291
Jasper	35,604
Jeff Davis	2,207
Jefferson	249,640
Jim Hogg	5,161
Jim Wells	39,950
Johnson	126,811
Karnes	15,411
Kendall	25,390
Kennedy	413
Kerr	43,653
Kimble	4,468
Kinney	3,379
Kleberg	31,015
Lampasas	18,846
Lasalle	5,866
Lavaca	18,935
Lee	16,329
Leon	15,885
Liberty	73,739
Liberty	72,620
Limestone	22,263
Lipton	3,057
Live Oak	12,177
Llano	17,758
Madison	13,105
Marion	10,941
Mason	3,738
Matagorda	38,157
Maverick	48,259
McColloch	8,205
McLennan	217,713
McMullen	849
Medina	39,304
Menard	2,366
Milam	24,880
Mills	5,151
Montgomery	328,449
Morris	13,048
Nacogdoches	59,514
Navarro	46,792
Newton	15,072
Nueces	312,470
Orange	84,582
Panola	22,756
Parker	88,495
Pecos	16,809
Polk	44,449
Presidio	7,304
Real	3,047
Reeves	13,137
Refugio	7,729
Robertson	16,044
Rusk	47,372
Sabine	10,469
San Augustine	8,946
San Jacinto	23,247
San Patricio	67,120
San Saba	6,186
Shelby	25,224
Smith	174,706
Somervell	6,809
Starr	54,671
Sutton	4,077
Tarrant	1,446,219
Terrell	1,081
Titus	28,118
Travis	850,813

Trinity	14,088
Tyler	20,743
Upshur	35,291
Val Verde	44,856
Victoria	84,932
Walker	62,388
Waller	34,057
Webb	201,292
Wharton	41,329
Willacy	19,905
Williamson	289,924
Wood	36,757
Zapata	12,461
Zavala	11,600
	18,728,368
NEW MEXICO	
Dona Ana	178,664
Grant	30,237
Hidalgo	5,343
Luna	25,238
Otero	61,577
Sierra	12,988
	314,047
ALABAMA	
Autauga	45,604
Baldwin	147,932
Bibb	21,838
Bullock	11,367
Butler	20,911
Chambers	36,251
Chilton	40,516
Choctaw	15,418
Clarke	27,577
Coffee	43,878
Conecuh	13,687
Coosa	11,871
Covington	11,871
Crenshaw	13,663
Dale	49,186
Dallas	45,653
Elmore	68,711
Escambia	38,347
Geneva	25,346
Greene	10,035
Hale	17,067
Henry	16,292

Houston	89,966
Lee	118,123
Lowndes	13,508
Macon	23,788
Marengo	22,475
Mobile	400,163
Monroe	24,043
Montgomery	223,346
Perry	11,637
Pike	29,588
Russell	49,415
Sumter	14,376
Tallapoosa	40,946
Washington	17,927
Wilcox	13,137
	1,825,459
ARIZONA	
Cochise	119,281
Coconino	120,295
Gila	51,565
Graham	33,141
Greenlee	7,828
Maricopa	3,194,798
Mojave	161,788
Pima	863,049
Pinal	188,846
Santa Cruz	39,590
Yavapai	175,507
Yuma	164,942
	5,120,630
CALIFORNIA	
Alameda	1,443,741
Amador	35,100
Butte	209,203
Butte	203,171
Calaveras	40,554
Contra Costa	948,816
Del Norte	27,507
El Dorado	156,299
Fresno	799,407
Glenn	26,453
Humboldt	126,518
Imperial	142,361
Inyo	17,945
Kern	661,645
Kings	129,461

Lake	61,970
Lake	58,309
Lassen	34,007
Los Angeles	9,519,338
Madera	123,109
Marin	247,289
Mariposa	17,130
Mendocino	86,265
Merced	210,554
Monterrey	401,762
Napa	124,279
Nevada	92,033
Orange	2,846,289
Placer	278,509
Plumas	20,890
Riverside	1,545,387
Sacramento	1,223,499
San Benito	53,234
San Bernardino	1,709,434
San Diego	2,813,833
San Francisco	776,733
San Joachim	563,598
San Luis Obispo	246,681
San Mateo	707,161
Santa Barbara	399,347
Santa Clara	1,682,585
Santa Cruz	255,602
Shasta	163,256
Sierra	3,552
Siskiyou	44,301
Solano	394,542
Sonoma	458,614
Stanislaus	446,997
Sutter	78,930
Tehama	56,039
Touloumne	54,501
Trinity	13,022
Tulare	368,021
Ventura	753,197
Yolo	168,660
Yuba	62,339
	34,132,979
ARKANSAS	
Arkansas	20,355
Ashley	23,875
Calhoun	5,681
Chicot	13,623

Clark	23,535
Columbia	25,343
Dallas	8,785
Desha	14,805
Drew	18,639
Hempstead	23,492
Lafayette	8,382
Little River	13,474
Miller	41,133
Nevada	9,742
Ouachita	27,868
Phillips	25,001
Pike	11,137
Sevier	15,811
Union	45,279
	375,960
FLORIDA	
Alachua	222,254
Baker	22,793
Bay	151,901
Bradford	26,297
Brevard	489,522
Broward	1,668,560
Calhoun	12,567
Charlotte	147,009
Citrus	122,470
Clay	147,542
Collier	265,769
Columbia	58,028
DeSoto	32,438
Dixie	14,063
Duval	792,434
Escambia	297,272
Flagler	54,964
Franklin	10,069
Gadsden	45,279
Gilchrist	14,720
Glades	10,750
Gulf	14,789
Hamilton	13,710
Hardee	26,759
Hendry	36,562
Hernando	135,751
Highland	88,972
Hillsborough	1,027,318
Holmes	18,628
Indian River	116,488

Jackson	46,408
Jefferson	13,695
Lafayette	7,009
Lake	227,598
Lee	462,455
Leon	243,995
Levy	35,953
Liberty	6,902
Madison	18,309
Manatee	274,523
Marion	267,889
Martin	130,313
Miami-Dade	2,289,683
Monroe	78,556
Nassau	60,558
Okaloosa	175,708
Okeechobee	36,385
Orange	923,311
Osceola	181,932
Palm Beach	1,165,049
Pasco	362,658
Pinellas	924,610
Polk	492,751
Putnam	70,880
Santa Rosa	127,212
Sarasota	335,323
Seminole	374,334
St Johns	131,684
St Lucie	200,018
Sumpter	54,504
Suwannee	36,121
Taylor	19,339
Union	13,877
Volusia	454,581
Wakulla	24,900
Walton	43,843
Washington	21,419
	16,419,963
GEORGIA	
Appling	17,650
Atkinson	7,712
Bacon	10,055
Baker	4,025
Baldwin	44,787
Ben Hill	17,450
Berrien	16,285
Bibb	154,824

Bleckley	11,855
Brantley	15,060
Brooks	16,428
Bryan	25,256
Bulloch	57,307
Burke	22,794
Calhoun	6,395
Camden	44,702
Candler	9,764
Charlton	10,533
Chatham	233,702
Chattahoochee	15,440
Clay	3,392
Clinch	6,904
Coffee	38,298
Colquitt	42,802
Columbia	94,958
Crawford	12,509
Crisp	22,018
Decatur	28,243
Dodge	19,047
Dooly	11,505
Dougherty	95,875
Early	12,172
Echols	3,842
Effingham	40,832
Emanuel	22,099
Evans	11,095
Glascock	2,598
Glynn	69,036
Grady	23,838
Hancock	10,026
Harris	25,092
Houston	116,768
Irwin	9,945
Jeff Davis	12,910
Jefferson	17,138
Jenkins	8,647
Johnson	8,676
Jones	24,492
Lanier	7,216
Laurens	45,890
Lee	27,382
Liberty	61,749
Long	10,761
Lowndes	93,658
Macon	14,062
Marion	7,238

McDuffie	21,438
McIntosh	11,150
Miller	6,400
Mitchell	23,974
Monroe	22,675
Montgomery	8,397
Muscogee	185,948
Peach	24,224
Pierce	15,982
Pulaski	9,716
Quitman	2,621
Randolph	7,451
Richmond	197,842
Schley	3,975
Screven	15,201
Seminole	9,310
Stewart	5,040
Sumter	33,247
Talbot	6,713
Tattnall	22,560
Taylor	8,913
Telfair	11,780
Terrell	10,871
Thomas	42,976
Tift	39,338
Toombs	26,388
Treutlen	6,837
Turner	9,691
Twiggs	10,545
Upson	27,773
Ware	35,558
Warren	6,211
Washington	20,803
Wayne	27,062
Webster	2,315
Wheeler	6,183
Wilcox	8,529
Wilkinson	10,357
Worth	21,767
	2,772,498
Louisiana	
Acadia	58,920
Allen	25,290
Ascension	79,873
Assumption	23,257
Avoyelles	41,467
Beauregard	33,328

Bienville	15,445
Bossier	100,736
Caddo	251,125
Calcaseiu	182,842
Caldwell	10,682
Cameron	9,805
Catahoula	10,890
Claiborne	16,452
Concordia	20,019
DeSoto	26,004
East Baton Rouge	412,008
East Carroll	9,101
East Felician	21,119
Evangeline	35,442
Franklin	20,851
Grant	18,732
Iberia	73,530
Iberville	33,095
Jackson	15,377
Jefferson	451,459
Jefferson Davis	31,275
Lafayette	190,894
LaFourche	90,273
LaSalle	14,216
Lincoln	42,351
Livingston	99,066
Madison	13,317
Morehouse	30,443
Natchitoches	38,663
Ouachita	147,302
Plaquemines	27,004
Pointe Coupee	22,569
Rapides	126,881
Red River	9,592
Richland	20,696
Sabine	23,598
San Martin	49,181
St Bernard	49,181
St charles	48,548
St James	21,224
St John Baptist	43,798
St Mary	52,833
St. Charles	49,250
St. Helena	10,403
St. Landry	88,199
St. Martin	49,657
St. Tammany	201,462
Tangipahoa	102,593

Tensas	6,493
Terre Bonne	105,123
Union	22,771
Vermillion	53,661
Vernon	51,008
Washington	43,882
Webster	41,509
West Baton Rouge	21,625
West Carroll	12,103
West Felician	15,140
Winn	16,497
	4,081,130
MISSISSIPPI	
Adams	33,573
Amite	13,451
Bolivar	39,839
Claiborne	11,735
Clarke	17,968
Coahoma	30,158
Copiah	28,808
Covington	19,728
Forrest	73,465
Franklin	8,349
George	19,797
Greene	13,095
Hancock	44,673
Harrison	190,936
Hinds	249,579
Holmes	21,651
Humphreys	10,750
Issaquena	2,194
Jackson	133,259
Jasper	18,286
Jefferson	9,661
Jefferson Davis	13,521
Jones	65,053
Lamar	41,167
Lauderdale	77,600
Lawrence	13,448
Leake	21,540
LeFlore	37,099
Lincoln	33,448
Madison	77,872
Marion	25,319
Neshoba	29,027
Newton	21,967
Pearl River	50,473

Perry	12,200
Pike	38,987
Rankin	121,577
Scott	28,338
Sharkey	6,252
Simpson	27,672
Smith	15,853
Stone	14,280
Sunflower	33,889
Walthall	15,141
Warren	49,443
Washington	61,315
Wayne	21,219
Wilkinson	10,228
Yazoo	28,199
	1,983,082
NEVADA	
Clark	1,464,653
Esmeralda	884
Lincoln	4,243
Mineral	4,834
Nye	34,499
	1,509,113
NORTH CAROLINA	
Bladen	135,893
Brunswick	78,567
Carteret	60,232
Columbus	54,930
Craven	91,926
Cumberland	303,328
Duplin	50,800
Jones	10,259
Lenoir	59,073
New Hanover	165,712
Onslow	149,003
Pender	42,734
Robeson	125,351
Sampson	61,256
Wayne	112,954
	1,502,018
SOUTH CAROLINA	
Aiken	145,276
Allendale	10,949
Bamberg	16,314

Barnwell	23,407
Beaufort	127,977
Berkeley	145,274
Calhoun	15,366
Charleston	316,559
Chesterfield	43,206
Clarendon	32,895
Colleton	38,804
Darlington	67,931
Dillon	30,914
Dorchester	100,833
Edgefield	24,868
Florence	127,237
Georgetown	58,263
Hampton	21,316
Horry	206,039
Jasper	20,969
Kershaw	53,630
Lee	20,450
Lexington	222,897
Marion	34,964
Marlboro	28,682
McCormick	10,218
Orangeburg	91,190
Richland	329,086
Saluda	19,247
Sumter	105,198
Williamsburg	36,491
	2,526,450
VIRGINIA	
Chesapeake City	206,665
Norfolk City	239,036
Suffolk City	69,966
Virginia Beach	433,934
	949,601
HAWAII	**1,224,398**
OREGON	
Benton	78,615
Clackamas	351,815
Clatsop	35,791
Columbia	45,313
Coos	62,459
Curry	21,118
Douglas	100,866

Hood River	20,805
Jackson	186,430
Josephine	77,496
Lane	324,316
Linn	104,941
Marion	293,155
Multnomah	677,626
Polk	64,657
Tillamook	24,308
Washington	473,263
Yamhill	88,055
	3,031,029
WASHINGTON	
Clallam	66,302
Clark	370,236
Cowlitz	94,514
Grays Harbor	68,470
Island	75,050
Jefferson	26,761
King	1,759,604
Kitsap	236,174
Lewis	69,710
Mason	51,008
Pacific	20,778
Pierce	732,282
San Juan	14,565
Skagit	106,926
Skamania	10,049
Snohomish	633,947
Thurston	217,641
Wahkiakum	3,793
Whatcom	174,362
	4,732,172