Importation of 'Hass' Avocado Fruit (*Persea Americana* cv. Hass) from Mexico

A Risk Asssesment

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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 risk assessment responds to a request to remove certain restrictions on the importation of avocados from Mexico. Its purpose is to analyze the risks of expanding the existing Mexican Hass avocado import program to authorize imports of Mexican Hass avocados to all states during the entire year. This assessment was thus prepared to assist APHIS in evaluating the request from Mexican avocado growers to expand the scope of the existing Mexican Hass avocado import program. APHIS phytosanitary regulations currently restrict avocado imports to Alaska and 31 northeastern and north central states and limit distribution to October 15 through April 15. This risk assessment evaluates the importation of Mexican avocado fruit to the entire United States during all months of the year. It analyzes the plant pest risks associated with fresh 'Hass' variety avocado fruits (*Persea americana*) grown in the state of Michoacán, Mexico.

The assessment lists one hundred sixteen avocado pests known to occur in Mexico that may have potential importance in the United States. After eliminating non-quarantine and non-pathway pests from the list, five pests (three seed weevils: *Conotrachelus aguacatae, C. perseae*, and *Heilipus lauri*; one stem weevil: *Copturus aguacatae*; and one seed moth: *Stenoma catenifer*) remain that have quarantine significance and are potentially able to follow the pathway.

The systems approach for 'Hass' avocados imported from Mexico includes a set of independent, redundant, and overlapping phytosanitary measures that collectively reduce the risk of pest introduction into the United States . The first level of controls can detect infested areas with a high degree of confidence. Exporting municipalities and orchards in Michoacán have been surveyed annually for six years with negative results for four of the five pathway pests: *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae*, and *Contrachelus perseae*. The remaining pathway pest, the stem weevil, *Copturus aguacate*, was detected in five surveys of orchards seeking to export to the United States over six years of surveillance. These five detections were part of field surveys (using traps, visual inspections and other sampling systems) and not part of the export fruit dissection program described below. Those positive surveys resulted in loss of export certification of the involved orchards until appropriate pest eradication measures were completed.

Cutting and inspection of fruit is the second level of control designed to detect fruit infested with any of the five pathway pests. Samples of fruit are collected in orchards, packing houses, and 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 100,000 at border inspection) for pest larvae. If an infested avocado were found, a trace-back mechanism in the systems approach allows APHIS and Mexican authorities to identify the source orchard. These orchards will lose their export certification until appropriate pest eradication measures are completed.

The mitigations in the systems approach are designed to reduce the risk from pathway pests. The success of this approach is evident from the failure to detect even one pest or infested avocado 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.

A quantitative model based only on the fruit cutting data predicts that the most likely number of imported, infested avocados is zero. Specifically, the most likely proportion of infested avocados was found to be zero; the 95% confidence interval ranged from 0 to 5.25×10^{-7} [that is, from 0 to 52.5/100,000,000].

A model that combined simulations of infested fruit with forecast number of fruit exported to the United States indicated a 95% level of confidence that the annual number of avocados distributed to avocado-growing counties in the U.S. will not exceed 66.

Even if an infested avocado were to arrive at a region with host material, several additional conditions are required for pest establishment: (a) The pest must survive in the avocado during transportation and storage; (b) The infested avocado must be discarded in close proximity to host material; (c) The pest must find a mate; (d) The pest must successfully avoid predation and other threats; (e) The adult pest must find appropriate host material; and (f) Suitable climatological and microenvironmental conditions must exist. Although information that would allow quantifying these conditions is not currently available, APHIS believes that collectively they substantially reduce the likelihood of pest establishment and the overall level of risk.

The rate of avocado pests entering the United States in legally imported commercial fruit, if these pests are entering at all, is certainly far lower than the rate in prohibited avocados arriving at U.S. ports of entry in the baggage of travelers. APHIS-PPQ data (PIN309) 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 thirty avocados infested with pathway pests were intercepted and denied entry into the United States each year. Between this period, 502 pathway pests were detected in intercepted avocados in baggage and cargo: *Conotrachelus* sp.: 242; *Copturus* sp.: 5; *Heilipus* sp.: 38; *Stenoma* sp.: 217. APHIS estimates that more than 80% of prohibited fruit escape detection (Miller et al, 1996; Meisner et al, 2003). Thus, 120 avocados infested with pathway pests are estimated to enter the United States each year through baggage and cargo. Prohibited avocados in baggage and cargo pose a substantially greater risk to U.S. agriculture than commercial imports of 'Hass' avocados from Mexico.

In the past, fruit flies (*Anastrepha* spp.) were a major concern. Recent research (Aluja et al, 2002) conducted under both field and laboratory conditions prompted a re-evaluation of the potential of *Anastrepha* spp. to infest 'Hass' avocados (Appendix C). Based on this research, APHIS concluded that commercially produced 'Hass'

avocados are not natural hosts for the *Anastrepha* spp. considered.

Finally, we note that as important as are the results of the quantitative model, we cannot ignore the risk-reducing effects of the systems approach, not all of which are captured by the quantitative model but are evidenced in USDA's experience with the program and fruit sampling information. We believe the repeated surveys, inspections, and the other requirements of the systems approach reduce risk substantially. Our confidence in these surveys and inspections is reinforced, first, by repeated site visits by APHIS headquarters personnel; second, by the active participation of APHIS field personnel in the surveys; third, by the redundancy of the systems approach mitigations; and fourth, by the fact that examination of over ten million fruit has not revealed even one pest.

Introduction

This risk assessment responds to a request to remove certain restrictions on the importation of 'Hass' avocados from Mexico; its purpose is thus to analyze the risks of expanding the existing Mexican Hass avocado import program to authorize imports of Mexican Hass avocados to all states during the entire year. This assessment was prepared to assist APHIS in evaluating the request from Mexican avocado growers to expand the scope of the existing Mexican Hass avocado import program. The request to expand the existing Mexican avocado import program will be referred to as the proposed modified systems approach. 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 pest risk assessment evaluates the importation of Mexican avocado fruit to the entire United States and during all months of the year. It analyzes the plant pest risks associated with fresh 'Hass' variety avocado fruits (*Persea americana*) grown in the state of Michoacán, Mexico. Whereas the current system is used as a reference point, this assessement focuses on the risks associated with a program that is expanded both geographically and in time.

This assessment first identifies and lists all pests of potential importance to the United States associated with Mexican avocados (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. Two quantitative endpoints of the likelihood of introduction of pathway pests are estimated: the number of infested avocados reaching the United States each year and the number of infested avocados reaching avocado producing regions in the United States each year. Given an importation of an infested avocado, the additional steps leading to pest spread and establishment are evaluated using qualitative evidence. Finally, the consequence of introduction is considered.

This document does not attempt to address the level of pest infestation that constitutes acceptable or negligible risk. However, information on the number of pathway pests in prohibited fruit in the baggage and cargo arriving in the United States is provided for comparison.

APHIS has completed several risk assessments of avocados imported from Mexico (USDA 1995, 1995a, 1996, APHIS 2001b). This document updates and supplements evidence presented in those assessments and analyses. Also, this assessment considers new evidence of the potential for *Anastrepha* fruit flies to infest 'Hass' avocados and the results of avocado inspections completed by Mexican and APHIS officials. To the extent possible, key elements of previously published risk assessments and APHIS documents are presented here to permit the reader to understand this assessment 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/.

Whereas the terms "assessment" and "assessment" have similar meaning, in the area

of risk assessment the term “assessment” is usually employed as a broader concept to describe a process where the hazard is characterized, impacts are assessed, mitigations evaluated, and communications considered. Risk “assessment” usually refers to the characterization of the hazards and the evaluation of impacts (that is, “assessment” *sensu stricto*, does not include risk mitigation and risk communication). Because this assessment is part of a process that will include separate communication elements, and for consistency with previous documents, we will refer to this document as a risk “assessment”. This document will evaluate hazards, impacts and evaluate some mitigation alternatives.

History of Avocado Importation from Mexico

Quarantine 56 (7 CFR § 319.56) provides general regulatory authority for 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).

Table 1 - Chronology of Mexican Avocado Importation

Year	Event
1914	APHIS prohibits importation of avocados from Mexico because of seed weevils.
1993	APHIS allows entry of Mexican Hass avocados into Alaska under certain conditions.
1997	APHIS allows entry of Mexican Hass avocados from Michoacán, Mexico to 19 northeastern states from November to February, subject to certain phytosanitary requirements.
2001	APHIS allows entry of Mexican Hass avocados from Michoacán, Mexico to 31 northeastern and north central states from October 15 through April 15, subject to certain phytosanitary requirements.

USDA has restricted importation of Mexican avocado fruit since 1914 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 petitioned repeatedly for authorization to import Mexican avocado fruit into the United States.

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 risks associated with imports into Alaska were low because imported pests could not survive or establish there. That assessment used a decision sheet format (Attachments 1 and 2 of Risk Management Assessment: 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 export 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. Also, APHIS officials prepared two documents as part of the

risk assessment. The first document, "Risk Management Assessment: A Systems Approach for Mexican Avocado," (USDA, 1995b), is an assessment of 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 such 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 (USDA, APHIS, 1997). 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) plus the District of Columbia but limited shipments to the months from 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 Sec. 319.56-2ff) avocados are currently allowed to enter 31 states and the District of Columbia between October 15 through April 15 of the following year. The current importations are subject to a series of mitigations, described in "Risk Management Assessment: A Systems Approach for Mexican Avocados" (USDA, 1995b, available at: http://www.aphis.usda.gov/ppq/avocados/). Under the regulations (7CFR Sec. 319.56-2bb) avocados may be imported in Alaska 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, redundant and overlapping phytosanitary measures that collectively mitigate the risk of pest introduction into the United States (Anon, 2002; and NAPPO Glossary of Phytosanitary Terms). The systems approach 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 introduction of pests (FAO, 2002). The systems approach for 'Hass' avocados has successfully protected U.S. agriculture for several years. 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 two components (components 6 and 9, Table 2), allowing avocados to enter all fifty states and during all times of the year.

1. Field surveys

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

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

Current components	Modifications to components
1. Field Surveys (municipalities and orchards)	*Anastrepha* spp. survey requirement removed
2. Trapping Activities	*Anastrepha* spp. trapping requirement removed
3. Field Sanitation	
4. Host Resistance	
5. Post-Harvest Safeguards	
6. Winter Shipping Only (Oct 15 – April 15)	No restriction on shipping season
7. Packing House Inspection and Fruit Cutting	
8. Port-or-Arrival Inspection and Clearance Activities	
9. Limited Distribution (31 states and the District of Columbia)	No restriction on distribution. Requirement for sealing trucks during transport within the United States removed.

Municipality Surveys

Current regulations and the proposed systems approach require the Government of Mexico to conduct annual area surveys of Michoacán municipalities for *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae* and *Contrachelus perseae* (7 CFR§319.56-2ff (c)(1)(ii)). The surveys must cover at least 300 randomly selected hectares in each municipality and include portions of commercial orchards, wild areas and backyards. 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; USDA, 2003; http://www.aphis.usda.gov/ppq/avocados/workplan_2003.pdf).

Six years of surveys found no evidence of the four pathway pests (*Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae* and *Contrachelus perseae*) in Michoacán municipalities certified to export to the United States (Tables 5a and 5b). Some experts doubt that climatic conditions in Michoacán are suitable for *Stenoma catenifer* or that the pest is even able to infest the 'Hass' variety of avocado (USDA/APHIS, 2001b Appendix E&F). The existence of *Contrachelus aguacate* and *Heilipus lauri* in Michoacán at any time in the past is questionable although they have been found in nearby states (USDA/APHIS, 2001b Appendix F). The seed weevil, *Conotrachelus perseae*, occurs only in one small area of Michoacán near Ziracuaretiro. 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/APHIS, 2001b Appendix F). We note that the detections of *Conotrachelus* have not occurred as part of the export fruit dissection, but as part of separate sampling procedures as described above. We further note that when quarantine pests have been found, those areas have been eliminated from the export program and eradication programs have ensued. This clarification is offered to explain the absence of pests in six years of systematic export fruit dissections as contrasted with sampling using alternative methods in all areas (not just export orchards) which has resulted in reports from the region (and subsequent eradication or exclusion efforts) of pests such as *Conotrachelus* and *Copturus*.

APHIS monitors Mexico's compliance with municipality survey procedures in Michoacán. If *Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae* or *Contrachelus perseae* were detected, the affected municipality would lose its pest-free certification. Sanidad Vegetal is required to inform APHIS about infestations and control/eradication measures and suspend avocado exports from the municipality involved. Exports could resume only if and when APHIS were to determine that Mexico has implemented effective measures and eradicated the pest from the infested municipality.

Orchard surveys

The current and proposed modified systems approach requires Mexican authorities to conduct annual surveys of orchards for the fifth pathway pest, the stem weevil, *Copturus aguacatae*.

Registration of orchards in the export program requires participation in a multi-level pest inspection and approval process outlined in Mexican regulation NOM-066. The registration 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 the pest-free export-eligible orchards, the Comite Estatal de Sanidad Vegetal (CESV - equivalent to a state agricultural office in the U.S.) again inspects those orchards and certifies freedom from the five pathway pests. Orchards that pass this inspection are approved to export for the next 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.

Fruit are sliced and inspected for pathway pests in the orchards during the surveys. A total of 8.8 million avocados from export orchards were inspected over the previous six years (an average of 1.4 million avocados per year) and no pathway pests were found.

APHIS monitors compliance with orchard survey requirements and APHIS personnel participate in the annual surveys. If the stem weevil, *Copturus aguacatae* is detected, the affected orchard is denied export certification for the entire shipping season. Exports can resume only when APHIS determines that Mexico has implemented effective measures and eradicated the pest from the infested orchard. During the past six years of surveillance, stem weevils were detected in five orchard surveys.

2. Trapping

The current rule requires trapping and field bait treatment for fruit flies *Anastrepha ludens*, *A. serpentina*, *A. obliqua*, and *A. striata.* Based on recent research, APHIS believes that commercial 'Hass' avocados are not natural hosts for *Anastrepha* species that occur in Mexico (Appendix C).

3. Field sanitation practices

The current and proposed modified systems approach require orchard sanitation measures. 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.). Pruning helps to prevent infestations of the stem weevil (*Copturus aguacate*) (USDA, APHIS; 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 annual orchard surveys.

4. Host resistance

The natural resistance 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 black color, rugose skin and other characteristics when ripe. Other varieties are green or smooth skinned. Accidental or deliberate substitution of other varieties is unlikely and can be easily detected.

5. Post-harvest safeguards

The current systems approach includes requirements designed to ensure that avocados originate from certified orchards and to maintain the identity of the orchard from

harvest until arrival at market in the United States. Refrigeration is required during transportation and storage. These requirements will be maintained in the proposed modified systems approach.

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 must be maintained from the field boxes to the shipping containers (7CFR§319.56-2ff(c)(3)(vii)). Prior to packing in boxes, each avocado must be labeled with the registration number of the packing house. In addition, avocados must be packed in boxes marked with the identity of the grower, packinghouse, and exporter. If a pest were found in an avocado at any point from the packinghouse to the market, APHIS and Sanidad Vegetal could 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 U.S. and Mexican authorities to determine the cause of a breakdown in the systems approach and respond with appropriate measures.

All shipments of avocados must be accompanied by a phytosanitary certificate issued by Sanidad Vegetal certifying that the conditions specified in the regulations have been met. Shipments are sealed during transit to the port of first arrival and certificates are checked by DHS inspectors at the port of first arrival. These measures ensure that shipments of fruit originate from certified orchards that are managed in accordance with the requirements of the rule.

The current and proposed modified systems approachs require transportation of avocados in refrigerated trucks or containers. In addition, avocados are refrigerated during storage as part of normal retail marketing and distribution of fruit. 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 below 4 to 10 degrees C (http://www.ento.vt.edu/Fruitfiles/Understanding_Degree_Days.html) and commonly exhibit high mortality as well, especially 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 will 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 must be listed in the annual work plan that Sanidad Vegetal provides 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. The proposed modified systems approach will retain these packinghouse requirements.

Avocados must be moved from the orchard to the packinghouse within 3 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)). These measures are all designed to exclude fruit flies (*Anastrepha* spp.). Although Hass avocados are not natural hosts for the fruit fly species commonly found in Mexico, some evidence suggests *Anastrepha* spp. may be able to infest avocados several hours after they are picked if fruit are forcibly exposed to sexually mature, gravid females under artificial laboratory conditions (Appendix C).

Stems and leaves must be removed from the fruit prior to packing in boxes. This requirement helps to ensure that pests infesting parts of the plant other than the fruit are excluded from the shipment. *Copturus aguacatae* is the only pathway pest that usually infests the stem rather than fruit.

Inspectors in the packinghouses slice and inspect 300 fruit per export shipment for the presence of the larva of pathway pests. In practice, this is accomplished by sampling 75 from each field truck arriving at the packing house from the orchard. Sanidad Vegetal inspectors have examined nearly 250,000 avocados per year for the past six years. A total of 1.5 million avocados were examined; no pests were found.

Packinghouses must label each fruit with a sticker with the registration number of the packinghouse and mark the boxes or crates with the identity of the grower, packinghouse, and exporter. 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 a pest were found at the packinghouse or the port of first arrival in the United States.

Another post-harvest requirement is refrigeration of trucks from the packinghouse to the market in the United States (7 CFR§319.56-2ff(3)(c)(viii)). The lethality of refrigeration on the five pathway pests is unknown but refrigeration does delay the development of all of the five pests. 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.

8. Port-of-arrival inspection

Mexican avocados currently may enter the United States only at designated locations. 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 (7CFR § 319.56 – 2ff (d)). Currently, DHS inspectors sample at least 30 boxes and/or 30 fruit per shipment. DHS (formerly, APHIS) inspectors have examined approximately 20,000 avocados per year for the past six years. A total of approximately 117,000 avocados have been examined; no pests were found.

These requirements remain unchanged in the proposed modified systems approach.

Summary of Key Safeguards

Surveys for pathway pests in municipalities and orchards are the first line of defense in preventing pests from entering the import pathway. Inspection of fruit at packinghouses and ports of entry is a secondary line of defense. In addition, fruit are sliced and inspection in orchards, packing houses, and ports of arrival in the United States. If a pathway pest is detected, APHIS and Mexican officials can trace 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 fruit in the import pathway.

APHIS conducted a risk management assessment for Mexican 'Hass' avocados in 1995 and described the degree to which the various elements of the systems approach are expected to mitigate the pest risk associated with such importations. The assessment 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 risk at a low level.

APHIS again reviewed the Mexican 'Hass' avocado import program in 2001 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 visit 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 staffed by Comite Estatal de Sanidad Vegetal (CESV) situated on the borders of all of the export approved municipalities. 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 also 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. APHIS believes 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 are 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 review group reported the following for pest distributions (USDA 2001b):

- The stem weevil, *Copturus aguacate*, 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 eradication. The quarantined area has been reduced from more than 600 acres to 140 acres (as of the USDA 2001b review).
- The seed weevils, *Conotrachelus aguacate* and *Heilipus lauri*, are not known in Michoacán.
- The seed moth, *Stenoma catenifer*, may not occur in Michoacán and would likely be detected by current sampling systems.

Pathway Assessment

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, namely avocados.

The approach taken in this assessment was first to identify all pests of Mexican avocados. From this initial list, non-quarantine pests (as defined by NAPPO and FAO above) were eliminated. From the list of quarantine pests, those pests that are not normally found on the plant part proposed for export (eg, those pests that would infest only roots) were eliminated. We then estimated the likelihood and consequence of introduction for the remaining pests. These steps include the three stages of the FAO guidelines plus additional detail consistent with the IPPC standard (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 seven steps.

Assessment of Weed Potential of Avocado

The initial step after receiving a request for 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 and are also marketed as landscape plants.

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").

IF: All of the above answers are no,

THEN: proceed with the pest risk assessment.

Source: FAO, 1995. International standards for phytosanitary measures. Section 1 – Import Regulations: Guidelines for Pest Risk Assessment (Draft standard). Secretariat of the Internaitonal Plant Protection Convention of the Food and Agriculture Organization of the United Nations. Rome, Italy.

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 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").

All pests listed in Table A-1 and A-2 are present in Mexico. For each pest in Table A-1 and A-2:

- Whether the pest occurs in the U.S is indicated.
- Information on the biology and regulatory history (*e.g.*, interception records) is provided; all pests intercepted at U.S. ports on avocado fruit from Mexico are included on the pest list.
- Selected references on the biology/distribution of each pest are provided.

Identification of Quarantine Pests

From the list of Mexican avocado pests identified in the assessment, all those that were not "quarantine" pests were eliminated. A quarantine pest is defined by the North American Plant Protection Organization (NAPPO) and the United Nations Food and Agriculture Organization (FAO) as, "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; NAPPO/FAO, 1991). The distribution of each pest was reviewed to determine if any official control programs exist. Only those pests that are absent from the United States or are present but are not widely distributed and are officially regulated fit the international standard for quarantine pests.

In table 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 US 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. Only those three are quarantine pests. Of the 86 arthropods in table A-2 (Appendix A), 51 are quarantine pests (49 exist only in Mexico and an additional two exist in the US but are under official control as indicated in the comments for the table).

Identification of Pathway Pests
From the list of quarantine pests, we eliminated those pests that are unlikely to follow the pathway. We reviewed the biology of each pest to determine if the pest is associated with the fruit and eliminated those that could not reasonably be expected to remain on the fruit after processing from further consideration.

Previous assessments (APHIS, 1995a) considered certain *Anastrepha* species as pests likely to be associated with avocado fruit. Those earlier assessments concluded that avocados are either non-hosts or at best, poor hosts, and that the probability of association of *Anastrepha* with the 'Hass' avocado imports is low (Pest risk assessment, addendum and review APHIS 1995a, 1996, 2001).

Recent research on four *Anastrepha* spp. (Aluja et al., 2002) prompted a re-evaluation of their designation as avocado pests (Appendix C). In field cages and laboratory trials, avocados were artificially exposed to large numbers of fertile females 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 cultivars. In the choice trials, avocado varieties other than 'Hass' were visited more frequently and had infestations that resulted in viable offspring. The no-choice studies included 'Hass' avocados only. In the no-choice studies, oviposition was attempted but infestation did not occur. Observations on the physiological responses to oviposition in 'Hass' cultivar avocados suggest that epicarp regeneration and callus formation inhibit larval development.

Field observations by Mexican and U.S. inspection personnel are consistent with Aluja, 2000 (APHIS, 2001; table 5). Ten million avocados were dissected over the past six years as part of the inspection of avocados imports to the United States; none were found positive for *Anastrepha* spp. Based on Aluja et al, 2000 and the dissection data, we conclude that commercially produced 'Hass' avocados are not a natural host for the *Anastrepha* species considered. In table A-2 (Appendix A) a "z" in the comments field indicates that a pest is known to commonly attack or infest fruit and it would be reasonable to expect the pest may remain with the fruit during processing and shipment. The table in Appendix A was updated and the "z" removed from the comments column for *A. ludens, A. opliqua*, *A. serpentina*, and *A. striata*.

The Mediterranean fruit fly (Medfly), *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), was excluded from further consideration because it is absent from the export area. The Mediterranean fruit fly is a quarantine pest with considerable economic importance to the United States. However, the Mediterranean fruit fly is under active control in Mexico and is only found on the Mexico-Guatemala border.

Five of the 54 quarantine pests could potentially follow the pathway. The three quarantine pathogens in Table 1-A were eliminated because they cause leaf spots and root rot and are associated with plant parts other than fruit. Most of the 51 quarantine

[7] shipped 29,990 tons of avocados from October 15 to April 15.

arthropods identified feed strictly on leaves and although they may be serious pests, they do not normally attack the fruit. The phytosanitary conditions required to satisfy existing regulations (e.g., 7 CFR § 319.56) are sufficient to ensure that these pests do not accompany shipments of fruit.

The following five arthropods satisfied both the quarantine and pathway criteria:

- *Conotrachelus aguacatae* - seed weevil
- *Conotrachelus perseae* - seed weevil
- *Heilipus lauri* - seed weevil
- *Copturus aguacatae* - stem weevil
- *Stenoma catenifer* - seed moth

These pests are referred to as pathway pests in this risk assessment; we categorized them as follows:

- seed weevils: *Conotrachelus aguacatae, C. perseae*, *Heilipus lauri*
- stem weevil: *Copturus aguacatae*
- seed moth: *Stenoma catenifer*

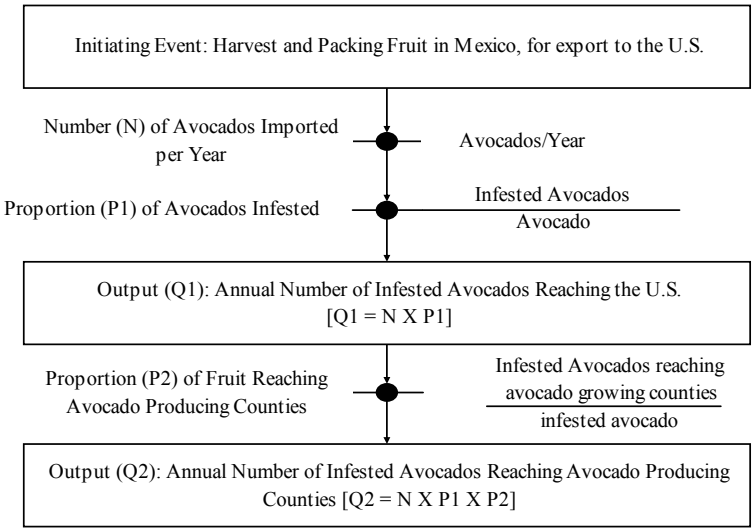
Pathway Scenario Model

A quantitative model was developed to estimate the risk of introduction of the five pathway pests: seed weevils, (*Conotrachelus aguacatae, C. perseae*, *Heilipus lauri*) stem weevils, (*Copturus aguacatae*) and seed moths (*Stenoma catenifer*). The scenario considered is the importation of 'Hass' avocados from Michoacán, Mexico and distribution to the entire United States during the entire year. The pathway extends from harvest and packing in Mexico, through all of the mitigations described in the key safeguards section, and terminates with infested avocados distributed to avocado-producing counties in the United States (Q2, Figure 1). Outputs of this model include estimates for the number of infested avocados that will reach the United States (Q1) and the number of avocados that will reach avocado producing counties in the United States each year (Q2). The model assumes compliance with the mitigations in the systems approach (key safeguards section).

N – Annual Number of Fruit Imported

Between 275 million to 442 million pounds of 'Hass' avocados (approximately, 528 million to 849 million avocados, based on 1.92 avocados per pound) per year will likely be imported from Mexico, if they are allowed to enter all states year-round. The number imported in 2002 totaled about 59 million pounds. Avocado imports from Mexico are thus expected to increase from four to seven times their current level. The estimated range of imported avocados could become 295 million pounds to 442 million pounds (approximately, 567 million to 849 million avocados) per year after five years due to population growth. Details of the approach used in the approximating these ranges can be found in Appendix E.

Figure 1 – Mexican Hass Avocado Pathway Scenario



A uniform distribution from 528 million to 849 million was used as an estimate of the number of 'Hass' avocados imported from Mexico under the expanded distribution scenario. The range used for N was based on the lower end-point approximation at present (528 million avocados) and the higher end-point approximation five years hence (approximately, 849 million avocados).

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 to that country from 1992-1994. Finally, data from foliage surveys for pests in Michoacán orchards between 1997 and 2000 were available (Table 5a and 5b). Only the first source (U.S. fruit cutting data) was used to estimate the proportion of avocados infested. The other two data sources were not used in the quantitative estimation but the results of all three data sources are consistent. That consistency reinforces our belief that the data is accurate. The three data sets are presented and discussed below.

US fruit cutting data

Mexican and U.S. officials inspected more than ten million avocados over the last six years and found zero infested avocados (APHIS, 2001b; table 4). The *Work Plan for the Exportation of 'Hass' Avocados from Mexico to the United States of America* (USDA, 2001b - Appendix C) details the procedures for avocado inspections. The inspectors cut the fruit into slices which are visually examined for fruit flies, seed pests, and stem weevils. Fruit are inspected in the orchards during harvest, in the packing houses in Mexico, and on arrival in the United States. In the packing houses, Mexican inspectors sample the equivalent of 300 fruit from each shipment to the United States. Seventy-five fruit are sampled from each field truck arriving at the packing house from the orchard. That level of sampling is equivalent to sampling 300 fruit from the shipment departing the packing house.

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

Season	Field Samples	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.

U.S. DHS inspectors examine 30 avocados selected from 30 boxes on each truck arriving at U.S. ports of entry.

The sensitivity of avocado inspection is estimated to be 50%, meaning that an inspector would identify 50% of infested, sampled avocados. This estimate is based on Gould (1995) who reported that the sensitivity of inspections for Caribbean fruit fly larva in grapefruit was 35% and that the sensitivity for starfruit inspections was 80%. The ability to detect larva was greater for fruit with uniform, smooth pulp. Avocados have uniform, smooth pulp and inspectors can easily find blemishes, pest tunnels, and larva. The estimate of 50% is slightly less than the average sensitivity reported for starfruit and grapefruit ([35% + 80%] ÷ 2 = 57.5%). This estimate is probably cautious (i.e. an underestimate) for four of the five pathway pests because avocados are more similar to starfruit than grapefruit in terms of ease of fly detection.

The sensitivity of avocado inspection may vary somewhat among the five pathway

pests. All five may damage the fruit pulp as part of feeding if 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 stem. Stem weevils, however, produce a white exudate on the stems of avocados that is readily visible. The larvae only rarely migrate into the fruit and when they do, they are usually localized to the area of the fruit near the stem. Stem weevil infestation can best be detected by examining the foliage in the orchard. Nonetheless, we believe 50% is a reasonable estimate of fruit inspection sensitivity for stem weevils.

Japanese fruit cutting data

Table 5a - 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 Weevil *Conotrachelus aguacatae*	Seed Weevil *Contrachelus 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 *Contrachelus perseae*
1997	42	200	0	0	0	0	0
1998		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 - U.S. Department of Agriculture, Animal and Plant Health Inspection Service, International Services. – NAR, 2003- Uruapan, Mich.

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 fruits) and reported none of the target pests of concern to the United States. This data is consistent with findings from the other two sources and increases our confidence in the validity of all three data sources.

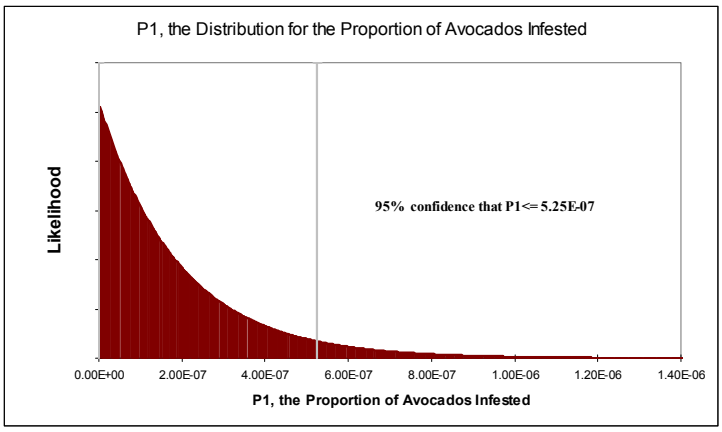
Foliage survey data

Data from orchard surveys is indirect evidence of the proportion of avocados infested (Tables 5a and 5b). The current avocado rule requires annual surveillance of municipalities approved to export avocados to the United States for four of the five pathway pests (*Heilipus lauri*, *Stenoma catenifer*, *Conotrachelus aguacatae*, and *Contrachelus perseae*). The surveys 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 surveys include foliage sampling from ten trees per hectare and visual inspection of the orchards for symptoms of the stem weevil. Foliage samples are collected by beating the lower branches of a tree over a white tarpaulin. The foliage and other material that falls onto the tarpaulin are examined for the presence of pests. These surveys will detect a pest if it is present in at least one percent (confidence level 95%) of the area surveyed.

The four pests controlled at the level of the municipality (*Heilipus lauri*, *Stenoma*

catenifer, *Conotrachelus aguacatae*, and *Contrachelus perseae*) were never found in six annual surveys of the municipalities in Michoacán (table 5a and 5b). The fifth pathway pest (stem weevil - *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, five orchards were positive over the six years that the surveys were conducted. 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 consistency between the survey and fruit cutting results increases our confidence in their validity. Clearly, the orchard surveys do not state that all pests are absent but the overall evidence that includes fruit dissection shows that mitigation measures are preventing pests from being in fruit for export.

Figure 2



In estimating the proportion of avocados infested, the sampling distribution arises from a binomial process. The implicit assumptions are that: (a) avocados are either infested or not infested; (b) infested avocados are randomly distributed throughout shipments; 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, thus reducing the likelihood of undetected pest entry.

Based on the data, the most likely proportion of infested avocados is zero; the 95% confidence interval ranges from 0 to 5.25×10^{-7} (table 8 and figure 2) (for details of the calculations see appendix D).

Of the three sources of data discussed (i.e. orchard surveys, Japanese inspection results, and U.S. inspection results), only the U.S. fruit cutting data was 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.

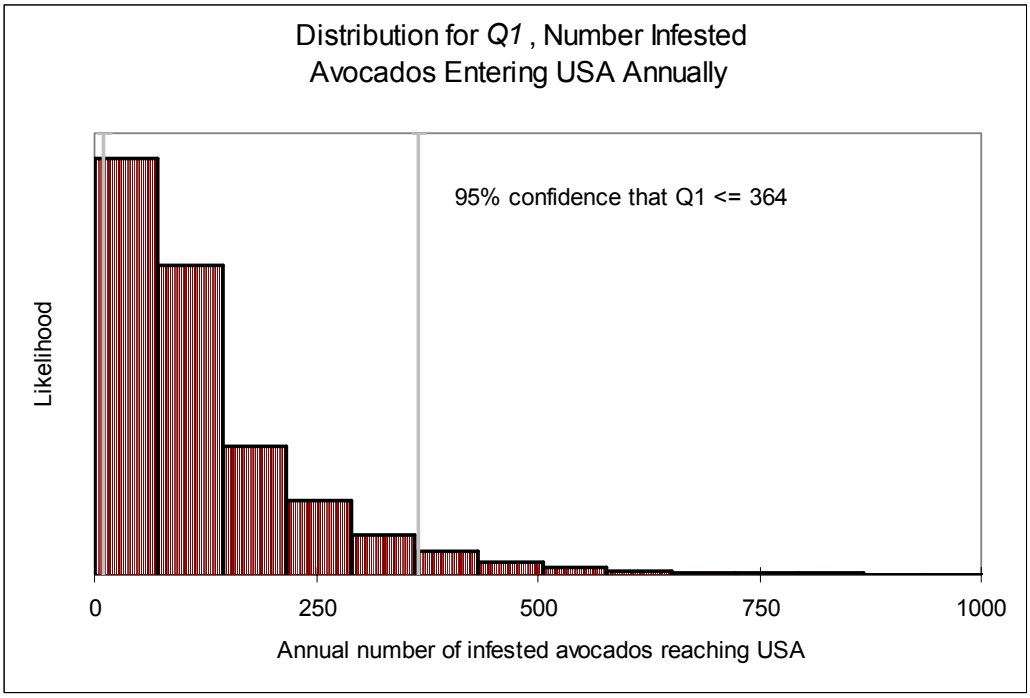
Q1 – Annual number of infested avocados reaching the United States

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 × P1 (Fig. 1). This estimate includes avocados reaching all areas, not just locations where suitable hosts occur.

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 (Figure 3). The most likely value for Q1 is zero; the distribution indicates 95% confidence that the annual number of infested avocados is less than 364 avocados (Figure 3 and Table 8).

P2 – Proportion of fruit that will reach commercial avocado production areas in the United States.

Figure 3.



A susceptible host population must be present for pests to become established. Avocados are the only known hosts in the United States for the five pathway pests. Although capable of flight, the adult stages of these pests do not travel long distances in search of host material. Consequently, U.S. counties with commercial avocado production were used to determine the susceptible habitat for the five pests.

The proportion of fruit that will reach avocado producing areas in the United States (P2) depends, in part, on the number of people living in those areas and the number of avocados they eat. In 2001 about 12 million people lived in avocado producing counties in California, Florida, and Hawaii (Table 6). The average per capita

consumption of avocados in the United States was 0.67 lbs of avocados/person/year (APHIS, 2001c). Avocado consumption is higher in California and other southwestern states (4.29 avocados/person/year) (APHIS, 2001c).

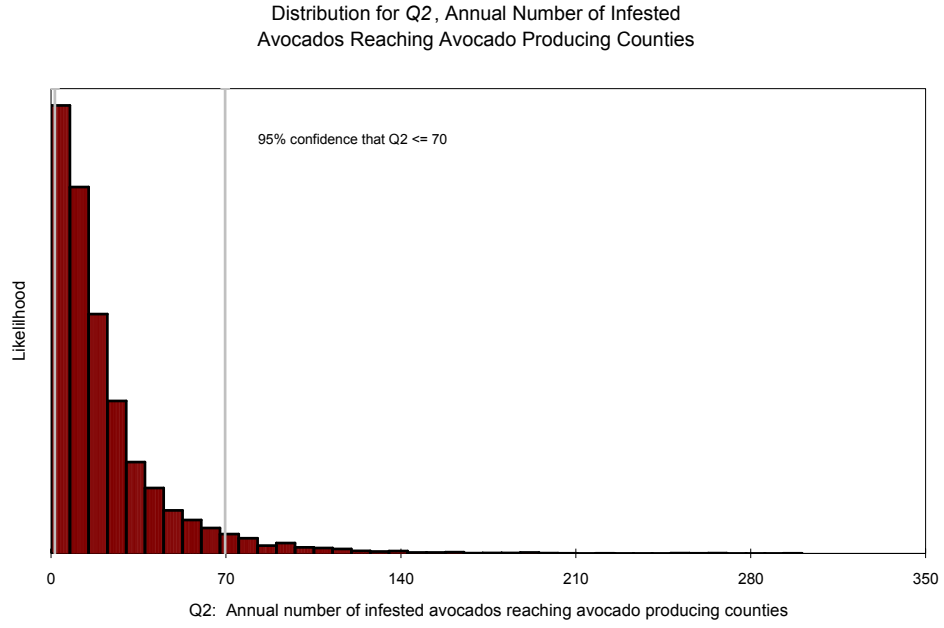
The proportion of imported avocados reaching avocado producing regions in the United States (P2) is estimated between 4.3% and 30%. The lower value (4.3%) was derived using the per capita consumption rate of avocados in the United States (0.67 lbs/person/year). The higher value (30%) was derived using the per capita consumption rate of avocados in the Southwest region of the United States (4.29 lbs/person/year). For details of the calculations see Appendix D.

Table 6 – Characteristics of Avocado Producing Counties in the United States

County	State	Acreage[1]	Population[2]
Orange	CA	1,669	2,890,444
Ventura	CA	11,608	770,630
San Diego	CA	22,862	2,862,819
Riverside	CA	6,074	1,635,888
Santa Barbara	CA	7,660	399,543
San Luis Obispo	CA	1,362	250,727
San Joaquin Valley	CA	89	595,324
Miami-Dade	FL	5,900	2,289,683
Hawaii	HI	230	152,083
Total		**57,454**	**11,847,141**

[1] Source: USDA- National Agriculture Statistics Service and California Avocado Commission. [2] Source: U.S. Census Bureau – Estimated 2001 U.S. Population 277,017,622. The total population for avocado producing counties represents ca. 4.3% of the total U.S. population.

Figure 4.



Factors other than those discussed above influence the proportion of avocados that reach avocados producing regions (P2). The supply in avocado producing regions is higher than the rest of the United States and may reduce the number of avocados

imported to those regions. On the other hand, counties with commercial avocado production underestimate the susceptible habitat for pathway pests because ornamental avocado trees and backyard avocados are also susceptible. These and other factors increase the uncertainty in the estimate for P2. Consequently, P2 is represented in the simulation by a uniform distribution with a minimum value of 4.3% and a maximum of 30% (all values between the minimum and maximum are equally likely).

Q2 – Annual number of infested avocados that reach regions of the United States where avocados are grown commercially.

The estimate of Q2 is a product of the number of avocados imported (N), the proportion infested (P1), and the proportion of avocado producing counties in the United States (P2) or $Q2 = N \times P1 \times P2$.

Monte Carlo simulation of the model using @Risk® resulted in a distribution for Q2 (Figure 4). The most likely annual number of infested avocados distributed to counties with host material is zero; the distribution indicates a 95% level of confidence that that number will not exceed 70 (Figure 4).

Estimates of Consequences of Introduction

We rated the potential consequences for each pest with respect to five different elements. The ranking considers pest potential in the absence of specific risk mitigation activities. Criteria for estimating consequences were qualitative. Numerical values (0, 1, 2, or 3 points) were assigned to each element to assist in categorization. The sum of the five individual ratings provided an estimate of potential consequences for each pest.

We estimated consequences of introduction for each of the pest categories listed in the previous section as candidates for further assessment. For each element (see below), each pest is assigned a value of high (3 points), medium (2 points), low (1 point), or none (0 points) as indicated.

The lowest possible ranking for consequences is 3; pests with values of 3-6 are not considered to represent significant impact, low impact pests have values of 7-9, medium impact pests have values of 10-12, and high impact pests have values of 13-15.

As a general guideline, cumulative rankings of 8 or less are low risk, 9-12 are medium risk, and 13-15 are high risk. This index is considered a biological indicator of the potential of the pest to establish, spread, and cause economic and environmental impact. However, the actual ranking remains a guideline, with primary emphasis given to available evidence for the purpose of reaching final conclusions.

This process of ranking pests and establishing a ranking for consequences is part of our guidelines. Whereas, these indices are considered a valuable indicator, the emphasis is on the evidence, not on a specific numeric outcome. Evaluation of the rankings permits an organized presentation of relevant evidence. Before presentation of the potential consequences, the ranking scheme (from current USDA guidelines, version 5.02) is reviewed below. The qualitative assessment of the likelihood of introduction from the guidelines has been replaced with a quantitative assessment.

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 to its native area. The evaluation will consider ecological zones, interaction between the geographic distribution of the pest and geographic distribution of 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 U.S. "Plant Hardiness Zones" as described by the U.S. Department of Agriculture (see Figure 2) (Cathey, 1990). Risk values were assigned according to the following. Due to the availability of both suitable host plants and suitable climate, the pest has 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.
None (0): In none of the plant hardiness zones.

Risk Element 2: Host range
The risk posed by a plant pest depends on both 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. For both arthropods and pathogens, we rated risk primarily as a function of host range as follows:
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 species in a single genus.

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
- whether 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 ― at least 20 km ― 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.
None (0): Pest does not cause any of the above impacts.

Risk Element 5: Environmental Impact
The assessment 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 species listed by Federal or State agencies as endangered, threatened, or 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 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): One or more 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

Climate/host interaction—Seed weevils infest avocado only (CPC, 2001), which has tropical or subtropical distribution in hardiness zones 9-10, this factor is thus rated medium as per the guidelines above. However, it is noted that the distribution of avocados is limited to a few counties in three states: California, Florida and Hawaii (National Agric. Statistics Service, http://www.usda.gov/nass/), thus the rating of medium may be biased since hardiness zones assume the entire zone is suitable and for the case of avocados, they exist only in a small proportion of hardiness zones 9 and 10. Given this fact, we note that a rating of low may also be considered.

Host range—Seed weevils species infest avocado only (CPC, 2001), thus the rating is low.

Dispersal potential— Seed weevils have long life cycles (60-120 days), 2-3 generations per year, and adults are long-lived (about 90 days). Females of *Conotrachelus* spp. can lay up to 70 eggs. Adults are sedentary and tend to remain in the foliage of the host tree but are capable of flying between orchards (CPC, 2001; Garcia, et al, 1998; Teliz, 2000). Larvae are internal and can be transported worldwide by man. Because of their sedentary nature, we considered a low rating. However, their long life span increases the likelihood of natural and assisted movement and that was our reasoning for a final ranking of high for this factor.

Economic impact—Seed weevils can cause up to 80% yield loss in the export area (Garcia, et al., 1998) and are predicted to cause up to 20% yield loss if they become established in the PRA area (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 be quarantined by other countries. This justified a rating of "high".

Environmental impact— Seed 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 occurs (Evangelou, et al., 1993). The sprays are not expected to have impacts on endangered

or threatened species beyond those impacts already caused by existing agriculture. This factor was thus rated as low.

Following the guidelines, the overall impact potential for seed weevils was considered High.

Stem weevil

Climate/host interaction. The stem weevil infests only avocado, which has tropical or subtropical distribution in hardiness zones 9-10 in the PRA area (Velez, 1959). This factor was rated medium. However, it was noted that the distribution of avocados is limited to a few counties in three states: California, Florida and Hawaii (National Agric. Statistics Service, http://www.usda.gov/nass/), thus the rating of medium may be biased since hardiness zones assume the entire zone is suitable and for the case of avocados, they exist only in a small proportion of hardiness zones 9 and 10. Given this fact, we note that a rating of low may also be considered.

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

Dispersal potential—The life cycle of the stem weevil is long (>150 days) with a protracted larval stage (>115 days) which limits the number of generations to 1-2 annually (Teliz, 2000). Females only lay up to eight eggs (Velez, 1959). Adults are capable of short flights, but mostly remain in foliage (Garcia, et al., 1998) within an orchard. Larva are internal and the main method of spread is by man. Because of their sedentary nature, we considered a low rating. Their long life span increases the likelihood of movement and that was our reasoning for a ranking of medium for this factor; however, a ranking of low was also considered.

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 (Evangelou, et al., 1993). Given the importance of the avocado as an industry, this factor was given the highest rating.

Environmental impact—The stem weevil infests avocado only. Spray programs will begin in commercial avocado-growing areas of the PRA area if an outbreak occurs (Evangelou, et al., 1993). The sprays are not expected to have impacts on endangered or threatened species beyond those due to existing agricultural practices. This factor was thus rated as low.

Following the guidelines, the overall impact potential for stem weevils was considered low to medium.

We note that the potential economic impacts of weevil infestations in California were analyzed in 1993 (Evangelou et al., 1993). They assumed that weevils would colonize all of the production areas in California. They further assumed that growers would resort to chemical control. The chemical controls would disrupt existing natural

balances, resulting subsequently in outbreaks of loopers, mites and other pests that would require additional treatments. They estimated that annual production costs would increase by 41% and avocado yields would decrease by an assumed 20% due to limited effectiveness of aerial treatments. They estimated social losses to total $123.6 million per year.

Seed moth

Climate/host interaction—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 are distributed in hardiness zones 7-9. This factor was thus rated medium; a rating of low was also considered for the same reasons cited for the pests above.

Host range—The seed moth infests species in several genera of Lauraceae, including greenheart (Chlocardium rodiei (Schomb.) Rohwer Richter & van der Werff) (Cervantes-Peredo, et al., 1999). However, avocado (*Persea americana*), is the only known host in the United States. This factor was thus rated low.

Dispersal potential—The seed moth occurs widely over the export area, but is limited there to avocados grown below 1,000 m elevation (Cervantes-Peredo, 2000). Adults can fly and females have high reproductive potential because they can lay up to 240 eggs (Jaramillo et al., 1972). Up to three generations per year are recorded (Garcia, et al., 1998). Because larvae are internal, worldwide spread by man is possible. This factor was rated high.

Economic impact—Fruit of all sizes are infested by seed moth. Fruit that are infested when small fall off the tree before reaching harvestable size (Cervantes-Peredo, 2000). Over 80% of the avocados (not Hass variety) in some orchards in Brazil were infested, and over 80% of those fell before reaching harvestable size (Ventura, et al., 1999). In field reports from South America, it was noted that 'Hass' avocados are not the preferred host for seed moth. None of the 'Hass' cultivars were infested, but more than 54% of other avocado cultivars received damage (Arellano-Cruz, 1998). However, 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 thus rated high.

Environmental impact—If an outbreak occurs in U.S. 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. The spray programs are not expected to have impacts on endangered or threatened species beyond those due to existing agriculture practices. This factor was thus rated as low.

Following the guidelines, the overall impact potential for the seed moth was considered medium.

The scores for each of the elements above for each pest are presented in Table 7. The potential consequences associated with each pest are estimated by adding together the values (one for each element). The table associates rankings to the selected quarantine pests, i.e., seed weevils, stem weevils, and seed moth.

Table 7 - Summary of potential consequences from quarantine pests

Pest	Climate/Host Interaction	Host range	Dispersal Potential	Economic Impact	Environmental Impact	Total
Seed weevils	1-2	1	3	3	1	9-10
Stem weevils	1-2	1	1-2	3	1	7-9
Seed moth	1-2	1	3	3	1	9-10

Note: Descriptions of elements and assignment of values are explained in the text; rankings resulted in "medium" consequences for weevils and the seed moth. This ranking did not consider specific mitigation practices.

Discussion

Table 8 Results – Pathway Scenario Assessment

Parameter	Most likely	95% CI
P1 – proportion infested (from sampling data)	0	0 - 5.25×10^{-7}
Q1 – Predicted annual number of infested avocados	0	0 to 350
Q2 – Predicted annual number of infested avocados reaching producing counties	0	0 to 66

We believe the most likely annual number of avocados infested with a pathway pest likely to be imported from Mexico each year under the expanded distribution scenario is zero. Based on the fruit cutting data alone (ie, ignoring the results of the area and orchard surveys and the risk-reducing effects of every element in the systems approach), the quantitative model indicates a 95% level of confidence that the annual number of infested avocados likely to reach avocado producing counties in the United States is not more than 66 (Table 8).

Even if 66 infested avocados were imported (or 350 to any area in the United States), we believe the likelihood pest establishment and spread is small. Establishment and spread would require that a) the pests survive during transportation and storage, b) the infested avocados must be discarded in close proximity to host material, c) the pests must find mates, d) the pests must successfully avoid predation, e) the adult pests must find host material, and f) the climatological and microenvironmental conditions must be suitable. We believe the likelihood of each of these steps is low. People generally consume the fruit they purchase and dispose of the waste material in a manner (ie, in plastic bags that are placed in trashcans and which are ultimately are either landfilled or incinerated) that precludes the release of pests into the environment.

As important as are the results of the quantitative model, we cannot ignore the risk-reducing effects of the systems approach. We believe the repeated surveys, inspections, and the other requirements of the systems approach reduce risk substantially. Our confidence in these surveys and inspections is reinforced, first, by repeated site visits by APHIS headquarters personnel; second, by the active participation of APHIS field personnel in the surveys; third, by the redundancy of the systems approach mitigations; and fourth, by the fact that examination of over ten million fruit has not revealed even one pest.

We believe the rate of avocado pests entering the United States in commercial avocados legally imported in compliance with the proposed modified systems approach is certainly far lower than the rate in prohibited avocados in passenger baggage and and other types of cargo . APHIS-PPQ port of entry interception database records (PIN309) indicate that pathway pests are routinely found in avocados (both 'Hass' and other varieties) intercepted at U.S. ports of entry. Between 1985 and 2002, over 500 pathway pests were detected in intercepted avocados in baggage and cargo. We are not aware of a single outbreak of any of the pathway pests as a result. We conclude that prohibited avocados in baggage and cargo pose a greater risk to U.S. agriculture than commercial imports of 'Hass' avocados from Mexico.

Conclusions

1. Hass avocados imported from Michoacán, Mexico are a potential pathway for only five of the 116 avocado pests known to occur in Mexico. These five include three seed weevils: *Conotrachelus aguacatae, C. perseae*, and *Heilipus lauri*; one stem weevil: *Copturus aguacatae*; and one seed moth: *Stenoma catenifer*.

2. The exporting municipalities in Michoacán have been and are likely to remain free of *Conotrachelus aguacatae, Heilipus lauri,* and *Stenoma catenifer* and *Conotrachelus perseae.* Repeated area surveys and inspections of orchards and processed fruit by Mexican and USDA-APHIS personnel for over six years have failed to find these pests. Over ten million fruit were examined for pest larva with negative results.

The remaining pathway pest (stem weevil, *Copturus aguacate*) is known to exist in Michoacán. The pest was detected five 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.

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 both on preventing infestation and on detecting infestion if it occurs. The systems approach includes redundant safeguards such as surveys, orchard inspections, certification, fruit inspection, and trace-back ability.

4. The most likely annual number of imported infested fruit is zero. The large and unprecedented number of avocados inspected allows estimation of the highest number of infested avocados that could be imported without detection with a high degree of precision. A quantitative model based only on the fruit cutting data predicts that the most likely number of imported, infested avocados is zero. Specifically, the most likely proportion of infested avocados was found to be zero; the 95% confidence interval ranged from 0 to 5.25×10^{-7} [that is, from 0 to 52.5/100,000,000].

5. A probabilistic assessment based on the fruit cutting data and forecast fruit exported to the United States found that the annual number of imported fruit infested with any pathway pest and distributed to avocado-producing counties per year is most likely zero and almost certainly would not exceed 66. Our belief that that the most likely number is in fact zero is supported by other evidence such as the annual surveys of municipalities and orchards (Table 5a and 5b) and Japanese fruit cutting data.

6. Commercially harvested and processed 'Hass' avocados are not hosts for *Anastrepha* fruit flies. In the past, these fruit flies were one of APHIS's greatest concerns. However, recent research (Aluja et al, 2002) indicates that avocados do not

serve as hosts for *Anastrepha spp*. This research, conducted under both field and laboratory conditions, demonstrated that *Anastrepha* spp. will not develop in 'Hass' avocados under commercial field conditions. When 'Hass' avocados were the only available host, oviposition occured but larvae did not mature.

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This pest risk assessment was prepared by the Center for Plant Health Science and technology (CPHST) within Plant Protection and Quarantine (APHIS-USDA), it contains material included in previous risk assessments for avocados from Mexico.
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*External review is sought by publication of this assessment and requesting stakeholder input.

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
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
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	a, x	Watson, 1971
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 Cercospora spot, Blotch	MX CA FL	c, f	Fucikovsky & Luna, 1987; Ploetz, *et al.*, 1994
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.	MX	a	Ploetz, *et al.*, 1994; Watson, 1971; CMI, 1985

Appendix A – Pest List

Table A-1: Pathogens.			
Scientific Name [1] and Common Name	**Distribution [2]**	**Comment [3]**	**References**
Black (Rosellinia) root rot			
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, f, x	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, f	Anonymous, 1984; 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: MX = Mexico; CA = California; FL = Florida; HI = Hawaii; TX = Texas; OT = Other, occurs in states other than CA, FL, HI, TX.

[3] Comments:

a = Pest associated with plant part other than commodity

c = Listed in U.S. Department of Agriculture (USDA) catalogue of pest interceptions as nonactionable

f = Pest occurs in the United States and is not currently subject to official restrictions and regulations (*i.e.*, not listed as actionable or non-actionable, and no official control program)

x = Multiple interception records exist

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution [1]**	**Comments [2]**	**References**
Acanthoscelides sp. (Coleoptera: Bruchidae)	MX	a	Adame, 1998
Acutaspis albopicta (Cockerell) (Homoptera: Diaspididae)	MX, US	a, g, j	Nakahara, 1982
Acutaspis perseae (Comstock) (Homoptera: Diaspididae)	MX, US	a, j	Ebeling, 1959
Aetalion quadratum Fowler (Homoptera: Aetalionidae)	MX	a, g	Ebeling, 1959
Agromyzidae (Diptera), Unidentified species	MX	a	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
Anthonomus sp. (Coleoptera: Curculionidae)	MX	a	Adame, 1998
Anastrepha fraterculus (complex) (Diptera Tephritidae)	MX	k	White, 1988
Anastrepha ludens (Loew) (Diptera: Tephritidae)	MX, US	R, g, w	Norrbom & Kim, 1988; Stone, 1942; Steck, 1991; 7 CFR 301.64
Anastrepha obliqua (Loew) (Diptera: Tephritidae)	MX	R, g	Norrbom & Kim, 1988; Aluja et al. 2002
Anastrepha serpentina (Wiedemann) (Diptera: Tephritidae)	MX	R, g	Norrbom & Kim, 1988; Aluja et al. 2002
Anastrepha striata (Diptera: Tephritidae)	MX	R, g	Ballou, 1936; Aluja et al. 2002
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	Adame, 1998
Attelabus sp. (Coleoptera: Curculionidae)	MX	a	Adame, 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
Capaneus humerosus Distant (Heteroptera: Coreidae)	MX	a	Ebeling, 1959
Caulophilus latinasus Say (Coleoptera: Curculionidae)	MX, US	a, c	McKenzie, 1935

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution [1]**	**Comments [2]**	**References**
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
Ceratitis capitata (Wiedemann) (Diptera: Tephritidae)	MX, US	g, l, w, z	Metcalf & Metcalf, 1993; White & Elson-Harris, 1992 7 CFR 301.78; 7 CFR 318.13;
Chrysomphalus agavis (Townsend & Cockerell) (Homoptera:Diaspididae)	MX, US	a, j	Ebeling, 1959
Chrysomphalus aonidum (L) (Homoptera: Diaspididae)	MX, US	a, c, j	Metcalf & Metcalf, 1993
Cicadellidae, species unidentified (Homoptera)	MX	a	Hennessey, 2002
Coccus hesperidum (L) (Homoptera: Coccidae)	MX, US	a, c	Ebeling, 1959
Conotrachelus aguacatae Barber (Coleoptera: Curculionidae)	MX	z, g	Arellano, 1975
Contrachelus perseae Barber (Coleoptera: Curculionidae)	MX	z, g	Ebeling, 1959
Conotrachelus sp. (Coleoptera: Curculionidae)	MX	z, g	Adame, 1998
Conotrachelus sp. probably *flavangulus* Champion	MX	a	Adame, 1998
Possibly *Copturomimus* sp. (Coleoptera: Curculionidae)	MX	a	Adame, 1998
Copturus aguacatae (Coleoptera: Curculionidae)	MX	z, g	MacGregor & Gutierrez, 1983; PPQ interception records
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	Adame, 1998
Probably *Cylindrocopturus* sp. (Coleoptera: Curculionidae)	MX	a	Adame, 1998
Deloyala guttata (Olivier) (Coleoptera: Chrysomelidae)	MX	a, c	Ebeling, 1959
Diaprepes abbreviatus (L) (Coleoptera: Curculionidae)	MX, US	a, g	Bennett, 1985

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution [1]**	**Comments [2]**	**References**
Dysdercus obliquus (Herrich-Schaeffer) (Heteroptera: Pyrrhocoridae)	MX, US	a, c	Ebeling, 1959; Henry & Froeschner, 1988
Farinococcus olivaceus (Cockerell) (Homoptera:Pseudococcidae)	MX	a	Ebeling, 1959
Formicidae species undetermined (Hymenoptera)	MX	a	Hennessey, 2002
Frankliniella cephalica (Crawford) (Thysanoptera: Thripidae)	MX, US	a, c	Ebeling, 1959
Hansenia pulverulenta (Guerin-Meneville) (Homoptera:Flatidae)	MX	a	MacGregor & Gutierrez, 1983
Heilipus albopictus Champion (Coleoptera: Curculionidae)	MX	a	MacGregor & Gutierrez, 1983
Heilipus lauri Bohemann (Coleoptera: Curculionidae)	MX	z, g	Ebeling, 1959
Heliothrips haemorrhoidalis (Bouche) (Thysanoptera:Thripidae)	MX, US	a, c	Ebeling, 1959
Hemiberlesia lataniae (Signoret) (Homoptera: Diaspididae)	MX, US	a, c, j	Nakahara, 1982
Hemiberlesia rapax (Comstock) (Homoptera: Diaspididae)	MX, US	a, c, j	Nakahara, 1982
Icerya montserratensis Riley & Howard (Homoptera: Margarodidae)	MX	a, g	Ebeling, 1959
Icerya purchasi Maskell (Homoptera: Margarodidae)	MX, US	a, c	Ebeling, 1959
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
Liothrips perseae (Watson) (Thysanoptera: Phlaeothripidae)	MX	a	MacGregor & Gutierrez, 1983; Nakahara, 1995
Lonchaeidae species undetermined (Diptera)	MX	a	Hennessey, 2002
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
Mycetaspis personata (Comstock) (Homoptera: *Diaspididae*	MX, US	a, c, j	Nakahara, 1982
Nipaecoccus nipae (Maskell) (Homoptera: Pseudococcidae)	MX, US	a, c	Ebeling, 1959

Table A-2: Arthropods			
***Genus species* Author (Order: Family)**	**Distribution [1]**	**Comments [2]**	**References**
Oligonychus yothersi (McGregor) (Acarina: Tetranychidae)	MX, US	a	MacGregor & Gutierrez, 1983; McMurtry, 1985
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
Paraleurodes sp. near *goyabae* (Goeldi) (Homoptera: Aleyrodidae)	MX	a	Ebeling, 1959
Planococcus citri (Risso) (Homoptera: Pseudococcidae)	MX, US	a, c	Ebeling, 1959
Polydrusus sp. (Coleoptera: Curculionidae)	MX	a	Adame, 1998
Pseudacysta perseae (Heidemann) (Heteroptera: Tingidae)	MX, US	a, c	MacGregor & Gutierrez, 1983; Henry & Froeschner, 1988
Pseudobaris sp. (Coleoptera: Curculionidae)	MX	a	Adame, 1998 (USDA foliage survey sheet)
Pseudococcus longispinus (Targioni-Tozzetti) (Homoptera: Pseudococcidae)	MX, US	a, c	Ebeling, 1959
Pseudococcidae unidentified species (Homoptera)	MX	a	Hennessey, 2002
Psychidae species unidentified (Lepidoptera)	MX	a	Hennessey, 2002
Pulvinaria simulans Cockerell (Homoptera: Coccidae)	MX	a	Ebeling, 1959
Pyrrhopyge chalybea Scudder (Lepidoptera: Hesperiidae)	MX	a, g	Diaz, 1976
Rhyssematus 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
Stenoma catenifer Walsingham (Lepidoptera: Oecophoridae)	MX	z, g	Ebeling, 1959
Trialeurodes similis Russell (Homoptera: Aleyrodidae)	MX	a, c	Ebeling, 1959
Trioza anceps Tuthill (Homoptera: Psyllidae)	MX	a, g	MacGregor & Gutierrez, 1983

[1] Distribution legend: MX = Mexico; US = United States.

[2] Comments:
a = Pest associated with plant part other than commodity.

Appendix A – Pest List

c = Listed in U.S. Department of Agriculture (USDA) catalogue of pest interceptions as non-actionable.

g = Listed in the USDA catalogue of intercepted pests as actionable.

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).

k = The population of this species complex that occurs in Mexico and Central America has never been associated with any variety of avocado fruit.

l = Pest reported to occur in export country but not known to occur in area of production and processing.

R = Revised from previous assessments to: *Pests that do not follow the pathway of commercially produced 'Hass' avocados from* Michoacán*, Mexico*. A review of recent research on *Anastrepha* spp. (Appendix C) concluded that commercially produced 'Hass' avocados are not hosts for the four species considered (*A. serpentina, A. ludens, A. striata, and A. obliqua*).

w = Program pest, occurs in the United States but not widely distributed and being officially controlled.

z = Pest is known to commonly attack or infest fruit and it would be reasonable to expect 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 Assessment: A Systems Approach for Mexican Avocados" (APHIS, 1995). Key evidence from those documents was revised and updated.

1. Conotrachelus perseae and *C. aguacate* (seed weevils)

a. Distribution -These seed weevils are reported to occur in Mexico and Central American as far south as Panama (Whitehead 1979; Ebeling 1959). In Mexico, *C. perseae* is reported for the states of Michoacán, Puebla, Veracruz, and Jalisco: *C. aguacate* is reported for the states of Coahuila. Jalisco, Michoacán, Nayarit, Queretaro, Guanajuato, Puebla, and Morelos (Whitehead 1979 and Sanidad Vegetal 1992), and is prevalent at high altitudes. FAO (1986) reports its occurrence in Mexico

b. Host -The only host reported for *C. perseae* and *C. aguacate* 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 from 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) also states that the damaged fruit falls to the ground before the fruit is fully developed and Sleeper (1978) states that infested fruits usually fall to the ground. PPQ has intercepted larvae in various stages of development in avocado fruits being smuggled into the United States, which would indicate that at least a portion of the infested fruits developed to a marketable stage (USDA 1941). The adults are active at night and feed to at least some degree 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 tunneling in 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 from Creole trees. Field controls reported by Sanidad Veqetal include fo1iage 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 from Mexico south to at least Colombia. In Mexico, it is reported from 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 altitudes.

b. Host -Sanidad Vegetal (1992) reports that it prefers Creole avocado tree (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 the 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 in 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 destruction of fallen fruit.

3. *Copturus aguacate* (an avocado stem weevi1)
a. Distribution -This weevil is known only 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. aguacate*. In recent years, larvae have been detected in 'Hass' avocado fruit intercepted by PPQ from Mexico, mainly at El Paso, Texas.
c. Biology -The weevil bores into the small new stems and branches, but can affect the older branches at high population densities. Eggs are laid in the epidermis of the plant. 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).
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 can cause reduction in size of the tree. Ebeling (1959), Sleeper (1978), and Whitehead (1979b) call this a major pest. Muniz (1959) states secondary infestions by viruses, bacteria and fungi may occur. This 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 from Mexico south to Brazil (Acevedo 1973), and has recently been reported in Guyana (Cervales Peredo et al. 1999). In Mexico, it is reported from 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 it 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, and 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 (Boscar and Godoy 1982). In tropical areas of Mexico, this pest is a limiting factor of 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).

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

Appendix C: Review of *Anastrepha* Species

Previous assessment and much of the focus from stakeholders in the past (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 slicing randomly selected fruit from nine packinghouses into one cm slices. No fruit flies were detected as 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 removal from the tree. They found that Hass avocados were not naturally infested while attached to the tree. Further, when fruit that was still attached, was artificially exposed to fruit flies, oviposition did occur but larvae did not develop. Enkerlin et al. (1993) report that biochemical processes are likely responsible for the lack of viability of eggs in fruit that is attached to the tree. However, 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. (2002) combined detailed field observations and laboratory studies. Field studies were conducted in 2001 and 2002 at 3 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 collected randomly from six orchards at the three different representative altitudes (N=76,941 fruit) did not reveal fruit fly infestations. Additionally, field cages were used to artificially infest avocado branches in commercial orchards with large numbers of viable fruit flies (wild and lab reared flies). Fruit flies did not infest avocados in any but two instances (two fruit). The two fruit that were found infested with fruit flies were held 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 (N=3600 fruit). Three fruit 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. *Anastrepha* fruit flies have complex host search behaviors and do not forage on the ground, as was shown in these studies.

As part of the observations by Aluja et al. (2002), fruit was sampled from packinghouses (N=8,100 fruit) and no infestation was detected. In laboratory trials, fruit was 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 varied from "choice" studies and "no-choice" studies in laboratory conditions. The no-choice studies included 'Hass' avocados only. 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 likely resistance mechanisms in avocados by Aluja et al. (2002) are 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. (2002) (all observations and design phases were overseen by USDA and independent reviewers) we conclude that commercially produced fruit from Michoacán, Mexico are not a host for the *Anastrepha spp.* considered. Previous assessments (APHIS, 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. However, those earlier assessments concluded that there was a very low probability of association of *Anastrepha* with the 'Hass' avocado imports (Pest risk assessment, addendum and review 1995a, 1996, 2001).

Appendix D - Quantitative Risk Assessment Model

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.

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

APHIS conducted a screening assessment on one hundred and sixteen (116) 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 five pathway pests of quarantine significance. These five include:

1. three seed weevils: *Conotrachelus aguacatae, Conotrachelus perseae*, and *Heilipus lauri*;
2. one stem weevil: *Copturus aguacatae*; and
3. one seed moth: *Stenoma catenifer*.

Since 1997 approximately 300 million 'Hass' avocados have been imported from Mexico under a systems management protocol that includes packing house and port of exit/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.

The proposed expanded avocado importation program will involve all States, including avocado growing states.

This risk assessment estimates the annual number of infested avocados entering the United States, and the annual number of infested avocados entering counties in the United States where avocados are grown.

This assessment does not evaluate the individual effectiveness of the systems mitigations in reducing the phytosanitary risks to the United States.

This assessment utilizes the results of six years of surveys to estimate the proportion of imported avocados that are infested. It 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 avocado growing counties 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 avocado growing counties.

APHIS has developed a risk assessment model that is presented in this document. The risk assessment predicts that 528 million to 849 million 'Hass' avocados will be imported annually from Mexico.

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

	95th percentile	Most Likely
Proportion of Mexican avocados that will be infested with a pathway pest	< 52.5/100,000,000	0
Proportion of infested avocados that will reach avocado producing areas in the United States	< 11/100,000,000	0
Number of avocados, infested with a pathway pest, that will enter the United States each year	< 350	0
Number of infested avocados that will reach avocado producing areas in the United States	< 66	0

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

METHODOLOGY

The study is comprised of an assessment 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 evaluating phytosanitary risk and providing information to facilitate or support decision-making tasks.

Based on the probabilistic scenario assessment 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 assessment on one hundred and sixteen (116) 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 of 116, and resulted in the identification of five pathway pests of quarantine significance. APHIS has identified the following five quarantine pests that could pose a threat to U.S.agriculture if introduced into avocado growing counties 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*

The phytosanitary hazard (or unwanted event) is the introduction (entry and establishment) of any one of these pests into avocado growing counties 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 introduction of any pathway pest into avocado growing counties in the US. However, because of lack of quantitative data, the end point of introduction (involving entry and establishment), was quantitatively terminated at entry. Therefore, the quantitative risk assessment estimates the likelihood of entry of the five avocado pests into avocado growing counties in the US. We estimate two quantitative endpoints: a) the number of infested avocados reaching the United States each year and b) the number of infested avocados

reaching avocado producing regions in the United States each year.
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.
This quantitative risk assessment answers the following specific questions:

1. What proportion of the 'Hass' avocados entering the United States is infested?
2. What proportion of imported 'Hass' avocados arriving at avocado growing counties in the United States?
3. How many infested 'Hass' avocados will enter the United States annually?
4. How many infested avocados enter avocado growing counties in the United States on an annual basis?

C. Scenario Tree

This risk assessment estimates:

1. the annual number of infested avocados entering the United States, and
2. the annual number of infested avocados entering avocado growing counties in the United States.

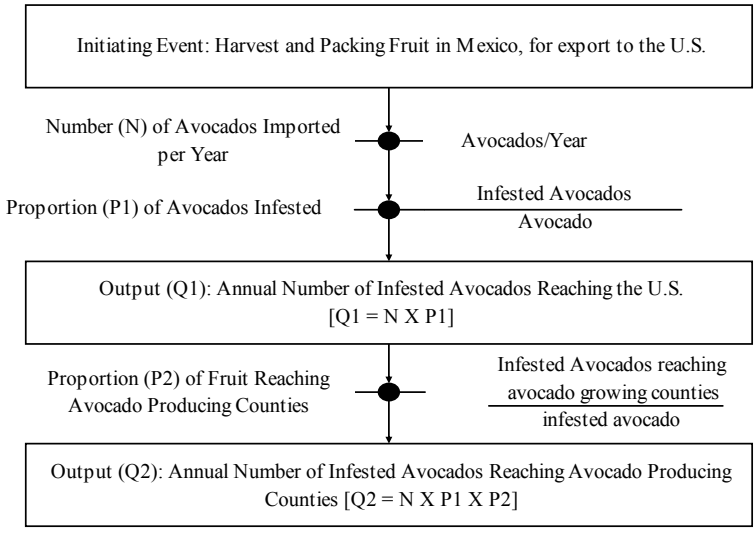
A scenario tree is a pictorial representation of all possible outcomes of an initiating event. A risk pathway tree depicts that subset of pathways that lead to manifestion of a hazard. The risk pathway tree is a pictorial representation of what could go wrong in order for infested 'Hass' avocados from Mexico to reach avocado producing counties in the US.
Infested 'Hass' avocados from Mexico could reach avocado producing counties in the United States if:

A. A quantity of avocados are harvested in Mexico for export to the US, and
B. a proportion of them are still infested after systems mitigations, and
C. some infested avocados are distributed to avocado growing counties.

The annual number of infested avocados entering avocado growing counties in the United States 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 end up in avocado growing counties in the US.

A scenario tree describing the risk pathway is presented below in figure 1.



D. Quantitative Model Assumptions:

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 reaching avocado production areas in the United States was estimated from the proportion of the total U.S.population represented in those counties, and the relative per-capita avocado consumption of individuals in those counties.
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.

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

Parameter Estimates

Parameter Estimate Node 1: Parameter: *N*

Description: Annual number of Haas avocado imported from Mexico.

Units:

Avocados

Year

Evidence on N:
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)

1. 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.

2. 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)
3. It is currently proposed that avocados be allowed into all 50 states, with no seasonal restrictions.

Evaluation:
APHIS believes that 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
b) the increased time frame in which importation will occur (October to October vs October to April)
c) the future increase in the U.S.population, and specifically of avocado consuming people in the US.
d) the increased market share that Mexican 'Hass' avocados will have in the US.

APHIS estimates that between 528 million and 849 million 'Hass' avocados[7] will be imported from Mexico annually under the expanded distribution scheme. This estimate is based on an economic assessment of the potential quantity of imported 'Hass' avocados from Mexico (Appendix E). This estimate is five to seven times the amount imported in the 2001/2002 season.

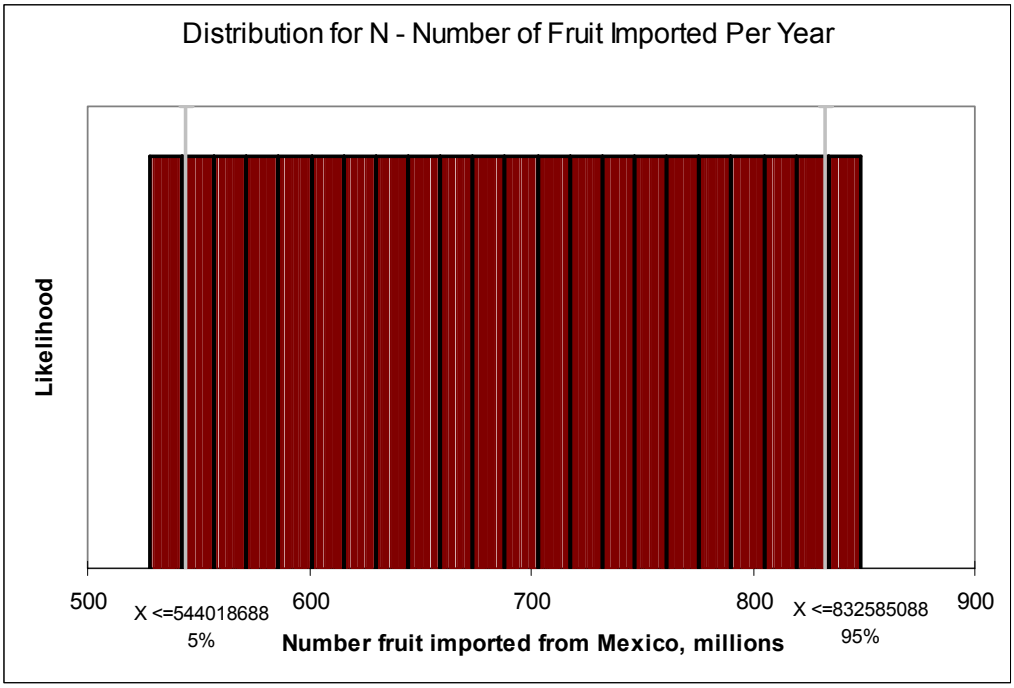
A uniform distribution was used for the annual number of avocados imported from Mexico, and is represented by the following equation:

N = RiskUniform(528 million , 849 million)

This uniform distribution is presented in Figure 2.

N = **RiskUniform(528 million , 849 million)**

Figure 2. Uniform distribution for the annual number of 'Hass' avocados imported into the US



Parameter Estimate Node 2: Parameter: *P1*

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

Units:

$$\frac{\textit{Infested Avocados}}{\textit{Avocado}}$$

Evidence on P1:

P1-1. APHIS has conducted a specific review of the program to allow the importation of Mexican Hass avocados. The review identified the following five quarantine pests that could pose a threat to US agriculture

a. seed weevils: *Conotrachelus aguacatae, Conotrachelus perseae*, and *Heilipus lauri*
b. stem weevil: *Copturus aguacatae*
c. seed moth: *Stenoma catenifer*

These pests are evaluated in this risk assessment.

P1-2. Seed weevils (*Conotrachelus aguacatae, Conotrachelus perseae*, and *Heilipus lauri*) and seed moths (*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 2 & 3 contain data obtained from surveys in Michoacan, Mexico

Table 2 - 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 Weevil *Conotrachelus aguacatae*	Seed Weevil *Contrachelus 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 3 – 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 *Contrachelus perseae*
1997	42	200	0	0	0	0	0
1998		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 - U.S. Department of Agriculture, Animal and Plant Health Inspection Service, International Services. – NAR, 2003- Uruapan,Mich.

P1-3. None of the orchards that were positive for Stem Weevil were permitted to export avocados to the US. They were removed from the export program for the shipping season. (7CFR§319.56-2ff(e)(2) p. 331)

P1-4. 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 follows in Table 4.

P1-5. Table 4. Fruit sampled for seed weevil, stem weevil, seed moth, and fruit flies*

Season	Field Samples	Packing house	Border Inspection	Season 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 update with numbers from the 2001/2002 and 2002/2003 shipping seasons.

Evaluation:

Examination of the survey data presented in tables 2 & 3 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 (Figure 2 & 3) 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 4, indicates that a total of 10,372,728 avocado were sampled, and no quarantine pests were found.

The goal is 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 how likely 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 4) 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:

$$p = \text{RiskBeta}(x+1, n-x+1)$$

.

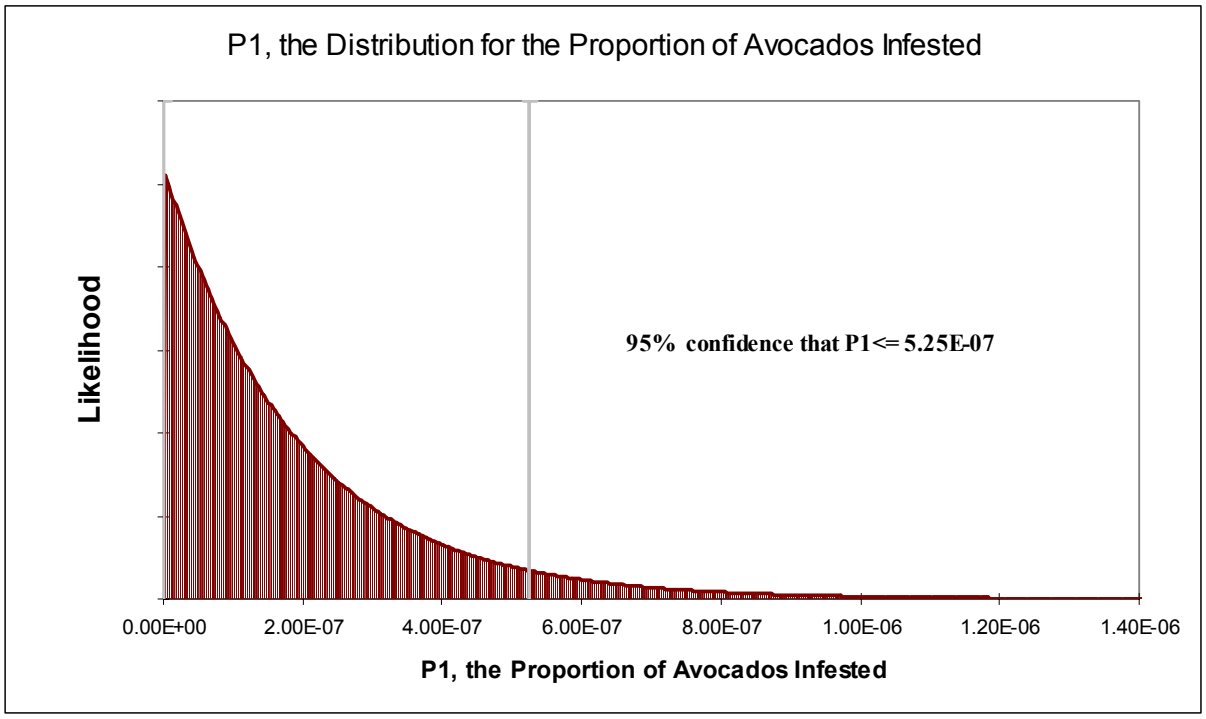
Because n is greater 7,000,000 the RiskBeta function in @Risk doesn't work. As a workaround we have made a transformation in the sample size, n as follows:

When the sensitivity of inspection is 100%, one needs half the sample size as one needs when the sensitivity is 50% to detect a given prevalence of infestation.
Therefore, sampling 10,372,728 avocados with a 50% sensitivity of inspection is equivalent to sampling 5186364 avocados with 100% sensitivity of inspection. This sample size works with the RiskBeta function.

APHIS has used the @Risk, RiskBeta function to generate the probability distribution for the proportion of infested avocados, P1. P1 is represented by the equation:

P1 = RiskBeta(x+1, n-x+1), where x =0 and n = 5186364

The resulting distribution is represented as follows:



There is a 95% confidence that the proportion of infested avocados is less or equal to 5.25×10^{-7}.
The most likely proportion of infested avocados is zero (0).

Parameter Estimate Node 3: Parameter: *P2*

Description: Proportion of Infested Avocados reaching the United States that end up in a susceptible county.

Units:

$$\frac{\textit{Infested Avocados reaching susceptible counties}}{\textit{Infested Avocado}}$$

Evidence:

P2-1. Table 6 summarizes information about the acreage, yield, and human population of avocado producing counties.

Table 6. Some characteristics of key avocado production areas in the United States

County	State	Acreage (1)	Production (1) (Mil. Lbs)	Population (2)
Orange	CA	1,669	16.0	2,890,444
Ventura	CA	11,608	99.9	770,630
San Diego	CA	22,862	190.6	2,862,819
Riverside	CA	6,074	41.1	1,635,888
Santa Barbara	CA	7,660	54.2	399,543
San Luis Obispo	CA	1,362	8.9	250,727
San Joaquin Valley	CA	89	2.1	595,324
Miami-Dade	FL	5,900	23.0	2,289,683
Hawaii	HI	230	0.3	152,083
Total		**57,454**	**436.0**	**11,847,141**

1/Source: USDA-National Agriculture Statistics Service and California Avocado Commission
2/Source: U.S.Census Bureau

P2-2. The U.S. population in 2001 was 277,017,622 people (US Census Bureau)

P2-3. The percapita consumption of avocados in the southwest of the US, and the whole country, are presented in table 7.

Table 7. Attributes of the Southeast United States compared to the whole US.

Region	**Percapita consumption**	**Population**	**Total Pounds consumed**	**Proportion of National pounds consumed (Lbs consumed by region, divided by Lbs consumed by whole country)**
South West	4.29	11,847,141	50,824,235	0.27
Rest of Country	0.51	265,170,481	135,236,945	0.73
Whole Country	0.67	277,017,622	186,061,180	1.00

P2 Evidence Evaluation:
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.
If the per-capita consumption of avocados were uniform throughout the US, then the proportion of infested fruit from Mexico that gets to avocado producing counties would be directly proportional to the fraction of the U.S.population represented in those counties.

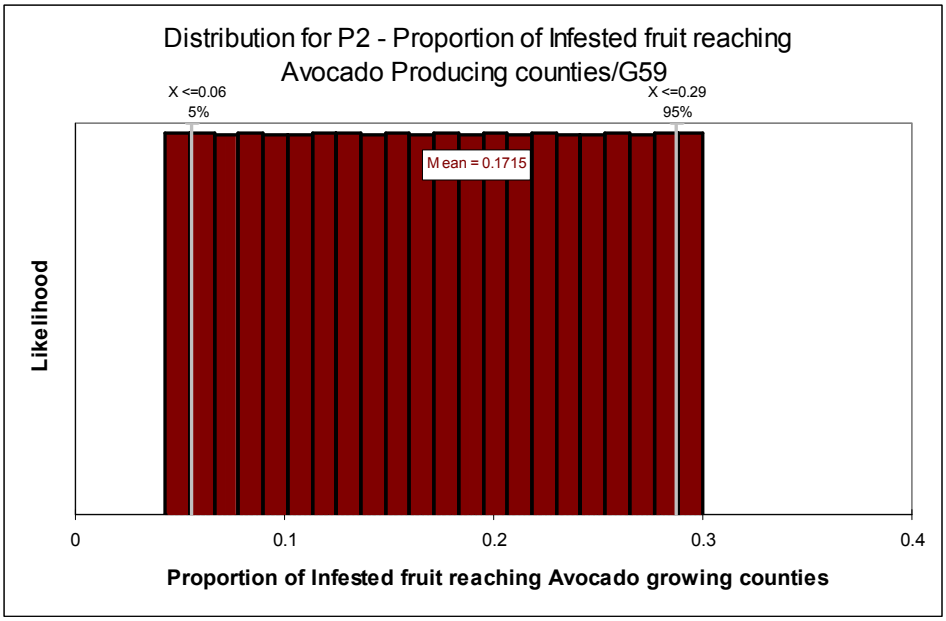
The fraction of the U.S.population in avocado growing counties is estimated to be 4.3% [by taking the ratio of the total population in avocado growing counties (11,847,141 from column 5 of Table 5), and the total U.S.population (277,017,622 from evidence P2-2)].

Because the percapita consumption of avocados in the avocado growing counties of the United States is greater than the national percapita consumption (Table 7), the proportion of infested fruit from Mexico that could potentially get to avocado producing counties is greater than 4.3%.

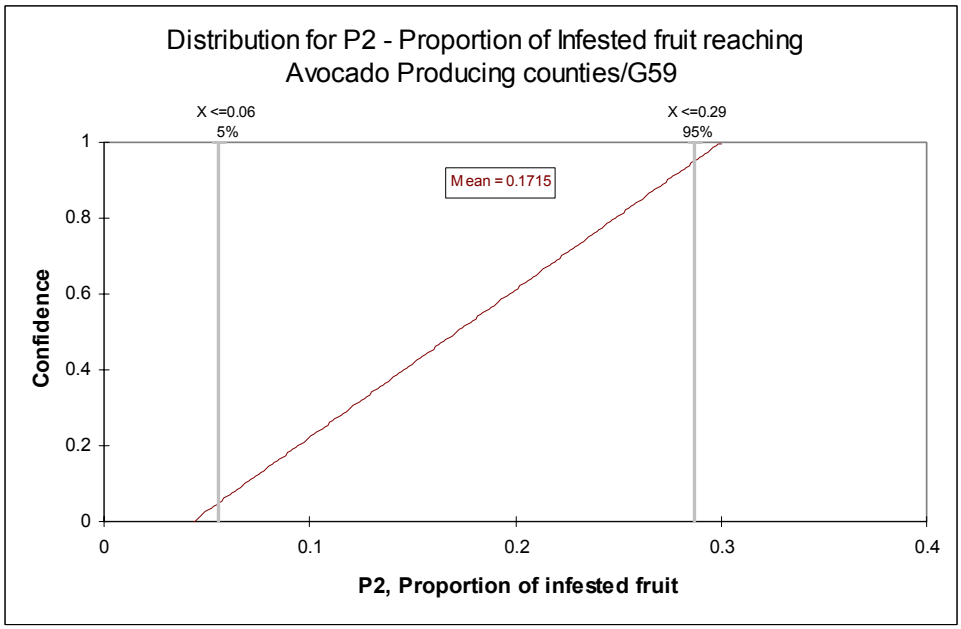
Based on the percapita consumptions from column 2 of Table 7, APHIS has estimated that the avocado growing counties of the southwest consume 27% of all the avocados in the U.S.market. APHIS estimates that other unconsidered market forces could increase this amount by as much as 10%. This implies that the maximum value for the proportion of avocados going to avocado growing counties could be as high as 110% of 27%, which is 29.7%.

P2, is represent by a uniform distribution that has a minimum value of 4.3% and a maximum value of 30% in order to adequately represent the uncertainty about the estimate.

The resulting probability distribution function (PDF) for P2 is presented below.



Also presented is the cumulative distribution function (CDF) for P2



F. **Mathematical** Model: Performing Calculations

This quantitative risk assessment estimates the number of infested Mexican 'Hass' avocados that enter avocado growing counties in the US, via the importation of avocados from Michoacán, Mexico.

The annual number of infested avocados entering susceptible counties 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 avocado growing counties in the US

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

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

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

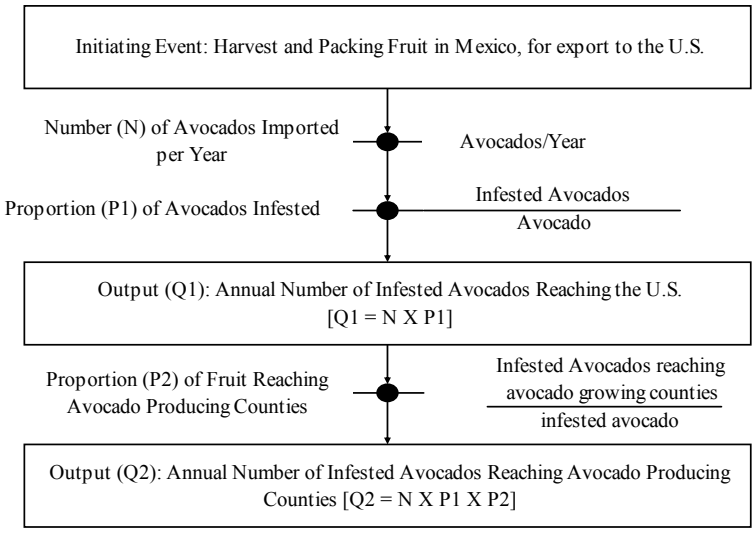
$$Q2 = \frac{Avocados}{Year} \times \frac{Infested\_Avocados}{Avocado} \times \frac{Infested\_Avocados\_reaching\_Avocado\_growing\_counties}{Infested\_Avocado}$$

Therefore:

$$Q2 = \frac{Infested\_Avocados\_reaching\_Avocado\_growing\_counties}{Year}$$

Each of the parameters N, P1, and P2 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 10,000 iterations of this model.



G. Results

APHIS estimates that between 528 million to 849 million 'Hass' avocados will be imported each year from Mexico. Following is a summary of the results of conducting the ten thousand MonteCarlo iterations of the risk assessment model using @Risk (Palisade Corporation, Newfield, New York) and Excel (Microsoft Corporation, Redmond, Washington).

APHIS estimates that as a result of this trade, carried out with the appropriate systems mitigations and safeguards:

- the most likely number of infested avocados reaching the United States each year is zero.
- the most likely number of infested avocados reaching avocado growing counties in the United States each year is zero.
- The most likely number of containers with at least one infested fruit is zero.

APHIS also estimates with a 95% confidence that as a result of importing 'Hass' avocados from Mexico:

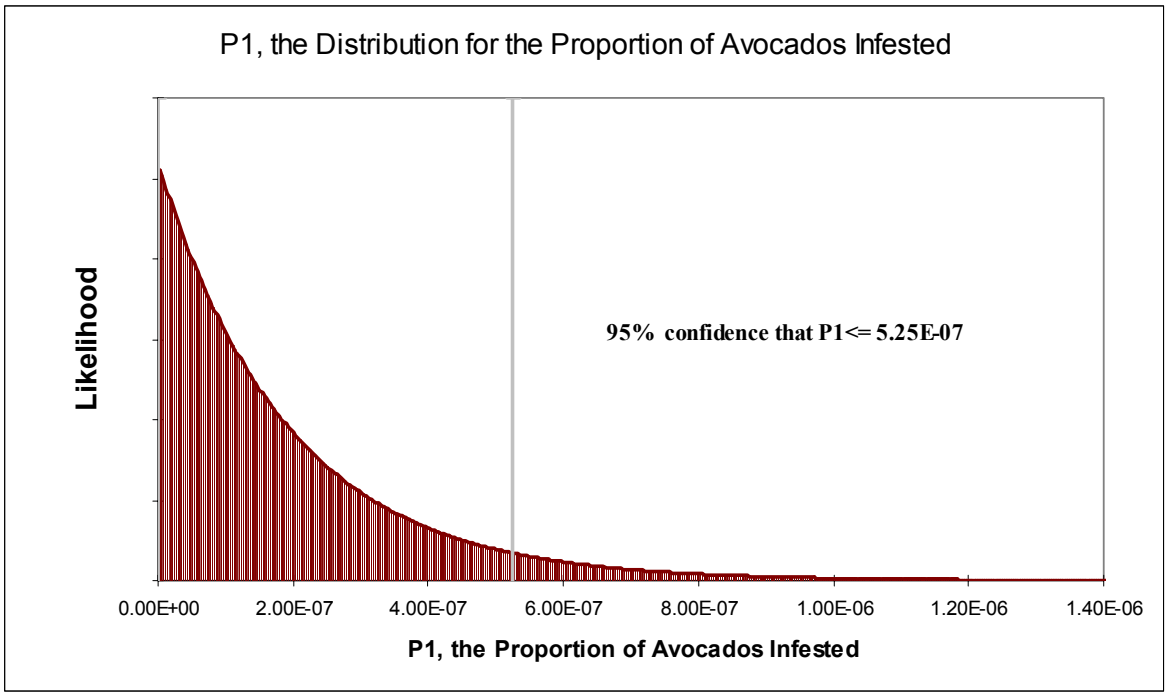
- less than 350 infested avocados will reach the United States each year.
- less than 66 infested avocados will reach avocado producing counties each year.

Summary of results:

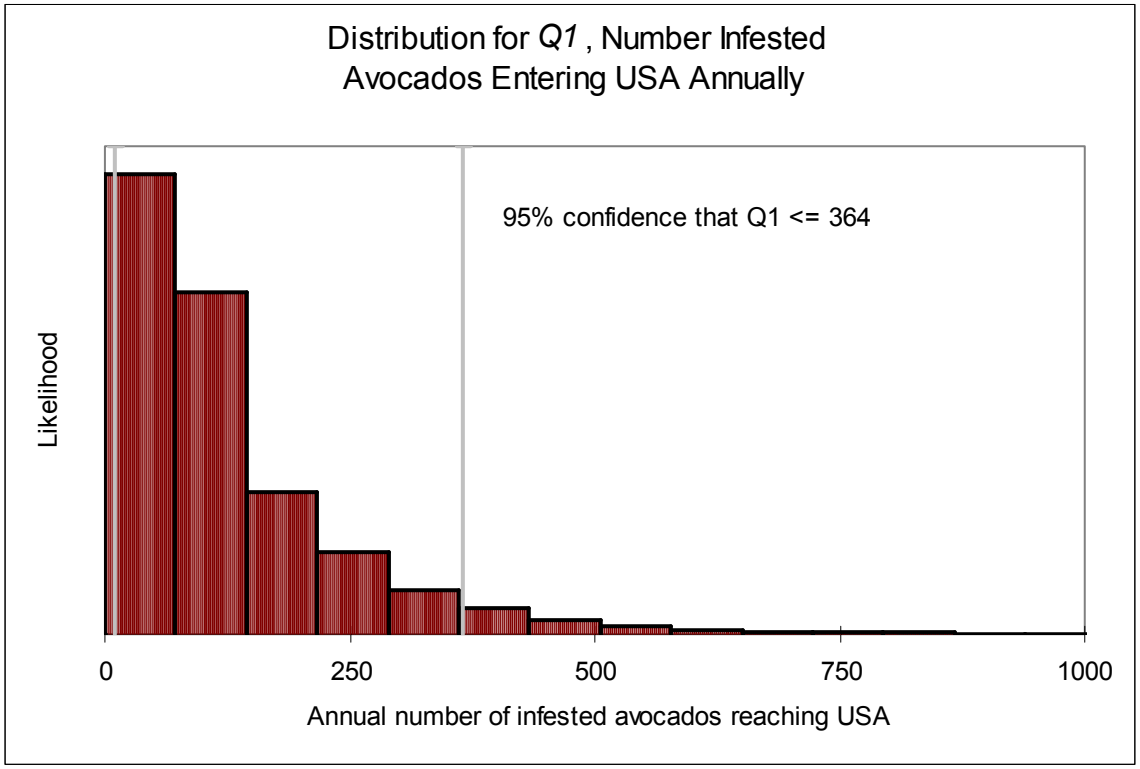
The probability distributions for results are presented below:

P1, Proportion of Avocados that are Infested

Probability Density Distribution

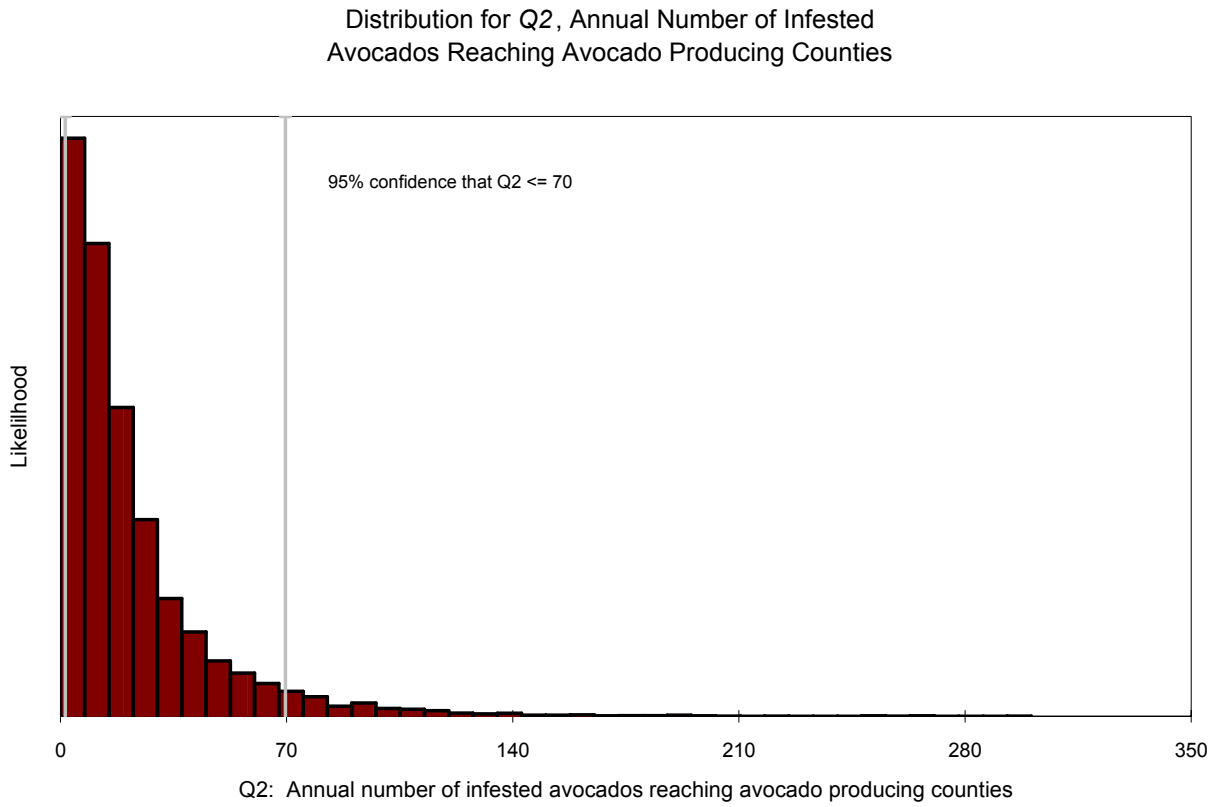


Q1, Annual number of Infested avocados reaching the US
Probability Density Distribution



Q2, Annual number of Infested Avocados reaching counties with susceptible host material

Probability Density Distribution



Appendix E – Approximation of the quantity of Hass avocados that would be imported from Mexico, if they were allowed to enter year-round into all States

Phylo Evangelou

This appendix is divided into three sections. The first presents an approximated range for the quantity of Hass avocados that would be imported into the United States from Mexico, if the Code of Federal Regulations were amended to allow year-round importation into all States. The second section sets forth some of the assumptions that underlie the approximation. The third section lists the steps followed in its derivation.

The approach taken rests on the premise that quantities of Hass avocados imported from Mexico during the past six years, together with quantities imported from other countries and those supplied domestically during and prior to this period, provide a basis for approximating expanded imports from Mexico. Changes in the supply of Hass avocados in regions approved for imports from Mexico are applied to regions and times of the year for which imports from Mexico are currently prohibited. A range of import quantities is approximated, taking into consideration Mexico's supply potential and differences among U.S. regional markets. Population projections are used to indicate how the approximated range may increase over time.

The approximated range of Hass avocado imports from Mexico, if they were allowed to enter all States year-round, is 275 million pounds to 413 million pounds per year. Hass avocado imports from Mexico in 2002 totaled about 59 million pounds. Thus, they may be expected to increase to between four and seven times their current level. All things equal, the approximated range could become 295 million pounds to 442 million pounds per year after five years.

Expanded Hass Avocado Imports from Mexico

Fresh Hass avocados from Mexico were allowed entry into the northeastern United States for the first time in November 1997.[1] Entry was allowed into 19 States and the District of Columbia during a four-month period, November through February. In 2001, the area approved for import was expanded by an additional 12 States, and the period of import was extended to six months, October 15 to April 15.[2]

The area previously approved to receive Hass avocados from Mexico corresponds to the Northeast and East Central regions designated in avocado shipment data compiled by the California Avocado Commission (CAC). States added to the approved area by the second rule correspond, with minor discrepancies, to CAC's West Central region.[3]

[1] The effective date of the final rule was March 7, 1997. The approved area included Connecticut, Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin.
[2] The effective date of the final rule was November 1, 2001. The States added were Colorado, Idaho, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming.
[3] The six regions are Northeast, East Central, West Central, Southeast, Southwest, and Pacific. The Pacific region includes shipment terminals in Idaho and Utah. Other than for these two States, all States approved by the 2001 final rule to receive Hass avocados from Mexico correspond to terminal markets in CAC's Northeast, East Central,

Entry of Hass avocados from Mexico into the Northeast and East Central regions, and more recently into the West Central region, has had dramatic supply effects. In the Northeast and East Central regions, the average supply of avocados during January, February, and December has increased by more than 140 percent, and in November, by more than 80 percent (Table 1). The simple average for the four months indicates an increase in total supply of 128 percent. At the same time, the quantity of Hass avocados supplied by California and foreign sources other than Mexico during the four months has fallen by an average of 57 percent (Table 2).

Similar changes can be seen when the West Central region is included (Tables 3 and 4). However, the effects are not as clear-cut. We cannot distinguish among regional destinations for imports from Mexico; observed market changes due to allowing Hass avocado imports from Mexico into the West Central region are dampened by imports into the Northeast and East Central regions prior to November 2001. Also, for the months of March, April, and October, there is only one year of data that includes imports from Mexico, namely 2002. Nonetheless, the same pattern of increased total supply and reduced supply by California and foreign sources other than Mexico is apparent.[1]

Table 5, scenario 1, shows percentage increases in the total supply of Hass avocados and percentage decreases in the quantity supplied by California and foreign sources other than Mexico that are based on the changes observed in Tables 1-4. Seasonal differences (higher percentage changes from October to March, lower ones from May to August, with April and September as transition months) are included to account for the seasonal variability of avocado production in Mexico.

Regional and total quantities of Hass avocados that would be imported from Mexico, assuming scenario 1 changes occurred in all regions are presented in Table 6, scenario 1. The results indicate that Hass avocado imports from Mexico would exceed 550 million pounds a year. This amount is greater than Mexico's current production that can be certified for export to the United States. In addition, we do not believe that the entry of Hass avocado imports from Mexico into the Pacific, Southeast, and Southwest regions would have as strong an effect, percentage-wise, as has occurred in the Northeast, East Central, and West Central regions. The latter have always been relatively minor markets for California producers and importers from sources other than Mexico, whereas the Pacific region and California in particular is their single largest area of demand. Because of the above scenario was not considered realistic (specifically, 550 million pounds exceeds production capacity as noted above), that scenario was not included in this assessment.

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and West Central regions. Since the quantities of Hass avocados shipped to Idaho and Utah are small, these discrepancies can be disregarded.

[1] In Table 4, the anomalous increase in October 2002 may be partly attributable to that year's surge in imports from sources other than Mexico (50% increase over 2001 imports) and October's historically large share of these imports (30 percent).

Table 1. Hass avocados supplied to the Northeast and East Central regions, January, February, November, and December, 1994 to 2001, including imports from Mexico, pounds

	January	February	November	December
1994	2,590,680	2,284,462	2,889,853	2,329,671
1995	2,930,085	2,463,722	4,702,680	2,883,405
1996	3,494,143	3,603,430	5,547,622	3,413,139
1997	4,239,303	3,926,758	6,031,334	5,978,564
1998	7,176,472	6,041,963	6,381,416	6,007,244
1999	6,936,146	6,729,956	8,724,254	6,688,487
2000	7,615,616	7,472,906	8,188,139	8,269,977
2001	9,913,767	9,943,446	11,106,149	8,061,474
Monthly average prior to imports from Mexico[1]	3,313,553	3,069,593	4,380,052	2,875,405
Monthly average for months that include imports from Mexico[2]	7,910,500	7,547,068	8,086,258	7,001,149
Percent change from the first to the second average	138.7%	145.9%	84.6%	143.5%

Sources: California Avocado Commission for shipments from California, and the U.S. Census Bureau for imports.
Note: The regional distribution of imports other than from Mexico is assumed to be the same as the distribution for California shipments. The monthly distribution of imports other than from Mexico is based on their 1985-1995 average distribution. The monthly distribution of imports from Mexico, November 1997 through December 2001, is assumed to be 25 percent each for January, February, November, and December. Data on imports has been adjusted to exclude non-Hass varieties. California shipments for which the regional destination was not identified are not included; they comprised, on average, only 0.4 percent of California shipments from 1994/95 to 2001/02.

[1] January, 1994-1997; February, 1994-1997; November, 1994-1996; December, 1994-1996.

[2] January, 1998-2001; February, 1998-2001; November, 1997-2001; December, 1997-2001.

Table 2. Hass avocados supplied to the Northeast and East Central regions, January, February, November, and December, 1994 to 2001, not including imports from Mexico, pounds

	January	February	November	December
1994	2,590,680	2,284,462	2,889,853	2,329,671
1995	2,930,085	2,463,722	4,702,680	2,883,405
1996	3,494,143	3,603,430	5,547,622	3,413,139
1997	4,239,303	3,926,758	1,590,326	1,537,556
1998	2,155,471	1,020,962	1,360,415	986,243
1999	565,800	359,610	2,353,908	318,141
2000	519,655	376,945	1,092,178	1,174,016
2001	2,999,281	3,028,960	4,191,663	1,146,988
Monthly average prior to imports from Mexico[1]	3,313,553	3,069,593	4,380,052	2,875,405
Monthly average for months when imports from Mexico were allowed[2]	1,560,052	1,196,619	2,117,698	1,032,589
Percent change from the first to the second average	-52.9%	-61.0%	-51.7%	-64.1%

Sources: California Avocado Commission for shipments from California, and the U.S. Census Bureau for imports.
Note: The regional distribution of imports is assumed to be the same as the distribution for California shipments. The monthly distribution of imports is based on their 1985-1995 average distribution. Data on imports has been adjusted to exclude non-Hass varieties. California shipments for which the regional destination was not identified are not included; they comprised, on average, only 0.4 percent of California shipments from 1994/95 to 2001/02.
[1] January, 1994-1997; February, 1994-1997; November, 1994-1996; December, 1994-1996.
[2] January, 1998-2001; February, 1998-2001; November, 1997-2001; December, 1997-2001.

Table 3. Hass avocados supplied to the Northeast, East Central, and West Central regions, January-April and October-December, 1994 to 2002, including imports from Mexico, pounds

	January	February	March	April	October	November	December
1994	3,701,598	3,030,810	4,197,798	4,719,436	4,204,455	3,534,724	3,432,717
1995	3,826,140	3,377,574	4,600,470	5,185,707	6,019,307	3,945,415	3,917,373
1996	4,800,544	4,885,705	5,584,586	6,963,758	6,105,430	5,358,173	4,529,584
1997	5,493,122	5,214,515	5,701,271	6,427,522	4,975,958	6,979,322	7,360,413
1998	8,894,686	7,433,600	5,255,560	7,670,960	8,915,562	7,842,602	7,978,211
1999	8,185,395	7,963,462	4,751,107	6,890,983	7,851,918	10,100,348	7,692,027
2000	9,306,298	8,905,448	6,434,911	7,739,903	10,162,448	10,634,987	9,730,278
2001	12,079,836	11,849,398	6,726,203	10,990,368	13,915,082	13,255,814	9,047,991
2002	13,694,206	14,042,418	12,206,594	8,174,666	19,183,379	12,571,385	12,896,700
Monthly average prior to imports from Mexico[1]	4,455,351	4,127,151	5,406,488	7,073,580	7,768,770	4,279,437	3,959,891
Monthly average for months that include imports from Mexico[2]	10,432,084	10,038,865	12,206,594	8,174,666	19,183,379	10,230,743	9,117,603
Percent change from the first To the second average	134.1%	143.2%	125.8%	15.6%	146.9%	139.1%	130.2%

Sources: California Avocado Commission for shipments from California, and the U.S. Census Bureau for imports.
Note: The regional distribution of imports other than from Mexico is assumed to be the same as the distribution for California shipments. The monthly distribution of imports other than from Mexico is based on their 1985-1995 average distribution. The monthly distribution of imports from Mexico, November 1997 through December 2001, is assumed to be 25 percent each for January, February, November, and December. The monthly distribution of imports from Mexico for 2002 is assumed to be as follows: January, February, and December, 18 percent; March and November, 16 percent; and April and October, 7 percent. Data on imports has been adjusted to exclude non-Hass varieties. California shipments for which the regional destination was not identified are not included; they comprised, on average, only 0.4 percent of California shipments from 1994/95 to 2001/02.

[1] January, 1994-1997; February, 1994-1997; March, 1994-2001; April, 1994-2001; October, 1994-2001; November, 1994-1996; December, 1994-1996.

[2] January, 1998-2002; February, 1998-2002; March, 2002; April, 2002; October, 2002; November, 1997-2002; December, 1997-2002.

Table 4. Hass avocados supplied to the Northeast, East Central, and West Central regions, January-April and October-December, 1994 to 2002, not including imports from Mexico, pounds

	January	February	March	April	October	November	December
1994	3,701,598	3,030,810	4,197,798	4,719,436	4,204,455	3,534,724	3,432,717
1995	3,826,140	3,377,574	4,600,470	5,185,707	6,019,307	3,945,415	3,917,373
1996	4,800,544	4,885,705	5,584,586	6,963,758	6,105,430	5,358,173	4,529,584
1997	5,493,122	5,214,515	5,701,271	6,427,522	4,975,958	2,538,314	2,919,405
1998	3,873,685	2,412,599	5,255,560	7,670,960	8,915,562	2,821,601	2,957,210
1999	1,815,049	1,593,116	4,751,107	6,890,983	7,851,918	3,730,002	1,321,681
2000	2,210,337	1,809,487	6,434,911	7,739,903	10,162,448	3,539,026	2,634,317
2001	5,165,350	4,934,912	6,726,203	10,990,368	13,915,082	6,341,328	2,133,505
2002	3,111,492	3,459,704	2,799,737	4,059,166	15,067,879	3,164,528	2,313,986
Monthly average prior to imports from Mexico[1]	4,455,351	4,127,151	5,406,488	7,073,580	7,768,770	4,279,437	3,959,891
Monthly average for months when imports from Mexico were allowed[2]	3,235,183	2,841,964	2,799,737	4,059,166	15,067,879	3,689,133	2,380,017
Percent change from the first To the second average	-27.4%	-31.1%	-48.2%	-42.6%	94.0%	-13.8%	-39.9%

Sources: California Avocado Commission for shipments from California, and the U.S. Census Bureau for imports.

Note: The regional distribution of imports is assumed to be the same as the distribution for California shipments. The monthly distribution of imports is based on their 1985-1995 average distribution. Data on imports has been adjusted to exclude non-Hass varieties. California shipments for which the regional destination was not identified are not included; they comprised, on average, only 0.4 percent of California shipments from 1994/95 to 2001/02.

[1] January, 1994-1997; February, 1994-1997; March, 1994-2001; April, 1994-2001; October, 1994-2001; November, 1994-1996; December, 1994-1996.

[2] January, 1998-2002; February, 1998-2002; March, 2002; April, 2002; October, 2002; November, 1997-2002; December, 1997-2002.

Table 5. Percentage changes in the total supply of Hass avocados and in the quantities supplied by California and foreign sources other than Mexico, if imports from Mexico were allowed to enter year-round into all States, for four scenarios

	Increase in Total Supply	Decrease in the Supply by California and Foreign Sources other than Mexico
Scenario 1		
January, February, March, October, November, December	120%	60%
April and September	80%	40%
May, June, July, August	40%	20%
Scenario 2		
January, February, March, October, November, December	90%	45%
April and September	60%	30%
May, June, July, August	30%	15%
Scenario 3		
January, February, March, October, November, December	75%	37.5%
April and September	50%	25%
May, June, July, August	25%	12.5%
Scenario 4		
January, February, March, October, November, December	60%	30%
April and September	40%	20%
May, June, July, August	20%	10%

Note: Assumed seasonal differences reflect the seasonality of production of Hass avocados in Mexico.

Table 6. Four approximations of the supply of Hass avocados by Mexico, and by California and foreign sources other than Mexico, if imports from Mexico were allowed to enter year-round into all States, pounds

	Imports from Mexico	CA Shipments and Imports other than from Mexico	Total Supply
Scenario 1			
Pacific	273,980,202	130,665,100	404,645,302
Southeast	57,140,036	23,152,393	80,292,430
Southwest	117,516,222	53,041,117	170,557,338
Northeast	34,948,304	22,133,188	57,081,492
East Central	38,106,275	22,123,533	60,229,808
West Central	28,522,107	13,905,616	42,427,723
Total	550,213,146	265,020,947	815,234,093
Scenario 2			
Pacific	205,485,151	153,496,783	358,981,935
Southeast	42,855,027	27,914,063	70,769,090
Southwest	88,137,166	62,834,135	150,971,301
Northeast	26,211,228	25,045,547	51,256,775
East Central	28,579,706	25,299,056	53,878,762
West Central	21,391,580	16,282,458	37,674,039
Total	412,659,860	310,872,042	723,531,902
Scenario 3			
Pacific	171,237,626	164,912,625	336,150,251
Southeast	35,712,523	30,294,898	66,007,420
Southwest	73,447,639	67,730,644	141,178,283
Northeast	21,842,690	26,501,726	48,344,416
East Central	23,816,422	26,886,817	50,703,239
West Central	17,826,317	17,470,879	35,297,196
Total	343,883,216	333,797,590	677,680,807
Scenario 4			
Pacific	136,990,101	176,328,467	313,318,568
Southeast	28,570,018	32,675,733	61,245,751
Southwest	58,758,111	72,627,154	131,385,264
Northeast	17,474,152	27,957,906	45,432,058
East Central	19,053,138	28,474,579	47,527,716
West Central	14,261,054	18,659,300	32,920,354
Total	275,106,573	356,723,138	631,829,711

Note: Approximations begin with regional yearly supply averages for the four-year period, 1999-2002, not including imports from Mexico. Assumed increases in the total supply of avocados, and decreases in the quantities supplied by California and foreign sources other than Mexico, are shown in Table 5.

Taking these factors into consideration, three other scenarios with lower percentage changes are

set forth (Table 5, scenarios 2-4), and the corresponding quantities calculated (Table 6, scenarios 2-4). Imports from Mexico for scenarios 2 and 4 are used as end-points for the approximated range: 275 million pounds to 413 million pounds per year. It is noted that approximated imports from Mexico for the Northeast, East Central, and West Central regions in scenario 3, 63 million pounds, is similar to the 59 million pounds of Hass avocados imported from Mexico by those regions during the allowed months of 2002.

An appreciation for how this range in imports from Mexico may increase over time can be gained by applying regional rates of population growth. As shown in Table 7, the approximated range would become 295 million pounds to 442 million pounds per year in five years, assuming Mexico's percentage share of the regional markets remained the same and without considering regional differences in per capita avocado consumption.

Table 7. Projected increase after five years in the approximated range of Hass avocado imports from Mexico, based on regional population growth rates, pounds

Region	Approximated Range of Imports from Mexico[1]			Annual Growth Rate[2]	Projected Range of Imports from Mexico after Five Years		
Pacific	136,990,101	to	205,485,151	1.7%	149,036,949	to	23,555,423
Southeast	28,570,018	to	42,855,027	1.1%	30,176,321	to	45,264,482
Southwest	58,758,111	to	88,137,166	1.7%	63,925,273	to	95,887,909
Northeast	17,474,152	to	26,211,228	0.4%	17,826,442	to	26,739,663
East Central	19,053,138	to	28,579,706	0.4%	19,437,261	to	29,155,892
West Central	14,261,054	to	21,391,580	0.4%	14,548,566	to	21,822,848
Total	275,106,573	to	412,659,860		294,950,811	to	442,426,217

Note: The projections assume that the relative shares of Hass avocados supplied by Mexico, other foreign sources, and California remain unchanged. Regional differences in per capita avocado consumption are not considered.

[1]Imports from Mexico, Table 6, scenarios 2 and 4.

[2]Campbell 1996. The population growth rate for the West, 1.7%, is used for the Pacific and Southwest regions.

Assumptions

1. Data on U.S. avocado supplies used in making the approximation can be appropriately restricted to the Hass variety.

Hass is the only variety allowed to be imported from Mexico as whole fresh fruit. Any regulatory change allowing expanded imports would also only concern Hass avocados. It is the principal variety grown in the United States, comprising 90 percent of California shipments, 1991/92 to 2001/02.[1] Avocado imports from countries other than Mexico are mainly Hass variety.

Hass avocados have a market distinct from green avocado varieties. Substantial and prevailing

[1] Hass avocados are not produced in Florida and the quantity that may be produced in Hawaii is negligible.

price differences underscore the Hass's low substitutability with other varieties. The fact that the avocado promotion, research, and information order issued last year by USDA's Agricultural Marketing Service is only for Hass avocados is an indication of domestic and foreign producers' interest in promoting the variety's distinctiveness (*Federal Register*, Vol. 67, No. 173, September 6, 2002).

2. The quantity of Hass avocados that could be potentially supplied by Mexico is considerably larger than is now being imported.

Only about two of every nine tons of Hass avocados produced per hectare in certified orchards in Mexico are exported to the United States.[1] The rest of the crop is exported to Europe or elsewhere, or consumed within Mexico. Thus, less than one-fourth of the certified fruit is being shipped to the United States, while the area certified for export to the United States continues to expand (12,149 hectares in 2001/02, 16,430 hectares in 2002/03, and a projected 23,000 hectares in 2003/04). In round figures, about 450 million pounds of Hass avocados could be available for export to the United States in 2003/04.[2]

3. Quantities of Hass avocados imported from Mexico are determined by importers' desire to maintain market prices, the flexibility afforded by lower production costs in Mexico compared to those in the United States, and projections for overall market growth.

The quantity of avocados offered for sale in the United States has a strong, negative impact on price (Carman and Craft 1998). The fact that Hass avocado imports from Mexico are but a fraction of the quantity that are certified for export to the United States and could be supplied underscores importers' appreciation of the fruit's inelastic demand, estimated by Carman and Green (1993) to be -0.86. This means that declines in price due to increased supply result in lower total revenue; the percentage drop in price is greater than the percentage increase in demand, or quantity of avocados sold.

On the other hand, lower costs of production in Mexico give that country's exporters an added cushion against price declines, and greater flexibility in responding to market changes. As has occurred in the Northeast, East Central, and West Central regions, imports from Mexico would be expected to claim sizable shares of expanding markets in the Pacific, Southeast, and Southwest regions. Producers in Mexico are better able to weather price declines than their U.S. counterparts.

4. Seasonality of Hass avocado production in Mexico may cause seasonal variation in exports to the United States, but the variation should be moderate.

Avocado growers can store the fruit on the tree for up to three or four months once it is ready to be harvested, to allow for market fluctuations; the fruit continues to grow. The timing of harvest therefore depends more on marketing opportunities than on the fruit's ripeness. Hass avocados have a longer season than other varieties, and in addition, those grown in Mexico have an extra bloom per season (*flor loco,* or crazy bloom). Five blooms per year compared to the four blooms

[1] Ron Campbell, SPS Consultants, personal communication.
[2] (23,000 hectares)(9,000 kilograms/hectare/year)(2.205 pounds/kilogram) = 456,435,000 pounds/year.

that are normal elsewhere is another reason why Mexico can produce avocados year-round with moderate seasonal variability.[1]

Although harvested year-round, Hass avocados grown in Mexico reach their peak productivity between October and February, with a broader period of above-average production from September through March.[2] In contrast, the main season for California shipments of Hass avocados is March to September.

5. The regional distribution of Hass avocado imports other than from Mexico is largely the same as the distribution of domestically produced Hass avocados.

This assumption is supported by industry opinion. California, for example, is the largest single market for both domestically produced Hass avocados and Hass avocados from Chile, our main foreign supplier.

Steps Followed

1. Using data supplied by the California Avocado Commission, a database was created of monthly Hass avocado shipments by regional destination (domestic shipments), beginning with the 1991/1992 season. (The crop year for avocados runs from November through October.)

2. Avocado import data reported by the Census Bureau and provided by the World Trade Atlas were adjusted to eliminate non-Hass imports. Hass avocado imports began to be reported separately in July 2001.[3] Each country's proportion of Hass avocado exports to the United States from mid-2001 to the end of 2002 was applied to previous years' exports, beginning in 1994.[4]

3. Hass avocado yearly import totals for foreign sources other than Mexico were distributed monthly, based on the average monthly distribution of imports reported for 1985-1995 (Carman and Craft 1998, Appendix Table 8).[5]

4. The Hass avocado import totals for foreign sources other than Mexico, by year and month, were added to domestic shipments and distributed among the regions in proportion to the domestic shipments.

5. Yearly Hass avocado imports from Mexico were distributed monthly as follows. For November 1997 through December 2001, 25 percent each was apportioned to November,

[1] Ron Campbell, SPS Consultants, personal communication.
[2] www.marketag.com/ma/bulletins/market/avocado.stm, and Ron Campbell, SPS Consultants, personal communication.
[3] Harmonized Schedule 0804.40.0010, Hass avocados and avocados determined by the Secretary of USDA to be Hass-like.
[4] Principal foreign sources of avocados and approximated shares of imports from these sources that were of the Hass variety, 1994-2002, are as follows: Chile, 99.7%; Mexico, 97.7%; New Zealand, 97.4%; Dominican Republic, 20.6%, Bahamas, none; Other, 98.8%. The percentage of avocados imported by the United States annually that were of the Hass variety averaged 84.2%, 1994-2002, and 89.6%, 1998-2002.
[5] Monthly distribution of imports: January, 6.4%; February, 1.6%; March, 0.3%; April, 0.4%; May, 0.5%; June, 1.3%; July, 2.3%; August, 3.2%; September, 15.4%; October, 29.9%; November, 27.4%; and December, 11.3%.

December, January, and February. For January though December 2002, 18 percent each was apportioned to January, February, and December; 16 percent each was apportioned to March and November; and 7 percent each was apportioned to April and October.[1]

At the time this assessment was done, we did not have access to information on monthly quantities of Hass avocados imported from Mexico. A recalculation using actual monthly import levels would not alter the approximations significantly.

6. Hass avocado imports from Mexico were added to the sum of domestic shipments and imports other than from Mexico, by month. Quantities for the Northeast and East Central regions were combined for November 1997 through December 2001. The West Central region was included for 2002.

7. Monthly percentage increases in the Hass avocado supply with Mexico's entry into the market were calculated for the Northeast and East Central regions, 1994 to 2001, and including the West Central region in 2002 (Tables 1 and 3). Percentage decreases in quantities of Hass avocados supplied by California and foreign sources other than Mexico were calculated for the same regions for the same periods (Tables 2 and 4).

8. The observed percentage changes in the Northeast, East Central, and West Central regions were generalized (Table 5, scenario 1). Expected seasonal variation in the supply of Hass avocados from Mexico was acknowledged by assuming smaller percentage changes when Mexico's production is lower. The generalized changes were applied to the four-year average, 1999-2002, of Hass avocado quantities supplied by California and foreign sources other than Mexico to all regions for all months (Table 6, scenario 1).

9. The generalized percentage changes were adjusted downward, in recognition of Mexico's supply capacity and the strong market positions held in the Pacific and Southwest regions by California and foreign suppliers other than Mexico (Table 5, scenarios 2-4). Application of these adjusted percentage changes yielded the approximated range of expanded Hass avocado imports from Mexico, as shown in scenarios 2 and 4 of Table 6.

10. Census Bureau regional population projections were applied to the approximated range to show how it may increase in the near future.[2]

REFERENCES

[1] The percentage distributions for November and December, 2001, were kept at 25% of the 2001 yearly total for ease of calculation. These two months' share of the yearly total may well have been higher, since the market had just broadened to include the West Central region.

[2] Annual rates of population increase projected for regions of the United States, 1995 to 2025, are Northeast, 0.4%; Midwest, 0.4%; South, 1.1%; and West, 1.7% (Campbell 1996). It is noted that U.S. annual per capita consumption of avocados increased from less than one-half pound in the early 1960s, to over two pounds in 1987 (Carman and Green 1993). Data indicate that there has not been an appreciable increase in U.S. per capita consumption since the mid-1980s. However, above-average per capita avocado consumption in the Pacific and Southwest would suggest even more rapid market growth could be expected in those fast-growing regions than is indicated by population projections alone.

Campbell, Paul R. 1996. "Population Projections for States by Age, Sex, Race, and Hispanic Origin: 1995 to 2025." U.S. Bureau of the Census, Population Division, www.census.gov/population/www/projections/ppl47.html.

Carman, Hoy F., and R. Kim Craft. 1998. "An Economic Evaluation of California Avocado Industry Marketing Programs, 1961-1995." Giannini Foundation Research Report Number 345, University of California.

Carman, Hoy F., and Richard D. Green. 1993. "Commodity Supply Response to a Producer-Financed Advertising Program: The California Avocado Industry." *Agribusiness*, Vol. 9, No. 6, 605-621.

Appendix F – 7CFR§319.56-2ff
Administrative instructions governing movement of Hass avocados from Michoacán, Mexico, to approved States.

Fresh Hass variety avocados (Persea americana) may be imported from Michoacan, 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 Michoacan 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 Michoacan 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)
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