Importation of Avocado Fruit (*Persea americana*) from Mexico

Supplemental Pest Risk Assessment:

Addendum I: Estimates for the Likelihood of Pest Outbreaks Based on the Draft Final Rule

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I. Introduction

A. General

In 1994, Mexico submitted the *Proposed Work Plan for the Exportation of Hass Variety Avocado from Mexico to the United States* (Direccion General de Sanidad Vegetal (DGSV), 1994)) for APHIS' consideration. 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) regarding importation of Mexican avocado fruit. After considering the comments received from the public regarding the Advanced Notice of Proposed Rulmaking (ANPR), APHIS published in the Federal Register a Proposed Rule (60 FR 34831-34842, Docket No. 94-116-3) to allow fresh Hass avocado fruit grown in approved orchards in approved municipalities in Michoacan, Mexico, to be imported into certain areas of the United States, subject to certain conditions. The Proposed Rule was accompanied by a plant pest risk assessment [*Importation of Avocado Fruit* (Persea americana) *from Mexico: Supplemental Pest Risk Assessment*]. The supplemental pest risk assessment addressed the importation of avocado fruit from Mexico as outlined in the provisions of the Proposed Rule. Details of the proposed program are given in *Risk Management Analysis: A Systems Approach for Mexican Avocados* (APHIS, 1995).

Following comments received from the public regarding the Proposed Rule, APHIS has considered modifications to the proposed program and produced a Draft Final Rule. The comments suggested that greater scrutiny was needed at each stage of any final importation program. Accordingly, APHIS has agreed to monitor any final importation program more closely and has made three explicit modifications to the proposed program to provide increased risk mitigation. The changes affect our estimates of the plant pest risk associated with importations of Mexican avocado fruit. These changes appear in the Draft Final Rule:

1. Fallen fruit must be removed from the orchard no less frequently than every seven days during harvest.

   This requirement affects our estimates for node P1, the probability that shipped fruit will be infested (see the Supplemental Pest Risk Assessment, May 1995 for a description of the nodes). See Section II.D. for details of reductions in estimated probabilities.

2. The Proposed Rule required that 250 fruit from each export lot be inspected for any pest, and specifically those pests analyzed in this assessment. The Draft Final Rule requires that 300 fruit be inspected meticulously.

   This change affects our estimates for node P2, the probability that pests will evade detection during harvest or packing). See Section II.D. for details of reductions in estimated probabilities.

3. The Draft Final Rule for importation of Mexican avocado fruit specifies that a sticker identifying the export grove must be placed on every individual fruit imported under the program.

   This requirement affects both the probability that pests will evade detection at the port of entry (node P4) and the probability that fruit will be transported to a habitat with suitable hosts and climate (node P5). See Section II.D. for details of reductions in estimated probabilities.

B. Consequences of Pest Introductions

In the Supplemental Pest Risk Assessment, we assessed the risk posed by nine pests that were grouped into the following four categories:

- **fruit flies:** *Anastrepha fraterculus, A. ludens, A. serpentina, A. striata*
- **seed weevils:** *Conotrachelus aguacatae, C. perseae, Heilipus lauri*
- **stem weevil:** *Copturus aguacatae*
- **seed moth:** *Stenoma catenifer*

Plant pest risk is composed of two general elements, the consequences of introduction of a particular pest and the likelihood that the pest will be introduced. Our assessment of the consequences of introduction was presented in the May 1995 assessment. Our assessment of the consequences of introduction has not changed. We rated the consequences of introduction of the four pest categories as follows (PRP=pest risk potential on a scale from 3-15; 3=lowest risk potential, 15=highest risk potential):

Table 1: Consequences of Introduction

Pest	PRP *	Risk Rating*	Comments
fruit flies	13	high	High rating results primarily from wide host ranges, high motility, and large potential economic impact.
seed weevils	10	medium	Although these pests could potentially have a significant economic impact on domestic avocado production, their host range is extremely narrow (only known to attack avocados), they have narrow climatic tolerance, and their dispersal potential is limited.
stem weevil	10	medium	Same as seed weevils
seed moth	11	medium	Similar to seed weevils, although this species is known to attack at least one other plant species.

* For full explanation, see May 1995 Supplemental Risk Assessment (USDA, 1995)

Table 1 shows our finding that the fruit flies have the potential for high negative impacts on American agriculture. The other three pest categories have the potential for medium impacts on American agriculture, primarily because of their narrow host ranges and climatic tolerances, limited dispersal potential, and limited potential impact on the environment (see May 1995 assessment for details). Although our assessment of the consequences of introduction of these pests has not changed, our estimate of the risk based on the Draft Final Rule has changed because the increased risk mitigations reduce the likelihood that these pests will be introduced.

II. Likelihood of Pest Outbreaks: Revised Estimates Based on Draft Final Rule

A. General

As described in the May 1995 Supplemental Risk Assessment, we estimated likelihood of introduction using Scenario Analysis and a series of Monte Carlo simulations. Changes made to the Proposed Rule do not warrant any changes to our reported scenario. Our scenario represents a "fault" model in that it identifies areas where failures must occur before pests can be introduced. We believe that our scenario as reported in the Supplemental Risk Assessment is sufficient and accurate.

It is important to note that our scenario does not include, nor did we assess, the risk posed to American agriculture by smuggling of Mexican avocado fruit into the United States. We consider only the risk posed by what would be legal importations of fruit as part of a program sanctioned and monitored at every stage by the governments of both Mexico and the United States. Smuggling occurs now and could conceivably continue during a legal importation program. However, it is likely that a legal importation program will lower the incentive to smuggle Mexican avocado fruit into the United States.

B. Scenario Analysis

The scenario analysis forms the basis for the Monte Carlo Simulations. The three primary components of the Monte Carlo simulations were:

1. Develop a mathematical model to estimate the probabilities of pest outbreaks.
2. Estimate probabilities for each component event in the model.
3. Calculate estimated probabilities of pest outbreaks using Monte Carlo sampling techniques.

C. Mathematical Model

Because the scenario represents the mathematical model used to estimate the likelihood/ probability of pest outbreaks and the because the scenario for pest introduction did not change for this addendum, our mathematical model did not change.

D. Revised Inputs for Monte Carlo Simulations

Changes to the proposed program provide additional levels of risk mitigation and we have changed our original probability estimates to reflect these additional safety measures.

F1: Boxes (i.e., number of boxes imported per year)

Unchanged

P1: Pest Infests fruit: pre- or post-harvest

The Draft Final Rule is more stringent regarding required grove sanitation, it specifies that fallen fruit must be removed from the ground at least every seven days (as opposed to merely "before harvest"). This requirement will reduce infestation of harvested fruit for at least two distinct reasons:

1. Fallen fruit provides ideal habitat for three of the four pest groups of concern (*i.e.*, fruit flies, seed weevils and seed moth). By removing these fruit no less frequently than every seven days during harvest, it is less likely that the pest will be capable of infesting the grove.

2. Fallen fruit present on the ground at the beginning of harvest present the greatest risk because they may have been available to pests for more than seven days. These fallen fruit will be removed first. As fallen fruit are removed repeatedly, fewer and fewer of these fruit will remain to be mistakenly included with harvested fruit.

Because of this change to the Proposed Rule the likelihood of pest infestation was divided by two for the fruit flies, seed weevils and seed moth. The likelihood of infestation by stem weevils was not reduced because removal of fallen fruit can not be expected to have a significant impact on this pest.

P2: Pest not detected during harvest or packing

The Proposed Rule required that 250 fruit from each export lot be meticulously inspected for any of the pests analyzed in this assessment. The Draft Final Rule requires that 300 fruit be inspected. Thus, the number of fruit to be inspected was increased by 20%. We assumed that this increase would reflect directly on the efficacy of the inspection; we reduced the likelihood that pests would evade detection by 20%.

P3: Pest survives shipment

Unchanged

P4: Pest not detected at port of entry inspection

As a result of comments on the Proposed Rule, the Draft Final Rule for importation of Mexican avocado fruit specifies that a sticker identifying the export grove must be placed on every individual fruit imported under the program. One of the benefits of this requirement is that it is less likely that fruit not from certified groves will be imported into the United States. Because fruit not grown in certified groves present a greater pest risk, reducing the likelihood that they will be imported reduces the likelihood that pests will evade detection. This probability was reduced 15-20% for the various pests.

P5: Fruit transported to area with suitable hosts and climate

The requirement that each fruit be stickered impacts mostly on this node. Individual stickers will reduce the likelihood that fruit will be moved from the program States (*i.e.*, the 19 northeastern states and the District of Columbia) for at least two reasons:

1. Inadvertent movement will be reduced because it will be possible to distinguish program fruit from non-program fruit.

2. Stickering the fruit will make smuggling of fruit from the program area to areas with suitable hosts and climate more difficult, more expensive, and more labor intensive.

The lower limit of this probability was reduced from 0.005 (0.5%) to 0.0005 (0.05%) and the upper limit for the probability was reduced from 0.05 (5.0%) to 0.02 (2.0%). Thus, our assessment is based on the assumption that as many as 2% (50,000 boxes of fruit) may be illegally smuggled not only out of the program area, but specifically to areas suitable for establishment of these pests. Areas suitable for establishment must have both suitable climate and hosts. Because three of the four pest categories (all but the fruit flies) are specific to avocados, the only suitable areas are those area where avocados are grown commercially (*i.e.*, parts of southern California and southern Florida). We consider our estimates for the number of program fruit that will be moved to habitat suitable for these pests to be conservative (high).

P6: Infested fruit in suitable habitat leads to outbreak

Unchanged

Tables 2-5 show the complete set of estimated probabilities (probability density functions) used for the revised Monte Carlo simulations. We used these revised input values to estimate probabilities of pest outbreaks for each of the four pests/pest categories. These input values and the resulting estimates for the probability/frequency of pest outbreaks reflect the risk posed by the importation of Mexican avocado fruit into the United States as described in the Draft Final Rule.

Table 2. Input data for Monte Carlo simulation: Fruit flies - *Anastrepha fraterculus, A. ludens, A. serpentina, A. striata*				
Program Alternative: — B — Systems Approach for risk mitigation: inputs based on Draft Final Rule for importation of Mexican avocado fruit				
Frequency (F_n) / Probability (P_n)		Distribution	Minimum	Maximum
B - F_1:	boxes of fruit imported per year	uniform	1,000,000	2,000,000
B - P_1:	pest infests fruit: pre- or post-harvest	uniform	5×10^{-8}	5×10^{-6}
B - P_2:	pest not detected during harvest or packing	uniform	8×10^{-5}	8×10^{-3}
B - P_3:	pest survives shipment	uniform	0.7	0.9
B - P_4:	pest not detected at port of entry inspection	uniform	0.6	0.8
B - P_5:	fruit transported to habitat suitable for pest	uniform	0.0005	0.02
B - P_6:	infested fruit in suitable habitat leads to outbreak	uniform	0.0001	0.001

Table 3. Input data for Monte Carlo simulation: Seed weevils - *Conotrachelus aguacatae, C. perseae, Heilipus lauri*				
Program Alternative: — B — Systems Approach for risk mitigation: inputs based on Draft Final Rule for importation of Mexican avocado fruit				
Frequency (F_n) / Probability (P_n)		Distribution	Minimum	Maximum
B - F_1:	boxes of fruit imported per year	uniform	1,000,000	2,000,000
B - P_1:	pest infests fruit: pre- or post-harvest	uniform	5×10^{-6}	5×10^{-5}
B - P_2:	pest not detected during harvest or packing	uniform	0.00016	0.016
B - P_3:	pest survives shipment	uniform	0.7	0.9
B - P_4:	pest not detected in port of entry inspection	uniform	0.4	0.7
B - P_5:	fruit transported to habitat suitable for pest	uniform	0.0005	0.02
B - P_6:	infested fruit in suitable habitat leads to outbreak	uniform	0.00005	0.0005

Table 4. Input data for Monte Carlo simulation: Stem weevil - *Copturus aguacatae*			
Program Alternative: — B — Systems Approach for risk mitigation: inputs based on Draft Final Rule for importation of Mexican avocado fruit			
Frequency (F_n) / Probability (P_n)	Distribution	Minimum	Maximum
B - F_1: boxes of fruit imported per year	uniform	1,000,000	2,000,000
B - P_1: pest infests fruit: pre- or post-harvest	uniform	0.001	0.01
B - P_2: pest not detected during harvest or packing	uniform	0.00016	0.016
B - P_3: pest survives shipment	uniform	0.7	0.9
B - P_4: pest not detected in port of entry inspection	uniform	0.6	0.8
B - P_5: fruit transported to habitat suitable for pest	uniform	0.0005	0.02
B - P_6: infested fruit in suitable habitat leads to outbreak	uniform	0.00005	0.0005

Table 5. Input data for Monte Carlo simulation: Seed moth - *Stenoma catenifer*			
Program Alternative: — B — Systems Approach for risk mitigation: inputs based on Draft Final Rule for importation of Mexican avocado fruit			
Frequency (F_n) / Probability (P_n)	Distribution	Minimum	Maximum
B - F_1: boxes of fruit imported per year	uniform	1,000,000	2,000,000
B - P_1: pest infests fruit: pre- or post-harvest	uniform	5×10^{-6}	5×10^{-5}
B - P_2: pest not detected during harvest or packing	uniform	0.00008	0.008
B - P_3: pest survives shipment	uniform	0.7	0.9
B - P_4: pest not detected in port of entry inspection	uniform	0.2	0.45
B - P_5: fruit transported to habitat suitable for pest	uniform	0.0005	0.02
B - P_6: infested fruit in suitable habitat leads to outbreak	uniform	0.00005	0.0005

E. Results: Re-Estimated Probability/Frequency of Pest Outbreaks

Results of the Monte Carlo simulations are shown in Table 6. Because the probability of pest outbreak was calculated 1,000 times for each Monte Carlo simulation (*i.e.*, 1,000 times for each pest/pest category), we present the results by specifying details of the output distribution. The center column of Table 6 presents details of the resulting output distributions (*i.e.*, the mode and mean of the probability distribution, and the minimum and maximum values) in terms of the frequency of pest outbreaks per year. In the far right column, we present our estimate for the number of years between pest outbreaks (calculated as the inverse of the mode of the outbreak frequency).

We consider these estimates for the frequency of pest outbreaks to be quite conservative. That is, we consider them to be very high estimates for the frequency of pest outbreaks. The results are conservative because we were triply conservative when estimating each of the input probabilities. Our input probabilities were conservative for at least three reasons:

- (Reason 1) Whenever we were in doubt about the magnitude of a probability, we intentionally made our estimates high (*i.e.*, conservative or "protectionist"). We were uncertain about all of the probabilities estimated so all were estimated conservatively.

- Because our estimates for the frequency of pest outbreaks were based on Monte Carlo simulations, we estimated our input values as probability density functions (see Supplemental Pest Risk Assessment, May 1995 for an explanation of Monte Carlo simulations and probability density functions). In the Supplemental Pest Risk Assessment, and in this addendum, we used uniform distributions for all of our input values. Uniform distributions provide very conservative outputs because of the way the sampling algorithm chooses values from the input distribution:

  (Reason 2) When using distributions with central tendency (*e.g.*, lognormal distribution), values from the "middle" of the distribution are sampled much more frequently than the less likely high values from the outlying upper tail of the distribution. Because uniform distributions attribute equal probability to any value between the minimum and maximum values, uniform distributions lead to use of high values from the upper portion of the distribution much more often than distributions with central tendency (*e.g.*, lognormal distribution). The result is that the output of the simulations (*i.e.*, estimates of the frequency of pest outbreaks) are relatively higher.

  (Reason 3) When using uniform distributions with a range greater than one order of magnitude (*i.e.*, greater than a factor of 10), values from the upper portion *(i.e.*, high probabilities) are chosen and used in the calculations much more often than values from the lower portion of the distribution. For example, one of our input distributions covered two orders of magnitude (minimum value=0.0002, maximum value=0.02). With this distribution, values between the minimum and the geometric mean (0.002) were chosen about 9% of the time and values between the geometric mean and the maximum were chosen about 91% of the time. Values between 0.01 and 0.02 (*i.e.*, the extreme upper portion of the distribution) were used for about 50% of the calculations.

Because each of the input probabilities was triply conservative, the mode (and its inverse) are conservative estimates for the likelihood of an outbreak and approach the concept of a "worst-case scenario".

Table 6. Pest Outbreak Frequency: Mexican Avocado Pest, By Program - Input Values Based on Draft Final Rule

Program Alternative	Pest	Outbreaks Frequency (per year)				Number of years between outbreaks [1]
		Mode	Mean	Minimum	Maximum	
B	Fruit flies	8.89×10^{-11}	4.85×10^{-8}	1.93×10^{-11}	5.01×10^{-7}	> million
	Seed Weevil	5.76×10^{-9}	4.01×10^{-7}	7.30×10^{-10}	4.90×10^{-6}	> million
Systems approach for risk mitigation	Stem Weevil	3.08×10^{-6}	1.03×10^{-4}	1.95×10^{-7}	9.47×10^{-4}	324,675
	Seed Moth	3.60×10^{-9}	1.19×10^{-7}	1.43×10^{-10}	1.11×10^{-6}	> million

[1] Calculated as inverse of mode.

III. Preparation, Consultation and Review

This addendum to the supplemental pest risk assessment was prepared by the Biological Assessment and Taxonomic Support (BATS) staff within Plant Protection and Quarantine (APHIS-USDA):

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