Importation of fresh yellow pitaya [*Selenicereus megalanthus* (K. Schum. ex Vaupel) Moran] into the Continental United States from Colombia

A Pathway-Initiated Risk Assessment

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Executive Summary

Colombia, South America requested to export fresh fruit of yellow pitaya [*Selenicereus megalanthus* (K. Schum. ex Vaupel) Moran] to the Continental United States. A list of yellow pitaya pests in Colombia was prepared based on documents submitted by the Colombia Agricultural Ministry, Colombia Agricultural Institute, Plant Protection Service, APHIS records of intercepted pests, the scientific literature and the opinion of experts in the field of yellow pitaya production. Pests likely to follow the yellow pitaya commodity into the United States were identified.

This pest risk assessment identified two quarantine pests in the pathway of introduction:

Anastrepha fraterculus (Wiedemann) [Diptera: Tephritidae]
Ceratitis capitata (Wiedemann) [Diptera: Tephritidae]

For each of these pests, the ratings for the Consequences of Introduction, Likelihood of Introduction and the Overall Pest Risk Potential were found to be High. The internal feeders *Anastrepha fraterculus* and *Ceratitis capitata* are unlikely to be detected during port-of-entry inspections and require pest risk mitigation measures. Colombia proposes to treat the pitayas for fruit flies pre-shipment with an approved vapor heat treatment.

Quarantine species identified as external feeders of yellow pitaya fruit from Colombia are unlikely to remain with the fruit, because two processes, a post-harvest mechanical process that removes spines from the fruit and a fungicide/bactericide dip, are highly likely to remove external pests. As long as this process is followed, surface pests are not likely to enter with the fresh pitaya fruit.

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I Introduction

This risk assessment was prepared by the Commodity Risk Assessment staff, Plant Protection and Quarantine, Animal and Plant Health Inspection Service (APHIS), United States Department of Agriculture (USDA) to examine potential pest risks associated with the importation into the continental United States of fresh yellow pitaya fruit [*Selenicereus megalanthus* (Schum. ex Vaupel) Moran] from Colombia. This pest risk assessment is called pathway-initiated because it is based on the risks that may be associated with the importation of this commodity. This risk assessment is qualitative and risk is expressed in descriptive terms (high, medium, and low) rather than in probabilities or frequencies. The methodology and rating criteria are explained in *Pathway-Initiated Pest Risk Assessments: Guidelines for Qualitative Assessments*, Version 5.02 (USDA, 2000).

International plant protection organizations such as the North American Plant Protection Organization (NAPPO) and the International Plant Protection Convention (IPPC) of the United Nations Food and Agriculture Organization (FAO) provide guidance for conducting pest risk analyses. The methods used in this plant pest risk assessment are consistent with these guidelines, are based on the Guidelines version 5.02 (USDA, 2000) and are in accordance to the Guidelines for pest risk analysis, Section 2 of the International Standards for Phytosanitary Measures (FAO, 1996). Biological and phytosanitary terms are in accordance with those in the Glossary of Phytosanitary Terms, Section 5 of the International Standards for Phytosanitary Measures (FAO, 2001). The cited guidelines describe three stages of pest risk analysis: Stage 1 (initiation), Stage 2 (risk assessment), and Stage 3 (risk management). The present document satisfies the requirements of Stages 1 and 2.

Selenicereus megalanthus (Cactaceae, tribe Cereeae, subtribe Hylocereeae) is a climbing epiphytic cactus originating in the forests of Tropical America (Mejia and Munera, 1988). Previous names for *S. megalanthus* include *Hylocereus triangularis* (L.) Britt. & Rose (Mejia and Munera, 1988), *Mediocactus megalanthus* (Schumann) (Britton and Rose, 1963), and *Cereus megalanthus* (ARS, 2001a). In Colombia it grows in a semi-wild state from sea level to 1,800 meters altitude, scrambling along walls and rocks or growing in the traditional coffee growing regions, using shade trees as supports. Weiss *et al.*, (1995) provided a complete botanical description of *S. megalanthus.*

Colombia is a major producer and exporter of yellow pitaya fruit. The visually appealing, egg-shaped, spiny fruit of *S. megalanthus* are bright yellow in color, with a thick knobby skin and white, juicy flesh surrounding numerous small, dark, edible, crunchy seeds. The fruits are covered with 1-2 cm-long spines that abscise upon ripening. Since fruits are typically harvested before full ripening, the spines are manually or mechanically removed with a brush or by rubbing with burlap bags (Becerra, 1986; OIRSA, 2000; Vidal-C. *et al.*, 1998).

In Colombia (Vidal-C. *et al.*, 1998), commercial yellow pitaya fruit are classified according to ripeness into 7 ripeness levels, using a rating scale of 0-6 (0 =least, 6=most). Yellow pitaya fruit are also graded based on caliper/weight of fruit (caliper 8 = $\geq$ 361 g; 9= 261-360 g; 12=201-260 g; 14 = 151-200 g; 16=111-150 g; 20=$\leq$110 g). The optimum size, weight and ripeness of Colombian yellow pitaya fruit for export is 8 cm long x 5 cm diameter, weighing between 200 and 250 g and having a ripeness rating of 2-4 (Becerra, 1986; Vidal-C. *et al.*, 1988).

The main use of yellow pitaya is as a fresh fruit. It is prized for its sweet, delicate, exquisite taste (Mizrahi *et al.*, 1997; OIRSA, 2000). The fruit of yellow pitaya may be used to make cocktails, soft drinks, juice, syrup, liquor, sauces and ice cream. In addition to its culinary uses, yellow pitaya fruit may be used medicinally to relieve disorders of the digestive system and heart. Seeds of *S. megalanthus* contain oil that has a laxative effect as well as a substance identified as cactina, which acts as a cardiac tonic. The skin of yellow pitaya fruit has an industrial application as a colorant and fruit may be used as an industrial source of pectin. A comprehensive overview of commercial yellow pitaya production in Colombia is presented by Becerra (1986).

II Risk Assessment

The conceptual model for this analysis is APHIS Guidelines v5.02 (USDA, 2000). In this risk assessment, the first five Risk Elements considered are combined to form an assessment of the risk associated with the Consequences of Introduction. The value for the Consequences of Introduction is interpreted by using those guidelines. Six Sub-Elements are evaluated and combined for the sixth Risk Element, as described in the guidelines, to give a value for the risk associated with the Likelihood of Introduction. Together, the Consequences of Introduction and the Likelihood of Introduction values form an evaluation of the Pest Risk Potential. These science-based evaluations of the risks associated with this importation are designed to inform decision-makers.

Pest Risk Assessment is a component of an overall pest risk analysis. The Guidelines for Pest Risk Analysis (FAO, 1996) describe three stages in pest risk analysis. This document satisfies the requirements of FAO Stages 1 (initiation) and 2 (risk assessment), by separately considering each area of inquiry.

A. Initiating Event: Proposed Action

This commodity-based, pathway-initiated assessment is in response to a request for USDA authorization to allow imports of a particular commodity presenting a potential plant pest risk. In this case, the importation into the Continental United States of fresh yellow pitaya fruit, grown in Colombia, is a potential pathway for introduction of plant pests). Title 7 of the Code of Federal Regulations 319, Part 56 (7CFR § 319.56) provides regulatory authority for the importation of fruits and vegetables from foreign sources into the United States.

This importation request was prompted by the development of a vapor heat treatment by Colombian researchers for yellow pitaya (Vidal-C. *et al.*, 1998). The vapor heat treatment T106-e (fruit core temperature of 114.8 degrees F for 20 minutes) has been approved by USDA (USDA, 2002b) to treat eggs and larvae of the tephritid fruit flies *Anastrepha fraterculus* (Wiedemann) and *Ceratitis capitata* (Wiedemann) that occur in the fruits (Vidal-C. *et al.*, 1998; Witherell, 2001). Colombia has stated that the treatment will be applied pre-shipment to all fruit exported to the United States.

B. Assessment of Weediness Potential of *Selenicereus megalanthus*

The results of the weediness screening for yellow pitaya did not prompt a weed-initiated risk assessment (Table 1).

Table 1. Assessment of Weediness Potential of *Selenicereus megalanthus*
Commodity: Scientific name and author: *Selenicereus megalanthus* (K. Schum. ex Vaupel) Moran [synonym (basionym) = *Cereus megalanthus* K. Schum. ex Vaupel] Plant family: Cactaceae Common name: yellow pitaya
Phase 1: The genus, *Selenicereus*, is not widely prevalent in the United States. One species of *Selenicereus* is native to the south tip of Texas, and two species are introduced into seven counties of Florida (Kartesz, 1998; NRCS, 2001;Wunderlin and Hansen, 2001). *Selenicereus megalanthus* is not reported to occur in the contiguous United States.
Phase 2: Is the species listed in: NO Geographical Atlas of World Weeds (Holm, *et al.,* 1979). NO World's Worst Weeds (Holm, *et al.,* 1977). NO Report of the Technical Committee to Evaluate Noxious Weeds; Exotic Weeds for the Federal Noxious Weed Act (Gunn and Ritchie, 1982). NO Economically Important Foreign Weeds (Reed, 1977). NO Composite List of Weeds (Weed Science Society of America, 1989). NO AGRICOLA, CAB, AGRIS. Other literature and database search indicating weediness: NO World weeds: natural histories and distributions (Holm, *et al.,* 1997). NO World Economic Plants (Wiersema and León, 1999). NO Noxious Weeds of Australia (Parsons and Cuthbertson, 1992). NO Florida's Invasive Species List, Florida Exotic Pest Plant Council (FLEPPC, 2001).
Phase 3: A weed-initiated risk assessment is not initiated for *S. megalanthus*, because the species is not widely prevalent in the United States and the answer to all of the above questions is no.

C. Current Status, Decision History and Pest Interceptions

Currently, yellow pitaya is not authorized entry from any country into the United States (USDA, 2002a). In 1992, the entry of *Selenicereus* sp. from Belize was denied due to the lack of an approved treatment for *Anastrepha* sp. and *Ceratitis capitata* (Wiedemann) (USDA, 1992). In 1993, two species of Pseudococcidae were intercepted on yellow pitaya in passenger baggage from Vietnam (PIN 309, 2001).

D. Pest Categorization - Identification of Pests of *Selenicereus megalanthus* in Colombia

Table 2 presents information about geographic distribution, host associations and regulatory data for yellow pitaya from Colombia and serves as a basis for selecting pests for risk assessment. The table includes: (1) the presence of pests in Colombia relative to presence in the United States, (2) the generally affected plant part or parts, (3) the quarantine status of the pest in the United States, (4) whether the pest is likely to follow the pathway into the United States on yellow pitaya, and (5) pertinent citations for either the distribution or the biology of the pest. Many organisms are eliminated from further consideration as sources of phytosanitary risk on yellow pitaya from Colombia because they do not satisfy the definition of a quarantine pest (FAO, 2001). A quarantine pest is defined 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, 2001).

Table 2: Pests of *Selenicereus megalanthus* in Colombia

Pest Scientific Name and Taxonomic Classification	Geographic Distribution[1]	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Arthropods					
Agrotis ipsilon (Hufnagel) (Lepidoptera: Noctuidae)	CO, US	Fruit, Stem	No	Yes	CAB, 2001a; CIE, 1969; Hill, 1983; Martinez, 1987
Anastrepha fraterculus (Wiedemann) (Diptera: Tephritidae)	CO	Fruit, Stem	Yes	Yes	CIE, 1958b; Martinez, 1987; PNKTO, 1982; Velez, 1997; Vergara and Perez, 1988a; Vidal-C. *et al*., 1998; White and Elson-Harris, 1992
***Anastrepha* sp.** (Diptera: Tephritidae)	CO	Fruit	Yes	Yes	Arnett, 1997; Becerra, 1986; Vergara and Perez, 1988a; White and Elson-Harris, 1992
Atta cephalotes (Linnaeus) (Hymenoptera: Formicidae)	CO	Flower, Fruit, Stem	Yes	No	CIE, 1982; Lopez and Ramírez, 1998b; Mackay and Mackay, 1986; Martinez, 1987; Medina *et al*., 1990; Vergara and Perez, 1988a
Atta cephalotes isthmicola Weber (Hymenoptera: Formicidae)	CO	Fruit, Stem	Yes	No	Vergara and Perez, 1988a

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Atta colombica Guerin (Hymenoptera: Formicidae)	CO	Fruit, Stem	Yes	No	Mackay and Mackay, 1986; Vergara and Perez, 1988a
Atta laevigata (Smith) (Hymenoptera: Formicidae)	CO	Fruit, Stem	Yes	No	Mackay and Mackay, 1986; Vergara and Perez, 1988a
Atta sexdens (Linnaeus) (Hymenoptera: Formicidae)	CO	Fruit, Stem	Yes	No	INKTO, 1957; Mackay and Mackay, 1986; Vergara and Perez, 1988a
***Brevipalpus* sp.** (Acarina: Tenuipalpidae)	CO	Fruit	Yes	No	CAB, 2001a; Lozano, 1998; Vergara and Perez, 1988b
Ceratitis capitata (Wiedemann) (Diptera: Tephritidae)	CO	Fruit	Yes	Yes	CIE, 1988; Mejia and Munera, 1988; Velez, 1997; Vidal-C. *et al.*, 1998; White and Elson-Harris, 1992
Cyclocephala ruficollis Burmeister (Coleoptera: Scarabeidae)	CO	Flower	Yes	No	CAB, 2001a; Vergara and Perez, 1988a
Cyclocephala signata (Fabricius) (Coleoptera: Scarabeidae)	CO	Flower	Yes	No	CAB, 2001a; Vergara and Perez, 1988a
Cyrtomenus bergi Froeschner (Hemiptera: Cydnidae)	CO	Root	Yes	No	CAB, 2001a; Mejia and Munera, 1988
Dasiops inedulis Steyskal (Diptera: Lonchaeidae)	CO	Flower	Yes	No	CAB, 2001a; Vergara and Perez, 1988a
Dasiops saltans Townsend (Diptera: Lonchaeidae)	CO	Flower	Yes	No	Infante, 1990; Lopez and Ramirez, 1998a; Lopez and Ramirez, 1998b; Lozano, 1998; Medina, *et al.*, 1990
***Dasiops* sp.** (Diptera: Lonchaeidae)	CO	Flower	Yes	No	Arnett, 1997; Lopez and Ramirez, 1998a; Lopez and Ramirez, 1998b

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Diabrotica fuscomaculata Jacoby (Coleoptera: Chrysomelidae)	CO	Stem	Yes	No	Martinez, 1987; Wilcox, 1975
***Diabrotica* sp.** (Coleoptera: Chrysomelidae)	CO	Stem	Yes	No	Castano, 1988; Vergara and Perez, 1988a
Diatraea saccharalis (Fabricius) (Lepidoptera: Pyralidae)	CO, US	Stem	No	No	CAB, 2001a; CIE, 1989; Martinez, 1987
***Draeculacephala* sp.** (Homoptera: Cicadellidae)	CO	Stem	Yes	No	CAB, 2001a; Vergara and Perez, 1988a
Drosophila melanogaster Meigen (Diptera: Drosophilidae)	CO, US	Fruit	No	Yes	Arnett, 2000; CAB, 2001; Martinez, 1987; Vergara and Perez 1988a
***Dysdercus* sp.** (Hemiptera: Pyrrhocoridae)	CO	Stem	Yes	No	Henry and Froeschner, 1988; Mejia and Munera, 1988; Vergara and Perez, 1988a
***Epitrix* sp.** (Coleoptera: Chrysomelidae)	CO	Stem	Yes	No	USDA, 1948; Vergara and Perez, 1988a; Wilcox, 1975
Estigmene acrea Drury (Lepidoptera: Arctiidae)	CO, US	Stem	No	No	Metcalf *et al.*, 1962; Vergara and Perez, 1988a
Gymnetis pantherina (Blanchard) (Coleoptera: Scarabeidae)	CO	Fruit, Stem	Yes	No	Arnett, 1983; Infante, 1990; Lopez and Ramirez, 1998b; Medina *et al.*, 1990; Vergara and Perez, 1988a
***Gymnetis* sp.** (Coleoptera: Scarabeidae)	CO	Fruit, Stem	Yes	No	Arnett, 1983; Arnett, 1997; Lopez and Ramirez, 1998b; Medina *et al.*, 1990; Vergara and Perez, 1988a
Gymnetis stellata Latreille (Coleoptera: Scarabeidae)	CO	Fruit, Stem	Yes	No	Arnett, 1983; Lopez and Ramirez, 1998b; Medina *et al.*, 1990

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Gynandrobrotica beata Baly (Coleoptera: Chrysomelidae)	CO	Stem	Yes	No	Constantino, 2000; Vergara and Perez, 1988a; Wilcox, 1975
Halysidota **sp.** (Lepidoptera: Arctiidae)	CO	Stem	Yes	No	Vergara and Perez, 1988a; Zhang, 1994
Hortensia **sp.** (Homoptera: Cicadellidae)	CO	Stem	Yes	No	CAB, 2001a; Vergara and Perez, 1988a
Leptoglossus **sp.** (Hemiptera: Lygaeidae)	CO	Flower, Fruit	Yes	No	Vergara and Perez 1988a
Leptoglossus stigma (Herbst) (Hemiptera: Lygaeidae)	CO	Fruit	Yes	No	Baranowski and Slater, 1986; CAB, 2001a; Lopez and Ramirez, 1998b; Medina *et al.*, 1990
Leptoglossus zonatus (Dallas) (Hemiptera: Lygaeidae)	CO, US	Flower, Fruit	No	No	Baranowski and Slater, 1986; CAB, 2001a; Henry and Froeschner, 1988; Lopez and Ramirez, 1998b; Lozano, 1998; Medina *et al.*, 1990
Lonchaea **sp.** (Diptera: Lonchaeidae)	CO	Flower	Yes	No	Arnett, 1997; Lopez and Ramirez, 1998b; Lozano, 1998; Vergara and Perez, 1988a
Megalopyge lanata (Stoll) (Lepidoptera: Megalopygidae)	CO	Fruit, Stem	Yes	No	CAB, 2001a; Martinez, 1987; Zhang, 1994
Musca domestica Linnaeus (Diptera: Muscidae)	CO, US	Fruit	No	Yes	Martinez, 1987; Sanchez-Arroyo, 1998; Vergara and Perez, 1988a
Parapilocrosis **sp.** (Lepidoptera: Pyralidae)	CO	Stem	Yes	No	Zenner, 1990
Pieris **sp.** (Lepidoptera: Pieridae)	CO	Stem	Yes	No	Arnett, 1997; Martinez, 1987

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Pseudococcidae sp. (Homoptera)	CO, VN	Fruit	Yes	No	PIN 309, 2001; Williams and Granara deWillink, 1992
***Spodoptera* sp.** (Lepidoptera: Noctuidae)	CO	Stem	Yes	No	Vergara and Perez, 1988a
***Stenoma* sp.** (Lepidoptera: Stenomidae)	CO	Fruit	Yes	Yes	Vergara and Perez, 1988a
***Systena* sp.** (Coleoptera: Crysomelidae)	CO	Stem	Yes	No	Castano, 1988; Vergara and Perez, 1988a; Wilcox, 1975
***Tetranychus* sp.** (Acarina: Tetranychidae)	CO	Fruit	Yes	No	Jeppson *et al.*, 1975; Vergara and Perez, 1988b
Trachyderes interrupta Dupont (Coleoptera: Cerambycidae)	CO	Stem	Yes	No	Chemsack and Linsley, 1982; Infante, 1990; Martinez, 1987; Mejia and Munera, 1988; Vergara and Perez, 1988a
Trachyderes succinta (Linnaeus) (Coleoptera: Cerambycidae)	CO	Stem	Yes	No	CAB, 2001a; Chemsak and Linsley, 1982; Vergara and Perez, 1988a
Trigona clavipes Fabricius (Hymenoptera: Apidae)	CO	Fruit, Stem	Yes	No	Vergara and Perez, 1988a
Trigona pellucida Cockerell (Hymenoptera: Apidae)	CO	Fruit, Stem	Yes	No	Vergara and Perez, 1988a
***Trigona* sp.** (Hymenoptera: Apidae)	CO	Fruit, Stem	Yes	No	Infante, 1990; Lopez and Ramirez, 1998b; Medina *et al.*, 1990; Mejia and Munera, 1988
Mollusks					
***Limnaea* sp.** (Mollusca: Limacidae)	CO	Fruit, Stem	Yes	No	Burch, 1960; Vergara and Perez, 1988b
Milax gagates (Draparnaud) (Mollusca: Milacidae)	CO, US	Fruit, Stem	No	Yes	Berg, 1994; Godan, 1983; Mejia and Munera, 1988

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Pest Scientific Name and Taxonomic Classification	**Geographic Distribution[1]**	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
***Milax* sp.** (Mollusca: Milacidae)	CO	Fruit, Stem	Yes	No	Berg, 1994; Vergara and Perez, 1988b
Fungi[2]					
***Alternaria* sp.** (Anamorphic fungi)	CO	Fruit, Stem	Yes	Yes	Castano and Salazar, 1986; Lopez and Ramirez, 1998b; Mejia and Munera, 1988
Bipolaris cactivora (Petr.) Alcorn. (Anamorphic fungi) =*Drechslera cactivora* (Petr.) M.B.Ellis =*Helminthosporium cactivorum* Petr.	CO, US	Fruit, Root, Stem	No	Yes	Alfieri *et al.*, 1994; Buritica, 1999; Farr *et al.*, 1989; Holmes Varela *et al.*, 1995; Lopez and Ramirez, 1998b
***Botryodiplodia* sp.** (Anamorphic fungi)	CO	Stem	Yes	No	Mejia and Munera, 1988; Vidal and Nieto, 1989
***Cephalosporium* sp.** (Anamorphic fungi)	CO	Fruit, Stem	Yes	Yes	Bibliowicz and Hernandez, 1998
***Colletotrichum* sp.** (Anamorphic fungi)	CO	Fruit, Stem	Yes	Yes	Becerra, 1986; Castano and Salazar, 1986; Infante, 1990; Lopez and Ramirez, 1998b; Lozano, 1998; Mejia and Munera, 1988
***Curvularia* sp.** (Anamorphic fungi)	CO	Stem	Yes	No	Castano and Salazar, 1986
***Diplodia* sp.** (Anamorphic fungi)	CO	Stem	Yes	No	Mejia and Munera, 1988
Fusarium avenaceum (Fr.:Fr.) Sacc. (Anamorphic fungi) =*F. anguioides* Sherb. =*Fusisporium avenaceum* Fr.:Fr. teleomorph=*Gibberella avenacea* R.J. Cook	CO, US	Stem	No	No	Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989; USDA, 1960

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Pest Scientific Name and Taxonomic Classification	**Geographic Distribution[1]**	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Fusarium chlamydosporum Wolleneb. & Reinking (Anamorphic fungi) =*Dactylium fusarioides* Gonz. Frag. & Cif. =*F. fusarioides* (Gonz. Frag. & Cif.) C. Booth =*F. sporotrichioides* var. *chlamydosporum* (Wollenweb. & Reinking) Joffe	CO, US	Fruit, Stem	No	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989
Fusarium equiseti (Corda) Sacc. (Anamorphic fungi) =*F. equiseti* var. *bullatum* (Wollenweb.) Wollenweb =*F. scirpi* Lambotte & Fautrey =*F. scirpi* var. *compactum* Wollenweb. teleomorph=*Gibberella intricans* Wollenweb.	CO, US	Fruit, Stem	No	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989
Fusarium heterosporum Nees:Fr (Anamorphic fungi). =*F. graminum* Corda, *pro parte* =*F. negundi* Sherb. =*F. reticulatum* var. *negundi* (Sherb.) Wollenweb. teleomorph=*Gibberella gordonia*	CO, US	Stem	No	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989
Fusarium moniliforme J. Sheld. (Anamorphic fungi) teleomorph=*Giberella fujikuroi* (Sawada) Ito in Ito & K. Kimura	CO, US	Flower, Fruit Stem	No	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989

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Fusarium oxysporum Schlechtend.:Fr. (Anamorphic fungi) =*F. angustum* Sherb. =*F. aurantiacum* (Link) Sacc. =*F. oxysporum* var. *aurantiacum* (Link) Wollenweb.	CO, US	Flower, Fruit, Stem	No	Yes	Bibliowicz and Hernandez, 1998; Farr, 1989
Fusarium redolens Wollenweb. (Anamorphic fungi) = *Dothidella alni* Peck =*F. oxysporum* var. *redolens* W.L. Gordon =*Platychora alni* (Peck) Petr.	CO, US	Flower, Fruit, Stem	No	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989; USDA, 1960
Fusarium roseum Link:Fr. (Anamorphic fungi) =*Gibberella zeae*	CO, US	Stem	No	No	Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989
Fusarium solani (Mart.) Sacc. (Anamorphic fungi) =*Fusarium lathyri* Taubenhaus teleomorph=*Nectria haematococca Berk. & Broome*	CO, US	Stem	No	No	Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989
***Fusarium* sp.** (Anamorphic fungi)	CO	Fruit, Stem	Yes	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Buritica, 1999; Infante, 1990; Lopez and Ramirez, 1998b; Lozano, 1998; Mejia and Munera, 1988; Vidal and Nieto, 1989
***Gliocladium* sp.** (Anamorphic fungi)	CO	Fruit	Yes	Yes	Bibliowicz and Hernandez, 1998

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***Hendersonia* sp.** (Anamorphic fungi)	CO	Fruit	Yes	Yes	Castano and Salazar, 1986
***Nigrospora* sp.** (Anamorphic fungi)	CO	Fruit, Stem	Yes	Yes	Bibliowicz and Hernandez, 1998; Mejia and Munera, 1988
Sphaeropsis lappae *Ellis & Everh.* (Anamorphic fungi) =*Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk =*Physalospora anthurii* R. Fischer =*P. cattleyae* Maubl. & Lasnier anamorph=*Colletotrichum gloesporioides* (Penz.) Penz. & Sacc. In Penz.	CO, US	Stem	No	No	Alfieri *et al.*, 1994; Buritica, 1999; Farr *et al.*, 1989; Infante, 1990
Selenophoma boltoniae (Dearn. *& Barth.)* Sivanesan (Anamorphic fungi) =*Botryodiplodia gossypii* Ellis & Barth. =*B. theobromae* Pat. =*Diplodia theobromae* (Pat.) W. Nowell =*Lasiodiplodia theobromae* (Pat.) Griffon & Maubl. =*Macrophoma boltoniae* Dearn. & Barth. synanamorph=*Phoma boltoniae* Dearn. & Barth.	CO, US	Fruit, Stem	No	Yes	Alfieri *et al.*, 1994; Buritica, 1999; Castaño *et al.*, 1991; Farr *et al.*, 1989

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Pest Scientific Name and Taxonomic Classification	**Geographic Distribution[1]**	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Sclerotinia minor Jagger (Ascomycetes: Helotiales) =*S. intermedia* Ramsey =*S. sativa* Drayton & Groves	CO, US	Fruit, Stem	No	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989
Sclerotinia sclerotiorum (Lib.) de Bary (Ascomycetes: Helotiales) =*S. libertiana* Fuckel =*Whetzelinia sclerotiorum* (Lib. Korf & Dumont anamorph=*Sclerotium varium* Pers.:Fr.	CO, US	Fruit	No	Yes	Alfieri *et al.*, 1994; Bibliowicz and Hernandez, 1998; Farr *et al.*, 1989
***Sclerotinia* sp.** (Ascomycetes: Helotiales)	CO	Fruit, Stem	Yes	Yes	Bibliowicz and Hernandez, 1998
Bacteria[3]					
***Erwinia* sp.** (Enterobacteraeae)	CO	Fruit, Stem	Yes	Yes	Alfieri *et al.*, 1994; Buritica, 1999; Castano and Salazar, 1986; Infante, 1990; Lozano, 1998
Nematodes[4]					
***Aphelenchoides* sp.** (Aphelenchoididae)	CO	Root, Stem	Yes	No	Castano and Salazar, 1986; Evans *et al.*, 1993; Lopez and Ramirez, 1998b
***Criconemoides* sp.** (Criconematidae)	CO	Root	Yes	No	Castaño and Salazar, 1986; Evans *et al.*, 1993
***Dorylaimus* sp.** (Dorylamidae)	CO	Root	Yes	No	Castaño and Salazar, 1986; Thorne, 1961
***Helicotylenchus* sp.** (Hoplolaimidae)	CO	Root	Yes	No	Buritica, 1999; Castano and Salazar, 1986; Castaño *et al.*, 1991; Evans *et al.*, 1993; Lopez and Ramirez, 1998b
Helicotylenchus dihystera (Cobb) Sher (Hoplolaimidae)	CO, US	Root	No	No	Buritica, 1999; Castaño *et al.*, 1991; Evans *et al.*, 1993

Table 2: Pests of *Selenicereus megalanthus* in Colombia					
Pest Scientific Name and Taxonomic Classification	**Geographic Distribution[1]**	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
***Hemicycliophora* sp.** (Criconematidae)	CO	Root	Yes	No	Buritica, 1999; Castaño *et al.*, 1991; Evans *et al.*, 1993
***Hoplotylus* sp.** (Hoplolaimidae)	CO	Root	Yes	No	Buritica, 1999; Castaño *et al.*, 1991; NGDC, 1984
***Longidorus* sp.** (Longidoridae)	CO	Root	Yes	No	Castaño and Salazar, 1986; Evans *et al.*, 1993
***Meloidogyne* sp.** (Meloidogynidae)	CO	Root	Yes	No	Buritica, 1999; Castaño and Salazar, 1986; Castaño *et al.*, 1991; Evans *et al.*, 1993; Infante, 1990; Lopez and Ramirez 1998b; Lozano, 1998; Mejia and Munera, 1988; Vidal and Nieto, 1989
Meloidogyne incognita (Kofoid & White) Chitwood (Meloidogynidae)	CO, US	Root	No	No	Buritica, 1999; CAB, 2001a; Palacino, 1990
***Meloidogyne incognita* Race 2** (Kofoid & White) Chitwood (Meloidogynidae)	CO, US	Root	No	No	CAB, 2001a; Castaño *et al.*, 1991
***Pratylenchus* sp.** (Pratylenchidae)	CO	Root	Yes	No	CAB, 2001a; Castano and Salazar, 1986; Evans *et al.*, 1993; Lopez and Ramirez, 1998b
***Trichodorus* sp.** (Trichodoridae)	CO	Root	Yes	No	Buritica, 1999; Castaño *et al.*, 1991; Evans *et al.*, 1993
Tylenchorhyncus martini (Fielding) (Belonolaimidae) =*T. annulatus* (Cassidy) Golden	CO, US	Root	No	No	Buritica, 1999; CAB, 2001a; Castaño *et al.*, 1991; NGDC, 1984

Table 2: Pests of *Selenicereus megalanthus* in Colombia					
Pest Scientific Name and Taxonomic Classification	**Geographic Distribution[1]**	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
***Tylenchorhynchus* sp.** (Belonolaimidae)	CO	Root	Yes	No	Buritica, 1999; Castaño *et al.*, 1991; Evans *et al.*, 1993
***Tylenchus* sp.** (Anguinidae)	CO	Root	Yes	No	Castaño and Salazar, 1986; Evans *et al.*, 1993
***Xiphinema* sp.** (Longidoridae)	CO	Root	Yes	No	Castano and Salazar, 1986

[1] Geographic Distribution: CO = Colombia; US = United States; VN = Vietnam.
[2] Fungal Nomenclature as in ARS, 2001b; Fungal Taxonomic Classification as in CAB, 2001b.
[3] Bacterial nomenclature and taxonomy as in Euzéby, 2002.
[4] Nematode nomenclature and taxonomy as in CAB, 2001a.

E. Quarantine Pests Likely to Follow the Pathway

Quarantine pests that would reasonably be expected to follow the pathway, *i.e.*, be included in commercial shipments of yellow pitaya fruit (Table 3), are analyzed in detail in this risk assessment [Steps 5-7 (USDA, 2000)].

Table 3. Quarantine Pests Likely to Follow the Pathway and Selected for Further Analysis	
Anastrepha fraterculus	(Wiedemann) (Diptera: Tephritidae) South American fruit fly
Ceratitis capitata	(Wiedemann) (Diptera: Tephritidae) Mediterranean fruit fly, Medfly

Other plant pests in this assessment, not chosen for further scrutiny, may be potentially detrimental to the agricultural production systems of the United States; however, there were a variety of reasons for not subjecting them to further analysis.

First, the pest's primary association is with plant parts other than the yellow pitaya fruit. This is the case for the arthropods: *Cyclocephala ruficollis*, *C. signata*, *Cyrtomenus bergi*, *Dasiops inedulus*, *D. saltans*, *Dasiops* sp., *Diabrotica fuscomaculata*, *Diabrotica* sp., *Draeculacephala* sp., *Dysdercus* sp., *Epitrix* sp., *Gynandrobrotica beata*, *Halysidota* sp., *Hortensia* sp., *Lonchaea* sp., *Parapilocrosis* sp., *Pieris* sp., *Spodoptera* sp., *Systena* sp., *Trachyderes interrupta, and T. succinta.* This also applies to the fungi: *Botryodiplodia* sp., *Curvularia* sp., and *Diplodia* sp. Similarly, the following nematodes do not affect pitaya fruit: *Aphelenchoides* sp., *Criconemoides* sp., *Dorylaimus* sp., *Helicotylenchus* sp., *Hemicycliophora* sp., *Hoplotylus* sp., *Longidorus* sp., *Meloidogyne* sp., *Pratylenchus* sp., *Trichodorus* sp., *Tylenchorhynchus* sp., *Tylenchus* sp. and *Xiphinema* sp. Should any of these pests be intercepted in shipments of yellow pitaya fruit, quarantine action may be taken and additional risk analyses may be conducted.

Second, the pests are associated with the yellow pitaya fruit, but it is not considered reasonable to expect these pests to remain with the fruit in a viable form during harvesting, culling, selection, grading, post-harvest treatment, packaging and shipping procedures. The yellow pitaya produced in Colombia have spiny fruit. After harvest, the spines are manually or mechanically removed with a brush or by rubbing with burlap bags, by workers wearing protective leather gloves. Following spine removal, the fruit are immersed in a fungicide/bactericide solution [Mertect (thiabendazole) 3.5 g/l; Tinsen (quaternary ammonium) 5.0 g/l] to reduce pathogen infestation and/or prevent pathogen infection (Vidal-C. *et al.*, 1998). It is very unlikely that external feeders that may be on the fruit during the harvest, even if they are of quarantine significance, will remain with the fruit after this manipulation. The external feeders which are very unlikely to remain with the fruit and are removed from the pathway are: *Atta cephalotes*, *Atta cephalotes isthmicola*, *Atta colombica*, *Atta laevigata*, *Atta sexdens*, *Brevipalpus* sp., *Gymnetis pantherina*, *Gymnetis* sp., *Gymnetis stellata, Leptoglossus* sp., *Leptoglossus stigma*, *Limnaea* sp., *Megalopyge lanata, Milax* sp., Pseudococcidae sp., *Tetranychus* sp., *Trigona clavipes*, *Trigona pellucida* and *Trigona* sp.

Third, organisms identified only to the genus or higher taxonomic level are not analyzed further, even though individual species within those taxonomic groups are potential pests that may or may not occur within the United States. The IPPC guidelines do not require risk assessment of pests identified only by genus name (FAO, 1996). By necessity, pest risk assessments focus on those organisms for which adequate biological and taxonomic information is available. Often there are many species within a genus, and it is not reasonable to assume that the biology of all organisms within a genus is identical. Lack of species identification may indicate the limits of the current taxonomic knowledge or the life stage or the quality of the specimen submitted for identification. The lack of identification at the specific level does not rule out the possibility that either a high-risk quarantine pest was intercepted or that the intercepted pest was not a quarantine pest. By developing detailed assessments for known pests that inhabit a variety of niches on the parent commodity, *e.g.*, on the surface of or within the stem or fruit, on the flowers, *etc.*, effective mitigation measures may be developed to eliminate the known pests and any similar unknown ones that inhabit the same niches.

Pests of yellow pitaya likely to follow the pathway, but reported only at the genus or higher taxonomic levels, are included in Table 2 but are not further analyzed in this risk assessment. This applies to the following fungi: *Alternaria* sp., *Cephalosporium* sp., *Colletotrichum* sp., *Fusarium* sp., *Gliocladium* sp., *Hendersonia* sp., *Nigrospora* sp. and *Sclerotinia* sp.; and the bacterium *Erwinia* sp. Lack of biological information on any given insect or pathogen should not be equated with low risk. If these or other pests identified only to higher taxa are intercepted on yellow pitaya fruit, then reevaluation of their risk may occur.

The arthropods and mollusks named above deserve further note. Although they are listed in the pathway on the pest list, it is unlikely that they will remain on the fruit surface and in the pathway as long as the mechanical spine removal and post-harvest dip procedures take place. Although it has not been confirmed, it is likely that the vapor heat treatment may have a mitigating effect on surface pests.

The internal arthropod pests, *Anastrepha* sp. and *Stenoma* sp., identified only to the genus level, are dropped from the analysis, but deserve special mention. *Anastrepha* sp. could include *A. fraterculus*. Because the various *Anastrepha* spp. would have similar life histories in yellow pitaya (White and Elson-Harris, 1992), the analysis and mitigation of *A. fraterculus* is considered to take into account other *Anastrepha* sp. Species of *Stenoma* are monophagous or oligophagous (Zhang, 1994). It is unlikely that the *Stenoma* sp. reported to occur in fruit of yellow pitaya (Vergara and Perez, 1988a), would be the same species that attacks avocado, *S. catenifer* Walsingham. Although it has not been confirmed, it is likely that the vapor heat treatment may have a mitigating effect on *Stenoma* sp.

Lastly, Plant Protection and Quarantine Officers may intercept pests that are biological contaminants of the yellow pitaya fruit during port of entry inspection; however, these contaminants are not expected to be present with every shipment.

Lack of biological information on any given insect or pathogen should not be equated with low risk. If these or other pests identified only to higher taxa are intercepted on yellow pitaya fruit, then reevaluation of their risk may occur.

F. Consequences of Introduction

For each of the quarantine pests listed in Table 3, the potential consequences of introduction are rated using five Risk Elements: Climate-Host Interaction, Host Range, Dispersal Potential, Economic Impact and Environmental Impact. For each Risk Element, pests are assigned a rating of Low (1 point), Medium (2 points) or High (3 points). A Cumulative Risk Rating is then calculated by summing all Risk Element values. The values determined for the Consequences of Introduction for each pest are summarized in Table 4.

Anastrepha fraterculus (Wiedemann)

Risk Element #1: Climate - Host Interaction
The *A. fraterculus* species complex is reported to have widespread distribution in Central and South America as well as restricted distribution in Mexico (CAB, 2001a; Weems, 1980). Appendix Table 1 lists the numerous reported hosts of the complex. Every region of the United States contains at least one or more introduced, cultivated or native plant species that are in the same genera as reported *A. fraterculus* hosts (NRCS, 2001; Kartesz, 1998). Climatic conditions necessary for the establishment of *A. fraterculus* are similar to those required for *A. ludens* (Sequeira *et al.*, 2001), with suitable climates occurring in southern Arizona, California, Louisiana, Mississippi, Alabama, Georgia, South Carolina and most of Florida and Texas. The plant hardiness zones (ARS, 1990) for this region of the United States are 7b – 11. The risk rating for Climate-Host interaction is High (3).

Risk Element #2: Host Range
Anastrepha fraterculus species complex is highly polyphagous on fleshy-fruited plants in South America (White and Elson-Harris, 1992). Hosts of *A. fraterculus* include at least thirty-three plant families and more than fifty-eight genera [(*see* Appendix Table 1) CAB, 2001a; White and Elson-Harris, 1992]. The risk rating for Host Range is High (3).

Risk Element #3: Dispersal Potential
Anastrepha spp. adults may disperse long distances rapidly by flight in search of hosts (Sequeira *et al.*, 2001; White and Elson-Harris, 1992). For example, *A. ludens* adults have been trapped in Texas 135 km from the closest known breeding site (Fletcher, 1989b). In international trade, the major means of dispersal to previously uninfested areas is the transport of fruit containing live larvae (OEEP/EPPO, 1981). The risk rating for Dispersal Potential is High (3).

Risk Element #4: Economic Impact
Anastrepha sp. can cause tremendous losses in the locations where its hosts are infested (Norrbom and Foote, 1989). Because of its economic significance, *A. fraterculus* is considered a major fruit fly pest (Foote *et al.,* 1993). This pest lowers yield because the feeding of larvae on internal fruit tissues causes breakdown and premature drop of the fruit (PNKTO, 1982). Crop production costs are increased because chemical and biological controls programs must be initiated to control adult flies (Becerra, 1986; Fletcher, 1989a; OEEP/EPPO, 1981; White and Elson-Harris, 1992). *Anastrepha* sp. also lowers the value of the commodity when larvae render the fruit completely unmarketable (PNKTO, 1982; Sequeira *et al.*, 2001). The risk rating for Economic Impact is High (3).

Risk Element #5: Environmental Impact
The potential effect of the proposed action on the environment and USFWS Threatened and Endangered (T & E or listed) plant and animal species is the combination of the threat the possible hazard poses and the possible risk of the hazard occurring. In this case, the proposed action is the importation of fresh yellow pitaya fruit from Colombia, and the possible hazard is the introduction, establishment and possible eradication of *A. fraterculus* that enters with the fruit, including both direct and indirect effects. The pest may directly affect individual native host plants or plant populations including listed plant species. Additionally, *A. fraterculus* may indirectly, via habitat and food source degradation, affect wildlife, including listed animal species.

Ports of entry in Arizona, California, Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, and Florida (Sequeira *et al.*, 2001) may provide pest opportunity and commercial/backyard fruit production areas may act as pest reservoirs for infestation of adjacent native hosts of *A. fraterculus.* Infestation of fleshy-fruited native plant species, such as pomaceous and drupaceous species of Rosaceae (e.g., *Crataegus, Mespilus, Prunus, Sorbus*), *Diospyros* (Ebenaceae) and *Juglans* (Juglandaceae), could cause direct and indirect negative impacts to host plant populations, community diversity and wildlife at a regional level, due to loss of habitat and food sources for wildlife and seed set for plant reproduction (Martin *et al.,* 1951; ARS, 2001a; Harlow *et al.*, 1996). Other notable potential hosts of *A. fraterculus* are rare plant species. In Florida, for example, populations of the state-listed rare plant species *Prunus myrtifolia* occur only in Dade County (Wunderlin and Hansen, 2001) where a port of entry and commercial host groves exist. In addition, the United States Fish and Wildlife Service (USFWS) Endangered Florida plant species, *Prunus geniculata* (Rosaceae), is a potential host of *A. fraterculus* (ARS, 2001a; USFWS, 2002b). It is native to two areas in central Florida, one of which has been converted almost entirely to citrus groves (USFWS, 2001). Agricultural landscapes in Florida as well as coastal and valley areas in California are prime habitats for historic and continued exotic fruit fly establishment. These regions are adjacent to closely monitored rare and native plant communities that, to date, have not been reported to be infested by exotic fruit flies (Martin, 2002; NatureServe, 2001; USFWS, 2001; Weekley, 2002; Weekley *et. al.,* 1999; Wunderlin and Hansen, 2001).

A potential indirect environmental effect of the introduction and establishment of exotic fruit flies is the continuance and possible increase in exotic fruit fly control programs. Introduction of *A. fraterculus* would stimulate chemical or biological control programs and affected states and APHIS would jointly launch an eradication program to prevent widespread damage similar to that estimated for controlling *A. ludens* (Erikson *et al.,* 2000). Detailed information regarding the affected environment, the environmental consequences of the introduction of exotic fruit flies, including *A. fraterculus,* and the proposed eradication program, is presented in the Fruit Fly Cooperative Control Program, Final Environmental Impact Statement (FEIS) – 2001 (USDA, 2001). The FEIS identifies the direct, indirect and cumulative effects of no action (introduction of the fruit fly without federal suppression), as well as the various management activities that would be employed for outbreaks of invasive alien fruit fly pests (USDA, 2001). The geographic area most at risk for future eradication programs falls within the boundaries of seven ecoregions. These ecoregions are the California Central Valley and Coast, Southwestern Basin and Range of Arizona and California, Lower Rio Grande Valley of Texas, Southeastern and Gulf Coastal Plain of Alabama, Florida, Georgia, Mississippi, South Carolina, and Texas, Mississippi Delta of Louisiana and Mississippi, Floridian, and the Marine Pacific Forest.

For the Fruit Fly Cooperative Control Program, the 'action area' for threatened and endangered species could possibly include all federally listed species for the entire United States, because all 50 States are subject to fruit fly infestations from one or more species (USDA, 2001). Listed species that may most likely be affected by *A. fraterculus* establishment and management are in the seven ecoregions listed above (USDA, 2001). During the last several years, APHIS has been consulting with USFWS and National Marine Fisheries Service (NMFS) regarding the States which are at the highest risk of fruit fly infestations: California, Florida, Texas and Washington. In consultation with USFWS and NMFS, APHIS is identifying which control methods may be safely used within the range and habitats of the endangered and threatened species. According to the Program FEIS, as fruit fly infestations are detected in other States, individual site-specific consultations with USFWS will continue to take place to ensure protection of the species (USDA, 2001). The risk rating for Environmental Impact is High (3).

***Ceratitis capitata* (Wiedemann)**

Risk Element #1: Climate - Host Interaction
Ceratitis capitata originates from Africa and has spread throughout the Mediterranean region, southern Europe, the Middle East, western Australia, South and Central America, and Hawaii and attacks fleshy-fruited species (White and Elson-Harris, 1992; USDA-PPQ, 1993). Hawaii remains infested with this pest and there have been more than twenty infestations in Florida, California, and Texas (one infestation) (CDFA, 2000). *Ceratitis capitata* possesses an ability to tolerate cooler climates better than most other species of fruit flies (Mau and Martin Kessing, 2002) but generally does not survive sub-zero winter temperatures (Fletcher, 1989a; Hendrichs, *et al.*, 1983). The numerous hosts reported for *C. capitata* are listed in Appendix Table 1 (Fasulo, 2001; Liquido *et al.,*

1991; White and Elson-Harris, 1992). Every region of the United States contains at least one or more introduced, cultivated or native plant species that are in the same genera as reported *C. capitata* hosts (NRCS, 2001; Kartesz, 1998). The intersection of hosts and climatic conditions necessary for the establishment of *C. capitata* in the United States exists in eight southern states from Georgia to California (Vo and Miller, 1993), which corresponds to plant hardiness zones 8b – 11 (ARS, 1990). The risk rating for Climate-Host interaction is High (3).

Risk Element #2: Host Range
Ceratitis capitata is a highly polyphagous species and its pattern of host relationships from region to region appears to relate largely to what fruits are available (White and Elson-Harris, 1992; USDA-PPQ, 1993). Hosts reported for *C. capitata* include at least thirty families and fifty-one genera [(*see* Appendix Table 1) Fasulo, 2001; Liquido *et al.,* 1991; White and Elson-Harris, 1992]. The risk rating for Host Range is High (3).

Risk Element #3: Dispersal Potential
There is evidence that adults of *C. capitata* can fly as far as 20 mi (Christenson and Foote, 1960; Steiner *et al.*, 1962), indicating that natural movement is an important means of spread for this fruit fly. In addition to adult flight, the transportation of infested fruit is another major means of movement and dispersal of this pest to uninfested areas (OEPP/EPPO, 1983). The risk rating for Dispersal Potential is High (3).

Risk Element #4: Economic Impact
This insect affects the standing crop and costs would be incurred to minimize its impact on crop production (Velez, 1997). The presence of larvae in fruit may make the fruit completely unmarketable resulting in the loss of international and interstate markets (Andrew et al., 1977). Introduction of *C. capitata* would stimulate chemical or biological control programs. Due to the wide host range, establishment of *C. capitata* is estimated to result in as much as a $10 million eradication program (Vo and Miller, 1993). The risk rating for Economic Impact is High (3).

Risk Element #5: Environmental Impact
The potential effect of the proposed action, the importation of fresh yellow pitaya fruit from Colombia, on the environment and threatened and endangered (listed) plant and animal species, is the combination of the threat posed by the potential introduction, establishment and possible eradication of *Ceratitis capitata* and the possible risk of these events occurring. *Ceratitis capitata* attacks a very wide range of unrelated fruit crops including many deciduous and subtropical fruit trees (Fletcher, 1989a; Hendrichs *et al.*, 1983; Metcalf *et al.*, 1962; White and Elson-Harris, 1992). Fleshy-fruited plants not yet recorded as hosts, therefore, could be utilized by this fruit fly (USDA-PPQ, 1993). Cultivated, introduced and native species within genera of reported hosts occupy regions throughout the United States, particularly within the climatically suitable range of *C. capitata* (plant hardiness zones 8b – 11) (Kartesz, 1998; NRCS, 2001). The geographic area most at risk for *C. capitata* establishment and subsequent eradication programs falls within the boundaries of seven ecoregions. These ecoregions are the California Central Valley and Coast, Southwestern Basin and Range of Arizona and California, Lower Rio Grande Valley of Texas, Southeastern and Gulf Coastal Plain of Alabama, Florida, Georgia, Mississippi, South Carolina, and Texas, Mississippi

Delta of Louisiana and Mississippi, Floridian, and the Marine Pacific Forest (USDA, 2001). The possible direct and indirect effects are the direct effects on listed and other plant species and plant populations and the indirect effects on wildlife and listed animal species due to habitat and food source degradation. Other indirect effects are the potential impacts to the environment caused by pest management programs that may affect all T & E species within the ecoregion(s).

A possible direct negative impact is the potential infestation of native hosts by *C. capitata,* causing a reduction of reproductive capacity if seed set is decreased. Because commercial orchards and backyard fruit trees may act as fruit fly reservoirs, fleshy-fruited native trees, shrubs and herbs such as, *Crataegus, Diospyros, Juglans, Mespilus, Opuntia* and *Prunus*, may be at risk of infestation if their habitats are adjacent to reservoir areas. If native hosts were infested, a possible indirect negative impact is the reduction of food sources, such as fruits and nuts, for wildlife (Martin, *et. al.,* 1951; ARS, 2001a; Harlow, *et. al.,* 1996). Potential hosts of *C. capitata* include State-listed rare plant species as well as T & E species. In Florida, for example, State-listed *Opuntia corallicola, Opuntia stricta, Opuntia triacanthos* and *Prunus myrtifolia,* (Wunderlin and Hansen, 2001) are fleshy-fruited and may be potential hosts. Examples of possible T & E hosts of *C. capitata* are the endangered *Opuntia basilaris var. treleasei* of California and *Prunus geniculata* of Florida (Hickman, 1993; USFWS, 2001). In the San Joaquin Valley, CA, natural *Opuntia* habitats have been converted to agricultural production areas that may serve as fruit fly reservoirs. To date, there have been no reports of *C. capitata* infestations of this endangered *Opuntia* species (USFWS, 2002b). *Prunus geniculata* is known to occur in four counties in central Florida. One area is almost entirely converted to citrus groves, which may provide a reservoir for the pest, however, presence of pests other than aphids have not been found on *P. geniculata* (Martin, 2002; USFWS, 2001).

California and Florida agricultural landscapes that are prime habitats for historic and continued exotic fruit fly establishment are adjacent to closely monitored rare and native plant communities. After *C. capitata* infestations of twenty-five years and seventy years, respectively, in California and Florida (CDFA, 2000), information sources regarding these native plant communities and listed species report no infestations by exotic fruit flies (Martin, 2002; NatureServe, 2001; USFWS, 2001; USFWS, 2002b; Weekley *et. al.,* 1999). In Hawaii, *C. capitata* has been established since 1910 (CDFA, 2000; Fasulo, 2001). Information sources note exotic insect issues for endangered plant communities on the Hawaiian Islands, however, none indicate invasion of these habitats by *C. capitata* (HDA, 1994; USFWS, 1994; USFWS, 1996; USFWS, 2000; USFWS, 2002a,b). The historic and current behavior of *C. capitata* may indicate that although it presents a potential hazard to fleshy-fruited plants and plant communities, that listed animals and other wildlife depend on, the risk may be low as evidenced by the lack of invasion despite decades of opportunity to establish on native hosts.

Another potential indirect effect of the establishment of *C. capitata* is the continuance and possible increase in exotic fruit fly control programs. Detailed information regarding affected environments and the environmental consequences of control programs is found in (1) the Medfly Cooperative Eradication Program, Final Environmental Impact Statement—1993 (USDA, 1993b), (2) the Oriental Fruit Fly Regulatory Program, Environmental Assessment, November 1991 (USDA, 1991), (3) the Biological Assessment, Mediterranean fruit fly cooperative eradication program (USDA, 1993a), and particularly, (4) the Fruit Fly Cooperative Control Program, Final Environmental Impact

Statement (FEIS) – 2001 (USDA, 2001). Indirect and cumulative effects of eradication programs are possible and are presented in the Fruit Fly Cooperative Control Program FEIS (USDA, 2001).

Since the Medfly Cooperative Eradication Program area within the above ecoregions overlap with endangered or threatened species habitats, APHIS consultation with the USFWS is in progress. A Biological Assessment (BA) (APHIS, 1993a) was prepared for programmatic evaluation of the potential consequences to T & E species. APHIS must confer with USFWS to ensure that the protective measures provided in the 1993 BA remain sufficient to eliminate any potential adverse effect on T & E species; the BA is incorporated by reference in the Fruit Fly Cooperative Control Program FEIS (USDA, 2001). APHIS is consulting with USFWS and NMFS concerning the States that are at the highest risk of fruit fly infestations: California, Florida, Texas, and Washington. In consultation with FWS and NMFS, APHIS is determining which control methods may be safely used within the range and habitats of the threatened and endangered species. According to the Program FEIS (USDA, 2001), if fruit fly infestations are detected in other States, individual site-specific consultations with USFWS will take place to ensure protection of the species. The risk rating for Environmental Impact is High (3).

Table 4. Risk Rating for Consequences of Introduction

Pest	**Risk Element #1** **Climate/Host Interaction**	**Risk Element #2** **Host Range**	**Risk Element #3** **Dispersal Potential**	**Risk Element #4** **Economic Impact**	**Risk Element #5** **Environmental Impact**	**Cumulative Risk Rating**
Anastrepha fraterculus	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Ceratitis capitata	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)

G. Likelihood of Introduction

Each pest is rated for the Likelihood of Introduction based on two separate components. First, an estimate is made concerning the amount of commodity likely to be imported (Sub-Element #1). Secondly, pest opportunity is estimated using five biological features (Sub-Elements #2-6). Details of the rating criteria are explained in USDA (2000). These ratings and the value for the Likelihood of Introduction are summarized in Table 5.

Risk Element #6: Pest Opportunity

Sub-Element #1: Quantity of commodity imported annually
Currently, Colombia has 249 hectares of active commercial plantations of pitaya fruit. During the export boom that Colombia had when pitaya fruit was exported to Japan, a total of 1200 hectares were under commercial production. Since commercial plantations take four years to reach export potential, a gradual increase in areas used for export is anticipated due to biological limitations. It is estimated that the first few years (1-4) following the acceptance of an export protocol, the quantity of commodity exported annually would be Low (1 point): < 10 shipping containers (40-ft)/year. The following years (5-8) the export potential could increase to Medium (2 points): 10 - 100 shipping containers (40-ft)/year (Gonzalez, 2002).

Sub-Element #2: Survive post harvest treatment
Anastrepha fraterculus and *C. capitata* are internal feeders and are likely to survive the above described post harvest spine removal and fungicide/bactericide treatment (Vidal-C. *et al.*, 1998; ICA, 1989). If the fruit is treated using the vapor heat treatment protocol (Vidal-C. *et al.*, 1998), the likelihood of survival of fruit flies is Low (1). If no treatment is used, the likelihood of survival of fruit flies is High (3).

Sub-Element #3: Survive shipment
Fruit fly larvae within fruits can survive shipments when exported without mitigating treatment (Vidal-C. *et al.*, 1998). Japan discontinued the importation of untreated yellow pitaya fruit from Colombia after the detection of fruit fly larvae at a port of entry. The Japanese Phytosanitary Authority currently allows the importation of yellow pitaya fruit from Colombia if the fruit are treated with hot water vapor under a defined protocol (Vidal-C. *et al.*, 1998). In the absence of a treatment, the risk associated with the survival of shipment of internal feeders is High (3).

Sub-Element #4: Not detected at the port of entry
Colombia does not have a protocol for fruit inspection at origin. In addition to this, internal feeders are difficult to detect during normal USDA inspection procedures at ports of entry (Gould, 1995). Because it is unlikely that internal feeders would be detected during routine inspections at ports of entry, the risk associated with the inability to detect these pests is High (3).

Sub-Element #5: Imported or moved to area with environment suitable for survival
The fruit flies *A. fraterculus* and *C. capitata* are pests with serious potential for establishment in parts of the United States (Mau and Martin Kessing, 2002; Sequeira *et al.,* 2001). The risk associated with their importation and subsequent establishment in the United States is High (3).

Sub-Element #6: Come into contact with host material suitable for reproduction
It is likely that if *A. fraterculus* and *C. capitata* enter the United States, they will find numerous hosts available for reproduction due to their polyphagous nature (Mau and Martin Kessing, 2002; Sequeira *et al.,* 2001). The rating for the risk that these imported fruit flies can find host material suitable for reproduction is High (3).

The likelihood that a particular pest would be introduced is reflected in the value for the Cumulative Risk Rating. The Cumulative Risk Rating is High (17 points) for *A. fraterculus* and High (17 points) for *C. capitata* (Table 5).

Table 5. Risk Rating for Likelihood of Introduction							
Pest	**Sub-Element #1 Quantity Imported Annually**	**Sub-Element #2 Survive Post-Harvest Treatment**	**Sub-Element #3 Survive Shipment**	**Sub-Element #4 Not Detected at Port of Entry**	**Sub-Element #5 Moved to Suitable Habitat**	**Sub-Element #6 Contact with Host Material**	**Cumulative Risk Rating**
Anastrepha fraterculus	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (3)	High (17)
Ceratitis capitata	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (3)	High (17)

H. Pest Risk Potential and Conclusion

The sum of the Cumulative Risk Rating for the Consequences of Introduction and the Cumulative Risk Rating for *A. fraterculus and C. capitata,* shown in Table 6, clearly indicate that these species pose a High Pest Risk Potential (32 points and 32 points, respectively).

Table 6. Pest Risk Potential			
Pest	**Consequences of Introduction Cumulative Risk Rating**	**Likelihood of Introduction Cumulative Risk Rating**	**Pest Risk Potential**
Anastrepha fraterculus (Wiedemann) (Diptera: Tephritidae)	High (15)	High (17)	High (32)
Ceratitis capitata (Wiedemann) (Diptera: Tephritidae)	High (15)	High (17)	High (32)

The fruit flies *A. fraterculus* and *C. capitata* are unlikely to be detected during port-of-entry inspections and require pest risk mitigation measures. The vapor heat treatment T106-e (USDA, 2002b) was designed to remove both species from the pathway. The Japanese authorities currently accept vapor heat treatment as a treatment for yellow pitaya being exported from Colombia into Japan (ACCI, 2000).

Quarantine species found as external feeders of the yellow pitaya fruit from Colombia are unlikely to remain with the fruit because the process used to remove spines together with the fungicide/bactericide dip are highly likely to also remove any external pests. As long as spine removal and dipping remain part of the post-harvest systems approach mitigation, surface pests should not enter the pathway.

Identification and selection of appropriate sanitary and phytosanitary measures to mitigate risk for pests with particular Pest Risk Potential ratings is undertaken as part of the risk management phase and is not finalized in this document. The appropriate risk management strategy for a particular pest depends on the risk posed by that pest. APHIS risk management programs are risk based and dependent on the availability of appropriate mitigation methods. Details of APHIS risk management programs are published, primarily, in the *Federal Register* as quarantine notices.

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V. Appendix

Appendix Table 1. Reported Plant Families and Host Plants of the Fruit Flies *Anastrepha fraterculus* and *Ceratitis capitata*[1]			
Host Plant Family	**Host Plant**	***Anastrepha fraterculus***	***Ceratitis capitata***
Anacardiaceae	*Anacardium occidentale*	✓	✓
"	*Mangifera indica*	✓	✓
"	*Spondias* spp.	✓	✓
Annonaceae	*Annona* spp.	✓	✓
Apocynaceae	*Carissa edulis*		✓
"	*Thevetia peruviana*		✓
Arecaceae	*Phoenix dactylifera*		✓
Cactaceae	*Opuntia* spp.		✓
Caricaceae	*Carica papaya*		✓
Clusiaceae	*Garcinia livingstonei*		✓
"	*Calophyllum* spp.		✓
Combretaceae	*Terminalia catappa*	✓	✓
Ebenaceae	*Diospyros spp.*	✓	✓
Elaeocarpaceae	*Muntingia calabura*		✓
Euphorbiacae	Reported to Family only	✓	
Flacourtiaceae	*Dovyalis caffra*	✓	✓
Juglandaceae	*Juglans spp.*	✓	✓
Lauraceae	*Persea americana*	✓	✓
Lythraceae	*Punica granatum*	✓	✓
Malpighiaceae	*Malpighia glabra*		✓
Mimosaceae	*Inga jinicuil*	✓	
Moraceae	*Ficus carica*	✓	✓
"	*Morus* spp.		✓
Myrtaceae	*Acca sellowiana* (syn: *Feijoa sellowiana)*	✓	✓
"	*Eugenia* spp.	✓	✓
"	*Psidium spp.*	✓	✓
"	*Syzygium* spp.	✓	✓
Olacaceae	Reported to Family only	✓	
Oxalidaceae	*Averrhoa carambola*	✓	✓
Passifloraceae	*Passiflora* spp.		✓
Proteaceae	*Banksia prionote*		✓
Rosaceae	*Cydonia oblonga*	✓	
"	*Eriobotrya japonica*	✓	✓

Appendix Table 1. Reported Plant Families and Host Plants of the Fruit Flies *Anastrepha fraterculus* and *Ceratitis capitata*[1]			
Host Plant Family	**Host Plant**	***Anastrepha fraterculus***	***Ceratitis capitata***
"	*Fragaria vesca*	✓	
Rosaceae (cont.)	*Malus domestica*	✓	✓
"	*Mespilus germanica*		✓
"	*Prunus* spp.	✓	✓
"	*Pyrus communis*	✓	✓
"	*Rubus* spp.	✓	✓
Rubiaceae	*Coffea* spp.	✓	✓
Rutaceae	*Casimiroa* spp.		✓
"	*Citrus* spp.	✓	✓
"	*Fortunella japonica*	✓	✓
Santalaceae	*Santalum album*		✓
Sapindaceae	*Litchi chinensis*		✓
Sapotaceae	*Chrysophyllum cainito*		✓
"	*Chrysophyllum oliviforme*		✓
"	*Manilkara zapota*	✓	✓
"	*Pouteria* spp.	✓	✓
Solanaceae	*Capsicum* spp.		✓
"	*Cyphomandra betacea*		✓
"	*Lycium* spp.		✓
"	*Physalis peruviana*		✓
"	*Solanum* spp.	✓	✓
Staphyleaceae	Reported to Family only	✓	
Sterculiaceae	*Theobroma cacao*	✓	✓
Vitaceae	*Vitis* spp.	✓	✓

[1] Any fleshy-fruited plant species could be a host (USDA-PPQ, 1993). Information compiled from Fasulo, 2001; Liquido *et al.,* 1991; and White and Elson-Harris, 1992.