Mini Risk Assessment
Rice cutworm, *Spodoptera litura* Fabricius
[Lepidoptera: Noctuidae]

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Introduction

Spodoptera litura is a polyphagous pest of vegetables and field crops. The degree of risk that the pest poses to US agriculture and ecosystems remains somewhat uncertain. In pathway-initiated risk assessments, this insect was judged moderately to highly likely of establishing in the US should it be introduced; the consequences of its establishment were considered moderate to severe (Lightfield 1996, Ogden and Podleckis 2000). Differences in judgments of risk primarily relate to the perceived dispersal potential of the insect and its ability to find a host. Because of its broad host range, this insect is also known as cluster caterpillar, common cutworm, cotton leafworm, tobacco cutworm, tobacco caterpillar, and tropical armyworm (USDA 1982).

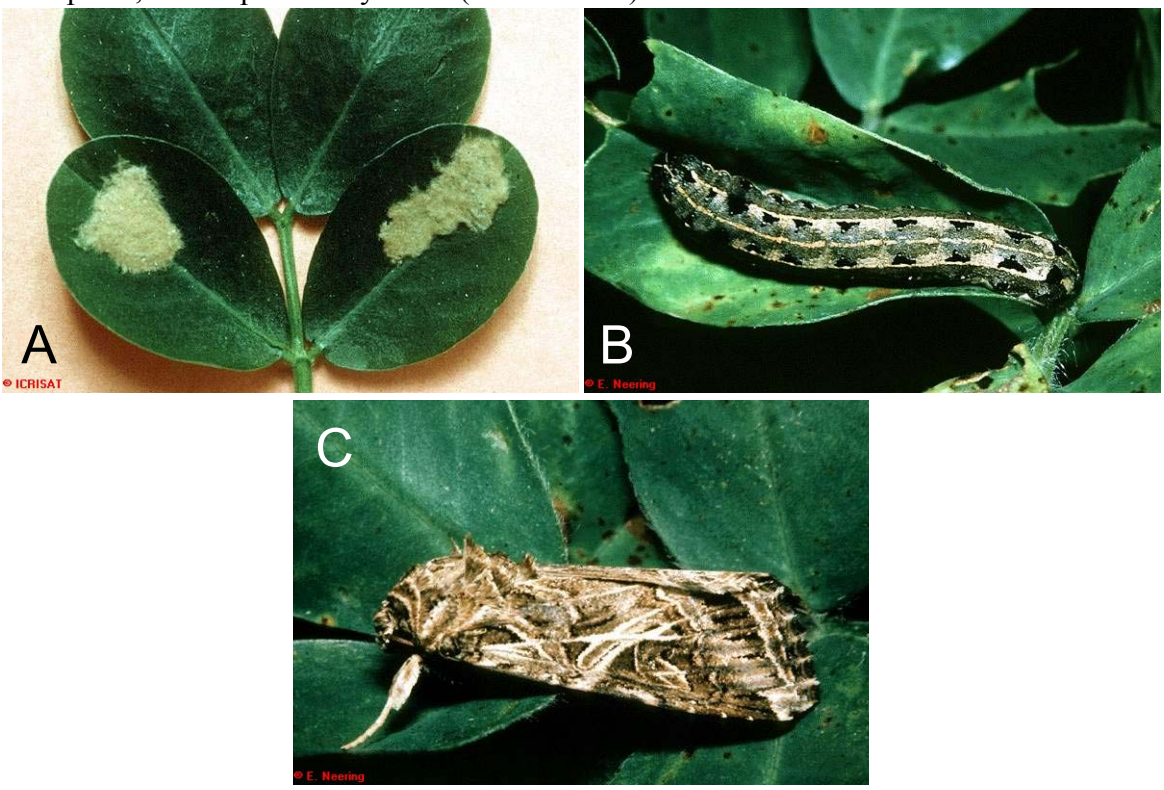

Figure 1. Life stages of *Spodoptera litura*, images not to scale: (A) egg mass covered in scales from female; (B) late instar larva; and (C), adult on leaf [Images from CAB (2003)]

1. **Ecological Suitability. Rating: High.** *Spodoptera litura* can be found in much of Asia and Oceania (i.e., Australia, New Zealand, and other Pacific Islands, including Hawaii) (IIE 1993, Zhang 1994). These regions contain dry, tropical, and temperate climates (CAB 2003). Available geographic records of the distribution of *S. litura* suggest the species may be most closely associated with deserts and xeric shrublands; temperate broadleaf and mixed forests; tropical and subtropical dry broadleaf forest; and tropical and subtropical moist broadleaf forests. Based on the distribution of climate zones in the US, we estimate that approximately 48% of the continental US would be suitable for *S. litura* (Fig. 2). See Appendix A for details of this analysis.

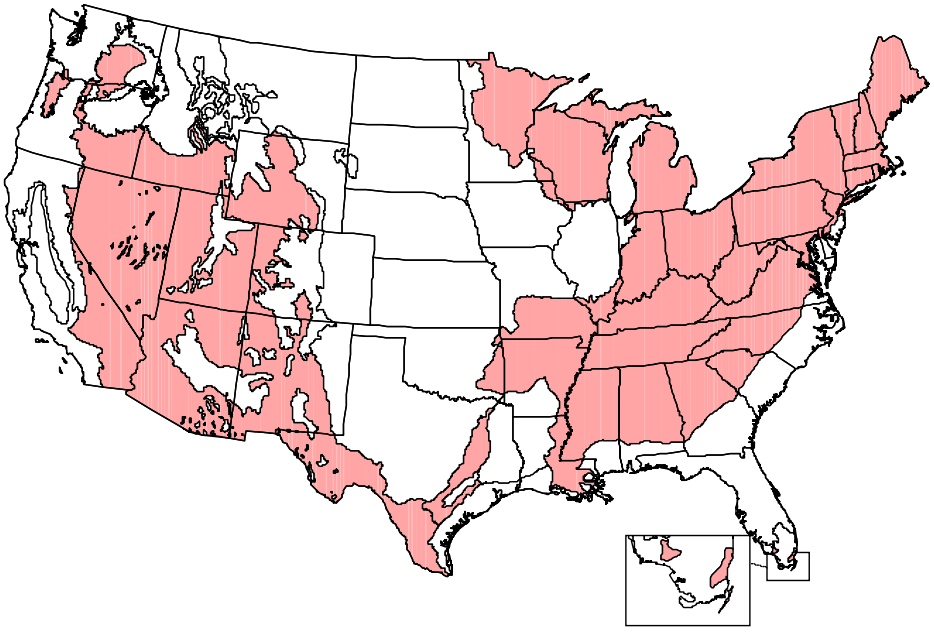

Figure 2. Predicted distribution of *Spodoptera litura* in the continental US. Southern Florida is enlarged for detail.

2. **Host Specificity/Availability. Rating Low/High** This pest feeds primarily on the leaves of more than 120 species of host plants, many of which are commonly produced in the US (Thomas et al. 1969, USDA 1982, Balasubramanian et al. 1984, Sharma 1994, Zhang 1994, CAB 2003, Pogue 2003). Host plants include: abaca (*Musa textilis*), acacia (*Acacia glauca*), adzuki bean (*Vigna angularis*), African oil palm (*Elaeis guineensis*), Ajowan caraway (*Trachyspermum copticum*), alfalfa/lucerne (*Medicago sativa*), alpinia (*Alpinia* sp.), amaranth/slender amaranth/spiny amaranth (*Amaranthus* sp., *A. viridis*, *A. spinosus*), apple (*Malus domestica*), asparagus (*Asparagus officinalis*), aubergine/eggplant (*Solanum melongena*), bambarra groundnut (*Vigna subterranea*), banana (*Musa x paradisiaca*), bean/green bean/kidney bean/dry edible bean (*Phaseolus* sp., *P. vulgaris*), beet (*Beta vulgaris*), black cumin (*Nigella sativa*), black gram (*Vigna mungo*), black nightshade (*Solanum nigrum*), blackeyed pea (*Vigna unguiculata*), broccoli (*Brassica oleracea* var. *botrytis*), cabbage (*Brassica oleracea*), Caesulia (*Caesulia* sp., *C. axillaris*), caladium/heart

of Jesus (*Caladium* sp., C. *bicolor*), carrot (*Daucus carota* ssp. *sativus*), castorbean (*Ricinis communis*), catjang (*Vigna catjang*), chard (*Beta vulgaris* var. *cicla*), chickory (*Cichorium* sp.), chickpea (*Cicer arietinum*), Chinese grass (*Boehmeria nivea*), chlorophytum (*Chlorophytum* sp.), chrysanthemum (*Chrysanthemum* sp.), citrus/lemon (*Citrus* spp., *C. limon*), coatbuttons (*Tridax procumbens*), coccinia (*Coccinia* sp.), coco yam (*Colocasia esculenta*), cocoa/cacao (*Theobroma cacao*), coffee (*Coffea* sp.), coriander (*Coriandrum sativum*), corkwood tree (*Duboisia myoporoides*), corn (*Zea mays*), cotton (*Gossypium* sp., *G. hirsutum*, *G. barbadense*), crookneck squash (*Cucurbita moschata*), cruciferous crops (*Brassica* spp.), derris (*Derris elliptica*), desert horsepurslane (*Trianthema portulacastrum*), devil's horsewhip (*Achyranthes aspera*), dunchi fiber (*Sesbania bispinosa*), eggplant/aubergine (*Solanum melongena*), Egyptian carissa (*Carissa edulis*), Egyptian clover (*Trifolium alexandrinum*), eryngo (*Eryngium* sp.), European waterclover (*Marsilea quadrifolia*), field sowthistle (*Sonchus arvensis*), Flavaria (*Flavaria* sp., *F. contriarvia*), flax (*Linum* sp., *L. usitatissimum*), fuchsia (*Fuchsia* sp.), garden ginger (*Zingiber officinale*), garden pepper (*Capsicum annuum*), giant taro (*Alocasia macrorrhizos*), gladiolus (*Gladiolus* sp.), gourd/pumpkin (*Cucurbita pepo*), guar (*Cyamopsis tetragonoloba*), hairy carpet weed (*Glinus lotoides*), hibiscus/rosemallow (*Hibiscus* sp.), hispid starburr (*Acanthospermum hispidium*), hyacinthbean (*Lablab purpureus*), India mustard (*Brassica juncea*), ivy gourd (*Coccinia grandis*), java-bean (*Senna obtusifolia*), jute/nalta jute (*Corchorus capsularis*, *C. olitorius*), kratom (*Mitragyna speciosa*), lambsquarters (*Chenopodium album*), lantana (*Lantana camara*), launaea (*Launea* sp., *L. aspleniifolia*), leek (*Allium porrum*), Leichhardt's duboisia (*Duboisia leichhardtii*), lettuce/prickly lettuce (*Lactuca sativa*, *L. scariola*), limonium (*Limonium* sp.), macaranga (*Macaranga* sp.), mango (*Mangifera indica*), millet (*Milium* spp., *Panicum* spp., *Pennisetum* spp.), Millingtonia (*Millingtonia* sp*., Millingonia hortensis*), mint (*Mentha* sp.), momordica/balsam pear (*Momordica* sp., *M. charantia*), Mulberry (*Morus* sp.), mung bean (*Vigna radiata*), okra /musk okra (*Abelmoschus esculentus*, *A. moschatus* ssp. *moschatus*), onion (*Allium cepa*), opium poppy (*Papaver somniferum*), oranges/other citrus (*Citrus* spp.), orchid (*Dendrobium* sp., *Oncidium* sp.), oriental trema (*Trema orientale*), pak choi (*Brassica chinensis*), papaya (*Carica papaya*), passionflower (*Passiflora* sp.), pea (*Pisum sativum*), peanut/groundnut (*Arachis hypogaea*), pepper (*Piper* sp.), pigeonpea (*Cajanus cajan*), pillpod sandmat (*Chamaesyce hirta*), pineapple (*Ananas comosus*), pink (*Dianthus* sp.), poison bulb (*Crinum asiaticum*), potato (*Solanum tuberosum*), radish (*Raphanus sativus*), ramtilla (*Guizotia abyssinica*), rattlebox (*Crotalaria* sp.), rice (*Oryza sativa*), ricinus (*Ricinus* sp.), river lily/spider lily/swamp lily (*Crinum pedunculatum*), rose (*Rosa* sp.), rough cockleburr (*Xanthium strumarium*), rubber tree (*Hevea brasiliensis*), sacred lotus (*Nelumbo nucifera*), Shoeback plant (*Hibiscus rosa-sinensis*), sicklefruit fenugreek (*Trigonella foenum-graecum*), sida (*Sida* sp.), silver cock's comb (*Celosia argentea* var. *plumosa*), sinkwa towelsponge (*Luffa acutangula*), sorghum (*Sorghum bicolor*), sorghum (*Sorghum bicolor*), soybean (*Glycine max*), spinach (*Spinacia oleracea*), sugarcane (*Saccharum officinarum*), sunflower

(*Helianthus annuus*), sunn hemp (*Crotalaria juncea*), swamp morning glory (*Ipomoea aquatica*), sweet fennel (*Foeniculum vulgare*), sweet potato (*Ipomoea batatas*), sweet potato (*Ipomoea batatas*), tapioca (*Manihot esculenta*), taro (*Colocasia esculenta*), tea (*Camellia sinensis*), teak (*Tectona grandis*), tobacco (*Nicotiana tabacum*), tomato (*Lycopersicon esculentum*), treadsoftly (*Cnidoscolus aconitifolius*), tropical kudzu (*Pueraria phaseoloides*), tropical whiteweed (*Ageratum conyzoides*), turkey berry (*Solanum torvum*), water hyacinth (*Eichhornia crassipes*), water-willow (*Justicia* sp., *J. procumbens*), waxweed (*Cuphea* sp.), white leadtree (*Leucaena leucocephala*), wild celery (*Apium graveolens*), willowleaf angelon (*Angelonia salicariifolia*), winged bean (*Psophocarpus tetragonolobus*), wishbone flower (*Torenia asiatica*), woodland strawberry (*Fragaria vesca*), yellow bur head (*Limnocharis flava*), zinnia/elegant zinnia (*Zinnia* sp., *Z. violacea*), and zonal geranium (*Pelargonium hortorum*).

See Appendix B for maps showing where various hosts are grown commercially in the US.

3. **Survey Methodology. Rating: Medium.** USDA has provided some considerations when sampling for *S. litura* that are similar to recommendations provided for *S. littoralis* because the biology of these two species is so similar (USDA 1982). Larval sampling can occur anytime foliage is present; early instars (<3rd) are likely to be found on the underside of leaves, skeletonized leaves provide evidence of the presence of larvae, sweep net sampling is particularly effective at dawn or dusk; submit specimens to a taxonomic expert to confirm identification (USDA 1982).

   A synthetic sex pheromone, a mixture of (*Z,E*)-(9, 11)-tetradecadienyl acetate (compound A) and (*Z,E*)-(9,12)- tetradecadienyl acetate (compound B) has proven effective for monitoring populations of *S. litura* (Yushima and Tamaki 1974). The compounds are most effective in a ratio (A:B) between 4:1 to 39:1 (Yushima and Tamaki 1974). The two components, in a ratio of 9:1, are available commercially as Litlure (Yushima and Tamaki 1974). Rubber septa impregnated with 1 mg of the sex attractant were equally attractive to males for up to 4 weeks (Das et al. 1990, Ranga Rao et al. 1991), though more male moths were captured with polyethylene vial dispenses loaded with 1 mg of a Litlure equivalent (Gupta and Pawar 1989). Loading a greater amount (i.e., >1 mg) of Litlure on a dispenser did not significantly improve trap catch (Krishnananda et al. 1992). Adding an antioxidant (25% butylated hydroxytoluene; BHT) extended the duration of the attractiveness of a lure(Krishnananda et al. 1992). The lure worked effectively with ICRISAT traps (Das et al. 1990). The lure was more effective with water-pan traps than sticky traps (Dhandapani 1985); the author conjectured that the large size of the moth lowers the chances that it will adhere to a sticky surface. Approximately 30% more moths were captured in water traps with the addition of an insecticide (Krishna Prasad et al. 1983). More moths were captures in a homemade dry, polyethylene sleeve trap than in a Zoecon sticky trap (Gupta and Pawar 1989). The color of the trap had no influence on the number of

male *S. litura* that were caught (Krishnananda and Satyanarayana 1989). Other traps have been specifically designed to increase captures of *S. litura* (e.g., Liu 1994).

In field and truck crops, traps should be placed 1 m above the ground and at least 100 m apart (Das et al. 1990). In a separate study, traps placed at 1.5 m caught significantly more moths than traps at 0.5, 1.0, 2.0, 3.0, 3.5, or 4.0 m (Krishnananda et al. 1992). Lee (1987) and Lee (1989) recommended placement of traps at 0.5 to 1.5 m high.

Although more moths were captured at a trap density of 4-5 traps per hectare, moth capture per trap was greatest at one trap per hectare (Ranga Rao et al. 1991). In areas where *S. litura* is well established, trap catches have been correlated with larval densities and feeding damage in cotton (Muthukrishnan and Balasubramanian 1992). Cheng (1989) recommends a density of 7 traps "in a monitoring area [to] provide reliable information." Lee (1987) suggests 10 traps per ha for routine monitoring. Traps with lures for *S. litura* and *H. armigera* captured significantly fewer *H. armigera* than traps with *H.-armigera* lures alone; thus, the authors recommend that the two lures not be used together (Pawar and Srivastava 1988). Lures for *S. litura* can be used with lures for *S. littoralis* in the same trap (PPQ 1993).

Pheromone baited traps are widely used to monitor male flight activity of *S. litura* (Ranga Rao et al. 1991, Mishra and Sontakke 1992).

Mass trapping with (*Z*,*E*)-(9,12)-tetradecadienyl acetate (30 traps/ha) did not control populations of *S. litura* (Cheng 1989). Das and Roy (1985) provide a review of the uses of pheromones, including mass trapping, for *S. litura* in India.

Light traps have also been used to monitor *S. litura* populations (Pawar and Srivastava 1986, Shrivastava et al. 1987). Capture of *S. litura* moths was affected by the stage of the moon, with the traps being least effective during the full moon and most effective during the new moon (Shrivastava et al. 1987). Light traps may interfere with the performance of a pheromone trap if the two traps are separated by <10 m (Pawar and Srivastava 1986). Captures in light traps correlated less well with infestation levels than did catches in McVeigh pheromone traps baited with (*Z*,*E*)-(9,11)-tetradecadienol acetate(El-Zanan and El-Hawary 1999). Similar findings were reported by Nandihalli et al. (1989) and Shih et al. (Shih and Chu 1995). However, Suharto and Manwan (1993) reported a variable relationship between trap catches and the number of egg masses in field of soybean.

4. **Taxonomic Recognition**. **Rating: Low.** Adults of *S. litura* are very similar in size and coloration to *S. ornithogalli* (present in the US); the "hind wings of female [*S. littura* are] darker than those of *S. ornithogalli* (USDA 1982). *Spodoptera litura* and *S. littoralis*, another exotic lepidopteran pest, have long

been "taxonomically confused" (Mochida 1973). Because of their morphological similarities, the two species were erroneously considered as a single species in historical literature (Hafez and Hassan 1969, CABI/EPPO 1997). Both species are difficult to distinguish without close examination of the genitalia (Mochida 1973, Brown and Dewhurst 1975, DEFRA 1999). With regard to geographical distribution, "the ranges of the two species do not currently overlap and neither has extended its range (except in the special case of glasshouses in Europe)" (CABI/EPPO 1997). Unlike *S. liura*, *S. littoralis* is found in the Mediterranean, Africa, and the Middle East (IIE 1993).

For a more detailed taxonomic and morphological description of *S. litura*, see Appendix C.

5. **Entry Potential. Rating: High.** Interceptions of *S. litura* or "*Spodoptera* sp." have been reported 1,759 times since 1985 on fruits, vegetables, ornamentals, and other miscellaneous plants (USDA 2003). Each year approximately 86 (±5.5 standard error of the mean) interceptions of *S. litura* or "*Spodoptera* sp." have been reported (USDA 2003). The majority of interceptions have been associated with permit cargo (62%), general cargo (22%), and international airline passengers (16%). The pest has been intercepted at 49 international ports of entry, including ports in Hawaii. The majority of interceptions have been reported from JFK International Airport (47%), Honolulu (17%), Los Angeles (9%), Miami (8%), Houston (2%), and San Francisco (2%). These ports are the first points of entry for cargo or international airline passengers coming into the US and do not necessarily represent the intended final destination of infested material. Movement of potentially infested material is more fully characterized later in the document.

   Spodoptera litura or "*Spodoptera* sp." have been intercepted in association with nearly 230 plant taxa.

6. **Destination of Infested Material. Rating: High.** When officers intercept an actionable pest, they ask for the intended destination of the conveyance. Cargo or passengers were destined for 34 states (including the District of Colombia). The most commonly reported destinations were New York (45%), California (21%), Florida (10%), Hawaii (4%), Texas (4%), New Jersey (3%), Pennsylvania (2%), Washington (2%), and Massachusetts (2%). We note that some portion of each of these states has a climate and hosts that would be suitable for establishment by *S. litura*.

7. **Potential Economic Impact. Rating: High.** *Spodoptera litura* has long been considered a pest of major economic importance in Australia, Southeast Asia, and Japan (USDA 1982). The economic consequences of establishment by *S. litura* would not be limited to its direct effects on production agriculture; *S. litura* could also adversely affect access to foreign markets. The European and Mediterranean Plant Protection Organization (EPPO) considers *Spodoptera litura* an A1

quarantine pest; the pest also has quarantine status with the Caribbean Plant Protection Commission (CPPC), the North American Plant Protection Organization (NAPPO), the Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), Belarus, Russia, Ukraine, and Turkey (CABI/EPPO 1997, EPPO 1999).

8. **Establishment Potential. Rating: High.** No infestations of *S. litura* have been reported in the wild in the United States. Thus, the potential for establishment remains speculative. This insect is intercepted regularly from cargo and international airline passengers that are destined for much of the US. Many of these areas are likely to provide a suitable climate, in terms of temperature and moisture. Because of the very broad host range of the species, this insect is likely to find a suitable host and establishment seems likely.

   For a detailed description of the biology of *S. litura*, see Ellis (2003).

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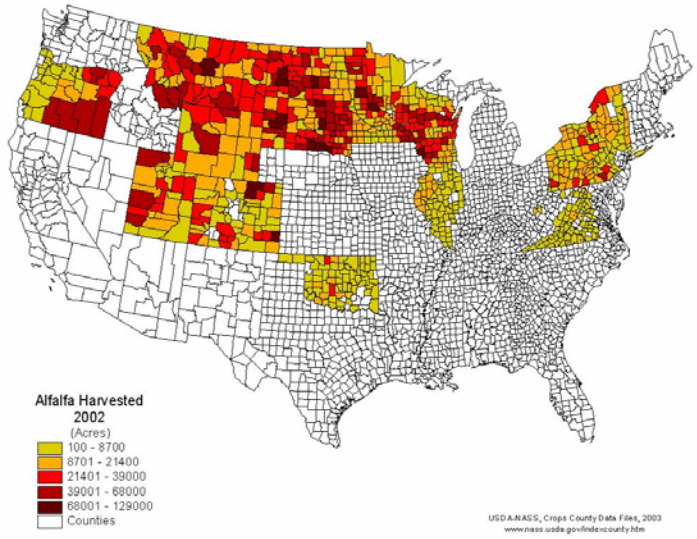
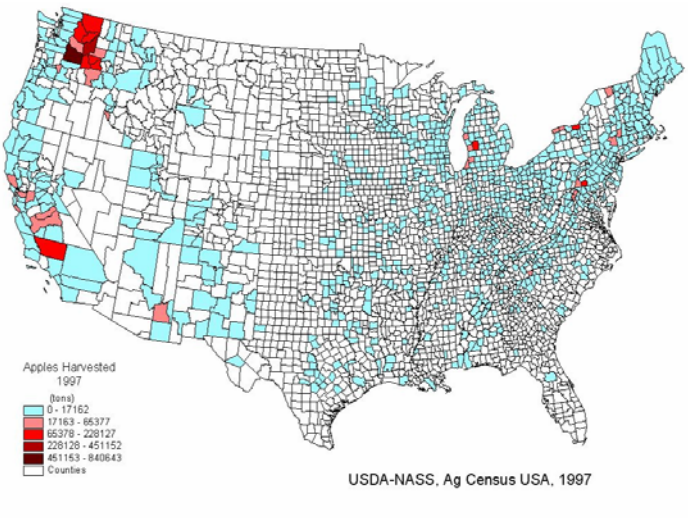
Appendix A. Comparison of climate zones. To determine the potential distribution of a quarantine pest in the US, we first collected information about the worldwide geographic distribution of the species (CAB 2003). We then identified which biomes (i.e., habitat types), as defined by the World Wildlife Fund (Olson et al. 2001), occurred within each country or municipality reported for the distribution of the species. Biomes were identified using a geographic information system (e.g., ArcView 3.2). An Excel spreadsheet summarizing the occurrence of biomes in each nation or municipality was prepared. The list was sorted based on the total number of biomes that occurred in each country/municipality. The list was then analyzed to determine the minimum number of biomes that could account for the reported worldwide distribution of the species. Biomes that occurred in countries/municipalities with only one biome were first selected. We then examined each country/municipality with multiple biomes to determine if at least one of its biomes had been selected. If not, an additional biome was selected that occurred in the greatest number of countries or municipalities that had not yet been accounted for. In the event of a tie, the biome that was reported more frequently from the entire species' distribution was selected. The process of selecting additional biomes continued until at least one biome was selected for each country. The set of selected biomes was compared to the occurrence of those biomes in the US.

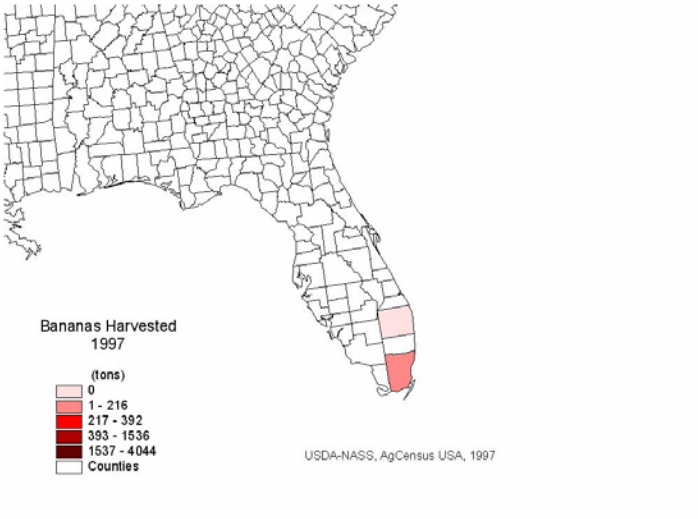
Appendix B. Commercial production of hosts of *Spodoptera litura* in the continental US.



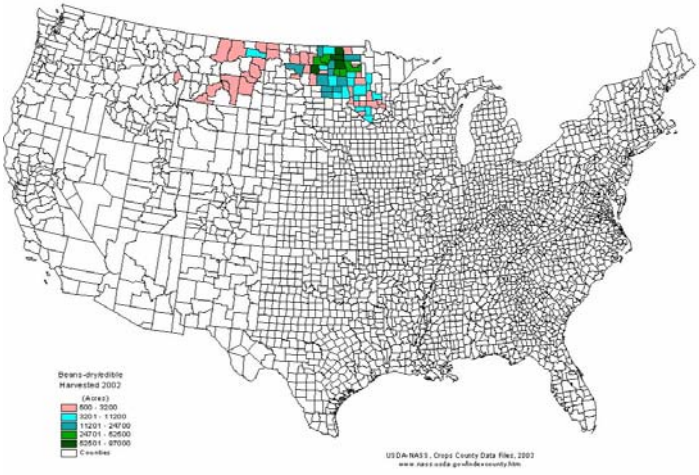
Map 1. Alfalfa (*Medicago sativa*)



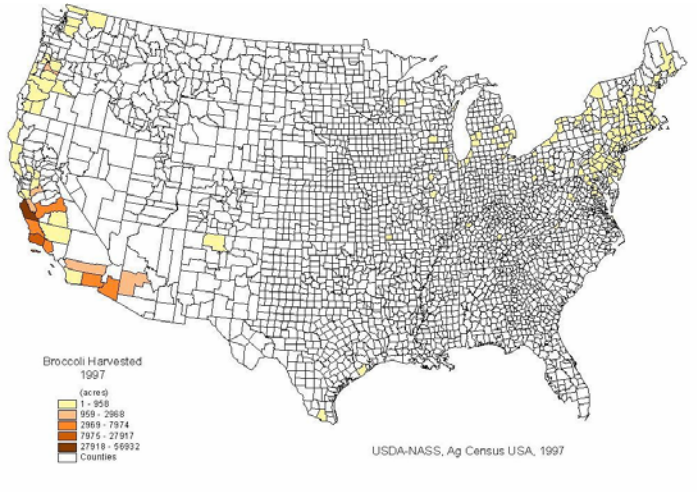
Map 2. Apple (*Malus domestica*)



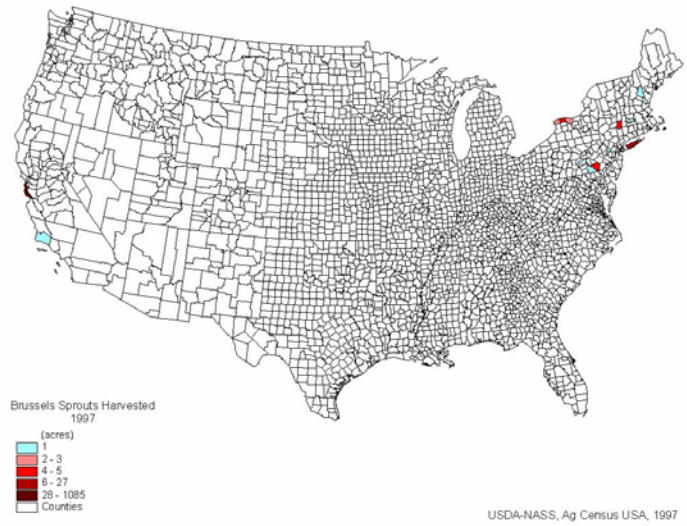
Map 3. Banana (*Musa x paradisiaca*)



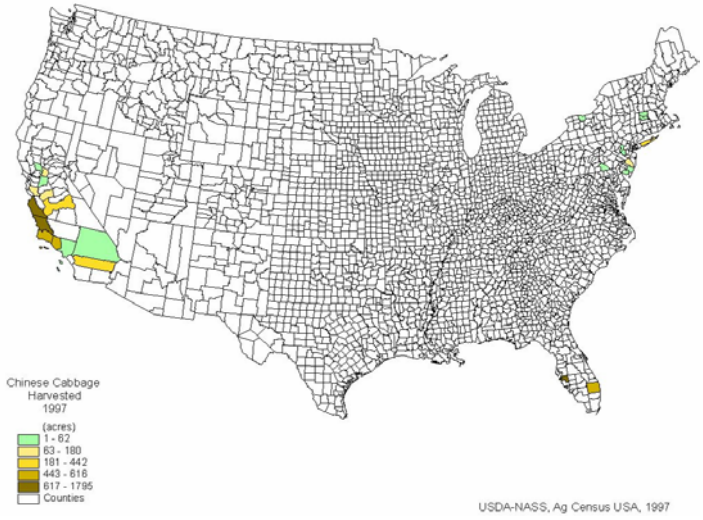
Map 4. Beans-dry edible (*Phaseolus vulgaris*)



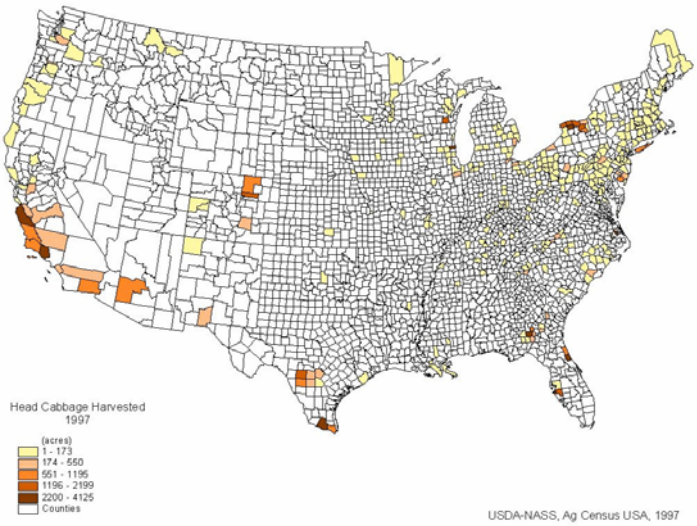
Map 5. Broccoli (*Brassica oleracea* ssp. *botrytis*)



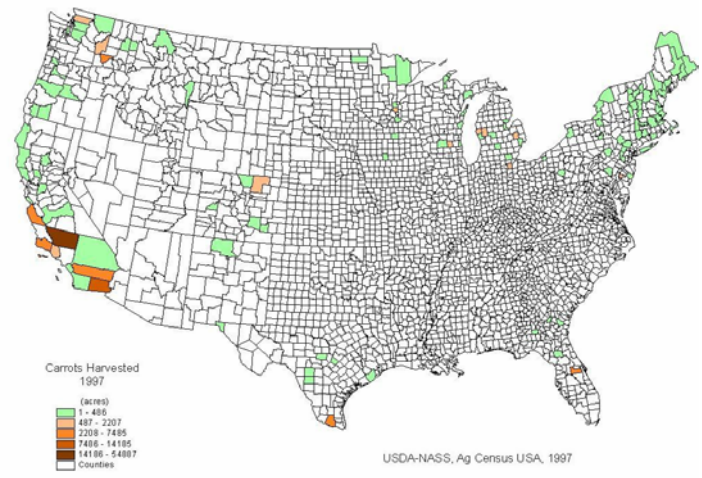
Map 6. Brussels Sprouts (*Brassica oleracea* ssp. *gemmifera*)



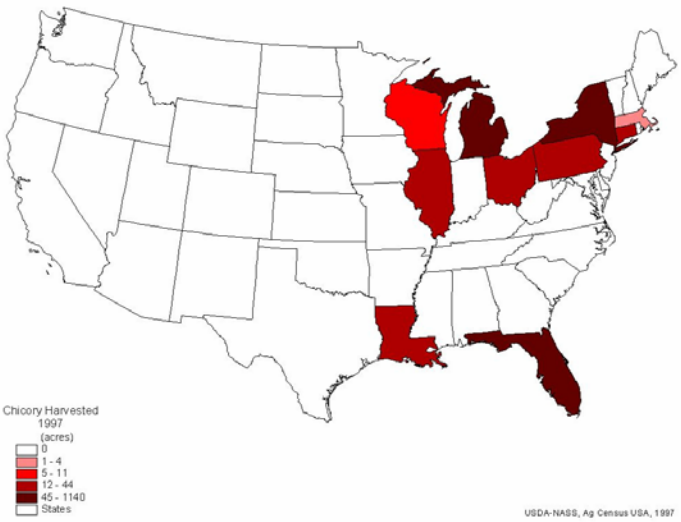
Map 7. Cabbage; Chinese (*Brassica oleracea* spp.)



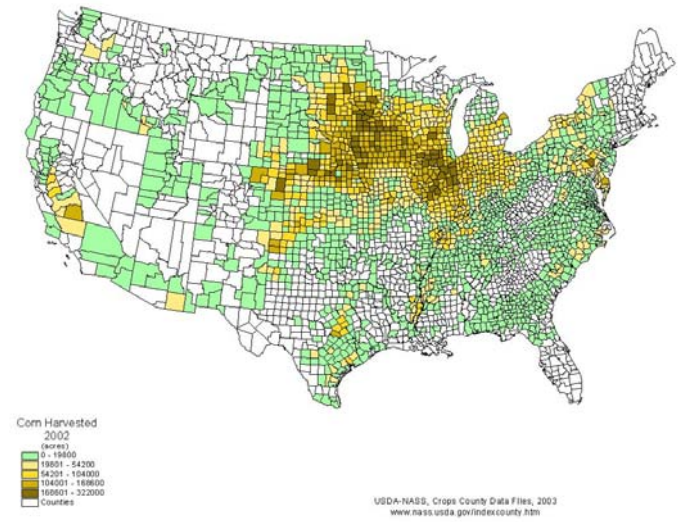
Map 8. Cabbage; Head (*Brassica oleracea* spp.)



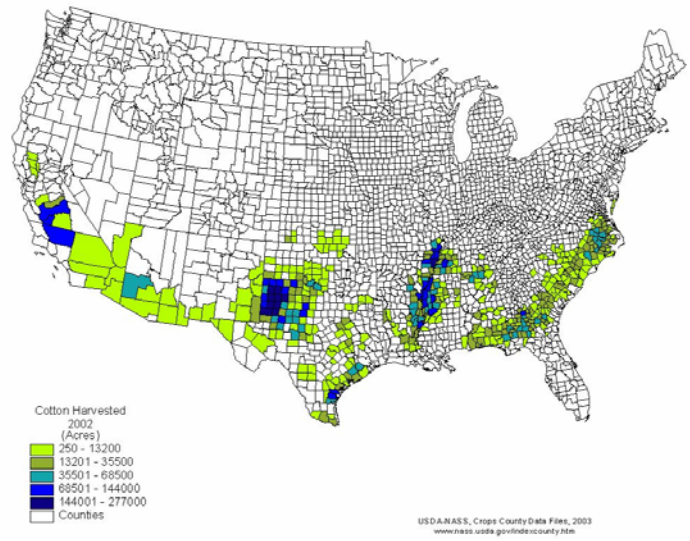
Map 9. Carrot (*Daucus carota* ssp. *sativus*)



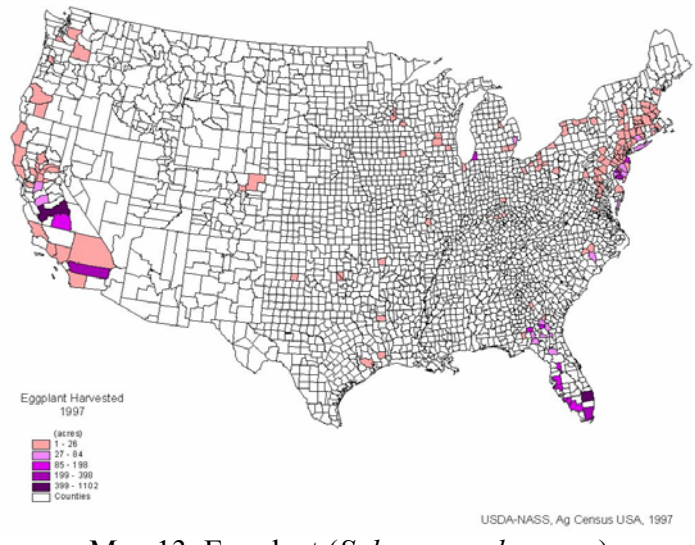
Map 10. Chicory (*Cichorium* sp.)



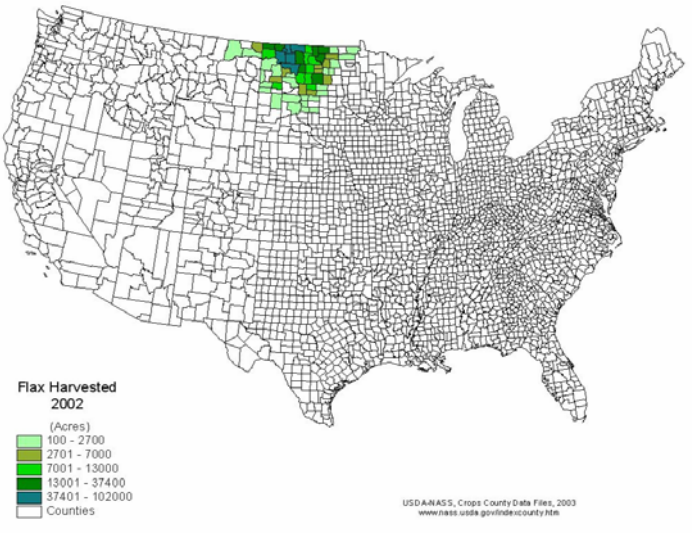
Map 11. Corn (*Zea mays*)



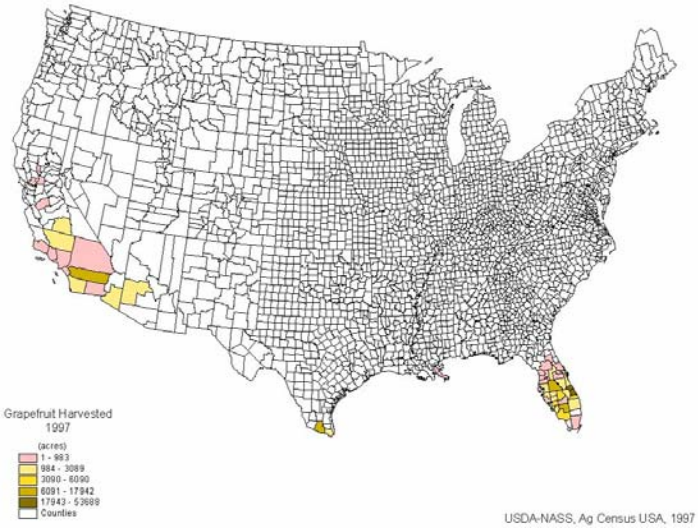
Map 12. Cotton (*Gossypium* spp.)



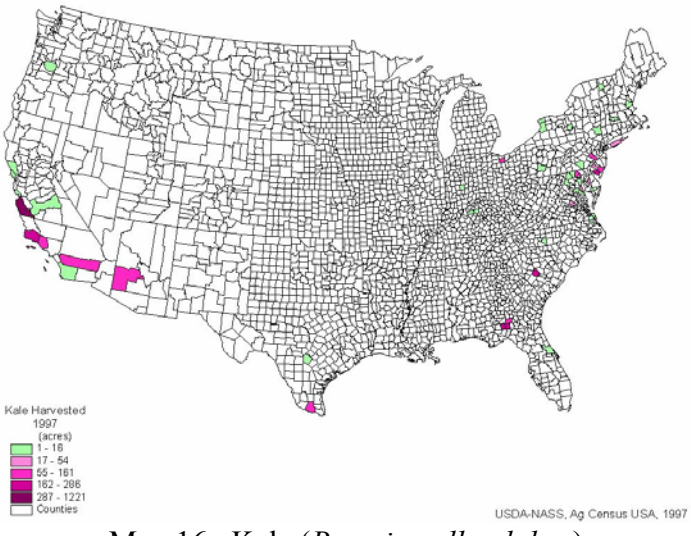
Map 13. Eggplant (*Solanum melongena*)



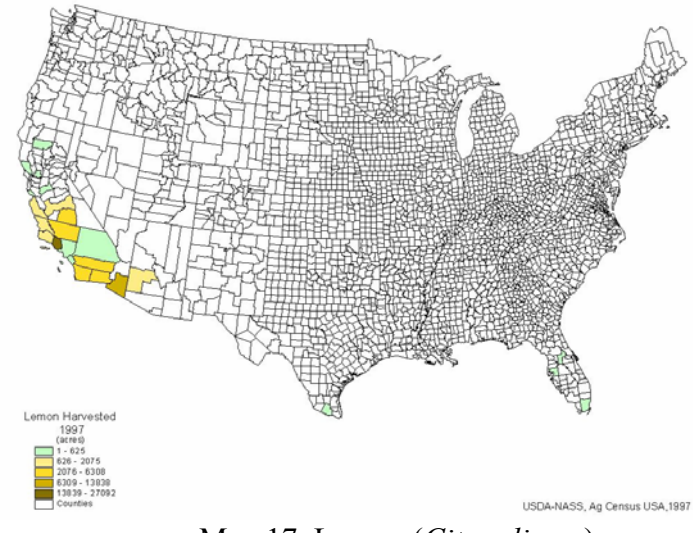
Map 14. Flax (*Linum* spp.)



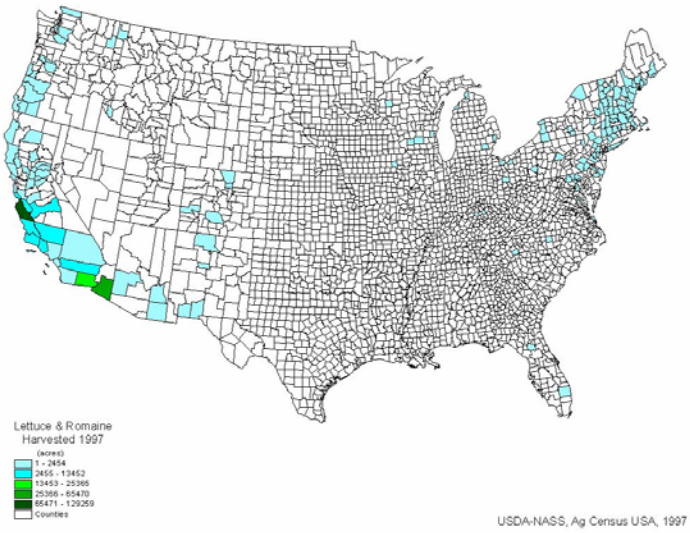
Map 15. Grapefruit (*Citrus paradisi*)



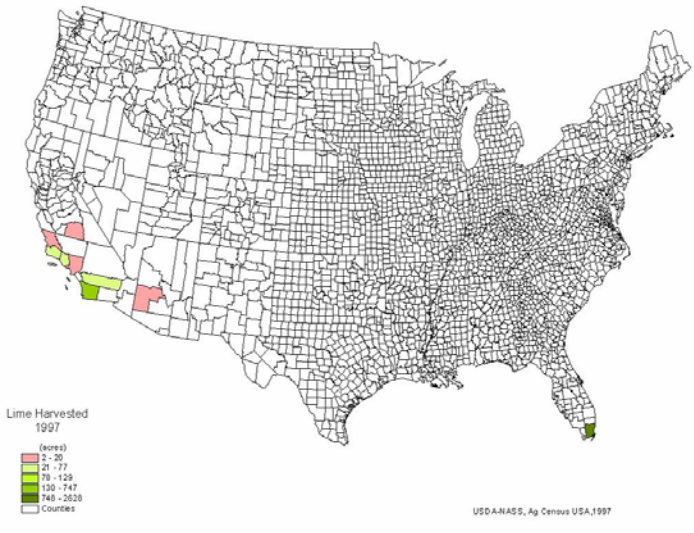
Map 16. Kale (*Brassica alboglabra*)



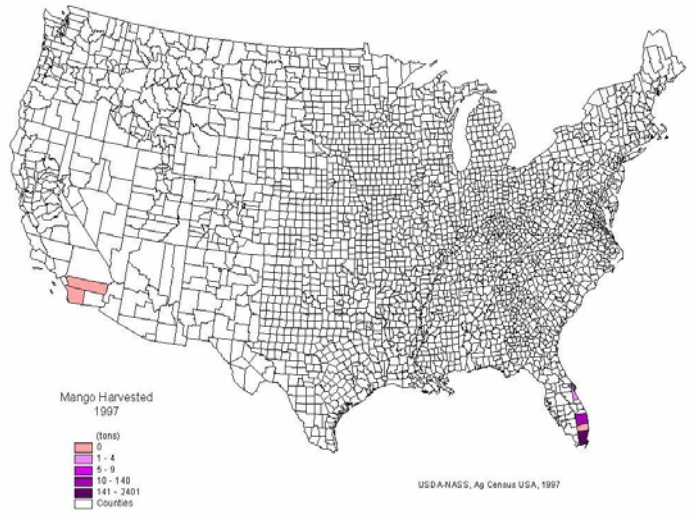
Map 17. Lemon (*Citrus limon*)



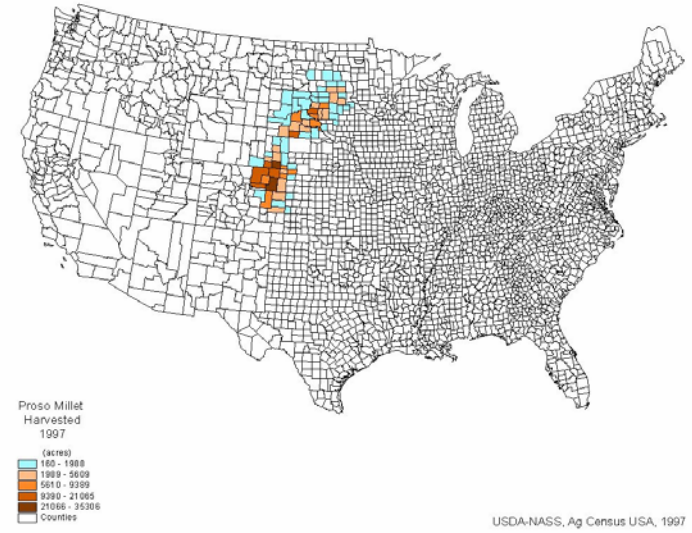
Map 18. Lettuce (*Lactuca sativa*)



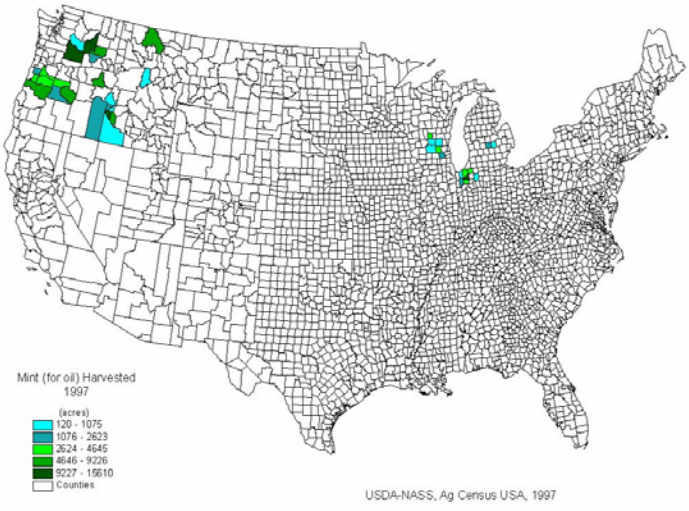
Map 19. Lime (*Citrus aurantifolia*)



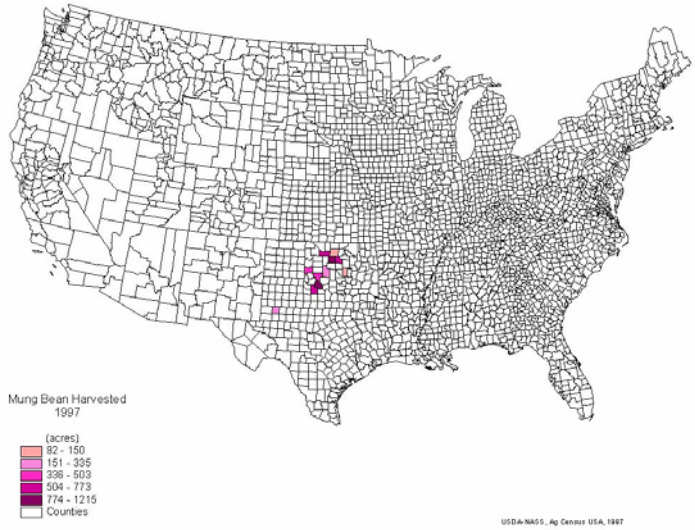
Map 20. Mango (*Mangifera indica*)



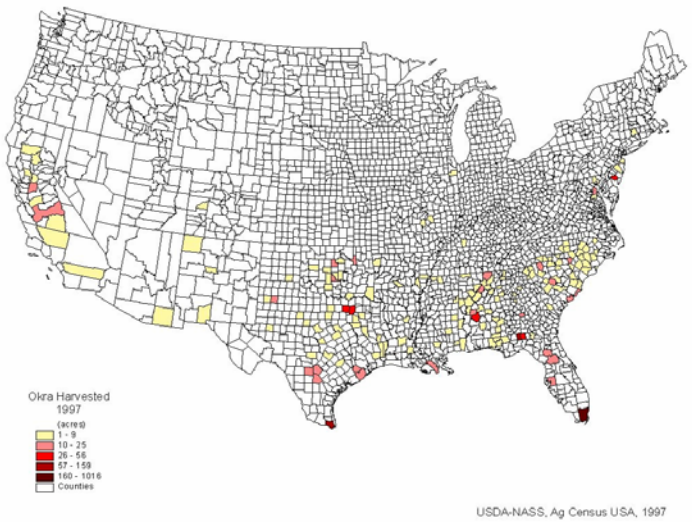
Map 21. Millet; Proso (*Panicum* spp.)



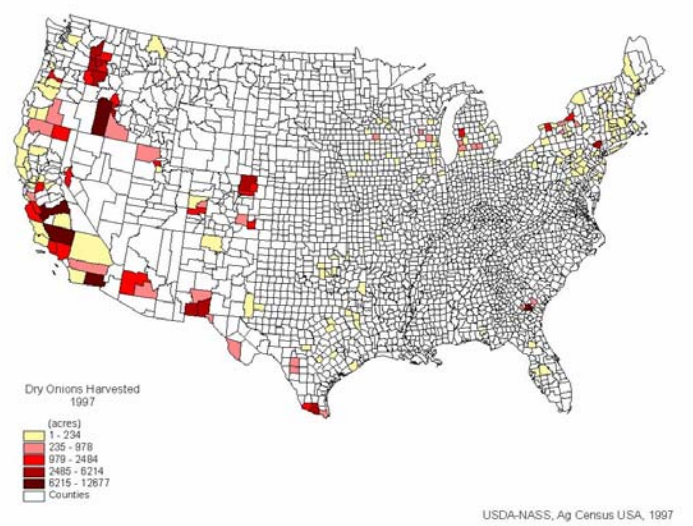
Map 22. Mint for oil (*Mentha* sp.)



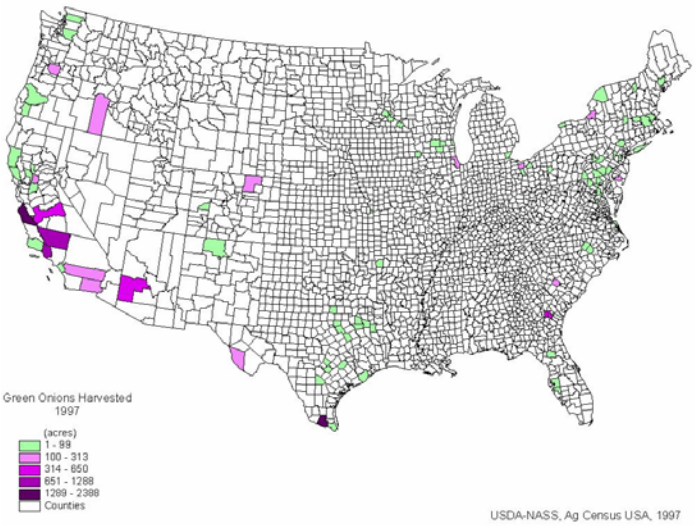
Map 23. Mung Bean (*Vigna radiata*)



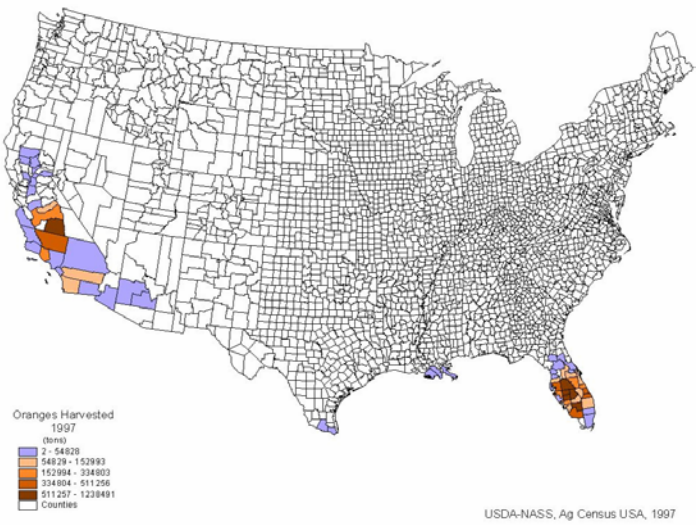
Map 24. Okra (*Abelmoschus* spp.)



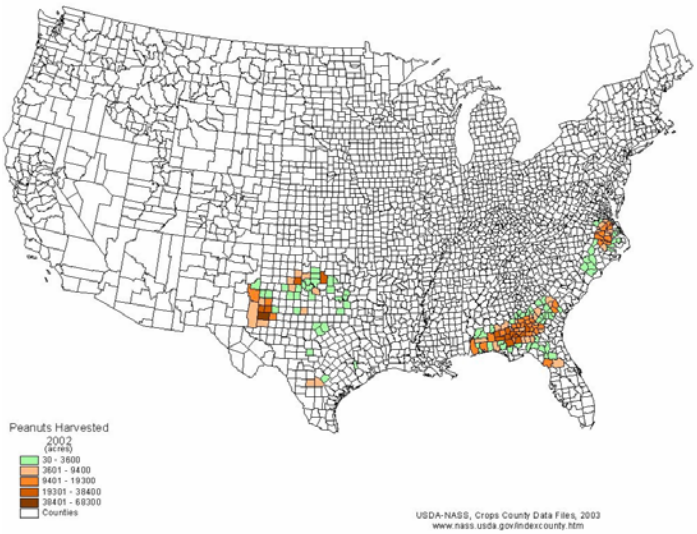
Map 25. Onion; dry (*Allium cepa*)



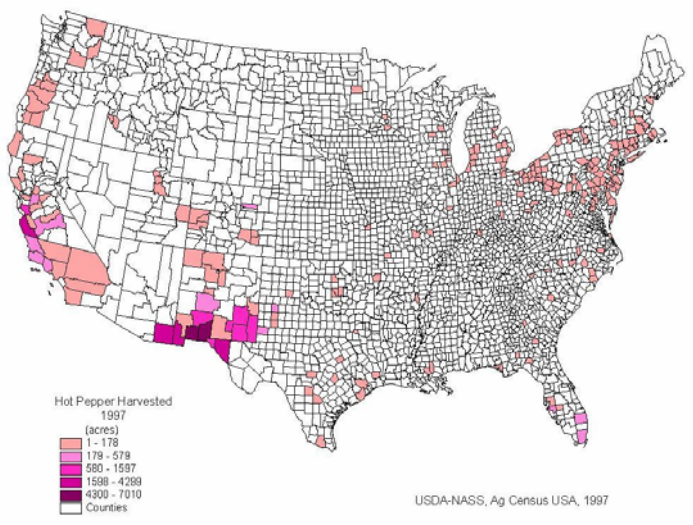
Map 26. Onion; green (*Allium cepa*)



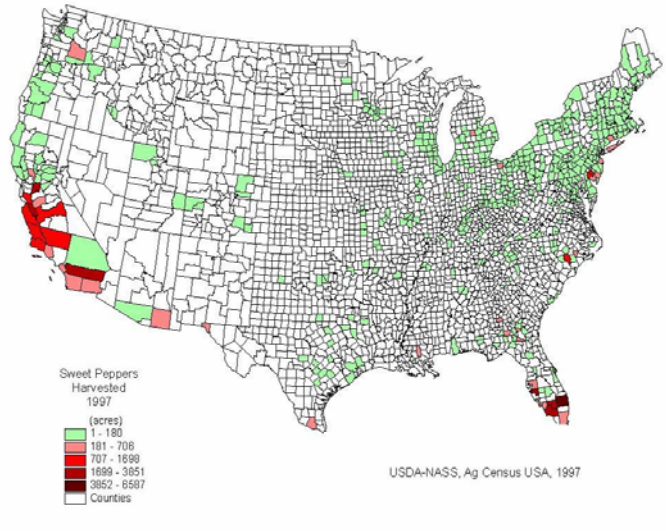
Map 27. Oranges (*Citrus* spp.)



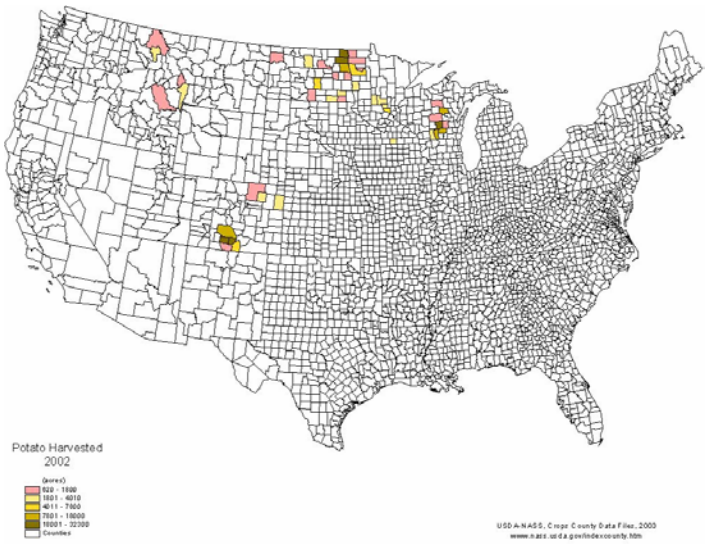
Map 28 Peanut (*Arachis hypogaea*)



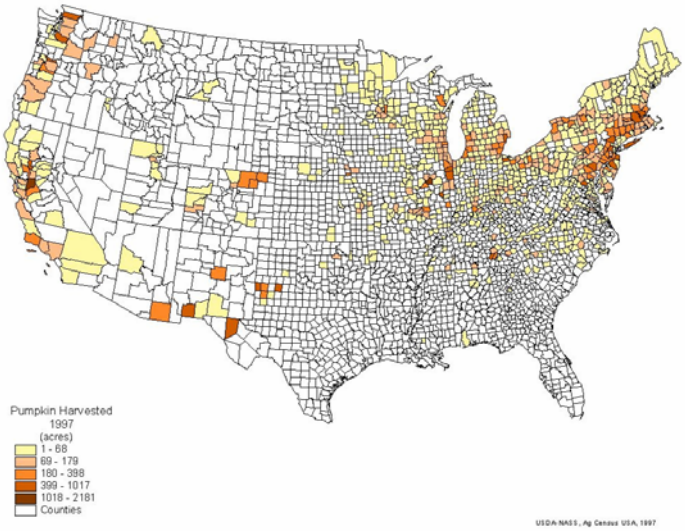
Map 29. Pepper; hot (*Capsicum annuum*)



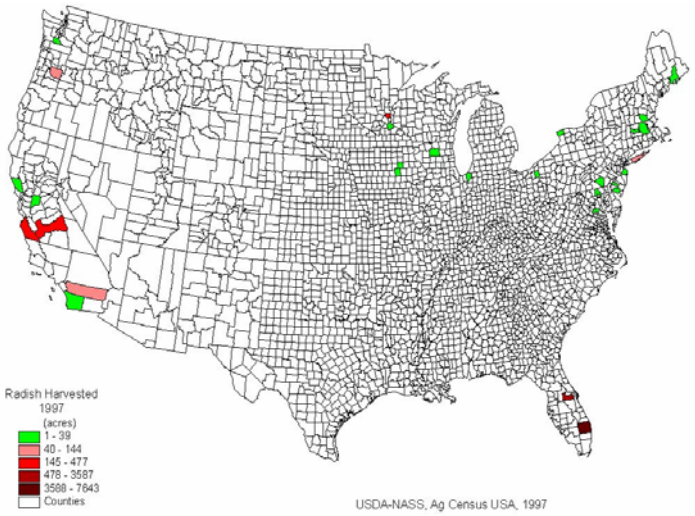
Map 30. Pepper; sweet (*Capsicum annuum*)



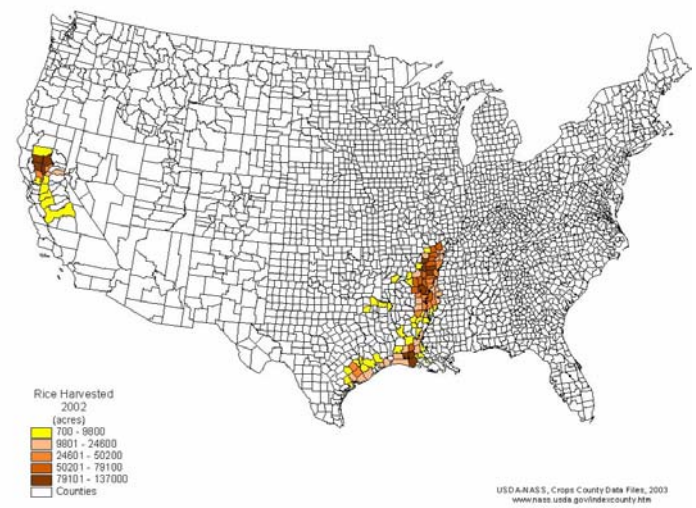
Map 31. Potato (*Solanum tuberosum*)



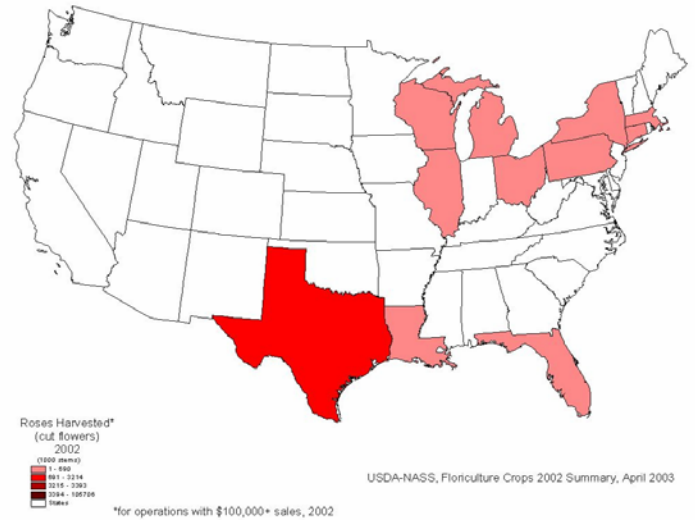
Map 32. Pumpkin (*Cucurbita pepo*)



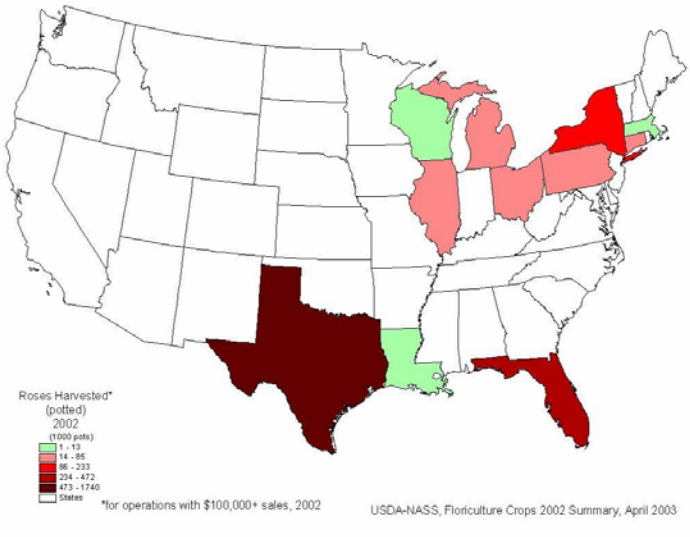
Map 33. Radish (*Raphanus sativus*)



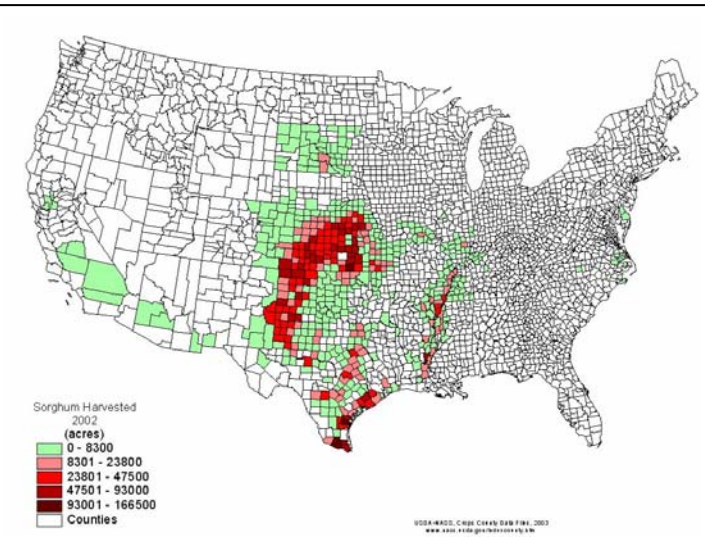
Map 34. Rice (*Oryza sativaa*)



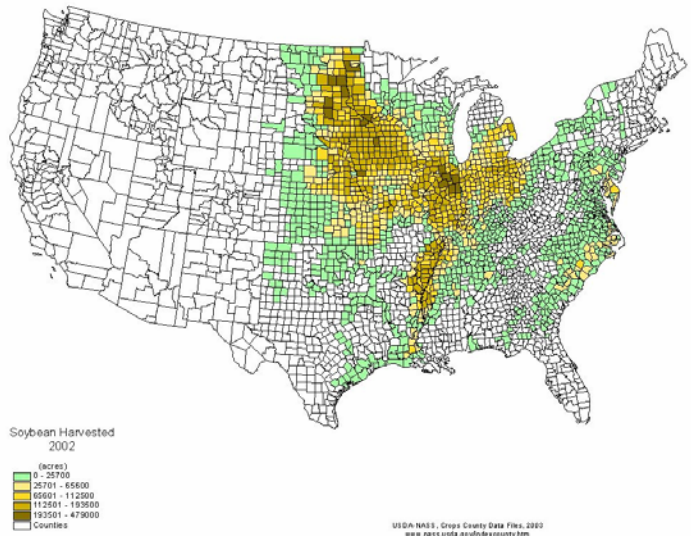
Map 35. Rose; cut (*Rosa* sp.)



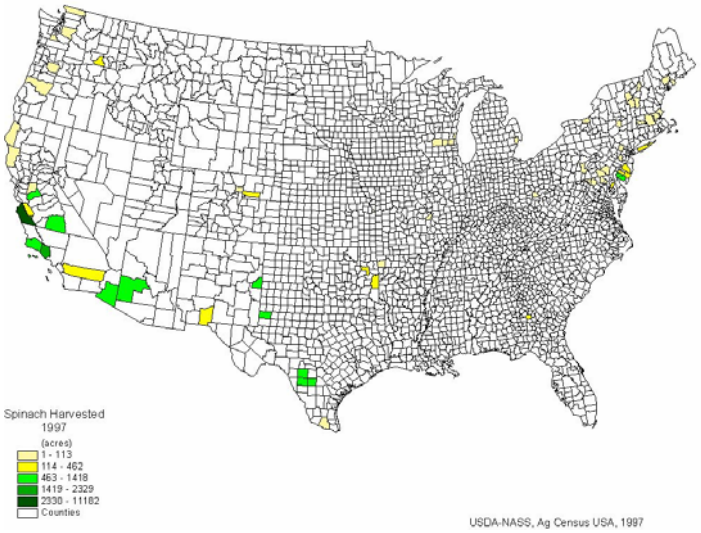
Map 36. Rose; potted (*Rosa* sp.)



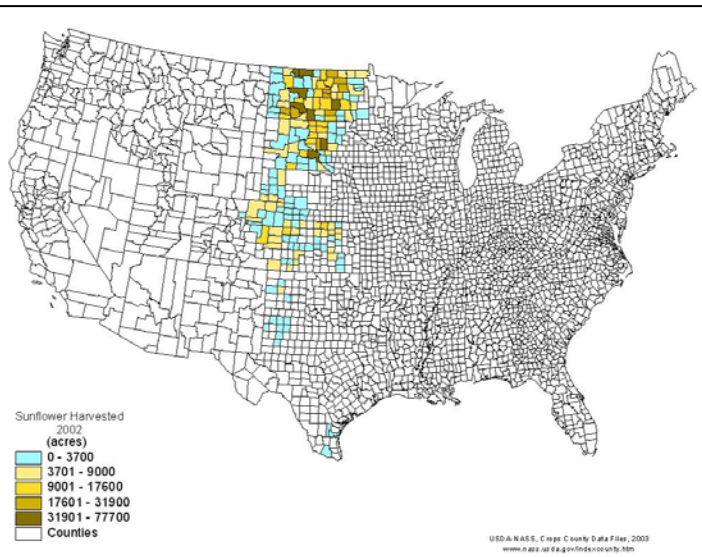
Map 37. Sorghum (*Sorghum bicolor*)



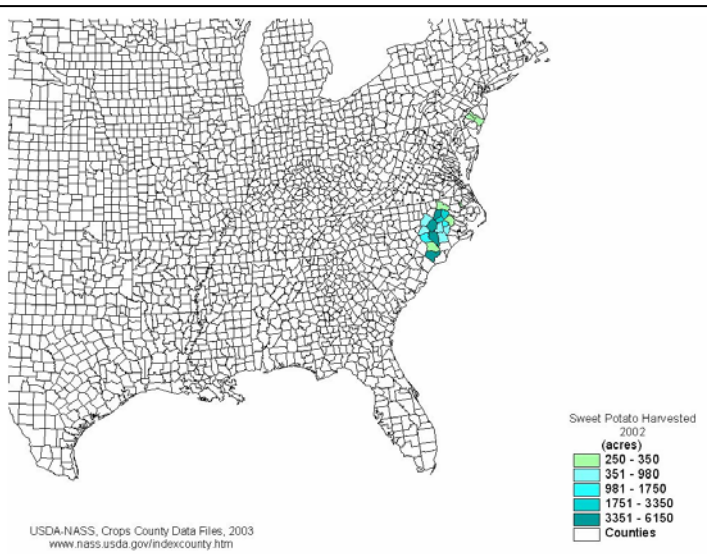
Map 38. Soybean (*Glycine max*)



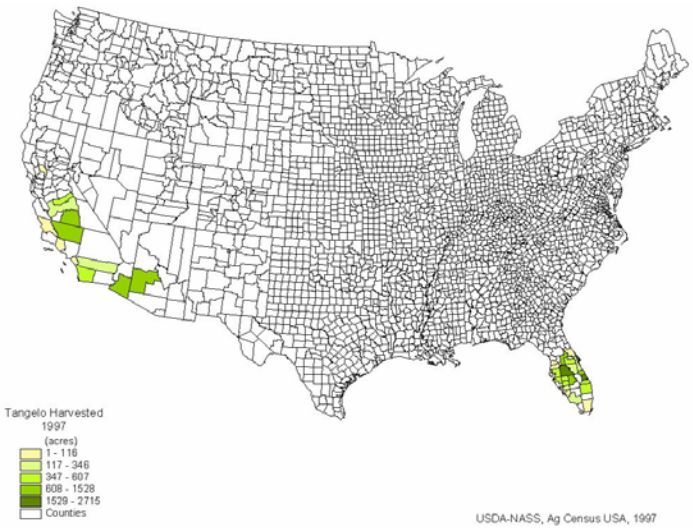
Map 39. Spinach (*Spinacia oleracea*)



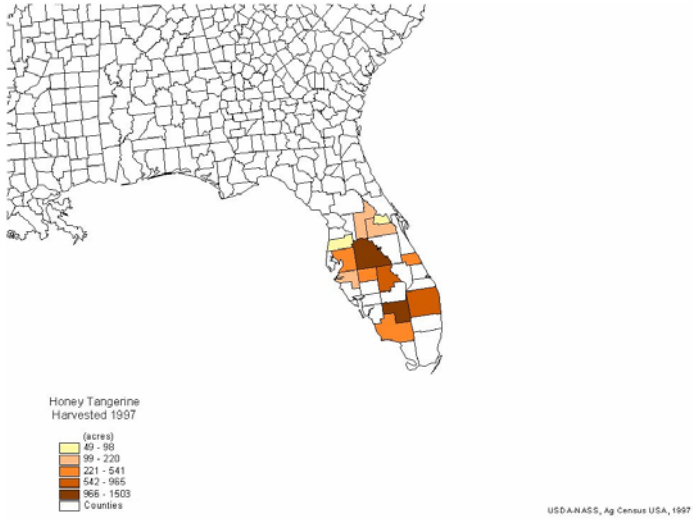
Map 40. Sunflower (*Helianthus annuus*)



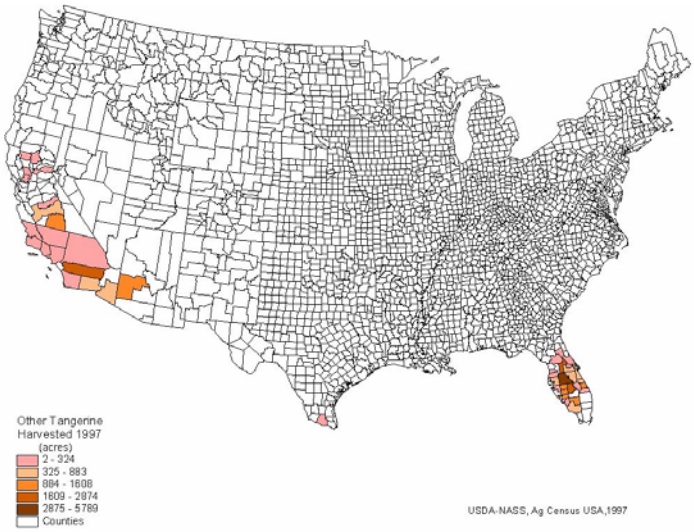
Map 41. Sweet Potato (*Ipomoea batatas*)



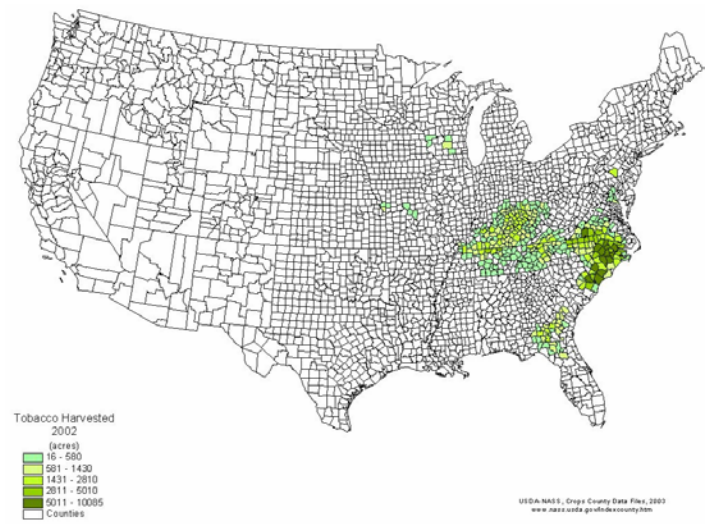
Map 42. Tangelo (*Citrus tangelo*)



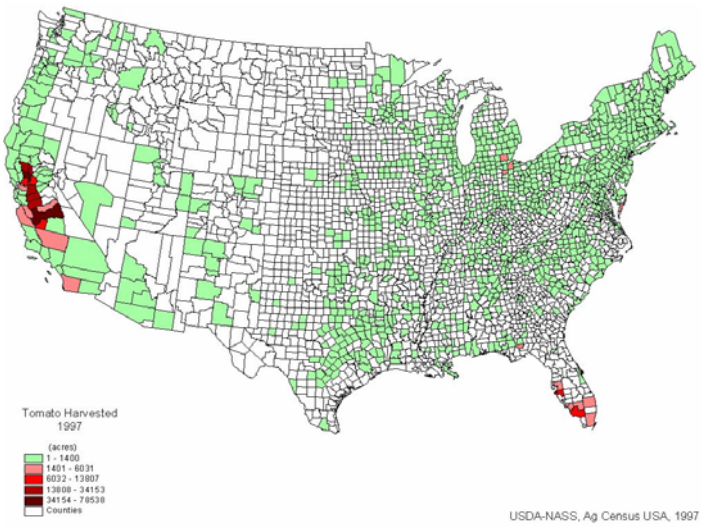
Map 43. Tangerine; honey (*Citrus reticulata*)



Map 44. Tangerine; other (*Citrus reticulata*)



Map 45. Tobacco (*Nicotiana tabacum*)



Map 46. Tomato (*Lycopersicon esculentum*)

Appendix C. Taxonomy of *Spodoptera litura* Fabricius and related Noctuidae (prepared by J. Zaspel).

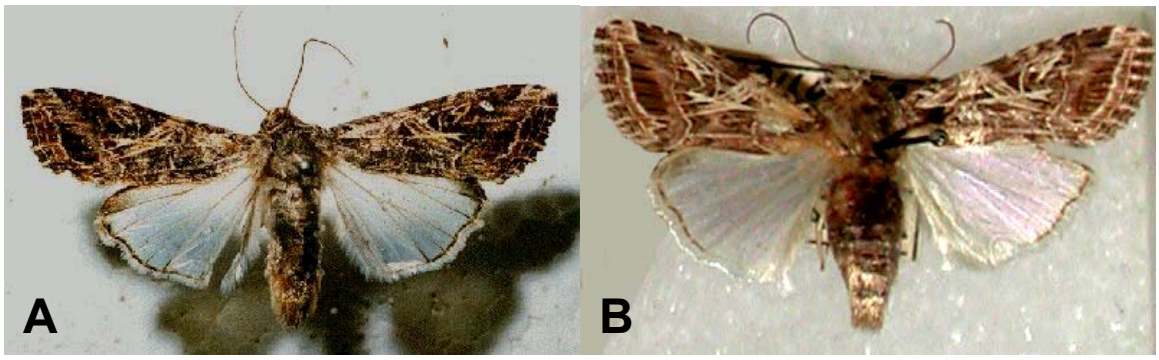


Figure C1. *Spodoptera litura* Fabricius
A. Female (Image from www.usyd.edu.au/su/macleay/larvae/noct/litura.html);
B. Male (Image by J. Zaspel)

Synonyms

At the generic level:
Spodoptera Viette 1863

- *Prodenia* (Guenée 1852a)

At the species level:
litura Fabricius; Hampson (1894)

- *tasmanica* (Guenée 1852a)
- *ciligera* (Guenée 1852a).

Diagnosis of the genus *Spodoptera*

[Description from Pogue (2002)] *Spodoptera* species can be recognized by the gray to brown forewing ground color and white hindwing. Several forewing patterns exist and once recognized can distinguish *Spodoptera* from other genera. In most male genitalia, the valvula is separate from the valve apically (Fig C2). Females have a large tuft of dense scales encircling the eighth abdominal segment.

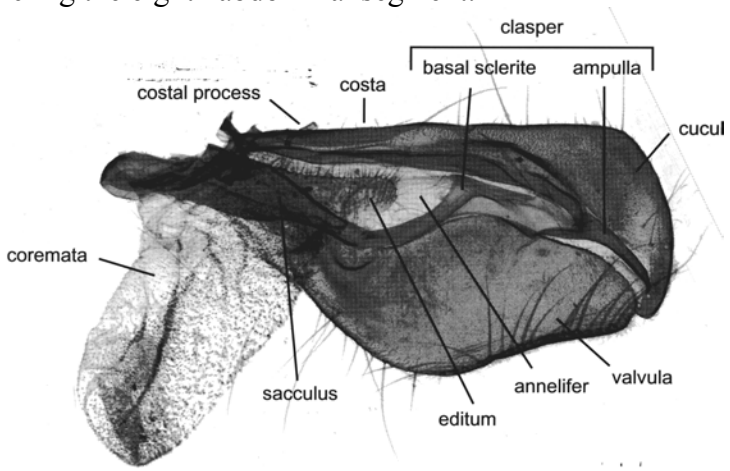


Figure C2 Generalized description of *Spodoptera* valve with structures labeled**.**

Diagnosis of *Spodoptera litura*

[Description from Pogue (2002)] Some males may look different from females externally, for example, most males have a yellowish forewing patch between the antemedial and postmedial lines below vein M (see description below). The orbicular spot is more solid in the male. Forewing length is 14-17mm, and forewing background color ranges from brown to cream. Male genitalia with juxta triangulate (Fig. C3); base of ampulla narrower than in *S. littoralis*; dorsal lobes of coremata almosts as long as ventral lobes (see descriptions below). Female genitalia with distal margin of ventral plate of ostium bursa a broad V-shaped notch; ductus bursae longer than *S. littoralis*.

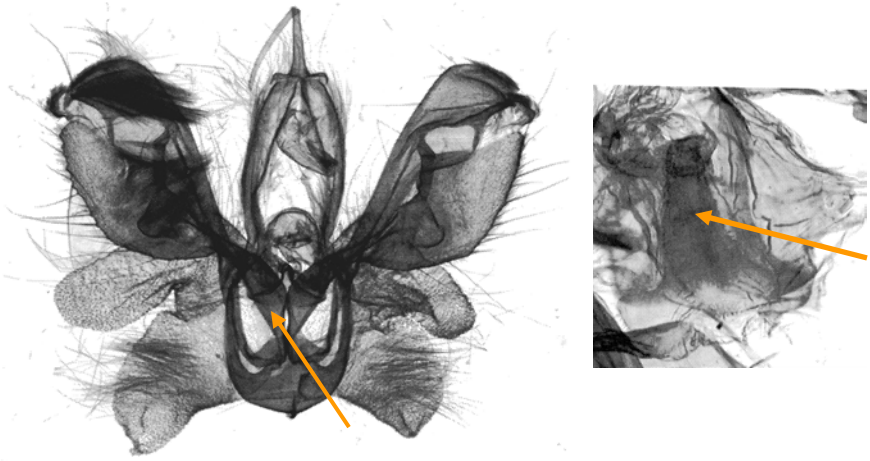


Figure C3. Male genitalia of *Spodoptera litura* ; arrows indicate position of juxta [Reproduced from Pogue (2002)]

Description [from Pogue (2002)]

***Adult Male Head*:** Basal segment of labial palpus cream with median patch variably mixed with black and rufous scales; median segment cream with black median band variably mixed with rufous scales; apical segment black, apex cream. Frons with short scales cream; long scales brown and cream; lateral spots at eye margin brown to black; vertex cream and brown; flagellum cream and brown.

***Thorax*:** Patagium light brown to brown flecked with black, median transverse bans white, apical margin white. Tegula light brown and white (black scales at caudomedial apex). Mesothorax light brown. Underside of thorax white. Prothoracic femur fuscous and cream; tibia with lateral scale tufts not extending beyond first tarsal segment, cream (can have fuscous scales present), subapical spot black; tarsal segments cream. Mesothoracic femur cream (mediolateral subapical patch fuscous); tibia fuscous and cream, inner spur more than twice the length of outer spur, mediolateral surface broadly devoid of scales on both spurs; tarsal segments 1-4 fuscous with cream apical rings, segment 5 cream. Metathoracic femur cream and rufous; tibia cream and rufous; tarsal segments 1-4 cream with bases fuscous, segment 5 cream.

***Forewing*:** ♂: Length 14-17mm; ground color brown; basal line absent; longitudinal black dash at base absent; R vein from base to reniform spot gray; basal triangular scale patch between R and Cu veins brown bordered by white [see Fig. C4 for description of forewing venation]; basal half circle scale patch below Cu vein light brown bordered by black; antemedial line black, indistinct; claviform spot absent; basal scale patch gray from costa to posterior margin (indistinct above Cu vein); gray patch covering anal cell and half of cell CuA2 absent; oblique brown mark from fifth outer marginal spot to vein CuA2 absent; curved white line from antemedial line to postmedial line absent; orbicular spot on oblique trapezoid, cream, with a light brown center bordered by light brown to black; reniform spot brown outlined in white on proximal border, distal apex is triangular light brown spot outlined in white, a white distal border extending to middle; white scales along Cu vein from orbicular spot to junction of veins M3, CuA1 which extend down to veins M3, CuA1, and CuA1 in postmedian area; subterminal line a light brown band bordered by white; apex with a few white scales, no distinct patch; dark gray spindle-shaped spots along outer margin; fringe gray. Underside ground color pale gray; outer margin with black crescent-shaped spots; reniform spot gray.

♀: Length, 15-18mm. Longitudinal black dash at base absent; basal scale patch small, gray, from midway between M and anal veins to anal vein; gray patch covering anal cell and half of cell CuA2 absent; orbicular spot and oblique trapezoid, cream, with a gray center, bordered by thin black line distally; reniform spot more gray with a light brown to gray apical spot outlined in white; postmedian band less distinct and tends to be more brown; black scale patches in middle of cells R4 to CuA2, patch in R4 basal to other patches, patch in R5 consisting of only a few scales in postmedian area.

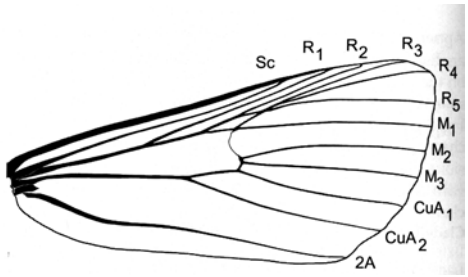


Figure C4. General diagram of forewing venation [Reproduced from Pogue (2002)]

***Hindwing*:** Ground color white; apex, outer margin, and veins with light brown scales; fringe white. Underside ground color white; costal cells C and Sc cream speckled with rufous and gray scales [see Fig. C5 for a description of hindwing venation]; outer margin with a few faint gray spots in middle of cells Sc to CuA1; no spot on underside.

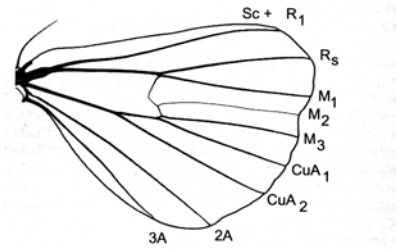


Figure C5. General diagram of hindwing venation [Reproduced from Pogue (2002)]

***Variation*:** Variation exists in the forewing ground color ranging from brown to cream. The lighter colored specimens are dominant among the islands of the Western Pacific. The ground color exhibits its full range in the Marquesasa Islands. Lighter forms are found on Kiribati, Christmas Island, Henderson island, Marshal Islands, and the Northern Marinas. The darker form is found in the Oriental and Australian realms, including the Philippines and Indonesia.

Sexual dimorphism is present. The male has a yellowish forewing patch between the antemedial and postmedial lines below vein M. Not all specimens show sexual dimorphism; some males have no yellowish patch. The orbicular spot is more solid in the male.

***Abdomen*:** ♂: Dorsum pale gray to gray; venter cream (rufous scales can be present); disto-lateral black spots on sternites sbasent (can have a few remnant scales on some specimens); 8th tergite with speculate patches present on caudal margin.

♀: Fine dense scales on 8th segment, cream.

***Male Genitalia*:** Uncus curved in apical half; slender, gradually narrowing toward pointed apex; setae absent or few. Scaphium elongate, weakly developed. Tegumen lacking a pair of projecting arms on upper third. Costa slightly bent at middle. Costal processes narrow, elongate; at base of costa on inner edge; perpendicular to costa of valve. Cucullus apex truncate; not produced (Fig. C6). Anellifer with lightly sclerotized plate bearing setae present. Ampulla elongate, slightly curved with a decurved apex; extending to just below apex of valve (Fig. C6). Clasper proper absent. Clavus a minute round projection. Sacculus widest at one-fourth its length, tapering distally; apex truncate. Valvula wider than valve; well differentiated from valve, apex free; apex truncate; indentation large, ventral margin round. Coremata elongate, ventral margin narrowly concave (Fig. C7). Anellus membraneous. Vinculum U-shaped with parallel arms and a robust base. Aedoeagus straight; coecum smaller in diameter than shaft; patch of spines absent on apex of membraneous sheath surrounding aedoeagus. Vesica curving ventrally; short, less than 0.75 length of aedoeagus; apicobasal cornutal patch a wide ribbon; length moderate, extending to before middle of vesica; cornuti in form of minute flat granules; lateral cornutal patch an elongate elliptical area; a mixture of small spines distally and large spines apically; dense cornutal patch subapical on vesica; distal cornutus a bulbous elliptical plate, apex pointed.

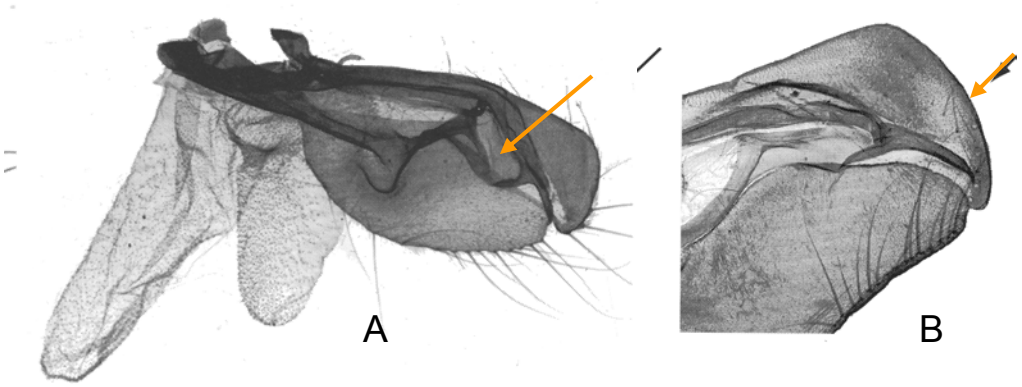


Figure C6. Male genitalia of *Spodoptera litura*; arrows indicate A: ampula, B: cucullus [Reproduced from Pogue (2002)].

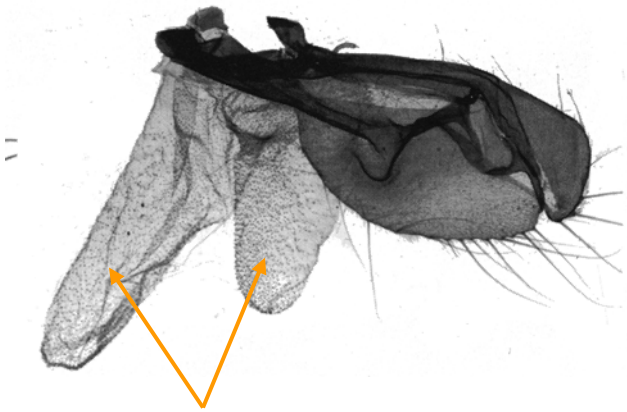


Figure C7. Male genitalia of *Spodoptera litura*; arrows indicate coremata [Reproduced from Pogue (2002)].

***Female Genitalia*:** Ventral plate of ostium bursa with height greater than width; distal margin with a broad V-shaped notch; ventolateral invaginated pocket of 8th sternite absent. Ductus bursae elongate (length greater than 3 times width); completely sclerotized. Appendix bursae membraneous. Corpus bursae bulbous, length is less than twice width; striate convolutions. Signum in apical half of corpus bursae; short, length less than 0.65mm; almost vertical.

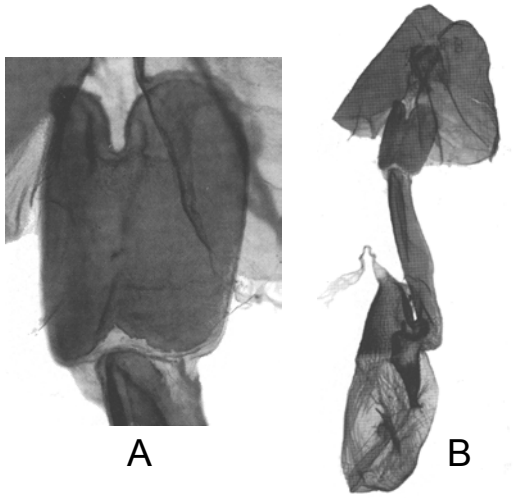


Figure C8. Female genitalia of *Spodoptera litura*; A: ostium bursa plate, B: habitus [Reproduced from Pogue (2002)].

***Larva*:** Head color brown; reticulate; frons brown; cutting edge of mandible serrate; P2 setae farther apart than P1 setae; ratio ecdysial line: frons height, averages between 0.63-0.84. Head dark brown to black, pale brown on vertex and with pael marks laterally; frons dark brown to black; adfrons white.

Pronotum with dorsolateral stripe conspicuous, either solid or consisting of closely spaced spots and dashes; middorsal stripe subequal to dorsolateral stripe. Mesothorax segmental spot semicircular to rectangular; with lateral dark spot present. Metathorax with segmental spot semicircular; white spot at base of segmental spot; lateral dark spot present. Pronotal shield black with pale speckling.

Figure C9. Larva of *Spodoptera litura*; A: Lateral view, B: Dorsal view. [Reproduced from Pogue (2002)].

Abdomen body smooth; setal pinacula minute. Middorsal stripe inconspicuous, narrower than dorsolateral stripe. Segmental spots on abdominal segments 7 and 8 larger than on 1-6 (variable, can be almost uniform in size on some specimens); wide on segments 1-6, almost extending to middorsal stripe (can be faint); with a distinct white spot near apex; spot on 8th abdominal segment larger than on meso thorax. Segment 1 with lateral dark spot present. Segments 2-6 with lateral dark spots in spiracular band present. Spiracular band reticulate; segments 1-6 in spiracular band with white or light colored spot caudal to spiracle present. Spiracles with black border and brown cernter; not stalked. Subspiracular stripe continuous through abdominal segment 1. Crochets uniordinal; total number on one side of body greater than 107 (range: 116-141; average: 127.3; n=10). Ground color dark grayish to blackish with pale speckling. Middorsal stripe yellow. Segmental spots black. Dorsolateral stripe yellow. Subspiracular stripe dull yellow. Spiracles black. Venter dull green. Thoracic legs black. Proleg shields black (Fletcher 1914; Gardner 1941).

Variation occurs in the ground color with both light and dark froms known. Ground color variation influences head color, which varies from yellowish brown to dark brown. Dorsal lateral abdominal marks can be prominent or greatly reduced to absent, especially on segments 2-6.

Similar species:

[Description from Pogue (2002)]. External pattern (Fig. C10) and color of *S. litura* are almost indistinguishable from *S. littoralis* and *S. picta* (Pogue 2002). See species diagnosis (above) for distinguishing characteristics.

Figure C10. Adult *Spodoptera* spp.; A: *S. litura*, B: *S. littoralis*, C: *S. picta* [Reproduced from Pogue (2002)].

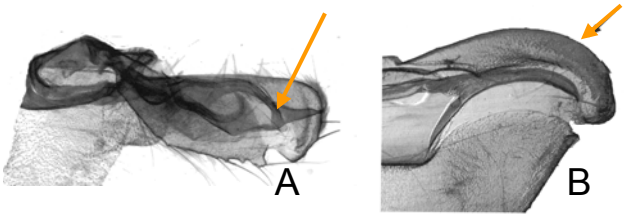


Figure C11. Male genitalia of *Spodoptera littoralis*; arrows indicate A: ampula, B: cucullus [Reproduced from Pogue (2002)].

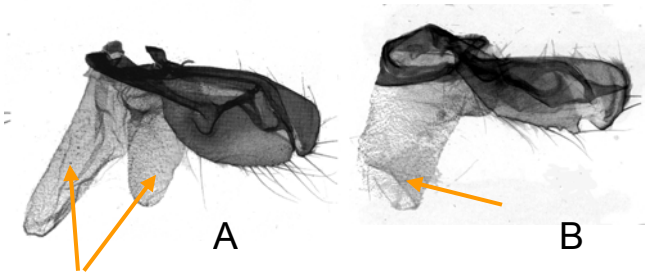


Figure C12. Coremata (indicated by arrows) of male genitalia; A: *Spodoptera litura*, and B: *S. littoralis* [Reproduced from Pogue (2002)]

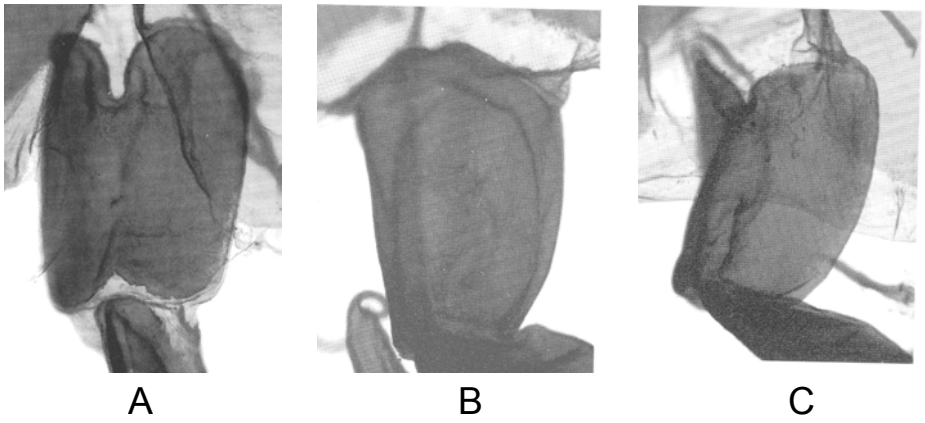


Figure C13. Ostium bursa plate of female genitalia; A: *Spodoptera litura*, B: *S. littoralis*, and C: *S. picta* [Reproduced from Pogue (2002)].

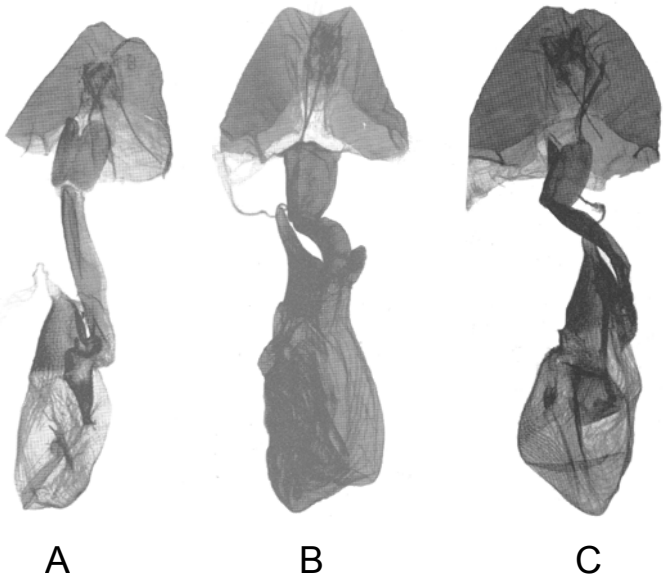


Figure C14. Habitus of female genitalia; A: *Spodoptera litura*, B: *S. littoralis*, and C: *S. picta* [Reproduced from Pogue (2002)].

Figure C15. Valves of male genitalia; A: *Spodoptera litura*, B: *S. littoralis*; and C: *S. picta* valves [Reproduced from Pogue (2002)].

Spodoptera litura can also be differentiated from *S. mauritia* by the serrate edge of the mandible in *S. litura*. This species can be separated from *S. exigua* because *S. litura* has dorsal lateral marks on the meso- and metathorax, a smaller number of crochets on the prolegs, and the ratio of the ecdysial line versus frons height averages between 0.63-0.84.