Mini Risk Assessment
Giant African Snail, *Achatina fulica* Bowdich
[Gastropoda: Achatinidae]

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Introduction

The giant African snail, *Achatina fulica*, occurs in a large number of countries around the world, but all of the countries in which it is established have tropical climates with warm, mild year-round temperatures and high humidity. The snail has been introduced purposefully and accidentally to many parts of the world for medicinal purposes, food (escargot), and for research purposes (Raut and Barker 2002). In many instances, the snail has escaped cultivation and established reproductive populations in the wild. In Florida and Queensland, established populations were eradicated (Raut and Barker 2002). Where it occurs, the snail has the potential to be a significant pest of agricultural crops. It is also an intermediate host for several animal pathogens. As a result, this species has been listed as one of the 100 worst invasive species in the world.

Figure 1. Giant African Snail (Image courtesy of USDA-APHIS).

Established populations of *Achatina fulica* are not known to occur in the United States (Robinson 2002). Because of its broad host range and geographic distribution, *A. fulica* has the potential to become established in the US if accidentally or intentionally introduced. This document evaluates several factors that influence the degree of risk posed by *A. fulica* and applies this information to the refinement of sampling and detection programs.

1. **Ecological Suitability. Rating: Low "***Achatina fulica* is believed to have originally inhabited eastern coastal Africa. It has been purposefully transported to other areas in Africa and today occupies at Ethiopia, Ghana, Kenya, Ivory Coast, Morocco, Mozambique, Somalia, and Tanzania.

Currently, achatinid distribution includes virtually all of sub-Saharan Africa (Raut and Barker 2002). These snails thrive in forest edge, modified forest, and plantation habitats; which is the very habitat which has been most profoundly influenced by the activities of man. Upon arrival in many of these areas, pest status was established anywhere from eight months to ten years following introduction (Raut and Barker 2002)"(Smith and Fowler 2003).

When *A. fulica* becomes established, the most severe infestations tend to be in disturbed areas including residential and crop lands, forest edges, shorelines and along roadways (Numazawa et al. 1988). Larger snails are capable of spreading into undisturbed areas (Numazawa et al. 1988). Snails can also hide beneath soft soil (Shah 1992).

Raut and Barker (2002) suggest that *A. fulica* is tolerant of a wide variety of environmental conditions. Data presented by these authors were used in a subsequent analysis by Smith and Fowler (2003) who concluded that temperatures in the southern-border and Pacific coast states were likely to be suitable to the snail. Our analysis of the worldwide geographic distribution of *A. fulica* suggests that this snail is most closely associated with tropical and subtropical moist broadleaf forests; and tropical and subtropical dry broadleaf forest. Tropical and subtropical dry broadleaf forest does not occur in the United States. Our analysis suggests that <<1% of the area within the continental US would be suitable for establishment of *A. fulica* (Fig. 2). It is interesting to note that the predicted suitable areas occur near Miami, where the only known established populations of *A. fulica* have been observed. Robinson (2002) notes that eradication program was carried out in Arizona and that the eradication effort was judged successful in the same year that the snails were detected. As a result, it is difficult to know for certain whether the species could tolerate environmental conditions in Arizona.

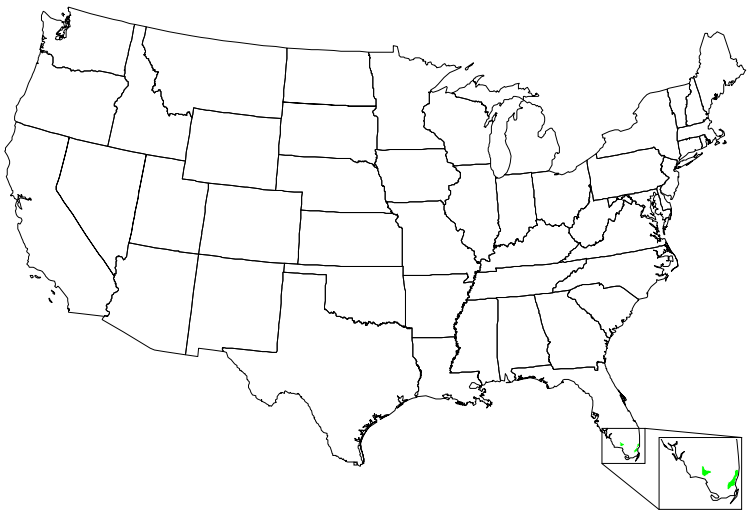

Figure 2. Predicted distribution (shaded green) of *Achatina fulica* in the continental US.

Our results are consistent with Bequaert (1950) who concluded: "*A. fulica* is for all practical purposes a typical tropical snail. The known distribution in its original East African home, between lat. N 7º 30' and lat. S 17º, is well within the tropics. This is true also for most of the areas to which it has spread, with the exceptions of Okinawa and the Bonins (lat. N 26º to 27º). The latter have an unusually warm climate for the latitude, owing to the powerful hot Northern Equatorial Current. Wherever it occurs, the snail keeps to the hot lowlands and the warm temperate lower slopes of the mountains. It evidently needs a combination of a constantly high temperature, well above freezing the year round, and much humidity at least during part of the year, the drier months being spent in dormant estivation. At the same time it is averse to sunshine, exposure to the direct rays of the sun killing it off rapidly. Conditions essential to the permanent survival of *A. fulica* do not seem to occur anywhere in the continental United States, no part of which is completely free at all times of winter frosts; while, in addition, most of the warmer areas are deficient in rainfall or lack protection against the sun. Nevertheless, controlled experiments, under strict supervision, but under natural conditions in a presumably favorable area, are called for in order to determine once and for all whether or not the snail could survive the winter and reproduce freely in the United States."

2. **Host Specificity/Availability. Rating: Low/High.** Table 1 lists host plants reported for *A. fulica.* This species has a remarkably broad host range. *Achatina fulica* appears to prefer certain plants for food; specifically, younger snails prefer soft textured banana (*Musa*), bean (*Beta vulgaris*) and marigold

(*Tagetes patula*) (Raut and Ghara 1989, Thakur 1998). As the snail matures, dietary preferences broaden to include a larger variety of plants (Singh and Roy 1979, Thakur 1998), including: brinjal (*Solanum melongena*), cabbage and cauliflower (*Brassica oleracea v. capitata* and *botrytis*), Lady's finger (*Abelmoschus esculentus*), sponge gourd (*Luffa cylindrica*), pumpkin (*Cucurbita pepo*), papaya (*Carica papaya*), cucumber (*Cucumis sativus*) and peas (*Pisum sativum*) (Thakur 1998).

Table 1. Host plants of *Achatina fulica.*

Common name	**Scientific name**	**Reference(s)**
African locust bean	*Parkia filicoidea*	(Smith and Fowler 2003)
African oil palm	*Elaeis quineensis*	(Raut and Barker 2002)
air potato	*Dioscorea bulbifera*	(Singh and Roy 1977, 1979)
aloe	*Aloe indica*	(Raut and Barker 2002, Smith and Fowler 2003)
alsophila	*Alsophila*	(Raut and Barker 2002, Smith and Fowler 2003)
amaranth	*Amaranthus*	(Singh and Roy 1979, Raut and Barker 2002, Smith and Fowler 2003)
apple	*Malus*	(Monney 1994, Sidelnikov and Stepanov 2000)
Arabian coffee	*Coffea arabica*	(Raut and Barker 2002)
aubergine	*Solanum melongena*	(Singh and Roy 1979, Sharma and Agarwal 1989, Raut and Barker 2002)
Aztec marigold	*Tagetes erecta*	(Raut and Barker 2002)
balsampear	*Momordica cochinchinensis*	(Raut and Barker 2002, Smith and Fowler 2003)
banana	*Musa*	(Mead 1961, Balasubramanian and Kalayanasundaram 1973, Sharma and Agarwal 1989, Padmanaban et al. 1999, Smith and Fowler 2003, Thakur 2003)
basella	*Basella alba*	(Raut and Barker 2002)
bauhinia	*Bauhinia acuminata*	(Raut and Barker 2002)
bean	*Phaseolus*	(Sharma and Agarwal 1989, Raut 1991, Smith and Fowler 2003)
betel	*Piper betel*	(Raut and Barker 2002)
Bird of Paradise	*Heliconia* spp.	(Smith and Fowler 2003)
bittermelon	*Momordica charantia*	(Smith and Fowler 2003)
blackeyed pea	*Vigna unguiculata*	(Raut and Barker 2002)
blimbi	*Averrhoa bilimbi*	(Raut and Barker 2002, Smith and Fowler 2003)
blue-sage	*Eranthemum* spp.	(Balasubramanian and Kalayanasundaram 1973)
bluestem	*Andropogon*	(Smith and Fowler 2003)

Common name	Scientific name	Reference(s)
boatlily	*Tradascantia spathacea*	(Raut and Barker 2002)
bottle gourd	*Lagenaria siceraria*	(Raut 1991, Smith and Fowler 2003)
bouganvillea	*Bougainvillea*	(Balasubramanian and Kalayanasundaram 1973, Raut and Barker 2002)
breadfruit	*Artocaropus altilis*	(Raut and Barker 2002, Smith and Fowler 2003)
brinjal (*see aubergine*)		
broccoli	*Brassica oleracea* var. *botrytis*	(Balasubramanian and Kalayanasundaram 1973)
buckhorn	*Opuntia*	(Raut and Barker 2002, Smith and Fowler 2003)
bulrush	*Scripus ternatanus*	(Tomiyama 1994)
butterfly pea	*Centrosema*	(Muniappan et al. 1986, Smith and Fowler 2003)
cabbage	*Brassica oleracea* var. *capitata*	(Balasubramanian and Kalayanasundaram 1973, Sharma and Agarwal 1989, Smith and Fowler 2003)
cacao	*Theobroma cacao*	(Raut and Barker 2002, Smith and Fowler 2003)
cactus	*Cereus*	(Raut and Barker 2002, Smith and Fowler 2003)
calophyllum	*Calophyllum inophyllum*	(Raut and Barker 2002, Smith and Fowler 2003)
canna	*Canna*	(Smith and Fowler 2003)
cantaloupe	*Cucumis melo* var. dudaim	(Raut and Barker 2002, Smith and Fowler 2003)
carambola	*Averrhoa carambola*	(Raut and Barker 2002, Smith and Fowler 2003)
carrot	*Daucus carota*	(Monney 1994, Sidelnikov and Stepanov 2000, Raut and Barker 2002, Smith and Fowler 2003)
cassava	*Manihot esculenta*	(Raut and Barker 2002, Smith and Fowler 2003)
castor	*Ricinus communis*	(Raut and Barker 2002)
cathedral bells	*Bryophyllum* [=*Kalanchoe*]	(Smith and Fowler 2003)
cauliflower (*see broccoli*)		
cayenne pepper	*Capsicum annuum*	(Raut and Barker 2002)
chandelier plant (*see cathedral bells*)		
cherimoya	*Annona cheirimoya*	(Smith and Fowler 2003)
chili pepper	*Capsicum*	(Singh and Roy 1979, Sharma and Agarwal 1989)
Chinese box	*Murraya*	(Smith and Fowler 2003)
Chinese chive	*Allium tuberosum*	(Smith and Fowler 2003)
chrysanthemum	*Chrysanthemum*	(Raut and Barker 2002)

Common name	Scientific name	Reference(s)
	coronarium var. *coronarium*	
clitoria	*Clitoria ternatea*	(Raut and Barker 2002)
coco yam	*Colocasia esculenta*	(Raut and Barker 2002, Smith and Fowler 2003)
coconut	*Cocos*	(Sharma and Agarwal 1989, Raut and Barker 2002)
coffee	*Coffea*	(Sharma and Agarwal 1989, Raut and Barker 2002)
corm	*Amorphophallus paeoniifolius*	(Raut and Barker 2002)
cosmos	*Cosmos*	(Raut and Barker 2002, Smith and Fowler 2003)
cotton	*Gossypium herbaceum*	(Raut and Barker 2002, Smith and Fowler 2003)
cowpea	*Vigna savi*	(Sharma and Agarwal 1989, Smith and Fowler 2003)
crinum	*Crinum* spp.	(Raut and Barker 2002, Smith and Fowler 2003)
crybaby tree	*Erythrina crista-galli*	(Smith and Fowler 2003)
cucumber	*Cucumis edulis, C. sativus*	(Raut 1982, Monney 1994)
dahlia	*Dahlia*	(Raut and Barker 2002)
Dancing-Lady orchid	*Oncidium*	(Smith and Fowler 2003)
Devil's tree	*Alstonia scholaris*	(Singh and Roy 1977)
Dixie rosemallow	*Hibiscus mutabilis*	(Raut and Barker 2002)
dracaena	*Dracaena*	(Balasubramanian and Kalayanasundaram 1973)
drum stick	*Moringa oleifera*	(Raut and Barker 2002, Smith and Fowler 2003)
dumbcane	*Dieffenbachia sequine*	(Raut and Barker 2002)
edible banana	*Musa acuminata*	(Raut and Barker 2002)
Edward rose (*see rose*)		(Balasubramanian and Kalayanasundaram 1973)
elephant's ear	*Xanthosoma*	(Smith and Fowler 2003)
eranthemum (*see blue-sage*)		
erythrina	*Erythrina*	(Raut and Barker 2002)
eucalyptus	*Eucalyptus*	(Raut and Barker 2002)
false nettle	*Boehmeria*	(Smith and Fowler 2003)
field mustard	*Brassica campestris* var. *rapa*	(Balasubramanian and Kalayanasundaram 1973, Smith and Fowler 2003)
field pumpkin	*Cucurbita pepo*	(Raut and Barker 2002)
fig	*Ficus hispida*	(Raut and Barker 2002)
French plantain	*Musa paradisiaca*	(Raut and Barker 2002)

Common name	Scientific name	Reference(s)
garden pea	*Pisum sativum*	(Raut and Barker 2002)
gardenia	*Gardenia angusta*	(Raut and Barker 2002)
garlic	*Allium oleraceum*	(Sharma and Agarwal 1989, Raut and Barker 2002)
giant taro	*Alocasia macrorrhizos*	(Raut and Barker 2002)
ginger	*Zingiber*	(Smith and Fowler 2003)
globe amaranth	*Comphrena globosa*	(Raut and Barker 2002)
goldenshower	*Cassia fistula*	(Smith and Fowler 2003)
gourd	*Cucurbita*	(Raut and Barker 2002)
grape	*Vitis vinifera*	(Singh and Roy 1977)
graveyard flower	*Plumeria acuminata*	(Smith and Fowler 2003)
great bouganvillea	*Bougainvillea spectabilis*	(Raut and Barker 2002)
green bean	*Glycine max*	(Raut and Barker 2002)
hoary pea	*Tephrosia*	(Smith and Fowler 2003)
horseradish tree (*see drum stick*)		
hyacinth bean	*Lablab purpureus*	(Raut 1982, Raut and Barker 2002)
impatiens	*Impatiens balsamina*	(Raut and Barker 2002)
Indian bark	*Cinnamonum tamala*	(Raut and Barker 2002)
Indian lettuce	*Lactuga indica*	(Raut and Barker 2002)
Indian marigold	*Tagetes patula*	(Singh and Roy 1979, Raut 1991, Raut and Barker 2002, Smith and Fowler 2003)
Indian mulberry	*Morinda citrifolia*	(Smith and Fowler 2003)
Indian oleander	*Nerium indicum*	(Raut and Barker 2002)
Indian shot	*Canna indica*	(Raut and Barker 2002)
indigo	*Indigofera*	(Smith and Fowler 2003)
Indonesian gum	*Eucalyptus deglupta*	(Raut and Barker 2002)
jackfruit	*Artocaropus heterophyllus*	(Raut and Barker 2002)
jasmine	*Jasmin sambac*	(Raut and Barker 2002)
jute	*Corchorus capsularis*	(Raut and Barker 2002)
kalanchoe	*Kalanchoe pinnatum*	(Raut and Barker 2002)
knol kohl	*Brassica oleracea* var. *cauiorapa*	(Sharma and Agarwal 1989)
kokko	*Albizzia lebbeck*	(Raut and Barker 2002)
kudzu	*Pueraria*	(Muniappan et al. 1986, Smith and Fowler 2003)
laceleaf	*Anthurium* spp.	(Smith and Fowler 2003)
Lady's finger	*Hibiscus esculentus*	(Singh and Roy 1979, Raut 1982)
lagenaria	*Lagenaria*	(Raut and Barker 2002)
lal sag (*see amaranth*)		

Common name	Scientific name	Reference(s)
leadtree	*Leucaena*	(Smith and Fowler 2003)
lemon	*Citrus limon*	(Smith and Fowler 2003)
lettuce	*Lactuga sativa*	(Sharma and Agarwal 1989, Raut 1991, Monney 1994, Raut and Barker 2002, Smith and Fowler 2003)
light-blue snakeweed	*Stachytarpheta jamaicensis*	(Mead 1961, Tomiyama 1994)
Lily of the Incas	*Alstroemeria*	(Smith and Fowler 2003)
lime	*Citrus aurantifolia*	(Smith and Fowler 2003)
lobia (*see cowpea*)		
locoto	*Capsicum baccatum*	(Raut and Barker 2002)
luffa	*Luffa cylindrica*	(Singh and Roy 1979, Raut 1982)
machete plant	*Erythrina berteriana*	(Smith and Fowler 2003)
mahogany	*Swietenia mahagoni*	(Raut and Barker 2002)
maiden grass	*Miscanthus condensatus*	(Mead 1961, Tomiyama 1994)
maize	*Zea mays*	(Sharma and Agarwal 1989, Raut and Barker 2002)
marigold (*see Indian marigold*)		
marshweed	*Limnophila* spp.	(Smith and Fowler 2003)
Madagascar periwinkle	*Lochnera rosea*	(Singh and Roy 1977)
Mandarin orange	*Citrus reticulata*	(Raut and Barker 2002)
monthan (*see banana*)		
moth orchid	*Phalaenopsis* spp.	(Raut and Barker 2002, Smith and Fowler 2003)
mulberry	*Broussonetia papyrifera*	(Raut and Barker 2002)
mung bean	*Phaseolus aureus, Vigna radiata*	(Balasubramanian and Kalayanasundaram 1973, Raut and Barker 2002)
naupaka	*Scaevola*	(Smith and Fowler 2003)
night queen	*Cestrum nocturnum*	(Singh and Roy 1977)
nightshade	*Solanum*	(Smith and Fowler 2003)
nodeweed	*Synedrella nodiflora*	(Singh and Roy 1979, Raut 1991)
okra	*Abelmoschus esculentus*	(Sharma and Agarwal 1989, Raut and Barker 2002, Thakur 2003)
oleander	*Nerium oleander*	(Raut and Barker 2002)
onion	*Allium cepa*	(Sharma and Agarwal 1989, Raut and Barker 2002)
orange	*Citrus sinensis*	(Raut and Barker 2002, Smith and Fowler 2003)
palm nut	*Areca catechu*	(Raut and Barker 2002)
pancratium	*Pancratium*	(Smith and Fowler 2003)
papaya	*Carica papaya*	(Singh and Roy 1979, Raut 1982, Sharma

Common name	Scientific name	Reference(s)
		and Agarwal 1989, Raut and Barker 2002, Smith and Fowler 2003)
paperflower (*see bouganvillea*)		
passion fruit	*Passiflora*	(Raut and Barker 2002, Smith and Fowler 2003)
passionflower (*see passion fruit*)		
patol	*Trichosanthes dioica*	(Singh and Roy 1977)
peacocksplume	*Falcataria moluccana*	(Raut and Barker 2002)
peanut	*Arachis hypogaea*	(Raut and Barker 2002, Smith and Fowler 2003)
pepper	*Piper*	(Smith and Fowler 2003)
periwinkle	*Catharanthus roseus*	(Raut and Barker 2002)
Peruvian groundcherry	*Physalis peruviana*	(Mead 1961, Tomiyama 1994)
pigweed (*see amaranth*)		
pigeon pea	*Cajanus cajan*	(Singh and Roy 1977)
pineapple	*Ananas comosus*	(Raut and Barker 2002)
pink wood sorrel	*oxalis corymbosa*	(Mead 1961, Tomiyama 1994)
pipturus	*Pipturus*	(Smith and Fowler 2003)
poovan (*see banana*)		
potato	*Solanum tuberosum*	(Raut and Barker 2002)
potato yam (*see air potato)*		
pothos	*Epipremnum pinnatum*	(Raut and Barker 2002)
pricklypear (*see buckhorn*)		
puni	*Basella rubra*	(Raut 1982)
purple amaranth	*Amaranthus blitum*	(Raut and Barker 2002)
purslane	*Portulaca grandiflora*	(Raut and Barker 2002)
quickstick	*Gliricidia sepium*	(Smith and Fowler 2003)
radish	*Raphanus sativus*	(Raut and Barker 2002, Smith and Fowler 2003)
rape	*Brassica napus* var. *napus*	(Smith and Fowler 2003)
rape-jasmine	*Tabernaemontana divaricata*	(Singh and Roy 1977)
rattlesnakemaster	*Eryngium*	(Smith and Fowler 2003)
rice	*Oryza sativa*	(Raut and Barker 2002)
robusta coffee	*Coffea canephora*	(Raut and Barker 2002)
rose	*Rosa* spp.	(Raut and Barker 2002)
rosemallow	*Hibiscus*	(Smith and Fowler 2003)
rubbertree	*Hevea brasiliensis*	(Raut and Barker 2002, Smith and Fowler 2003)

Common name	Scientific name	Reference(s)
sadabahar	*Lachnera rosea*	(Singh and Roy 1979)
sage	*Salvia*	(Smith and Fowler 2003)
sanchezia	*Sanchezia nobilis vargeta*	(Singh and Roy 1977)
sanseviera	*Sansevieria trifasciata*	(Raut and Barker 2002)
scarlet pimpernel	*Anagallis arvensis*	(Mead 1961, Tomiyama 1994)
screw pine	*Pandanus tectorius*	(Raut and Barker 2002)
sensitive plant	*Mimosa*	(Smith and Fowler 2003)
sesame	*Sesamum indicum*	(Singh and Roy 1977)
shishu	*Dalbergia sissoo*	(Raut and Barker 2002)
shoeback plant	*Hibiscus rosasinensis*	(Balasubramanian and Kalayanasundaram 1973, Raut and Barker 2002)
silktree	*Albizzia*	(Raut and Barker 2002, Smith and Fowler 2003)
sinkwa towelsponge	*Luffa acutangula*	(Raut and Barker 2002)
slender amaranth	*Amaranthus viridis*	(Raut and Barker 2002)
snake gourd	*Trichosanthes anguina*	(Raut and Barker 2002)
Solomon's seal	*Polygonatum odoratum*	(Smith and Fowler 2003)
sorghum	*Sorghum*	(Sharma and Agarwal 1989)
soursop	*Annona muricate*	(Raut and Barker 2002, Smith and Fowler 2003)
spiderwisp	*Gynandropsis* [=*Chleome*]	(Raut and Barker 2002, Smith and Fowler 2003)
spinach	*Spinacia oleracea*	(Raut and Barker 2002)
spleenwort	*Asplenium nidus*	(Raut and Barker 2002, Smith and Fowler 2003)
sponge gourd	*Luffa aegyptiaca*	(Raut and Barker 2002)
striped brake	*Pteris quadriaurita*	(Tomiyama 1994)
sugarbeet	*Beta vulgaris* var. *rapa*	(Singh and Roy 1977)
sugarcane	*Saccharum*	(Sharma and Agarwal 1989)
sunflower	*Helianthus annuus*	(Raut and Barker 2002)
swamplily (*see crimum*)		
sweet potato	*Ipomoea batatas*	(Singh and Roy 1979, Raut and Barker 2002)
sweet potato cactus (*see cactus*)		
synedrella (*see nodeweed*)		
tagar (*see nodeweed*)		
Tahitian spinach	*Xanthosoma braziliense*	(Raut and Barker 2002)
tampala	*Amaranthus tricolor*	(Singh and Roy 1977, Raut and Barker 2002)
tapioca (*see cassava*)		

Common name	Scientific name	Reference(s)
taro	*Alocasia*	(Smith and Fowler 2003)
tea	*Camellia sinensis*	(Raut and Barker 2002)
teak	*Tectona grandis*	(Raut and Barker 2002, Smith and Fowler 2003)
theobroma	*Theobroma*	(Smith and Fowler 2003)
thespesia	*Thespesia*	(Smith and Fowler 2003)
tiplant	*Cordyline* spp.	(Smith and Fowler 2003)
tobacco	*Nicotiana tabacum*	(Raut and Barker 2002, Smith and Fowler 2003)
tomato	*Solanum lycopersicum*	(Sharma and Agarwal 1989, Raut and Barker 2002, Smith and Fowler 2003)
towelsponge	*Luffa*	(Raut and Barker 2002, Smith and Fowler 2003)
trattlepod	*Crotolaria*	(Smith and Fowler 2003)
treedaisy	*Montanoa hibiscifolia*	(Smith and Fowler 2003)
treemelon (*see papaya*)		
type of East Asian (China) *Cucurbita*	*Edgaria darjeelingensis*	(Raut and Barker 2002)
vanda orchid	*Vanda*	(Raut and Barker 2002, Smith and Fowler 2003)
vanilla	*Vanilla*	(Raut and Barker 2002)
water yam	*Dioscorea alata*	(Raut and Barker 2002)
watermelon	*Citrullus lanatus*	(Raut and Barker 2002, Smith and Fowler 2003)
white leadtree	*Leucaena leucocephala*	(Tomiyama 1993, 1994)
white mulberry	*Morus alba*	(Raut and Barker 2002)
wild pepper	*Heckeria*	(Smith and Fowler 2003)
wild tantan	*Desmathus virgatus*	(Mead 1961, Tomiyama 1994)
winter squash	*Cucurbita maxima*	(Singh and Roy 1979, Raut 1982, Sharma and Agarwal 1989, Raut and Barker 2002, Smith and Fowler 2003)
woman's tongue (*see kokko*)		
woodnettle	*Laportea*	(Smith and Fowler 2003)
yam	*Colocasia*	(Smith and Fowler 2003)
yam bean	*Pachyrhizus erosus*	(Singh and Roy 1977, Raut and Barker 2002)
zinnia	*Zinnia linearis*	(Singh and Roy 1979, Raut and Barker 2002, Smith and Fowler 2003)

3. **Survey Methodology. Rating: Low.** The USDA outlines a survey procedure listing three optimum times to survey, which include early morning hours when dew is still present, cloudy days and during or after a rain event (Anon 1973, Shah 1992). Snails are most often found attached to objects such as limbs of trees and shrubs, boards, buildings, rock piles, cement blocks, or in piles of lawn clippings, flower beds and bases of trees (Anon 1973). Currently, visual inspections of potential host plants or habitats are the only means to detect the species.

   The USDA's survey plan includes a letter/number system where individual residential properties within an identified infestation area are assigned numbers and letters based on their infestation status. These properties are then surveyed every two weeks (Anon 1973). Information included in this survey include possible pathways of spread, the number and size of living and dead snails, the number of clutches and eggs, the date and amount of time spent on the actual survey as well as names and addresses of property owners (Anon 1973).

   Subba and Ghosh (2001) employed a method of recording shape, color and habitat of samples collected from suspected infestation sites. Samples were preserved in 70% ethanol for further morphological investigations. Shells were also washed, dried and contained in plastic or small vials (Subba and Ghosh 2001).

4. **Taxonomic Recognition**. **Rating: High.** Within the Achatinidae , four species are classified as giant African snails *Achatina achatina, Achatina fulica, Archachatina marginata*, and *Limicolaria aurora* (Smith and Fowler 2003). Of these species, only *Achatina fulica* and *A. marginata* are "truly giant African snails, as the largest specimens recovered [by PPQ] have been in the range of 750 grams and 8 inches shell length" (Smith and Fowler 2003). *Achatina achatina* is the largest gastropod among the giant African snails with a maximum recorded shell length of 27 cm, *A. marginata* is second largest and *A. fulica* the smallest, but only being "somewhat" smaller than it's west African cousin *A. marginata* (CAB 2003). *Achatina fulica* and *A. marginata* both share a determinate shell growth, but *A. marginata* produces a peristome with a reflected lip and reaches sexual maturity 2-4 months later than *A. fulica* (Raut and Barker 2002).

   The difference between *Achatina* spp and *Archachatina* spp is largely in the ranges of habitat. *Achatina* is found throughout sub-Saharan Africa while *Archachatina* species inhabit less humid areas (Raut and Barker 2002). While *Achatina* sp. has been found to favour more humid areas, they are considered to be extremely adaptable to human-induced disturbed areas such as plantations (Raut and Barker 2002)

For a detailed description of the taxonomy and morphology of *A. fulica*, see Appendix B.

5. **Entry Potential. Rating: Low.** Smith and Fowler (2003, 2003) conducted a series of detailed pathway analyses describing the likely arrival of *A. fulica* and three other snail species into the continental US. Their analysis was based on pest interception records from January 1993-June 2003. They write:"Baggage constituted the main pathway for giant African snails. Of the 863 interceptions made, 673 were associated with baggage, and another117 "at large" during inspections (USDA 2004). Therefore, the entry potential is high. Also, 652 of 863 interceptions, or 75% originated in African countries where achatinids are considered edible.... Another 182, or 21%, originated in Hawaii, where the snail is now established on the islands of Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu (Mead 1979, Srivastava 1992)." We agree with their conclusion that the entry potential for Achatinids is high via several pathways. It is important to emphasize that their analysis was for four species, not *A. fulica* alone.

   In a follow-up analysis, Smith (2003) found only 79 interceptions of *A. fulica* had been reported over the same period from 1993-2003. This finding suggests that annually only ~8 interceptions of *A. fullica* are made. Eight additional Achatinid specimens, ~1 per year, were intercepted but not identified to species. The majority of interceptions were associated with international airline passengers' baggage (71%) and the remainder seems to have been associated with cargo (Smith 2003). All of the interceptions of *A. fulica* were made in Hawaii as part of pre-departure clearance inspections. The intended destination of these snails is more fully characterized in the next section (see 'Destination of Infested Material')."

6. **Destination of Infested Material. Rating: High.** When an actionable pest is intercepted, officers ask for the intended final destination of the conveyance. Materials infested with *Achatina fulica* were destined for several states. The majority of international airline passengers found to be carrying *A. fulica* were destined for California (59%), Washington (10%), and New Jersey (5%) (Smith 2003).

7. **Potential Economic Impact. Rating: High.** Costs are incurred not only for actual monetary damage to crops but also for control measures and survey methods. Attempts at control can range from $60,000 dollars (US) for one seven-month manual procedure (Muniappan et al. 1986), to over $700,000 dollars (US) for eradication in Florida (Smith and Fowler 2003). According to Smith and Fowler (2003):

   "Florida estimated annual losses of $11 million [in 1969 dollars] if *Achatina fulica* was left unchecked (USDA 1982). Based on 2002 dollars, that figure

would have become $53,921,568; adjusted for inflation; had eradication not been successful (Garrett 2003)" (Smith and Fowler 2003).

Achatina fulica may be of economic importance as a medicinal and nutritional (protein) source ((Muniappan 1990), (Santos Carvalho et al. 2003)), but remains a serious agri-horticulural pest throughout the Indo-Pacific Islands (Raut 1982). The snail presents possible public health hazards with regards to the spread of diseases such as angiostrongylosis and eosinophilic meningoencephalitis due to its important role as a host in the life cycle of *Angiostrongylus cantonensis* (CAB 2003, Santos Carvalho et al. 2003). Plant diseases such as black pod disease caused by *Phytophthora palmivora* are also spread through the faeces of the snail (Raut and Barker 2002, CAB 2003).

It may be difficult to estimate the extent of possible damage due to the fact that feeding rates will vary depending on the size of the snails and the age of the plants (Raut 1982). Experimental results of different sized snail groups with different food sources show that *A. fulica* does pose a "serious problem to our agri-horticutural economy" (Raut 1982).

Mead (1961) lists four categories of plants that are likely to be damages by the snail. The first category is garden flowers and ornamentals, which are completely susceptible at any stage of development. The second category is mostly vegetables with a higher probability of damage to Cruciferae, Cucurbitaceae and Leguminosae. The third category represents plants usually not eaten at the mature stage but are damaged earlier in development by bark being completely removed as is the case with breadfruit, cassava and teakwood. The final category includes crops upon which damage is indirectly incurred (e.g. when snails destroy a preceding cover crop) (Mead 1961, Muniappan et al. 1986)).

8. **Potential Environmental Impact. Rating: High.** Smith and Fowler (2003) address potential environmental impacts from giant African snails:

"Introduction of an exotic can lead to costs to nature; that is, loss of native populations and communities impacted by the invader; but measuring the economic value of a population of a rare species that is not used by humans is difficult (Civeyrel and Simberloff 1996). Giant African snails can be a hazard on roads, causing skidding of cars that hit them; and they are unsightly and unwelcome visitors to small residential gardens. Their decaying bodies create a stench and their shells can neutralize acid soils, thereby damaging acid-loving plants (Mead 1961)."

Environmental impacts include damage to native plant species, alterations to the food chain through competition with native species and by also providing increased food sources for predators (Mead 1961). The snail aids in the spread of diseases to native organisms through faecal matter and mucus trails

and damages non-food vegetation through large population densities which may cause breakage of limbs and stems (Raut and Barker 2002).

See Appendix C for a list of threatened and endangered plant species that might be adversely affected by *A. fulica.*

9. **Establishment Potential. Rating: Low.** Humans are likely to continue bringing accidentally or intentionally *A. fulica* to the continental US. Smith and Fowler (2003) note:

"Humans have been the main agent of introduction of the giant African snail (Mead 1961). The island of Bioko, Equatorial Guinea, 32 kilometers distant from the African mainland country of Cameroon and infestations of giant African snails, has no achatinid populations ((Raut and Barker 2002); (CIA 2003)). In the Florida infestation, five of six new infestations were associated with movement of yard plants and soil-bearing tools (Mead 1979), and natural dispersal is negligible compared to dispersal occurring via trade and traffic (Anon 1989). The most active individuals tracked in a study moved 500 meters in six months (Tomiyama and Nakane 1993), and natural spread is estimated to be a few hundred meters per year (Lambert and Tillier 1993)"

Our analysis suggests that the likelihood for repeated arrival and successful establishment of *A. fulica* over wide areas of the United States is low. Southern Florida is clearly at greatest as climatic models and historical experiences demonstrate. Where *A. fulica* becomes established, it has the potential to cause severe economic, environmental, and social impacts.

See Appendix D for a more detailed description of the biology of *A. fulica*.

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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 (Table A1). Using a geographic information system (e.g., ArcView 3.2), 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 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. 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. Finally, the set of selected biomes was compared to only those that occur in the US.

Table A1. Reported geographic distribution of *A. fulica*.

Locations	**Reference(s)**
Bangladesh	(Aslam et al. 2000, Smith and Fowler 2003)
Barbados	(Smith 2003, Smith and Fowler 2003)
Bhutan	(Mead 1961, Raut 1999)
Burma (Myanmar)	(Mead 1961, Smith and Fowler 2003)
Brazil	
State of Bahia	(Santos Carvalho et al. 2003)
State of Espirito Santo	(Santos Carvalho et al. 2003)
State of Goias	(Santos Carvalho et al. 2003)
State of Minas Gerais	(Raut and Barker 2002, Santos Carvalho et al. 2003, Smith 2003, Smith and Fowler 2003)
State of Para	(Santos Carvalho et al. 2003)
State of Paraiba	(Santos Carvalho et al. 2003)
State of Parana	(Raut and Barker 2002, Smith and Fowler 2003)
State of Pernambuco	(Santos Carvalho et al. 2003)
State of Piaui	(Santos Carvalho et al. 2003)
State of Rio de Janeiro	(Raut and Barker 2002, Santos Carvalho et al. 2003, Smith 2003, Smith and Fowler 2003)
State of Rondonia	(Santos Carvalho et al. 2003)
State of Santa Catarina	(Raut and Barker 2002, Santos Carvalho et al. 2003, Smith 2003, Smith and Fowler 2003)
State of Sao Paulo	(Raut and Barker 2002, Santos Carvalho et al. 2003, Smith 2003, Smith and Fowler 2003)
Brunei	(Smith and Fowler 2003)
Cambodia	(Muniappan 1990, Smith and Fowler 2003)

Locations	Reference(s)
China	(Mead 1961, Muniappan 1990, Smith and Fowler 2003)
Hong Kong	(Mead 1961, Smith and Fowler 2003)
Taiwan	(Mead 1961, Lambert 1974, Chiu and Chou 1978, Muniappan 1990, Smith and Fowler 2003)
Christmas Island	(Sproul 1983, Lake and O'Dowd 1991)
Comoros	(Smith and Fowler 2003)
Cook Islands	(Lambert 1974)
Cote d'Ivoire	(De Winter 1989, Raut and Barker 2002, Smith and Fowler 2003)
Ethiopia	(Raut and Barker 2002, Smith and Fowler 2003)
Federated State of Micronesia	(Mead 1961, Lambert 1974, Commission 1993, Raut and Barker 2002, Smith and Fowler 2003)
Kiribati (formerly Gilbert Is.)	(Lambert 1974)
Tuvalu (formerly Ellice Is.)	(Lambert 1974)
Chuuk (formerly Truk Is.)	(Lambert 1974)
Ponape Is.	(Lambert 1974)
Yap	(Lambert 1974)
Fiji	(Lambert 1974)
French Polynesia	
Tahiti	(Gerlach 2001, Raut and Barker 2002, Smith and Fowler 2003)
Rikitea	(Gerlach 2001, Raut and Barker 2002, Smith and Fowler 2003)
French West Indies	(Raut and Barker 2002)
Guadeloupe	(Muniappan 1990, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Martinique	(Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Ghana	(Raut and Barker 2002, Smith and Fowler 2003)
Hawaiian Islands	(Mead 1961, Lambert 1974, Raut 1991, Sidelnikov and Stepanov 2000, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Hawaii	(Mead 1961)
Kauai	(Mead 1961)
Maui	(Mead 1961)
Oahu	(Mead 1961)
India	(Mead 1961, Balasubramanian and Kalayanasundaram 1973, Singh and Roy 1979, Sharma and Agarwal 1989, Muniappan 1990, Raut 1991, Shah 1992, Rao and Singh 2000, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)

Locations	Reference(s)
Andaman & Nicobar Islands	(Balasubramanian and Kalayanasundaram 1973, Singh and Roy 1979, Sharma and Agarwal 1989, Shah 1992, Sidelnikov and Stepanov 2000, Smith and Fowler 2003)
Province of Assam	(Balasubramanian and Kalayanasundaram 1973, Singh and Roy 1979, Sharma and Agarwal 1989, Shah 1992)
N. Bengal (see Bhutan)	(Mead 1961, Raut 1999)
West Bengal	(Balasubramanian and Kalayanasundaram 1973, Singh and Roy 1979, Sharma and Agarwal 1989, Shah 1992, Raut and Barker 2002)
Bihar	(Balasubramanian and Kalayanasundaram 1973, Singh and Roy 1979, Sharma and Agarwal 1989, Shah 1992, Raut 1999, Thakur 2003) (Raut and Barker 2002)
Bombay	(Mead 1961)
Calcutta	(Mead 1961, Raut and Ghara 1989, Raut 1999, 2002)
Kerala	(Balasubramanian and Kalayanasundaram 1973, Singh and Roy 1979, Sharma and Agarwal 1989, Shah 1992)
Manipur (Imphal)	(Raut and Barker 2002)
Jharkand (Chaibasa, Dumka)	(Raut and Barker 2002)
Orissa	(Balasubramanian and Kalayanasundaram 1973, Sharma and Agarwal 1989, Shah 1992)
Rajikot (state of Gujarat)	(Mead 1961)
Tamil Nadu	(Balasubramanian and Kalayanasundaram 1973, Singh and Roy 1979, Sharma and Agarwal 1989, Shah 1992, Padmanaban et al. 1999)
Indonesia	
Irian Jaya (New Guinea)	(Mead 1961, Lambert 1974)
Java	(Mead 1961, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Sumatra	(Mead 1961, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Niue (island near New Zealand)	(Lambert 1974)
Japan	(Mead 1961, Lambert 1974, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Bonin islands (Chichjima, Hahajima, Anijima)	(Mead 1961, Numazawa et al. 1988, Tomiyama 1993, Takeda and Ohtake 1994, Tomiyama 1994, 1996, Raut and Barker 2002, Okochi et al. 2004)
Ryukyu Islands	(Mead 1961, Raut and Barker 2002)
Kenya	(Balasubramanian and Kalayanasundaram 1973, Muniappan 1990, Raut 1999, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Laos	(Muniappan 1990)
Madagascar	(Muniappan 1990, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Malaysia	(Mead 1961, Muniappan 1990, Smith 2003, Smith and Fowler 2003)

Locations	Reference(s)
Malaya	(Mead 1961, Lambert 1974, Raut and Barker 2002)
Sabah (North Borneo)	(Mead 1961, Lambert 1974)
Maldive Islands	(Mead 1961, Muniappan 1990, Smith and Fowler 2003)
Mariana Islands	
Guam	(Mead 1961, Lambert 1974, Commission 1993, Smith and Fowler 2003)
Northern Marianas	(Mead 1961, Padmanaban et al. 1999, Smith and Fowler 2003)
Saipan	(Lambert 1974)
Marshall Islands	(Lambert 1974)
Mauritius	(Mead 1961, Muniappan 1990, Raut 1999, Gerlach 2001, Craze and Mauremootoo 2002, Raut and Barker 2002, Smith 2003)
Morocco	(van Bruggen 1987, Raut and Barker 2002, Smith and Fowler 2003)
Mozambique	(Raut and Barker 2002, Smith and Fowler 2003)
Myanmar (see Burma)	(Mead 1961, Smith and Fowler 2003)
Nepal	(Raut 1999, Subba and Ghosh 2001)
New Caledonia	(Commission 1993, Gerlach 2001, Raut and Barker 2002, Smith and Fowler 2003)
Papua New Guinea	(Commission 1993, Padmanaban et al. 1999, Raut and Barker 2002, Smith and Fowler 2003)
Manum	(Lambert 1974)
Bismarck Archipelago	
New Britain	(Mead 1961, Lambert 1974, Raut and Barker 2002, Smith and Fowler 2003)
New Ireland	(Mead 1961, Lambert 1974, Raut and Barker 2002)
Philippines	(Mead 1961, Raut and Barker 2002, Smith 2003, Smith and Fowler 2003)
Benguet	(Baoanan 2002)
Bugsuk (Palawan Island)	(Muniappan et al. 1986)
Reunion	(Mead 1961, Muniappan 1990, Gerlach 2001, Smith and Fowler 2003)
Saint Lucia	(Smith 2003, Smith and Fowler 2003)
Samoa	
American Samoa	(Lambert 1974, Commission 1993, Padmanaban et al. 1999, Raut and Barker 2002, Smith and Fowler 2003)
Western Samoa	(Lambert 1974)
Seychelles	(Mead 1961, Muniappan 1990, Gerlach 2001, Smith and Fowler 2003)
Singapore	(Mead 1961, Lambert 1974, Chiu and Chou 1978, Muniappan 1990)
Solomon Islands (British Solomon Islands)	(Lambert 1974)

Locations	Reference(s)
Somalia	(Raut and Barker 2002, Smith and Fowler 2003)
South Africa	(Padmanaban et al. 1999)
Sri Lanka	(Mead 1961, Muniappan 1990, Raut and Barker 2002, Smith and Fowler 2003)
Tanzania	(Raut and Barker 2002, Smith and Fowler 2003)
Thailand	(Mead 1961, Muniappan 1990, Smith and Fowler 2003)
Tokelau	(Lambert 1974)
Tonga	(Lambert 1974)
Vanuatu	(Commission 1993, Raut and Barker 2002, Smith and Fowler 2003)
Vietnam	(Mead 1961, Muniappan 1990, Smith and Fowler 2003)
Wake Island	(Smith and Fowler 2003)
Wallis and Futuna	(Commission 1993)

Appendix B. Taxonomy and Morphology of *Achatina fulica*

Achatina fulica Bowdich, 1822

The following description of *A. fulica* is quoted from Bequaert (1950).

"When full-grown, the shell of *A. fulica* consists of from 7 to 9 (very exceptionally 10) whorls, with a moderately swollen body-whorl and a sharply conical spire, which is distinctly narrowed but scarcely drawn out at the apex. The outline varies greatly, even in the same colony, from very slender to moderately obese, the broader specimens tending to be shorter for the same number of whorls. All whorls are decidedly convex, due to the broadly impressed sutures. The aperture is relatively short, even in the broadest specimens, being always shorter than the spire, often considerably so. The outer lip is usually sharp and thin, rarely somewhat thickened or even slightly expanded in very old specimens; it is very convex, evenly curved into a regular semi-ellipse, and inserted on the body-whorl at a sharp, open angle, the upper part of the body-whorl being scarcely or not flattened behind the lip. The columella is more or less concave, sometimes rather weakly so, in which case may be slightly or even much twisted; it tends to be more concave in the broader shells. It should be noted that in *A. fulica* all stages, from the nepionic shell on, have the umbilical slit completely closed and the columella truncate. In all specimens seen, which on general shape and sculpture were referable to *A. fulica*, both columella and parietal callus are white or bluish white., without any trace of pink. The importance ...more fully discussed under *A. fulica hamillei* and *A. panthera* (not included in this description).

The newly hatched, nepionic shell is 5 to 5.5 mm long and about 4.5 mm wide, of 2½ nearly smooth whorls, without any granulation or decussation and with only the weakest traces of vertical wrinkles. The first half post-nepionic whorl is more distinctly wrinkled vertically, but not yet decussate; after this the vertical growth striae become gradually stronger and are now cut by spiral engraved lines, into elongate, vertical welts; at first weak, the decussation gains in strength on the fourth and fifth whorls, where it is visible to the naked eye, after which it decreases again, being superficial on thesixth and usually lacking on the seventh and succeeding whorls. In young shells, the periostracum of the early post-nepionic whorls shows in addition to the decussation a superficial, microscopic criss-cross texture, as if a finely woven cloth had been pressed onto the surface; but no trace of this remains on older shells. In the largest full-grown adult shells, of 7 to 9 whorls, the body whorl is nearly even, the growth-striae being very low or superficial, except below the suture where they form short, strong folds, very lightly crenulating the irregular sutural line. When the periostracum is fresh and intact, the terminal whorls appear not only smooth, but also glossy. The ground color and markings vary greatly (discussed further under the several races; not included with this description). When present in the adult, the darker markings appear almost at once on the first post-nepionic whorl as faint, vertical, straight, pale-brown streaks; in very young shells, these streaks stop at the periphery, forming there slightly deflected spots.

The egg is broadly ellipsoidal, 5 to 5.5 mm by 4 to 4.5 mm, slightly larger in subsp. *hamellei* than in the nominate race, white or slightly yellowish, with a very thin and brittle calcareous shell."

Appendix C. Threatened or endangered plants potentially affected by *Achatina fulica*.

Achatina fulica has the potential to adversely affect threatened and endangered plant species. However, because *A. fulica* only occurs outside the US and threatened and endangered plant species under consideration only occur within the US, it is not possible to confirm the host status of these rare plants from the scientific literature. From these host records, we infer that threatened or endangered plant species which are closely related to known host plants might also be suitable hosts (Table C1). For our purposes closely related plant species belong to the same genus.

Table C1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Achatina fulica*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Asplenium nidus	*A. auritum*.	eared spleenwort		FL (E)
	A. monanthes	singlesorus spleenwort		FL (E) NC (E)
	A. myriophyllum	limestone spleenwort		FL (E)
	A. pumilum	dwarf spleenwort		FL (E)
	A. serratum	wild birdnest fern		FL (E)
	A. trichomanes-dentatum	toothed spleenwort		FL (E)
	A. x*curtissi* Underwood (pro sp.) [*abscissum* x *myriophyllum*]			FL (E)
Cassia fistula	*C. keyensis*	narrowpod sensitive pea		FL (E)
Cereus	*C. robinii*	Key tree cactus		FL (E)
	C. pentagonus	triangle cactus		FL (E)
	C. gracilis var. *aboriginus*	prickly applecactus		FL (E)
	C. eriophorus var. *fragrans*	Caribbean applecactus	Endangered	FL (E)
Clitoria ternatea	*C. fragrans*	sweetscented pigeonwings	Endangered	FL (E)
Cucurbita	*C. okeechobeensis*	Okeechobee gourd	Endangered	FL (E)
Eryngium	*E. cuneifolium*	wedgeleaf eryngo	Endangered	FL (E)
Gossypium herbaceum	*G. hirsutum*	upland cotton		FL (E)
Helianthus annuus	*H. carnosus*	lakeside sunflower		FL (E)
Ipomoea batatas	*I. microdactyla*	calcareous morning-glory		FL (E)
	I. tenuissima	rockland morning-glory		FL (E)

Table C1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Achatina fulica*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Malus	*M. angustifolia*	southern crabapple		FL (T) IL (E)
Oncidium	*O. bahamense*	variegated orchid		FL (E)
	O. floridanum	Florida orchid		FL (E)
	O. luridum	Cape Sable orchid		FL (E)
Opuntia	*O. spinosissima*	semaphore pricklypear		FL (E)
	O. stricta	erect pricklypear		FL (T)
	O. triacantha	Spanish lady		FL (E)
Pteris quadriaurita	*P. bahamensis*	Bahama brake		FL (E)
Salvia	*S. urticifolia*	nettleleaf sage		FL (E) KY (E) MD (E)
Scaevola	*S. plumieri*	gullfeed		FL (T)
Swietenia mahagoni	*S. mahagoni*	West Indian mahogany		FL (E)
Tephrosia	*T. angustissima*	narrowleaf hoarypea		FL (E)
Vanilla	*V. barbellata*	wormvine orchid		FL (E)
	V. dilloniana	leafless vanilla		FL (E)
	V. mexicana	Mexican vanilla		FL (E)
	V. phaeantha	leafy vanilla		FL (E)
	V. planifolia	vanilla		FL (E)

1. E= Endangered; T=Threatened

Appendix D. Biology of *Achatina fulica* – quoted primarily from Smith and Fowler (2003)**:**

Population phenology

"Although most members of Achatinidae are tropical and subtropical, at least some species, most notably *Achatina fulica*, can inhabit ranges much further removed from tropical parameters. *A. fulica* remains active at a temperature range of 9^{o} – 29^{o} C., and survives temperatures of 2^{o} C. by hibernation and 30^{o} C. by aestivation. Humidity has been found to be a more reliable predictor of naturalization and activity of *A. fulica* than temperature, and continuous activity is restricted largely to areas with 80% relative humidity. Environmental equivalents to these requirements may be found as far north as 40^{o} latitude ((Raut and Barker 2002); Map 1), and was reasonably predicted by Mead (1973) who stated: "*A. fulica* will eventually spread north to the Carolinas and west, through the Gulf states, spottedly through the Southwestern 'desert' states, and into southern California"."

Stage specific biology

"*A. fulica* is an obligate-outcrossing hermaphrodite, which means that one externally fertilized snail can establish a population. Large adults can successfully aestivate for 10 months, while hatchling snails are restricted to about 2 months due to dessication. One snail can lay 100 eggs at six month's of age and fecundity lasts approximately 400 days, even though snail lifetimes of 4.5 to 9 years have been recorded. The combination of factors in south Florida that were instrumental in *Achatina fulica's* growth, survival, and rapid dispersal consisted of lush tropical foliage, abundance of calcium carbonate, lack of predators, and mild winters (Poucher 1975), as well as land cover in Florida dominated by human-produced habitats, which are preferred by *A. fulica* (Simberloff 1996)."

Adult

"Mead's estimate stated that one snail, laying four batches of eggs per year, averaging 150 eggs per batch, and living for five years, could potentially generate 8 billion offspring in three years, and 16 quadrillion in five years (Mead 1961). No matter which estimate is used, the reproductive potential of giant African snails is extremely high."

Egg

"A. fulica's large eggs, 4.5 to 5.5 mm diameter ((Ghose 1963); (Srivastava et al. 1985)), resembling miniature hens' eggs (Planck 2001), do not hatch at temperatures below 15^{o} C (Raut and Ghose 1984)."

Hatchling

"Hatchling snails exhibit exploratory and voracious feeding behavior immediately following emergence from the soil. Snails with shell heights of 5 to 30 mm are most predacious on living vegetation, with very small and older individuals preferring detritus and decaying vegetation. The major requirement of hatchlings is calcium until their shell reaches the 5 mm size ((Mead 1961); (Mead 1979); (Srivastava 1992)). Snails six to twelve months old have laid eggs, up to 100 their first year, and up to 500 in their second year. Fecundity declines after the second year, but snails may live up to five years with a

total egg clutch of up to 1,000 (Raut and Barker 2002). Raut and Barker (2002) used these figures to estimate that 100 hatchling snails could produce 1 trillion individuals in a little over 7 years, but added that most hatchlings do not survive their first aestivation/hibernation."