PEST RISK ASSESSMENT
ON CHINESE WATER SPINACH

PEST *Ipomoea aquatica* Forskal

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I. TAXONOMY, SYNONYMS, COMMON NAMES

Convolvulaceae
Ipomoea aquatica Forskal. Fl. Aegypt.-Arab. CVI,44. 1775.

Ipomoea is one of 55 genera of the family Convolvulaceae. Of the approximately 500 species of Ipomoea, only Ipomoea aquatica is reported to be aquatic (Gilbert, 1984).

SYNONYMS

Ipomoea reptans Poir. in Lamk., Encycl. Suppl. 3:460. 1814.
Ipomoea repens Roth., Nov. Pl. Sp. 110. 1821.
Ipomoea subdentata Miq. Fl. Ind. Bat. 2:614. 1857.
Convolvulus repens Vahl., Symb. Bot. 1:17. 1790.
(non Convolvulus reptans L. ex Roth., Nov. pl. sp. 110.1821)

COMMON NAMES

In United States....water spinach, water green, water convolvulus, swamp morningglory, creeping swamp morningglory, tropical spinach, swamp cabbage, green engtsai, Chinese convolvulus, kancon, bindweed plant
In China........... Ong tsoi, tung sum tsoi, weng cai, ung-choi
In Fiji............ Ota karisi
In India........... kalami sag, karmi, koilangu, tooti koora, vellai kerai, nali, patuasag, Kalmisak, Kalmihak, sornalika-sag, Nadishaka, Nalanibhaji, Tutikura, Vellaikeerai, Ganthian, nari, Sarnali
In Hong Kong....... Ching Quat, Pak Quat
In Philippines..... Kangkong, cancong, balangog, galatgat, tankung, tangkong
In Thailand........ Paagboong, gka-lampok
In Malaysia
and Indonesia...... Kangkung, Kangkoong
In Vietnam......... Rau Muong
In Laos............ Phak bong
In Cambodia........ Tra kuon
In Latin America... Batatilla acuatica, batatilla de puerco
In Sudan........... Argala

II. DESCRIPTION

Ipomoea aquatica is a fast growing, annual or perennial, glabrous, sprawling vine, creeping on mud or floating on water; semi-aquatic or amphibious.

Stems long, smooth, succulent, creeping, 3-7 mm. thick; when floating becoming hollow or spongy within and slightly inflated; often 3 meters in length (one plant was recorded to be 23 meters long.) Length of internodes varies. Secreting milky juice when broken. Without tubers.

Roots varying in length from 14-460 mm. One to ten develop from each node and hang freely in water. The main plant and branches on water margins have their roots in soil.

Leaves alternate, simple, cordate, ovate, ovate-oblong, elliptic, triangular, sagittate, or sometimes lanceolate, up to 20 cm. long.

Inflorescence axillary, one to several flowered. Flowers erect, regular, funnelform, bisexual, 8 mm. long and showy, sepals 5, glabrous, persistent. Corolla funnel-shaped, 3-8 cm. long; pink, pale lilac, or purple (rarely white), often with dark purple center.

Fruit a smooth, brown, ovoid, glabrous, thin-walled, four valved capsule, 7 to 9 mm. across.

Seeds 4 or fewer per capsule, 4 mm. long, 5-7 mm. broad, light bright brown to black, pubescent, with omega-shaped border surrounding the hilum.

The species is variable; two or three local cultivars are described in most places where it is cultivated as a vegetable. These types may differ in leaf and stem size, texture, and color, leaf morphology, flower color, growth habit and habitat. (Van Steenis, 1953)(Ochse, 1980)(Edie and Ho, 1969)(Bautista et al, 1988)(Tiwari and Chandra, 1985). In Taiwan, water spinach varieties are generally graded into three types, large, medium and small (Chen and Chen, 1970).

III. Propagation and Physiology

<u>Ipomoea</u> <u>aquatica</u> is easily propagated by cuttings. Vegetative propagation is common as pieces of branches, striking root at every node, become separated from the main plant and produce new plants. New plants can root within a week (Satpathy, 1964) and may be carried by water, animal and human agencies (Patnaik, 1976).

The species is also propagated by seeds; 175 to 250 seeds per plant have been reported. Exhibiting primary dormancy, the seeds do not germinate immediately upon harvest. Seeds that are first dried and then planted achieve 80% (Datta and Biswas, 1970) to 100% (Creager, 1993) germination within three days. If seeds are held in storage, a secondary dormancy may set in. This secondary dormancy can be broken by scarification or seed coat removal

(Datta & Biswas, 1970). Seeds falling at edges of lakes and ditches produce new seedlings as rains begin (Holm, 1981).

Although the species thrives during rainy seasons, it can adapt to dry conditions. Branches develop shorter internodes and leaves tend to be shorter and narrower (Mullan, 1935). Without standing water, the vine roots at every node and becomes woody and inedible (Satpathy, 1964).

Optimum growth requirements include:

- Moist soil. Marshy lands and waterlogged soils are favored. Shallow ponds, ditches, peripheries of deep ponds, tanks and slopes of wet soils are suitable.

- Nutrient rich heavy clay or silty clay, organic soils.

- pH of 6.5-8.5 (Tiwari and Chandra, 1985).

- Full sun.

- High Temperatures. The plants are tolerant to heat (Liou, 1981).

Limiting factors include:

- Low temperature. Ipomoea aquatica grows poorly in cold weather but can tolerate very light frost that affects only the outer leaves (Synder et al, 1981). The seeds can withstand some freezing (Gilbert, 1984). Huang reported that it cannot be grown under 20/15 degrees Celsius (Huang, 1981), which seems questionable in light of its recorded range.

- Sunlight. Plants grown in shade are weak and thin (Tiwari and Chandra, 1985).

- Ipomoea aquatica is not tolerant of salt conditions (Backer and Van den Brink, 1965).

An average annual fresh weight yield of 90,000, 70,000 and 100,000 tons/ha have been reported in Hong Kong, Fiji and The Netherlands, respectively (Edie, H.H. & Ho, B.W.C. 1969) (Payne, 1956) (Samson, 1972). Yields obtained in South Florida trials were as high or higher (Synder et al, 1981). Under optimum conditions it grows up to 16 cm. (4 inches) a day (Gilbert, 1984).

IV. DISTRIBUTION

Ipomoea aquatica is native to Southeast Asia, possibly India (Herklots, 1972). It is now distributed in:

> Argentina, Aruba, Australia, Bangladesh, Borneo, Burkina, Cambodia, China, Colombia, Costa Rica, Dahomey, Egypt, Fiji, Ghana, Guam, Guyana, Hawaii, Hong Kong, India, Indonesia, Ivory Coast, Jamaica, Kenya, Korea, Laos, Malaysia, Melanesia, Micronesia, Mozambique, New Guinea, Nigeria, Pakistan, Philippines, Puerto Rico, Rhodesia, Senegal, Singapore, Sudan, Sri Lanka, Surinam, Taiwan, Tanzania, Thailand, Trinidad and Tobago, (Tropical Africa), Tunisia, Turkey, United Kingdom, United States, Vietnam, Zaire, Zambia, Zimbabwe

In the United States: one location is known in Texas and several locations in Florida and California. Waterspinach is naturalized in Hawaii, especially in old taro patches (Reed, 1977).

("Naturalized" is used here to mean escaped from cultivation and reproducing and spreading on its own.)

V. USES

Human association with Ipomoea aquatica is ancient, as evidenced by the first known reference during the Chin Dynasty (290-307 A.D.) of China in a book entitled A Description of Plants in the South (Edie & Ho, 1969). Uses are many:

1. HUMAN FOOD. Water spinach is grown as a green vegetable crop in many tropical countries. The highly nutritious young stems and leaves are eaten raw, boiled, stir-fried, steamed or pickled as a vegetable throughout Asia. The percentage of protein in the leaves is high as well as vitamin A, iron, calcium and phosphorus (Bautista et al , 1988).

2. MEDICINAL. (Reported)
   - Leaves and juice are used as a mild purgative (laxative) (Subramanyam, 1962) (Ochse, 1980).
   - A chemical resembling insulin is present in the buds of pigmented variety and is recommended as a food for diabetics (Petelot, 1971).
   - The plant is used as an antidote for opium and arsenic poisoning (Anon, 1959)(Holm, 1981).
   - Buds are used in the treatment of ringworm (Anon, 1959).
   - The plant is used as a poultice in febrile delirium (Anon, 1959).
   - Increased consumption of the vegetable is protective

against high blood pressure and nosebleeds (Chen et al, 1991).

3. ANIMAL FEED. Plants are fed to livestock (cattle, pigs, ducks, chickens.)

4. FISH CULTURE (Ye Yizuo, et al, 1991).
Plants are often planted against dikes of fish ponds so that the floating stems can be eaten by fish (Ochse, 1980).

5. GREEN MANURE for rice (Reddy, et al 1987).

6. WATER PURIFICATION. Ipomoea aquatica can scavenge some organic and inorganic components including some heavy metals from waste water. The weed absorbs and incorporates dissolved materials into its own system (Jain et al, 1987). I. aquatica could be useful for removing nitrates from contaminated water, such as farm drainage and municipal waste (Snyder, Morton and Genung, 1981). The weed shows maximum capacity in water containing about 15-20% effluents (Chin & Fong, 1978).

   Water spinach has greater potential than cattail (Typha) or water hyacinth (Eichhornia crassipes) for use in controlling nutrient runoff into lakes from agricultural lands and from waste treatment plants (Bruemmer and Roe, 1979).

7. SOIL CONSERVATION. In India, the plants prevent erosion on the periphery of farm ponds and percolation tanks (Satpathy, 1964).

8. BIOMASS AS A SUBSTRATE FOR FOOD PRODUCTION: The edible mushroom Pleurotus sajor-caju (oyster mushroom) grows readily on it. Of the three hosts studied, Ipomoea aquatica supported growth best. With an enhanced nitrogen content after the mushroom growth, these aquatic weeds could be better biofertilizer than a direct application as green manure (Jain et al , 1988).

9. COUNTERACTIVE TO VIRUSES. Ipomoea aquatica deactivates some viruses and minimizes the virulence of abaca mosaic when the virus passes through it as an intermediate host (Tabora, 1979).

VI. HISTORY OF DOMESTIC INTRODUCTION

Ipomoea aquatica is believed to have been introduced into Hawaii by Chinese immigrants sometime before 1888 (Degener, 1946). Importation of the species is allowed into Hawaii by noxious weed permit, which requires that all material remain in Hawaii.

The species was first prohibited under the Federal Noxious Weed Act beginning May 4, 1983. Prior to that date, several companies regularly imported seed: six companies in California, one in Connecticut, one in Maryland, one in Illinois (USDA-APHIS weed files).

Before and after its listing as a Federal Noxious Weed, Ipomoea aquatica has been offered for sale in oriental markets throughout the United States. Populations have been found under cultivation in Florida, California, and Texas.

Although Florida prohibits the importation, transportation, or cultivation of this species (Tarver et al 1979), more than 20 outbreaks of Ipomoea aquatica have been found and treated in Florida since its listing. Most or all of these populations were planted deliberately for food. In Florida, it is often sold underground and generally to people of oriental ancestry (Kipker, 1992).

In Texas, Ipomoea aquatica is one of 13 prohibited aquatic species regulated by game wardens (Johnson, 1992).

California's Department of Agriculture does not consider this species a problem and places no restrictions on its cultivation. Individuals in the state are probably producing water spinach as a specialty crop in many locations on a small scale (Haas, 1993).

Since it was listed as a noxious weed, this species has been intercepted frequently at ports of entry (about 2,500 times). Most of the attempted importations are intentional, but some are inadvertent. Seeds have been intercepted as contaminants of Ionopsis utricularioides leaves, Ipomoea cairica seeds, Citrus sp. seeds, Oryza sativa seeds, Sesamum indicum seeds, Cucumis sp., Pittosporum leaves, Cuminum sp. seeds, and tractor trailer debris (USDA, PPQ, 309 Database).

VII. ASSOCIATED PESTS

Associated nematodes and diseases:

1. Host of root-knot nematode, Meloidogyne javanica in North West Nigeria. (Salawu, Ambursa and Manga, 1991)
2. Susceptible to the nematode Meloidogyne hapla in Taiwan. (Ruelo, 1980)
3. Host of nematode Paratrophurus sp. (Teruya, 1979) in Ryukyu Islands.
4. White Rust Disease: Albugo ipomoeae-aquaticae (Khoo and Lim, 1989) and Albugo ipomoeae panduranae (Ho and Edie, 1969).
5. Some fungi, viz. Cercospora sp., Alternaria sp., Cercosporella sp. and Phomopsis sp., cause leaf-spot disease, but it is of minor importance (Tiwari and Chandra, 1985).
6. Host to various viruses, such as abaca mosaic virus.

Associated insects:

1. Tortoise beetle, Cassida circumdata Herbst (George and Venkataraman, 1987).
2. Taro planthopper, Tarophagus proserpina (Duatin and De Pedro, 1986).

VIII. RATING ELEMENTS

Estimate probability of pest spreading beyond the colonized area. High - VC

The ability of the weed to establish itself in both aquatic and terrestrial habitats indicates its adaptability to a wide range of environments within the southernmost United States.

The ease of propagation and ability to be disseminated by human activity, water, and animals favor the spread of the weed beyond the colonized area.

The high interception rate at ports of entry, continuing sale of the vegetable in oriental markets, and clandestine cultivation indicate that the weed has ample opportunity for introduction, establishment and spread.

At present, no economically feasible control method is available to eliminate this species in aquatic environments.

Estimate economic impact if established. High - RC

(Refer to document by Philip Kemere, Economist, USDA, PPD, PAD, for detailed assessment and estimated dollar losses.)

Zimdahl (1983) includes Ipomoea aquatica in his list of 21 weeds that may threaten U.S. agriculture. It is a serious weed in India, Mozambique, and Thailand, and a principal weed in Dahomey, Cambodia and the Philippines (Holm et al, 1979).

If further established in the United States, it can be expected to reduce yields in rice and sugarcane through competition. Flooding and submersion caused by rampant weed growth, coupled with inadequate drainage, can lead to reduction of yield in rice (Rao and Murty, 1967).

As water sources are polluted by erosion, agro-chemicals, eutrophication, industrial and domestic wastes, rapid growth of aquatic macrophytes is encouraged. Ipomoea aquatica has potential to become an uncontrollable nuisance (Chin & Foong, 1978). Irrigation systems, reservoirs, ponds and impoundments could be affected, as well as navigation and recreation on fresh waterways.

Although Ipomoea aquatica provides food for some animals, its tendency to outcompete other native plant species may reduce the native animal species that feed on the native plants. Thus the plant could have a negative economic impact on hunting and fishing, which could, in turn, have a negative impact on tourism (Florida Dept. of Natural Resources, 1990).

Herbicide costs for controlling this weed in aquatic habitats can be extremely high. (See pages 10 and 11 for details on control measures.)

On the other hand, this species has commercial value for those cultivating and selling it as a vegetable. The general economy could benefit from new investment opportunities.

Estimate environmental impact if established. High - RC

In natural settings such as rivers and lakes, it may out-compete native vegetation and limit the use of such water. In a Florida study, Ipomoea aquatica when left unattended in a vat with several other species, protruded up through the densely matted Hydrilla and proceeded to grow over the remaining species (Gilbert, 1984).

Ipomoea aquatica could become established in natural areas in which it would be difficult to detect and control, such as Lake Okeechobee, the Kissimmee River, or worse yet, the Everglades (Kipker, 1992).

"This plant species is considered to be aggressive and its potential naturalization represents a significant threat to Florida's waterways and wetlands" (Schmitz, 1990).

By reducing the effects of pollution and controlling erosion, Ipomoea aquatica may have positive effects on the environment as well.

Estimate impact from social and/or political influences. Medium - RC

We can expect these groups to approve of de-regulation of Ipomoea aquatica:

- Novelty vegetable industry and entrepreneurs
- Seed companies
- Asian community and others who enjoy the vegetable

None of these groups are solely dependant on the availability of Ipomoea aquatica for their livelihood.

We can expect these groups to oppose de-regulation:

- Southern state governments (J), especially Florida (Kipker, 1992) (for letter codes, please see Appendix B, page 22)
- Environmental organizations (E)
- Rice and sugarcane growers (J)

Since this species absorbs heavy metals such as neurotoxic methyl mercury in polluted water, cultivation in such water could pose a health hazard to those consuming the vegetable (Suckcharoen, 1980), and a possible health benefit to polluted or unstable bodies of water.

IX. PEST RISK POTENTIAL RATING (low, medium, high) High - RC

Definition of Pest Risk Potential Rating:

Low = acceptable risk - organism of little concern to PPQ (does not justify denied entry or regulation)

Medium = unacceptable risk - organism of moderate concern to PPQ (either deny entry or regulate)

High = unacceptable risk - organism of major concern to PPQ (either deny entry or regulate)

X. SPECIFIC QUESTIONS

1. If removed from the Federal Noxious Weed list, what effects would Ipomoea aquatica have on agricultural crops (rice, sugarcane, etc.), wetlands, and natural resource areas?

If removed from the Federal Noxious Weed list, seeds of Ipomoea aquatica will be imported in large quantities again. The likelihood of escape from cultivation will increase along with the number of people planting the seeds.(J)

Ipomoea aquatica is a weed of rice in Cambodia, Nigeria, Indonesia and Thailand (Holm, 1981), and a weed of sugarcane in Fiji (Parham, 1958) and India (Holm, 1981). If introduced into the growing areas, it can be expected to reduce yields for these crops in the United States. The weed also poses a threat to irrigation systems, which may be blocked by intertwined vegetation.

In wetlands and natural settings such as rivers and lakes, the weed can limit the use of such water and out-compete native vegetation. The tangled axial branches could impede water flow especially if other smaller plants and inorganic or decaying materials become trapped (Gilbert, 1984), thereby altering sensitive aquatic habitats.

However, because of its ability to improve water quality and prevent ersosion, the species also has potential for stabilizing severely damaged habitats.

2. How much of its ecological range is already infested as compared to its potential range of spread? What states are likely to suffer economic damage if APHIS regulations are removed?

Known populations in Florida are under treatment or eradicated. Many more infestations are probably as yet undiscovered (Kipker, 1992). The Texas Department of Parks and Wildlife is evaluating their 8-acre site for regulatory action (Fowler, 1993). I. aquatica has escaped from cultivation and is widespread in Hawaii. It is probably widely cultivated in California (Hass, 1993).

Ipomoea aquatica has potential to become established in Plant Hardiness Zones 9 through 11, (Hawaii, California, Arizona, Florida, southern Lousiana and Texas), wherever fresh water bodies or moist or waterlogged soils are available (J). It may survive in Zone 8b up to ten years, long enough to cause problems in sugarcane and rice fields. Because of its salt intolerance, I. aquatica is not expected to invade brackish or marine areas (Backer and Van den Brink, 1965). Conditions in south and central Florida are ideal for its growth, flowering and seed production (Gilbert, 1984) (Florida Alert Bull.).

No study has been completed for a precise estimate of potential range. (See map on next page showing estimated potential range, based on hardiness zones.)

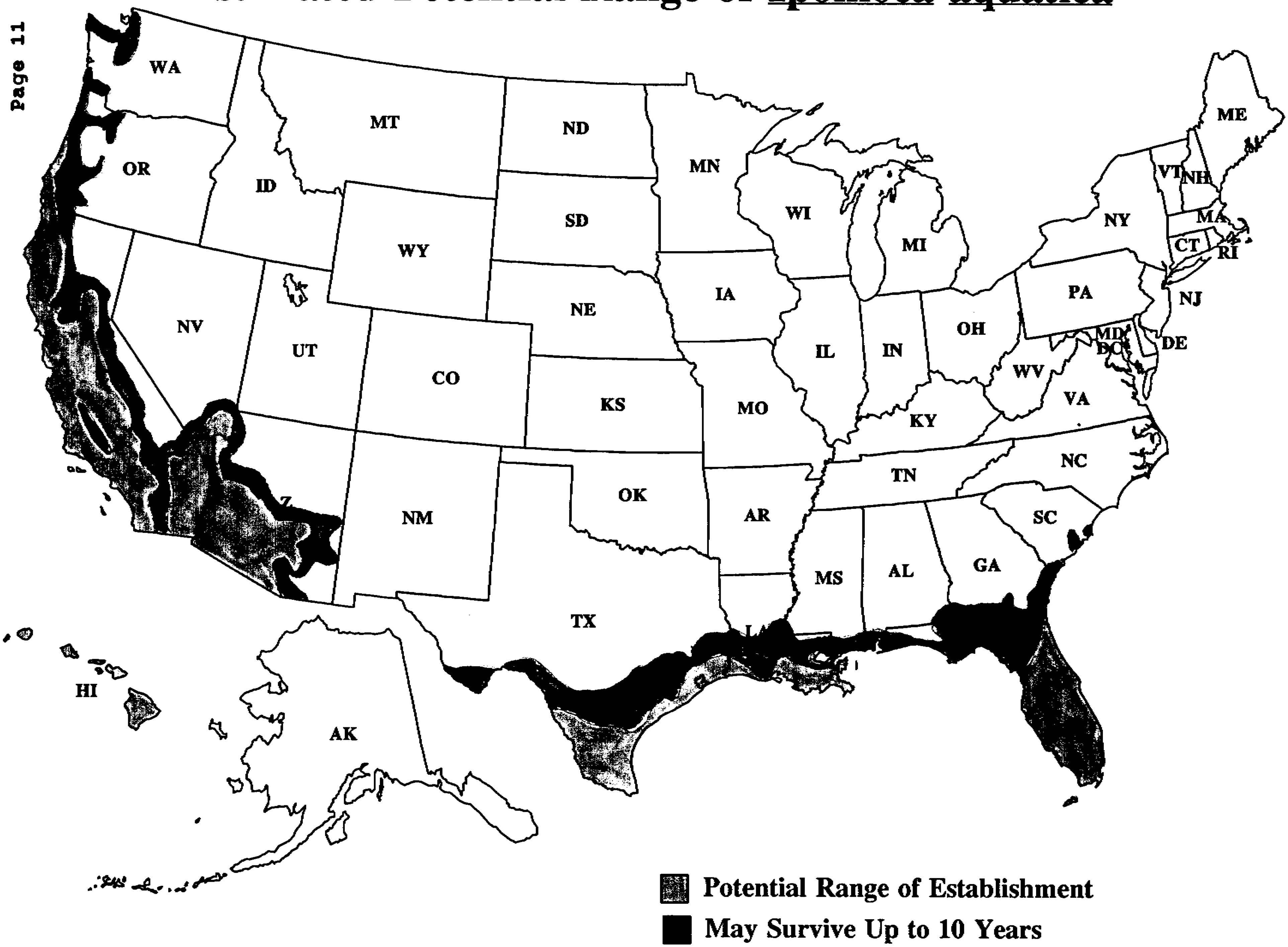
States most likely to suffer economic damage are Florida, Texas, and Louisiana (Because of rice and\or sugarcane production and climate.)

3. What effect would it have on foreign imports if not regulated?

Before Ipomoea aquatica's Federal Noxious Weed status, PPQ denied requests to import vegetative parts of the plant:

- From Haiti, because of the associated pathogens,
- From the Dominican Republic, because of associated & pathogens and insect pests.

Estimated Potential Range of Ipomoea aquatica



If the species is removed from the Federal Noxious Weed Act list, PPQ would evaluate requests for importation of vegetative material individually under Q.56. Associated pests from each country of origin would be considered at the time of request. Seeds would be inspected upon entry, but otherwise unrestricted.

United States exports to other countries would be unaffected; no other country specifically lists it as a prohibited species (Jones, 1992).

4. Are control measures that are environmentally accepted available?

CONTROL MEASURES

1. MANUAL. In an experimental study conducted in north-central India, Ipomoea aquatica died when clipped underwater. (Middleton 1990) However, complete eradication by manual means is not possible (Chin & Fong, 1978). The degree of control depends on frequency of clearing. The advantage of mechanical control is that it involves very little direct hazard to fish, wildlife or humans. However, such methods are inefficient and uneconomical (Gangstad, 1972).

2. BIOLOGICAL CONTROL.

- The tortoise beetle (Cassida circumdata Herbst) is used as a biological control agent in Keoladeo National Park, Bharatpur, India. Grubs feed on chlorophyll from the underside of the leaves and skeletonize them completely (George and Venkataraman, 1987).

- Fish, such as the triploid grass carp, may have potential for biological control, since the plant is palatable to fish. (E)

- Pathogens, such as white blister rust, may have potential (Creager, 1993).

Specific research and development programs would be required to evaluate these agents for use in target areas in the United States.

3. HERBICIDES.

To be successful at controlling Ipomoea aquatica, an agricultural herbicide should meet two requirements:

- registered for aquatic use,
- economical.

Economical, **non-selective** herbicides are available that will control it, but they are not registered for aquatic use. Ipomoea aquatica has been contolled with 2,4-D amine, Rodeo (glyphosate) and Diquat. These are non-selective, but require follow-up treatments to be effective.

Banvel 720 is effective, but the registration is not being renewed. After existing stock is depleted, this chemical will no longer be available.

Sonar (Fluoridone) is registered for aquatic use and achieves 100% kill, but costs about $1,000 per gallon (Creager, 1993). An average application rate is one quart per acre ($250 per acre).

Chemical herbicides would not be effective against seeds.

XI. SUMMARY AND DISCUSSION

Ipomoea aquatica poses a dilemma. Because of its popularity as food, especially within the Asian community, and desirability for other uses, many will want to import and cultivate it. But because of its potential to harm natural ecosystems, rice and sugarcane growers, irrigation systems, navigation and recreation throughout wet areas of the South, it is rightly considered a noxious weed.

Potential monetary or social benefits realized by de-regulating the species are outweighed by the potential damage and cost of control (Kipker, 1992) (J). Ipomoea aquatica possesses the attributes of a serious weed and will be competitive in many aquatic and some terrestrial environs of the United States (Zimdahl, 1983).

Aside from the biological issue, APHIS has two basic policy options:

1. APHIS can leave Ipomoea aquatica on the Federal Noxious Weed Act (FNWA) list, based on its potential to do harm.

2. APHIS can remove Ipomoea aquatica from the FNWA list, based on its distribution.

The FNWA defines "Noxious Weed" as "any parasitic or other plant of a kind, or subdivision of a kind, which is of foreign origin, is new to or not widely prevalent in the United States, and can directly or indirectly injure crops, other useful plants, livestock, or poultry or other interests of agriculture, including irrigation, or navigation or the fish and wildlife resources of the United States or the public health."

Since the Act does not define "widely prevalent", this species continues to meet the subjective definition of noxious weed.

The current legal interpretation of the FNWA requires APHIS to impose a quarantine and become actively involved in an eradication program before regulating the interstate movement of a listed weed. Continued diligence by Florida and other concerned states to enforce local prohibitions should be supplemented by increased efforts by APHIS to change the interstate regulation restrictions under the FNWA.

RECOMMENDATIONS

While APHIS probably cannot stop the clandestine sale and cultivation of Ipomoea aquatica completely, APHIS should try to prevent its further escape and spread. Specifically, APHIS should:

1. Leave the species on the FNWA list based on its potential to harm natural ecosystems, irrigation systems, rice and sugarcane growers, recreation and navigation in the southern United States.

2. When this species is found as an incidental contaminant on non-propagative importations destined to states outside of its potential range, allow it to enter under noxious weed permit.[1]

3. Conduct surveys to determine distribution.

4. Establish quarantines and eradication programs in the areas most at risk. A small eradication program within Florida would satisfy the FNWA requirement for regulating interstate movement.

5. Support research on biological control agents.

6. Increase educational/awareness programs for potential producers and consumers.

In the meantime, APHIS should address policy issues that affect noxious weeds in general. APHIS should develop an internal definition of "widely prevalent" for the definition of a Federal Noxious Weed. The definition should distinguish between incipient infestations and established populations. Any listed noxious weed species whose range in the U.S. exceeds that of the

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[1] This is a modification of Port Operations' recommendation that APHIS not take action when Ipomoea aquatica is found as an incidental contaminant on non propagative importations, regardless of destination.

new definition should be proposed for removal from the Federal Noxious Weed Act (FNWA) list.

Whether or not Ipomoea aquatica should be removed from the FNWA list will become clear when its distribution is known from survey results and when the internal definition of "widely prevalent" is developed.

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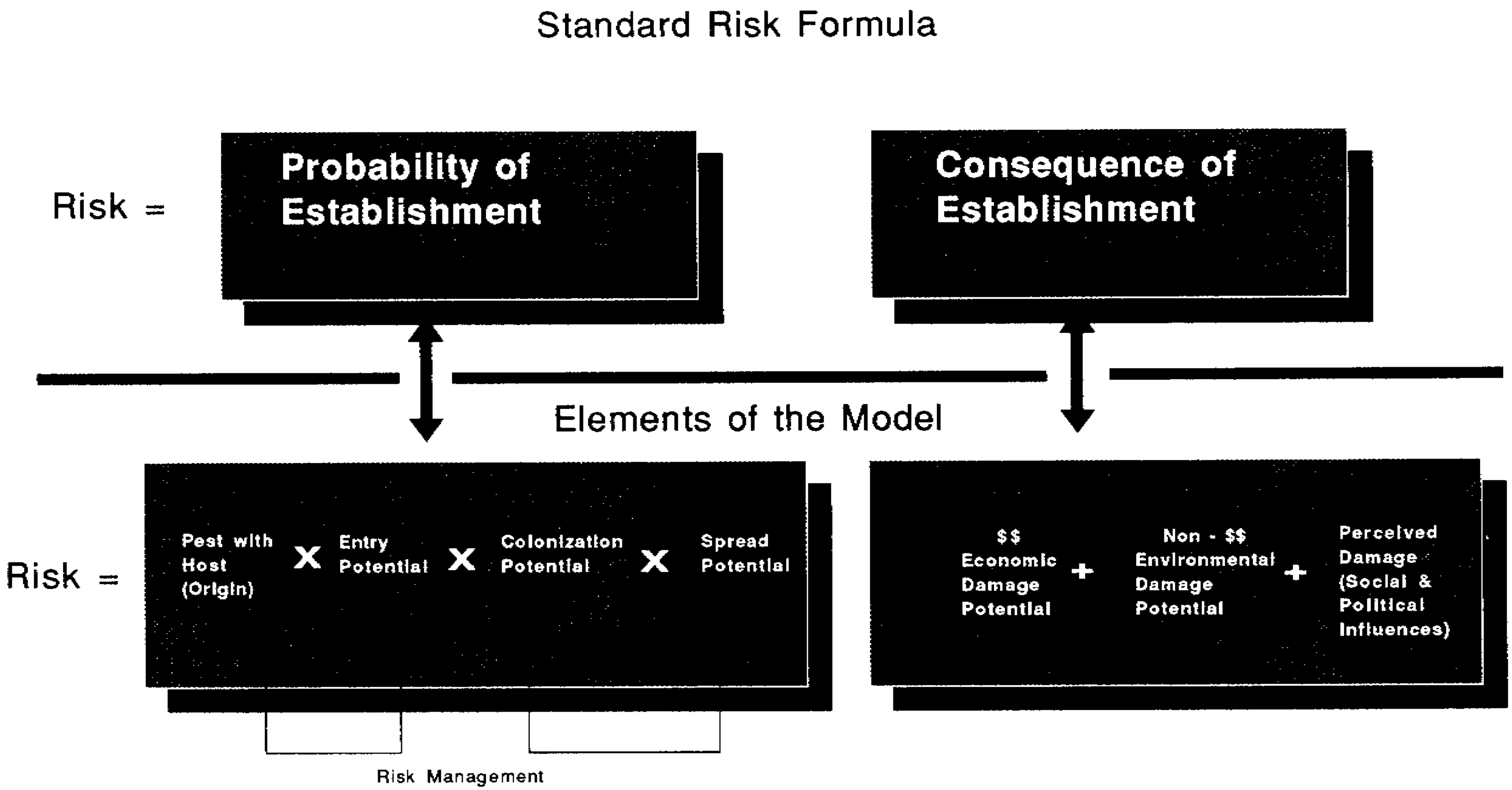
Pest Risk Assessment Model



- For model simplification the various elements are depicted as being independent of one another
- The order of the elements in the model does not necessarily reflect the order of calculation.

APPENDIX B

REFERENCE CODES TO ANSWERED QUESTIONS

Reference Code	Reference Type
(G)	General Knowledge, no specific source
(J)	Judgmental Evaluation
(E)	Extrapolation; information specific to pest not available; however information available on similar organisms applied
(Author, Year)	Literature Cited

UNCERTAINTY CODES TO INDIVIDUAL ELEMENTS

Uncertainty Code	**Symbol**	**Description**
Very Certain	VC	As certain as I am going to get
Reasonably Certain	RC	Reasonably certain
Moderately Certain	MC	More certain than not
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	A guess