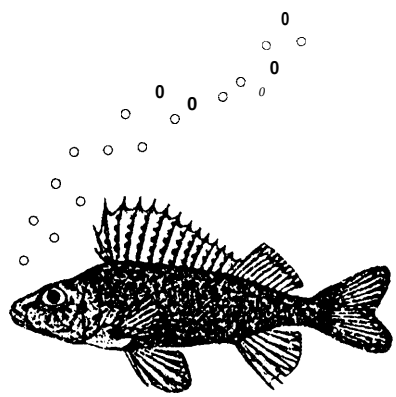
Summary, Issues, and Options 1

The movement of plants, animals, and microbes beyond their natural range is much like a game of biological roulette. Once in a new environment, an organism may simply die. Or it may take hold and reproduce, but with little noticeable effect on its surroundings. But sometimes a new species spreads unimpeded, with devastating ecological or economic results. This latter category-including species like the zebra mussel *(Dreissena polymorpha)* and the gypsy moth *(Lymantria dispar)-is* largely the focus of, and the reason for, this assessment. This opening chapter both summarizes the assessment and spells out the policy issues and options for Congress that emerged from the analysis.

SUMMARY OF FINDINGS

The summary portion of this chapter compiles *the* more detailed findings from the individual chapters that follow (box 1-A). It is organized to reflect the three focal points of the report:

- . an overview of the status of harmful non-indigenous species (MS) in the United States (chs. *2, 3);*
- *o an* analysis of the technological issues involved in dealing with harmful NIS (chs. *4, 5, 9);* and
- an examination of the institutional organization in place (chs. 6, 7).



Two chapters cut across these areas. Chapter *8* presents detailed case studies for two States with particularly severe NIS-related problem-Hawaii and Florida. Chapter 10 discusses the future and the international context in which NIS issues will evolve. In each case, the pertinent chapter provides additional documentation.

Box I-A—A Road Map to the Full Assessment

This assessment has three focal points: the status of harmful non-indigenous species (NIS) in the United States; technological issues regarding decisionmaking and species management; and institutional and policy frameworks. Each chapter elaborates on the findings summarized here **and contains additional examples of problem** species and their locations.

Chapter

1 Summary, Issues, and Options
chapter findings; 8 major issues; policy options; New Zealand's approach

2 **The Consequences of Harmful Non-indigenous Species**
definitions and scope; benefits; economic, health, and environmental costs;extinctions and biological diversity

3 The Changing Numbers, **Causes, and Rates of introductions**
pathways into and within the country; numbers per taxonomic group, state, decade; new detections since 1980

4 The Application of Decisionmaking Methods
uncertainty; 'dean' and 'dirty' lists; risk analysis; environmental impact assessment; benefit/cost analysis; protocols; values; new approaches; Siberian timber

5 Technologies **for Preventing and Managing Problems**
inspection and detection; databases; quarantine and containment; control methods; eradication; environmental education; ecological restoration; FIFRA reregistration

6 A Primer on Federal Policy
summary lessons; President Carter's Executive Order; Aquatic Nuisance Species Task Force; activities of 21 agencies by type of activity and organisms affected

7 State and Local Approaches **from a National Perspective**
Federal/State relations; States' legal approaches, standards, gaps, and statutes on fish and wildlife; survey results; State laws on plants, insects, and other invertebrates; model State laws; enforcement; exemplary approaches

8 Two Case Studies: Non-indigenous **Species In Hawaii and Florida**
the States' uniqueness; introduction rates; critical species; affected sectors; newprograms; fruit flies and brown tree snakes in Hawaii; melaleuca and Hurricane Andrew in Florida

9 Genetically **Engineered Organisms As a Special Case**
technical and Policy controversies; Federal regulation since 1984; ecological **rlsk assessment; scale-up of releases; transgenic fish and squash; NIS vs. GEOs;**

10 **The Context of the Future: international Law and Global Change**
treaties and trade agreements; CITES **as a model;** technological change; impacts of current trends; future pests; climate change; worst and best case scenarios

Appendixes
list **of boxes,** figures, and tables; authors, workshop participants, reviewers, and survey respondents; references

indexes
common and scientific names of species; general index

Table I-l—Estimated Numbers of Non-Indigenous Species in the United States[a]

Species with origins outside of the United States		
Category	**Number**	**Percentage of total species in the United States in category**
Plants	>2,000	b
Terrestrial vertebrates	142	5=60/0
Insects and arachnids	>2,000	=2%
Fish	70	= 8 %
Mollusks (non-marine)	91	=4%
Plant pathogens	239	b
Total	4,542	

Species of U.S. origin introduced beyond their natural ranges		
Category	**Number**	**Percentage of total species in the United States in category**
Plants	b	b
Terrestrial vertebrates	51	=2%
Insects and arachnids	b	b
Fish	57	=17YOC
Mollusks (non-marine)	b	b
Plant pathogens	b	b

a Numbers should be considered minimum estimates. Experts believe many more NIS are established in the country, but have not yet been detected.
b Number or proportion unknown.
c Percentage for fish is the calculated average percentage for several regions, Percentages for all other categories are calculated as the percent of the total US. flora or fauna in that category.

SOURCES: Summarized by the Office of Technology Assessment from: J.C. Britton, "Pathways and Consequences of the Introduction of Non-Indigenous Freshwater, Terrestrial, and Estuarine Mollusks in the United States," contractor report prepared for the Office of Technology Assessment, October 1991; W,R. Courtenay, Jr., "Pathways and Consequences of the Introduction of Non-Indigenous Fishes in the United States," contractor report prepared for the Office of Technology Assessment, September 1991; K.C. Kim and A.G. Wheeler, "Pathways and Consequences of the Introduction of Non-Indigenous Insects and Arachnids in the United States," contractor report prepared for the Office of Technology Assessment, December 1991; R.N. Mack, "Pathways and Consequences of the Introduction of Non-Indigenous Plants in the United States," contractor report prepared for the Office of Technology Assessment, September 1991; C.L. Schoulties, "Pathways and Consequences of the Introduction of Non-Indigenous Plant Pathogens in the United States," contractor report prepared for the Office of Technology Assessment, December 1991; S. A. Temple and D.M. Carroll, "Pathways and Consequences of the Introduction of Non-Indigenous Vertebrates in the United States," contractor report prepared for the Office of Technology Assessment, October 1991.

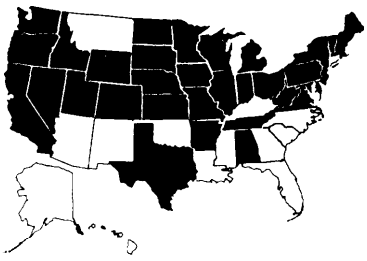
Non-Indigenous Species Today: Numbers, Pathways, Rates, and Consequences

Many more NIS—those plants, animals, and microbes found beyond their natural geographical ranges—are in the United States today than there were 100 years ago. At least 4,500 species of foreign origin have established free-living populations in this country. These include several thousand plant and insect species and several hundred non-indigenous vertebrate, mollusk, fish, and plant pathogen species (table l-l). Approximately 2 to 8 percent of each group of organisms is non-indigenous to the United States.

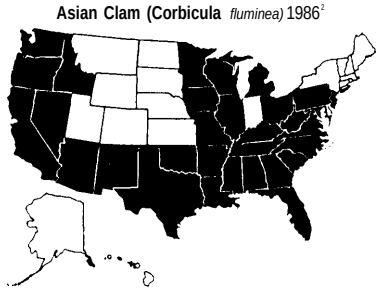
Some NIS are clearly beneficial. Non-indigenous crops and livestock-like soybeans *(Glycine roux),* wheat *(Triticum* spp.), and cattle *(Bos* taurus)-form the foundation of U.S. agriculture, and other NIS play key roles in the pet and nursery industries, fish and wildlife management, and biological control efforts. These and other positive contributions of NIS are largely beyond the scope of this study, however. OTA's work takes a comprehensive look at the damaging

Figure I-l-State by State Distribution of Some High Impact Non-Indigenous Species

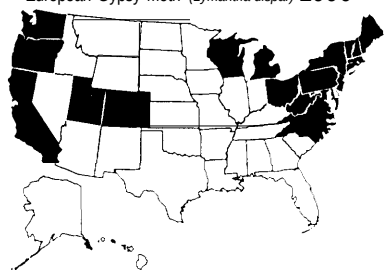
Purple Kiisestrufe *(Lythrurm salicaria)* 1985[1]



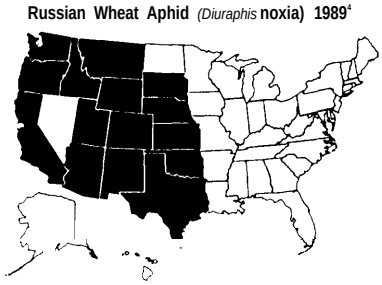
Asian Clam (Corbicula *fluminea)* 1986[2]



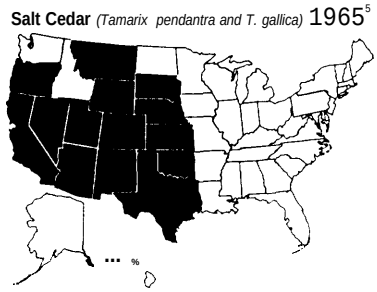
European Gypsy Moth *(Lymantria dispar)* 1990[3]



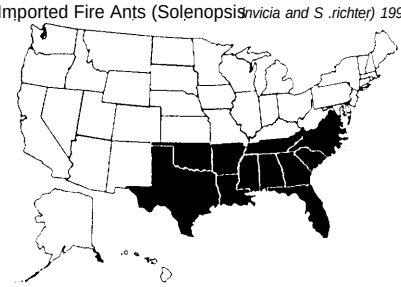
Russian Wheat Aphid *(Diuraphis* **noxia) 1989**[4]



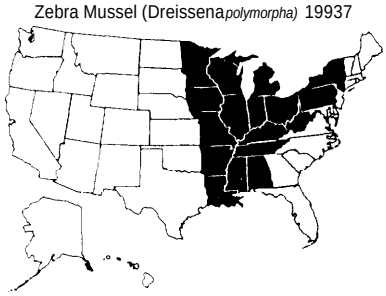
Salt Cedar *(Tamarix pendantra and T. gallica)* 1965[5]



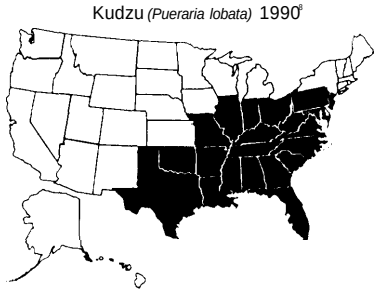
Imported Fire Ants (Solenopsis *invicia and S .richter) 1992*[6]



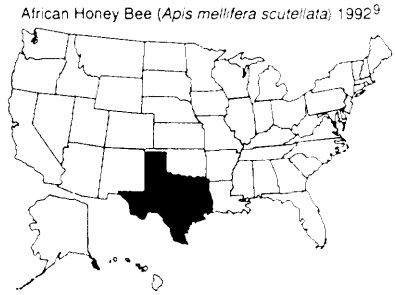
Zebra Mussel (Dreissena *polymorpha)* 19937



Kudzu *(Pueraria lobata)* 1990[8]



African Honey Bee (*Apis mellifera scutellata)* 1992[9]



SOURCES:

1. **D.Q. Thompson, R.L. Stuckey, E.B. Thompson, "Spread, Impact, and Control of Purple Loosesttife (Lythrum salicaria) in North American Wetlands" (Washington, DC: U.S. Department of the Interior Fish and Wildlife Service, 1987).**
2. **Clement L. Counts, Ill, 'The Zoogeography and History of the Invasion of the United States by** *Corbicula Fluminea* **(Bivalvia: Corbiculidae),"** *American MalacologicalBulletin* **Special Edition No. 2, 1986, pp. 7-39.**
3. **P.W. Schaefer and R.W. Fuester, "Gypsy Moths: Thwarting Their Wandering Ways," Agricultural** *Research,* **vol. 39, No. 5, May 1991, pp. 4-11; M.L. McManus and T. McIntyre, "Introduction," The Gypsy Moth: Research** *Toward Integrated Pest Management, C.C.* **Deane and M.L. McManus (eds.) Technical Bulletin No. 1584 (Washington, DC: U.S. Forest Service, 1981), pp. 1-8; T. Eiber, "Enhancement of Gypsy Moth Management, Detection, and Delay Strategies," Gypsy Moth News, No. 26, June 1991, pp. 2-5.**
4. **S.D. Kindler and T.L. Springer, "Alternative Hosts of Russian Wheat Aphid" (Homoptera: Aphididae),** *Journal of Economical Entomology,* **vol. 82, No. 5, 1989, pp. 1358-1362.**
5. **T.W. Robinson, "Introduction, Spread and Areal Extent of Saltcedar (Tamarix) in the Western States," Studies of Evapotranspiration, Geological Survey Professional Paper 491-A (Washington, DC: U.S. Government Printing Office, 1965).**
6. **V.R. Lewis et al., "Imported Fire Ants: Potential Risk to California,"** *California Agriculture, vol. 46, No* **1, January-February 1992, pp. 29-31; D'Vera Cohn, "insect Aside: Beware of the Fire Down Below, Stinging Ants From Farther South Have Begun to Make Inroads in Virginia, Maryland,"** *Washington Post,* **June 2, 1992, p. B3.**
7. **U.S. Department of the Interior, Fish and Wildlife Service, briefing delivered to the Senate Great Lakes Task Force, May 21, 1993.**
8. **Anonymous,** *National Geographic Magazine,* **'Scourge of the South Maybe Heading North," vol. 178, No. 1, July 1990.**
9. **M.L. Winston, "Honey, They're Here! Leaning to Cope with Africanized Bees," The** *Sciences,* **vol. 32, No. 2, March/April 1992, pp. 22-28.**

Table 1-2—Estimated Cumulative Losses to the United States From Selected Harmful Non-Indigenous Species, 1906-1991

Category	Species analyzed (number)	Cumulative loss estimates (millions of dollars, 1991)	Species not anaiyzed[a] (number)
Plants[b]	15	603	—
Terrestrial vertebrates	6	225	>39
insects	43	92,658	>330
Fish	3	467	*>30*
Aquatic invertebrates	3	1,207	>35
Plant pathogens	5	867	>44
Other	4	917	—
Total	79	96,944	>478

a Based on estimated numbers of known harmful species per category (figure 2-4).
b Excludes most agricultural weeds; these are covered in box 2-D.

NOTES: The estimates omit many harmful NIS for which data were unavailable. Figures for the species represented here generally cover only one year or a few years. Numerous accounting judgments were necessary to allow consistent comparison of the 96 different reports relied on; information was incomplete, inconsistent, or had other shortcomings for most of the 79 species.

SOURCE: M. Cochran, "Non-Indigenous Species in the United States: Ecmnomic Consequences," contractor report prepared for the Office of Technology Assessment, March 1992.

species: how they get here, their impacts, and what can be done about them.

Distinguishing between "good" and "bad" NIS is not easy. Some species produce both positive and negative consequences, depending on the location and the perceptions of the observers. Purple loosestrife *(Lythrum salicaria),* for example, is an attractive nursery plant but a major wetland weed. Approximately 15 percent of the NIS in the United States cause severe harm, High-impact species—such as the zebra mussel, gypsy moth, or leafy spurge *(Euphorbia esula)* (a weed)----occur throughout the country (figure l-l). Almost every part of the United States confronts at least one highly damaging NIS today. They affect many national interests: agriculture, industry, human health, and the protection of natural areas.

The number and impact of harmful NIS are chronically underestimated, especially for species that do not damage agriculture, industry, or human health. Harmful NIS cost millions to perhaps billions of dollars annually. From 1906 to 1991, just 79 NIS caused documented losses of $97 billion in harmful effects, for example (table 1-2). A worst-case scenario for 15 potential high-impact NIS puts forth another $134 billion in future economic losses (table 1-3). The figures represent only a part of the total documented and possible costs—that is, they do not include a large number of species known to be costly but for which little or no economic data were available, e.g., non-indigenous agricultural weeds. Nor do they account for intangible, nonmarket impacts.

Harmful NIS also have had profound environmental consequences, exacting a significant toll on U.S. ecosystems. These range from wholesale ecosystem changes and extinction of indigenous species (especially on islands) to more subtle ecological changes and increased biological sameness. The melaleuca tree *(Melaleuca quinquenervia) is* rapidly degrading the Florida Everglades wetlands system by outcompeting indigenous plants and altering topography and soils. In Hawaii, some NIS have led to the extinction of indigenous species, and the brown tree snake *(Boiga irregularisis)* may further this process.

Naturally occurring movements of species into the United States are uncommon. Most new NIS arrive in association with human activity, transport, or habitat modification that provides new opportunities for species' establishment. Numerous harmful species arrived as unintended byproducts of cultivation, commerce, tourism, or travel.

Table 1-3-Worst Case Scenarios: Potential Economic Losses From 15 Selected Non-Indigenous Species[a]

Group	Species studied	Cumulative loss estimates (in millions, $1991)[b]
Plants	melaleuca, purple loosestrife, witchweed	4,588
Insects	African honey bee, Asian gypsy moth, boll weevil, Mediterranean fruit fly, nun moth, spruce bark beetles	73,739
Aquatic invertebrates	zebra mussel	3,372
Plant pathogens	annosus root disease, larch canker, soybean rust fungus	26,924
Other	foot and mouth disease, pine wood nematodes	25,617
Total	15 species	134,240

a see index for scientific names.
b Estimates are net present values of economic loss projections obtained from various studies and report selected potentially harmful NIS. Many of the economic projections are not weighted by the probability that the invasions would actually occur. Thus, the figures represent worst case scenarios. The periods of the projections range from 1 to 50 years.

SOURCE: M. Cochran, "Non-Indigenous Species in the United States: Economic Consequences," contractor report prepared for the Office of Technology Assessment, March 1992.

For example, they arrived as contaminants of bulk commodities, packing materials, shipping containers, or ships' ballast. Weeds continue to enter the country as contaminants in seed shipments; both plant and fish pathogens have arrived with diseased stocks. Some NIS stow away on cars and other conveyances, including military equipment.

Other harmful NIS were intentionally imported as crops, ornamental plants, livestock, pets, or aquiculture species-and later escaped. Of the 300 weed species of the western United States, at least 36 escaped from horticulture or agriculture. A number of NIS were imported and released for soil conservation, fishing and hunting, or biological control and later turned out to be harmful. A few illegal introductions also occur.

Different groups of organisms arrive by different pathways. Some fish are imported intentionally to enhance sport fisheries; others are illegally released by aquarium dealers or owners or escape from aquiculture facilities. Most foreign terrestrial vertebrates are intentional introductions. Insects (except for biological control organisms) and aquatic and terrestrial mollusks usually hitchhike with plants, commercial shipments, baggage, household goods, ships' ballast water, or aquarium and aquiculture shipments.

Far more unintentional introductions of insects and plant pathogens have had harmful effects than have intentional introductions. For terrestrial vertebrates, fish, and mollusks, however, intentional introductions have caused harm approximately as often as have unintentional ones, suggesting a history of poor species choices and complacency regarding their potential harm.

Far more is known about pathways of foreign NIS into the United States than the routes by which NIS have spread beyond their natural ranges within the country. Once here, NIS spread both with and without human assistance. A few of these pathways have no international counterpart, e.g., the release of bait animals like the sheepshead minnow *(Cyprinodon variegates). Known* or potentially harmful NIS that are commercially distributed or officially recommended for various applications can spread especially quickly.

OTA found no clear evidence that the rate of harmful NIS imports has climbed consistently over the past 50 years. The ways and rates at which species are added from abroad fluctuate widely because of social, political, and technological factors, e.g., new trade patterns and innovations in transportation. Such factors have had major significance in the past and will continue to operate. For example, State and Federal plant quarantine laws slowed rates of introduction of insect pests and plant pathogens after 1912. However, rates rarely reach zero and they have been higher throughout the 20th century than in the preceding one.

More than 205 NIS from foreign countries were first introduced or detected in the Unites States since 1980, and 59 of these are expected to cause economic or environmental harm. There may be limits to the acceptable total burden of harmful NIS in the country. This consideration has yet to be incorporated into policy decisions such as setting tolerable annual levels of species entry.

OTA has carefully examined the best available evidence on the numbers, rates, pathways, and impacts of NIS. Six scientists prepared background papers on the pathways and consequences of NIS within their area of expertise. Another 36 experts from industry, academia, and government reviewed their work. OTA supplemented this work with its own analysis of the science and policy literature.

Based on this extensive review of the **status** of NIS, OTA concludes **that the total** number of harmful NIS and their cumulative impacts are creating a growing economic and environmental burden for the country. This conclusion leads to certain policy issues discussed later in this chapter. These address:

- the merits of prompt congressional action to create a more stringent national policy (pp. 15-19), and
- ways to provide funding for new or expanded efforts and to increase accountability for actions that lead to damage (pp. 40-45).

Technological Issues: Decisionmaking About NIS, Pest Management, and the Special Case of Genetically Engineered Organisms

Some of the most harmful NIS-like kudzu *(Pueraria lobata),* water hyacinth *(Eichhornia crassipes),* and feral goats *(Capra hircus)---were* imported and released intentionally, with their negative effects unanticipated or underestimated. The central issues for MS and genetically engineered organisms (a special subset) are the same: deciding which to keep out, which to release, and how to control those that have unexpected harmful effects. Consequently, part of OTA's study focused on the kinds of decisionmaking tools available.

AGRICULTURAL RESEARCH SERVICE

Federal laws helped decrease the number of harmful non-indigenous insect pests, plant pathogens, and weeds imported with crop seeds and plants.

Uncertainty in predicting risks and impacts of NIS remains a problem. Generally, the impact of new species cannot be predicted confidently or quantitatively. Risk can be reduced, or at least made explicit, using methods such as risk analysis, benefit/cost analysis, environmental impact assessment, and decisionmaking protocols. Expert judgment, however, is most broadly feasible. By and large, three interrelated problems remain largely unsolved:

1. determining levels of acceptable risk;
2. setting thresholds of risk or other variables above which more formal and costly decisionmaking approaches are invoked; and

Table 1-4-Lag Times Between Identification of Species' Pathway and implementation of Prevention Program.

Species	Pathway	Date pathway identified	Date prevention program implemented	Remaining gaps
Mediterranean fruit fly *(Ceratitis capitata)*	Fruit shipped through first-class "domestic-mail from Hawaii	mid 1930s	1990, mail traveling from Hawaii to California inspected	First-class mail from elsewhere or other potential pathways (e.g., Puerto Rico to California)
Aquatic vertebrates, invertebrates, and algae	Ship ballast water	1981	1992, Coast Guard proposes guidelines for treating ballast water into the Great Lakes	International shipping into other U.S. ports; ship ballast water from domestic ports
Asian tiger mosquito (Aedes *albopictus)*	Imported used tires	1986	1988, protocols established for imported used tires	Interstate used tire transport
Forest pests	Unprocessed wood (including dunnage, logs, wood chips, etc.)	1985	1991, first restrictions imposed on log imports from Siberia	Wood imports other than from Siberia

SOURCES: Bio-environmental Services Ltd., The *Presence and Implication of Foreign Organisms in Ship Ballast Waters Discharged into the Great Lakes,* vol 1, March 1981; C.G. Moore, D.B. Francy, D.A. Eliason, and T.P. Monath, *"Aedes albopictus* in the United States: Rapid Spread of a Potential Disease Vector," *Journal of the American Mosquito Control Association, vol. 4, No. 3* September 1988, pp. 356-361; I.A. Siddiqui, Assistant Director, California Department of Food and Agriculture, Sacramento, CA, testimony at hearings before the Senate Committee on Governmental Affairs, Subcommittee on Federal Services, Post Offices, and Civil Services, *Postal Implementation of the Agriculturall Quarantine Enforcement Act,* June 5, 1991; United States Department of Agriculture, Animal and Plant Health Inspection Service, "Wood and Wood Product Risk Assessment," draft, 1985.

3. identifying tradeoffs when deciding in the face of uncertainty.

Federal methods and programs to identify risks of potentially harmful NIS have many shortcomings-including long response times (table 1-4). Procedures vary in stringency throughout the Animal and Plant Health Inspection Service (APHIS) in the Department of Agriculture (USDA), risks to nonagricultural areas are often ignored, and generally, new imports are presumed safe unless proven otherwise. Even with these flaws, APHIS's risk assessments are more rigorous than those conducted by the Fish and Wildlife Service (FWS) in the Department of the Interior. Most regulatory approaches to MS importation and release use variations of 'clean' (allowed) or "dirty" (prohibited) lists of species or groups. Combining both kinds of lists, with a ''gray" list of prohibited-until-analyzed species would reduce risks.

Nevertheless, preventing new introductions of harmful species is the first line of defense. Various methods can help decisionmakers avert unintentional and poorly planned intentional introductions that are likely to cause harm. Port inspection and quarantine are imperfect tools, though, so prevention is only part of the solution. Some organisms are more easily controlled than intercepted. Aiming for a standard of ''zero entry" has limited returns, especially when prevention efforts come at the expense of rapid response or essential long-term control.

When prevention fails-for technical or political reasons—rapid response is essential. Then managers can choose among a variety of methods for eradication, containment, or suppression (table 1-5); these choices are not necessarily easy or obvious. For example, the choice may be not to control already widespread organisms, or those for which control is likely to be too expensive and/or ineffective. For any management program,

Table 1-5-Examples of Control Technologies for Non-indigenous Species

	Physical control	Chemical control	Biological control
Aquatic plants	Cutting or harvesting for temporary control of Eurasian watermilfoil *(Myriophylllum spicatum)* in waters	Various glyphosate herbicides (Rodeo is one brand registered for use in aquatic sites) for controlling purple loosestrife (Lythrum *salicaria)*	Imported Klamathweed beetle *(Agasicles hygrophila)* and a moth *(Vogtia ma//o/)* to control alligator weed *(Alternanthera philoxeroides)* in southeastern United States
Terrestrial plants	Fire and cutting to manage populations of garlic mustard (Alliaria *petiolata)* in natural areas	Paraquat for the control of witchweed *(Striga asiatica)* in corn fields	Introduction of a seed head weevil *(Rhinocyllus conicus)* to control musk thistle *(Carduus nutans)*
Fish	Fencing used as a barrier along with electroshock to control non-indigenous fish in streams	Application of the natural chemical rotenone to control various non-indigenous fish	Stocking predatory fish such as northern pike (Esox *lucius)* and walleye (Stizostedion *vitreum)* to control populations of the ruffe *(Gymnocephalus cernuus)*
Terrestrial vertebrates	Fencing and hunting to control feral pigs (Sus *scrofa)* in natural areas	Baiting with diphacinone to control the Indian mongoose (Herpestes *auropunctatus)*	Vaccinating female feral horses *(Equuscallus)* with the contraceptive PZP (porcine zona pellucida) to limit population growth
Aquatic invertebrates	Washing boats with hot water or soap to control the spread of zebra mussels *(Dreissena polymorpha)* from infested waters	In industrial settings, chlorinated water treatments to kill attached zebra mussels	No known examples of successful biological control of non-indigenous aquatic invertebrates (Target specificity is a major concern)
Insects/mites	Various agricultural practices, including crop rotation, alternation of planting dates, and field sanitation practices	Mathathion bait-sprays for control of the Mediterranean fruit fly *(Ceratitis capitatis)*	A parasitic wasp (Encarsia partenopea) and a beetle *(Clitostethus arcuatus)* to control ash whitefly *(Siphoninus phillyreae)*

SOURCE: Office of Technology Assessment, 1993.

accurate and timely species identification is essential but sometimes not available.

Eradication of harmful NIS is often technically feasible but complicated, costly, and subject to public opposition (box l-B). Chemical pesticides play the largest role now in management. They will remain important for fast, effective, and inexpensive control. In the future, an increased number of biologically based technologies will probably be available. Genetic engineering will increase the efficacy of some. Development of biological and chemical pesticides entail the same difficulties, however-ensuring species specificity, slowing the buildup of pest resistance to the pesticide, and preventing harm to nontarget organisms. So there are no ‘‘silver bullets’ for NIS control and some troublesome gaps may appear in the next 10 years. Pests have already developed resistance to some microbial pesticides, one alternative to chemical methods. A number of chemical pesticides are being phased out for regulatory or environmental reasons. And new alternatives are slow to come online. Ecological restoration, by changing the conditions

Box I-B—Failure and Success: Lessons From the Fire Ant and Boll Weevil Eradication Programs

Imported Fire Ant Eradication:

Two species of imported fire ants are assumed to have entered at Mobile, Alabama, in dry ship ballast: Solenopsis richteri in 1918, and, around 1940, Solenopsis invicta The ants became a public health problem and had significant negative effects on commerce, recreation, and agriculture in the States where they were found. in late 1957, a cooperative Federal-State eradication program began. It exemplifies what can go wrong with an eradication program.

Funding was provided to study the fire ants, but information on the biology of the species was lacking, and the ant populations increased and spread. Various chemicals (heptachlor and mirex) were used to control and eradicate the ants over a 30-year period. Although they did kill the ants, the chemicals caused more ecological harm than good. Their widespread application, often by airplane, destroyed many non-target organisms, including fire ants' predators and competitors, leaving habitats suitable for recolonization by the ants.

The chemicals eventually lost registration by the Environmental Protection Agency, leaving few alternatives avaliable. in the 5 years after 1957, fire ant infestations increased from 90 million to 120 million acres.

Boll Weevil Eradication:

The bolli weevil, *Anthonomus grands,* a pest of cotton, naturally spread into Texas, near Brownsville, from Mexico, in the early 1890s and crossed the Mississippi River in 1907. By 1922, it infested the remainder of the southeastern cotton area. Unlike t he imported fire ant eradication program, boll weevil eradication does not rely solely on chemicals.

The eradication program centers around the weevil's life cycle and uses many different techniques. Part of the boll weevil population spends the winter in cotton fields. insecticides are used to suppress this late season population. in spring and early summer, pheromone bait traps and chemical pesticides reduce populations before they have a chance to reproduce. Still other control technologies (e.g., sterile male release or insect growth regulators) limit the development of a new generation of boll weevils.

Boll weevil eradication trials were conducted from 1971=1973 (in southern Mississippi, Alabama, and Louisiana) and from 1978-1980 (in North Carolinaand Virginia). Although results of the trials were mixed, cotton producers in the Carolinas voted in 1983 to support the boll weevil eradication program in their areaand to provide 70 percent of the funding. The USDA Animal and Plant Health inspection Service was charged with overall management of the program.

By the mid-1980s, the boll weevil was eradicated from North Carolina and Virginia. This 1978-1987 eradication program achieved a very high rate of return, mainly from increased cotton yields and lower chemical pesticide spending and use. in 1986, pesticide cost savings, additions to land value, and yield increases amounted to a benefit of $76.65 per acre. The benefit was $78.32 per acre for the expansion area in southern North Carolina and South Carolina.

SOURCES: G.A. Carlson, G. Sappie, and M. Hamming, "Economic Returns to Boll Weevil Eradication," U.S. Department of Agriculture, Economic Research Service, September 19S9, p. 31; W. Klassen, "Eradication of Introduced Arthropod Pests: Theory and Historical Practice," Entomological Society of America, Miscellaneous Publications, No. 73, November 19S9; E.P. Lloyd, "The Boll Weevil: Recent Research Developments and Progress Towards Eradication in the USA," Management *and Control of Invertebrate Crop Pests*, G.E. Russell (cd.) (Andover, England: Intercept, 19S9), pp. 1-19; and C.S. Lofgran, WA. Banks, and B.M. Glancey, "Biology and Control of Imported Fire Ants," *Annual Review of Entomology* vol. 30, pp. 1-30,1975,

that may make a habitat suitable for NIS, shows promise for preventing or limiting the establishment or spread of some harmful NIS. Continued research and development on new ways to manage harmful NIS remain essential.

OTA commissioned 3 papers on decisionmaking methods for this study, submitted those papers to peer review by 20 experts, held a workshop for the papers' authors and several additional specialists, and added a staff review of control methods and biotechnology policy, along with another expert paper on genetic engineering-each with extensive informal input from technical and policy specialists.

Based on this work regarding technical aspects, OTA concludes that some continued unintentional introductions are inevitable, as are illegal ones, and ones with unexpected effects. Perfect screening, detection, and control are technically impossible and will remain so for the foreseeable future. These results lead to certain of the congressional policy issues discussed later in this chapter. These include the need for:

- more effective screening for fish, wildlife, and their diseases (pp. 22-24);
- more stringent evaluations of new plant introductions for their potential as weeds (PP. 28-30); and
- more rapid response to emergencies and better means for setting priorities (pp. 36-40).

Continued intentional introductions of certain species are, of course, desirable. None of the policy options are intended to stop them.

Institutional Issues: the Federal and State Policy Patchwork

The current Federal effort is largely a patchwork of laws, regulations, policies, and programs. Many only peripherally address NIS, while others address the more narrowly drawn problems of the past, not the broader emerging issues.

The need for a more restrictive national policy on introductions and use is widely acknowledged. Development of such a policy is impeded by historical divisions among agencies, user groups, and constituencies. Technical barriers also obstruct accurate and consistent Federal policy. For example, terms and definitions differ greatly among NIS-related statutes, regulations, policies, and publications.

At least 20 Federal agencies work at researching, using, preventing, or controlling desirable and harmful NIS (table 1-6), with APHIS playing the largest role. Federal agencies manage about 30 percent of the Nation's lands, some of which have severe problems with NIS. Yet management policies regarding harmful NIS range from being nearly nonexistent to stringent. The National Park Service has fairly strict policies. However, removal or control of unwanted NIS is not keeping pace with invasions, and concerns are growing that NIS threaten the very characteristics for which the Parks were established.

Federal agencies do not uniformly evaluate the effects of NIS before using them for federally funded activities. However, a Federal interagency group is planning to coordinate work on noxious weeds. Another interagency task force is developing a major program on aquatic nuisance species.

Federal laws leave both obvious and subtle gaps in the regulation of harmful MS. Most State laws have similar shortcomings. Significant gaps in Federal and State regulation exist for nonindigenous fish, wildlife, animal diseases, weeds, species that affect nonagricultural areas, biological control agents, and vectors of human diseases. Many of these gaps also apply to genetically engineered organisms (GEOs), which are commonly regulated under the same laws. Commercial development is imminent for several such categories of GEOs.

Pre-release evaluations for certain GEOs have been more stringent than for NIS-reflecting past underestimates of NIS risks. Some of these stricter GEO-related methods might be used for NIS. So far, APHIS has only evaluated proposals

Table 1-6—Areas of Federal Agency Activity Related to NIS

Agency[a]	Movement into U.S.		Interstate movement within U.S.		Regulate product content or labeling	Control or eradication programs	Fund or do introductions	Federal land management		Fund or do research		Aquiculture development	Biocontrol development
	Restrict	Enhance	Restrict	Enhance				Prevent eradication or control	Introduce or maintain	Prevention control eradication	uses of species		
APHIS	J		J		J	J	J	J		J	J		J
AMS			J		J								
FAS	[b]												
USFS						✓	J	J		✓	J		
ARS	✓	J		J			J			✓	J		J
SCS		J		J						✓	J		
ASCS							J						
CSRS										J	J	J	J
FWS	J				J	J	J	J	✓	J	J	J	J
NPS						J		J	J	✓	J		✓
BLM								J	J	✓			J
BIA						J							
BOR						J	J	J		✓			
NOAA	J					J		J		J	J	J	
DOD	J	J				J		J		J		J	J
EPA	J				J					J	[d]		
PHS	J									✓			
Customs	J												
USCG	J									J			
DOE								[e]	[e]				
DEA	J												

[a] Acronyms of Frederal Agencies Department of Agriculture-Animal and plant Health Inspection Service (APHIS); Agricultural Marketing Service (AMS); Foreign Agricultural Service (FAS); Forest Service (USFS); Agricultural Research Service (ARS); Soil Conservation Service (SCS); Agricultural Stabilization and Conservation Service (ASCS); Cooperative State Research Service (CSRS). Department of the Interior—Fish and Wildlife Service (FWS); National Park Sevice (NPS); Bureau of Land Management (BLM); Bureau of Indian Affairs (BIA); Bureau of Reclamation (BOR)."Department of Commerce-National Oceanic and Atmospheric Administration (NOAA). Department of Defense (DOD): Environmental Protection Agency (EPA). Department of Health h and Human Services-Public Health Service (PHS). Department of the Treasury-Customs Service (Customs). Department of Transportation-Coast Guard (USCG). Department of Energy (DOE). Department of Justice-Drug Enforcement Agency (DEA).
[b] Monitors animal diseases abroad.
[c] Monitors spread of human disease vectors within the United States.
[d] Regulates experimental releases of microbial pesticides.
[e] DOE lacks policies on NIS.

SOURCE: Office of Technology Assessment, 1993.

for releasing low risk GEOs. Setting acceptable risk levels for higher risk GEOs will be more difficult, a problem the agency has not solved for NIS. Experience with NIS shows overwhelmingly that organisms' effects and ecological roles can change in new environments. Thus, caution is warranted when extrapolating from small to large-scale GEO releases and when exporting GEO's to other countries.

State laws on NIS vary from lax to exacting and use a variety of basic legal approaches (table 1-7). They are relatively comprehensive for agricultural pests but only spotty for invertebrate and plant pests of nonagricultural areas.

States play a larger role than the Federal Government in the importation and release of fish and wildlife. Several States present exemplary approaches. Yet many State laws are weak and their implementation inadequate. For example, most State fish and wildlife agencies rate their own resources for implementing and enforcing their own NIS laws as "less" or ''much less" than adequate; they would need, on average, a 50-percent increase in resources to match their responsibilities. States' evaluations of new releases are not stringent: no States require the use of scientific protocols for evaluating proposed introductions, and about one-third do not even require a general determination of potential negative impacts. States prohibit a median of only eight potentially harmful fish and wildlife species or groups; about one-third of the agency officials OTA surveyed believe their own lists of prohibited species are too short. About one-fourth of the States lack legal authority over the importation or release of at least one major vertebrate group. About 40 percent of the agency officials would like additional regulatory authority from their State legislatures.

Federal and State agencies cooperate on many programs related to agricultural pests, but their policies can also conflict, e.g., when agencies manage adjacent lands for different purposes. Sometimes Federal law preempts State law, more often regarding agriculture than fish and wildlife. Conflicts between States also occur, often without forums for resolving the disputes. Regional approaches —used mostly to evaluate aquatic releases-provide means for States to affect their neighboring States' actions. Such approaches are promising but limited by the fact that participation is not mandatory.

For the section on institutional issues, OTA commissioned 3 background papers, on the Department of Interior, USDA generally, and APHIS in particular; 20 people took part in the papers' external peer review. Also, OTA did extensive internal research on the missions and activities of Federal agencies. In addition, OTA compiled State laws and regulations relating to NIS, with assistance from an expert group, and surveyed the heads of State fish and wildlife agencies.

Based on this institutional analysis, OTA concludes that Federal and State efforts are not protecting national interests in certain important areas. Thus, OTA highlights congressional policy issues on:

- needed changes to the Lacey Act for fish and wildlife (pp. 19-24);
- new roles for the States in fish and wildlife management (pp. 24-25);
- needed changes to the Federal Noxious Weed Act (pp. 25-28); and
- improved weed management on Federal lands (pp. 30-31);
- other gaps in legislation and regulation (pp. **45-50).**

The Special Cases of Hawaii and Florida

Virtually all parts of the country face problems related to harmful NIS, but Hawaii and Florida have been particularly hard hit because of their distinctive geography, climate, history, and economy. In both States, natural areas and agriculture bear the brunt of harm and certain NIS threaten the State's uniqueness. As a set of islands, Hawaii is particularly vulnerable to sometimes devastating ecological impacts. More than one-half of Hawaii's free-living species are non-indigenous.

Table 1-7—Basic Legal Approaches Used by States for Fish and Wildlife Importation and Release

	Importation[a,b]		Release	
Basic approach	Number	States	Number	States
All species are prohibited unless on allowed ("clean") list(s).	2 + 1 pt[c]	HI, IDpt, VT[d]	1 + 5pt	AKpt, FLpt, GApt, HI, IDpt, KYpt
All species may be allowed except those on prohibited ("dirty") list(s).				
Prohibited list(s) have 5 or more identified species or groups.	*20* + 3pt	AL, AR, CO, CT, FL, IL, KS, KY, MI, MN, MTpt, NC, NE, NY, OH, PA, SCpt, SD, TN, TXpt, UT WA, WY	14+ 6pt	AL, AR, CO, CT, FLpt, GApt, IL, KS, KYpt, MN, NE, NY, OHpt, PA, SCpt, TN, TXpt, UT WA, WY
Prohibited list(s) have fewer than 5 identified species or groups.	11 + 3pt	AK, DE, IN, LApt, MD, ME, MS, NH, NV, NJ, ORpt, RI, VA, WVpt	11 + 6pt	AKpt, IN, LApt, NC, NDpt, NJ, MD, MN, MS, NH, NV, OR, RIpt, SD, VA, VTpt, Wvpt
All species may be allowed; there is no prohibited list.	11 + 7pt	AZ, CA, GA, IDpt, 1A, LApt, MA, MO, MTpt, ND, NH, NM, OK, ORpt, SCpt, TXpt, *WI,* Wvpt	12+ 9pt	AZ, CA, DE, IDpt, 1A, LApt, MA, ME, MI, MO, MT, NDpt NM, OHpt, OK, RIpt, SCpt, TXpt, VTpt, WI, WVpt

[a] State regulation of "possession" of a group or groups is considered here as regulation of both "importation" and "release," since neither act can be done without having possession. For the few States that specifically regulate "importation with intention to release (or introduce)," it is not treated here as comprehensive regulation of "release" because it covers only acts of importation done with a specific intent.
b Many states that regulate importation of particular groups exempt mere transportation through the State. These are not distinguished here.
[c] *Some States treat* different groups of vertebrates differently, This is designated, where applicable, by using the abbreviation "pt" after the State initial to indicate the entry covers only "part" of the vertebrates regulated. They are totaled separately.
d The summary classifications are general; in many states there are limited exemptions, such as for scientific research, and other minor provisions which are not covered here. The extensive State regulation of falconry is excluded.

SOURCES: Office of Technology Assessment, 1993 and Center for Wildlife Law, University of New Mexico Law School, "Selected Research and Analysis of State Lawson Vertebrate Animal Importation and Introduction," contractor report prepared for the Office of Technology Assessment, Washington, DC, April 1992.

New species played a significant role in past extinctions of indigenous species and continue to do so. In Florida, several non-indigenous aquatic weeds and invasive trees seriously threaten the Everglades wetlands system.

Hawaii's isolation makes it most in need of a comprehensive policy to address NIS. Differing Federal and State priorities have made this difficult to achieve, however. Cooperative efforts have sprung up in both States among State and Federal agencies, nongovernmental organizations, agricultural interests, and universities. Increasingly, these groups see harmful NIS as a unifying threat and public education as an important tool to address it. The situation in Hawaii and Florida, while unusual in some ways, nevertheless heralds what other States face as additional harmful NIS enter and spread throughout the United States and people become more aware of their damage.

For this chapter, OTA commissioned a background paper on each State and 12 experts reviewed this work. Two contractors conducted extensive interviews and site visits in Hawaii and OTA staff did the same in Florida. Also, OTA commissioned a survey and assessment of U.S. environmental education programs.

Based on this work, OTA concludes that the situation in Hawaii and Florida, while unusual in some ways, nevertheless heralds what other States face as additional harmful NIS enter and spread throughout the United States and people become more aware of their damage. These results lead to the policy options discussed later in this chapter on:

- better protection for National Parks and other natural areas throughout the country (pp. 31-34), and
- the role of information and environmental education in preventing future problems in these States and elsewhere (pp. 34-36).

The Look of the Future

Increasing international trade, including commerce in biological commodities, will open new pathways for NIS. International regulation of NIS has a poor track record and is not likely to stem this flow. Technology is likely to open additional pathways as well as provide better ways to detect, eradicate, and manage harmful NIS. Many observers expect increasingly negative impacts from NIS introductions-a world of increasing biological sameness. Climate change is the wild card: it would require re-thinking definitions of indigeneity and could drastically change patterns of species movement. These are forecasts, based on analyzable and nearly irreversible trends already underway. Visions, however, are about the desirable and imagined. OTA's Advisory Panelists envisioned a future in which beneficial NIS contributed a great deal to human well-being and indigenous species were preserved (box 1-C). Deciding this vision's worthiness is not a question for science. Which species to import and release and which to exclude are ultimately cultural and political choices-choices about the kind of world in which we want to live.

POLICY ISSUES AND OPTIONS

In this section, OTA sets out the major policy issues that emerged from its analysis. Related congressional options seem straightforward in some cases, e.g., changes to the Lacey Act[1] or the Federal Noxious Weed Act (FNWA).[2] In other cases, policy actions are not so apparent. Therefore, the policy options that follow vary in their specificity and the degree to which OTA has evaluated their implications and alternatives. Few prior reports on NIS have addressed policy changes. OTA's work is, in effect, exploratory-a frost step in highlighting policy needs and a few of the means to fill them. The discussion is organized around these eight policy issues:

Issue 1: Congress and a More Stringent National Policy
Issue 2: Managing Non-Indigenous Fish, Wildlife, and Their Diseases
Issue 3: The Growing Problem of Non-Indigenous Weeds
Issue 4: Damage to Natural Areas
Issue 5: Environmental Education as Prevention
Issue 6: Emergencies and Other Priorities
Issue 7: Funding and Accountability
Issue 8: Other Gaps In Legislation and Regulation

Issue 1: Congress and a More Stringent National Policy

The most fundamental issue is whether the United States needs a more stringent and comprehensive national policy on the introduction and management of harmful NIS. General agreement exists that the United States has no such policy now. The United States has, through various Federal and State laws and President Carter's Executive Order 11987, attempted to prevent and manage the impacts of harmful NIS. However, applicable legislation has significant gaps and the Executive Order has not been implemented fully (55,70) (ch. 6). Invasive NIS continue to enter, spread, and cause economic and environmental harm, despite governments' collective efforts (chs. 2, 3). In one of the most extensive State studies to date, the Minnesota Interagency Exotic Species Task Force noted:

[1] Lacey Act (1900), as amended (16 U.S.C.A. 667 *et seq.*, 18 U.S.C.A. 42 et seq.)
[2] Federal Noxious Weed Act of 1974, as amended, (7 U.S.C.A. 2801 *et seq.)*

Box 1-C-OTA's Advisory Panel Envisions the Future

OTA's Advisory Panelists (p. iv) have been dealing with NIS for much of their professional lives and are more expert than most in assessing what the future might hold. Following are some of the fears and hopes they identified when asked to ponder the best and worst that might be ahead.

Life Out of Bounds . . .

"The future will bring more reaction to zebra mussels (Dreissena polymorpha) and inaction to the massive alteration of natural habitats and natural flora and fauna . . . By the mid-21st Century, biological invasions become one of the most prominent ecological issues on Earth . . . A few small isolated ecosystems have escaped the hand of [humans] and in turn NIS. . . One place looks like the next and no one cares . . . The homogeneity may not be aesthetically or practically displeasing, but inherently it diminishes the capacity of the biotic world to respond to changing environments such as those imposed by global warming . . . The Australian melaleuca tree *(Melaleuca-quinquenervia)* continues its invasive spread and increases from occupying half a million acres in the late 1980s to more than 90 percent of the Everglades conservation areas."

. . . **Or Life In Balance**

"An appropriate respect for preserving indigenous species becomes national goal by consensus . . . All unwanted invasions are treated with species-specific chemicals or by vast releases of 100 percent sterile triploids (created quickly) that depress the exotic populations. Invasions slow to a trickle and fade away like smallpox . . . Jobs for invasion biologists fade away . . . There is] an effective communication network, an accessible knowledge base, a planned system of review of introductions, and an interactive, informed public . . . Native [species] are still there in protected reserves . . . The contribution of well-mannered NIS-for abuse-tolerant urban landscaping, for ornamental in gardens, for biological control of pests, for added interest for increased biodiversity, for new food and medicine-is appreciated. The overarching criterion for judging the value of a species is its contribution to the health of its host ecosystem."

SOURCE: Advisory Panel Meeting, Office of Technology Assessment July 2930,1092, Washington, DC.

> Needed is a plan to address all [non-indigenous species], changes in the laws that provide closer monitoring of new introductions, and coordination among all State and Federal agencies that control [non-indigenous] species. (70)

Gaps in the Federal, regional, and State system arise from several sources. First, Federal and many State agencies lack broad authority over NIS as a whole, e.g., to protect against NIS' negative effects on biological diversity, or to ensure that environmental impact assessments take potentially harmful NIS into account (box l-D). In turn, the agencies have been reluctant to exert authority where statutes are not clear. Consequently, MS issues often receive governmental attention on a piecemeal basis *after* major infestations, such as that of the zebra mussel. Attention wanes between harmful episodes.

Second, the lack of information on the origins, numbers, distribution, and potential impacts of many NIS hampers the design of appropriate responses (chs. 2, 4). Distinguishing indigenous species from NIS and beneficial NIS from harmful ones is difficult in some cases yet these are crucial distinctions for regulatory and control efforts. Some NIS escape detection at ports-of-entry and ordinary quarantines cannot contain them because of inadequate scientific knowledge and detection technologies.

Third, the U.S. system for dealing with harmful NIS involves a complex interplay of Federal and State authorities, with numerous Federal, State, and regional coordinating bodies attempting to enhance consistency and resolve conflicts. Sometimes the respective Federal and State roles are

not adequately defined (l), especially for problems that cross State boundaries.

Certain trends specific to NIS are likely to continue-trends that shape public policy. These point to increased public and scientific awareness of the damage some NIS cause and a concomitant caution toward importing new ones (46). The U.S. press is giving more attention to NIS-related problems caused by single species, e.g., zebra mussels, African honey bees *(Apis mellifera scutellata),* or cheatgrass *(Bromus tectorum).*

At the same time, many forces are elevating the visibility of harmful NIS on a broader, ecosystem basis. Some Federal and State agencies-e. g., the National Park Service, the Bureau of Land Management, the Minnesota Department of Natural Resources, and the Illinois Department of Conservation—are considering and in some cases adopting, more stringent policies (chs. 6, 7). In addition, the use of indigenous (native) plants and animals is increasingly popular in public and private landscaping, reforestation, fisheries management, wildlife enhancement, and other projects (96,130). These trends suggest that management of at least some harmful NIS is likely to improve even without congressional action.

On the other hand, the current situation provides considerable cause for concern (ch, 2). A *status quo* approach comes with certain, sizable risks-for example, that important resources such as the Everglades and Haleakala National Parks will lose their uniqueness (ch. 8); that western U.S. forests will be threatened by a more virulent gypsy moth (ch. 4); and that, in the absence of unifying Federal action, private firms importing or shipping live organisms will face increasingly inconsistent State and local regulations (ch. 7).

Environmental groups, professional organizations of scientists, and individual biologists are among those urging far stronger efforts to restrict the entry and spread of NIS. Participants in a conference sponsored by the U.S. Environmental Protection Agency (EPA) recommended that the United States aim for no new introductions of non-indigenous aquatic nuisances (132). One of the Nonindigenous Aquatic Nuisance Prevention and Control Act's several goals is similar: "to prevent unintentional introduction and dispersal of nonindigenous species into waters of the United States through ballast water management and other requirements. ' The North American Native Fishes Association recommends banning all introductions of non-native fish (79). Some credible scientific sources--specially those with first-hand knowledge of the worst U.S. problems—have recommended bans on biological control introductions in natural areas or against indigenous pests; on the release of non-indigenous big game animals into public natural areas; on particularly risky types of imports such as unprocessed wood; or on all further intentional introductions for whatever purposes (25,61,69,100).

Usually, though, suggestions fall short of a ban on all new NIS introductions because broad-brush bans risk handicapping entry of desirable NIS that cause no harm. The International Union for the Conservation of Nature and Natural Resources (44) formulated a model national law on NIS and suggested that:

- release of NIS be considered only if clear and well-defined benefits to humans or natural communities can be foreseen;
- release be considered only if no indigenous species is suitable;
- no NIS be deliberately released into any natural area and releases into seminatural areas not occur without exceptional reasons; and
- planned releases, including those for biological control, include rigorous assessment of desirability, controlled experimental releases, then careful post-release monitoring and pre-arrangement for control or eradication, if necessary.

[3] Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended (16 U. S.C.A. 4701 *et seq.,* 18 U, S.C.A. 42)

Box I-D—The National Environmental Policy Act and Non-Indigenous Species

The National Environmental Policy Act (NEPA), which mandates environmental impact assessment has rarely been applied to decisions about introductions of non-indigenous species (NIS) (ch. 7). NEPA makes no explicit mention of NIS. Many potentially significant actions, such as allowing wood imports from risky new sources, have not been considered sufficient to trigger NEPA review. A recent exception, however, is the environmental impact statement prepared regarding the New Jersey Division of Fish, Game, and Wildlife's proposal to introduce chinook salmon (Oncorhynchus *tshawytasha)* from the Pacific coast into the Delaware Bay. A number of NIS-related Federal activities are categorically excluded from NEPA review, including:

. low-impact range management activities, such as . . . seeding (U.S. Forest Service).
. all activities of the Plant Materials Centers, such as comparative field plantings, release of cooperatively improved conservation plants, production of limited amounts of foundation seed and plants, and assisting nurseries in plant production (Soil Conservation Service).
● the reintroduction (stocking) of native or established species into suitable habitat within their historic or established range (U.S. Fish and Wildlife Service).
. highway landscaping (Federal Highway Administration)

Full NEPA application to problems of NIS is unlikely without explicit~direction from Congress. Various measures are available. In the most rigorous application, Congress could declare that new, unanalyzed releases of NIS are, per se, potentially significant environmental impacts that require analysis. Or Congress could require that NIS concerns be specified in the checklists used for preliminary environmental assessments and for making decisions regarding the need for further evaluation. Or Congress could limit related exclusions (see also ch. 7.)

Recently, a Federal court ruled that NEPA applied to the North American Free Trade Agreement-for which no environmental impact statement had been prepared. That decision has been appealed so NEPA's application remains legally unclear (ch. 10). Any eventual application of NEPA is likely to highlight concerns regarding NIS. International trade is a major pathway for the movement of potentially harmful NIS yet related issues have received little consideration in free trade discussions so far.

A comprehensive environmental impact assessment would address, among other possible impacts, the extent to which risks from harmful NIS would increase with any introduction and the capability of U.S. agencies to respond to any such increase. In the past, these agencies often have lacked the institutional and financial flexibility to anticipate and respond quickly to new risks (chs. 4, 6).

SOURCES: J. Kurdila, "The Introduction of Exotic Species Into the United States: There Goes the Neighborhood" ***Environmental Affairs,*** *vet.* **16,1988,** pp. 85-1 **1S; U.S. Departrnentofthe Interior, Fish and Wildlife Service,** ***Administrative Manual: Environment, NEPA*** *Handbook,* **Part 516, April 30, 19S4; Versar, Inc., "Introduction of Pacific Salmonids into the Delaware River Watershed," draft environmental impact statement prepared for the U.S. Fish and Wildlife Service and the New Jersey Division of Fish, Game and Wildlife, July 25, 1891; 23 CFR 771.1 17(7), as amended (Aug. 2S, 1987) (Federal Highway Administration); 56** ***Federal Register*** **19718 (U.S. Forest Service); 7 CFR 613, 650.6 (Soil Conservation Service).**

The nursery, pet, aquiculture, and agriculture industries have traditionally been strong advocates for further introductions of desirable NIS and have noted the burdens of more time-consuming and complex evaluations of their potential risks. These groups can be expected to be cautious about any congressional action that would make U.S. policy more stringent. For example, those in the nursery industry fear that banning NIS and requiring the use of indigenous plants would create complex definitional problems regarding which species are indigenous; outlaw the hardy non-indigenous plants most suitable for urban landscapes; require using indigenous plants that are less resistant to diseases and pests than their close foreign relatives; and eliminate highly ornamental plants that many people prefer to less showy indigenous ones (52).

However, pressures on Congress and Federal and State agencies to enact some partial measures are likely to increase as NM-related issues receive more attention. Florida has prohibited any releases of non-indigenous marine plants or animals into State waters.[4] The New Mexico State Legislature recently considered a bill that would have led to the eradication of several "exotic" non-indigenous game animals and required the Department of Game and Fish to ban further game introductions (101). (State game officials considered the legislation extreme and opposed it, whereas hunting and environmental groups were divided.) Several local ordinances require landscape architects, designers, and contractors to use a percentage of indigenous plants in their projects (52).

Bans are intended to slow the intentional introduction of organisms into and within the United States. Even the strictest ban could not stop unintentional introductions. Nor could it limit damage caused by the continuing spread of harmful NIS already in the country. Therefore, even the most restrictive policies regarding new introductions would not solve all problems associated with harmful MS.

New Zealand, a small island nation with MS problems as severe as Hawaii's, is often cited as the country that addresses MS most effectively (77). Its approach merits consideration here (box l-E). New Zealand's recent policy changes illustrate an attempt to be comprehensive, forward looking, fair to importers, and responsible, However, New Zealand is much smaller and less diverse than the United States. In this country, States play an important role in setting and implementing U.S. national priorities. Therefore only some of New Zealand's approaches would be feasible here.

Attempts to formulate a similarly comprehensive and more stringent national policy on harmful NIS would need to account for the following seven issues. In most of these areas, OTA suggests possible statutory changes. These should be approached with one caution. The release of MS and GEOs is regulated by many of the same statutes. legislative changes intended to affect harmful NIS could inadvertently apply to GEOs if definitions are not crafted with care.

Issue 2: Managing Non-Indigenous Fish, Wildlife, and Their Diseases

Federal and State governments presently divide responsibilities for introductions of fish, wildlife, and their diseases. The Lacey Act is the primary Federal vehicle for excluding harmful imports. Under the Lacey Act, the U.S. Fish and Wildlife Service (FWS) restricts importation into the country of fish or wildlife that pose a threat ''to humans, agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States.' Current regulations restrict only 2 taxonomic families of fish (1 to prevent entry of 2 fish pathogens), **13** genera of mammals and shellfish, and 6 species of mammals, birds, and reptiles.[6] The USDA's APHIS and the Public Health Service prohibit entry of a several additional wildlife species (reptiles, birds, and mammals) to prevent entry of pathogens affecting poultry or livestock or because they pose human health threats.[7]

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 authorized FWS and the National Oceanic and Atmospheric Administration (NOAA) to issue regulations related to the prevention of unintentional introductions of aquatic nuisance species, like the zebra mussel.[8] Al-

[4] 28 Fla. Stat. Annot. sec. 370.081(4)
[5] 18 U, S.C.A. 42(a)(1)
[6] 50 CFR 16 (Jan. 4, 1974)
[7] 9 CFR 92, as amended (Aug. 2, 1990)
[8] 6 U. S.C.A. 4722

Box I-E-How New Zealand Addresses Non-Indigenous Species

New Zealand's legal and institutional framework and the nature of its programs are key to its current successes managing harmful non-indigenous species (NIS). As in the United States, however, protecting agriculture has received higher priority than safeguarding the indigenous flora and fauna. Sores aspects of New Zealand's approach that are absent or rare in the United States are given here:

Legal and Institutional Aspects:

- Agency performance standards implemented through agency "contracts" to provide specified governnental services and through detailed annual reports.
- Detailed national standards for animal imports and strong authority to require bonds for potential costs of escape and to impose other conditions.
- A "user pays" approach to cover most costs of inspection, surveillance, scientific analysis, and enforcement against violators.

Programmatic Aspects:

- Intensive inspection of arriving passengers, baggage, and goods with random checks to evaluate interception rates.
- 100 percent treatment of arriving aircraft with insecticide.
- Computerized tracking of imports, from arrival to unloading.
- Detailed surveillance of and contingency planning for forest pests.
- Extensive enlistment of public support for pest surveys and monitoring.

Recently, New Zealand determined that its more than a dozen major acts and several hundred subsidiary regulations pertaining to agriculture needed consolidation and revamping. The new approach will regulate ail potentially harmful imports through an appointed Hazards Control Commission.

An independent professional staff will advise the Commission, with input from expert advisory committees. Proposals for imported and genetically engineered organisms will be advocated by private or governmental proponents. Countervailing arguments will be presented by the Department of Conservation. The law provides for full economic and ecological consideration, public hearings, and opportunities for appeal. Known low-risk organisms will receive less scrutiny. Decisions must balance "the benefits which may be obtained from . . . new organisms against the risks and damage to the environment and to the health, safety and economic, social and cultural well being of people and communities." If this new approach succeeds, it could provide a broad model for the United States.

SOURCES: Anonymous, "Biosecurity Bill: Update," *Sentinel*, New Zealand Ministry of Agriculture and Fisheries, Wellington, No. 19, Feb. 1,1932, p. 3; Director of the Law Commission, "VIII. Public Welfare Emergencies," *Final Report on Emergencies*, Law Commission Report No. 22, Wellington, New Zealand, December 1991, pp. 230-24S; Office of the Minister of Agriculture, Ministry of Agriculture and Fisheries, Wellington, New Zealand, memorandum regarding Agricultural Regulation Reform, to Chairman, Cabinet Strategy Committee, undated; A. Moeed, Chairperson, Interim Assessment Group, Ministry for the Environment Wellington, New Zealand letter to P.T. Jenkins, Office of Technology Assessment Feb. 10,1992; D. Towns, IUCN Regional Member, Department of Conservation, Aukland Conservancy Office, Aukland, New Zealand, letter to P.T. Jenkins, Office of Technology Assessment, Oot. 29,1031.

though none have been issued to date, eventual regulations under the Act could impose additional restrictions on the importation of harmful aquatic MS (30).

In practice, then, the Federal Government places only a few piecemeal constraints on the *importation* of fish, wildlife, and their diseases. Tens of thousands of different species (most of the world's fauna, excluding insects) potentially could be legally imported into the United States (81). Well over 300 non-indigenous fish and wildlife species of foreign origin have established here already, approximately 122 of which are known to cause harm (ch. 2) (8,23,104).

The Federal Government currently plays a small role in restricting *interstate* transfers of non-indigenous fish and wildlife (ch, 6). FWS does not impose regulations or quarantines to prevent interstate transfers of harmful fish, wildlife, or fish diseases, since neither are authorized under the Lacey Act. APHIS sometimes quarantines wildlife to prevent the spread of pathogens, but only for those causing significant diseases of poultry or livestock. Amendments to the Lacey Act in 1981 authorized the FWS to enforce State laws prohibiting transport of species into a State,[9] but FWS enforcement is understaffed, underfunded, and has numerous other pressing responsibilities (74, 121). Future implementation of the Nonindigenous Aquatic Nuisance Prevention and Control Act could impose domestic regulations or quarantines for aquatic species (30).

States play the prominent role in many areas related to fish and wildlife. They vary in how rigorously they guard their own borders or prevent releases of harmful species. States prohibit relatively few injurious species; their standards of review for predicting harm are low; and enforcement is weak (55) (ch. 7). The same conditions apply to the States' roles in releasing fish and wildlife within their borders.

Taken together, these Federal and State gaps constitute a serious threat to the Nation's ability to exclude, limit, and rapidly control harmful fish and wildlife. For example, importation and transfer of zebra mussels within much of the United States remained legal for approximately 2 years after they had inadvertently entered the United States and demonstrated their devastating potential. An opportunity to slow their spread was lost. The potential for spread of pathogens of fish and aquatic invertebrates is another example. Federal regulations under the Lacey Act require accurate labeling of shipping containers for species identity and numbers. Screening for contamination by pathogens is not required. There is no Federal quarantine of diseased fish stocks and in many States diseased fish and invertebrates can be legally imported and released.

RON PEPLOWSKI

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 authorized new regulations and programs for aquatic species like the costly zebra mussel (Dreissenna polymorpha).

Some observers have called for an increased Federal presence to fill gaps like those above. Julianne Kurdila (55), for example, suggested either implementing President Carter's 1977 Executive Order 11987 (box 6-B) or the passage of new legislation to correct the Lacey Act's deficiencies, recommendations passed along by the Minnesota Interagency Exotic Species Task Force (70). USDA officials see the need to screen fish for diseases, like they do for livestock (56).

Proposals to expand the Federal role have engendered considerable controversy in the past. However, OTA's survey of State fish and wildlife agencies asked whether they would like to see the Federal role "increase," ''decrease, ' or "stay about the same in the regulation of nonindigenous fish and wildlife (ch. 7). A clear majority-63 percent—favored an increased Federal role; 23 percent favored keeping the role about the same; only one State (Wisconsin) preferred to see the Federal role decreased (3 percent were not sure and 8 percent did not answer). Peter Schuyler conducted a separate survey of 271 resource managers and others

[9] 16 U. S.C.A. 3372

involved with issues related to non-indigenous animals. Of the 265 U.S. respondents, 65 percent perceived the problem's biological aspects to have international significance (92, 93)-clearly beyond local or State scope.

Two areas in which the Federal Government might strengthen its role are in:

1. increasing the rigor of screening before importation and release of fish and wildlife; and
2. defining new State roles.

The frost area arises from widespread criticism that the Lacey Act is failing to protect the United States from entry of harmful new MS; also, many decisions to introduce NIS are made without thorough risk assessment (ch. 4). The second area regarding State roles emerges from OTA's analysis of State laws and regulations regarding fish and wildlife (ch. 7).

TIGHTENING FISH AND WILDLIFE SCREENING

Option: Congress could amend the Lacey Act to lengthen its list of excluded injurious wildlife and to speed the process by which new listings are added.

Option: Congress could require that Federal agencies and others using Federal funds to introduce non-indigenous fish and wildlife develop and adopt specific, rigorous decisionmaking methods for screening species prior to release.

A number of problems have been documented with the Lacey Act and its implementation by FWS (55,83). The most commonly acknowledged problem is that regulation and enforcement hinge on a short and noncomprehensive list of ''injurious wildlife and adding new species to the list is time-consuming (1 16). The Lacey Act is also criticized for not providing comprehensive regulation of interstate transport of federally listed species and for not being clear regarding its application to hybrid and feral animals. FWS enforcement of the Act's sparse interstate transport provisions is limited and programs to control or eradicate non-indigenous fish and wildlife are piecemeal, lack emergency measures, and have no proactive components to catch problems early.

Only five new species or taxonomic groups were added over the 7-year period from 1966 to 1973, with one more addition over the next 15 years. Several potentially injurious species are under consideration in 1993 for listing, on a species by species basis. Efforts to list the mitten crab *(Eriocheir* spp.) took at least 2 years, with some evidence that they were successfully introduced during this time (83). This means that organisms are unregulated when they are most amenable to control and eradication, i.e., shortly after entry when their populations are small.

The greatest potential for the Lacey Act is to reduce problems related to NIS used in the pet and aquarium trades, "exotic' non-indigenous game ranching, and aquiculture.l" The potential risks of species in these groups are relatively well known and most of these NIS can be readily identified and detected at ports of entry. However, greater use of the Lacey Act would require aggressive efforts to expand the Act's list of injurious species (6). This has not been tried since 1977. The current FWS approach remains largely reactive, with little outside pressure to change or increase the list of species (83).

Congressional action to amend the Lacey Act (box l-F) could address some concerns without changing the basic, Federal "dirty list' regulatory approach. The dirty list approach prohibits certain unacceptable species and allows unlisted species to be imported. This puts the burden on

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10 The Federal interagency Aquatic Nuisance Task Force has concluded that the escape, accidental release, or improper disposal of intentionally introduced organisms is "virtually inevitable' and that these should not be considered unintentional (122). By this interpretation, non-indigenous aquiculture species could be listed under the Lacey Act. The newer Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 would not apply, because it covers only unintentional introductions.

Box I-F–How To Improve the Lacey Act

The following changes to the Lacey Act would provide more comprehensive protection and management of the Nation's resources. The U.S. Fish and Wildlife Service (FWS) would need additional staff and other resources to make these changes. The FWS currently spends approximately $3 million annually for port inspections for fish and wildlife. In contrast, the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) spends approximately $80 million for agricultural port inspections. The two agencies do not need comparable budgets but clearly an amended Lacey Act would require budgetary changes for the FWS.

Lengthen the list of injurious wildlife. Congress could provide the FWS with increased guidance on the purpose of this list and the specific criteria for adding species to it. Proposed amended criteria would be discussed with outside experts and be as comprehensive as possible. One possibility would be to include harmful species indigenous tot he United States, but established outside their range, as injurious. A quite different alternative would be to supplement this current approach with a "clean list" approach (ch. 4).

Speed the listing process. Congress could add provisions to: 1) eliminate, reduce, or expedite the most time-consuming parts of the listing process (public notice and comment, etc.), 2) use emergency listing procedures more often, or 3) give FWS authorit y to **impose emergency control,** with **monitoring,** while the usual listing process takes place. Eliminating requirements for public notice and comment could have unintended negative effects: decreasing officials' accountability, limiting access by stakeholders, and excluding broad expert participation from an already-limited group of decisionmakers. If Congress gave FWS emergency authority, reasonable time limits could be set for study and reaching decisions on final listings. FWS and APHIS might together streamline their listing processes to ensure procedural consistency between the Lacey Act and the Federal Noxious Weed Act.

Consider whether FWS should assist with enforcement of State injurious wildlife lists and provide FWS with authority for emergency quarantine and emergency actions. First, the respective Federal and State responsibilities would need to be clarified. Then, Congress could take any of several steps: direct FWS to strengthen its role; provide additional resources to States for enforcement; and/or amend t he Lacey Act to provide for Federal quarantines on interstate movement of injurious wildlife.

SOURCES: M.J. Bean, "The Role of the U.S. Department of the Interior in Nonindigenous Species Issues," contractor report prepared for the Off ice of Technology Assessment, November 1991; J. Kurdila, "The Introduction of Exotic Species into the United States: There Goes the Neighborhood" *Environmental Affairs,* **vol. 16, 1988, pp. 95-1 18; R.A. Peoples, Jr., J.A. McCann, and L.B. Starnes, "Introduced Organisms: Policies and Activities of the U.S. Fish and Wildlife Service,"** *Dispersal of Living Organisms Into Aquatic Ecosystems,* **A. Rosenfield and R. Mann (eds.) (College Park, MD: Maryland Sea Grant, 1992), pp. 325-352; U.S. Department of the Interior, Fish and Wildlife Service, internal memorandum, 1987.**

regulators to determine whether a species is harmful. Commonly cited alternatives to dirty lists are ''clean lists" or combinations of clean and dirty list approaches (ch. 4). The clean list approach prohibits all species unless they are determined to be acceptable, that is, unless they merit being on the clean list, This puts the burden on the importer to prove a species is not harmful. States, such as Hawaii, that are most concerned about NIS are moving from simple dirty list regulatory approaches toward using both clean and dirty lists.

Clean lists can only be used for certain kinds of organisms. Many pathogens and invertebrates are too little known to classify their impacts as acceptable or not. Generally, though, clean lists represent a more stringent, proactive policy, especially when dirty lists are short and noncomprehensive. What is "clean' in one part of the United States is not necessarily so elsewhere, however. Therefore, any new policy using clean lists would need regional flexibility.

Some contend that any Federal clean list is infeasible because of lingering opposition from FWS's earlier attempts to adopt this approach

(83) (box 4-A). The pet industry, along with portions of the zoological and scientfic communities, spearheaded opposition in the 1970s (55). Marshall Meyers, general counsel for the Pet Industry Joint Advisory Council, articulates the industry's continuing opposition to regulations viewed as overly restrictive, vague, or poorly justified (14), as they found previous clean list proposals. On the other hand, the pet industry recently joined environmental groups in supporting tighter regulation of importation of wild-caught birds.11

Both clean and dirty lists require determining whether species pose acceptable risks. Formal decisionmaking protocols, risk analysis, cost-benefit analysis, and other techniques attempt to accomplish this goal (ch. 4). Each has advantages and disadvantages. For example, protocols like the American Fisheries Society's for the release of fish (51) represent a high level of decisionmaking rigor and best suit the most potentially risky types of introductions. Typically, these methods require large amounts of highly technical information and are therefore demanding in financial and scientific terms. Also, these methods are controversial because their usefulness has not been established clearly.

No single method is ideal for assessing all Federal and federally funded introductions of non-indigenous fish and wildlife. However, formal decisionmaking methods designed to more carefully assess and decrease risks are considered to be prudent alternatives to banning all potentially risky introductions (83). Congress could require that agencies develop and adopt either a recognized decisionmaking protocol or another formal and rigorous method suited to their situations. This was the approach taken in the proposed Species Introduction and Control Act of 1991 regarding non-indigenous fish and wildlife. [12]

DEFINING NEW STATE ROLES IN FISH AND WILDLIFE INTRODUCTION

Option: Congress could address weaknesses in some States' fish and wildlife laws by implementing national minimum standards. These standards would provide legal authority to regulate harmful NIS and be linked to funding for States to implement them.

Option: Alternately, Congress could encourage wider adoption of a federally developed model State law to make legal authority among States more comprehensive.

The strength of the U.S. Federal system is that the 50 States provide a testing ground for new ideas. Such new ideas turn up in the exemplary approaches discussed in chapter 7. On the other hand, federalism leads to duplication of efforts and highly variable, and sometimes conflicting, regulations (72). This has been the case for non-indigenous fish and wildlife.

States' standards vary considerably regarding which species and groups are regulated and how carefully they are regulated; many State efforts to regulate importation, possession, introduction, and release are inadequate (ch. 7) (55). In some cases, the weaknesses of State programs stem from incomplete legal authority.

The Lacey Act leaves decisions on almost all intentional introductions of fish and wildlife to the States; only the relatively few organisms on the list of injurious wildlife are prohibited. Thus, correcting problems would entail full exercise of State prerogatives (83). However, Federal programs support many State-sponsored introductions, so the Federal Government has a strong interest in this area.

A variety of approaches could be used to encourage improved State performance. Federal pre-emption of State NIS laws is unlikely to be justifiable or politically feasible. Two more

11 The Wild Bird Conservation Act of 1992, Public Law 102-440, Title I, Section 102, Oct. 23, 1992; 106 stat. 2224.

12 H.R. 5852, introduced by Rep. H. James Saxton.

tenable and often-suggested methods are national minimum standards and wider use of model State laws. Either method could ensure that State fish and wildlife laws provide adequate authority for more comprehensive regulation.

Box 1-G illustrates a national minimum standards approach. Three elements would be needed:

1. a process to determine whether State laws are consistent with the new national minimum standards,
2. a program of incentives for States to adopt or retain laws meeting the national minimum standards and to provide sanctions against States that do not, and
3. a means to provide reliable sources of revenue to fund these efforts.

Also, careful individual State review is needed in several other areas: quarantine requirements; containment specifications; responsibility for control of escapees; and regulation of live bait fish and invertebrates affecting nonagricultural areas.

Incentives could include Federal grants or matching funds to States for initial reviews of their fish and wildlife laws. Also, Federal funds could be made available for NIS control or eradication for States whose NIS laws meet the national minimum standard. Sanctions would most reasonably include denial of Federal funds for fish and wildlife restoration and/or other Federal aid-to-States programs. Sanctions could be phased in over a suitable period, such as 5 years.

A national minimum standards program could be administered by FWS, another existing agency, or a new Federal office or commission. Its duties would include: monitoring and reporting on State compliance; processing requests for State funding; and maintaining up-to-date, publicly available compilations of States' fish and wildlife statutes, regulations, quarantines, and other important information.

An alternate approach would be to provide incentives for States to adopt a federally developed, comprehensive model State law. Voluntary examples already have been used to some extent for fish and wildlife.

The Southeast Cooperative Wildlife Center's model law combined laws on endangered species, injurious wildlife, disease control, public health, wildlife management, humane care, and interstate control. The model was reviewed by all States and parts of it used by a few. Missouri used part of the model, while Utah considered it but adopted their own approach (ch. 7). This specific model State law, however, received substantial criticism for being overly broad and creating excessive administrative rules and paperwork (67).

Generally, voluntary approaches for environmental compliance are receiving increased attention for a number of problems. Industry groups often support such initiatives, claiming that voluntary programs are more effective and cut costs (99). Few environmental groups have endorsed voluntary programs, however (88).

Issue 3: The Growing Problem of Non-Indigenous Weeds

The continuing entry and spread of non-indigenous weeds in the United States raises serious concerns in many quarters. State agriculture and natural resource officials, Federal land managers, members of conservation organizations, and scientists have expressed their concern that existing Federal weed laws are flawed, their implementation incomplete, and too few resources have been directed toward weed problems (chs. 2, 3, 6). In some cases, listing prohibited weeds under State noxious weed and seed acts may reduce the interstate spread of non-indigenous weeds otherwise allowed by Federal laws and regulations. However, the States can only partially compensate for insufficient Federal presence.

Three areas seem to call for a strengthened Federal role:

1. improving the Federal Noxious Weed Act (FNWA), by broadening its coverage and simplifying its procedures;

Box I-G–National Minimum Standards for State Fish and Wildlife Laws

OTA finds in chapter 7 that States need the following types of legal authority and decisionmaking procedures to ensure comprehensive treatment of non-indigenous fish and wildlife:

1. Each State needs statutory or regulatory provisions that allow the State to regulate the importation, possession, and release of all classes of non-indigenous animals (including ferals and non-indigenous hybrids). This authority could allow for appropriate exemptions. The authority over importation would apply to NIS originating in foreign countries and to that from other parts of the United States. The authority over introduction would apply to both public and private property.
2. State laws need to provide authority to regulate intrastate stocking of species where hybridization with indigenous species or other harmful impacts may occur.
3. All States need legal authority to list potentially harmful NIS in all taxonomic groups as prohibited from importation, possession, and/or release. Their lists would supplement the Lacey Act list. In this and other listing processes, States would actively solicit expert technical advice and public comment. However, under extraordinary circumstances States would also have emergency authority to prohibit species without administrative delays.
4. States' decisions regarding importation, possession, and release of NIS would be based on defined and rigorous standards of review that comprehensively consider the new releases' environmental impacts. Detailed studies, equivalent to an environmental impact statement would be required in cases of potentially significant impacts.
5. All decisions to approve new releases would be conditioned onthefollowing: a)notification and comment given to other potentially affected States, the Federal Government, and Canada and Mexico if they are potentially affected; b) stipulations for follow-up monitoring and review; and c) provisions governing public and/or private responsibility for the costs of control or eradication and for damages if unanticipated negative impacts occur.

SOURCE: Office of Technology Assessment, 1993.

2. increasing weed management on public lands; and
3. tightening screening before the release of new, potentially weedy non-indigenous plants.

The first area arises from concerns that FNWA is an inadequate tool for preventing the problems now facing resource managers. The second area arises from existing massive and spreading weed problems, especially on western public lands, and the view that the Federal Government has not fully met its responsibility here. Finally, those responsible for introducing new plants for horticulture and soil conservation have been reluctant to recognize the importance of rigorous screening for weediness before a plant's release.

THE FEDERAL NOXIOUS WEED ACT AND FEDERAL SEED ACT

Option: *Congress could amend and expand the Federal Noxious Weed Act to rectify several widely acknowledged problems regarding definitions, interpretation, and its relationship to the Federal Seed Act.*

The Federal Noxious Weed Act and the Federal Seed Act[13] provide the main authority for APHIS to restrict entry and spread of noxious weeds. The FNWA prohibits importation of listed noxious weeds and provides authority to quarantine species already in the country. The Act has been criticized by the Weed Science Society of America, environmental groups, State and some industry representatives, and scientific experts (60,

[13] Federal Seed Act **(1939), as amended (7** U. S.C.A.1551 *et seq.*)

112, 113). Commonly cited shortcomings include: problems with the definition of a "noxious weed; confusion between this Act and the Federal Seed Act; the inadequacy of the list of prohibited species and the cumbersome nature of the listing process; and APHIS' interpretation limiting the restriction of interstate weed transfer to only those species under quarantine (36,60,70,98).

A major shortcoming is that the Act is applied to too few species. APHIS took 8 years to place 93 species on the current list of Federal noxious weeds, yet at least 750 weeds meeting the Act's definition remain unlisted (98). Unlisted weeds can continue to be legally imported, although their potential for causing damage is known. APHIS' narrow interpretation of the definition of a Federal noxious weed has kept it from regulating clearly harmful NIS with wider distributions, including those meriting restriction to prevent further spread (86). Purple loosestrife, Brazilian pepper *(Schinus terebinthifolius),* and Eurasian watermilfoil *(Myriophyllum spicatum) are* prominent unlisted weeds. Moreover, the requirement that a noxious weed be of foreign origin means FNWA does not cover plants like the western wetland invader smooth cordgrass *(Spartina alterniflora),* which originated in the eastern United States. Difficulties make the listing process slow ***(36,98), yet*** FNWA has no emergency mechanism to allow rapid action on unlisted species causing incipient problems.

APHIS has barely implemented FNWA's Section 4, which requires a permit for moving listed species between States. Under APHIS interpretation of the Act's legislative history, this restriction only applies when the agency has imposed a specific quarantine under Section 5, Yet in 18 years, APHIS has imposed only one quarantine for a noxious weed. As a result, at least nine Federal noxious weeds were sold in interstate commerce as of 1990 ***(98),*** APHIS has maintained this interpretation in the face of steady pressure from some State officials to change it (49).

APHIS has traditionally emphasized insect and disease problems and lacked professional weed


LEWIS WATERS

Purple loosestrife (Lythrum salicaria) *is among the prominant weeds not listed by the Federal Noxious Weed Act.*

scientists in key positions (128), contributing to the low priority of weed management among its various responsibilities (ch. 7). Then Administrator Glosser contended, however, that lack of finding-not priority setting-limits APHIS' weed control programs (36).

Some gaps in FIWVA might eventually be filled under the recently enacted Nonindigenous Aquatic Nuisance Prevention and Control Act. NOAA and the FWS could eventually move to regulate importations or impose quarantines of aquatic or wetland weeds, although no such regulations are either in place or planned.

The Federal Seed Act provides for accurate labeling and purity standards for seeds in commerce. Only 12 species have been listed under the Federal Seed Act, with "tolerances" set for contamination by small amounts of their seed.

Just one of these species is listed among the 93 prohibited entry under FNWA (62). It has not been clear whether species prohibited under FNWA could be legally imported and transported within the country as part of seed shipments. In 1988, APHIS initially allowed importation of grass seed contaminated by serrated tussock *(Nassella trichotoma)—a* weed listed under the Federal Noxious Weed but not the Federal Seed Act. In 1992, a Federal district court judge ruled that the Federal Noxious Weed Act applied to seed shipments; however, the case is on appeal at this writing.[14]

A second limitation of the Federal Seed Act is it only applies to agricultural and vegetable seed. The Act's requirements for truth in advertising do not cover horticultural seeds, including "wildflower" and ''native grass' mixtures. Such commercial mixtures are increasingly popular, especially for use in suburban and seminatural areas. The use of ''wildflower' and ''native' may be misleading, because the mixtures frequently contain plants that do not grow naturally in the wild, either in the United States or in the region for which they are promoted (62). Some even contain Federal or State listed noxious weeds. State laws on consumer protection and accurate weights and measures could provide States with general authority to address horticultural seed mixtures, but little indication exists that they have done so (50).

Commonly suggested changes to improve FNWA include those in box 1-H. Some of these are included in amendments that Senator Byron Dorgan anticipates introducing in fall, 1993.

In 1990, APHIS attempted to consolidate its plant protection statutes into one piece of legislation. While that attempt failed, the Agency expects to try again. Any such consolidation could address the concerns raised here, without amending FNWA and the Federal Seed Act. It could also address the need for emergency and proactive measures discussed in a later section. Congress would need to ensure that no important functions were dropped in the consolidation process, however. Consolidated legislation would include many additional complex and potentially controversial issues. Its passage is not likely to be straightforward or rapid.

TIGHTENING PLANT SCREENING

Option: *Congress could require that all entities introducing non-indigenous plant material conduct pre-release evaluations of its potential for invasiveness.*

Option: Congress could require that APHIS conduct periodic evaluations of its port and seed inspection systems to test their adequacy and provide feedback for improvements.

At a minimum, Congress could ensure that current laws and regulations are adequately enforced. This requires that APHIS report on the effectiveness of its inspection system and regularly seek improvements. Also, a minimal approach would ensure that all new, potentially damaging introductions be screened for invasiveness. Past experiences show that releasing unscreened introductions is asking for trouble. Specifying methods to use for such screening, including review under NEPA (box l-D), would require congressional intervention.

Intentional introductions of plants are almost entirely unregulated, unlike certain other categories of potentially harmful NIS that require permits or receive some Federal scrutiny. Yet some of the worst U.S. weeds were intentionally introduced by people who thought that they would be beneficial: kudzu, water hyacinth, and multiflora rose *(Rosa multiflora)* (60), and experts express concern about the possible invasiveness of some contemporary releases (ch. 6).

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14 Memorandum Opinion in *Pennington Enterprises, Inc.* v. *United States,* Civil Action No. 90-1067 (U.S. District Court, District of Columbia), on appeal to the D.C. Circuit Court of Appeals, Case No. 92-5179.

Box I-H-How to Improve the Federal Noxious Weed Act

Change the definition of a "noxious weed." Redefine so that plant pests of nonagricultural areas and weeds of **U.S.** origin-but outside their natural ranges-are clearly included. (These definitional weaknesses commonly apply to State noxious weed laws, too.) The 1990 FNWA amendments directed Federal agencies to undertake several actions against "undesirable plant species" on Federal lands. These were defined to include noxious, harmful, exotic, injurious, or poisonous plants pursuant to Federal or State law but not including plants "indigenous to an area where control measures are to be taken." Thus, a precedent exists for basing definitions on U.S. ranges of plants.

Address weeds widespread within the United **States.** The lack of an approach to deal with widespread weeds is serious enough t hat APHIS should be asked to prepare a strategic plan for dealing with pests of this type. Then, other policy questions could be addressed, including whether to change the number of States that determine when APHIS ends its involvement. (APHIS presently interprets the Act to mean found in no more than two States).

Address the inconsistency between the Federal **Noxious Weed Act and the Federal Seed Act. This** could be done by deleting the provision in Section 12 that prohibits the application of FNWA to seed shipments regulated under the Seed Act; or by amending the Seed Act to make its list of excluded species identical to that of FNWA, whichever is more extensive.

Provide for emergency listing of weeds. Streamline the listing process or grant APHIS emergency authority to exclude those plants that meet the definition of a Federal noxious weed but have not yet been listed as such, As in the Lacey Act, current requirements for public notice and comment are important. However, they can create inordinate delay when time is essential. Therefore, strengthening t he agency's authority to take emergency action before listing might be more desirable. APHIS and the Fish and Wildlife Service might develop emergency listing processes together to ensure their procedural consistency.

Clarify APHIS' role **in regulating the interstate transport of weeds.** This may require an amendment; Congress has conducted oversight in this area in the past and problems remain. One possibility would be to: **Make planting, distributing, and possessing noxious weeds with intent to distribute them illegal under almost all circumstances.** This would make interstate distribution of Federally listed weeds clearly illegal regardless of the existence of an APHIS quarantine. Minnesota recently took a stricter approach by prohibiting most instances of transport, possession, sale, purchase, import propagation, or release of approximately 30 species of plants and animals.

Increase resources for control programs, including those on Federal lands. APHIS allocates few resources **tot he control and eradication of noxious weeds and other Federal agencies face similar shortfalls. (See issue** 7 for means to increase resources.)

SOURCES: D.H. Kludy, **"Federal Policy on Non-indigenous Species: The Role of the United States Department of Agriculture's Animal and Plant Health Inspection Service," contractor report prepared for the Office of Technology Assessment, Washington, DC, December 1991; R.N. Mack, Professor and Chair, Department of Botany, Washington State University, Pullman, WA, letter to P. Windle, OTA, Aug. 4, 1992; Minnesota Rules Chapter 6216, "Ecologically Harmful Exotic Species," St. Paul, MN, effective Aug. 12, 1993; D.C. Schmitz, Florida Department of Natural Resources, Tallahassee, FL, statement submitted at hearings before the Senate Subcommittee on Agricultural Research and General Legislation, Committee on Agriculture, Nutrition, and Forestry, "Preparation for the 1990 Farm Bill: Noxious Weeds," Mar. 28, 1990, pp. 357-360; H.M. Singletary, Director, Plant Industry Division, North Carolina Department of Agriculture, Statement submitted before the Senate Subcommittee on Agricultural Research and General Legislation, Committee on Agriculture, Nutrition, and Forestry, Mar. 28,1990, pp. 354-356; Weed Science Society of America, "WSSA Position Statement on Changes In the Federal Noxious Weed Act," Davis, CA, May 8, 1990.**

Current Federal restrictions on importation and interstate transport of plants (other than noxious weeds listed under FNWA) relate to preventing transfers of plant pests and pathogens—not evaluating the plant itself for harmful qualities. The USDA's Agricultural Research Service (ARS) annually imports large quantities of foreign plant material to develop new species or varieties for horticulture, soil conservation, or agriculture. Neither the Soil Conservation Service (SCS) nor

ARS specifically evaluates plants for invasiveness before their release for soil conservation or horticulture. These plants undergo little or no systematic evaluation for weediness and risk to nonagricultural systems (ch. 3). Evaluation of horticultural varieties developed abroad and imported for commercial sale is similarly lax.

More careful and consistent pre-release screening is needed. Some screening methods are already in place. Usually these methods are applied only to agricultural threats, however. APHIS initially used an expert panel, the Technical Committee to Evaluate Noxious Weeds (TCENW), to designate species for the Federal list of noxious weeds.[15] These or similar screening methods could serve as models for the ARS Germplasm Resources Laboratory to evaluate plant material. Possibilities include the use of risk analysis, benefit/cost analysis, safe minimum standards, and review under NEPA (ch. 4).

Harmful NIS commonly present insidious, long-term, low-probability, but high-risk problems. Under these circumstances, many standard decisionmaking methods fit only partially. For example, eventual costs may be impossible to predict, making economic projections of little use. Any new screening methods should be adopted on a test basis and evaluated before broader implementation. Certain additional decisionmaking steps are fairly clear now, however:

- increasing the role of technical advisory groups *(98);*
- expanding the scope of scientific and other expertise available to these advisory groups to include evolutionary and conservation biologists and ecologists (46);
- ensuring that decisionmaking processes are documented, clear, open to public scrutiny, and periodically evaluated;
- guaranteeing input from industries, States, other Federal agencies, and special interest groups that may be affected by the decision (49); and
- ensuring that the final decision is implemented effectively (61).

WEED MANAGEMENT ON PUBLIC LANDS

Option: *Congress could monitor and evaluate closely the weed control efforts undertaken by Federal agencies as a result of FNWA amendments to the 1990 Farm Bill.*

Management of non-indigenous weeds is a growing problem involving local, State, and Federal agencies (1 13). Most land management agencies now acknowledge the problems of noxious weeds and are beginning to attempt control. However, these programs generally are small, underfunded, and need additional support (chs. 6, 7). The Bureau of Land Management (BLM), for example, identified seven major deficiencies in its programs: funds and staff; policy guidance and awareness of the problem; basic information on expansion of weed populations; attention to nonrangelands; active and preventive programs; training beyond pesticide application; and coordination with other Federal, State, and county agencies (1 15). Many areas with severe non-indigenous weed problems are among the most protected categories of federally managed lands. Their problems are distinct enough to be discussed separately in the next section.

Congress gave weed control on Federal lands an important stimulus in 1990. Amendments to the Federal Noxious Weed Act[16] included in the 1990 Farm Bi11[17] require that each Federal land management agency establish and fund an undesirable plant management program for lands under its jurisdiction (6). Sustained congressional

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15 The Committee was disbanded in 1983 after suggesting an additional 750 Federal noxious weeds and developing 261 statements Of harm for the *Federal Register.* Its recommendations were not followed.

16 7 U.S.C.A. 2814

17 The Food, Agriculture, Conservation, and Trade Act of 1990, Public Law 101-624

interest is needed now, along with preparations for a thorough evaluation of these amendments' effectiveness within the next few years. Such an evaluation might assess the degree to which each program met its goals; the speed with which agencies responded to new weed problems; the extent and adequacy of interagency Federal-State cooperation, and so on.

Many Federal lands with serious non-indigenous weed problems are vast, remote, and have low economic value. These features make chemical control costly and difficult and biological control an attractive alternative. Biological control organisms are non-indigenous and also capable of harm if not properly screened. Of the Federal land management agencies, only BLM has clearly defined policies for evaluating the safety of non-indigenous biological control agents before their release onto public lands. Comparable policies are needed by other agencies (see biological control section below).

Managers complain that suitable biological control agents are difficult to obtain. Similarly, indigenous germplasm and products are in short supply. The agencies or Congress could ease such technical bottlenecks.

The use of non-indigenous plants for applications such as landscaping and erosion control sometimes comes about because of the high cost or unavailability of indigenous species. For example, farmers cut planting costs per acre by 17 percent when they chose non-indigenous rather than indigenous grasses for acreage enrolled in the Federal Conservation Reserve Program (20). However, a cooperative State-Federal program in Illinois demonstrated that propagation of indigenous plants for large-scale uses is economically and technically feasible (39) (box 7-E).

An indigenous perennial clover *(Trifolium carolinianum)* has been found to be a better and less expensive ground cover than many newly developed non-indigenous varieties (2). However, lack of commercial sources is a barrier to its use in the Federal Conservation Reserve Program, Managers of national parks similarly find that indigenous plants are not readily available from nurseries (33). Such problems stimulated a successful collaboration in which SCS propagates indigenous plants for park restoration (1 18).

Wider availability of indigenous plants at comparable costs, along with public education, could go far towards increasing their use—especially if combined with new requirements for truthful reporting of plant origins for commercially sold seeds and plants. The Federal Government could play a significant role in encouraging the use of indigenous plants. Current USDA programs of ARS (the National Plant Germplasm System) and SCS (Plant Materials for Conservation Program) collect plant germplasm and make it widely available for use by plant breeders and producers (ch. 7). Congress could require an increased emphasis on the collection, development, and distribution of indigenous germplasm by these programs.

Issue 4: Damage to Natural Areas

Option: Congress could assign broad and explicit responsibility for the control of non-indigenous species that damage natural areas to APHIS, the Forest Service, or another agency and provide resources for its implementation.

Option: Congress could require that the National Park Service commit, in measurable ways, to elevating the priority of natural resource management.

Option: Congress could appropriate additional funds for the Park Service to implement large-scale control and eradication programs for those natural areas most damaged by NIS. Alternately, Congress could provide more funds for these purposes by changing the amount or structure of park entrance or user fees.

A variety of Federal (and State and local) agencies manage protected areas. Among the

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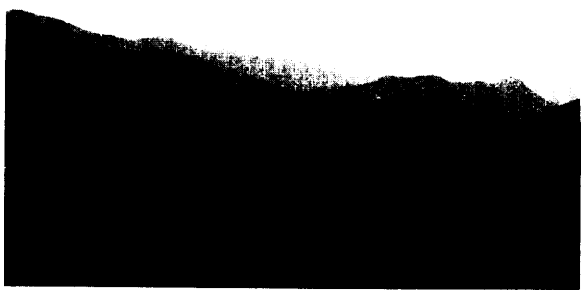

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most ''natural' of federally owned lands are the National Parks and other areas managed by the National Park Service (NPS). These represent a small fraction (approximately 3 percent) of U.S. land, but their significance in preserving and protecting natural and cultural resources goes far beyond their relatively small acreage. The U.S. Forest Service, BLM, and FWS manage more modified, yet largely undeveloped, lands-as much as 23 percent of U.S. land.

These areas are significant for maintaining indigenous animals and plants—the biological diversity of the United States. Also, these lands can harbor troublesome NIS that degrade resources and move to private land.

No Federal agency clearly sees its mission as protecting natural areas from harmful NIS. Although some protection incidentally arises from Federal coverage of other areas, it is noncomprehensive and misses many harmful species. State coverage varies and is similarly incomplete. The harmful effects of NIS in natural areas tends to be poorly documented-a cause and a consequence of the lack of focused Federal and State attention. For example, the significance of harmful non-indigenous insects in natural areas can only be guessed, since the U.S. fauna is so poorly known. The effects of at least one-third of the non-indigenous insects in the country are undocumented (ch. 3) (48). Nevertheless, harmful NIS clearly threaten nonagricultural areas like the National Parks (chs. 2, 8).

State efforts do not compensate for the lack of Federal attention (ch. 7). State regulation of fish and wildlife is patchy. State coverage of invertebrates outside of agriculture varies from spotty to nonexistent.

The Federal Government historically has had a small and erratic role in assisting the States with control programs. The recent Nonindigenous Aquatic Nuisance Prevention and Control Act sought to remedy this with a program for Federal funding of State programs to eradicate or control harmful aquatic species that were unintentionally introduced. In the 3 years since its authorization, no funds have yet been appropriated. Moreover, the rocky start of its Federal interagency Aquatic Nuisance Species Task Force makes its future potential uncertain.

Responsibility for studying, regulating, and controlling harmful NIS in nonagricultural areas such as parks and protected areas is a large enough problem that it needs to be assigned explicitly to some agency or institution. This could be APHIS, although it lacks expertise in this area. Such responsibility would entail a substantial expansion of duties, which could conflict with APHIS' traditional mission to protect agriculture. APHIS, at least, should consider the impact of NIS on natural areas when listing weeds under FNWA (49), when restricting other NIS, and if the agency begins to screen fish for pathogens.

Alternately, the Forest Service might be able to assume responsibility for non-indigenous weed control in nonagricultural areas, with its approach to forest pests serving as a model for nonforest organisms. This would require developing authority for interagency cooperative programs to act outside National Forest System lands.

Others have suggested that control of NIS on nonagricultural lands be assigned to an agency outside USDA, perhaps to BLM, EPA, or a new

institution that would take over a majority of NIS-related functions. The efficiency, cost-savings, effectiveness of government reorganizations is far from clear (105). Undoubtedly, NIS control on nonagricultural lands should be the responsibility of an organization with an interest in protecting biological diversity and ecological expertise.

Of all Federal land management agencies, the National Park Service (NPS) has the most restrictive and elaborate policies regarding NIS (ch. 6). Despite these policies, harmful NIS are causing fundamental changes inside and nearby some National Parks. As early as 1980, a NPS report to Congress cited encroachment of NIS as one of the threats to the Parks (1 17). The changes prompted by NIS are large enough now to jeopardize some Parks' abilities to meet the goals for which the Parks were established (41,60). In a survey done in 1986 and 1987, respondents rated non-indigenous plants as the most common threat to park natural resources while non-indigenous animals ranked fourth (41).

Threats to Hawaii's National Parks are probably worst, although many other Parks are damaged by MS, such as wild hogs (Sus *scrofa) in* Great Smoky Mountains National Park, a non-indigenous thistle *(Cirsium vulgare) in* Yosemite National Park, and gypsy moths in Shenandoah National Park (6); feral rabbits *(Oryctolagus cuniculus) in* Channel Islands National Park, salt cedar *(Tamarix* spp.) in Canyonlands and Big Bend National Parks, and non-indigenous vines on Theodore Roosevelt Island (59) (table 2-4). Although the Parks face many threats, harmful NIS are considered more pervasive, subtle, and harder to rectify than other disturbances that threaten biological diversity (27).

A growing recognition exists that NPS' funding priorities will have to shift if it is to address degradation of the Parks' natural resources, including funding related to NIS (76, 102). Natural resource management generally has low priority. The Park Service allocates no more than 2 percent of its annual budget to research, management, and control of NIS and the backlog of unmet needs is growing (6,45).

Ambiguity in the NPS Organic Act[18] is partly responsible for the lack of focus in NPS management; neither the 1970 nor 1978 amendments defined or set priorities for use, versus preservation, of the Parks (94). Further amendments could clarify these sometimes conflicting goals, but disagreement exists as to their necessity. A major recent report—prepared by an independent steering committee for the NPS Director drawing on a 700-participant symposium-recommended that protection of Park resources from internal and external impairment be NPS primary responsibility. The authors saw this choice as within the current authority of NPS leaders (102).

Park Service officials seem less willing to make such a choice without legislative change. An internal NPS workshop on protecting biological diversity in the Parks, for example, recommended new legislation to make such protection an explicit statutory responsibility and to secure a mandate for restoration of extirpated or degraded ecosystems (27). Specifically, this group called for reducing the densities of harmful NIS within and around Parks to levels where their influence is minimized or eliminated.

New NIS control and eradication efforts, along with other priority resource management tasks, would require additional funds. The steering committee, in their 1992 report, suggested a variety of funding mechanisms in addition to regular congressional appropriations: funding the Land and Water Conservation Fund Act to the full extent authorized; a ''modest" gasoline tax; returns from concessions and extractive operations; small levies on activities and equipment; voluntary income tax check-offs; sale of tokens and passes for admission; and returning 50 percent of visitor fees to Park units (102).

18 National Park Service Organic Act of 1916, as amended (16 U, S.C.A.1 *et seq.*)

The Park Service alone cannot solve its pressing resource management problems. Up to 70 percent of the external threats to Parks result from actions by other Federal agencies or by State or local governments (75). This suggests NPS must work closely with adjacent land managers. Specifically, Congress could require that NPS initiate agreements for managing those NIS that threaten park lands from outside their boundaries. Those projects that serve multiple goals, e.g., NIS removal and recovery of endangered species, are the best candidates for top priority (6).

A Keystone Center Policy Dialogue on biological diversity (47) suggested an agency-by-agency approach to NIS on public lands. Participants recommended that each agency: prohibit potentially harmful new releases of NIS, including any intended to control indigenous species; identify, control, or replace already established NIS; eliminate any newly discovered NIS; and maintain those beneficial NIS that do not interfere with biological diversity.

Congress' 1990 amendments to the FNWA took a similar approach, requiring each agency to develop plans for weed control on lands under its jurisdiction. The FNWA could further protect natural areas if this function were more explicit (98). The definition of a Federal noxious weed includes species affecting ''fish and wildlife resources. Nevertheless, critics complain that APHIS has been slow or failed to act on weeds of natural areas such as melaleuca and Australian pine *(Casuarina equisetfolia)* (ch. 8). At least one State—Washington-has recently provided more complete protection for natural areas from weeds (box 7-D) (124).

Improved implementation of the Lacey Act and future implementation of the Nonindigenous Aquatic Nuisance Prevention and Control Act might go far towards protecting natural areas from harmful, non-indigenous fish and wildlife (including aquatic invertebrates). Today, however, protection of natural areas from these *NIS* is almost nonexistent. For example, mollusks that harm natural areas continue to arrive in the country (ch. 3) (8). APHIS may screen out some mollusks during inspection of plant imports, but only if they are potential agricultural pests. Just one species would be stopped due to a prohibition under the Lacey Act—the well-known zebra mussel, which was listed far too late to stop its spread across the country.

Congress might delay further legislation on harmful aquatic *NIS* until the 1990 Nonindigenous Aquatic Nuisance Prevention and Control Act is fully implemented, although the Federal interagency Aquatic Nuisance Species Task Force has been slow to fulfill its required assignments (table 6-l). Instead, Congress might evaluate the Task Force program to date, urge faster implementation, and ensure that funds are provided for State control in a timely manner.

Issue 5: Environmental Education as Prevention

Option: *Congress could require that the 20-some Federal agencies involved with NIS develop broadly based environmental education programs to increase public awareness of problems caused by damaging or unpredictable NIS.*

Option: Alternately, Congress could develop a smaller scale initiative to take greater advantage of current programs and information.

Option: Congress could require that airlines, port authorities, and importers intensify their public educational efforts regarding harmful NIS.

Although public appreciation of U.S. biological diversity is increasing (ch. 4), the difference between indigenous and NIS in natural surroundings is not commonly perceived—thus the neglect of a coherent public policy regarding harmful NIS.

Lack of awareness on the part of the public and policymakers is mutually reinforcing. Many,

including OTA's expert contractors and its Advisory Panelists, believe this cycle of ignorance must be broken *(22,46,49,60,104).* Also, this theme surfaces frequently in recommendations by nongovernmental groups (46) and scientists and managers ***(83,93),***

Education on NIS ranks low in priority in most State and Federal agencies and private organizations that are involved with natural resources, receiving an estimated less than 1 percent of most organizations' budgets ***(96).*** Numerous activities are under way, but efforts are fragmented, uncoordinated, with little formal institutional backup.

In 1989, a coalition of at least 100 environmental groups recommended a sweeping approach to environmental education, including

1. re-establishing an Office of Environmental Education in the U.S. Department of Education,
2. appointing a National Advisory Council on Environmental Education within that Department, and
3. requiring that USDA, the Department of the Interior, and EPA develop and distribute environmental programs and materials (15).

The first two activities were estimated at an additional $20 million annually. In part, they were seen as fulfilling unmet goals of the 1970 Environmental Education Act, which expired in 1982.

The North American Association for Environmental Education (NAAEE) suggested a less sweeping strategy, based on its survey for OTA of current NIS-related programs. Previous education campaigns have not been systematically evaluated, which made recommending definitive changes difficult (96). NAAEE's suggestions included: cooperative government-private programs for groups working on similar NIS; improved exchange of already-developed educational materials; designation of specialized "centers of excellence' for particular species or approaches; teacher training; and improved links between

COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY

Agricultural items that can harbor foreign pests are prohibited from entry but these banned items arrived with international travelers on just one fight.

scientists (who often are charged with designing education campaigns) and educators (who have more expertise in programs' effectiveness) (96).

Regardless of approach, program evaluations should be incorporated from their beginning.

The public has the greatest need for education related to non-indigenous animals, according to survey responses of 271 U.S. resource managers and others involved with these issues (93). However, few environmental education campaigns are initiated for the general public for logistical reasons; efforts are more realistically focused on particular groups of people (96). Education regarding harmful NIS will be more effective if focused on people whose incentives for harmful introductions or other actions are weak and for whom the information is likely to tip

the balance of their behavior. Little research has been done on why people bring plants and animals into the United States illegally or why they dump NIS outside their property. Also, careful quantitative analysis of the pathways by which NIS reach the United States and the rate at which these pathways lead to serious problems has not been linked to educational efforts for the people using these pathways. Such an analysis could be a highly effective way to set priorities for educational programs.

Few NIS are introduced intentionally and illegally (smuggled), with the exception of sport fish (ch. 3). For smugglers, steep frees may be more appropriate than education. On the other hand, Ralph Elston, from the Battelle Marine Sciences Laboratory in Sequim, WA, suggests that commercial groups transporting aquatic NIS can be expected to respond to education and self-enforcement (31). For other vertebrates, people may intentionally release animals believing they are doing the right thing, or at least not understanding the possible harmful effects of their actions. Educational efforts aimed at buyers at the point of import or sale might effectively change this behavior. Warnings on packages or special forms describing dangers might alert importers. Horticulturist Gary Keller (52) of the Arnold Arboretum, for example, suggests that plants like running bamboo species,[19] which are known to be highly invasive, be sold with individual warning labels so that gardeners recognize their danger and prevent their spread.

International travelers' baggage is often cited as an important source of unintentional (but illegal) introductions (1 1). This suggests that airline crews, immigrants, and departing or returning residents should receive intensified education. Also, foreign travel might automatically trigger certain steps: handouts from travel agents, enclosures with airline tickets, visas or passports (77), or videos on aircraft that graphically portray the potential damage from NIS. Similar attempts sometimes failed in the past because too little care was taken in developing a clear message; the support of the Advertising Council was not secured for media saturation; travel agents and air carriers were reluctant to distribute information; and APHIS usually did not include other inspection agencies (64). These lessons need to be heeded in the future.

Issue 6: Emergencies and Other Priorities

Option: *Congress could ensure that all Federal agencies conducting NIS control on public lands have adequate authority-via existing or new legislation-and funding to handle emergency infestations of damaging NIS.*

Option: Congress could set deadlines for APHIS' completion and implementation of comprehensive regulations for the importation of unprocessed wood.

Option: Congress could specify that APHIS and FWS conduct high-level, strategic reviews of how the agencies balance resources directed to excluding, detecting, and managing harmful NIS.

For agricultural pests, Federal and State statutes are relatively comprehensive. Many problems in this area are due to slow or incomplete implementation, difficulties coordinating Federal and State roles, or a tendency to inadequately address larger strategic questions.

In 1991 and 1992, APHIS allowed entry of several shipments of timber or wood chips from Chile, New Zealand, and Honduras without careful analysis (57). Critics complained that APHIS was ill-prepared and slow to recognize the risks that such shipments could carry significant new pests to U.S. forests (see ch. 4, box 4-B). Moreover, when APHIS moved to regulate 'logs,

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19 Keller's reference to running bamboo species includes plants in 15 different genera. The most invasive in northern North America are *Arundinaria* spp., *Phyllostachys* spp., *Pleioblastus* spp., and *Sasa* spp. (53).

lumber, and certain other wood products" in 1992,[20] these proposed regulations were incomplete, failing to address not only crates, pallets, or packing material made from unprocessed wood but also the control of ships and containers coming to the United States from high-risk areas.

Also, an unwillingness by APHIS to see localized problems as potential national concerns has been a source of continuing tension between the agency and State departments of agriculture (chs. 7, 8). APHIS has several times failed to act on significant pests because they were considered local problems. For example, the agency ignored Florida's 1987 problems with infestations of varroa mites *(Varroa jacobsoni) in* honey bee *(Apis mellifera)* colonies (l)--only to see the pest spread to at least 30 States by 1991 (73). Similar situations have arisen regarding plant pests and providing APHIS with emergency powers under the Federal Noxious Weed Act could clarify APHIS' role and speed responses (86).

EMERGENCY RESPONSES

Rapid response requires: careful monitoring for invasive or potentially invasive species to ascertain incipient problems; quickly deciding whether to attempt eradication, and, if so, being willing to eliminate more species than might eventually prove hazardous; and having the resources to implement that or other control decisions quickly.

The current situation contrasts sharply with the ideal (ch. 6). APHIS systematically monitors for a number of agricultural pests in various parts of the country, e.g., African honey bees, Mediterranean fruit flies *(Ceratifis capitata),* cotton boll weevils *(Anthonomus grandis),* and gypsy moths (49). However, improvements to the U.S. detection system are recommended by many scientists for plant pathogens (89), additional insects (48), weeds (60), and mollusks and other aquatic invertebrates (8). No centralized list of recently detected or potential new pests exists (ch. 3, 10). And databases that might provide such information have received sporadic support (ch. 5).

In contrast, New Zealand's forest industries conducted a detailed benefit/cost analysis of different levels of pest detection surveys. Maximum benefits were achieved by aiming to detect 95 percent, not 100 percent, of new introductions (13) (figure 4-3). Relatively few detailed economic studies of this kind are available to guide U.S. NIS programs (ch. 4).

Federal and State agencies are capable of rapid response after eradication decisions are made. A cooperative Federal-State program to eradicate chrysanthemum rust *(Puccinia chrysanthemi) in the* early 1990s was rapid and successful (90). Joint action in 1992 by APHIS and the Forest Service with the Oregon and Washington Departments of Agriculture eradicated infestations of the *Asian* gypsy moth. Forest Service expenditures for *European* gypsy moth suppression and eradication on Federal, State, and private lands in the eastern United States averaged $10,322,000 annually from 1987 to 1991 (126). Entomologists are concerned that the Asian gypsy moth, if established, could require a similar scale of effort.

On the other hand, Donald Kludy, a former official of the Virginia Department of Agriculture, cites three cases where regulatory changes to quarantines were delayed, sometimes repeatedly: Mexican citrus *(Citrus* spp.), fruit from Bermuda, and the Federal gypsy moth quarantine (49). S.A. Alfieri (1), a Florida agricultural official, also was less sanguine about the Federal-State partnership and its effectiveness in responding quickly to small infestations. He recommended that funds be set aside for emergency pest problems and that action plans be developed and continuously updated for each serious potential pest and disease, accompanied by cost-benefit analyses.

For fast response and eradication, safe and effective chemical pesticides are needed. Classical biological control cannot take their place, although it can be feasible for long-term control

20 57 *Federal Register* 43628-43631 (Sept. 22, 1992)

of widespread infestations, e.g., noxious weeds on western rangelands. By design, however, classical biological control allows pest populations to persist at tolerable levels. This is counterproductive in a rapid response program aimed at completely eradicating incipient pest populations.

Major concerns exist whether chemicals that are considered safe and effective now are likely to remain available because of regulatory changes (ch. 5). Many registered chemical pesticides are due for renewal under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).[21] Most herbicides for agricultural use are expected to be re-registered. Manufacturers are not expected to seek reregistration for many of the minor use insecticides, rodenticides, avicides, and fungicides. Reregistration is time-consuming and expensive, especially for chemicals with small markets. Chemicals used to control nonagricultural pests, including aquatic plants and large vertebrates, fall into this group. Manufacturers' decisions, as well as government policy, will have important implications. For example, costs of aquatic weed control could jump from $10 to at least $100 per hectare if 2,4-D amine is not reregistered; because many weed control budgets are capped, higher herbicide costs will translate into fewer areas controlled (34).

Section 18 of FIFRA does, however, provide for emergency use of unregistered pesticides. According to the General Accounting Office, Section 18 exemptions were intended for several situations, including the quarantine of pests not previously known in the United States.

Two Federal programs might prove instructive regarding policies on NIS-related minor use pesticides. The Interregional Research Program Number 4 (IR- 4), in USDA's Cooperative State Research Service, develops and synthesizes data to clear existing pesticides for minor uses on food and feed crops. However, it is heavily burdened and unlikely to meet reregistration deadlines (ch. 5) (110). Nor does it address problems of new pesticide development. Congress used the Orphan Drug Act[22] to address similar problems with developing limited-use pharmaceutical products. This Act provides pharmaceutical companies with 7 years' exclusive marketing rights and tax credits for developing drugs for rare diseases. The Act has successfully prompted new drug development (3), although controversy regarding several drugs' high profitability has prompted Congress to consider modifications.

APHIS

Although officials anticipated that the Asian gypsy moth (Lymantria dispar) *could accompany timber imports, grain ships brought an early infestation and State and Federal agencies cooperated to quickly eradicate it,*

SETTING PRIORITIES

Decisions about which organisms to prevent, eradicate, or control are not always made systematically or strategically, despite the large amounts of money involved. This risks wasting money, given the biology of invasions. The APHIS line-item budget directs most NIS-related funds to particular species and different programs compete against each other for priority. Highly visible programs with strong support of industry, States, or the public receive highest priority. As a

21 Federal Insecticide, Fungicide, and Rodenticide Act (1947) as amended, (7 U. S.C.A.136, *et seq.*)

22 Orphan Drug Act of 1983, as amended Public Law 97-414, Public Law 100-290.

result, potential new diseases and pests often lack attention, although money could be well invested at an early stage (49). State officials express confusion as to how APHIS decides whether and when to begin and end its programs,

James Glosser, former APHIS Administrator, stated that: "Probably the greatest problem confronting us in noxious weed control is identifying what constitutes a noxious weed and how to establish priorities for control efforts" (36). Managers tend to set priorities based on either species' impact or the likelihood of successful control. USDA's Noxious Weed Technical Advisory Group suggested criteria based on potential economic damage, size of infestation, and support for a control or eradication program (80).

Ranking current and potential plant pests was a major task of the Minnesota Interagency Exotic Species Task Force (70). Florida's Exotic Plant Pest Council is also developing an extensive, prioritized list of harmful non-indigenous plants (26). The McGregor Report (64) was among the Federal Government's frost attempts to rank agricultural pests and diseases, although it had limited impact. The seven western States participating in BLM's research plan for restoring diversity on degraded rangelands listed four high priority non-indigenous weeds[23] (1 14).

Others would give highest priority to harmful NIS in their earliest stages of invasion. Plant invasions are typical of many NIS in that their populations do not spread at steady rates. Weeds are easiest to control or eradicate immediately after detection, before their population growth accelerates (71). Richard Mack, Professor of Botany at Washington State University, suggests that eradication aimed at already well-established, widespread weeds is likely to produce only temporary gains unless control is permanently maintained. This is costly and difficult. The most aggressive plant pest control program ever conducted in the United States succeeded in restricting, but not eradicating, barberry (Berberis *vulgaris) (62).* Nor, according to Mack, could all possible weeds be prevented from entering the United States at a tolerable cost: society would not accept the expense and delays involved in inspecting all arriving cargo, luggage, and passengers. For these reasons, he would increase resources for detecting newly established weeds, add species to the Federal Noxious Weed Act, but keep quarantine, port inspection, and control of widespread weeds near current levels (62).

Richard Mack's recommendations are a clear strategic statement that could guide policy. However, those advocating higher priority for control of widespread weeds would sharply disagree with his approach and they can also make a strong case (see preceding section on non-indigenous weeds). A large proportion (39 percent) of those involved in issues related to non-indigenous animals feel that the length of time a population has existed should bear little influence on the decision to remove or control it (93). However, significantly more administrators than other types of workers supported using length of time in making decisions about non-indigenous animals (93). Such fundamental disagreements on priorities highlight the lack of information, dialogue, and consensus on managing harmful NIS.

Approaches to setting priorities may vary, depending on the type of organisms involved and the state of scientific knowledge. Containment of non-indigenous fish and other aquatic species is difficult. Once released, large aquatic invertebrates and fish spread easily within river systems, and their larval, sub-adult and adult forms may each be disruptive (44). Attempts to eradicate fish after they have developed a substantial range are often a waste of time and resources (22). Thus, groups like the American Fisheries Society have often focused on the need for stricter pre-introduction screening.

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[23] Medusa head (*Taenniatherum asperum*), cheatgrass (*Bromus tectorum*), diffuse knapweed (*Centaurea diffusa*), and spotted knapweed (*Centaurea maculosa*) (1 14).

For plant pathogens, overseas screening by commodity, along with inspection at ports of exit, might be most effective (91). USDA has focused on identifying foreign pathogens likely to be damaging in the United States (89). With a list of potential pathogens running to 1,000 pages and limited detection methods for micro-analysis, complete exclusion at ports of entry is impossible. Pathogens tend to be insidious-they may become apparent only *after* populations are beyond what would amount to ''early detection' for larger and less mobile NIS. Pathogen hosts must be eradicated to eliminate diseases, but many hosts are valuable commodities, and their destruction can be costly and controversial.

Others have recommended alternative criteria for setting priorities. For example, Walter Westman, of Lawrence Berkeley Laboratory in Berkeley, CA, suggested that priorities might be based on severity of impact on indigenous biota, with wilderness areas receiving higher priority than urban recreation areas. Also, control might be emphasized for more easily contained NIS (e.g., those with slow rates of spread, localized occurrence, and susceptibility to available methods) and/or those that threaten endangered species. Those NIS that play a role in ecosystem function (e.g., controlling soil erosion control or supporting wildlife) and cannot be readily replaced could be given lower priority (129). Stanley Temple, a zoologist at the University of Wisconsin, likewise suggests NIS that threaten endemic species on remote islands deserve special, high-priority treatment (103). The International Union for the Conservation of Nature and Natural Resources (IUCN) took a similar approach. Its Species Survival Commission counseled that special efforts should be made to eradicate harmful NIS in: islands with a high percentage of endemic plants and animals, centers of biological uniqueness, areas with high species or ecological diversity, and in places where a NIS jeopardizes a unique and threatened plant (44).

In the long-term, strategic decisionmaking, like better detection and more rapid response, requires solid databases (with information from foreign sources) and substantial taxonomic expertise. The inadequacy of the former and the dwindling of the latter are common concerns in the scientific community (ch. 5) (24,60,63).

Issue 7: Funding and Accountability

Option: *Congress could increase user fees that relate directly to the evaluation, use, and management of potentially or actually harmful NIS. Also, Congress could require that recreational fees collected by Federal land management agencies be made available for management of harmful NIS on public lands.*

Option: *Congress could examine the adequacy of Federal and State fines related to illegal and poorly planned introductions. If necessary, Congress could develop additional mechanisms to recoup an increased proportion of the costs for preventing and minimizing damage from NIS that become public nuisances.*

Option: *Congress could change the Aid-to-States program to encourage projects that limit damage from non-indigenous fish and wildlife.*

Many small-scale efforts related to NIS could be improved without large funding increases. Some of the options suggested for issues above fall into that category. However, some initiatives are large enough to require additional money. These needs are likely to grow as the number and impact of harmful NIS also grows.

Options that give additional responsibilities to Federal or State agencies-e. g., for more complex risk assessment or earlier pest detection—need to be matched with increased funding if they are to be effective. The problems faced by the Federal interagency Aquatic Nuisance Species Task Force-delays in reporting to Congress, lack of funding and staff-illustrate what happens when new obligations are assigned without the resources to implement them. Some Federal

officials find that funding is the primary factor in agencies' ability to proactively deal with harmful NIS (17). In a survey of those working with issues related to non-indigenous animals, for example, respondents listed funding problems as the single largest contributing factor to the lack of success in control programs (93).

This problem is not confined to MS. Both Federal and State environmental legislation has multiplied during the 1980s and early 1990s (32,84). At the same time, the funding available to States and localities has been decreasing (32,95). Clearly, questions of funding will be crucial for new or improved efforts to succeed.

To date, the total costs of harmful NIS to the national interest have not been tabulated. Quarantine containment can fail; a newly imported species can become unexpectedly invasive; a previously innocuous pathway can become a conduit for a major new pest. However, little explicit accountability exists for the damage caused in such cases, especially as compared with other areas of potential environmental harm. Federal, State, and local governments have borne significant costs that could be more appropriately assigned to individuals and industries, e.g., for the Asian gypsy moth and the zebra mussel.

Expensive and time-consuming lawsuits provide virtually the only avenue for assigning liability and recovering control or eradication costs. In part, this may be because many damaging NIS have been associated with agriculture and agriculture has engendered less Federal intervention with respect to its environmental consequences than other industries (84).

Long lag times between the action of the responsible party (if that party can be determined) and the impacts of NIS are typical. For example, witchweed *(Striga asiatica)* probably arrived in North Carolina with military equipment from Africa after World War II; it was detected some *20 years* later. The APHIS eradication program in North and South Carolina cost $5.2 million in fiscal year 1991 (90). Often the effects, as well as origin, of a given NIS will be uncertain and undocumentable. And one area or economic sector could be severely harmed by a NIS while another might benefit. Relying solely on U.S. courts to assign damages and to recoup costs is an ineffective policy under these circumstances.

FEES AND OTHER FUNDING

Fees are a prevalent means of raising funds for matters directly and indirectly related to NIS and Federal and State governments are expanding user fees. Typically, fees are structured to raise revenue, not to recoup damages or to change people's behavior (85). As of the late- 1980s, Evelyn Shields, in a report for the National Governors' Association, (95) found that 43 States used fees to fund local, State, and Federal environmental programs, generating roughly $240 million. In fiscal year 1991, State parks and similar areas alone produced approximately $433 million from entrance and user fees (1 19).

However, the more public organizations rely on funding that is independent of the appropriations process, the more independent they are of congressional control (105). This has been a common issue in the continuing debate in Congress regarding fees.

Relating user or other fees[24] directly to harmful NIS or services associated with them has an advantage since management of harmful NIS otherwise suffers when finding drops and populations outstrip control. For example, 1993 funding cuts to the South Florida Water Management District mean reduced melaleuca control in the Everglades conservation areas; Donald Schmitz (87), an aquatic weed specialist with the Florida Department of Natural Resources, anticipates some past gains in melaleuca control will be lost

[24] The definition of a "user fee" varies, depending on the author. Doyle (28) describes 4 general types of fees: impact fins, user fees, and fees for services and discharges. The agencies discussed here distinguish user and entrance fees for reporting to Congress. GAO (109) appears to have grouped all FWS fees as "user fees.

Some funding for melaleuca **(Melaleuca** quinquenervia) *control is dropping while associated problems are increasing-the type of situation that user fees are intended to prevent.*

and future efforts made more difficult as a result. Ideally, NIS funding would be predictable and increase if NIS-related problems do. User fees can be tailored so that this occurs.

In 1991 and 1992, APHIS published regulations implementing the user fees for international inspection services authorized in the 1990 Farm Bill;[25] these range from *$2.00* for air passengers and commercial trucks, $7 for loaded commercial railroad cars, to $544 for commercial vessels of at least 100 tons (49). User fees for agricultural inspection, issuance of plant health certificates, animal quarantines and disease tests, and export health certificates were also authorized and are expected to be in place by the beg inning of fiscal year 1994.[26] In contrast, Congress struck down APHIS' attempt to institute a domestic quarantine user fee between Hawaii and the mainland (ch. 8). In fiscal year 1992, user fees provided 80.7 percent of program funding for APHIS' Agricultural Quarantine Inspection program; this was estimated **at** 78.6 percent for fiscal year 1993 (78).

Additional opportunities exist to more closely match fees to MS use and the prevention and minimization of NIS damage. For example, private parties in New Zealand pay all costs associated with risk analysis and port inspection for imported NIS. In contrast, those commercial interests advocating Siberian timber imports to the United States spent about $200,000 to develop Russian contacts and promote imports. The U.S. Government spent approximately $500,000 more to analyze associated risks. These were not additional appropriations but came from U.S. Forest Service contingency funds.

Seven Federal land management agencies[27] are authorized by Congress to charge entrance or user fees under the Land and Water Conservation Fund Act of 1965 (LWCFA), as amended.[28] Fees generated by the LWCFA account for amounts ranging from 1 percent (BLM) to 85 percent (NPS) of the agencies' total receipts from sale and use of land and resources (4).

Congress has considered numerous amendments to the LWCFA since 1965 to prohibit, authorize, or re-establish various agencies' ability to charge fees, to change the amount of different fees, and to change the purposes to which fees can be put (9,108). legislative changes generally have expanded and increased fees to meet the agencies' growing needs for operating and maintenance funds. Making entrance or user fees available for NIS-related programs would likely require further changes in this legislation.

Changes to the LWCFA have been controversial, in part because of the tradition of free public access to Federal recreational lands (9). Other specific user fees, e.g., grazing permits on Federal

25 56 *Federal* Register 14844 (Apr. 12, 1991); 57 *Federal Register 769, 770* (Jan. *9,* 1992); 57 *Federal Register* 62472, 62473 (Dec. 31, 1992)

26 Proposed regulations are in 56 *Federal Register 37481-37493 (Aug. 7,* 1991)

27 Bureau of Land Management, Bureau of Reclamation, Army Corps of Engineers, Forest Service, Fish and Wildlife Service, National Park Service, and Tennesee Valley Authority.

28 16 U. S.C.A. 4601-6.

lands, also have been highly controversial, as is the general issue of charging full market value for Federal services. However, sizable amounts of potential revenue are involved. For five Federal land management agencies, 80 to 99 percent of recreational visits are to sites for which no fees are charged; the National Park Service, on the other hand, charges fees for about 65 percent of visits (1 19). In some cases, agencies consider sites too dispersed for ready fee collection; in other cases, Congress or the agency has designated particular units as nonfee areas. Internal audits estimated that approximately $24 million could be collected annually with new or increased fees by NPS, BLM, FWS, and the Minerals and Management Service (120). The Forest Service estimates that charging full value for its recreational services would generate $5 billion annually (85).

A variety of additional means—besides increases in fees-could fund various MS-related activities. For up-front funding, Congress could levy taxes on those who use the pathways by which harmful NIS enter the United States and move within the country. Such users include importers, retailers, and consumers of foreign seeds, nursery stock, and timber, exotic pets and wildlife, and non-indigenous aquiculture and aquarium stock. Similarly, a tax could appropriately be applied to international airline and train tickets, docking fees, and gasoline. The Minnesota Exotic Species Task Force (70), focusing on NIS pathways, suggested these sources of new revenue:

- establish a surcharge on boat trailer licenses;
- establish a tax on the sale of non-indigenous nursery products such as trees, shrubs, and flowers;
- establish a ballast tax on foreign ships;
- require licenses and license fees for importers; and
- . continue and expand the surcharge on boat licenses.

State and Federal Governments use taxpolicy—excise taxes,[29] exclusions and other modifications to income taxes, and tax credits—to meet a variety of environmental goals and provide funding for targeted programs (1 11). Most tax policies have little relationship to NIS. However, sales taxes are collected on pets and nursery plants and excise taxes are imposed on airline tickets for the Airport and Airway Trust Fund (67).

Also, the Federal Government collects a 10 to 11 percent manufacturers' excise tax on firearms and hunting and fishing supplies (1 11). These funds are returned, in the next fiscal year, to States for fish and wildlife management projects (ch. 6; fig. 6-l). In fiscal year 1991, payments to States totaled more than $320 million (107).

These funds are intended for projects that benefit wildlife. They have been used to introduce MS and for projects that indirectly affect wildlife, e.g., restoration of wetlands. States could be encouraged to fund projects that repair damage from past introductions of harmful non-indigenous fish and wildlife. Alternately, Congress could amend the program to set aside funds for eradication and control of harmful MS or restoration of indigenous species' habitats. Such projects are already eligible for funding. A set-aside, however, could further encourage States to undertake such efforts without removing State control of the program's money. Attempts to do so could provoke considerable State resistance. Currently, only State agencies qualify for these funds. Some observers have suggested that the program be changed so Federal projects might be eligible for a portion of these funds.

INCREASING ACCOUNTABILITY

Responsibility for the costs of harmful introductions could be shifted to those who benefit

[29] Excise taxes are collected on commodities—their manufacture, sale, or consumption—or a privilege. The latter are often assessed as licenses.

from the relatively open U.S. system of importation. At the same time, the benefits of introductions could be preserved without unduly burdening private individuals or groups. Those engaged in intentional introductions are most easily assigned certain costs—for example, fees for prerelease risk assessments and fines for illegal releases. For unintentional introductions, all users of high-risk pathways (e.g., shippers using ballast water) could be charged for their pooled risk with funds paid into a trust fund.

The Species Survival Commission of IUCN recommended that each nation have legislation to ensure that persons or organizations introducing harmful NIS, not the public, bear costs for their control. Further, the Commission stated that parties responsible for illegal or negligent introductions should be legally liable for damages, including costs of eradication and habitat restoration, if needed. F.C. Craighead, Jr. and R,F. Dasmann, two wildlife biologists, made a similar recommendation regarding non-indigenous big game animals that spread onto public lands (25). A number of States have programs to hold game breeders, private owners, or importers liable for controlling escapees and for damages (ch. 7).

A host of mechanisms is available to increase accountability. Bonding and insurance, for example, could be required of importers, but have been little used. Permits and frees are most commonly used now.

The Federal Government imposes fines for bringing foreign material into the United States illegally, e.g., international, interstate, and intrastate violations of the Plant Pest Act,[30] the Plant Quarantine Act,[31] and the Lacey Act.[32] Both civil and criminal sanctions are involved. The 1981 Lacey Act amendments increased maximum penalties and jail sentences for violations ($20,000, imprisonment for up to 5 years) and provided for forfeiture of wildlife;[33] frees were further increased by the 1987 Omnibus Crime Control Act[34] (55). Hawaii's recently amended laws provide some of the largest frees for violating its importation permit laws—up to $10,000 for a first offense and up to $25,000 for subsequent offenses within 5 years of a prior offense (ch. 7).

Agricultural inspectors (APHIS) can fine violators up to $10,000 but most civil penalties are under $1,000. Officials estimate about 30,000 actions per year, with almost all settled for less than $100 immediately (40). In fiscal year 1990, APHIS found 1,303,000 baggage violations and assessed $723,345 in penalties for 23,676 of these (37), for an average of approximately $30.

Release of organisms into National Parks is a citable offense.[35] The BLM has a policy to hold people responsible for damages and control costs for unauthorized introductions of "exotic wildlife;' however, no law or regulation specifies such liability beyond the common law, so the policy's implications are not clear (6).

For frees to be effective deterrents, enforcement must be a priority. A recent advisory commission found that FWS law enforcement division was seriously understaffed and underfunded, lacked clear priorities, provided inadequate staff supervision, and had insufficient technical expertise to identify species (121). The U.S. General Accounting Office (109) concurred,

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30 Federal Plant Pest Act (1957), as amended (7 U. S.C.A. 147a *et seq.*),

31 Nursery Stock Quarantine Act (1912), as amended (7 U. S.C.A. 151 *et seq.*.; 46 U. S.C.A. 103 *et seq.*

32 The Lacey Act's 1981 amendments allow FWS agents to use the Act when enforcing any Federat law, treaty, refutation, or tribal law. It provides for warrantless search and seizure and allows prosecution regardless of whether offenders crossed State lines. These provisions compensate for weaknesses in the authority of other Federal wildlife laws. FWS agents prefer the Lacey Act for these reasons and because its allows larger fines (109).

3316 U. S.C.A. 3373, 3374.

34 Omnibus Crime Control Act (1987), as amended (18 U. S.C.A. 3571).

3536 CFR Part 2. l(a)(2) (June 30, 1983).

The Fish and Wildlife Service confiscated these cockatoos under a treaty banning their import. The agency's efforts to enforce both international and domestic laws may be inadequate to deter violators.

finding that the number of investigations is too low to minimally deter crime, that FWS is increasingly unable to assist States with investigations, and that FWS has no reliable direct measures of their law enforcement's effectiveness. Many States also lack adequate law enforcement resources (ch. 7). Thus, frees could only be a larger source of revenue and a greater disincentive for illegal behavior if enforcement is improved. However, frees are just one means of creating disincentives for wrong doing-and they carry with them the potential for ''fund raising through harassment" (67). Generally, prosecutions for environmental crimes are climbing (54) but critics charge that their deterrent potential is far from clear (12).

Taxes, fees, frees, and other tools are designed to achieve one of several aims, i.e., to increase the benefits or decrease the costs of doing right, to increase the costs or decrease the benefits of doing wrong, or to increase the probability that such benefits and costs will occur (72). The overall trend in U.S. public policy is toward greater use of incentives for doing right, according to Stuart Nagel, a political scientist at the University of Illinois.

However, little attention has been directed toward creating positive incentives regarding harmful NIS, e.g., for encouraging adequate containment of aquiculture species. In some cases, bounties are paid for removing harmful NIS, rewards are provided for tips leading to successful prosecutions, and the Lacey Act's 1981 amendments included provisions[36] for rewarding those who provide information leading to enforcement against or conviction of violators (55). Increasing other types of incentives may require new statutes and/or regulations.

Issue 8: Other Gaps in Legislation and Regulation

As a result of the Federal and State patchwork of laws, regulations, and programs, important types of non-indigenous organisms remain potential sources of damaging introductions. The most serious gaps are discussed above. Additional organisms are not adequately covered by Federal and/or State laws, however, and are the basis for a second tier of possible options. In priority order, these gaps pertain to:

1. vectors of human diseases;
2. sale and release of biological control organisms;
3. live organisms moved by first-class mail, shipping services, and catalog sales;
4. hybrid and feral animals;
5. NIS used in research; and
6. new strains of already established harmful NIS.

Some of these gaps require legislative change to fill; others need more adequate implementation by Federal agencies.

[36] 16 U, S.C.A. 1531-1543.

VECTORS OF HUMAN DISEASES

Option: *Congress could lay groundwork by investigating the adequacy of the Nation's response to NIS that pose significant threats to human health. This might begin with a General Accounting Office investigation of APHIS and the Public Health Service's respective roles.*

Non-indigenous human health threats are largely beyond the scope of this study. Two cases, however, illustrate continuing, significant problems with Federal management.

The Centers for Disease Control and Prevention of the Public Health Service (PHS) responded slowly to the threat posed by the Asian tiger mosquito *(Aedes albopictus),* a potential vector for several serious viral diseases. These non-indigenous mosquitoes apparently entered the United States in 1985 in used automobile tires and have now spread to 22 States (ch. 3; box 3-A). The Centers' lack of action to stop the insects' spread raises questions regarding its effectiveness in dealing with MS new to the United States.

The African honey bee poses a public health threat and a threat to U.S. agriculture. Because of the latter, APHIS is responsible for developing responses to control the bee's spread from Mexico. However, APHIS cannot fully address the human health issues.

Researching and preventing acute infectious diseases, many of which have non-indigenous mammal or insect vectors, have received a reduced national commitment since the 1950s, according to a recent report by the Institute of Medicine (58). This report, on emerging microbial threats, recommends increased surveillance for infectious diseases and their vectors. It also calls for enhancing information data bases and improving the structure of PHS and inter-agency cooperation.

These seem to be matters of improving Federal implementation, The frost step might be congressional oversight designed to provide increased public scrutiny.

THE SALE AND RELEASE OF BIOLOGICAL CONTROL ORGANISMS

Option: *Congress could either create new legislation or amend existing law to more comprehensively regulate biological control agents.*

Option: Congress could increase the level of environmental review required for importations of biological control agents by making them subject to NEPA.

Biological control agents used in the United States include non-indigenous microbes, insects, and other animals that damage, or eat, undesirable plants or insects. Congress has never directly addressed biological control. No single Federal statute requires that biological control agents be reviewed before introduction (69) or regulates importation, movement, and release of biological control agents (19). Instead, potential risks are dealt with by existing regulations, supplemented with a complex system of voluntary protocols or guidelines (19).

Federal regulation of biological control agents—like genetically engineered organisms-uses several laws designed for other purposes, e.g., laws on quarantine, product registration, and environmental protection. EPA regulates the commercial sale and release of pesticidal microbes under FIFRA. Biological control agents that are not microbes are exempt from FIFRA and fall under APHIS's jurisdiction, although the agency has not yet promulgated regulations specifically for such biological control agents. Instead, APHIS requires researchers and producers to follow procedures and permitting requirements developed for plant pests under authority of the Federal Plant Pest Act and the Plant Quarantine Act (10). NEPA, along with the Endangered Species Act, also affects importation and research on biological control organisms (19), although NEPA's application has been uneven and poorly defined.

Several aspects of commercial distribution and sale of biological control agents are among the

topics not addressed by current statutes or regulations. No requirements exist for clear and accurate labeling of insects or other animals (e.g., nematodes) used for biological control. No law specifically gives APHIS authority to regulate the labeling, purity, or disease status of these insects and animals. Nor are those who release improperly screened or tested agents accountable for any resultant damage. It is unclear whether current statutory authority covers all the categories of biological control agents APHIS is seeking to regulate. Specifically, it is questionable whether beneficial insects that prey on insect pests fit under the Federal Plant Pest Act's definition of "plant pest. '

Opinion is divided regarding the suitability of the current system and how its weaknesses should be corrected. Peter Kareiva, an ecologist at the University of Washington, expressed a particular concern about APHIS lack of formal criteria for approving releases of biological control agents (46). Francis Howarth and Arthur Medeiros, from the Bishop Museum in Honolulu and Haleakala National Park, in Makawao, HI, respectively, suggested requiring formal environmental impact statements or environmental assessments to ensure the widest possible public review (42). Ecologist Gregory Aplet and attorney Marc Miller (69) contend that current laws do not—and cannot be amended to-fill critical gaps. They propose a Federal Biological Control Act that would ensure public participation in decisionmaking and correct what they see as serious shortcomings in the current review process:

. harm to noneconomic species and ecosystems is ignored;
. repeated introductions are allowed when a given organism is approved, even into new ecological settings with different, potentially damaging consequences;
- transfers of biological controls within the United State or within States are disregarded; and
- no formal, enforceable requirements are required for research and follow-up to determine whether detrimental impacts have occurred (69).

The Species Survival Commission of IUCN (44) recommended that biological control organisms should be subject to the same care and procedures as other NIS.

On the other hand, USDA biological control experts such as J.R. Coulson and Richard Soper prefer the current voluntary system for assessing risks of new introductions, updated by biological control and quarantine specialists (19). U.S. biological control programs have excellent safety and environmental records, they maintain, and have accommodated needs to consider impacts on nontarget species. Therefore, environmental impact statements are not only unnecessary but also would demand superfluous or frivolous studies, slowing or halting the use of many biological control agents. Coulson and Soper hope that further development of informal guidelines can limit adverse effects on existing biological control programs and preempt stricter legislation or regulations developed by nonspecialists. Miller, Aplet, Coulson, Soper, and Howarth all agree that more post-release evaluations are needed.

Federal and State protocols for introductions protect only a limited part of the United States but eventually need to address all of North America (19). Miller and Aplet describe laws in seven States that encourage the development and application of biological control.[37] They consider Wisconsin's provisions the most protective. An earlier survey found just three States with particular laws addressing biological control species and only one—North Carolina-addressed issues related to commercial sales (66).

[37] Arizona, California, Connecticut, Florida, Minnesota, New York, and Washington encourage biocontrol *generally,* for specific pests, or as part of integrated pest management (69).

Eventually, specific biological control legislation may be the vehicle to extend needed protection throughout the country. States could potentially deal with problems related to product labeling and performance through their weights and measures or consumer protection statutes, although a complaint would be necessary to trigger action (50). For example, the Pennsylvania State Bureau of Consumer Protection recently brought a lawsuit against the manufacturer of a biological control product when it was discovered that the product contained no trace of the active pesticidal microbe (16).

Regardless of the approach Congress takes, issues associated with biological control are likely to be increasingly visible and controversial as public interest grows. Biological control's popularity increases the risk of unwise introductions by amateurs (19). The potential danger of biological control releases has been scrutinized more closely in conjunction with proposals for releases of genetically engineered organisms.

LIVE ORGANISMS MOVED BY FIRST CLASS MAIL, SHIPPING SERVICES, AND CATALOGUE SALES

Since the time when Benjamin Franklin lived in Europe, Americans have sent attractive or promising NIS home (125). In the early part of this century, the Commissioner of Patents used congressional franking privileges to distribute foreign seeds to farmers (125). Domestic and international mail is also a known pathway for the spread of harmful non-indigenous plants and prohibited agricultural pests however (49,61) (ch. 3). Some introductions of Mediterranean fruit flies in California are thought to have originated in tropical produce mailed first-class from Hawaii (97).

The Constitution and Federal laws protect domestic first class private and commercial mail against unreasonable searches. On the other hand, most international mail is subject to unrestricted searches, but finding and personnel to do this are scarce.

Many live organisms are shipped via international and domestic mail; only limited searches are allowed for domestic first-class mail.

In 1990, APHIS and the U.S. Postal Service began a trial program in Hawaii using trained dogs to identify outgoing packages containing agricultural products. This evidence is then used to obtain warrants to open the package to determine whether the products are illegal. The program reportedly has been quite successful (106). It is cumbersome, however, which may justify easing the warrant requirements.

Congress recently passed a law specific to Hawaii, the Alien Species Prevention and Enforcement Act,[38] which is to allow the same sort of inspection for mail coming into Hawaii as for outgoing mail (ch. 8). The Federal and State agencies involved have fallen behind schedule in

38 Alien Species Prevention and Enforcement Act (1992), Public Law 102-383, section 631.

setting up a cooperative agreement for the inspection, however, because of the agencies' differing regulatory authorities regarding inspections and types of organisms.

Similar programs do not exist for other areas where first-class mail poses pest risks, e.g., from Puerto Rico into California (97). Donald Kludy (49), a former official with the Virginia Department of Agriculture, suggests that mail shipments are a serious enough problem to extend the Hawaii U.S. Postal Service pilot program to items mailed from Puerto Rico and other U.S. territories or to pass new legislation for all mail originating outside the contiguous 48 States. Congress might evaluate the Hawaii inspection program and, based on this information, consider whether its application to other areas is warranted and feasible.

Many live organisms now are available through catalogue sales, including insects and other animals for biological control, as well as a wide variety of plants and seeds. Adherence to Federal or State laws that limit areas to which species may be shipped is largely voluntary. Catalogue sales do not present the same inspection and regulatory opportunities that are available in the case of ordinary retail outlets. Nurseries and aquatic plant dealers sell several federally listed noxious weeds through the mail, such as the rooted water hyacinth *(Eichhornia asurea),* which can clog waterways and cause a navigation hazard (127). Packages sent via private delivery services are not protected from inspection as is first-class mail. However, they are unlikely to be inspected unless the package is broken or leaking.

This opens the possibility that commercial distribution may provide a pathway for spread of potentially harmful NIS, including pathogens and parasites. The wasp parasite *(Perilitus coccinel-/ae)* of the indigenous convergent lady beetle *(Hippodamia convergent),* for example, already has been spread in this manner (43). The 16-member expert Working Group on *Non-Apis* Bees expressed similar concerns regarding the movement of bumble bee *(Bombus* spp.) colonies between eastern and western North America. Rental and sale of bee colonies has increased in the past 5 years, along with the potential spread of accompanying non-indigenous nematodes, mites, diseases, and parasites (131).

HYBRID AND FERAL ANIMALS

Option: Congress could amend the Lacey Act so that it clearly applies to harmful hybrid and feral animals and they could be includedin any new Federal initiatives for States' roles.

Non-naturally occurring hybridization with NIS can present a serious threat to indigenous species by diluting gene pools (59) and causing other genetic harm (38). Most Federal and State laws that protect indigenous species, or prohibit harmful NIS, lack clarity in their application to hybrids. This can lead to controversy, such as the dispute over a policy adopted by FWS, that narrowly interpreted the protection of hybrids offered by the Endangered Species Act (82). Unclear or disputed taxonomy, particularly in the delineation of subspecies, can contribute to the ambiguity (35).

Non-indigenous hybrids require flexible policies, adaptable to each case. Hybrids can represent important genetic diversity to be preserved—this applies to economically and ecologically important species such as the endangered Florida panther *(Felis concolor coryi)* (ch. ***2). In*** contrast, hybrids between dogs *(Canis familiars)* (non-indigenous) and wolves *(Canis lupus)* (indigenous), which are popular as pets, are not only dangerous to humans, they also obstruct recovery of endangered wolves in the wild (5,7). They often escape or are released by owners unable to manage them. An international group of wolf experts has called for governments to prohibit or tightly restrict wolf-dog hybrid ownership and breeding (65).

Most Federal laws are silent in their treatment of feral animals-wild populations of formerly domestic animals. Few State laws covering the accidental or intentional introduction of such animals or responsibility for damage they may cause.

Yet feral animals continue to cause significant damage. In a recent survey, managers of national parks and other reserves named feral cats *(Felis cattus)* and feral dogs to be two of the three most common subjects of wildlife control efforts. The other was wild pigs *(Sus scrofa),* many populations of which are feral (29). Feral cats kill large numbers of small mammals and birds, dogs attack livestock and indigenous wildlife, and pigs destroy indigenous plants and do other damage (123).

Federal or State laws could be amended to more clearly apply to hybrid and feral animals.

NON-INDIGENOUS SPECIES USED IN RESEARCH

Scientific researchers initially introduced several very harmful NIS, including gypsy moths, African honey bees (in South America), and peanut stripe virus (48,89). The rapid spread of the Asian clam *(Corbicula fluminea),* a serious fouler of power plant pipes, is thought to have been assisted by inadvertent research releases (21).

Research organisms are not generally subject to the same scrutiny as those for other applications. The Lacey Act allows certain organisms to be imported or moved interstate for research and many State laws allow research imports of otherwise prohibited species. Microbes can be freely imported for research if they do not pose a risk to agriculture or human health.

Some Federal and federally funded research on NIS is evaluated for the risk of species escape or potential effects. ARS has extensive protocols governing its research on biological control agents (19). The Federal interagency Aquatic Nuisance Species Task Force recently issued protocols for research on harmful aquatic NIS. These protocols will be mandatory for any research funded under the Nonindigenous Aquatic Nuisance Species Prevention and Control Act and have been voluntarily adopted by agencies on the Task Force (18,122). However, most of the research protocols developed by Federal agencies do not apply to research funded by outside sources (ch. 6).

NEW STRAINS OF ALREADY ESTABLISHED HARMFUL NON-INDIGENOUS SPECIES

APHIS does not consistently prevent repeated importation of pest species that are already established here. New, different strains of some species potentially may be imported, worsen effects, and spread into areas where the pest is not yet well-established. Regulating strains would pose significant technical difficulties; rapid identification would be difficult, for example. Nevertheless, some pest experts express concerns that new strains of widespread pests like the Russian wheat aphid *(Diuraphis noxia)* and bromegrasses *(Bromus* spp.) are allowed continued entry (48,60,68).

CHAPTER REVIEW

This chapter summarized what we know about harmful NIS in the United States: their growing numbers and impacts, their routes of entry and movement, the methods by which they are evaluated and managed, and related State and Federal policies.

This chapter also presented policy options on 8 issues—those most in need of attention, according to OTA. Each issue allows for a range of options, demanding greater or fewer resources. If each area is not addressed in some form problems are likely to worsen, with no assurance that the biological resources of the United States will be protected. Only Congress can decide how stringent national policy should be. Everyday management of non-indigenous fish, wildlife, and weeds, though, falls to many Federal and State agencies and they need better guidance and support. Also, natural areas must be better safeguarded if they are to retain their unique character. Emergencies must be handled more quickly to keep problems from snowballing. And the public needs better education so their actions prevent, rather than cause, problems.

To reach these conclusions, OTA gathered an array of data. The next chapter lays out OTA's methods, then begins to present results.