Introduced species policy, management, and future research needs

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Introduced species represent an accelerated global change, and current efforts to manage them, though effective in particular situations, are not controlling the general problem. In the US, this failure is the result of insufficient policy, inadequate research and management funding, and gaps in scientific knowledge. Comparative policy analysis is urgently needed; the main US shortcoming is the absence of a coherent set of policies to address the entire issue, rather than individual invaders. Deliberate introductions should be more stringently regulated and risk assessments must become more predictive. Monitoring and attempts to identify new invasions (both deliberate and inadvertent) are technically feasible but not sufficiently funded and coordinated. Techniques to manage established invaders have often succeeded, but have been hamstrung by inconsistent funding. All of these problems could be improved by more fundamental research, ranging from basic natural history and simple advances in control technologies to more sophisticated ecological modeling and remote sensing techniques.

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As humans move an ever-increasing number of species to new regions, they are producing enormous global change, resulting in wide-ranging ecological and economic impacts (Mack *et al.* 2000). Most fall within a few well-defined categories: introduced invaders eat native species, change their habitat, compete with them, hybridize with them, and infect them. Some introduced species can drastically change an entire ecosystem. The pathogen causing sudden oak death, *Phytophthora ramorum*, has killed tens of thousands of trees in California (Figure 1), infecting many different hosts, including oaks and tanoaks, Douglas fir, and redwood (Rizzo and Garbelotto 2003). Not only does this disease threaten the dominant tree species of several California ecosystems, as well as animals that depend on them, but since 2003 it has widely affected the US nursery industry. Introduced species are widely recognized as the second greatest threat (after habitat destruction) to biodiversity; in the US, they cause or contribute to the decline of almost half of all imperiled species (Wilcove *et al.* 1998)

In a nutshell:

- Introduced species create huge economic and environmental costs
- Attempts to prevent invasions, to find them quickly and eradicate them, and to manage those that are established are stymied by insufficient biological knowledge, inadequate policy, and deficient budgets, skewed towards a few agricultural pests
- US federal policy on introductions has been inconsistent, resting on arbitrary, poorly quantified risk assessments, and providing little economic incentive to limit invasions
- Every potential introduced species and every pathway that might carry such species requires expert evaluation
- More basic research is needed to counter the environmental and economic impacts of invasive species

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Economic impacts are varied, and also fall into several categories: crop, forest, and fishery losses to introduced pests or predators; human, livestock, and poultry diseases from introduced pathogens; fouling losses to introduced molluscs; and structural damage from introduced termites. In the US alone, Pimentel *et al.* (2000a) estimated an annual cost of $137 billion, while an analogous figure for the US plus the United Kingdom, Australia, India, South Africa, and Brazil was in excess of $336 billion (Pimentel *et al.* 2000b).

Certain introduced species, such as crop pests, have been recognized as problematic for centuries (Mack 2003). However, it was Charles Elton (1958) who first recognized that global biogeographic rearrangement constitutes a general problem of enormous scope. A surge of interest in this issue in the academic and environmental communities occurred about 20 years later, driven by the increasing number and severity of problems caused by introduced species, combined with the rise of the environmental movement in the 1970s. Interest continues to build, especially in academia and the media. The invasion in Maryland (and now other states) of the northern snakehead, *Channa argus* (Figure 2), was an international news sensation (Dolin 2003). However, attention from the policy and environmental communities has been inconsistent.

There have been victories over individual invaders –

the eradication of the weed *Kochia scoparia* from Western Australia (Randall 2001), the removal of the Caribbean black-striped mussel (*Mytilopsis sallei*) from Darwin Harbour (Bax *et al.* 2002), and a substantial decline in coverage of melaleuca (*Melaleuca quinquenervia*; Figure 3) in south Florida (Silvers 2004).

However, many non-native species continue to increase locally, regionally, and nationally (Union of Concerned Scientists 2003), as do their ecological and economic impacts. Is this deteriorating situation an inevitable consequence of increasing trade and travel? Could changes in policy, enforcement, management, or funding reverse the trend? What role can biological research play in shifting the tide?

Figure 1. *Sudden oak death (*Phytophthora ramorum*) in Marin County, California.*

From the accumulation of experiences from different countries, states, and local municipalities, we have learned that there are many different ways to tackle invasive species (eg Klein 2004; Miller 2004). We need to synthesize information gained from this collective experience. For example, comparative policy analysis can be used to elucidate which policy approaches result in effective outcomes, both for regulating new introductions and for responding to ongoing invasions. Similarly, comparative field studies and sharing of information across continents and among agencies is a vital part of improving management of invasive species on the ground (Simberloff 1999). Here we focus on some of the most pressing issues in invasive species policy and management, and suggest how research could improve our current practices.

Battling against invaders.

Attempts to impede invasions can be divided into three stages (Mack *et al.* 2000; Simberloff 2002b): (1) keeping them out; (2) if they get in, finding and trying to eradicate them quickly; and (3) if they cannot be eradicated, managing them at low levels.

Keeping them out

With respect to interdiction, deliberate and inadvertent introductions present different challenges and require different research and policy approaches.

Deliberate introductions

One might expect fewer deliberate introductions to be problematic, as compared to accidental ones. Where data exist, however, deliberate introductions account for about half of all problem introductions (eg OTA 1993; Mack and Erneberg 2002). It seems we ought to be able to do a better job by simply putting stricter limitations on deliberately introducing species that are likely to become invasive. However, there are two impediments to this: conflicting interests and unpredictability.

First, various stakeholders dispute whether the harm caused by an introduced species will outweigh its benefits. For example, retailers may rely on high-volume sales of a horticultural plant that officials, with taxpayer funding, are trying to eliminate from nearby parks. Stakeholders who benefit from the largely unrestricted flow of species across US borders do not pay when things go wrong. Thus, importers and retailers have little economic incentive to limit introductions. Some have acted on political or ethical grounds to encourage responsible behavior; for instance, the International Council for the Exploration of the Sea has had a voluntary code of practice regarding the

Figure 2. *Northern snakehead,* Channa argus.


Courtesy of DC Schmitz

***Figure 3.** Australian paperbark (*Melaleuca quinquenervia*) in Palm Beach County, Florida.*

can produce a highly educated, qualitative prediction (Simberloff and Alexander 1998). The Australian Import Risk Analysis (Pheloung 2003) is similar.

As these assessments are performed, it is critical to evaluate their effectiveness; how often did decisions lead to problem invasions? Has the risk assessment procedure improved on historical frequencies of invasion, or has it become little more than a rubber stamp for economic interests? This is an area where biologists, social scientists, and regulators must work together to scrutinize the consequences of current policy and its alternatives. Such evaluations are routine for decisions on air and water pollution policy and are overdue for the management of invasive species (eg Harrington *et al.* 2004).

movement of marine organisms since the 1970s (ICES 1995). In 2001, stakeholders drafted voluntary codes of conduct for nurseries, gardeners, botanic gardens, and others to prevent plant invasions (Fay 2002). Sometimes industries adopt voluntary measures as public or expert opinion shifts, in the hope of heading off regulation. Awareness of invasive species issues has never been higher in the US. Nevertheless, federal policy is far from providing a coherent approach to the intentional introduction of species (eg by stipulating levels of acceptable risk). Nor does it lay out a conception of ecological place (eg by expressing a preference for indigenous species in wildlands) – what Miller (2004) calls a "vision gap".

Second, the notorious unpredictability of introduction impacts (Williamson 1996) affects two central aspects of risk assessment: predicting specific negative consequences and estimating their probability. Our current lack of generalizations interferes with credible risk assessment, but the dramatic expansion of global trade and associated multilateral trade treaties has led to a situation in which introductions are assumed "innocent until proven guilty", and risk must be established by formal risk assessment procedures (National Research Council 2000) before species are put on a "dirty list" and restricted. The US uses a delphic process (summarized by Orr 2003), in which experts estimate various aspects of risk connected with a proposed introduction and combine estimates by an arbitrary algorithm. No confidence limits are calculated. This process can give an unwarranted sense of quantification, and it can be cumbersome enough that the species under consideration may be released or escape while the assessment is in progress. However, at least this procedure forces explicit consideration of many factors and

Given the widespread acceptance of quantitative risk assessment as the basis for permitting introductions, plus the difficulty of producing defensible assessments, it is hard for a nation to exclude a species or a product that might carry such risks without being charged with economic protectionism. The recent rejection by the World Trade Organization of Australia's attempt to exclude frozen salmon from Canada is partly due to the Australians' inability to assess quantitatively the risk that the salmon might carry pathogens (Victor 2000), despite precedents for this (for instance, the introduction of trout whirling disease to North America).

To conservation biologists, the unpredictable nature of invasions implies that the only sensible approach is to evaluate each potential introduction. The reasons why a particular invasion wreaks havoc depend on the interaction between the species and the habitat (Tucker and Richardson 1995; Kolar and Lodge 2002), so blanket exemptions are unlikely ever to be defensible on ecological grounds (Simberloff 2001). Those who advocate for biodiversity argue for just such a "guilty until proven innocent" or "clean list" approach (Ruesink *et al.* 1995). New Zealand's 1993 Biosecurity Act established this principle, which has been a key factor in curbing damaging introductions (Parliamentary Commissioner for the Environment 2000). However, the US has not adopted this principle. Some state governments are trying stricter approaches. Since 1996, Minnesota has combined two "dirty" lists, of prohibited and regulated non-native species, a "clean" list of unregulated ones, and a fourth category of organisms considered "unlisted" (Klein 2004). The last group may be owned, sold, or transported, but anyone wanting to release them into the wild must apply for permission. The species is then evaluated and classified as prohibited, regulated, or unregulated.

What sort of research will help implement these new, hybrid approaches? What is needed to make the entire field of invasion biology more predictive, and to make risk assessments more accurate, is more information on the basic natural history and demography of species considered for introduction. Mack (1996) advocated controlled experiments in contained facilities, similar to "field trials" of genetically modified organisms. Even without such experimental approaches, knowing the most basic facts about these species – eg what habitats they survive in, what they eat, what eats them – would be a big improvement over the current level of scrutiny. The preferred option would be to base introduction decisions on a solid understanding of what regulates populations in their native range; however, this goal may be hopeless unless society is willing to put a complete stop to large numbers of introductions while this information is gathered. Eventually, we may discover traits that are more broadly predictive of invasiveness. For example, Grotkopp *et al.* (2002) linked invasiveness in pines to specific cellular and physiological traits that can be measured in species not yet introduced. While many have abandoned the idea of universal rules of invasiveness, this is still an important area of research.

Figure 4. *Octopus hidden in a sea of the introduced alga* Caulerpa taxifolia, *Mediterranean coast of France*.

Certain aspects of invasions may make them inherently unpredictable. There is often a time lag, during which an introduced species is more or less restricted and innocuous, after which its numbers and range increase dramatically and it causes substantial damage (Kowarik 1995). Another research priority is to determine the frequency and causes of these lags. Invaders may evolve in ways that make them worse pests, such as increasing host range or adapting to climatic conditions. Although some aspects of evolution, such as mutation, are basically random, others could potentially be predictable, for example the relationship between propagule number, genetic variability, and rate of evolution in response to selection (Parker *et al.* 2003). Finally, the impacts of a particular introduced species are often exacerbated by interaction with another invader – the phenomenon of "invasional meltdown" (Simberloff and Von Holle 1999). Until risk assessments can account for time lags, evolution, and meltdown, they will underestimate risks.

Inadvertent introductions

While many of the same issues apply to inadvertent introductions, these are even more difficult to exclude. These species hitchhike on people (eg weed seeds) or on products such as timber or fruit (eg insects), or exploit pathways that might carry many invaders (eg ballast water or untreated wooden packing). To keep these species out, pathways must be enumerated, ranked, and disrupted (Ruiz and Carlton 2003).

Most US policies regarding inadvertent introductions are designed to protect crops and domestic animals. However, the devastating impacts of several new aquatic species in the Great Lakes in the 1980s and 1990s highlighted the importance of pathways unrelated to agriculture and spurred new and more comprehensive invasive species legislation. We now have a more complete – albeit daunting – picture of the large number of pathways by which species are unintentionally moved.

Several new research approaches could contribute here; one is to use molecular techniques to determine origins and invasion pathways. For example, Jousson *et al.* (1998) and Wiedenmann *et al.* (2001) proved that the "killer alga" (*Caulerpa taxifolia;* Figure 4) introduced to the Mediterranean was an aquarium strain that originated near Australia. Another approach is to develop methods for detecting organisms hidden by containers or packing materials. A third is to introduce policies and control efforts that target pathways rather than species (Tamburri *et al.* 2002). Risk assessment procedures for entire pathways are in the earliest stages and currently consist of simply listing species that might use a given pathway, then combining risks associated with each such species (see Andow 2003; Orr 2003). Although rough, these broader risk assessments have strengthened policy. A series of country-specific studies of forest pests, for example, helped justify new federal regulations on wood imports in 1995 – a pathway scientists had been warning about since at least the 1970s (Campbell and Schlarbaum 2002).


Courtesy of Jack Jeffrey, Hawaii Field Station, National Wildlife Research Center

Figure 5. *The black rat (*Rattus rattus*), a voracious predator of birds and other animals, has been eradicated from many islands worldwide.*

■ Finding invasives quickly and eradicating them

Partly because of a few well-publicized failures, eradication of introduced species has been written off as likely to fail and, even worse, to have potentially devastating side effects (eg Dahlsten 1986). However, Veitch and Clout (2002) demonstrate that eradication is often feasible (Figure 5). Success is more likely if the following criteria are met: (1) Although widely established invaders have been eradicated (eg Randall 2001), success is more likely if the distribution is limited. This puts a premium on early discovery and quick action. Cutting-edge technologies for remote sensing are likely to make detection less haphazard and lead to major advances in invasive species management. Several remote sensing technologies have the potential to map invasive species across large areas with greater accuracy and precision than field-based methods. Aerial photographs in particular have been effective (Everitt *et al.* 1995, 1996). More recently, researchers used multi- and hyper-spectral imagery to map invasions (eg Carson *et al.* 1995; Underwood *et al.* 2003). These efforts are technically challenging but offer great promise. For example, a partial spectral unmixing technique detected yellow starthistle (*Centaurea solstitialis*) populations with cover values as low as 10% in a 1m x 1m pixel (S Swope unpublished data). Information technology will be equally important. As of 2004, an automated US Department of Agriculture "webcrawler" searches the Internet for sales of federally prohibited plants, triggering letters from the USDA. Another system introduced by the US Geological Survey in 2004 alerts subscribers to non-indigenous aquatic species that have recently been detected in the US. Developing observatory networks, such as the National Ecological Observatory Network (NEON; Froelich 2003) and the Global Ocean Observing System (GOOS; UNESCO 2004), will facilitate recognition of new invaders and help determine their rates of spread. These new tools should revolutionize detection and consequently eradication efforts. (2) There must be adequate resources to complete an eradication. Potentially successful attempts have failed when funding was withdrawn once the pest was sufficiently diminished to the point of no longer being considered a problem. For example, an early opportunity to eradicate the gypsy moth was lost because Massachusetts legislators pulled funding from the program when moth numbers plummeted (Dreistadt and Weber 1989). Lack of continuous funding commonly plagues control programs, even when eradication is not the goal. (3) There must be clear legal grounds for action, as well as unambiguous lines of authority, so that responsibility belongs to an individual or agency, and they can undertake the necessary actions. Eradication programs often cross jurisdictional lines and different stakeholders may view the costs and benefits of a management action differently. Yet eradication requires full cooperation and can be subverted by individual acts (Simberloff 2002c). (4) The biology of the target organism must be sufficiently understood that a valid strategy can be planned. For example, eradication of the giant African snail (*Achatina fulica*) from parts of Florida (Mead 1979) was possible only because this snail does not self-fertilize. (5) Eradication should not do more harm than good. For example, will another invader simply replace the eradicated species? Are there plans to restore a site once the invader has been eradicated (Figure 6)? On Santa Cruz Island, California, removal of introduced grazers produced a huge increase of exotic weeds (Dash and Gliessman 1994).

■ Maintenance management at low levels

If eradication strategies fail, there are several ways to keep an introduced species at low levels. However, none of these is a silver bullet. The four main methods are physical and mechanical control, chemical control, biological control, and ecosystem management (Simberloff 2002b).

Physical and mechanical means include shooting and trapping animals and cutting and burning vegetation. Physical or mechanical removal is often highly effective but is labor-intensive. Paid labor can be used, provided that society will shoulder the expense (McQueen *et al.* 2000); in the US, for instance, there is increasing use of convict labor (Campbell and Carter 1999). However, many successful programs rely on volunteers (Randall *et al.* 1997). An important benefit of both volunteer and public works efforts is the opportunity to attract media attention as well as to educate people about invasive species.

Chemicals (herbicides, rodenticides, insecticides, microbial pesticides) are sometimes effective but often controversial. Early pesticides had many non-target impacts. Publicity about pesticides has engendered a chemophobia among some conservationists (Williams 1997), but others (including many managers of natural areas) accept pesticides as necessary tools with risks of their own. Many modern pesticides have fewer non-target impacts, but there are other disadvantages (Simberloff 2002b). They are often expensive, a problem that worsens as species evolve resistance, as have 172 weeds worldwide (WeedScience.org 2003). Even so, pesticides are often useful and may work well together with mechanical control (Ver Steeg 2002), as in the campaign to reduce melaleuca (Silvers 2004).

The goal of classical biological control – introducing an enemy (predator, herbivore, parasite, or pathogen) of an introduced pest – is not eradication, but rather a homeostasis mechanism, so that an increase in the pest population triggers an increase in the enemy population. There have been many successes; for instance, in Africa, a South American mealybug (*Phenacoccus manihoti*) that ravaged cassava (*Manihot esculenta*) was controlled by means of the South American wasp *Epidinocarsis lopezi* (Bellotti *et al.* 1999). Such examples have led to the view that biological control is a "green" alternative to chemicals. McFadyen (1998) argues that "biocontrol offers the only safe, economical, and environmentally sustainable solution" to introduced weeds. When it works, biological control has two clear advantages over chemical control: the control can spread on its own and the solution is permanent.

However, classical biological control is no panacea, for three main reasons: (1) biocontrol usually does not work. Many introduced enemies never become established, but of those that do, about three times as many species survive in their new range as actually control the target (Williamson 1996). (2) Non-target impacts sometimes occur (Simberloff and Stiling 1996). For example, many endemic land snails were eliminated from Pacific islands by the predatory rosy wolf snail (*Euglandina rosea*), introduced in a failed attempt to control the giant African snail, *Achatina fulica* (Cowie 2002). (3) Biological control agents often spread to distant areas where they are unwanted. For example, the South American cactus moth, *Cactoblastis cactorum*, brought to the island of Nevis to control prickly pear (*Opuntia* spp), has spread in the West Indies and into the US; it has attacked a narrowly restricted native species and threatens to spread to the Southwest and to Mexico, where it could become a serious conservation and agricultural problem (Stiling and Simberloff 2000). Federal officials contend that current biological control practices are strict enough to prevent these kinds of problems. However, most documentation on decisions to release biological control organisms is unavailable to the public and monitoring for long-term, non-target impacts after release is inadequate, so claims of safety are suspect.

Managing an entire ecosystem may create conditions


Courtesy of A Pickart

Figure 6. *Restoration of dune vegetation after removal of European beachgrass (*Ammophila arenaria*) at Lanphere Dunes Unit of the Humboldt Bay National Wildlife Refuge, California.*

that are more favorable to native than to introduced species. For instance, in longleaf pine (*Pinus palustris*) forests of the southeastern US, maintaining a semblance of a natural fire regime may have impeded invasion by exotic plants and animals (Simberloff 2001). However, any set of natural conditions will be susceptible to invasion by some introduced species; for example, longleaf pine forests are threatened by Asian cogon grass (*Imperata cylindrica*), a rapidly spreading, fire-adapted species. Thus, ecosystem management will never solve all our problems and invasive species will often require direct population management.

Discussion

For eradication and control programs, many of the most effective strategies used to date entail brute-force, scorched-earth methods rather than sophisticated science (Simberloff 2003). Research can certainly be useful in these arenas; there is no reason why someone cannot invent a better mousetrap. States, in particular, have called for additional research on control methods, especially for aquatic invasive species. Although some knowledge is needed about a target species (depth of its roots, germination or activity time, preferred habitats, etc), this

Table 1. Fiscal year 2005 agency invasive species budgets

Department	2004 ($1000)	2005 ($1000)	Difference 2004–2005 ($1000)
DOD	$10 355	$15 355	$5000
USDA	$376 009	$466 750	$90 741
DOI	$9369	$11928	$2559
DOC	$0	$0	$0
EPA	$75	$75	$0
Smithsonian	$325	$325	$0
Total	$396 133	$494 433	$98 300

Compiled by the US National Invasive Species Council.

research does not, for the most part, involve sophisticated scientific techniques. By contrast, methods for keeping out invasive species (both hitchhikers and deliberate introductions), including risk assessments, could profit greatly from intensive, cutting-edge ecological research. It will be necessary to combine fundamental studies of the natural history and taxonomy of new and potential invaders with modern methods, instrumentation, and analysis (eg Peterson *et al.* 2003). For instance, the Judas goat technique exploits the gregarious behavior of goats (Campbell and Donlan in press). Goats with telemetry collars find other goats, even when the latter are scarce; the accompanying goats are then tracked on foot or by helicopter and shot. Recently developed methods involving hormone therapy and sterilization should improve the technology, which has already been effective on many islands (Campbell and Donlan in press). More complex approaches will be needed to predict the influence of interactions with other species (both native and introduced) and the potential for evolution to influence invasion risk. In addition, there is a great need for ecologically sophisticated contributions in the areas of chemical and biological control.

Invasion biology was not a well-defined discipline until about 5 years ago, and few universities had courses covering this topic. The relatively recent advent of the field is a key reason research is in a "catch-up" mode. Ecologists have identified broad, ambitious research agendas (see Ewel *et al.* 1999; D'Antonio *et al.* 2001) as well as more narrowly drawn recommendations (eg Carlton [2001] for a national marine bioinvasions research program and a National Research Council committee's [2002] suggestions to improve risk assessment). Research is a major component of the National Invasive Species Council's national management plan (NISC 2001).

Given the decentralized nature of the US research community, it is difficult to tell to what extent the above research recommendations are being implemented. Increases in research funding might provide an indication. However, 23 federal agencies deal with this issue, and it cuts across bureaucratic lines in ways that obscure the overall picture. In fiscal years 1999 and 2000, ten federal departments estimated that approximately $94.6 and $104.9 million, respectively, was spent on invasive species research and development, most of it on agricultural pests (GAO 2000). In those same years, the National Science Foundation's invasive species budget was $4.7 and $5.2 million. Between fiscal years 2002 and 2004, combined research spending on invasive species by an undesignated number of federal departments increased by approximately 10% per year, reaching about $184 million; a similar increase is proposed for fiscal year 2005 (NISC 2004; Table 1). While federal agencies such as the US Geological Survey, NOAA's Sea Grant, and USDA's Economic Research Service have elevated the issue internally, they appear to be spending several million dollars or less per year on their discrete (and thus readily identifiable) intra- or extramural research programs.

However, the scale of the response may be changing slowly to match the scale of the problem. Although it stalled after winning approval from the House of Representatives' Science Committee, the proposed Aquatic Invasive Species Research Act (HR 1081) would have authorized more than $214 million for research, development, and demonstration programs, including $75 million for extramural research grants over 5 years. This is only one of more than a dozen invasive species bills introduced in the last Congressional session – an unprecedented level of activity – although a large portion of the bills addressed control of single species, such as tamarisk and the brown tree snake, as do many executive branch initiatives (Table 2).

The recent surge of interest in invasive species, not just in Washington but also as one of the most popular

Table 2. Fiscal year 2005 interagency federal budget for specific invasive species issues

Initiative	2004 ($1000)	2005 ($1000)	Change from 2004–2005 ($1000)	Percent change from 2004–2005
Brown Treesnake	$3368	$4247	$879	26.1%
Tamarisk	$5929	$4822	-$1107	-18.7%
Emerald Ash Borer	$2018	$16 978	$14 960	741.3%
Leafy Spurge / Yellow Star Thistle	$3690	$3916	$226	6.1%
Ballast Water	$945	$945	$0	0.0%
Screening	$0	$0	$0	?
Prevention thru Education	$649	$649	$0	0.0%
Aquatic Area Monitoring	$2647	$2647	$0	0.0%
Early Detection / Rapid Response	$259 457	$353 669	$94 212	36.3%
Innovative Control Technologies	$117 430	$106 560	-$10 870	-9.3%
Total	$396 133	$494 433	$98 300	24.8%

Compiled by the US National Invasive Species Council.

research subjects at meetings of the Ecological Society of America, the Society for Conservation Biology, and the American Institute of Biological Sciences, may cause ecologists to feel that the urgency of this issue is already widely understood. However, outside of the scientific community, and particularly in the policy arena, few people are aware of the true magnitude of the problem.

Scientists have always been the strongest voice for change on this issue. Their continued involvement is essential if the best of this legislation is to pass and if federal and state officials are to feel pressure to do more. There are important tasks at every level of involvement, from writing letters to the editor on local problems to petitioning officials to add more invasive foreign species to those prohibited from import, from contributing to a pre-import risk assessment to sitting down with a member of Congress to urge passage of key legislation.

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