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Failure of the Lacey Act to protect US ecosystems against animal invasions

Andrea J Fowler, David M Lodge, and Jennifer F Hsia

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Harmful non-indigenous species may be introduced, either accidentally or intentionally, into the US through commerce, and may subsequently drive reductions in abundances of native species and changes in ecosystem function. The "injurious wildlife provision" of the Lacey Act (1900) is the primary legal tool protecting US non-agricultural ecosystems against the introduction and spread of invasive animal species. We evaluated the efficacy of this provision at disrupting the invasion processes involved in transport, introduction, establishment, and spread, and found that the wildlife provision prohibits importation of only 17 taxa. While the Lacey Act may have been somewhat effective at preventing transport into the country of the few taxa listed prior to their introduction, over half of listed taxa were already present in the US when listed, and most taxa already established in the wild continued to spread after listing. Currently, five taxa are being considered for listing. Mean time for a petitioned listing has increased to over 4 years, and only one species has been added by petition in the past decade. If the goals of the provision are to be met in the face of increasing international trade in live organisms, then revision or replacement of the provision is required.

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Invasive species cause declines in abundances of native species and undesirable changes in ecosystem function (Sala *et al.* 2000), as well as economic losses (Lovell *et al.* 2006; Olson 2006). Once released or escaped into natural areas, many non-indigenous species establish and spread quickly. For example, about 50% of introduced vertebrate species establish self-sustaining populations, and about 50% of these species spread widely (Jeschke and Strayer 2005). After establishment, most invasive species are extremely difficult and costly to eradicate, if eradication is even possible. The cumulative economic loss due to invasive species in the US is very high (Lovell *et al.* 2006; Olson 2006), but is not well understood. No attempt has been made to estimate most non-market losses, including reductions in native biodiversity and declines in ecosystem goods and services.

Legal tools to regulate invasive species exist at the federal, state, and local levels, but only at the federal level can species from other countries be denied entry into the US. The Department of Agriculture, concerned primarily with protecting agriculture, relies heavily on the Plant Protection Act of 2000 to control the domestic importation of weeds and plant pests (mostly insects, plant pathogens, and plant parasites), while the Department of Health and Human Services has statutory authority under the Public Health Service Act of 1946 to prohibit entry of species that pose a risk to human health. However, species that do not directly damage human health or agriculture are rarely regulated under these statutes. The oldest relevant federal statute, the "injurious wildlife provision" of the Lacey Act of 1900, provides the US Fish and Wildlife Service (USFWS) with jurisdiction to prohibit the importation and interstate transport of wildlife included in a list of prohibited taxa which are "deemed to be injurious or potentially injurious to the health and welfare of human beings, to the interest of forestry, agriculture, and horticulture, and to the welfare and survival of the wildlife or wildlife resources of the United States" (Code of Federal Regulations, title 50, part 16; Figure 1). This provision of the Lacey Act is still employed as the primary tool to prevent the importation and spread of invasive animal species considered harmful to natural ecosystems. Unless regulated under another federal law, any live, wild mammal or bird, live or dead fish, mollusk, or crustacean, live amphibian or reptile, or the eggs of any of these, which are not specifically listed in the injurious wildlife provision of the Lacey Act, may be imported, subject only to a declaration at customs and, in some cases, a permit for commercial shipments from the USFWS (Code of Federal Regulations, title 50, part 16; USFWS 2006b).

History of the Lacey Act's injurious wildlife provision

The earliest version of the Lacey Act was introduced by Congressman John Lacey of Iowa in 1900, to "aid in the

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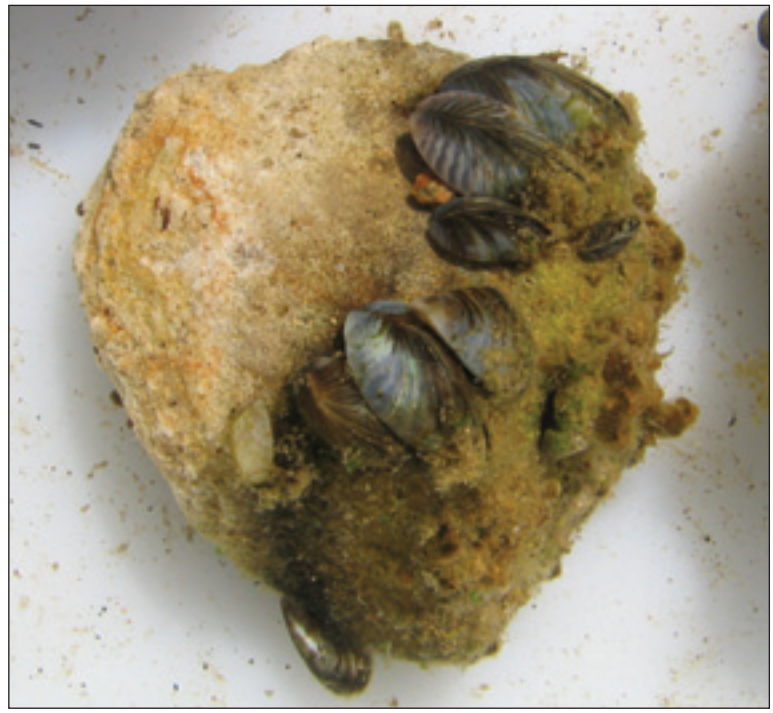
Note in proof:

On July 10, 2007, after this paper was accepted for publication, the USFWS added silver and largescale carp to the Lacey Act list of injurious wildlife. The Final Rule went into effect on August 9, and may be viewed at: www.fws.gov/contaminants/ANS/pdf_files/FR-silver-largescale-silver-carp.pdf. Black carp, bighead carp, and *Boiga* tree snakes are still being considered for listing by USFWS.

restoration of such birds…where the same have become scarce or extinct, and also to regulate the introduction of American or foreign birds or animals in localities where they have not heretofore existed" (Lacey Act 1900). Among the causes of native bird population decline, Congressman Lacey listed, along with hunting and the production of ladies' hats, the introduction of non-native species (Anderson 1995). The original act prohibited the importation of four non-native taxa: mongoose, fruit bats or flying foxes, English sparrows, and starlings, which were listed only by common name (Lacey Act 1900). Although the clause was omitted prior to the 1940s for unknown reasons, Section 2 of the original Act also prohibited the importation of any "foreign wild animal or bird except under special permit from the United States Department of Agriculture". Currently, most imported species need only be declared to customs or permitted through the USFWS.



Courtesy of D Bruesewitz

Figure 1. *The zebra mussel, a highly destructive invasive species, is listed as injurious wildlife by the Lacey Act.*

While the Lacey Act originally regulated only birds and mammals, it was expanded to include amphibians, reptiles, mollusks, and crustaceans in 1969, and fish in 1981. For these groups, only taxa included in the list of "injurious wildlife" are currently prohibited entry to the US and transportation or sale between states. Consistent with the original Section 2 of the Act, in 1973 the USFWS attempted to modify the injurious wildlife provision to prohibit the importation of all species unless they were included on a list of wildlife posing a low risk of invasiveness (USFWS 1973). This low-risk list was never implemented.

A USFWS press release at the time, which sought to dispel rumors that all pets except dogs and cats would be prohibited (USFWS 1974), indicates opposition to the proposal. In 1975, USFWS rewrote the proposal, again limiting importation to a list of low-risk wildlife (USFWS 1975). Ensuing public comments criticized USFWS on the grounds that there was "insufficient proof to support a determination that all wildlife is injurious", and that the USFWS's criteria for determining what constituted low risk were suspect and unpublished (USFWS 1977). Finally, in 1977, USFWS abandoned the low-risk list and instead attempted to add substantially to the list of prohibited taxa (WebTable 1), this time including the criteria that defined "injurious" (USFWS 1977; WebTable 2). Again, these efforts were unsuccessful, in part because of strong opposition from the pet industry.

In its current form, the injurious wildlife provision of the Lacey Act (Code of Federal Regulations, title 50, part 16) regulates the importation and interstate transport of salmonids (§16.3), live wild mammals (§16.11), live wild birds or their eggs (§16.12), live or dead fish, mollusks, crustaceans, or their eggs (§16.13), live amphibians or their eggs (§16.14), and live reptiles or their eggs (§16.15), and outlines a certification procedure to assure that all live salmonid products are disinfected prior to importation (§16.13). Unless a species is listed as injurious wildlife, importation into the US is allowed.

Although the Lacey Act is the primary legal tool available to protect US ecosystems from invasive animal species, its efficacy at preventing the introduction and establishment of species and mitigating the spread of already established invasive species has not been rigorously scrutinized. By analyzing the implementation history of the Lacey Act, we provide such an assessment. We first examine how many species have been listed and whether the listing process has been timely enough to add taxa to the injurious wildlife list before they are established or widespread. Second, we assess the extent to which listing a taxon has been associated with halting the progress of an invasion. That is, we ask whether establishment was prevented for taxa that were not established at the time of listing, and whether spread was halted for taxa that were already established in the US at the time of listing. Finally, we discuss the shortcomings of this legislation, and suggest one possible solution, based on successful precedents in other countries.

Methods

We searched for all Federal Register documents containing the names of the listed taxa, references to the Fish and Wildlife Service, the Lacey Act, wildlife, or injurious wildlife, to establish when taxa were first considered for listing and when the taxa were officially added to the injurious wildlife provision of the Act. If we did not locate a reference to a listed taxon in the Federal Register,

Table 1. Taxa currently on the list of injurious wildlife, plus taxa that once were listed (entries 3–5) and species currently involved in the listing process (entries 20, 22–24)

Entry	Common name	Family, genus, or species	Date listed	First mention	Petition?
1 ▶	Fruit bat[1]	Genus *Pteropus*[2]	May 25, 1900[1]	n/a	no[1]
2 ▶	Mongoose/meerkat[1]	Genera *Atilax*[3], *Cynictis*[3], *Helogale*[3], *Herpestes*[3] (*accropunctatus*[2]), *Ichneumia*[3], *Mungos*[3], and *Suricata*[3]	May 25, 1900[1]	n/a	no[1]
3	Starling[1]	*Sturnus*[4] *vulgaris*[2]	May 25, 1900[1]	n/a	no[1]
4	English sparrow[1]	*Passer domesticus*[2]	May 25, 1900[1]	n/a	no[1]
5	Myna[5]	*Acridotheres*[4] *tristis*[2] *A cristatellus*[2] *A fuscus*[2] *A gingianus*[2] *A albocincutus*[2]	Aug 13, 1952[4]	Jun 11, 1952[5]	no[5]
6 ▶	European rabbit[5]	(*Lepus cuniculus*[5]) (*Lepus europaeus*[5]) Genus *Oryctolagus*[3]	Aug 13, 1952[4]	Jun 11, 1952[5]	no[5]
7 ▶	Pink starling[3]	*Sturnus roseus*[3]	Aug 3, 1965[6]	Apr 13, 1965[3]	no[3]
8 ▶	Indian wild dog[3]	Genus *Cuon*[3]	Aug 3, 1965[6]	Apr 13, 1965[3]	no[3]
9 ▶	Multimmate rat or mouse[3]	Genus *Mastomys*[3]	Aug 3, 1965[6]	Apr 13, 1965[3]	no[3]
10 ▶	Dioch[7]	*Quelea quelea*[7]	Jul 1, 1968[8]	Jul 27, 1967[7]	no[7]
11 ▶	Java sparrow[7]	*Padda oryzivora*[7]	Jul 1, 1968[8]	Jul 27, 1967[7]	no[7]
12 ▶	Red-whiskered bulbul[7]	*Pycnonotus jacosus*[7]	Jul 1, 1968[8]	Jul 27, 1967[7]	no[7]
13 ▶	Salmonids[7]	Family Salmonidae[7]	Jul 1, 1968[8]	Jul 27, 1967[7]	no[7]
14 ▶	Walking catfish[9]	Family Clariidae[9]	Jan 1, 1970[10]	Aug 19, 1969[9]	no[9]
15 ▶	Raccoon dog[11]	*Nyctereutes procyonoides*[11]	Nov 1, 1982[11]	Dec 1, 1981[11]	yes[11]
16 ▶	Mitten crabs[12]	Genus *Eriocheir*[12]	Jun 23, 1989[13]	Sep 16, 1986[12]	yes[12]
17 ▶	Brown tree snake[14]	*Boiga irregularis*[14]	May 25, 1990[15]	Jan 19, 1990[14]	no[14]
18 ▶	Zebra mussel[16]	Genus *Dreissena*[16]	Dec 9, 1991[16]	Nov 7, 1991[16]	no[16]
19 ▶	Brushtail possum[17]	*Trichosurus vulpecula*[17]	Jul 11, 2002[18]	Jul 11, 1995[17]	yes[17]
20	Black carp[18]	*Mylopharyngodon piceus*[18]	n/a	Jun 2, 2000[19]	yes[19]
21 ▶	Snakeheads[19]	Genera *Channa*[19] and *Parachanna*[19]	Oct 4, 2002[20]	Jul 26, 2002[21]	no[21]
22	Silver carp[21]	*Hypophthalmichthys molitrix*[22]	n/a	Oct 16, 2002[23]	yes[22]
23	Bighead carp[22]	*Hypophthalmichthys nobilis*[23]	n/a	Oct 16, 2002[22]	yes[22]
24	*Boiga* snakes[24]	Genus *Boiga*[24]	n/a	May 27, 2003[24]	yes[24]
25	Largescale carp[25]	*Hypophthalmichthys harmandi*[25]	n/a	Jul 14, 2006[25]	no[25]

Notes: ▶ indicates currently listed taxa. Parentheses indicate specific taxa within a currently listed common name that have been removed from the list. The snakehead fishes are listed both as entire genera and as individual species. In this analysis, they were counted as genera.

[1]Lacey Act 1900; [2]FWS 1954; [3]USFWS 1965a; [4]FWS 1952b; [5]FWS 1952a; [6]USFWS 1965b; [7]USFWS 1967a; [8]USFWS 1967b; [9]USFWS 1969a; [10]USFWS 1969b; [11]USFWS 1982a; [12]USFWS 1987; [13]USFWS 1989; [14]USFWS 1990a; [15]USFWS 1990b; [16]USFWS 1991; [17]USFWS 1996; [18]USFWS 2002a; [19]USFWS 2000; [20]USFWS 2002c; [21]USFWS 2002b; [22]USFWS 2003a; [23]USFWS 2003c; [24]USFWS 2003b; [25]USFWS 2006a

we searched the database of the USFWS's historic news releases for the years 1914 through 2006 (http://news.fws.gov/historic/) for references to taxon names, the Lacey Act, or injurious wildlife. Finally, we examined other publications, including law reviews, for any missing information.

We determined that a listing event was initiated "by petition" if the USFWS indicated that they had received correspondence from an entity outside the Department of the Interior (DOI, of which the USFWS is part). If the impetus for listing was an issue of compliance within the government, or if the DOI acted of its own accord, we determined that the taxon was not listed by petition. We defined the listing interval as the time in years between the date a petition was received (or, lacking that information, the date that USFWS first mentioned the possible listing of the taxon in the Federal Register or a press release), and the date at which the Final Rule, which officially adds the taxon to the injurious wildlife provision, took effect. If the effective date of the Final Rule was not available, we have used the date of the Final Rule's announcement in the Federal Register. For taxa listed under the original (1900) Act, we assigned a listing interval of zero and a non-petitioned status.

Federal Register documents were also used as our pri-

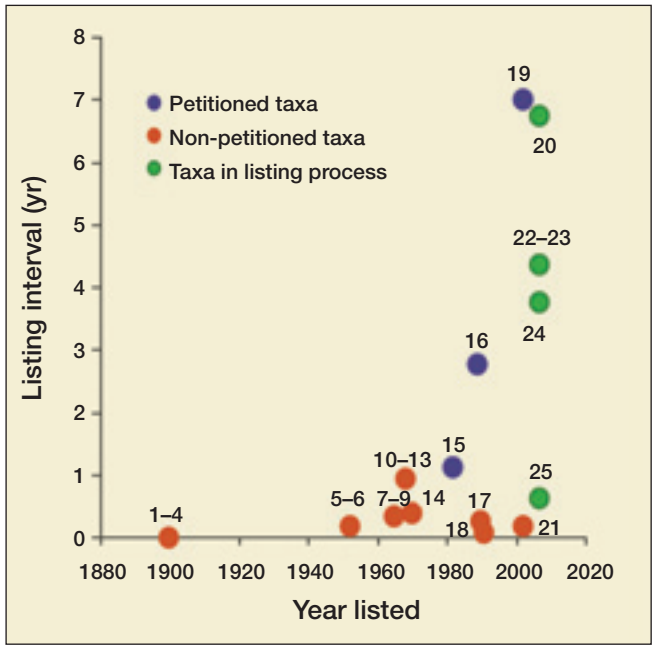


Figure 2. *Increases in the listing interval through time of taxa successfully listed under the injurious wildlife provision of the Lacey Act. Taxa currently involved in the listing process as of March 1, 2007 are included in this graph. Numbers assigned to each dot correspond to entry numbers in Table 1.*

mary source of information concerning whether a taxon was present in the continental US at the time of listing. When this information was not available in the Federal Register, as was the case for many early listing events, we searched three online databases, the ISSG Global Invasive Species Database, the University of Michigan's Animal Diversity Web, and Avibase, which include invasive species and/or historical species distributions. Finally, if historical distribution information was unavailable, we referred to published literature, species-specific books, and collections such as the Birds of North America (Islam 1997; Islam and William 2000). When a thorough search yielded no report of taxon presence in the continental US, we assumed that the taxon had never been present. The only bias which may have been introduced by this assumption is that we may underestimate the number of species already present in the country at the time of listing. Likewise, if the same searches did not indicate spread between the continental states, we assumed no spread. Unsuccessful listing attempts, such as the numerous additional species proposed by the Fish and Wildlife Service for injurious status in the mid-1970s (WebTable 1) and, more recently, the green iguana and Asian swamp eel, were excluded from our analysis. We excluded other species that were proposed for listing but were not listed, because those records are incomplete. The USFWS is not required to issue notification of a listing request.

Results

Twenty-four individual species, genera, or families are currently listed as injurious (Table 1). In addition to taxa now listed, Table 1 includes the five taxa (black carp [*Mylopharyngodon piceus*], silver carp [*Hypophthalmichthys molitrix*], bighead carp [*H nobilis*], largescale carp [*H molitrix*], and *Boiga* tree snakes, in addition to *Boiga irregularis*) still involved in the listing process as of March 1, 2007, as well as three taxa (starling [*Sturnus vulgaris*], English sparrow [*Passer domesticus*], and mynah birds

Table 2. Invasion status in the continental US of currently listed taxa, at the time of listing and subsequent to listing

Common name	*In continental US when listed?*	*Outside captivity when listed?*	*Population established after listing?*	*Spread in wild after listing?*
Fruit bat	No[1]	No[1]	No[1]	n/a
Mongoose/meerkat	No[1]	No[1]	No[1]	n/a
European rabbit	Yes[2]	Yes[2]	n/a	No[3]
Pink starling	No[1,4]	No[1,4]	No[1,4]	n/a
Indian wild dog	No[1,5]	No[1,5]	No[1,5]	n/a
Multimmate rat or mouse	No[1]	No[1]	No[1]	n/a
Dioch	No[1]	No[1]	No[1]	n/a
Java sparrow	Yes[6]	Yes[6]	n/a	No[6]
Red-whiskered bulbul	Yes[7]	Yes[7]	n/a	Yes[7]
Walking catfish	Yes[8]	Yes[8]	n/a	Yes[9]
Raccoon dog	Yes[10]	No[10]	No[1]	n/a
Mitten crab	Yes[11]	Yes[11]	n/a	Yes[9]
Brown tree snake	No[12]	No[12]	No[1]	n/a
Zebra mussel	Yes[9]	Yes[9]	n/a	Yes[9]
Brushtail possum	Yes[13]	No[13]	No[1]	n/a
Snakehead fish	Yes[14]	Yes[14]	n/a	Yes[9]

Notes: Salmonidae are not included on this list. Many species in this family are native, and the purpose of their listing was to prevent the spread of disease.

[1]A search of the literature and animal and invasive species databases yielded no indication of taxa presence in the continental US; [2]Layne 1997; [3]A search of the literature and animal and invasive species databases yielded no indication that the taxa had spread in the wild between states in the continental US; [4]Avibase 2006; [5]Sheldon 1992; [6]Islam 1997; [7]Islam and William 2000; [8]USFWS 1969a; [9]USGS 2005; [10]USFWS 1982b; [11]USFWS 1989; [12]USFWS 1990a; [13]USFWS 2002a; [14]USFWS 2002b

[*Acridotheres*]) that once were listed, but have been removed for unknown reasons.

Following a petition, an optional public notice of inquiry, a general request for public comments and information, a proposed rule, additional public comment, and a Final Rule may follow. Although a petition often provides impetus for the process, the USFWS may create a proposed rule without a petition if scientific data support such a rule (Hare and Whitfield 2003), or if the Lacey Act is amended to conform to other legislation. USFWS does not act under any time restrictions for listing a taxon. The listing time has generally increased from < 1 year in the mid-20th century to a mean of at least 4.8 years for taxa (n = 4) that were pending listing as of March 1, 2007 (excluding the largescale carp, which only entered the listing process in July 2006). Mean listing interval has been 3.6 years for petitioned taxa (n = 3 taxa). In contrast, the mean interval for listings initiated by USFWS has been only 0.4 years (n = 17 taxa; Figure 2).

Lacey Act injurious wildlife listings have produced mixed success at preventing the introduction, establishment, or spread of invasive species (Table 2). At least nine of 16 taxa (56%) currently listed were already in the continental US at the time of listing, and at least seven of 16 taxa (44%) had established populations outside of captivity in the continental US when listed (Table 2). Of the seven taxa established by the time of listing, at least five (71%) have spread to additional states since listing.

On the other hand, there have been some successes that may be attributable to listing. None (0%) of the seven taxa that were absent from the country at the time of listing have subsequently established populations, and two of the taxa that were present only in captivity (raccoon dog and brushtail possum) did not establish wild populations (Table 2). Finally, two taxa that were established outside captivity at the time of listing (European rabbit [*Oryctolagus cuniculus*] and Java sparrow [*Padda oryzivora*]) have not spread between states since listing (Table 2).

Discussion

Despite 107 years of regulatory authority to protect the country's native species and ecosystems from harmful nonindigenous animals, only 17 taxa are currently denied entry into the US under the Lacey Act's injurious wildlife provision. Few knowledgeable observers would doubt that a great many more taxa – hundreds if not thousands, including pathogens – are "injurious or potentially injurious to the… survival of the wildlife or wildlife resources of the United States" (Code of Federal Regulations, title 50, part 16), and should thus be prohibited entry under the Lacey Act's blacklist approach (Kolar and Lodge 2001; Keller *et al.* 2007a).

Is the listing process timely?

The process of adding taxa to the list of injurious wildlife requires time and resources. Since the passage of the Lacey Act in 1900, only three taxa have been successfully added to the list by petition. Only one of these three, the brushtail possum, has been added in the past decade, in a process that took 7 years. Five more taxa – the *Boiga* snakes, black carp, bighead carp, largescale carp, and silver carp – entered the listing process by petition and have been caught in an iterative loop of review: requests for public comments by USFWS, the Service's response, and subsequent request for more public comments. As of March 1, 2007, the black carp had been in the listing process for over 6 years, and the silver and bighead carp for over 4 years.

The Lacey Act includes no emergency measures prior to official listing to prohibit the importation or interstate transport of organisms. Unless a species is listed, importation and transport across state lines is allowed. Thus, a species may enter the country and legally be transported between states while it is being considered for listing. A petition for listing may therefore provide an incentive for commercial interests to import a species during the lengthy listing process.

Does the Lacey Act disrupt the invasion process?

The effectiveness of the Lacey Act at interrupting any of the four steps of the invasion process (transport, introduction, establishment, and spread; Kolar and Lodge 2001), is difficult to quantify precisely, but is certainly not high. For the few taxa that have been prohibited entry, more than half were already present in the US at the time of listing, and spread occurred for most established species subsequent to listing. Thus, the listing process does not seem to have accomplished the intended goal, even for the majority of the very few taxa that were listed. Because the Lacey Act does not authorize containment measures for listed species and possession remains legal after listing, it probably does little to prevent the accidental release of a species (eg by flooding, in the case of farmed fish).

Only for the few taxa that were listed before importation is there any evidence of success. Of course, other confounding factors aside from the Lacey Act listing, including low commercial potential or unsuitable conditions, may also have prevented the importation or establishment of these taxa.

With respect to species spread, the injurious wildlife provision prohibits the transport of listed species across state borders. However, five of the seven taxa with established populations have continued to spread since their listing (Table 2), indicating either that the Lacey Act does not effectively regulate the interstate transport of invasive species, or that species are spreading across state lines without direct human assistance. Both processes are highly likely. The Lacey Act has no authority, nor does it entail any funding, to manage the spread of established wild populations. Listing a taxon that is already present in the country may therefore do very little to prevent its spread (Panel 1).

Panel 1. Spread of three invasive carp species in the US

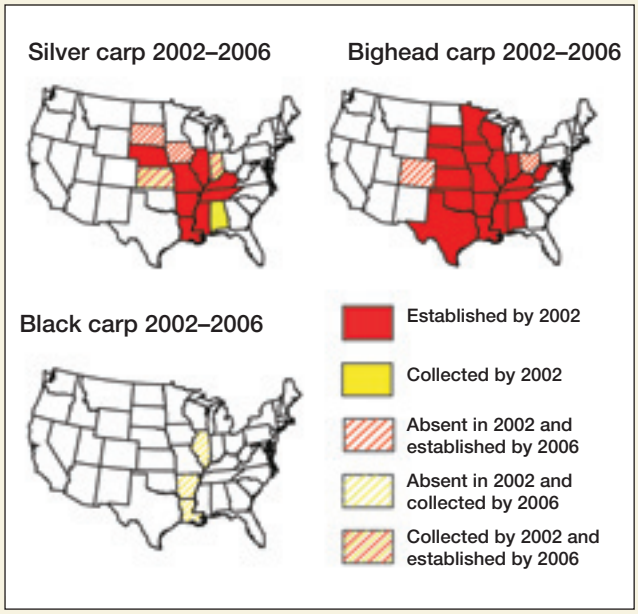


Figure 3. *Distribution of three Asian carp species within the US. Data from http://nas.er.usgs.gov/queries.*

Silver carp, bighead carp, and black carp are currently under consideration for listing as injurious wildlife species under the Lacey Act. All three species are native to Asia, and were intentionally introduced into outdoor aquaculture facilities in the lower Mississippi basin. All three species have escaped into natural waterways. Black carp were petitioned for listing in 2000 (USFWS 2000), followed by silver and bighead carp in 2003 (USFWS 2003a). Both silver and bighead carp are planktivorous throughout their lives, with diets largely overlapping with those of the juveniles of many native fish species. Black carp consume mollusks, many species of which are already imperiled by the environmental changes caused by dams and other waterway modifications. Silver and bighead carp have achieved such high abundances in some stretches of the Mississippi, Illinois, and Missouri Rivers that commercial fishing, which usually targets other species, has been harmed. In response to boat traffic, silver carp often leap out of the water, and many boaters have been injured by collisions with leaping carp. As adults, all three species achieve such a large size that they are immune to predation by all species except humans, but demand for this species in North America is low.

Black, silver, and especially bighead carp are often sold alive in the Asian food markets of major cities. In some religious traditions, especially Buddhism, live release of potential food organisms is encouraged. In response to concern about the escape or release of Asian carp into Lake Michigan, the city of Chicago banned the sale of live individuals of these species in 2003. In addition, the city of Chicago and state and federal agencies have supported the construction and improvement of electric barriers to impede the movement of Asian carp and other alien fish species in the Chicago Ship and Sanitary Canal. The canal connects the Mississippi watershed with the Great Lakes–St Lawrence river watershed, rendering each basin vulnerable to invasions that occur in the other. A temporary barrier, installed in 2002, cost approximately $2.2 million, while a more permanent and effective barrier, estimated at about $9 million, is under construction. None of the three Asian carp species illustrated here are believed to have established populations in the Great Lakes, where their impact on fisheries and ecosystem function could be great.

During the years that USFWS has been considering the listing petitions, silver carp have spread more widely, bighead carp have remained widespread, and black carp have become established in the wild (Figure 3). During the same time, the local abundance of these species has increased in many places, including the LaGrange pool on the Illinois River (Figure 4).

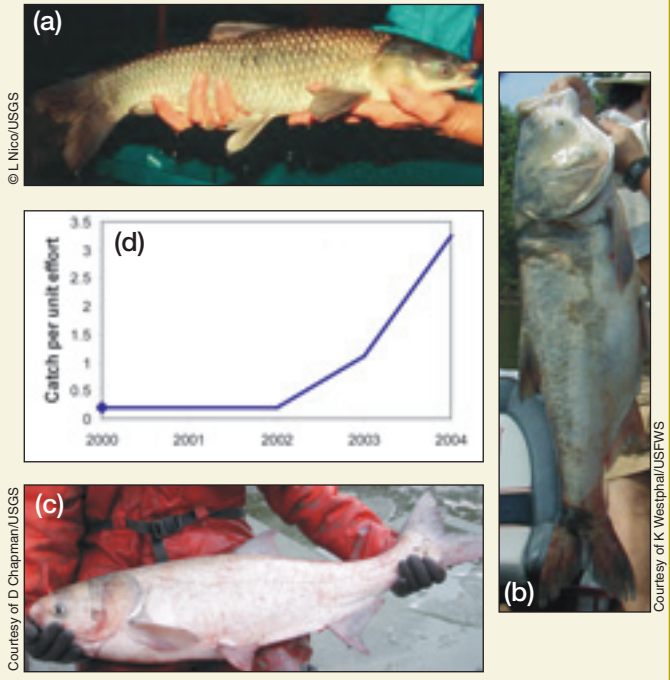


Figure 4. *(a) Black carp, (b) bighead carp, and (c) silver carp caught in the US. (d) Catch per unit effort of silver carp at an upstream site at the LaGrange pool on the Illinois River from 2000 to 2004. Data from www.umesc.usgs.gov/data_library/fisheries/graphical/.*

Conclusions

The effectiveness of the Lacey Act as a modern invasive species regulatory tool is further undermined by the lack of an efficient and consistently applied risk assessment procedure, which would allow USFWS to control the one step of the invasion process which the Act may effectively interrupt: initial transport into the country. To accomplish the goals of the Lacey Act's injurious wildlife provision, which are more relevant today than in 1900 due to increased international trade, the provision should be revised or new legislation enacted to provide a time limit on the listing process, emergency measures to temporarily prohibit importation and transport of species during the listing process, mandatory risk assessments for all species proposed for importation (to determine whether such species should be added to the injurious species list), and prohibitions on the possession of listed species. USFWS could compensate owners for confiscated organisms in order to remove incentives for owners to release listed species. Finally, appropria-

tions to the USFWS must be commensurate with its responsibilities.

These recommendations are consistent with recommendations in the US National Invasive Species Management Plan (NISC 2001) and a recent position paper from the Ecological Society of America (Lodge *et al.* 2006). Specifically, the DOI, the Environmental Protection Agency, and the US Department of Agriculture (USDA) agreed in the National Management Plan to jointly develop new risk analysis approaches for intentionally introduced non-indigenous species. In addition, USDA is currently considering rules to require the prescreening of all plants proposed for importation into the US. Prescreening, as well as switching from a black list of prohibited species to a white list of approved species, would better protect the nation's environment, and would probably bring net economic benefits as well (Keller *et al.* 2007b).

Such risk assessment strategies are consistent with World Trade Organization rules and have proven successful in other countries. In Australia, for example, plant species proposed for importation are screened, after which they are either permitted or denied importation. If the choice is not clear, species are prohibited unless the importer is willing to assume the cost of a more rigorous risk assessment (Pheloung 2003). While providing substantial environmental protection, the Australian policy also produces net economic benefits (Keller *et al.* 2007b). If the US is to reduce the probability of future damage from invasive animal species, revision or replacement of the Lacey Act's injurious wildlife provision is essential. The contemporary threat of invasive species has far outstripped current authority and practices under this statute.

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WebTable 1. Proposed expanded list of injurious wildlife, reproduced from the US Fish and Wildlife Service's unsuccessful attempt to substantially lengthen the list of injurious wildlife in 1977 (USFWS 1977)

	Common name	*Family*	*Genus*	*Species*
Mammals	Flying foxes, fruit bats	*Pteropidae*	*Pteropus*	all
	Vampire bats	*Phyllostomatidae*	*Desmodus*	all
			Diphylla	all
			Diaemus	all
	Weasels, ferrets, stoats	*Mustelidae*	*Mustela*	all (except *M vison*)
	Mongoose, meerkats	*Viverridae*	*Atilax*	all
			Cynictis	all
			Helogale	all
			Herpestes	all
			Ichneumia	all
			Mungos	all
			Suricata	all
	European rabbit	*Lepidae*	*Oryctolagus*	all
	Indian wild dog, red dog, dhole	*Canidae*	*Cuon*	all
	Multimammate rat or mouse	*Muridae*	*Mastomys*	all
Birds	Bulbuls	*Pycnonotidae*	*Pycnonotus*	all
	Japanese white-eye	*Zosteropidae*	*Zosterops*	*japonica*
	Starlings, mynahs	*Sturnidae*	*Acridotheres*	all
			Gracula	all
			Sturnus	all
	Dioch, Quelea	*Plocidae*	*Quelea*	*quelea*
	Java sparrow	*Estrildidae*	*Padda*	*oryzivora*
Reptiles	Vipers	*Viperidae*	*Atheris*	all
			Atractaspis	all
			Bitis	all
			Causus	all
			Echis	all
			Eristocophis	all
			Vipera	all
	Pit vipers, rattlesnakes	*Crotalidae*	*Agkistrodon*	all
			Bothrops	all
			Calloselasma	all
			Crotalus	all
			Lachesis	all
			Sistrurus	all
			Trimeresurus	all
	Cobras	Elapidae	*Bungarus*	all
			Dendroapis	all
			Hemachatus	all
			Micrurus	all
			Naja	all
			Ophiophagus	all

(Continued)

WebTable 1. *Continued*

	Common name	*Family*	*Genus*	*Species*
	Boomslang, vine snake	*Colubridae*	*Dispholidus*	*typus*
			Thelotornis	*kirtlandii*
Amphibians	Newts, salamanders	*Salamandridae*	*Cynops*	all
			Paramesotrition	all
			Salamandra	all
			Triturus	all
			Tylotriton	all
	African clawed frog	*Pipidae*	*Xenopus*	*laevis*
	Giant toad	*Bufonidae*	*Bufo*	*marinus*
Fishes	Climbing fishes	*Anabantidae*	*Anabas*	all
	Venomous toadfishes	*Batrachoididae*	*Daector*	all
			Thalassophryne	all
	Nile perch	*Centropomidae*	*Lates*	all
	Piranhas and caribes	*Characidae*	*Astyanax*	all
			Pygopristis	all
			Serrasalmus	all
	Cichlids	*Cichlidae*	*Batrachops*	all
			Boulengerochromis	all
			Cichla	all
			Crenicichla	all
			Rhamphochromis	all
			Sartherodon	all
			Serranochromis	all
			Tilapia	all
	n/a	*Citharinidae*	*Belanophago*	all
			Citharinus	all
			Paraphago	all
			Phago	all
	n/a	*Ctenoluciidae*	*Boulengerella*	all
			Ctenolulius	all
	Carps and minnows	*Cyprinidae*	*Aristichthys*	all
			Ctenopharyngodon	all
			Hypothalmichthys	all
			Luciscus	all
			Mylopharyngodon	all
			Opsariichthys	all
	Stingrays	*Dasyatidae*	all	all
	Dientudos and trahiras	*Erythrinidae*	*Erythrinus*	all
			Hoplerythrinus	all
			Hoplias	all
			Pseuderythrinus	all
	Knifefishes and electric eels	*Gymnothidae*	*Electrophorus*	all

(Continued)

WebTable 1. ***Continued***

Common name	*Family*	*Genus*	*Species*
n/a	*Hepsetidae*	*Hydrocynus*	all
		Sarcodales	all
n/a	*Lebiasinidae*	*Lebiasina*	all
		Piabucina	all
Electric catfishes	*Malapteruridae*	*Malapterurus*	all
Snakeheads and channas	*Ophiocephalidae*	*Channa*	all
		Ophicephalus	all
Catfishes	*Plotosidae*	*Plotosus*	all
Top minnows	*Poeciliidae*	*Belonesox*	all
Freshwater stingrays	*Potamotrygonidae*	all	all
Scorpion fishes	*Scorpaenidae*	*Brachirus*	all
		Dendrochirus	all
		Inimicus	all
		Pterois	all
		Synanceja	all
Electric rays	*Torpedinidae*	all	all
Catfishes	*Trichomycteridae*	*Stegophilus*	all
		Trichomycterus	all
		Vandellia	all
Weeverfishes	*Trachinidae*	*Trachinus*	all
Salmon, trout	*Salmonidae*	all	all
Walking catfishes	*Clariidae*	all	all

Note: Some taxon names have changed since publication of this list in 1977.

WebTable 2. Proposed criteria for listing a species as "injurious wildlife", defined in the US Fish and Wildlife Service's unsuccessful attempt to substantially lengthen the list of injurious wildlife in 1977 (USFWS 1977)

"The species which this proposal would add to the present list of injurious wildlife have been determined by the Secretary to be injurious on the basis of one or more of the following criteria:

1. The species occupies an ecological niche (including feeding habits, roosting habits, requirements for reproduction, and other factors) that overlaps to a considerable extent the ecological niche of a native species;

2. The species is a close relative of a native species with which it might be expected to compete for food, space, or some other resource, or with which it might be expected to interbreed;

3. The species has behavioral traits, feeding habits, or ecological requirements that could be disruptive or destructive to natural communities or environmental features, or in conflict with man's use of the environment;

4. The species is known to have feeding or foraging habits that include crops or other agricultural products or harvested natural resources, or that suggest that it may readily be able to adapt to such food resources;

5. The species is known to be the host of a parasite that would be detrimental to humans, domestic animals, or native wildlife, or is known to be a reservoir or vector of, or the host of a parasite that is a vector of, a disease that can readily be transmitted to humans, domesticated animals, or native wildlife;

6. The species is known to be dangerously venomous or toxic or otherwise noxious to man or to other animals;

7. The species occupies ecologically disturbed areas, particularly urbanized areas or those altered by the addition of exotic vegetation, as a major portion of its habitat;

8. The species has demonstrated an ease of establishment, colonization, or dispersal or has reproductive characteristics that suggest an ease of establishment in the absence of its normal populations controls; or

9. The species is a close relative of a species that falls into one of the above categories."