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PERSPECTIVES AND PARADIGMS

Invasive animals and wildlife pathogens in the United States: the economic case for more risk assessments and regulation

Peter T. Jenkins

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Abstract The United States faces numerous invasions by non-native animal species and wildlife pathogens that pose high risks to the economy, the environment, human health and wildlife health. Nevertheless, the Federal government spends less than $500,000 annually on preventing harmful animal invasions in its "injurious species" listing program under the Lacey Act, which can prohibit imports and interstate commerce in designated taxa. This program is ineffective; numerous costly invasions by intentionally-imported animals have occurred despite the Lacey Act. Additionally, the majority of emerging zoonotic diseases worldwide originate in wildlife and the role the wildlife trade plays in disease emergence is increasing over time. Recent findings demonstrate that conducting risk assessments for the wildlife trade is relatively inexpensive and they can provide net economic benefits for the nation. However, in order to accrue those benefits, dramatic policy improvements are needed centered around developing and funding a proactive, rapid, Federal risk assessment program.

Keywords Invasive animals · Wildlife pathogens · Prevention · Economics · Cost/benefit analysis

P. T. Jenkins (✉)
Center for Invasive Species Prevention,
Washington, DC, USA
e-mail: jenkinsbiopolicy@gmail.com

Policy overview

The United States faces numerous invasions by a large array of non-native animal species and wildlife pathogens that pose high risks to the economy, the environment, human health and wildlife health. Terrestrial and aquatic resource managers are compelled to expend scarce funds to control harmful taxa such as suckermouth catfish (*Hypostomus* spp.), red lionfish (*Pterois volitans* and *P. miles*) and Nile monitor (*Varanus niloticus*) at the same time the same species are still sold to the public as exotic pets, aquarium fish, live bait or live seafood, providing a ready source for more introductions (Jenkins et al. 2007). Over 2,200 different non-native wildlife species were in the US import trade in the last decade. A "coarse" risk screening of them in 2007, based on a rapid review of scientific publications and databases, indicated that about 300 of those species were known or potential invaders or disease risks (Jenkins et al. 2007). Yet, the US is addressing these threats under an antiquated, extremely burdensome, regulatory law enacted in 1900, the Lacey Act (18 US Code sec. 42). The Federal government program of implementing that Act has been broadly criticized as too small, too reactive, too slow and glaringly inadequate to address the globalized live animal trade (Fowler et al. 2007). New research demonstrates the failures of this program impose a net economic cost to the nation.

Some background economic facts:

- The total US national costs and losses attributed to invasive animals and associated animal diseases are estimated at up to $35 billion per year. This includes the ongoing impacts of animals introduced through history, such as feral hogs and Norway rats that originated centuries ago, as well as costs and damages caused by more recent invasions and disease outbreaks (Pimentel et al. 2005).
- For fiscal years 2010 and 2011, the Federal government budgeted approximately $120 million primarily allocated to control one invasive animal group: Asian carps (especially silver carp, *Hypophthalmichthys molitrix*). The US is spending tens of millions more to control other invaders, such as wetland-degrading nutria (*Myocaster corpus*) in multiple States and two giant constrictor snakes species (*Python molorus bivittatus* and *P. sebae*) established in south Florida.[1] State and local agencies, as well as private landowners, also must devote funds resources to reduce the impacts of these and other harmful invasions.
- Kroeger (2007) estimated that, for the year 2004, the national costs and damages associated with major diseases that either conclusively (i.e., exotic Newcastle disease) or potentially (i.e., West Nile virus and avian influenza) entered the US via live wild animal imports, or for which imported live animals acted as a reservoir for infections (reptile-associated salmonellosis), were between $397 million to $911 million.

The Federal government spends less than $500,000 annually on preventing harmful animal invasions in its "injurious species" listing program under the Lacey Act, which can prohibit imports and interstate commerce in designated taxa. The Fish and Wildlife Service program has fewer than three "full-time equivalent" employees and has finalized only about 19 regulatory listings in the last 46 years; its recent pace has been about one listing completed every *4 years* (Fowler et al. 2007). This is a remarkably impeded agency given that there are scores and perhaps hundreds of species that should be regulated and the nation continues to suffer new invasions. "Appendix" identifies 30 taxa that qualify for listing immediately; however, at the agency's current pace, listing them could take 120 years!

No Federal regulatory agency has a mandate to prevent entry of infectious wildlife pathogens such as the recent devastating outbreaks of chytrid fungus (*Batrachochytrium dendrobatidis*), which is harming amphibian populations worldwide (Skerratt et al. 2007), and white-nose syndrome (WNS) fungus (*Geomyces destructans*), which is decimating native US bat species (Lorch et al. 2011). A study on reductions of bat numbers attributable to WNS, as well as to impacts of new energy windmills, estimated agricultural losses resulting from reduced insect predation by bats could amount to $3.7 billion annually (Boyles et al. 2011).

The majority (71.8 %) of emerging zoonotic diseases globally originate in wildlife and the role that wildlife trade plays in disease emergence is increasing over time (Jones et al. 2008). A recent global review documented that 63 disease agents, including many emerging human pathogens, have been transmitted via movement of wildlife (Travis et al. 2011). A separate review found seven disease agents were introduced into the United State via live animal imports from 1996 to 2006 (Jenkins et al. 2007). Animal invasions can alter whole ecosystems and food webs and can lead to outbreaks of both endemic and novel diseases, such as avian botulism outbreaks in the Great Lakes resulting from vast infestations of zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis bugensis*). Risk assessment methods are improving for disease risks associated with transported live wildlife, but the scope of the trade and associated threats have risen dramatically in recent decades. The impacts of climate change are likely to exacerbate the pathogen threat, facilitating more outbreaks of tropical diseases.

A recent study reported in *Ecological Economics,* using years of United States data on amphibian and

[1] The US Government, working with many partner organizations, spent US $13.8 million for nutria control from 2000 through 2011 just in the State of Maryland (they have invaded in several other States as well, where costs are less well-documented), see webpage: Chesapeake Bay Nutria Eradication Project, www.fws.gov/chesapeakenutriaproject/Index.html (Accessed 18 July 2012) and it has spent more than $6 million since 2005 seeking solutions to Burmese pythons and other large invasive constrictor snakes in Florida, see Factsheet: The economic cost of large constrictor snakes, see www.fws.gov/home/feature/2012/pdfs/EconImpact.pdf. Accessed 18 July 2012.

Box 1 International examples of basic risk assessment costs for non-native animals

Nations differ in their legal requirements for proposed non-native animal imports. In the relatively few nations where pre-import assessment is mandated, variation exists as to whether the applicant or the government agency conducts the risk research. Risk research and assessment costs should be distinguished from costs of related steps that some governments may require, such as writing eradication contingency plans and conducting economic cost/benefit studies

Rough descriptions of three types of risk assessments are as follows: (1) rapid assessments, e.g., invasive elsewhere + climate match = likely invader; (2) mid-level assessments, e.g., statistical models, using variations of the multiple-question Australian weed risk modeling approach (Pheloung et al. 1999); and (3) intensive literature review and expert opinion-based risk assessments. For some nations the activities may be phased, e.g., a rapid preliminary assessment is prepared that determines whether a more intensive and costly assessment must follow. Interestingly, it appears no systematic data show that spending more time and funds on doing more labor-intensive risk assessments is justified by any increase in accuracy of the information as far as deciding the basic question of whether or not to allow a proposed animal to be imported

Some of the costs presented below are well-documented and others are approximations or projections of future costs and there is variability as to the tasks the estimates cover. Costs are per species assessed in ascending order (converted to $US)

Israel Nature and Parks Authority: $200–for cost of contracted graduate student research (Simon Nemtzov, pers. comm.)

U.K. Dept. of Environment, Food & Rural Affairs (Defra): $1,642—for species in aquaculture (Gordon Copp, pers. comm., referring to figures in Defra 2009)

Australia, Dept. of Agriculture and Food: $2,068—for average of 40 assessments done in 2009 (Win Kirkpatrick, pers. comm.)

New Zealand Environmental Protection Authority: minimum $2,485; maximum $74,417 (Donna Campbell, pers. comm.; note the high variation between the minimum and maximum is due to differences in the types of proposals and the assessment tasks included)

Florida Fish and Wildlife Conservation Commission: $12,200—a projection based on assumption of 30 species analyzed at a cost of $366,000 (Unpublished memo. A federal-state partnership to improve screening and interdiction of non-native wildlife. Florida Fish and Wildlife Comm.)

Institute for European Environmental Policy (IEEP): $60,224—a projection that includes assessment costs for both animal and plant imports (Shine et al. 2010)

While there are outliers (low: Israel's costs; high: the IEEP's projected costs), and the broad variability in terms of the tasks included makes averaging and comparison difficult, the most common cost range for a basic risk assessment appears to lie between about US $1,600 and US $12,000 per animal species assessed

reptile imports, demonstrated how doing pre-import risk assessments for that segment of the trade can "pay off" in reduced costs for the nation (Springborn et al. 2011). The study estimated the long-term expected net benefits from using a risk screening system range from roughly $54,000 to $141,000 for each species assessed, including both those species found to be harmful and non-harmful, assuming typical import scenarios and mid-range impacts. While based on amphibian and reptile imports, the authors proposed that similar benefits likely apply to risk screening for birds, mammals and other groups. Their findings are consistent with findings from Australia documenting how pre-import risk assessments for the plant trade are cost-beneficial for that nation (Keller et al. 2007).

More rapid invasiveness risk screening methods have been developed with some, but not all, relying on predictive modeling based on climate matching and on traits and history of the species being assessed (Hayes and Barry 2008; Simons and DePoorter 2009). Recently-gathered international data shows the most common cost range to conduct a basic risk assessment for a proposed non-native animal lies between about $1,600 and $12,000 per species (Box 1). Australia, New Zealand, Israel and other nations carry out risk assessments and species regulation relatively quickly and inexpensively and are not suffering from new invasions via the intentional importation pathway.

No existing legal obstacles prevent the United States from pursuing such an approach. Indeed, the failure to implement risk screening contravenes a 10 year-old Executive branch policy directive that committed the government to pursue an improved screening approach for animals. The National Invasive Species Management Plan, which was agreed to by all the major relevant Federal agencies, called for:[2]

> *…the development of a risk-based screening process for intentionally introduced species in a series of steps or phases. During the* ***first phase*** *a*

[2] Task 14 in National Invasive Species Council (NISC). 2001. National management plan: meeting the invasive species challenge. Washington, DC: NISC.

> *screening system for first-time intentional introductions will be developed, with different agencies taking the lead as appropriate for the different types of species. The screening system will then be modified by those same lead agencies during the* ***second phase*** *to deal with species already moving in the US*

The Plan called for the first phase to be complete by December 2003, the second phase by 2006. None of the screening processes have been finalized as of mid-2012 and there is no discernible date set for their public release, despite being 5 to 8 years past due. The lack of progress toward a rigorous, enforceable Federal screening program is inexplicable in view of the serious threats involved.[3]

Again, the Fish and Wildlife Service "injurious species" program averages 4 years to finish a Lacey Act listing, at a very high cost per species. Worse, the United States continues to suffer new invasions from intentional imports in the process (Fowler et al. 2007). However, if the program could conduct risk assessments at costs comparable to the range of international costs in Box 1, followed by actual regulatory listings (such as for the species in "Appendix") that are not bogged down in expensive bureaucratic processes, it could provide strong net economic benefits to the country, per the findings of Springborn et al. (2011).

Risk research costs can be placed largely on the proponent seeking importation of the species involved. They do not necessarily need to be borne by the government. In New Zealand, for example, the proponent of the importation bears the research costs (Donna Campbell, New Zealand Environmental Protection Authority, pers. comm.).[4]

The National Environmental Coalition on Invasive Species (NECIS) estimates that the US Federal government could implement an effective program to prevent future animal invasions and wildlife disease outbreaks for a small program increase of between $2 and $3 million annually.[5] This would expand the currently very small Fish and Wildlife Service injurious species program by a factor of about five. As with the New Zealand "externalization" of the research costs onto the proponents, the additional funds to expand the US program as suggested would not necessarily have to come from the general Federal budget. Rather, funds could primarily come from user fees paid by those sectors that import live animals (see Jenkins 2002). Live animals already must be declared and inspected at US ports, for which a small Federal user fee is charged (under Subpart I of part 14 of title 50, US Code of Federal Regulations). Charging a comparable additional user fee would be a fair way to internalize much—but not all—of the risk assessment costs that now are externalized, that is, paid by other people and institutions instead of those who profit from the trade. If the government does not require importers to at least partially internalize the costs of the species they import, then they are rational to simply continue as "free riders". But, the public taxpayers and others are harmed in the bargain; natural ecosystems, native wildlife and public and animal health are threatened as well.

As an aside, and to put the animal import issue in context, it is noteworthy that US Federal policy as far as non-native plant imports became more proactive as of 2011. It took 6 years to develop, but the US Department of Agriculture (USDA) gained expanded powers to more quickly halt imports of plants that are likely to be weeds or to carry plant pests.[6] The new regulation allows USDA's Animal and Plant Health Inspection Service (APHIS) to prohibit a plant without

[3] It should be recognized that the analysis here does not address movement of animals that are native within the United States but that are moved from their native ecological range into a non-native ecological range by movement to a different State within the country, e.g. Atlantic salmon moved to the Pacific coast. The regulation of such movements is traditionally a matter of State law and is not systematically monitored as international imports are monitored.

[4] See New Zealand Environmental Protection Authority, Application to import for release or to release from containment new organisms with controls under the Hazardous Substances and New Organisms Act www.epa.govt.nz/Publications/Application%20form%20to%20release%20new%20organisms%20with%20controls.doc. Accessed 18 July 2012.

[5] Estimate by NECIS (a multi-NGO coalition, see www.necis.net) in a fact sheet: harmful animal invaders—the economic realities. (nd). Washington, DC: NECIS. www.necis.net/wp-content/uploads/2011/11/Factsheet_necis_economics_final.pdf. Accessed 18 July 2012.

[6] Final Rule—Importation of Plants for Planting; Establishing a Category of Plants for Planting Not Authorized for Importation Pending Pest Risk Analysis, Federal Register Vol. 76, No. 103, Friday, May 27, 2011. Pages 31,172-31,210. www.regulations.gov/#!documentDetail;D=APHIS-2006-0011-0267. Accessed 18 July 2012.

needing to first do a full-blown risk assessment, if reliable risk screening data is available for the species at issue. This reform created the precautionary regulatory category known as "not authorized pending pest risk analysis" (NAPPRA).[7] This NAPPRA model, which APHIS is instituting without needing significant additional funding, could be applied to animal imports as well, particularly because the new, relatively simple, risk screening approaches based on history of invasiveness and climate match have been developed.

Conclusions

New economic information about the impacts of the intentionally-imported non-native animal trade, and the relatively low costs of assessing the risks of the trade, underscore the benefits that would accrue if the United States were to adopt a more proactive regulatory system. Other nations have implemented precautionary systems and as a result have reduced non-native animal invasions and secured national economic benefits in the process. No new technology is needed to reduce the risks of this invasion pathway; the missing ingredient has been political will.

Policy solutions to improve the current ineffective US regulatory system include:

- New legislation should provide clear direction to the Fish and Wildlife Service to do more risk assessments and reduce bureaucratic delays in the current program. Most of the costs should come from user fees paid by importers. Other associated reforms are needed, such as providing the agency with emergency powers and the duty to address imported wildlife diseases that no other agency is addressing, and directing the agency to coordinate more closely with the States.
- New legislation is not needed for the United States to emulate how other countries use rapid and effective approaches to conduct risk assessments within the cost range of the typical international estimates in Box 1. The Fish and Wildlife Service should be more proactive in using existing authority to cost-effectively protect the taxpayers, the environment and public and wildlife health.

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Appendix: Thirty non-native animals that clearly qualify for listing under the Lacey Act as either currently or potentially injurious taxa in the United States

Note: This list is illustrative, not exhaustive. The effect of regulating these taxa under the Lacey Act would be to prohibit their import and interstate commerce, but it would not prohibit continued ownership of previously-owned animals. Also, permits could be obtained from the US Fish and Wildlife Service by research, educational or display institutions to import and move them interstate.

African clawed frog (*Xenopus laevi*)[a]
Australian redclaw crayfish (*Cherax quadricarinatus*)
African giant snail (*Achatina fulica*)[a]
Australian spotted jellyfish (*Phylorhiza punctata*)
Asian green mussel (*Perna viridis*)[a]
Asian swamp eel (*Monopterus albus*)
Black and white tegu (*Tupinambis merianae*)[a]
Black Sea silverside (*Atherina boyeri*)
Boa constrictor (*Boa constrictor*)[a,b]
Caribbean tree frog (*Eleutherodactylus coqui*)[a]
Eurasian minnow (*Phoxinus phoxinus*)
Great green tree frog (*Litoria caerula*)[a]
Green anaconda (*Eunectes murinus*)[b]
Green crab (*Carcinus maenas*)[a]
Indian or common mynah (*Acridotheres tristis*)[a]
Macaques (*Macaca* spp.)[a]
Mozambique tilapia (*Oreochromis mossambicus*)
Mud crab (*Scylla serrata*)
Nile monitor (*Varanus niloticus*)[a]
Nile perch (*Lates niloticus*)
Oriental weatherfish (*Misgurnus anguillicaudatus*)
Piranha (*Pygocentrus* spp.)[a]
Red lionfish (*Pterois volitans* and *P. miles*)[a]

[7] 7 Code of Federal Regulations 319.37. www.access.gpo.gov/nara/cfr/waisidx_11/7cfr319_11.html. Accessed 18 July 2012.

Reticulated python (*P. reticulatus*)[b]
Stone moroko (*Pseudorasbora parva*)
Suckermouth catfish (*Hypostomus* spp.)[a]
Tree shrews (*Tupaiidae*)
Wels catfish (*Silurus glanis*)
Yabbie crayfish (*Cherax destructor*)
All amphibians not certified to be free of chytrid fungus (*Batrachochytrium dendrobatidis*)[a,b]
All bats not certified to be free of whitenose syndrome fungus (*Geomyces destructans*)[a]

Sources: Jenkins et al. (2007); Kolar and Lodge (2002); PetWatch website www.petwatch.net and research by the author

[a] Already invasive in the United States

[b] Formally proposed for Lacey Act listing, but not resolved as of July 18, 2012

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