

Vertebrate species introductions in the United States and its territories

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Abstract At least 793 introduced vertebrate species have become established in the United States and its territories, including at least 81 mammalian, 99 avian, and 80 reptilian/amphibian, and 533 fish species. Examples in each major taxonomic group include domestic cat, small Indian mongoose, red fox, goat, pig, rabbit, rats, house mouse, gray squirrel, nutria, starling, Indian common myna, red-vented bulbul, brown treesnake, red-eared slider, brown trout, tilapia, and grass carp. I briefly review some of these species and the types of damage they cause. I then review the basic types of methods used for control or eradication of each taxonomic group, including physical, chemical, biological, and cultural methods. I discuss some of the challenges in managing these species, including issues with the use of toxicants, land access, public attitudes, and monitoring difficulties. Finally, I list some ongoing research and future research needs, including fertility control, improved detection methods, improved attractants, improved barriers, improved capture methods, and risk assessment methods [*Current Zoology* 57 (): – , 2011].

Key words Eradication, Introductions, Invasive species, Management, United States

1 Introduction

Vertebrate species have been introduced to almost all parts of the world for thousands of years. The large volume of worldwide trade and transportation has accelerated the rate of introductions in the last 150 years or so. Animals are introduced for many reasons, both purposeful and accidental. Purposeful introductions occur for food and fur, work animals, sport hunting and fishing, companion animals, aesthetics, pets, and pest control. Accidental introductions occur because of stowaways in transport vehicles, released animals (without an original intent to release), escapees, and, in some cases, because of range expansion of a species (often facilitated by human activities and land uses).

While many introduced vertebrate species have provided important resources and economic gains for humans and many do not cause undue adverse effects (especially with appropriate management), some have increased their distribution and have caused serious adverse effects. These include disease and safety hazards, predation and competition with native species, crop consumption and contamination both in the field and during storage, livestock predation, and, in some cases, significant environmental degradation. Unfortunately, for many species of introduced

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vertebrates, we do not yet know if they are causing, or in the future will cause, significant harm to the environment or human resources. Hence, my frequent use of the term “introduced” rather than “invasive” vertebrate species.

While some lists of vertebrate introductions have been compiled, this has not been done across the various taxa of vertebrates. Additionally, there has generally been little discussion of impacts and control efforts. As political and social awareness has grown, so have efforts to assess introduced species and their economic impacts (e.g., Pimentel et al., 2005). In this paper, I present a list of vertebrate species by taxonomic grouping that have been introduced into the United States and its territories. I also discuss some of the more damaging species and some of the management methods and strategies being used to manage or eradicate invasive vertebrates in the United States. Finally, I consider and discuss some of the remaining challenges in addressing invasive vertebrate management in the United States and some research needs.

2 Vertebrate Species Introduced into the United States

I compiled the list of introduced vertebrate species by taxonomic groups from a variety of sources, including several publications (e.g., American Ornithologist’s Union, 1998; Bury and Luckenbach, 1976; Fuller, 2003; Fuller et al., 1999; Hawaii Audubon Society, 1989; Kraus, 2009; Lever, 1987, 2003; Long, 1981, 2003; Meshaka, 2006; Mooney and Drake, 1986; Moulton and Pimm, 1986; Teer, 2003; Witmer and Lewis, 2001), but also from several federal, state wildlife agency and conservation organisation websites (e.g., www.NIISS.org, www.issg.org, www.nbii.org, www.invasivespecies.net, www.fort.usgs.gov, www.hear.org). Preliminary lists of common and scientific names of these species were presented in Witmer et al. (2007, non-fish vertebrates) and in Fuller et al. (1999, fish species). My focus was on the United States mainland and Hawaii, so some of the species introduced to United States territories (e.g., Virgin Islands, Puerto Rico, American Samoa, Guam, and the Commonwealth of the Northern Marianas) have probably been overlooked. An important exception is the inclusion of the brown treesnake *Boiga irregularis* in Guam as it is a major problem invasive species receiving a considerable investment in research and control efforts. The species list that I have compiled is quite long because I have included many species that are native to North America, but have been translocated to states or regions in which they did not occur historically. I have also included some species that have expanded their historic range in recent decades because, in many cases, this range expansion has been facilitated, at least in part, by the activities and land uses of humans. The list may actually be considerably longer, but for many species, we cannot yet be sure that they are well established and will sustain themselves over time. For example, Florida agencies use a “10 year rule” of documentation of breeding and establishment in several counties before the species is put on its list of introduced and established species. It appears that a large portion of the introduced vertebrates occur in Florida, Texas, California, and Hawaii; however, all states and territories have a number of well-established introductions. While all the reasons for the high numbers of species in Florida, Texas, California and Hawaii are not entirely known, it may well be related factors such as a mild year-round climate which allows animals to survive whether accidentally or purposefully released, a climate that allows people to keep wild animals outside year-round and the presence of major live animal port-of-entries. Because of the incompleteness of surveys for introduced species in many areas, my list of species is definitely not exhaustive. It should be considered preliminary and I hope to update it periodically.

At least 81 species of mammals have become established in parts of the United States (Table 1). Mammals were mainly introduced for sport hunting, but also for food and fur (Kraus, 2003). The largest single group is ungulates with 33 species. This group includes many species used for sport hunting (e.g., aoudad *Ammotragus lervia*, gemsbok *Oryx*

gazelle, nilgai *Boselaphus tragocamelus*, eland *Taurotragus oryx*), but also feral populations of species that were used for work (eg., horses *Equus caballus*, burros *E. asinus*) or for food (eg., cattle *Bos taurus*, pigs *Sus scrofa*). The second largest group of mammals is the rodents (18), many of which were introduced accidentally via cargo and transport vehicles (commensal rats *Rattus* spp. and mice *Mus musculus*), but some were purposefully introduced for fur (e.g., nutria *Myocastor coypus*). Numerous carnivores (14 species) have been introduced, in some cases for their fur (e.g., foxes *Vulpes vulpes*, raccoons *Procyon lotor*), but also in efforts to control pests such as rats and snakes (e.g., mongoose *Herpestes auro-punctatus*, weasels *Mustela* spp.). There are also large populations of feral, formerly companion animals (e.g., dogs *Canis familiaris*, cats *Felis catus*) throughout the United States and its territories. Interestingly, at least 6 species of primates have become established in parts of the United States.

At least 99 species of birds have become established in parts of the United States (Table 1). Most introductions were as pets, but many were introduced for sport hunting (Kraus, 2003). Most of these are passerine birds (42 species), but many are psitticines (20 species, popular animals in the pet industry). There are also a large number (25 species) of “upland game” (galliformes) birds (both native and non-native) that have been introduced to various parts of the United States. Interestingly, many more avian species have been introduced to Hawaii than the mainland (Lever, 1987).

At least 80 species of reptiles and amphibians (henceforth called ‘herptiles’) have been introduced in parts of the United States (Table 1). Most introductions were as pets, but many were also introduced as accidentals in cargo (Kraus, 2003). This is a group of animals that are also very popular in the pet industry. Florida is a very large importer of herptiles which may be why that state seems to have the largest number of established species. The largest single group of herptiles is the lizards (56 species). Other groups (frogs and toads, turtles, snakes) comprise smaller (1–10 species) and relatively similar numbers of species per group. Only one crocodylian (caiman *Caiman crocodiles*) has become established, with a few populations in the United States.

At least 533 species of fish have been introduced in parts of the United States (Table 1). About half of these are non-native to the United States, while the other half are native to the United States, but were translocated from one region to another. While some species of fish were accidental introductions (e.g., round goby *Neogobius melanostomus* from sources such as ballast water), most were for sport fishing (e.g., trout *Oncorhynchus* spp., *Salmo* spp., *Salvelinus* spp., bass *Micropterus* spp.), but many were released pets (e.g., walking catfish *Clarias batrachus*) or bait fish (e.g., numerous species of minnows and shiners) releases (Fuller, 2003). A few were introduced as a food source (e.g., tilapia *Oreochromis* spp.) and a few species (e.g., grass carp *Ctenopharyngodon idella*, mosquito fish *Gambusia* spp.) were widely introduced to control aquatic vegetation or mosquito larvae. The list is dominated by two taxon groups comprising 314 species (see Table 1).

3 Some Problematic Introduced Vertebrates

A number of species within each major taxonomic group of vertebrates pose serious problems over portions of the United States. I provide a few examples in each group, based on one or more of these criteria: their widespread nature and population sizes, the seriousness of the problems they cause, the amount of investment in prevention and control, and the number of requests of USDA/APHIS Wildlife Services (WS) to deal with specific damage situations. WS has a mission of reducing conflicts between wildlife and humans for the protection of agriculture, property, human health and safety, and natural resources. WS involvement in invasive vertebrate damage situations was compiled and discussed by Bergman et al. (2002) and Rennie et al. (2004).

Feral cats are found throughout the United States and its territories and cause significant predation of native birds and other native animals (Pimentel et al., 2005; Pitt and Witmer, 2007; Witmer et al., 2005). Likewise, feral dogs can be found in most of the States and territories. They pose human safety issues, prey on livestock, and hybridise with some species of native canids (Pimentel et al., 2005; Witmer et al., 2005). Feral pigs are found in at least half of the states in the US, including some states along the US' northern border (e.g., Idaho, North Dakota, Wisconsin, Michigan, and New York). They cause serious environmental degradation, prey on native species, damage crops, and pose a disease hazard to livestock and wildlife (Pimentel et al., 2005; Pitt and Witmer, 2007; Witmer et al., 2003). Several species of herbivores (exotic and feral rabbits and introduced nutria) also cause ecosystem and crop damage (Witmer and Lewis, 2001). One or more species of commensal rats and mice occur everywhere worldwide and widely in the United States and its territories. These rodents cause disease and sanitation problems, consumption and contamination of foodstuffs (both in the field and in storage), and property damage (Pimentel et al., 2005; Pitt and Witmer, 2007; Witmer et al., 1995). They have also caused the extinction or endangerment of many endemic species on islands (Howald et al., 2007).

Starlings, pigeons, and house sparrows are found almost worldwide and throughout almost all of the United States and its territories. They are so well established in the United States so as to be considered "naturalised" and many people no longer even consider them invasive species. Nonetheless, they cause sanitation and disease problems, compete with native birds, and consume and contaminate livestock feed (Pimentel et al., 2005; Witmer and Lewis, 2001). Other serious invasive bird problems are of a more localised nature, such as mute swans *Cygnus olor* in several northeastern states. They pose human safety concerns because of their aggressive behaviour and they compete with native bird species (Avery and Tillman, 2005). Populations of monk parakeets have become established in several states where they cause power outages by nesting in transformers (Avery and Tillman, 2005). They also pose a significant threat of crop damage if populations become sizeable in agricultural areas. Finally, ring-necked pheasants were introduced to many states for sport hunting. They cause serious crop damage in some localised situations and may compete for resources with native upland bird species (Witmer and Lewis, 2001).

Perhaps the most widespread invasive herptile in the United States is the bullfrog *Rana catesbeiana*. While native to the eastern United States, bullfrogs have been introduced to many western states. They prey on many aquatic animal species across all taxa, compete for resources, and have contributed to the threatened or endangered status of many regionally-endemic species of frogs (Pitt et al., 2005; Pitt and Witmer, 2007; Witmer and Lewis, 2001). Other invasive herptile problems in the United States are much more localised. In Guam, the brown treesnake predated upon, and competes with, native species of vertebrates and has caused the extinction of several of those species; they also regularly cause power outages and pose a safety hazard to people, especially children (Pimentel et al., 2005; Pitt et al., 2005; Pitt and Witmer, 2007). Coqui frogs *Eleutherodactylus coqui* have become well established in Hawaii where their calling all night long disturbs peoples' rest and has caused a decline in property values (Pitt et al., 2005; Pitt and Witmer, 2007). Several large, aggressive, carnivorous species of herptiles (in particular, Burmese pythons *Python molurus* and Nile monitor lizards *Varanus niloticus*) have become established in parts of Florida. They pose human and companion animal safety hazards, as well as issues of competition and predation with native vertebrate species (Pitt and Witmer, 2007).

The impacts of many of the introduced fish species are not really known, but can be numerous and significant (Moyle et al., 1986; Fuller, 2003; Fuller et al., 1999). One introduction that people hear perhaps the most about is the sea lamprey *Petromyzon marinus*. This cartilaginous, eel-like fish is native to the Atlantic Ocean, but gained access to the

Great Lakes by by-passing natural barriers via man-made canals. The species parasitises native fish such as trout, resulting in large losses of sport and commercial fish. Millions of dollars are spent annually to control sea lamprey (Fuller et al., 1999). Mosquito fish are native to many eastern States, but have been widely introduced into western States to control mosquito larvae. Instead, they have become a significant predator of small native fish, and have even caused the endangerment of numerous species in the western States (Fuller et al., 1999). Brown trout *Salmo trutta* are native to Europe, but were introduced to most States as a sportfish. They are voracious predators and will eat almost anything they can get in their mouth (Fuller et al., 1999). Blue tilapia *Oreochromis aureus* and other species of tilapia are native to tropical and subtropical Africa, but were introduced to many States as sportfish, a food source, and for aquatic weed control. In some cases, they also escaped or were released from aquaculture facilities. They damage native aquatic vegetation and compete with native fish species for spawning areas, food, and space (Fuller et al., 1999). Likewise, grass carp (native to eastern Asia), were introduced to many states to control aquatic weeds. Instead, they often denude large areas of aquatic plants (Fuller et al., 1999).

4 Management and Eradication Methods and Strategies

A wide array of methods is used to manage introduced vertebrates and the damage they cause in the United States. The methods vary somewhat by taxonomic group. Methods include traps and snares, netting, shooting, fishing, frightening devices, decoys, toxicants, dogs, Judas animals, purposely introduced predators, habitat manipulation, barriers, and sterilants. In some cases, cultural methods may also be used (e.g., sanitation, the type of crop selected and the timing of planting and harvest, compensation and insurance programs, etc.). Details on most of these methods, how they are used, and their advantages and disadvantages were presented by Conover (2002), Hygnstrom et al. (1994), and VerCauteren et al. (2005). Eradication strategies are more complex and are discussed by taxonomic group.

Management of invasive rodents most often utilises rodenticides, and primarily anticoagulants (Howald et al., 2007). Traps (kill traps, live traps, glue boards) are used in some situations, but to a much lesser extent. These methods are supplemented in and around buildings, with practices of exclusion, sanitation, and habitat modification (Timm, 1994). Day and night shooting is used with some larger species (e.g., nutria; LeBlanc, 1994). Most island eradications have utilised anticoagulant rodenticides—hand broadcast, in bait stations, and/or aerially broadcast (Howald et al., 2007).

A wide array of methods is used for carnivore management and eradication (Nogales et al., 2003; Witmer et al., 2005). Carnivores are captured with leg-hold traps, cage traps and snares. For smaller species, kill traps (e.g., conibear traps) are also used. Shooting (day, night, with calling) is often used. Occasionally, aerial shooting is used. Exclusion is sometimes used, especially to protect small colonies of endangered species. Toxicants are used on a limited basis: toxic baits and the M-44 cyanide device are sometimes used, especially on islands (Nogales et al., 2003; Witmer et al., 2005). A number of methods are not effective with carnivores and rodents (frightening devices, repellents, taste aversion), although research continues on these and other methods. Relatively few carnivore eradications have been attempted in the United States. For example, in the review of 48 worldwide cat eradications on islands, Nogales et al. (2003) reported only three United States islands. However, over a several decades period, introduced foxes have been eradicated from over 40 Aleutian Islands with the use of shooting, traps, and toxic baits (Ebbert, 2000).

A wide array of methods is used for ungulate management and eradication (Butchko et al., 2003; Campbell and Donlan, 2005; Lowney et al., 2005). These include shooting (day, night, over bait, aerial), trapping (individual cage traps, snares, group/corral cage traps), pursuit with dogs, exclusion, food removal, and Judas animals. Eradications have occurred on a few islands and on some sizeable, fenced/contained areas of the mainland (Butchko et al., 2003; Campbell

and Donlan, 2005; Lowney et al., 2005; Ramsey et al., 2008). Generally, several methods have been employed to assure success.

Managing birds, even introduced and invasive species, is a sensitive issue because of their charismatic nature and the enthusiasm of bird watchers. Additionally, there are state and federal regulations (e.g., Migratory Bird Treaty Act) protecting many bird species. Methods used to manage invasive bird populations include traps (with or without live bird decoys), shooting, exclusion, and limited use of toxicants (Starlicide [also known as “DRC 1339” from Denver Research Center compound 1339]; Avery and Tillman, 2005; Millet et al., 2004; Pitt and Witmer, 2007; Witmer and Lewis, 2001). Additionally, egg and nest destruction is sometimes used and frightening devices are often used to protect relatively small areas. While few, if any, bird eradications have been conducted in the United States, Millett et al. (2004) used shooting and toxicants to eradicate invasive common mynahs *Acridotheres tristis* from several small islands in the Seychelles. They noted that larger islands were much more difficult, if not impossible, to eradicate, and that re-invasion was often a problem on all but the most remote islands.

Our tool box for management and eradication of invasive vertebrates is perhaps weakest for amphibians and reptiles (Pitt and Witmer, 2007; Witmer and Lewis, 2001). The most methods development has occurred for brown treesnakes in Guam and coqui frogs in Hawaii (Pimentel et al., 2005; Pitt et al., 2005; Pitt and Witmer, 2007). Trapping, hand-capture or pit fall traps are perhaps most commonly used with herptiles. Drift fences are often used to increase effectiveness by directing animals to traps or pit falls. Night search-and-capture with spotlights can be used, and with brown tree snakes, night fence searches are conducted. Detector dogs are used to inspect cargo for brown treesnakes and to help locate Burmese pythons in Florida’s Everglades National Park. Toxicants have been developed and registered for brown treesnakes (acetaminophen) and for coqui frogs (citric acid and hydrated lime solutions; Pitt et al., 2005; Pitt and Witmer, 2007). I am not aware of any eradications of introduced herptiles in the United States.

While there are considerable methods that have been developed for invasive fish control, effective control or eradication is seldom achieved because of the complications posed by native species which we do not want to harm excessively (Dawson and Kolar, 2003; Fuller et al., 1999). Some of the methods used include water-level manipulations, barriers, targeted overharvest, stocking predators, sterilants, toxic baits, and gynogenesis (Dawson and Kolar, 2003). Toxicants (piscicides) have been used in some situations for lake-wide invasive or unwanted fish eradications (e.g., Finlayson et al., 2000). Some materials registered for use in the United States include antimycin, rotenone, TFM, and Bayluscide (Dawson and Kolar, 2003). The latter two materials are lampricides developed for invasive sea lamprey control. Generally, multiple methods must be used to achieve a reasonable level of control of the invasive fish species. As with herptiles, research is needed to develop more effective and species-specific methods of invasive fish control.

5 Challenges in Addressing Introduced Vertebrates in the United States

While some progress has been, and is being, made with invasive vertebrates in the United States, there are still many challenges and issues to resolve (Pimentel et al., 2005; National Invasive Species Council, 2001). The major emphasis, in terms of attention and funding, for invasive species in the United States has been focused on plants, insects, and pathogens (Pimentel et al., 2005). This may be because of the greater threat posed by these taxonomic groups to agriculture and human health which are valued more highly than biodiversity or aesthetics. Relatively little effort and resources have been directly dedicated to vertebrates with the main exceptions of brown tree snakes in Guam and feral pigs (on many islands and mainland areas).

Public perception and lack of support have affected efforts to manage or eradicate vertebrate species in the United States, as elsewhere in the world (National Invasive Species Council, 2001). Knowledge levels regarding invasive species and the harm they can cause are relatively low amongst the general public (Conover, 2002; National Invasive Species Council, 2001). Furthermore, the public does not readily distinguish between native and non-native species: as long as an animal looks nice and is not threatening people or causing undue harm, the public tends to view species equally (Wittenberg and Cock, 2001). Regarding importation, once it has been established that a species will not cause undue environmental or human resource harm, it can be placed on a “white” list (Fowler et al., 2007). By and large, species importations are viewed as “innocent until proven guilty” (“gray” list) and what is needed is the development of a much more inclusive prohibited species “black” list (Fowler et al., 2007; Pitt and Witmer, 2007; Witmer and Lewis, 2001). However, the pet industry is a well organized, large, and influential industry in the US (Ginsburg, 2004). Exotic pets are very popular with a sizeable portion of the public. And yet, the pet industry is a major pathway for the introduction of vertebrates into the United States (Kraus, 2003). Very few vertebrate species are prohibited from entry into the United States with a prevailing attitude of “innocent until proven guilty” (Pitt and Witmer, 2007; Witmer and Lewis, 2001). Greater cooperation along with more regulation and enforcement of the pet industry might help remedy this situation (Jenkins, 2007).

The ultimate solution to an invasive species is the eradication of all individuals in a given area; however, much of the public has a strong dislike for the killing of animals (Conover, 2002). Certain species such as feral cats, feral dogs, wild horses, and primates are particularly sensitive species to address. Furthermore, much of the public has a strong fear and distrust of chemicals, and in particular, toxicants. Hence, the management of invasive vertebrates, like all wildlife, is being conducted in an increasingly complex arena (Conover, 2002; Fall and Jackson, 2002).

Access to all relevant land and properties is essential for the successful management and eradication of invasive vertebrates. However, managers often face the situation where the work is needed across a wide array of jurisdictions and ownerships. Getting permission to access all these areas rarely occurs and can prevent the success of even a well-planned, well-funded eradication effort. Furthermore, the land management mandates and regulations of federal and state agencies vary considerably. This affects the type of management activities (burning, chemical use), type of vehicles, and tools (leg-hold traps, firearms, toxicants) that can be used on certain properties. Some laws actually protect invasive vertebrate species, such as the Wild Horse and Burro Act and the Migratory Bird Treaty Act. The latter was amended in 2004 to exclude protection of some non-native migratory bird species in the United States such as the mute swan. The amendment occurred as a result of findings in a lawsuit focused specifically on halting mute swan control actions in 2003 in Maryland by invoking the Migratory Bird Treaty Act.

Finally, there is relatively little coordination and cooperation across jurisdictions and agencies of all levels of government in the United States. Consequently, one of the goals of the National Invasive Species Management Plan (National Invasive Species Council, 2001) is to rectify that situation. Eradicating an invasive vertebrate species is rarely an easy undertaking. Very careful planning is needed, along with adequate resources, public and agency buy-in, highly trained and motivated personnel, contingency plans, and a sustained effort (Broome, 2005). Each situation is unique in one or more ways; hence, a cook-book approach cannot be used (Broome, 2005).

With the possible exception of rodents and ungulates, the methods and strategies used for management, and especially eradication, of invasive vertebrates need improvement (Wittenberg and Cock, 2001). Much research needs to be conducted to improve detection methods; develop attractants needed to attract individuals to traps, bait stations, and

detection stations; and to improve the effective and safe delivery of toxicants, vaccines, and fertility control agents. Trained, rapid response teams are needed for many more invasive species. Accessible databases on potential invasive species are needed that give species identification, biology, ecology, and effective detection and management methods. The databases should also identify expertise and literature that can be consulted. Although a variety of databases and websites exist (Sellers et al., 2005) it would be very useful if these could be centralised and standardised (Sellers et al., 2004). Finally, risk assessments are needed to determine on which species we should focus our efforts and resources (Hayes, 2003).

6 Conclusions

At least 793 species of introduced/invasive vertebrate species occur in the United States and its territories. I suspect that invasive vertebrate species will continue to challenge land and resource managers, ecologists, and biologists for a long time to come. I also suspect that the list of invasive vertebrate species will continue to grow; but, hopefully, some species will also be removed from the list. In the United States, there have been some good successes with invasive species management and eradications, especially on islands, but also on some areas of the mainland. As a result of this, along with our collaborations with international colleagues and a growing interest and involvement by the public and agencies, we are becoming more knowledgeable and pro-active in responding to invasive vertebrate species. We still have a long way to go in terms of national organisation and cooperation on these issues, resolving various logistical and financial issues, and improving methods and strategies for many more species.

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- Note: Conference Proceedings papers can be accessed via these websites:

Table 1 Number of vertebrate species introduced into the United States by taxonomic grouping*

Taxonomic Order	Taxonomic Subgrouping	Number of Species
Mammalia (81 spp.)	Marsupials	2
	Insectivores	2
	Lagomorphs	6
	Rodents	18
	Carnivores	14
	Ungulates	33
	Primates	6
Aves (99 spp.)	Aniseriformes	5
	Galliformes	25
	Ciconiiformes	1
	Columbiformes	7
	Strigiformes	1
	Psittaciformes	20
	Passeriformes	40
Reptilia (69 spp.)	Crocodylians	1
	Lizards	56
	Snakes	6
	Turtles	6
Amphibia (11 spp.)	Frogs, Toads	10
	Salamanders	1
Pices (mostly Osteichthyes (533 spp.))	Lampreys	3
	Sturgeons, Paddlefishes	4
	Gars	4
	Bowfins	1
	Bonytongues, Knifefishes, Mooneyes,	4
	Featherfishes	
	Tarpons	1
	Bonefishes	1
	Freshwater Eels	4
	Anchovies, Herrings	10
	Milkfishes	1
	Minnnows, Suckers, Loaches	156
	Headstanders, Trahiras, Characins	18
	Catfishes	37
	Pikes, Mudminnows	10
	Smelts	4
	Trouts	30
	Trout-perches, Pirate Perches, Cavefishes	3
	Cods	1
	Mullets	2
	Rainbowfishes, Silversides	7
	Ricefishes, Needlefishes	3
	Rivulins, Topminnows, Livebearers, Splitfins,	54
	Pupfishes	
	Sticklebacks	4
	Swamp Eels	1
	Sculpins	4
	Flounders	8
	Snooks, Basses, Perches, Jacks, Sunfishes,	158
	Roosterfishes, Grunts, Mojarras, Drums, Sea	
	Chubs, Flagtails, Cichlids, Surfperches, Wrasses,	
	Gobies, Mackrels, Tunas, Butterfishes,	
	Gouramies, Butterfishes, Snakeheads	

* See the supplemental materials on website for detailed information about the species, and see text for a listing of the major references used to compile the numbers in this table.

Appendix 1 Vertebrate introductions into parts of the United States

Part 1 Mammals introduced into parts of the United States

<p>MARSUPIALS Opossum <i>Didelphis marsupialis</i> Brush-tailed rock wallaby <i>Petrogale penicillata</i></p> <p>PRIMATES Squirrel monkey <i>Saimiri sciureus</i> Vervet monkey <i>cercopithecus aethiops</i> Crab-eating Monkey <i>Macaca fascicularis</i> Japanese macaque <i>M. fuscata</i> Rhesus monkey <i>M. mulatto</i> Chimpanzee <i>Pan troglodytes</i></p> <p>INSECTIVORES Nine-banded armadillo <i>Dasybus novemcinctus</i> Pallas's mastiff bat <i>Molossus molossus</i></p> <p>LAGOMORPHS Eastern cottontail <i>Sylvilagus floridanus</i> European rabbit <i>Oryctolagus cuniculus</i> Snowshoe hare <i>Lepus americanus</i> Black-tailed jackrabbit <i>L. californicus</i> European hare <i>L. europaeus</i> White-tailed jackrabbit <i>L. townsendii</i></p> <p>RODENTS Arctic ground squirrel <i>Spermophilus parryii</i> Prairie dog <i>Cynomys ludovicianus</i> Abert's squirrel <i>Sciurus aberti</i> Mexican red-bellied squirrel <i>S. aureogaster</i> Gray squirrel <i>S. carolinensis</i> Fox squirrel <i>S. niger</i></p>	<p>Red squirrel <i>S. vulgaris</i> Kangaroo rat <i>Dipodomys ordii</i> Deer mouse <i>Peromyscus maniculatus</i> Red-backed vole <i>Clethrionomys rutilus</i> Muskrat <i>Ondatra zibethicus</i> Polynesian rat kiore <i>Rattus exulans</i> Norway brown rat <i>R. norvegicus</i> Ship black, roof rat <i>R. rattus</i> Gambian giant pouched rat <i>Cricetomys gambianus</i> House mouse <i>Mus musculus</i> Beaver <i>Castor canadensis</i> Nutria <i>Myocastor coypus</i></p> <p>CARNIVORES Red fox <i>Vulpes vulpes</i> Arctic fox <i>Alopex lagopus</i> Feral dog <i>Canis familiaris</i> Coyote <i>C. latrans</i> Raccoon <i>Procyon lotor</i> Coatimundi <i>Nasua nasua</i> White-nosed coati <i>N. narica</i> Stoat ermine, short-tailed weasel <i>Mustela erminea</i> Least weasel <i>M. nivalis</i> European polecat <i>M. putorius</i> American mink <i>M. vison</i> Small Indian mongoose <i>Herpestes auropunctatus</i> Feral cat <i>Felis catus</i> Jaguarundi <i>F. yagouaroundi</i></p>	<p>UNGULATES Donkey burro (<i>Equus asinus</i>) Feral horse <i>E. caballus</i> Burchell's zebra <i>E. burchelli</i> Feral pig <i>Sus scrofa</i> Camel <i>Camelus bactrianus</i> Axis deer <i>Cervus axis</i> Fallow deer <i>C. dama</i> Swamp deer <i>C. duvauceli</i> Wapiti American elk, red deer <i>C. elaphus</i> Sika deer <i>C. nippon</i> Sambar deer <i>C. unicorn</i> Black-tailed deer <i>Odocoileus hemionus</i> Roe deer <i>Capreolus capreolus</i> Moose <i>Alces alces</i> Reindeer caribou (<i>Rangifer tarandus</i>) Pronghorn antelope <i>Antilocapra americana</i> Eland <i>Taurotragus oryx</i> Nilgai <i>Boselaphus tragocamelus</i> Water buffalo <i>Bubalus bubalis</i> Feral cattle <i>Bos Taurus</i> Bison <i>Bison bison</i> Gemsbok <i>Oryx gazelle</i> Blackbuck <i>Antelope cervicapra</i> Mountain goat <i>Oreamnos americanus</i> Chamois <i>Rupicapra rupicapra</i> Musk-ox <i>Ovibos moshatius</i> Himalayan tahr <i>Hemitragus jemlahicus</i> Feral goat <i>Capra hircus</i> Alpine ibex <i>C. ibex</i> Aoudad Barbary sheep <i>Ammotragus lervia</i> Mouflon sheep <i>Ovis ammon</i> Feral sheep <i>O. aries</i> Bighorn sheep <i>O. canadensis</i></p>
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Part 2 Birds introduced into parts of the United States

<p>ANSERIFORMES Mute swan <i>Cygnus olor</i> Mandarin duck <i>Aix galericulata</i> Muscovy duck <i>Cairina moschata</i> American black duck <i>Anas rubripes</i> Mallard <i>A. platyrhynchos</i></p> <p>CICONIIFORMES Cattle egret <i>Bubulcus ibis</i></p> <p>GALLIFORMES Plain chachalaca <i>Ortalis vetula</i> Bobwhite quail <i>Colinus virginianus</i> Mountain quail <i>Oreortyx picta</i> California quail <i>Lophortyx californicus</i> Gambel's quail <i>L. gambellii</i> Scaled quail <i>Callipepla squamata</i> Chukar partridge <i>Alectoris chukar</i> Barbary partridge <i>A. Barbara</i> Grey partridge <i>Perdix perdix</i> Black francolin <i>Francolinus francolinus</i> Grey francolin <i>F. pondicerianus</i> Erkel's francolin <i>F. erkelii</i> Himalayan snowcock <i>Tetragalus himalayensis</i> Common quail coturnix quail <i>Coturnix coturnix</i> Chinese bamboo partridge <i>Bambusicola thoracica</i> Kalij pheasant <i>Lophura leucomelana</i> Red jungle fowl <i>Gallus gallus</i> Common ring-necked pheasant <i>Phasianus colchicus</i> Reeve's pheasant <i>Syrnaticus reevesii</i> Helmeted guineafowl <i>Numida meleagris</i> Common peafowl <i>Pavo cristatus</i> White-tailed ptarmigan <i>Lagopus leucurus</i> Common turkey <i>Melagris gallopavo</i> Chesnut-bellied sandgrouse <i>Pterocles exustus</i> Ruffed grouse <i>Bonasa umbellus</i></p>	<p>COLUMBIFORMES Feral pigeon rock dove <i>Columba livia</i> African collared dove <i>Streptopelia roseogrisea</i> Eurasian collared dove <i>S. decaocto</i> Spotted dove <i>S. chinensis</i> Barred zebra dove <i>Geopelia striata</i> White-winged dove <i>Zenaida asiatica</i> Mourning dove <i>Z. macroura</i></p> <p>PSITTACIFORMES Monk parakeet <i>Myiopsitta monachus</i> Ring-necked rose-winged parakeet <i>Psittacula krameri</i> Canary-winged white-winged parakeet <i>Brotogeris versicolurus</i> Blue-crowned parakeet <i>Aratinga acuticaudata</i> Budgerigar <i>Melopsittacus undulatus</i> Green-cheeked Amazon red-crowned parrot <i>Amazona viridigenalis</i> Yellow-crowned Amazon <i>A. ochrocephala</i> Yellow-headed Amazon <i>A. oratrix</i> Blue-fronted Amazon <i>A. aestiva</i> Lilac-crowned parrot Senegal parrot <i>Poicephalus senegalus</i> Blue-fronted conure <i>Aratinga cruentata</i> Brown-throated conure <i>A. pertinax</i> Mitered conure <i>A. mitrata</i> Nanday conure black-hooded parakeet <i>Nandayus nenday</i> Lovebird <i>Agapornis</i> spp. Cockatiel <i>Nymphicus hollandicus</i> Sulphur-crested cockatoo <i>Cacatua galerita</i> White-crested cockatoo <i>C. alba</i> Giffin's cockatoo <i>Cacatua goffini</i></p> <p>STRIGIFORMES Barn owl <i>Tyto alba</i></p> <p>PASSERIFORMES Edible-nest swiftlet <i>Aerodramus fuciphagus</i> Mariana swiftlet <i>A. bartschi</i></p>	<p>Skylark <i>Alauda arvensis</i> Western meadowlark <i>Sturnella neglecta</i> Red-vented bulbul <i>Pycnonotus caferi</i> Red-whiskered bulbul <i>P. jocosus</i> Northern mockingbird <i>Mimus polyglottos</i> White-rumped shama <i>Copsychus malabaricus</i> Melodious laughing thrush <i>Garrulax canorus</i> Greater necklaced laughing thrush <i>G. pectoralis</i> Red-billed leiothrix <i>Leiothrix lutea</i> Japanese bush warbler <i>Cettia diphone</i> Varied tit <i>Parus varius</i> Japanese white-eye <i>Zosterops japonica</i> Saffron finch <i>Sicalis flaveola</i> Yellow-faced grassquit <i>Tiaris olivacea</i> Red-crested cardinal <i>Paroaria coronata</i> Yellow-billed cardinal <i>P. capitata</i> Common northern cardinal <i>Cardinalis cardinalis</i> Spot-breasted oriole <i>Icterus pectoralis</i> Yellow-fronted canary <i>Serinus mozambicus</i> Common canary <i>S. canaria</i> House finch <i>Carpodacus mexicanus</i> Red-cheeked condon-bleu <i>Uraeginthus benglaus</i> Lavender waxbill <i>Estrilda caerulea</i> Orange-cheeked waxbill <i>E. melpoda</i> Common waxbill <i>E. astrild</i> Black-rumped waxbill <i>E. troglodytes</i> Red avadavat <i>Amandava amandava</i> Nutmeg manikin <i>Lonchura punctulata</i> Black-headed manikin <i>L. malacca</i> Warbling silverbill <i>L. malabarica</i> Orange bishop <i>Euplectes franciscanus</i> Java sparrow <i>Padda oryzivora</i> House sparrow <i>Passer domesticus</i> European tree sparrow <i>P. montanus</i> European starling <i>Sturnus vulgaris</i> Common mynah <i>Acridotheres tristis</i> Hill mynah <i>Gracula religiosa</i> Crested mynah <i>Acridotheres cristatellus</i></p>
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Part 3 Reptiles and amphibians introduced into parts of the United States

<p>FROGS AND TOADS Giant toad cane toad <i>Bufo marinus</i> Green-and-black poison dart frog <i>Dendrobates auratus</i> Greenhouse frog <i>Eleutherodactylus planirostris</i> Coqui frog <i>E. coqui</i> Cuban treefrog <i>Osteopilus septentrionalis</i> Rio Grande leopard frog <i>Rana berlandieri</i> Green frog <i>R. clamitans</i> American bullfrog <i>R. catesbeiana</i> Japanese wrinkled frog <i>Glandirana rugosa</i> African clawed frog <i>Xenopus laevis</i></p> <p>SALAMANDERS Tiger salamander <i>Ambystoma tigrinum</i></p> <p>TURTLES Red-eared slider <i>Trachemys scripta elegans</i> Painted turtle <i>Chrysemys picta</i> Spiny softshell <i>Trionyx spiniferus</i> Wattle-necked softshell <i>Palea steindachneri</i> Chinese softshell <i>Pelodiscus sinensis</i> Snapping turtle <i>Chelydra serpentina</i></p> <p>CROCODILIANS Spectacled common caiman <i>Caiman crocodilus</i></p> <p>LIZARDS Red-headed agama <i>Agama agama</i> Giant ameiva <i>Ameiva ameiva</i> Large-headed anole <i>Anolis cybotes</i> Green anole <i>A. carolinensis</i> Bark anole <i>A. distichus</i></p>	<p>Hispaniolan green anole <i>A. chlorocyanus</i> Puerto Rican crested anole <i>A. cristatellus</i> Knight anole <i>A. equestris</i> Cuban green anole <i>A. porcatius</i> Jamaican giant anole <i>A. garmani</i> Marie Gallant Sail-tailed anole <i>A. ferreus</i> Brown anole <i>A. sagrei</i> Brown basilisk <i>Basiliscus vittatus</i> Veiled chameleon <i>Chamaeleo calyptratus</i> Jackson's chameleon <i>C. jacksonii</i> Butterfly lizard <i>Leiolepis belliana</i> Oriental garden lizard variable bloodsucker <i>Calotes versicolor</i> Rainbow whiptail lizard <i>Cnemidophorus lemniscatus</i> Giant whiptail lizard <i>C. [Aspidoselis] motaguae</i> New Mexico whiptail lizard <i>C. neomexicanus</i> Plateau striped whiptail <i>C. velox</i> Northern curlytail lizard <i>Leiocephalus carinatus</i> Red-sided curlytail lizard <i>L. schreibersii</i> Common wall lizard <i>Podarcis muralis</i> Italian wall lizard <i>P. sicula</i> Texas horned lizard <i>Phrynosoma cornutum</i> Black Gray's spinytail iguana <i>Ctenosaura similis</i> Mexican spinytail iguana <i>C. pectinata</i> Green iguana <i>Iguana iguana</i> Ashy gecko <i>Sphaerodactylus elegans</i> Ocellated gecko <i>S. arg</i> Gold dust day gecko <i>Phelsuma laticauda</i> Giant day gecko <i>P. madagascariensis</i> Orange-spotted day gecko <i>P. guimbeaui</i></p>	<p>Moorish gecko <i>Tarentola mauritanica</i> Ringed wall gecko <i>T. annularis</i> Mourning gecko <i>Lepidodactylus lugubris</i> Multilating gecko <i>Gehyra mutilata</i> Rough-tailed gecko <i>Cyrtopodion scabrum</i> Tokay gecko <i>Gekko gekko</i> Common house gecko <i>Hemidactylus frenatus</i> Tropical house gecko wood stave <i>H. mabouia</i> Asian flat-tailed gecko <i>H. platyurus</i> Indo-Pacific gecko <i>H. garnotti</i> Mediterranean gecko <i>H. turcicus</i> Yellow-headed gecko <i>Gonatodes albogularis</i> Indo-Pacific tree gecko <i>Hemiphyllodactylus typus</i> Moth skink <i>Lipinia noctua</i> Azure-tailed skink <i>Emoia impar</i> Copper-tailed skink <i>E. cyanura</i> Many-lined grass skink <i>Mabuya multifasciata</i> Pacific snake-eyed skink <i>Cryptoblepharus poecilopleurus</i> Plague skink <i>Lampropholis delicata</i> Western green lacerta <i>Lacerta bilineata</i> Nile monitor <i>Varanus niloticus</i> Argentina giant tegu <i>Tupinambis merianae</i></p> <p>SNAKES Common boa <i>Boa constrictor</i> Burmese python <i>Python molurus</i> Brahminy blind snake <i>Ramphotyphlops braminus</i> Javan filesnake <i>Acrochordus javanicus</i> Diamondback water snake <i>Nerodia rhombifer</i> Brown treesnake <i>Boiga irregularis</i></p>
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Part 4 Fishes introduced into parts of the United States compiled from Fuller et al. 1999

<p>ACIPENSERIDAE Lake sturgeon <i>Acipenser fulvescens</i> White sturgeon <i>Acipenser transmontanus</i> Sturgeon eastern species <i>Acipenser</i> or <i>Scaphirhynchus</i> sp.</p> <p>ADRIANICHTHYIDAE Japanese medaka <i>Oryzias latipes</i></p> <p>ALBULIDAE Bone fish <i>Albula vulpes</i></p> <p>AMBLYOPOSIDAE Spring cavefish <i>Forbesichthys agassizi</i></p> <p>AMIIDAE Bowfin <i>Amia calva</i></p> <p>ANABANTIDAE Climbing perch <i>Anabas testudineus</i> Twospot climbing perch <i>Ctenopoma nigropanosum</i></p> <p>ANGUILLIDAE European eel <i>Anguilla anguilla</i> Shortfin eel <i>Anguilla australis</i> Unidentified anguillid eel <i>Anguilla</i> sp. American eel <i>Anguilla rostrata</i></p> <p>ANOSTOMIDAE Banded leporinus <i>Leporinus fasciatus</i></p> <p>APHREDODERIDAE Pirate perch <i>Aphredoderus sayanus</i></p> <p>APLOCHEILIDAE Striped panchax <i>Aplocheilichthys lineatus</i> Redtail nothobranch <i>Nothobranchius guentheri</i></p> <p>ATHERINIDAE Siverside <i>Atherinops regius</i> Charal <i>Chirostoma jordani</i> Gulf grunion <i>Leuresthes sardine</i> Brook silverside <i>Labidesthes sicculus</i> Rough silverside <i>Membras martinica</i> Inland silverside <i>Menidia beryllina</i></p> <p>AUCHENIPTERIDAE Driftwood catfish <i>Parauchenipterus gealeatus</i></p> <p>BELONIDAE Inland silversides <i>Strongylura marina</i></p> <p>Asian needlefish <i>Xenentodon cancila</i></p> <p>BELONTIIDAE Siamese fighting fish <i>Betta splendens</i> Banded gourami <i>Colisa fasciata</i> Thicklip gourami <i>Colisa labiosa</i> Dwarf gourami <i>Colisa lalia</i> Paradise fish <i>Macropodus opercularis</i> Pearl gourami <i>Trichogaster leerii</i> Blue gourami <i>Trichogaster trichopterus</i> Croaking gourami <i>Trichopsis vittata</i></p> <p>BOTHIDAE Fringed flounder <i>Etropus crossotus</i> Halibut <i>Paralichthys</i> sp. Atlantic needlefish <i>Paralichthys albigitata</i> River carpsucker <i>Paralichthys lethostigma</i></p> <p>CALLICHTHYIDAE Cascaraudo <i>Callichthys callichthys</i> Green corydoras <i>Corydoras aeneus</i> Corydoras <i>Corydoras</i> sp.</p>	<p>Brown hoplo <i>Hoplosternum littorale</i></p> <p>CARANGIDAE Green jack <i>Caranx caballus</i> Paloma pompano <i>Trachinotus paitensis</i></p> <p>CATOSTOMIDAE Quillback <i>Carpoides carpio</i> Highfin carpsucker <i>Carpoides cyprinus</i> Utah sucker <i>Carpoides velifer</i> Longnose sucker <i>Catostomus ardens</i> White sucker <i>Catostomus catostomus</i> Owens sucker <i>Catostomus commersoni</i> Sacramento sucker <i>Catostomus fumeiventris</i> Dusky mountain sucker <i>Catostomus occidentalis</i> Mountain sucker <i>Catostomus platyrhynchus</i> Rio Grande sucker <i>Catostomus plebeius</i> Santa Ana sucker <i>Catostomus santaanae</i> Tahoe sucker <i>Catostomus tahoensis</i> Little Colorado River sucker <i>Catostomus undescribed</i> sp. Shortnose sucker <i>Chasmistes brevirostris</i> Lake chubsucker <i>Erimyzon sucetta</i> Alabama hog sucker <i>Hypentelium etowanum</i> Northern hog sucker <i>Hypentelium nigricans</i> Smallmouth buffalo <i>Ictiobus bubalus</i> Bigmouth buffalo <i>Ictiobus cyprinellus</i> Black buffalo <i>Ictiobus niger</i> Spotted sucker <i>Minytrema melanops</i> Golden redhorse <i>Moxostoma erythrurum</i> Shorthead redhorse <i>Moxostoma macrolepidotum</i> Black jumprock <i>Scartomyzon cervinus</i> Greater jumprock <i>Scartomyzon lachneri</i> Striped jumprock <i>Scartomyzon rupiscartes</i> Torrent sucker <i>Thoburnia rhothoeca</i></p> <p>CENTRARCHIDAE Roanoke bass <i>Ambloplites cavifrons</i> Ozark bass <i>Ambloplites constellatus</i> Rock bass <i>Ambloplites rupestris</i> Sacramento perch <i>Archoplites interruptus</i> Flier <i>Centrarchus macropterus</i> Warmouth <i>Chaenobryttus gulosus</i> Bluespotted sunfish <i>Enneacanthus gloriosus</i> Redbreast sunfish <i>Lepomis auritus</i> Green sunfish <i>Lepomis cyanellus</i> Pumpkinseed <i>Lepomis gibbosus</i> Orangespotted sunfish <i>Lepomis humilis</i> Bluegill <i>Lepomis macrochirus</i> Longear sunfish <i>Lepomis megalotis</i> Redear sunfish <i>Lepomis microlophus</i> Redspotted sunfish <i>Lepomis miniatus</i> Redeye bass <i>Micropterus coosae</i> Smallmouth bass <i>Micropterus dolomieu</i> Spotted bass <i>Micropterus punctulatus</i> Largemouth bass <i>Micropterus salmoides</i> Guadalupe bass <i>Micropterus treculi</i> Shoal bass <i>Micropterus undescribed</i> sp. White crappie <i>Pomoxis annularis</i> Black crappie <i>Pomoxis nigromaculatus</i></p> <p>CENTROPOMIDAE Tanganyika lates <i>Lates angustifrons</i> Bigeye lates <i>Lates mariae</i> Nile perch <i>Lates niloticus</i></p> <p>CHANIDAE Milkfish <i>Chanos chanos</i></p> <p>CHANNIDAE Giant snakehead <i>Channa micropeltes</i> Chevron snakehead <i>Channa striata</i></p>	<p>CHARACIDAE Bloodfin tetra <i>Aphyocharax anisitsi</i> Mexican tetra <i>Asytanax mexicanus</i> Tambaquí <i>Colossoma macropomum</i> Unidentified pacu <i>Colossoma/Piaractus</i> sp. Black tetra <i>Gymnocorymbus ternetzi</i> Head-and-tail tetra <i>Hemigrammus ocellifer</i> Serpae tetra <i>Hyphessobrycon serape</i> Metynnis <i>Metynnis</i> sp. Redeye tetra <i>Moenkhausia sanctaefilomenae</i> Redhook pacu <i>Myleus rubripinnis</i> Neon tetra <i>Paracheirodon innesi</i> Pirapatinga <i>Piaractus brachypomus</i> Small-scaled pacu <i>Piaractus mesopotamicus</i> Red piranha <i>Pygocentrus nattereri</i> Unidentified piranha <i>Pygocentrus/Serrasalmus</i> sp. Redeye piranha <i>Serrasalmus rhombeus</i></p> <p>CICHLIDAE Blue acara <i>Aequidens pulcher</i> Oscar <i>Astronotus ocellatus</i> Peacock cichlid <i>Cichla ocellaris</i> Speckled pavon <i>Cichla temensis</i> Green guapote <i>Cichlasoma beani</i> Black acara <i>Cichlasoma bimaculatum</i> Midas cichlid <i>Cichlasoma citrinellum</i> Rio Grande cichlid <i>Cichlasoma cyanoguttatum</i> Red devil <i>Cichlasoma labiatum</i> Jaguar guapote <i>Cichlasoma managuense</i> Firemouth cichlid <i>Cichlasoma meeki</i> Convict cichlid <i>Cichlasoma nigrofasciatum</i> Jack Dempsey <i>Cichlasoma octofasciatum</i> Yellowbelly cichlid <i>Cichlasoma salvini</i> Blue-eyed cichlid <i>Cichlasoma spilurum</i> Redhead cichlid <i>Cichlasoma synspilum</i> Threespot cichlid <i>Cichlasoma trimaculatum</i> Mayan cichlid <i>Cichlasoma urophthalmus</i> Pearl eartheater <i>Geophagus brasiliensis</i> Redstriped eartheater <i>Geophagus surinamensis</i> Banded jewelfish <i>Hemichromis elongates</i> Jewelfish <i>Hemichromis letourneauxi</i> Banded cichlid <i>Heros severus</i> Scrapermouth cichlid <i>Labeotropheus</i> sp. Golden mbuna <i>Melanochromis auratus</i> Bluegray mbuna <i>Melanochromis johanni</i> Blue tilapia <i>Oreochromis aureus</i> Longfin tilapia <i>Oreochromis macrochir</i> Mozambique tilapia <i>Oreochromis mossambicus</i> Nile tilapia <i>Oreochromis niloticus</i> Wami tilapia <i>Oreochromis urolepis</i> Rainbow krib <i>Pelvicachromis pulcher</i> African Lake cichlid <i>Pseudotropheus</i> sp. Zebra mbuna <i>Pseudotropheus zebra</i> Freshwater angelfish <i>Pterophyllum</i> sp. Blackchin tilapia <i>Sarotherodon melanotheron</i> Red discus <i>Symphysodon discus</i> Lake Tanganyika dwarf cichlid <i>Telmatochromis bifrenatus</i> Spotted tilapia <i>Tilapia mariae</i> Redbreast tilapia <i>Tilapia rendalli</i> Banded tilapia <i>Tilapia sparrmannii</i> Redbelly tilapia <i>Tilapia zillii</i> Unidentified tilapias <i>tilapine cichlids</i></p> <p>CLARIIDAE Walking catfish <i>Clarias batrachus</i> Whitespotted clarias <i>Clarias fuscus</i></p> <p>CLUPEIDAE Blueback herring <i>Alosa aestivalis</i> Skipjack herring <i>Alosa chrysochloris</i> Alewife <i>Alosa pseudoharengus</i> American shad <i>Alosa sapidissima</i></p>
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WITMER GW: Vertebrate introductions in the United States

<p>Gizzard shad <i>Dorosoma cepedianum</i> Threadfin shad <i>Dorosoma petenense</i> Deepbody thread herring <i>Opisthonema libertate</i></p> <p>COBITIDAE Oriental weatherfish <i>Misgurnus anguillicaudatus</i> Chinese fine-scaled loach <i>Misgurnus mizolepis</i> Coolie loach <i>Pangio kuhlii</i></p> <p>COTTIDAE Prickly sculpin <i>Cottus asper</i> Bear Lake sculpin <i>Cottus extensus</i> Shoshone sculpin <i>Cottus greenei</i></p> <p>CYPRINIDAE Zebra danio <i>Brachydanio rerio</i> Central stoneroller <i>Camptostoma anomalum</i> Largescale stoneroller <i>Camptostoma oligolepis</i> Goldfish <i>Carassius auratus</i> Crucian carp <i>Carassius carassius</i> Redside dace <i>Clinostomus elongatus</i> Rosyside dace <i>Clinostomus funduloides</i> Lake chub <i>Couesius plumbeus</i> Grass carp <i>Ctenopharyngodon idella</i> Satinfin shiner <i>Cyprinella anolostana</i> Whitetail shiner <i>Cyprinella galactura</i> Red shiner <i>Cyprinella lutrensis</i> Fieryblack shiner <i>Cyprinella pyrrhomelas</i> Spotfin shiner <i>Cyprinella spiloptera</i> Blacktail shiner <i>Cyprinella venusta</i> Steelcolor shiner <i>Cyprinella whipplei</i> Common carp <i>Cyprinus carpio</i> Malabar danio <i>Danio malabaricus</i> Desert dace <i>Eremichthys across</i> Tonguetied minnow <i>Exoglossum laurae</i> Cutlips minnow <i>Exoglossum maxilllingua</i> Utah chub <i>Gila atraria</i> Tui chub <i>Gila bicolor</i> Blue chub <i>Gila copei</i> Leatherside chub <i>Gila orcutti</i> Arroyo chub <i>Gila Pandora</i> Rio Grande Chub <i>Gila purpurea</i> Virgin River chub <i>Gila robusta</i> California roach <i>Hesperoleucus symmetricus</i> Brassy minnow <i>Hybognathus hankinsoni</i> Plains minnow <i>Hybognathus placitus</i> Eastern silvery minnow <i>Hybognathus regius</i> Bigeye chub <i>Hybopsis amblops</i> Clear chub <i>Hybopsis winchelli</i> Silver carp <i>Hypophthalmichthys molitrix</i> Bighead carp <i>Hypophthalmichthys nobilis</i> Least chub <i>Iotichthys phlegethois</i> Hitch <i>Lavina exilicauda</i> White River spinedace <i>Lepidomeda albivallis</i> Virgin spindace <i>Lepidomeda mollispinis</i> Ide <i>Leuciscus idus</i> White shiner <i>Luxilus albeolus</i> Crescent shiner <i>Luxilus cerasinus</i> Striped shiner <i>Luxilus chrysocephalus</i> Warpaint shiner <i>Luxilus coccogenis</i> Common shiner <i>Luxilus cornutus</i> Bandfin shiner <i>Luxilus zonistius</i> Rosefin shiner <i>Lythrurus ardens</i> Blacktip shiner <i>Lythrurus atrapiculatus</i> Pearl dace <i>Margariscus margarita</i> Spikedace <i>Meda fulgida</i> Moapa dace <i>Moapa coriacea</i> Black sharkminnow <i>Morulus chrysophekadion</i> Black carp <i>Mylopharyngodon piceus</i> Hornyhead chub <i>Nocomis biguttatus</i> Bluehead chub <i>Nocomis leptoccephalus</i> River chub <i>Nocomis micropogon</i></p>	<p>Bull chub <i>Nocomis raneyi</i> Golden shiner <i>Notemigonus crysoleucas</i> Comely shiner <i>Notropis amoenus</i> Popeye shiner <i>Notropis ariommus</i> Emerald shiner <i>Notropis atherinoides</i> Rough shiner <i>Notropis baileyi</i> Red River shiner <i>Notropis bairdi</i> Bridle shiner <i>Notropis bifrenatus</i> River shiner <i>Notropis blennioides</i> Bigeye shiner <i>Notropis boops</i> Silverjaw minnow <i>Notropis buccatus</i> Smalleye shiner <i>Notropis buccula</i> Ghost shiner <i>Notropis buchmanii</i> Redlip shiner <i>Notropis chiliticus</i> Rainbow shiner <i>Notropis chrosomus</i> Bigmouth shiner <i>Notropis dorsalis</i> Arkansas River shiner <i>Notropis girardi</i> Redeye chub <i>Notropis harperi</i> Spottail shiner <i>Notropis hudsonius</i> Highscale shiner <i>Notropis hypsilepis</i> Tennessee shiner <i>Notropis leuciodus</i> Longnose minnow <i>Notropis longirostris</i> Sand shiner <i>Notropis ludibundus</i> Yellowfin shiner <i>Notropis lutipinnis</i> Ozark minnow <i>Notropis nubilus</i> Sharpnose shiner <i>Notropis oxyrhynchus</i> Ozark shiner <i>Notropis ozarcanus</i> Chub shiner <i>Notropis potteri</i> Swallowtail shiner <i>Notropis procne</i> Rosyface shiner <i>Notropis rubellus</i> Saffron shiner <i>Notropis rubricroceus</i> Silverband shiner <i>Notropis shumardi</i> Mirror shiner <i>Notropis spectrunculus</i> Telescope shiner <i>Notropis telescopes</i> Weed shiner <i>Notropis texanus</i> Mimic Shiner <i>Notropis volucellus</i> Coosa shiner <i>Notropis xaenoccephalus</i> Sacramento blackfish <i>Orthodon microlepidotus</i> Suckermouth minnow <i>Phenacobius mirabilis</i> Northern redbelly dace <i>Phoxinus eos</i> Mountain redbelly dace <i>Phoxinus oreas</i> Bluntnose minnow <i>Pimephales notatus</i> Fathead minnow <i>Pimephales promelas</i> Slim minnow <i>Pimephales tenellus</i> Bullhead minnow <i>Pimephales vigilax</i> Woundfin <i>Plagopterus argentissius</i> Flathead chub <i>Platygobio gracilis</i> Splittail <i>Pogonichthys macrolepidotus</i> Sacramento squawfish <i>Ptychocheilus grandis</i> Northern squawfish <i>Ptychocheilus oregonensis</i> Umpqua squawfish <i>Ptychocheilus umpquae</i> Rosy barb <i>Puntius conchonius</i> Blacksport barb <i>Puntius filamentosus</i> Dwarf barb <i>Puntius gelius</i> Tinfoil barb <i>Puntius schwanenfeldii</i> Green barb <i>Puntius semifasciolatus</i> Tiger barb <i>Puntius tetrazona</i> Relict dace <i>Relictus solitarius</i> Blacknose dace <i>Rhinichthys atratulus</i> Longnose dace <i>Rhinichthys cataractae</i> Longfin dace <i>Rhinichthys chrysogaster</i> Speckled dace <i>Rhinichthys osculus</i> Bitterling <i>Rhodeus sericeus</i> Redside shiner <i>Richardsonius balteatus</i> Lahontan redbelly <i>Richardsonius egregius</i> Rudd <i>Scardinius erythrophthalmus</i> Creek chub <i>Semotilus atromaculatus</i> Fallfish <i>Semotilus corporalis</i> Tench <i>Tinca tinca</i></p> <p>CYPRINODONTIDAE</p>	<p>Devils Hole pupfish <i>Cyprinodon diabolis</i> Desert pupfish <i>Cyprinodon macularius</i> Amargosa pupfish <i>Cyprinodon nevadensis</i> Owens pupfish <i>Cyprinodon radiosus</i> Red River pupfish <i>Cyprinodon rubrofluvialis</i> Salt Creek pupfish <i>Cyprinodon salinus</i> Sheepshead minnow <i>Cyprinodon variegatus</i> Flagfish <i>Jordanella floridae</i></p> <p>DORADIDAE Ripsaw catfish <i>Oxydoras niger</i> Raphael catfish <i>Platydoras costatus</i> Granulated catfish <i>Pterodoras granulosus</i> Thorny catfish <i>Pterodoras sp.</i></p> <p>EMBIOTOCIDAE Tule perch <i>Hysterocarpus traski</i></p> <p>ENGRAULIDAE Northern Gulf anchovy <i>Anchoa mundeoloides</i> Anchoveta <i>Cetengraulis mysticetus</i> Northern anchovy <i>Engraulis mordax</i></p> <p>ERYTHRINIDAE Trahira <i>Hoplias malabaricus</i></p> <p>ESOCIDAE Grass pickerel <i>Esox americanus</i> Northern pike <i>Esox lucius</i> Muskellunge <i>Esox masquinongy</i> Chain pickerel <i>Esox niger</i> Amur pike <i>Esox reicherti</i></p> <p>FUNDULIDAE Northern studfish <i>Fundulus catenatus</i> Golden topminnow <i>Fundulus chrysotus</i> Banded killfish <i>Fundulus diaphanus</i> Gulf killfish <i>Fundulus grandis</i> Mummichog <i>Fundulus heteroclitus</i> Lined topminnow <i>Fundulus lineolatus</i> Blackstripe topminnow <i>Fundulus notatus</i> Plains topminnow <i>Fundulus sciadicus</i> Seminole killfish <i>Fundulus seminolis</i> Southern studfish <i>Fundulus stellifer</i> Plains killfish <i>Fundulus zebrinus</i> Bluefin killfish <i>Lucania goodei</i> Rainwater killfish <i>Lucania parva</i></p> <p>GADIDAE Burbot <i>Lota lota</i></p> <p>GASTEROSTEIDAE Fourspine stickleback <i>Apeltes quadracus</i> Brook stickleback <i>Culaea inconstans</i> Threespine stickleback <i>Gasterosteus aculeatus</i> Ninespine stickleback <i>Pungitius pungitius</i></p> <p>GERREIDAE Spotfin mojarra <i>Eucinostomus argenteus</i> Pacific flagfin mojarra <i>Eucinostomus gracilis</i></p> <p>GOBIIDAE Yellowfin goby <i>Acanthogobius flavimanus</i> Longjaw mudsucker <i>Gillichthys mirabilis</i> Mudsucker <i>Gillichthys seta</i> Naked goby <i>Gobiosoma bosc</i> Round goby <i>Neogobius melanostomus</i> Tubenose goby <i>Proterorhinus marmoratus</i> Shokihaze goby <i>Tridentiger barbatus</i> Shimofuri goby <i>Tridentiger bifasciatus</i> Chameleon goby <i>Tridentiger trigonocephalus</i></p>
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WITMER GW: Vertebrate introductions in the United States

<p>IDAE Butterfly splitfin <i>Ameia splendens</i> Hiko White River springfish <i>Crenichthys baileyi</i> Railroad Valley springfish <i>Crenichthys nevadae</i> Pahrump killfish <i>Empetrichthys latos</i></p> <p>HAEMULIDAE Sargo <i>Anisotremus davidsonii</i></p> <p>HELOSTOMATIDAE Kissing gourami <i>Helostoma temminckii</i></p> <p>HIODONTIDAE Goldeye <i>Hiodon alosoides</i> Mooneye <i>Hiodon tergisus</i></p> <p>ICTALURIDAE Snail bullhead <i>Ameiurus brunneus</i> White catfish <i>Ameiurus catus</i> Black bullhead <i>Ameiurus melas</i> Northern black bullhead <i>Ameiurus natalis</i> Yellow bullhead <i>Ameiurus nebulosus</i> Brown bullhead <i>Ameiurus platycephalus</i> Blue catfish <i>Ictalurus furcatus</i> Yaqui catfish <i>Ictalurus pricei</i> Channel catfish <i>Ictalurus punctatus</i> Slender madtom <i>Noturus exilis</i> Stonecat <i>Noturus flavus</i> Orange-fin madtom <i>Noturus gilberti</i> Tadpole madtom <i>Noturus gyrinus</i> Margined madtom <i>Noturus insignis</i> Brindled madtom <i>Noturus miurus</i> Flathead catfish <i>Pylodictis olivaris</i></p> <p>KUHLIIDAE Nato <i>Kuhlia rupestris</i></p> <p>KYPHOSIDAE Opaleye <i>Girella simplicidens</i></p> <p>LABRIDAE Rock wrasse <i>Halichoeres semicinctus</i> Tautog <i>Tautoga onitis</i></p> <p>LEPISOSTEIDAE Alligator gar <i>Atractosteus spatula</i> Spotted gar <i>Lepisosteus oculatus</i> Shortnose gar <i>Lepisosteus platostomus</i> Gar <i>Lepisosteus sp.</i></p> <p>LORICARIIDAE Suckermouth catfish <i>Ancistrus sp.</i> Clown knife <i>Peckoltia sp.</i> Vermiculated sailfin catfish <i>Pterygoplichthys disjunctivus</i> Orinoco sailfin catfish <i>Pterygoplichthys multiradiatus</i> Amazon sailfin catfish <i>Pterygoplichthys pardalis</i></p> <p>MEGALOPIDAE Tarpon <i>Megalops atlanticus</i></p> <p>MELANOTAENIIDAE Black-banded rainbowfish <i>Melanotaenia nigrans</i></p> <p>MORONIDAE White perch <i>Morone americana</i> White bass <i>Morone chrysops</i> Yellow bass <i>Morone mississippiensis</i> Stiped bass <i>Morone saxatilis</i></p> <p>MUGILIDAE Striped mullet <i>Mugil cephalus</i> White mullet <i>Mugil curema</i></p> <p>NEMASTISTIIDAE Roosterfish <i>Nemastiftius pectoralis</i></p>	<p>NOTOPTERIDAE Clown knife <i>Chitala ornata</i></p> <p>OSMERIDAE Wakasagi <i>Hypomesus nipponensis</i> Delta smelt <i>Hypomesus transpacificus</i> Rainbow smelt <i>Osmerus mordax</i> Ayu <i>Plecoglossus altivelis</i></p> <p>OSPHRONEMIDAE Giant gourami <i>Osphronemus goramy</i></p> <p>OSTEOGLOSSIDAE Arawana <i>Osteoglossum becirrhosum</i></p> <p>PERCIDAE Florida sand darter <i>Ammocrypta bifascia</i> Western sand darter <i>Ammocrypta clara</i> Greenside darter <i>Etheostoma blenniodes</i> Rainbow darter <i>Etheostoma caeruleum</i> Arkansas darter <i>Etheostoma cragini</i> Brown darter <i>Etheostoma edwini</i> Iowa darter <i>Etheostoma exile</i> Swamp darter <i>Etheostoma fusiforme</i> Johnny darter <i>Etheostoma nigrum</i> Watercress darter <i>Etheostoma nuchale</i> Tessellated darter <i>Etheostoma olmstedii</i> Snubnose darter <i>Etheostoma simoterum</i> Banded darter <i>Etheostoma zonale</i> Ruffe <i>Gymnocephalus cernuus</i> Yellow perch <i>Perca flavescens</i> Logperch <i>Percina caprodes</i> Bigscale logperch <i>Percina macrolepidia</i> Blackside darter <i>Percina maculata</i> Roanoke darter <i>Percina roanoka</i> River darter <i>Percina shumardi</i> Snail darter <i>Percina tanasi</i> Sauger <i>Stizostedion canadense</i> Zander <i>Stizostedion lucioperca</i> Walleye <i>Stizostedion vitreum</i></p> <p>PERCOPSIDAE Trout-perch <i>Percopsis omiscomaycus</i></p> <p>PETROMYZONTIDAE Silver lamprey <i>Lampetra appendix</i> Sea lamprey <i>Petromyzon marinus</i></p> <p>PIMELODIDAE Leopard catfish <i>Perrunichthys perruno</i> Redtail catfish <i>Phractocephalus hemiolioperus</i> Bagre <i>Rhamdia quelen</i></p> <p>PLEURONECTIDAE Diamond turbot <i>Hysopsetta guttulata</i> European flounder <i>Platichthys flesus</i> Starry flounder <i>Platyichthys stellatus</i></p> <p>POECILIIDAE Pike killfish <i>Belonesox belizanus</i> Western mosquitofish <i>Gambusia affinis</i> Largespring gambusia <i>Gambusia geiseri</i> Eastern mosquitofish <i>Gambusia holbrooki</i> Pecos gambusia <i>Gambusia nobilis</i> Least killifish <i>Heterandria formosa</i> Cuban limia <i>Limia vittata</i> Amazon molly <i>Poecilia formosa</i> Sailfin molly <i>Poecilia latipinna</i> Broadspotted molly <i>Poecilia latipunctata</i> Shortfin molly <i>Poecilia mexicana</i> Swordtail molly <i>Poecilia petenensis</i> Guppy <i>Poecilia reticulata</i> Liberty molly <i>Poecilia sphenops</i></p>	<p>Porthole livebearer <i>Poeciliopsis gracilis</i> Livebearer <i>Poeciliopsis sp.</i> Unidentified <i>Poeciliopsis Poeciliopsis sp.</i> Green swordtail <i>Xiphophorus hellerii</i> Southern platyfish <i>Xiphophorus maculatus</i> Variable platyfish <i>Xiphophorus variatus</i></p> <p>POLYODONTIDAE Paddlefish <i>Polydon spathula</i></p> <p>RIVULIDAE Argentine pearlfish <i>Cynolebias bellottii</i> Blackfin pearlfish <i>Cynolebias nigripinnis</i> Giant rivulus <i>Rivulus hartii</i> Rio pearlfish <i>Simpsonichthys whitei</i></p> <p>SALMONIDAE Vendace <i>Coregonus albula</i> Cisco <i>Coregonus artedii</i> Lake whitefish <i>Coregonus clupeaformis</i> Powan <i>Coregonus lavaretus</i> Huchen <i>Hucho hucho</i> Golden trout <i>Oncorhynchus aguabonita</i> Cutthroat trout <i>Oncorhynchus clarki</i> Gila trout <i>Oncorhynchus gilae</i> Pink salmon <i>Oncorhynchus gorbuscha</i> Chum salmon <i>Oncorhynchus keta</i> Coho salmon <i>Oncorhynchus kisutch</i> Cherry salmon <i>Oncorhynchus masou</i> Rainbow trout <i>Oncorhynchus mykiss</i> Kokanee <i>Oncorhynchus nerka</i> Chinook salmon <i>Oncorhynchus tshawytscha</i> Round whitefish <i>Prosopium cylindraceum</i> Bonneville cisco <i>Prosopium gemmifer</i> Mountain whitefish <i>Prosopium williamsoni</i> Ohrid trout <i>Salmo letnica</i> Atlantic salmon <i>Salmo salar</i> Brown trout <i>Salmo trutta</i> Arctic char <i>Salvelinus alpinus</i> Blueback trout <i>Salvelinus aureolus</i> Brook trout <i>Salvelinus fontinalis</i> Dolly Varden <i>Salvelinus malma</i> Lake trout <i>Salvelinus namaycush</i> Arctic grayling <i>Thymallus arcticus</i></p> <p>SCIAENIDAE Freshwater drum <i>Aplodinotus grunniens</i> Bairdiella <i>Bairdiella icistia</i> Spotted seatrout <i>Cynoscion nebulosus</i> Scaly corvine <i>Cynoscion othonopterus</i> Shortfin corvina <i>Cynoscion parvipinnis</i> Orangemouth corvine <i>Cynoscion xanthulus</i> Spot <i>Leiostomus xanthurus</i> Corbina <i>Menticirrhus nasus</i> California corbina <i>Menticirrhus undulatus</i> Croaker <i>Micropogonias megalops</i> Atlantic croaker <i>Micropogonias undulatus</i> Black drum <i>Pogonias cromis</i> Red drum <i>Sciaenops ocellatus</i> Totuava <i>Totoaba macdonaldi</i></p> <p>SCOMBRIDAE Gulf sierra <i>Scombreromorus concolor</i></p> <p>SERRANIDAE Spotted sand bass <i>Paralabrax maculatofasciatus</i></p> <p>SYNBRANCHIDAE Swamp eel <i>Nothopterus albus</i></p> <p>UMBRIDAE Alaska blackfish <i>Dallia pectoralis</i> Olympic mudminnow <i>Novumbra hubbsi</i> Central mudminnow <i>Umbra limi</i></p>
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