

Vertebrate species introductions in the United States and its territories

Gary W. WITMER^{1*}, Pam L. FULLER²

¹USDA/APHIS/WS National Wildlife Research Center, 4101 Laporte Avenue, Fort Collins CO 80521-2154, USA

²USGS/BRD, Southeast Ecological Science Center, 7920 NW 71st Street, Gainesville FL 32653, USA

Abstract At least 1,065 introduced vertebrate species have been introduced in the United States and its territories, including at least 86 mammalian, 127 avian, 179 reptilian/amphibian, and 673 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. We briefly review some of these species and the types of damage they cause. We then review the basic types of methods used for control or eradication of each taxonomic group, including physical, chemical, biological, and cultural methods. We discuss some of the challenges in managing these species, including issues with the use of toxicants, land access, public attitudes, and monitoring difficulties. Finally, we list some ongoing research and future research needs, including improved detection methods, improved attractants, improved barriers, improved capture methods, fertility control, and risk assessment methods [*Current Zoology* 57 (5): 559–567, 2011].

Keywords 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, hitch hikers or stow-aways in or on other commodities, 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 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, our 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, we present a list of vertebrate species by taxonomic grouping that have been introduced into the United States and its territories. We 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, we 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

We compiled the list of introduced vertebrate species by taxonomic groups from a variety of sources, inclu-

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* Corresponding author. E-mail: gary.w.witmer@aphis.usda.gov

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ding 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, nas.er.usgs.gov, www.fort.usgs.gov, www.hear.org, myfwc.com). 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). Our 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 we have compiled is quite long because we have included many species that are native to North America, but have been translocated to states, drainages, or regions in which they did not occur historically. We 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. Many species on this list have failed to reproduce, have been eradicated, or do not have breeding populations. Establishment is often difficult to determine in an area and different agencies use different definitions. For example, Florida agencies use a "10 year rule" of documentation of breeding and establishment in several counties (until it is considered too widespread to be eradicated) before the species is put on its listed of introduced and established species. The US Geological Survey's Nuisance Aquatic Species program defines it as reproducing and overwintering. Others consider establishment to be equivalent to "persisting", hence long lived species can persist without reproducing or can be maintained through stocking. 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 be related to factors such as a mild year-round climate which al-

lows 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, our list of species (See journal webpage for the supplemental material) is definitely not exhaustive. It should be considered preliminary and we hope to update it periodically. Additionally, some of these introduced populations may die out over time or may be extirpated.

At least 86 species of mammals have been introduced in parts of the United States (Table 1 and the supplemental material at the journal webpage). Mammals were mainly introduced for sport hunting, but also for food and fur (Kraus, 2003). The largest single group is the ungulates (hooved mammals) with 35 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 (19), 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 auropunctatus*, 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 7 species of primates have become established in parts of the United States.

At least 127 species of birds have been introduced in parts of the United States (Table 1 and journal webpage). Most introductions were as pets, but many were introduced for sport hunting (Kraus, 2003). Most of these are passerine birds (43 species), but many are psitticines (31 species, popular animals in the pet industry). There are also a large number (27 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). This situation may have changed, however, with the many recent bird introductions in Florida.

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

Taxonomic Group	Taxonomic Order	Number of Species
Mammals (86 spp.)	Didelphimorphia (Opossums)	2
	Soricomorpha (Shrews)	1
	Chiroptera (Bats)	1
	Cingulata (Armadillos)	1
	Lagomorpha (Rabbits, Hares)	6
	Rodentia (Rodents)	19
	Carnivora (Carnivores)	14
	Perissodactyla (Odd-toed ungulates)	3
	Artiodactyla (Even-toed ungulates)	32
	Primates (Primates)	7
Birds (127 spp.)	Anseriformes (Ducks, Geese, Swans)	13
	Galliformes (Fowls)	27
	Ciconiiformes (Egrets, Ibises)	3
	Columbiformes (Doves)	9
	Strigiformes (Owls)	1
	Psittaciformes (Parrots)	31
	Passeriformes (Perching birds)	43
Reptiles (126 spp.)	Crocodylia (Crocodilians)	4
	Squamata (Lizards)	78
	Squamata (Snakes)	18
	Testudines (Turtles)	26
Amphibians (53 spp.)	Anura (Frogs, Toads)	42
	Caudata (Salamanders, Newts)	11
Fishes (673 fish spp.)	Petromyzontiformes (Lampreys)	3
	Orectolobiformes (Carpet sharks)	1
	Caracharhiniformes (Ground sharks)	1
	Polypteriformes (Bichirs)	1
	Acipenseriformes (Sturgeons, Paddlefishes)	3
	Semionotiformes (Gars)	5
	Amiiformes (Bowfins)	1
	Osteoglossiformes (Bonytongues)	4
	Elopiformes (Tarpons)	1
	Albuliformes (Bonefishes)	1
	Anguilliformes (Eels)	6
	Clupeiformes (Anchovies, Herrings)	13
	Gonorhynchiformes (Milkfishes)	1
	Cypriniformes (Minnows, Suckers, Loaches)	176
	Characiformes (Leporins and Piranhas)	19
	Siluriformes (Catfishes)	50
	Esociformes (Pikes, Mudminnows)	11
	Osmeriformes (Smelts)	4
	Salmoniformes (Salmons)	50
	Percopsiformes (Trout-perches)	4
	Gadiformes (Cods)	1
	Mugiliformes (Mulletts)	3
	Atheriniformes ((Silversides)	7
	Beloniformes ((Needlefishes)	3
	Cyprinodontiformes (Killifishes)	60
	Gasterosteiformes (Sticklebacks)	4
	Synbranchiformes (Swamp Eels)	3
Perciformes (Perch-like fishes)	224	
Plueronectiformes (Flounders, Soles)	8	
Tetraodontiformes (Puffers, Triggerfishes)	5	

* See text for a listing of the major references used to compile the species numbers in this table

At least 179 species of reptiles and amphibians have been introduced in parts of the United States (Table 1 and the supplemental material at the journal webpage). 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 reptiles and amphibians which may be why that state seems to have the largest number of established species. The largest single group of reptiles and amphibians is the lizards (78 species). Substantial numbers of frog and toad species (42) have also been introduced. Other groups (salamanders and newts, turtles, snakes, crocodylians) comprise smaller numbers (3–26 species) per group.

At least 673 taxa (includes subspecies and hybrids) of fish have been introduced in parts of the United States (Table 1 and the supplemental material at the journal webpage). This list is derived from the US Geological Survey's Nonindigenous Aquatic Species database and includes freshwater and marine species from the mainland US, Hawaii, Alaska, Puerto Rico and the Virgin Islands. It comprises all species with documented introductions, even if the introduction is believed to have failed. Hybrids are included if they are stocked as hybrids, but not if the hybrids arise in the wild because of stocking a non-native parent species. About half of these species 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 [Appollonia] 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., goldfish *Carassius auratus*, red-bellied pacu *Piaractus brachyomus*) 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 taxonomic orders (Cypriniformes and Perciformes) comprising at least 400 species (see Table 1).

3 Some Problematic Introduced Vertebrates

A number of species within each major taxonomic group of vertebrates pose serious problems over por-

tions of the United States. We 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 amphibian 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 reptiles and amphibians 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 reptiles (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 unknown, but they 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 sportsfish. 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), Dawson and Kolar (2003), 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 eradication have utilised anticoagu-

lant 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; Millett 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, 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. The state of Florida has attempted eradication of two species, purple swamphen *Porphyrrio porphyrio* and sacred ibis *Threskiornithes aethiopicus* using shooting and trapping by state and federal personnel. To date, efforts to eradicate these two species of invasive birds in Florida have been unsuccessful (Scott Hardin, pers. comm.).

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 amphibians and reptiles. 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). We are not aware of any eradications of introduced reptiles and amphibians 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 reptiles and amphibians, 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 treesnakes 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 undo 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 organised, 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 may be relatively little coordination and cooperation across some 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 may benefit from 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). Short of this difficult task, the databases could be made to be searchable from a single portal. Two such efforts are underway and have made significant progress. NISbase (nisbase.org) searches numerous aquatic databases. The Global Invasive Species Information Network (GISIN.org) is building a global system for all species. Finally, risk assessments are needed to determine on which species we should focus our efforts and resources (Hayes, 2003).

6 Conclusions

At least 1,065 species of introduced/invasive vertebrate species occur in the United States and its territories (See journal webpage for the supplemental material). We suspect that invasive vertebrate species will continue to challenge land and resource managers, ecologists, and biologists for a long time to come. We also suspect that the list of invasive vertebrate species will continue to grow; but, hopefully, some species will also be removed from the list by being extirpated or by dying out on their own. 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. Areas for progress include 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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Supplemental material: Vertebrate introductions into parts of the United States

Part 1 Mammals introduced into parts of the United States

DIDELPHIMORPHIA

Opossum *Didelphis virginiana*

Brush-tailed rock wallaby *Petrogale penicillata*

SORICOMORPHA

House shrew *Suncus murinus*

CHIROPTERA

Pallas's mastiff bat *Molossus molossus*

CINGULATA

Nine-banded armadillo *Dasypus novemcinctus*

LAGOMORPHA

Eastern cottontail *Sylvilagus floridanus*

European rabbit *Oryctolagus cuniculus*

Snowshoe hare *Lepus americanus*

Black-tailed jackrabbit *L. californicus*

European hare *L. europaeus*

White-tailed jackrabbit *L. townsendii*

RODENTIA

Arctic ground squirrel *Spermophilus parryii*

Prairie dog *Cynomys ludovicianus*

Abert's squirrel *Sciurus aberti*

Mexican red-bellied squirrel *S. aureogaster*

Gray squirrel *S. carolinensis*

Fox squirrel *S. niger*

Red squirrel *S. vulgaris*

Kangaroo rat *Dipodomys ordii*

Deer mouse *Peromyscus maniculatus*

Red-backed vole *Clethrionomys rutilus*

Muskrat *Ondatra zibethicus*

Polynesian rat kiore *Rattus exulans*

Norway brown rat *R. norvegicus*

Ship black, roof rat *R. rattus*

Gambian giant pouched rat *Cricetomys gambianus*

House mouse *Mus musculus*

Beaver *Castor canadensis*

Nutria *Myocastor coypus*

Capybara *Hydrochaeris hydrochaeris*

CARNIVORA

Red fox *Vulpes vulpes*

Arctic fox *Alopex lagopus*

Feral dog *Canis familiaris*

Coyote *C. latrans*

Raccoon *Procyon lotor*

Coatimundi *Nasua nasua*

White-nosed coati *N. narica*

Stoat ermine, short-tailed weasel *Mustela erminea*

Least weasel *M. nivalis*

European polecat *M. putorius*

American mink *M. vision*

Small Indian mongoose *Herpestes auropunctatus*

Feral cat *Felis catus/silvestris*

Jaguarundi *Puma yagouaroundi*

PERISSODACTYLA

Donkey burro *Equus asinus*

Feral horse *E. caballus*

Burchell's zebra *E. burchelli*

ARTIODACTYLA

Feral pig *Sus scrofa*

Camel *Camelus bactrianus*

Axis deer *Cervus axis*

Fallow deer *Dama. dama*

Swamp deer *C. duvauceli*

Wapiti, American elk, red deer *C. elaphus*

Sika deer *C. nippon*

Sambar deer *C. unicolor*

Philippine deer *C. mariannus*

Black-tailed deer *Odocoileus hemionus*

Roe deer *Capreolus capreolus*

Gray duiker *Sylvicapra grimmia*

Moose *Alces alces*

Reindeer caribou *Rangifer tarandus*

Pronghorn antelope *Antilocapra Americana*

Eland *Taurotragus oryx*

Nilgai *Boselaphus tragocamelus*

Water buffalo *Bubalus bubalis*

Feral cattle *Bos taurus*

Bison *Bison bison*

Gemsbok *Oryx gazelle*

Blackbuck *Antelope cervicapra*

Mountain goat *Oreamnos americanus*

Chamois *Rupicapra rupicapra*

Musk-ox *Ovibos moshatatus*

Himalayan tahr *Hemitragus jemlahicus*

Feral goat *Capra hircus*

Alpine ibex *C. ibex*

Aoudad Barbary sheep *Ammotragus lervia*

Mouflon sheep *Ovis ammon*

Feral sheep *O. aries*

Bighorn sheep *O. canadensis*

PRIMATES

Squirrel monkey *Saimiri sciureus*

Vervet monkey *Cercopithecus aethiops*

Green (Velvet) monkey *Chlorocebus aethiops*

Crab-eating Monkey *Macaca fascicularis*

Japanese macaque *M. fuscata*

Rhesus monkey *M. mulatta*

Chimpanzee *Pan troglodytes*

Part 2 Birds introduced into parts of the United States

ANSERIFORMES

Mute swan *Cygnus olor*
 Whooper swan *C. cygnus*
 Black swan *C. atratus*
 Mandarin duck *Aix galericulata*
 Muscovy duck *Cairina moschata*
 American black duck *Anas rubripes*
 Mallard *A. platyrhynchos*
 Bean goose *A. fabalis*
 Greylag goose *A. anser*
 Swan goose *A. cygnoides*
 Egyptian goose *Alopochen aegyptiaca*
 Ringed teal *Callonetta leucophrys*
 Coscoroba swan *Coscoroba coscoroba*

CICONIIFORMES

Cattle egret *Bubulcus ibis*
 Scarlet ibis *Eudocimus ruber*
 Sacred ibis *Threskiornis aethiopicus*

GALLIFORMES

Plain chachalaca *Ortalis vetula*
 Bobwhite quail *Colinus virginianus*
 Mountain quail *Oreortyx picta*
 California quail *Lophortyx californicus*
 Gambel's quail *L. gambellii*
 Scaled quail *Callipepla squamata*
 Chukar partridge *Alectoris chukar*
 Barbary partridge *A. Barbara*
 Grey partridge *Perdix perdix*
 Black francolin *Francolinus francolinus*
 Grey francolin *F. pondicerianus*
 Erkel's francolin *F. erkelii*
 Himalayan snowcock
Tetragallus himalayensis
 Common quail *Coturnix coturnix*
Coturnix coturnix
 Chinese bamboo partridge
Bambusicola thoracica
 Kalij pheasant *Lophura leucomelana*
 Red jungle fowl *Gallus gallus*
 Common ring-necked pheasant
Phasianus colchicus
 Reeve's pheasant *Syrnaticus reevesii*

Helmeted guineafowl *Numida meleagris*
 Common peafowl *Pavo cristatus*
 White-tailed ptarmigan *Lagopus leucurus*
 Common turkey *Melagris gallopavo*
 Chesnut-bellied sandgrouse *Pterocles exustus*
 Ruffed grouse *Bonasa umbellus*
 Purple swamphen *Porphyrio porphyrio*

COLUMBIFORMES

Feral pigeon rock dove *Columba livia*
 Inca dove *Columbina inca*
 African collared dove
Streptopelia roseo grisea
 Eurasian collared dove *S. decacocto*
 Ringed turtle-dove *S. risoria*
 Spotted dove *S. chinensis*
 Barred zebra dove *Geopelia striata*
 White-winged dove *Zenaidra asiatica*
 Mourning dove *Z. macroura*

PSITTACIFORMES

Monk parakeet *Myiopsitta monachus*
 Ring-necked rose-winged parakeet
Psittacula krameri
 Canary-winged white-winged parakeet
Brotogeris versicolurus
 Yellow-chevroned parakeet *B. chiriri*
 Budgerigar *Melopsittacus undulatus*
 Green-cheeked parakeet *Pyrrhura molinae*
 Maroon-bellied parakeet *P. frontalis*
 Green-cheeked Amazon, Red-crowned
 parrot *Amazona viridigenalis*
 Yellow-crowned Amazon *A. ochrocephala*
 Yellow-headed Amazon *A. oratrix*
 Blue-fronted Amazon *A. aestiva*
 Lilac-crowned parrot *A. finschi*
 Orange-winged parrot *A. amazonica*
 Red-lored parrot *A. autumnalis*
 Hispaniolan parrot *A. ventralis*
 Senegal parrot *Poicephalus senegalus*
 Rupeppell's parrot *P. rueppellii*
 Blue-fronted conure *Aratinga cruentata*
 Blue-crowned parakeet *A. acuticaudata*
 Brown-throated conure *A. pertinax*

Mitered conure *A. mitrata*
 Red-masked parakeet *A. erthogenys*
 Dusky-headed parakeet *A. weddellii*
 Nanday conure black-hooded parakeet
Nandayus nenday
 Lovebird *Agapornis* spp.
 Cockatiel *Nymphicus hollandicus*
 Sulphur-crested cockatoo *Cacatua galerita*
 White-crested cockatoo *C. alba*
 Giffin's cockatoo *C. goffini*
 Blue-and-yellow macaw *Ara ararauna*
 Chesnut-fronted macaw *A. severa*

STRIGIFORMES

Barn owl *Tyto alba*

PASSERIFORMES

Edible-nest swiftlet *Aerodramus fuciphagus*
 Mariana swiftlet *A. [Collocalia] bartschi*
 Skylark *Alauda arvensis*
 Western meadowlark *Sturnella neglecta*
 Red-vented bulbul *Pycnonotus caferi*
 Red-whiskered bulbul *P. jocosus*
 Northern mockingbird *Mimus polyglottos*
 White-rumped shama *Copsychus malabaricus*
 Melodious laughing thrush *Garrulax canorus*
 Greater necklaced laughing thrush
G. pectoralis
 Red-billed leiothrix *Leiothrix lutea*
 Japanese bush warbler *Cettia diphone*
 Varied tit *Parus varius*
 Japanese white-eye *Zosterops japonica*
 Saffron finch *Sicalis flaveola*
 Yellow-faced grassquit *Tiaris olivacea*
 Red-crested cardinal *Paroaria coronata*
 Yellow-billed cardinal *P. capitata*
 Common northern cardinal
Cardinalis cardinalis
 Spot-breasted oriole *Icterus pectoralis*
 Yellow-fronted canary *Serinus mozambicus*
 Common canary *S. canaria*
 House finch *Carpodacus mexicanus*
 Red-cheeked condon-bleu

<i>Uraeginthus benglaus</i>	Nutmeg manikin <i>Lonchura punctulata</i>	European tree sparrow <i>P. montanus</i>
Lavender waxbill <i>Estrilda caeruleus</i>	Black-headed manikin <i>L.malacca</i>	European starling <i>Sturnus vulgaris</i>
Orange-cheeked waxbill <i>E. melpoda</i>	Warbling silverbill <i>L. malabarica</i>	Common mynah <i>Acridotheres tristis</i>
Common waxbill <i>E. astrild</i>	Chesnut munia <i>L. atricapilla</i>	Hill mynah <i>Gracula religiosa</i>
Black-rumped waxbill <i>E. troglodytes</i>	Orange bishop <i>Euplectes franciscanus</i>	Crested mynah <i>Acridotheres cristatellus</i>
Red avadavat <i>Amandava amandava</i>	Java sparrow <i>Padda oryzivora</i>	
Zebra finch <i>A. subflava</i>	House sparrow <i>Passer domesticus</i>	

Part 3 Reptiles and amphibians introduced into parts of the United States

ANURA

American toad <i>Bufo americanus</i>	Hong Kong whipping frog <i>Polypedates megacephalus</i>	Red-eared slider <i>Trachemys scripta elegans</i>
Giant cane toad <i>B. marinus</i>	Green and black dart-poison frog	Spiny softshell <i>Apalone spiniferus</i>
Southern California toad <i>B. halophilus</i>	<i>Dendrobates auratus</i>	Wattle-necked softshell <i>Palea steindachneri</i>
European toad <i>B. bufo</i>	Yellow-banded dart-poison frog <i>D. leucomelas</i>	Chinese softshell <i>Pelodiscus sinensis</i>
Coastal plain toad <i>B. nebulifer</i>	Pacific tree frog <i>Pseudacris regilla</i>	Snapping turtle <i>Chelydra serpentina</i>
Suriname toad <i>Pipa pipa</i>	Baja California tree frog <i>Pseudacris hypochondriaca</i>	Pacific pond turtle <i>Actinemys marmorata</i>
Greenhouse frog <i>Eleutherodactylus planirostris</i>	Japanese wrinkled frog <i>Glandirana rugosa</i>	Florida softshell turtle <i>Apalone ferox</i>
Coqui frog <i>E. coqui</i>	Red Snouted tree frog <i>Scinax ruber</i>	Common map turtle <i>Graptemys geographic</i>
Red-eyed coqui <i>E. antillensis</i>	Rio Grande chipping frog <i>Syrnhophus cystignathoides</i>	River cooter <i>Pseudemys concinna</i>
Mountain coqui <i>E. portoricensis</i>	African clawed frog <i>Xenopus laevis</i>	Florida red-bellied cooter <i>P. nelsoni</i>
Rio Grande chirping frog <i>E. cystignathoides</i>		American box turtle <i>Terrapene carolina</i>
Cuban treefrog <i>Osteopilus septentrionalis</i>		Matamata <i>Chelus fimbriatus</i>
Rio Grande leopard frog <i>Rana berlandieri</i>		Chinese three-keeled pond turtle <i>Chinemys reevesii</i>
Green frog <i>R. clamitans</i>	CAUDATA	Painted turtle <i>Chrysemys picta</i>
American bullfrog <i>R. catesbeiana</i>	Tiger salamander <i>Ambystoma tigrinum</i>	Southern painted turtle <i>C. dorsalis</i>
Northern red-legged frog <i>R. aurora</i>	Barred tiger salamander <i>A. mavortium</i>	Yellow margined box turtle <i>Cuora flavomarginata</i>
California red-legged frog <i>R. draytonii</i>	Northern dusky salamander <i>Desmognathus fuscus</i>	Florida chicken turtle <i>Deirochelys reticularia</i>
Pig frog <i>R. grylio</i>	Black-bellied salamander <i>D. quadramaculatus</i>	Blanding's turtle <i>Emydoidea blandingii</i>
Gunther's frog <i>R. guentheri</i>	Southern two-lined salamander <i>Eurycea cirrigera</i>	Wood turtle <i>Glyptemys insculpta</i>
Northern leopard frog <i>R. pipiens</i>	Common mudpuppy <i>Necturus maculosus</i>	Bog turtle <i>G. muhlenbergii</i>
Wrinkled frog <i>R. rugosa</i>	Red-backed salamander <i>Plethodon cinereus</i>	Barbour's map turtle <i>Graptemys barbouri</i>
Southern leopard frog <i>R. sphenocephala</i>	Northern gray-cheeked salamander <i>P. montanus</i>	Northern map turtle <i>G. geographic</i>
Wood frog <i>R. sylvatica</i>	Shenandoah salamander <i>P. Shenandoah</i>	Mississippi map turtle <i>G. pseudogeographic</i>
Black-spotted frog <i>R. nigromaculata</i>	Japanese fire-bellied salamander <i>Cynops pyrrhogaster</i>	Ouachita map turtle <i>G. ouachitensis</i>
Grass (cricket) frog <i>Fejervarya limnocharis</i>	Red-skinned newt <i>Taricha granulose</i>	Scorpion mud turtle <i>Kinosternon scorpioides</i>
Northern cricket frog <i>Acris crepitans</i>		Eastern mud turtle <i>K. subrubrum</i>
American green tree frog <i>Hyla cinerea</i>		
Barking tree frog <i>H. gratiosa</i>		CROCODILIA
Australian green tree frog <i>Litoria caerulea</i>		Spectacled common caiman
Eastern dwarf tree frog <i>L. fallax</i>		<i>Caiman crocodilus</i>
Cuban tree frog <i>Osteopilus septentrionalis</i>		American alligator <i>Alligator mississippiensis</i>
Guangdong rice frog <i>Microhyla pulchra</i>	TESTUDINES	American crocodile <i>Crocodylus acutus</i>

Nile crocodile <i>C. niloticus</i>	Marie Gallant sail-tailed anole <i>A. ferreus</i>	Asian flat-tailed gecko <i>H. platyurus</i>
	Brown anole <i>A. sagrei</i>	Indo-Pacific gecko <i>H. garnotti</i>
SQUAMATA - SNAKES	Brown basilisk <i>Basiliscus vittatus</i>	Mediterranean gecko <i>H. turcicus</i>
Common boa <i>Boa constrictor</i>	Veiled chameleon <i>Chamaeleo calypttratus</i>	Yellow-headed gecko <i>Gonatodes albogularis</i>
Burmese python <i>Python molurus</i>	Jackson's chameleon <i>C. jacksonii</i>	Indo-Pacific tree gecko
African rock python <i>P. sebae</i>	Butterfly lizard <i>Leiolepis belliana</i>	<i>Hemiphyllodactylus typus</i>
Reticulated python <i>P. reticulatus</i>	Oriental garden lizard variable bloodsucker	Moth skink <i>Lipinia noctua</i>
Brahminy blind snake	<i>Calotes versicolor</i>	Azure-tailed skink <i>Emoia impar</i>
<i>Ramphotyphlops braminus</i>	Blue-crested lizard <i>C. mystaceus</i>	Copper-tailed skink <i>E. cyanura</i>
Javan filesnake <i>Acrochordus javanicus</i>	Rainbow whiptail lizard	Many-lined grass skink <i>Mabuya multifasciata</i>
Brown treesnake <i>Boiga irregularis</i>	<i>Cnemidophorus lemniscatus</i>	Pacific snake-eyed skink
Yellow anaconda <i>Eunectes notataeus</i>	Giant whiptail lizard <i>C. [Aspidoselis] motaguae</i>	<i>Cryptoblepharus poecilopleurus</i>
Green anaconda <i>E. murinus</i>	New Mexico whiptail lizard <i>C. neomexicanus</i>	Plague skink <i>Lampropholis delicata</i>
Prairie rattlesnake <i>Crotalus viridis</i>	Plateau striped whiptail <i>C. velox</i>	Western green lacerta <i>Lacerta bilineata</i>
Cottonmouth <i>Agkistrodon piscivorus</i>	Northern curlytail lizard <i>Leiocephalus carinatus</i>	Argentina giant tegu <i>Tupinambis merianae</i>
Southern water snake <i>Nerodia fasciata</i>	Red-sided curlytail lizard <i>L. schreibersii</i>	New Mexico whiptail <i>Aspidoscelis neomexicana</i>
Northern water snake <i>N. sipedon</i>	Common wall lizard <i>Podarcis muralis</i>	Curious skink <i>Carlia aylanpalai</i>
Diamondback water snake <i>N. rhombifer</i>	Italian wall lizard <i>P. sicula</i>	Cuban rock iguana <i>Cyclura nubile</i>
Brown water snake <i>N. taxispilota</i>	Texas horned lizard <i>Phrynosoma cornutum</i>	Asian flattail house gecko <i>Cosymbotus platyurus</i>
Tessellated water snake <i>Natrix tessellate</i>	Black Gray's spinytail iguana	Roughtail gecko <i>Cryptopodion scabrum</i>
Crab-eating water snake <i>Fordonia leucobalia</i>	<i>Ctenosaura similis</i>	Stump-tailed gecko <i>Gehyra mutilata</i>
Short-headed garter snake <i>Thamnophis brachystoma</i>	Mexican spinytail iguana <i>C. pectinata</i>	Mourning gecko <i>Lepidodactylus lugubris</i>
	Green iguana <i>Iguana iguana</i>	Bibron's thick-toes gecko <i>Pachydactylus bibronii</i>
SQUAMATA - LIZARDS	Ashy gecko <i>Sphaerodactylus elegans</i>	Common ocellated gecko <i>Sphaerodactylus argus</i>
Red-headed agama <i>Agama agama</i>	Ocellated gecko <i>S. argus</i>	Green-legged curlytail lizard <i>Leiocephalus personatus</i>
Giant ameiva <i>Ameiva ameiva</i>	Gold dust day gecko <i>Phelsuma laticauda</i>	Butterfly lizard <i>Leiolepis belliana</i>
Puerto Rican ground lizard <i>A. exsulis</i>	Giant day gecko <i>P. madagascariensis</i>	Western fence lizard <i>Sceloporus occidentalis</i>
Large-headed anole <i>Anolis cybotes</i>	Orange-spotted day gecko <i>P. guimbeui</i>	Eastern fence lizard <i>Sceloporus undulates</i>
Green anole <i>A. carolinensis</i>	Moorish gecko <i>Tarentola mauritanica</i>	Nile monitor <i>Varanus niloticus</i>
Bark anole <i>A. distichus</i>	Ringed wall gecko <i>T. annularis</i>	Mangrove monitor lizard <i>V. indicus</i>
Hispaniolan green anole <i>A. chlorocyanus</i>	Mourning gecko <i>Lepidodactylus lugubris</i>	Golden tegu <i>V. teguixin</i>
Puerto Rican crested anole <i>A. cristatellus</i>	Multilating gecko <i>Gehyra mutilata</i>	Water monitor <i>V. salvator</i>
Knight anole <i>A. equestris</i>	Rough-tailed gecko <i>Cryptopodion scabrum</i>	Savannah monitor <i>V. exanthematicus</i>
Jamaican anole <i>A. grahami</i>	Tokay gecko <i>Gekko gekko</i>	
Leach's anole <i>A. leachii</i>	Common house gecko <i>Hemidactylus frenatus</i>	
Cuban green anole <i>A. porcatius</i>	Tropical house gecko wood stave	
Jamaican giant anole <i>A. garmani</i>	<i>H. mabouia</i>	
Barbados anole <i>A. extremus</i>		

Part 4 Fishes introduced into parts of the United States

PETROMYZONTIFORMES

Petromyzontidae

Silver lamprey *Ichthyomyzon unicuspis*

American brook lamprey *Lampetra appendix*

Sea lamprey *Petromyzon marinus*

ORECTOLOBIFORMES	Tarpon <i>Megalops atlanticus</i>	Highfin carpsucker <i>Carpiodes velifer</i>
Hemiscylliidae		Utah sucker <i>Catostomus ardens</i>
Brownbanded bambooshark <i>Chiloscyllium punctatum</i>	ALBULIFORMES	Longnose sucker <i>Catostomus catostomus</i>
	Albulidae	White sucker <i>Catostomus commersonii</i>
	Bonefish <i>Albula vulpes</i>	Owens sucker <i>Catostomus fumeiventris</i>
CARCHARHINIFORMES		Flannelmouth sucker <i>Catostomus latipinnis</i>
Carcharhinidae	ANGUILLIFORMES	Sacramento sucker <i>Catostomus occidentalis</i>
Pacific sharpnose shark <i>Rhizoprionodon longurio</i>	Anguillidae	Mountain sucker <i>Catostomus platyrhynchus</i>
	European eel <i>Anguilla anguilla</i>	Rio Grande sucker <i>Catostomus plebeius</i>
	Shortfin eel <i>Anguilla australis</i>	Santa Ana sucker <i>Catostomus santaanae</i>
POLYPTERIFORMES	Marbled eel <i>Anguilla marmorata</i>	Tahoe sucker <i>Catostomus tahoensis</i>
Polypteridae	American eel <i>Anguilla rostrata</i>	Little Colorado River sucker <i>Catostomus</i>
Bichir <i>Polypterus delhezi</i>	Unidentified eel <i>Anguilla</i> sp.	undescribed sp.
	Muraenidae	Shortnose sucker <i>Chasmistes brevirostris</i>
ACIPENSERIFORMES	Unidentified moray <i>Gymnothorax</i> sp.	Lake chubsucker <i>Erimyzon sucetta</i>
Acipenseridae		Alabama hog sucker <i>Hypentelium etowanum</i>
White sturgeon <i>Acipenser transmontanus</i>	CLUPEIFORMES	Northern hog sucker <i>Hypentelium nigricans</i>
Sturgeon (eastern species) <i>Acipenser</i> or <i>Scaphirhynchus</i> sp.	Clupeidae	Smallmouth buffalo <i>Ictiobus bubalus</i>
Polyodontidae	Blueback herring <i>Alosa aestivalis</i>	Bigmouth buffalo <i>Ictiobus cyprinellus</i>
Paddlefish <i>Polyodon spathula</i>	Skipjack herring <i>Alosa chrysochloris</i>	Black buffalo <i>Ictiobus niger</i>
	Alewife <i>Alosa pseudoharengus</i>	Spotted sucker <i>Minytrema melanops</i>
SEMIONOTIFORMES	American shad <i>Alosa sapidissima</i>	Black jumprock <i>Moxostoma cervinum</i>
Lepisosteidae	Gizzard shad <i>Dorosoma cepedianum</i>	Golden redbreast <i>Moxostoma erythrurum</i>
Alligator gar <i>Atractosteus spatula</i>	Threadfin shad <i>Dorosoma petenense</i>	Geater jumprock <i>Moxostoma lachneri</i>
Spotted gar <i>Lepisosteus oculatus</i>	Goldspot herring <i>Herklotsichthys quadrimaculatus</i>	Shorthead redbreast <i>Moxostoma macrolepidotum pisolabrum</i>
Shortnose gar <i>Lepisosteus platostomus</i>	Deepbody thread herring <i>Opisthonema libertate</i>	Striped jumprock <i>Moxostoma rupiscartes</i>
Florida gar <i>Lepisosteus platyrhynchus</i>	Marquesan sardine <i>Sardinella marquesensis</i>	Torrent sucker <i>Thoburnia rhothoeca</i>
AMIIFORMES	Engraulidae	Cobitidae
Amiidae	Deepbody anchovy <i>Anchoa compressa</i>	Oriental weatherfish <i>Misgurnus anguillicaudatus</i>
Bowfin <i>Amia calva</i>	Northern Gulf anchovy <i>Anchoa mundeoloides</i>	Chinese fine-scaled loach <i>Misgurnus mizolepis</i>
OSTEOGLOSSIFORMES	Anchoveta <i>Cetengraulis mysticetus</i>	Coolie loach <i>Pangio kuhlii</i>
Hiodontidae	Northern anchovy <i>Engraulis mordax</i>	Cyprinidae
Goldeye <i>Hiodon alosoides</i>		Longfin dace <i>Agosia chrysogaster</i>
Mooneye <i>Hiodon tergisus</i>	GONORHYNCHIFORMES	Tricolor sharkminnow <i>Balantiocheilos melanopterus</i>
Notopteridae	Chanidae	Tinfoil barb <i>Barbonymus [=Barbus] schwanenfeldii</i>
Clown knife <i>Chitala ornata</i>	milkfish <i>Chanos chanos</i>	Zebra danio <i>Brachydanio rerio</i>
Osteoglossidae	CYPRINIFORMES	Central stoneroller <i>Camptostoma anomalum</i>
Arawana <i>Osteoglossum bicirrhosum</i>	Catostomidae	Largescale stoneroller <i>Camptostoma oligolepis</i>
ELOPIIFORMES	River carpsucker <i>Carpiodes carpio</i>	
Megalopidae	Quillback <i>Carpiodes cyprinus</i>	

Goldfish <i>Carassius auratus</i>	White River spinedace <i>Lepidomeda albivallis</i>	Eastern blacknose shiner <i>Notropis heterolepis</i>
Crucian carp <i>Carassius carassius</i>	Virgin spinedace <i>Lepidomeda mollispinis</i>	Spottail shiner <i>Notropis hudsonius</i>
Redside dace <i>Clinostomus elongatus</i>	<i>mollispinis</i>	Highscale shiner <i>Notropis hypsilepis</i>
Rosyside dace <i>Clinostomus funduloides</i>	Big Spring spinedace <i>Lepidomeda mollispinis pratensis</i>	Tennessee shiner <i>Notropis leuciodus</i>
Lake chub <i>Couesius plumbeus</i>	Ide <i>Leuciscus idus</i>	Longnose shiner <i>Notropis longirostris</i>
Grass carp <i>Ctenopharyngodon idella</i>	White shiner <i>Luxilus albeolus</i>	Yellowfin shiner <i>Notropis lutipinnis</i>
Grass carp x bighead carp <i>Ctenopharyngodon idella</i> x	Crescent shiner <i>Luxilus cerasinus</i>	Ozark minnow <i>Notropis nubilis</i>
<i>Hypophthalmichthys nobilis</i>	Striped shiner <i>Luxilus chrysocephalus</i>	Sharpnose shiner <i>Notropis oxyrhynchus</i>
Satinfin shiner <i>Cyprinella analostana</i>	Warpaint shiner <i>Luxilus coccogenis</i>	Ozark shiner <i>Notropis ozarcanus</i>
Whitetail shiner <i>Cyprinella galactura</i>	Common shiner <i>Luxilus cornutus</i>	Chub shiner <i>Notropis potteri</i>
Red shiner <i>Cyprinella lutrensis</i>	Bandfin shiner <i>Luxilus zonistius</i>	Swallowtail shiner <i>Notropis procne</i>
Fieryblack shiner <i>Cyprinella pyrrhomelas</i>	Rosefin shiner <i>Lythrurus ardens</i>	Rosyface shiner <i>Notropis rubellus</i>
Spotfin shiner <i>Cyprinella spiloptera</i>	Blacktip shiner <i>Lythrurus atripiculus</i>	Saffron shiner <i>Notropis rubricroceus</i>
Blacktail shiner <i>Cyprinella venusta</i>	Scarlet shiner <i>Lythrurus fasciolaris</i>	Silverband shiner <i>Notropis shumardi</i>
Steelcolor shiner <i>Cyprinella whipplei</i>	Pinewoods shiner <i>Lythrurus matutinus</i>	Mirror shiner <i>Notropis spectrunculus</i>
Common carp <i>Cyprinus carpio</i>	Sicklefin chub <i>Macrhybopsis meeki</i>	Sand shiner <i>Notropis stramineus</i>
Malabar danio <i>Danio malabaricus</i>	Pearl dace <i>Margariscus margarita</i>	Telescope shiner <i>Notropis telescopus</i>
Desert dace <i>Eremichthys acros</i>	Spikedace <i>Meda fulgida</i>	Weed shiner <i>Notropis texanus</i>
Tonguetied minnow <i>Exoglossum laurae</i>	Moapa dace <i>Moapa coriacea</i>	Mimic shiner <i>Notropis volucellus</i>
Cutlip minnow <i>Exoglossum maxillingua</i>	Peamouth <i>Mylocheilus caurinus</i>	Coosa shiner <i>Notropis xaenocephalus</i>
Utah chub <i>Gila atraria</i>	Black carp <i>Mylopharyngodon piceus</i>	Sacramento blackfish <i>Orthodon microlepidotus</i>
Tui chub <i>Gila bicolor</i>	Hornyhead chub <i>Nocomis biguttatus</i>	Suckermouth minnow <i>Phenacobius mirabilis</i>
Mohave tui chub <i>Gila bicolor mohavensis</i>	Bluehead chub <i>Nocomis leptocephalus</i>	Northern redbelly dace <i>Phoxinus eos</i>
Lahontan tui chub <i>Gila bicolor obesa</i>	River chub <i>Nocomis micropogon</i>	Finescale dace <i>Phoxinus neogaeus</i>
Owens tui chub <i>Gila bicolor snyderi</i>	Bull chub <i>Nocomis raneyi</i>	Mountain redbelly dace <i>Phoxinus oreas</i>
Hot Creek Valley tui chub <i>Gila bicolor</i> sp.	Golden shiner <i>Notemigonus crysoleucas</i>	Bluntnose minnow <i>Pimephales notatus</i>
Blue chub <i>Gila coerulea</i>	Comely shiner <i>Notropis amoenus</i>	Fathead minnow <i>Pimephales promelas</i>
Arroyo chub <i>Gila orcuttii</i>	Pugnose shiner <i>Notropis anogenus</i>	Slim minnow <i>Pimephales tenellus</i>
Rio Grande chub <i>Gila pandora</i>	Popeye shiner <i>Notropis ariommus</i>	Bullhead minnow <i>Pimephales vigilax</i>
Virgin chub <i>Gila seminuda seminuda</i>	Emerald shiner <i>Notropis atherinoides</i>	Woundfin <i>Plagopterus argentissimus</i>
California roach <i>Hesperoleucus symmetricus</i>	Rough shiner <i>Notropis baileyi</i>	Flathead chub <i>Platygobio gracilis</i>
Brassy minnow <i>Hybognathus hankinsoni</i>	Red River shiner <i>Notropis bairdi</i>	Splittail <i>Pogonichthys macrolepidotus</i>
Mississippi silvery minnow <i>Hybognathus nuchalis</i>	Bridle shiner <i>Notropis bifrenatus</i>	Sacramento pikeminnow <i>Ptychocheilus grandis</i>
Plains minnow <i>Hybognathus placitus</i>	River shiner <i>Notropis blennioides</i>	Umpqua pikeminnow <i>Ptychocheilus umpqua</i>
Eastern silvery minnow <i>Hybognathus regius</i>	Bigeye shiner <i>Notropis boops</i>	Rosy barb <i>Puntius conchonius</i>
Bigeye chub <i>Hybopsis amblops</i>	Silverjaw minnow <i>Notropis buccatus</i>	Blackspot barb <i>Puntius filamentosus</i>
Clear chub <i>Hybopsis winchelli</i>	Smalleye shiner <i>Notropis buccula</i>	Dwarf barb <i>Puntius gelius</i>
Silver carp <i>Hypophthalmichthys molitrix</i>	Ghost shiner <i>Notropis buchani</i>	Green barb <i>Puntius semifasciolatus</i>
Bighead carp <i>Hypophthalmichthys nobilis</i>	Redlip shiner <i>Notropis chiliticus</i>	Tiger barb <i>Puntius tetrazona</i>
Least chub <i>Iotichthys phlegethontis</i>	Rainbow shiner <i>Notropis chrosomus</i>	Relict dace <i>Relictus solitarius</i>
Black sharkminnow <i>Labeo chrysophekadion</i>	Bigmouth shiner <i>Notropis dorsalis</i>	
Hitch <i>Lavinia exilicauda</i>	Arkansas River shiner <i>Notropis girardi</i>	
	Redeye chub <i>Notropis harperi</i>	

Blacknose dace <i>Rhinichthys atratulus</i>	Red piranha <i>Pygocentrus nattereri</i>	Suckermouth catfish <i>Hypostomus plecostomus</i>
Longnose dace <i>Rhinichthys cataractae</i>	White piranha <i>Serrasalmus rhombeus</i>	Suckermouth catfish <i>Hypostomus</i> sp.
Speckled dace <i>Rhinichthys osculus</i>	Erythrinidae	Suckermouth catfish <i>Hypostomus</i> sp. (watwata group)
Klamath speckled dace <i>Rhinichthys osculus klamathensis</i>	Trahira <i>Hoplias malabaricus</i>	Suckermouth catfish <i>Otocinclus</i> sp.
Lahontan speckled dace <i>Rhinichthys osculus robustus</i>	SILURIFORMES	Clown pleco <i>Peckoltia</i> sp.
Bitterling <i>Rhodeus sericeus</i>	Auchenipteridae	Southern sailfin catfish <i>Pterygoplichthys anisitsi</i>
Redside shiner <i>Richardsonius balteatus</i>	Driftwood catfish <i>Parauchenipterus galeatus</i>	Vermiculated sailfin catfish <i>Pterygoplichthys disjunctivus</i>
Bonneville redbreast <i>Richardsonius balteatus hydrophlox</i>	Callichthyidae	Orinoco sailfin catfish <i>Pterygoplichthys multiradiatus</i>
Lahontan redbreast <i>Richardsonius egregius</i>	Cascarudo <i>Callichthys callichthys</i>	Amazon sailfin catfish <i>Pterygoplichthys pardalis</i>
Rudd <i>Scardinius erythrophthalmus</i>	Green corydoras <i>Corydoras aeneus</i>	Sailfin catfish <i>Pterygoplichthys</i> sp.
Creek chub <i>Semotilus atromaculatus</i>	Corydoras <i>Corydoras</i> sp.	Mochokidae
Fallfish <i>Semotilus corporalis</i>	Brown hoplo <i>Hoplosternum littorale</i>	Squeaker <i>Synodontis</i> sp.
Leatherside chub <i>Snyderichthys copei</i>	Clariidae	Pangasiidae
White cloud mountain minnow <i>Tanichthys albonubes</i>	Walking catfish <i>Clarias batrachus</i>	Iridescent shark <i>Pangasius hypophthalmus</i>
Tench <i>Tinca tinca</i>	Whitespotted clarias <i>Clarias fuscus</i>	Pimelodidae
Gyrinocheilidae	Doradidae	Leopard catfish <i>Perrunichthys perruno</i>
Chinese algae-eater <i>Gyrinocheilus aymonieri</i>	Spotted rafaél catfish <i>Agamyxis pectinifrons</i>	Redtail catfish <i>Phractocephalus hemiolioperus</i>
CHARACIFORMES	Raphael catfish <i>Platydoras costatus</i>	Tiger catfish <i>Pseudoplatystoma fasciatum</i>
Alestiidae	Ripsaw catfish <i>Pseudodoras niger</i>	Bagre <i>Rhamdia quelen</i>
Congo tetra <i>Phenacogrammus interruptus</i>	Granulated catfish <i>Pterodoras granulosus</i>	Unidentified shovelnose catfish <i>Sorubim</i> spp.
Anostomidae	Thorny catfish <i>Pterodoras</i> sp.	Firewood catfish <i>Sorubimichthys planiceps</i>
Banded leporinus <i>Leporinus fasciatus</i>	Ictaluridae	Schilbeidae
Characidae	Snail bullhead <i>Ameiurus brunneus</i>	False Siamese shark <i>Platytrapius siamensis</i>
Bloodfin tetra <i>Aphyocharax anisitsi</i>	White catfish <i>Ameiurus catus</i>	ESOCIFORMES
Banded astyanax <i>Astyanax fasciatus</i>	Black bullhead <i>Ameiurus melas</i>	Esocidae
Mexican tetra <i>Astyanax mexicanus</i>	Yellow bullhead <i>Ameiurus natalis</i>	Redfin pickerel <i>Esox americanus americanus</i>
Tambaqui <i>Colossoma macropomum</i>	Brown bullhead <i>Ameiurus nebulosus</i>	Grass pickerel <i>Esox americanus vermiculatus</i>
Black tetra <i>Gymnocorymbus ternetzi</i>	Flat bullhead <i>Ameiurus platycephalus</i>	Northern pike <i>Esox lucius</i>
Head-and-tail light tetra <i>Hemigrammus ocellifer</i>	Blue catfish <i>Ictalurus furcatus</i>	Tiger muskellunge <i>Esox lucius</i> x <i>E. masquinongy</i>
Serpae tetra <i>Hypessobrycon serpae</i>	Yaqui catfish <i>Ictalurus pricei</i>	Northern pike x amur pike <i>Esox lucius</i> x <i>E. reicherti</i>
Silver dollar <i>Metynnis hypsauchen</i>	Channel catfish <i>Ictalurus punctatus</i>	Muskellunge <i>Esox masquinongy</i>
Metynnis <i>Metynnis</i> sp.	Slender madtom <i>Noturus exilis</i>	Chain pickerel <i>Esox niger</i>
Redeye tetra <i>Moenkhausia sanctaefilomenae</i>	Stonecat <i>Noturus flavus</i>	Amur pike <i>Esox reicherti</i>
Redhook pacu <i>Mylius rubripinnis</i>	Orange fin madtom <i>Noturus gilberti</i>	Umbridae
Neon tetra <i>Paracheirodon innesi</i>	Tadpole madtom <i>Noturus gyrinus</i>	
Pirapatinga, red-bellied pacu <i>Piaractus brachypomus</i>	Margined madtom <i>Noturus insignis</i>	
Small-scaled pacu <i>Piaractus mesopotamicus</i>	Brindled madtom <i>Noturus miurus</i>	
	Freckled madtom <i>Noturus nocturnus</i>	
	Flathead catfish <i>Pylodictis olivaris</i>	
	Loricariidae	
	Bristlenosed catfish <i>Ancistrus cf. temminckii</i>	
	Leopard pleco <i>Glyptoperichthys gibbiceps</i>	

Alaska blackfish <i>Dallia pectoralis</i>	Pink salmon <i>Oncorhynchus gorbuscha</i>	Trout-perch <i>Percopsis omiscomaycus</i>
Olympic mudminnow <i>Novumbra hubbsi</i>	Chum salmon <i>Oncorhynchus keta</i>	
Central mudminnow <i>Umbra limi</i>	Coho salmon <i>Oncorhynchus kisutch</i>	GADIFORMES
	Cherry salmon <i>Oncorhynchus masou</i>	Gadidae
OSMERIFORMES	Rainbow trout <i>Oncorhynchus mykiss</i>	burbot <i>Lota lota</i>
Osmeridae	Coast rainbow trout <i>Oncorhynchus mykiss</i>	
Wakasagi <i>Hypomesus nipponensis</i>	<i>irideus</i>	MUGILIFORMES
Delta smelt <i>Hypomesus transpacificus</i>	Kamloops trout <i>Oncorhynchus mykiss</i>	Mugilidae
Rainbow smelt <i>Osmerus mordax</i>	<i>kamloops</i> strain	Striped mullet <i>Mugil cephalus</i>
Ayu <i>Plecoglossus altivelis</i>	Redband trout <i>Oncorhynchus mykiss</i> ssp.	White mullet <i>Mugil curema</i>
	Little Kern golden trout <i>Oncorhynchus</i>	Kanda <i>Valamugil engeli</i>
SALMONIFORMES	<i>mykiss whitei</i>	
Salmonidae	Kokanee, sockeye <i>Oncorhynchus nerka</i>	ATHERINIFORMES
Vendace <i>Coregonus albula</i>	Chinook salmon <i>Oncorhynchus tshawytscha</i>	Atherinidae
Cisco <i>Coregonus artedii</i>	Round whitefish <i>Prosopium cylindraceum</i>	Mesa silverside <i>Chirostoma jordani</i>
Lake whitefish <i>Coregonus clupeaformis</i>	Bonneville cisco <i>Prosopium gemmifer</i>	False grunion <i>Colpichthys regis</i>
Powan <i>Coregonus lavaretus</i>	Mountain whitefish <i>Prosopium williamsoni</i>	Brook silverside <i>Labidesthes sicculus</i>
Maraena whitefish <i>Coregonus maraena</i>	Ohrid trout <i>Salmo letnica</i>	Gulf grunion <i>Leuresthes sardina</i>
Golden trout <i>Oncorhynchus aguabonita</i>	Atlantic salmon <i>Salmo salar salar</i>	Rough silverside <i>Membras martinica</i>
Cutthroat trout <i>Oncorhynchus clarkii</i>	Landlocked Atlantic salmon <i>Salmo salar</i>	Inland silverside <i>Menidia beryllina</i>
Yellowstone cutthroat trout <i>Oncorhynchus</i>	<i>sebago</i>	Melanotaeniidae
<i>clarkii bouvieri</i>	Sambrown <i>Salmo salar</i> x <i>S. trutta</i>	Black-banded rainbowfish <i>Melanotaenia</i>
Fine-spotted Snake River cutthroat trout	Brown trout <i>Salmo trutta</i>	<i>nigrans</i>
<i>Oncorhynchus clarkii carmichaeli</i>	Tiger trout <i>Salmo trutta</i> x <i>Salvelinus</i>	
Lahontan cutthroat trout <i>Oncorhynchus</i>	<i>fontinalis</i>	BELONIFORMES
<i>clarkii henshawi</i>	Arctic char <i>Salvelinus alpinus</i>	Adrianichthyidae
West slope cutthroat trout <i>Oncorhynchus</i>	Blueback trout, Sunapee trout <i>Salvelinus</i>	Japanese medaka <i>Oryzias latipes</i>
<i>clarkii lewisi</i>	<i>aureolus oquassa</i>	Belonidae
Colorado River cutthroat trout <i>Oncorhynchus</i>	Bull trout <i>Salvelinus confluentus</i>	Atlantic needlefish <i>Strongylura marina</i>
<i>clarkii pleuriticus</i>	European species of trout <i>Salvelinus</i>	Asian needlefish <i>Xenentodon cancila</i>
Paiute cutthroat trout <i>Oncorhynchus clarkii</i>	European sp.	
<i>seleniris</i>	Brook trout <i>Salvelinus fontinalis</i>	CYPRINODONTIFORMES
Bear Lake cutthroat trout <i>Oncorhynchus</i>	Splake <i>Salvelinus fontinalis</i> x <i>S. namaycush</i>	Aplocheilidae
<i>clarkii</i> ssp. 1	Dolly Varden <i>Salvelinus malma</i>	Striped panchax <i>Aplocheilus lineatus</i>
Pikes Peak cutthroat trout <i>Oncorhynchus</i>	Lake trout <i>Salvelinus namaycush</i>	Redtail notho <i>Nothobranchius guentheri</i>
<i>clarkii</i> ssp. 2	Arctic grayling <i>Thymallus arcticus</i>	Cyprinodontidae
Greenback cutthroat trout <i>Oncorhynchus</i>		Devils Hole pupfish <i>Cyprinodon diabolis</i>
<i>clarkii stomias</i>	PERCOPSIFORMES	Sonoyta pupfish <i>Cyprinodon eremus</i>
Bonneville cutthroat trout <i>Oncorhynchus</i>	Amblyopsidae	Desert pupfish <i>Cyprinodon macularius</i>
<i>clarkii utah</i>	Spring cavefish <i>Forbesichthys agassizii</i>	Amargosa pupfish <i>Cyprinodon nevadensis</i>
Rio Grande cutthroat trout <i>Oncorhynchus</i>	Southern cavefish <i>Typhlichthys subterraneus</i>	Owens pupfish <i>Cyprinodon radiosus</i>
<i>clarkii virginalis</i>	Aphredoderidae	Red River pupfish <i>Cyprinodon</i>
Gila trout <i>Oncorhynchus gilae</i>	Pirate perch <i>Aphredoderus sayanus</i>	<i>rubrofluviatilis</i>
Apache trout <i>Oncorhynchus gilae apache</i>	Percopsidae	Salt Creek pupfish <i>Cyprinodon salinus</i>

Sheepshead minnow <i>Cyprinodon variegatus</i>	Gila topminnow <i>Poeciliopsis occidentalis</i>	Anabantidae
Flagfish <i>Jordanella floridae</i>	<i>occidentalis</i>	Climbing perch <i>Anabas testudineus</i>
Fundulidae	Green swordtail <i>Xiphophorus hellerii</i>	Twospot climbing perch <i>Ctenopoma nigropannosum</i>
Northern studfish <i>Fundulus catenatus</i>	Red swordtail <i>Xiphophorus hellerii</i> x <i>X. maculatus</i>	Belontiidae
Golden topminnow <i>Fundulus chrysotus</i>	Platyfish/swordtail <i>Xiphophorus hellerii</i> x <i>X. variatus</i>	Siamese fighting fish <i>Betta splendens</i>
Banded killifish <i>Fundulus diaphanus</i>	Southern platyfish <i>Xiphophorus maculatus</i>	Banded gourami <i>Colisa fasciata</i>
Gulf killifish <i>Fundulus grandis</i>	Platyfish/swordtail <i>Xiphophorus maculatus</i> x <i>X. variatus</i>	Thicklippered gourami <i>Colisa labiosa</i>
Mummichog <i>Fundulus heteroclitus</i>	Variable platyfish <i>Xiphophorus variatus</i>	Dwarf gourami <i>Colisa lalia</i>
Plains killifish <i>Fundulus kansae</i>	Swordtail platy <i>Xiphophorus xiphidium</i>	Paradisefish <i>Macropodus opercularis</i>
Lined topminnow <i>Fundulus lineolatus</i>	Rivulidae	Pearl gourami <i>Trichogaster leerii</i>
Blackstripe topminnow <i>Fundulus notatus</i>	Argentine pearlfish <i>Cynolebias bellottii</i>	Blue gourami <i>Trichogaster trichopterus sumatranus</i>
Plains topminnow <i>Fundulus sciadicus</i>	Blackfin pearlfish <i>Cynolebias nigripinnis</i>	Croaking gourami <i>Trichopsis vittata</i>
Seminole killifish <i>Fundulus seminolis</i>	Giant rivulus <i>Rivulus hartii</i>	Blenniidae
Southern studfish <i>Fundulus stellifer</i>	Rio pearlfish <i>Simpsonichthys whitei</i>	Tessellated blenny <i>Hypsoblennius invemar</i>
Plains killifish <i>Fundulus zebrius</i>	GASTEROSTEIFORMES	Freckled blenny <i>Hypsoblennius ionthas</i>
Bluefin killifish <i>Lucania goodei</i>	Gasterosteidae	Fang-toothed blenny <i>Omobranchus ferox</i>
Rainwater killifish <i>Lucania parva</i>	Fourspine stickleback <i>Apeltes quadracus</i>	Blenny <i>Parablennius thysanurus</i>
Goodeidae	Brook stickleback <i>Culaea inconstans</i>	Carangidae
Butterfly splitfin <i>Ameiops splendens</i>	Threespine stickleback <i>Gasterosteus aculeatus</i>	Green jack <i>Caranx caballus</i>
Hiko White River springfish <i>Crenichthys baileyi grandis</i>	Ninespine stickleback <i>Pungitius pungitius</i>	Paloma pompano <i>Trachinotus paitensis</i>
Railroad Valley springfish <i>Crenichthys nevadae</i>	SYNBRANCHIFORMES	Centrarchidae
Pahrump killifish <i>Empetrichthys latos</i>	Mastacembelidae	Roanoke bass <i>Ambloplites cavifrons</i>
Poeciliidae	Spotfin spiny eel <i>Macrognathus siamensis</i>	Ozark bass <i>Ambloplites constellatus</i>
Pike killifish <i>Belonesox belizanus</i>	Synbranchidae	Rock bass <i>Ambloplites rupestris</i>
Western mosquitofish <i>Gambusia affinis</i>	Asian swamp eel <i>Monopterus albus</i>	Sacramento perch <i>Archoplites interruptus</i>
Largespring gambusia <i>Gambusia geiseri</i>	Asian swamp eel <i>Monopterus</i> sp. (not <i>albus</i>)	Flier <i>Centrarchus macropterus</i>
Eastern mosquitofish <i>Gambusia holbrooki</i>	PERCIFORMES	Bluespotted sunfish <i>Enneacanthus gloriosus</i>
Pecos gambusia <i>Gambusia nobilis</i>	Acanthuridae	Redbreast sunfish <i>Lepomis auritus</i>
Least killifish <i>Heterandria formosa</i>	Whitespotted surgeonfish <i>Acanthurus guttatus</i>	Green sunfish <i>Lepomis cyanellus</i>
Cuban limia <i>Limia vittata</i>	Red Sea surgeonfish <i>Acanthurus sohal</i>	Pumpkinseed <i>Lepomis gibbosus</i>
Amazon molly <i>Poecilia formosa</i>	Orangespine unicornfish <i>Naso lituratus</i>	Warmouth <i>Lepomis gulosus</i>
Lyretail black molly <i>Poecilia hybrid</i>	Sailfin tang <i>Zebrasoma desjardini</i>	Orangespotted sunfish <i>Lepomis humilis</i>
Sailfin molly <i>Poecilia latipinna</i>	Yellow tang <i>Zebrasoma flavescens</i>	Bluegill <i>Lepomis macrochirus</i>
Black molly <i>Poecilia latipinna</i> x <i>P. velifera</i>	Brown tang <i>Zebrasoma scopas</i>	Dollar sunfish <i>Lepomis marginatus</i>
Tamesi molly <i>Poecilia latipunctata</i>	Sailfin tang <i>Zebrasoma veliferum</i>	Longear sunfish <i>Lepomis megalotis</i>
Shortfin molly <i>Poecilia mexicana</i>	Yellowtail tang <i>Zebrasoma xanthurum</i>	Redear sunfish <i>Lepomis microlophus</i>
Peten molly <i>Poecilia petenensis</i>		Redspotted sunfish <i>Lepomis miniatus</i>
Guppy <i>Poecilia reticulata</i>		Shoal bass <i>Micropterus catarractae</i>
Unidentified poeciliid (hybrid) <i>Poecilia</i> sp.		Redeye bass <i>Micropterus coosae</i>
Mexican molly <i>Poecilia sphenops</i>		Smallmouth bass <i>Micropterus dolomieu</i>
Guaru <i>Poecilia vivipara</i>		Spotted bass <i>Micropterus punctulatus</i>
Porthole livebearer <i>Poeciliopsis gracilis</i>		Largemouth bass <i>Micropterus salmoides</i>

Guadalupe bass <i>Micropterus treculii</i>	Mozambique tilapia <i>Oreochromis mossambicus</i>	Highfin goby <i>Gobionellus oceanicus</i>
White crappie <i>Pomoxis annularis</i>		Naked goby <i>Gobiosoma bosc</i>
Black crappie <i>Pomoxis nigromaculatus</i>	Nile tilapia <i>Oreochromis niloticus</i>	Mangrove goby <i>Mugilogobius cavifrons</i>
Chaetodontidae	Wami tilapia <i>Oreochromis urolepis</i>	Helmeted goby <i>Mugilogobius parvus</i>
Raccoon butterflyfish <i>Chaetodon lunula</i>	Wami tilapia <i>Oreochromis urolepis hornorum</i>	Round goby <i>Neogobius [Apollonia] melanostomus</i>
Red Sea bannerfish <i>Heniochus intermedius</i>	Wolf cichlid <i>Parachromis dovii</i>	Tube-nose goby <i>Proterorhinus semilunaris</i>
Bannerfish <i>Heniochus</i> sp.	Jaguar guapote <i>Parachromis [=Cichlasoma] managuense</i>	Amur goby <i>Rhinogobius brunneus</i>
Channidae	Rainbow krib <i>Pelvicachromis pulcher</i>	Shokihaze goby <i>Tridentiger barbatus</i>
Northern snakehead <i>Channa argus</i>	Zebra mbuna <i>Pseudotropheus zebra</i>	Shimofuri goby <i>Tridentiger bifasciatus</i>
Blotched snakehead <i>Channa maculata</i>	Freshwater angelfish <i>Pterophyllum scalare</i>	Chameleon goby <i>Tridentiger trigonocephalus</i>
Bullseye snakehead <i>Channa marulius</i>	Blackchin tilapia <i>Sarotherodon melanotheron</i>	Grammatidae
Giant snakehead <i>Channa micropeltes</i>	Red discus <i>Symphysodon discus</i>	Fairy basslet <i>Gramma loreto</i>
Cichlidae	Lake Tanganyika dwarf cichlid <i>Telmatochromis bifrenatus</i>	Haemulidae
Blue acara <i>Aequidens pulcher</i>	Theraps hybrid <i>Theraps melanurus</i> x <i>T. zonatus</i>	Sargo <i>Anisotremus davidsonii</i>
Oscar <i>Astronotus ocellatus</i>	Zebra tilapia <i>Tilapia butikoferi</i>	Spotted sweetlip <i>Plectorhinchus chaetodonoides</i>
Butterfly peacock bass <i>Cichla ocellaris</i>	Spotted tilapia <i>Tilapia mariae</i>	Helostomatidae
Speckled pavon <i>Cichla temensis</i>	Redbreast tilapia <i>Tilapia rendalli</i>	Kissing gourami <i>Helostoma temminckii</i>
Sinaloa cichlid <i>Cichlasoma beani</i>	Unidentified tilapia <i>Tilapia</i> sp.	Kuhliidae
Black acara <i>Cichlasoma bimaculatum</i>	Banded tilapia <i>Tilapia sparrmani</i>	Rock flagtail <i>Kuhlia rupestris</i>
Midas cichlid <i>Cichlasoma citrinellum</i>	Redbelly tilapia <i>Tilapia zillii</i>	Kyphosidae
Midas x mayan cichlid hybrid <i>Cichlasoma citrinellum</i> x <i>C. urophthalmus</i>	Cirrhitidae	Gulf opaleye <i>Girella simplicidens</i>
Rio Grande cichlid <i>Cichlasoma cyanoguttatum</i>	Dwarf hawkfish <i>Cirrhitichthys falco</i>	Labridae
Red devil <i>Cichlasoma labiatum</i>	Coral hawkfish <i>Cirrhitichthys oxycephalus</i>	Rock wrasse <i>Halichoeres semicinctus</i>
Firemouth cichlid <i>Cichlasoma meeki</i>	Cottidae	Tautog <i>Tautoga onitis</i>
Moga <i>Cichlasoma nicaraguensis</i>	Prickly sculpin <i>Cottus asper</i>	Latidae
Convict cichlid <i>Cichlasoma nigrofasciatum</i>	Mottled sculpin <i>Cottus bairdii</i>	Tanganyika lates <i>Lates angustifrons</i>
Jack Dempsey <i>Cichlasoma octofasciatum</i>	Bear Lake sculpin <i>Cottus extensus</i>	bigeye lates <i>Lates mariae</i>
Yellowbelly cichlid <i>Cichlasoma salvini</i>	Shoshone sculpin <i>Cottus greenei</i>	Nile perch <i>Lates niloticus</i>
Blue-eyed cichlid <i>Cichlasoma spilurum</i>	Embiotocidae	Lethrinidae
Redhead cichlid <i>Cichlasoma synspilum</i>	Tule perch <i>Hysterothorax traskii</i>	Emperor <i>Lethrinus</i> sp.
Threespot cichlid <i>Cichlasoma trimaculatum</i>	Ephippidae	Lutjanidae
Mayan cichlid <i>Cichlasoma urophthalmus</i>	Orbulate batfish <i>Platax orbicularis</i>	Blacktail snapper <i>Lutjanus fulvus</i>
Eartheater <i>Geophagus</i> sp.	Gerreidae	Humpback snapper <i>Lutjanus gibbus</i>
Eastern happy <i>Haplochromis callipterus</i>	Spotfin mojarra <i>Eucinostomus argenteus</i>	Spotted rose snapper <i>Lutjanus guttatus</i>
Banded jewelfish <i>Hemichromis elongatus</i>	Graceful mojarra <i>Eucinostomus gracilis</i>	Bluestripe snapper <i>Lutjanus kasmira</i>
African jewelfish <i>Hemichromis letourneuxi</i>	Gobiidae	Emperor snapper <i>Lutjanus sebae</i>
Banded cichlid <i>Heros severus</i>	Yellowfin goby <i>Acanthogobius flavimanus</i>	Moronidae
Scrapermouth cichlid <i>Labeotropheus</i> sp.	Llongjaw mudsucker <i>Gillichthys mirabilis</i>	White perch <i>Morone americana</i>
Golden mbuna <i>Melanochromis auratus</i>	Sortjaw mudsucker <i>Gillichthys seta</i>	White perch x striped bass <i>Morone americana</i> x <i>M. saxatilis</i>
Bluegray mbuna <i>Melanochromis johannii</i>		White bass <i>Morone chrysops</i>
Blue tilapia <i>Oreochromis aureus</i>		
Longfin tilapia <i>Oreochromis macrochir</i>		

White bass x yellow bass <i>Morone chrysops</i> x <i>M. mississippiensis</i>	Goldspotted angelfish <i>Apolemichthys xanthopunctatus</i>	Gulf sierra <i>Scomberomorus concolor</i>
Wiper <i>Morone chrysops</i> x <i>M. saxatilis</i>	Lemonpeel angel <i>Centropyge flavissima</i>	Scorpaenidae
Yellow bass <i>Morone mississippiensis</i>	Flaming angelfish <i>Centropyge loricula</i>	Lionfish <i>Pterois volitans</i> / <i>P. miles</i>
Yellow bass x striped bass <i>Morone mississippiensis</i> x <i>M. saxatilis</i>	Vermiculated angelfish <i>Chaetodontoplus mesoleucus</i>	Serranidae
Striped bass <i>Morone saxatilis</i>	Blue ringed angelfish <i>Pomacanthus annularis</i>	Peacock hind <i>Cephalopholis argus</i>
Mullidae	Arabian angel <i>Pomacanthus asfur</i>	Darkfin hind <i>Cephalopholis urodeta</i>
Bandedtail goatfish <i>Upeneus vittatus</i>	Emperor angelfish <i>Pomacanthus imperator</i>	Humpback grouper <i>Chromileptes altivelis</i>
Nematistidae	Yellowbar angelfish <i>Pomacanthus maculosus</i>	Blacktip grouper <i>Epinephelus fasciatus</i>
Roosterfish <i>Nematistius pectoralis</i>	Semicircle angelfish, zebra angelfish <i>Pomacanthus semicirculatus</i>	Star-spotted grouper <i>Epinephelus hexagonatus</i>
Osphronemidae	Bluefaced angel <i>Pomacanthus xanhomeoton</i>	Marquesan grouper <i>Epinephelus irroratus</i>
Giant gourami <i>Osphronemus gorami</i>	Regal angelfish <i>Pygoplites diacanthus</i>	Dwarf spotted grouper <i>Epinephelus merra</i>
Percidae	Pomacentridae	White-streaked grouper <i>Epinephelus ongus</i>
Florida sand darter <i>Ammocrypta bifascia</i>	Whitetail damselfish <i>Dascyllus aruanus</i>	Spotted sand bass <i>Paralabrax maculatofasciatus</i>
Western sand darter <i>Ammocrypta clara</i>	Three spot damselfish <i>Dascyllus trimaculatus</i>	Stromateidae
Greenside darter <i>Etheostoma blennioides</i>	Scat <i>Scatophagus argus</i>	Pacific butterfish <i>Peprilus simillimus</i>
Rainbow darter <i>Etheostoma caeruleum</i>	Sciaenidae	Zanclidae
Arkansas darter <i>Etheostoma cragini</i>	Freshwater drum <i>Aplodinotus grunniens</i>	Moorish idol <i>Zanclus cornutus</i>
Brown darter <i>Etheostoma edwini</i>	Bairdiella <i>Bairdiella icistia</i>	PLEURONECTIFORMES
Iowa darter <i>Etheostoma exile</i>	Spotted seatrout <i>Cynoscion nebulosus</i>	Paralichthyidae
Swamp darter <i>Etheostoma fusiforme</i>	Spotted seatrout x orangemouth corvina <i>Cynoscion nebulosus</i> x <i>C. xanthulus</i>	Fringed flounder <i>Etropus crossotus</i>
Johnny darter <i>Etheostoma nigrum</i>	Gulf corvina <i>Cynoscion othonopterus</i>	Cortez halibut <i>Paralichthys aestuarius</i>
Watercress darter <i>Etheostoma nuchale</i>	Shortfin corvina <i>Cynoscion parvipinnis</i>	Gulf flounder <i>Paralichthys albigutta</i>
Tessellated darter <i>Etheostoma olmstedi</i>	Orangemouth corvina <i>Cynoscion xanthulus</i>	Southern flounder <i>Paralichthys lethostigma</i>
Snubnose darter <i>Etheostoma simoterum</i>	Spot <i>Leiostomus xanthurus</i>	Dappled flounder <i>Paralichthys woolmani</i>
Banded darter <i>Etheostoma zonale</i>	Highfin kingfish <i>Menticirrhus nasus</i>	Pleuronectidae
Ruffe <i>Gymnocephalus cernuus</i>	California corbina <i>Menticirrhus undulatus</i>	Diamond turbot <i>Hypsopsetta guttulata</i>
Yellow perch <i>Perca flavescens</i>	Gulf croaker <i>Micropogonias megalops</i>	European flounder <i>Platichthys flesus</i>
Logperch <i>Percina caprodes</i>	Atlantic croaker <i>Micropogonias undulatus</i>	Starry flounder <i>Platichthys stellatus</i>
Bigscale logperch <i>Percina macrolepidia</i>	Black drum <i>Pogonias cromis</i>	TETRADONTIFORMES
Blackside darter <i>Percina maculata</i>	Black drum x red drum <i>Pogonias cromis</i> x <i>Sciaenops ocellatus</i>	Balistidae
Blackbanded darter <i>Percina nigrofasciata</i>	Red drum <i>Sciaenops ocellatus</i>	Clown triggerfish <i>Balistoides conspicillum</i>
Stripeback darter <i>Percina notogramma</i>	Totoaba <i>Totoaba macdonaldi</i>	Lagoon triggerfish <i>Rhinecanthus aculeatus</i>
Shield darter <i>Percina peltata</i>	Scombridae	Bursa triggerfish <i>Rhinecanthus verrucosus</i>
Roanoke darter <i>Percina roanoka</i>		Tetraodontidae
River darter <i>Percina shumardi</i>		Masked pufferfish <i>Arothron diadematus</i>
Snail darter <i>Percina tanasi</i>		Spotted green pufferfish <i>Tetraodon nigroviridis</i>
Sauger <i>Sander canadensis</i>		
Zander <i>Sander lucioperca</i>		
Walleye <i>Sander vitreus</i>		