American Bullfrog (*Lithobates catesbeianus*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, June 2015
Revised, July 2015 and January 2017
Web Version, 2/9/2018

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1 Native Range and Status in the United States

Native Range

From CABI (2015):

"[…] native to eastern North America, ranging naturally from Nova Scotia, southern Quebec and Ontario in Canada, down through the eastern United States and Mississippi drainage, and southward along the east coast of Mexico."

Status in the United States

From McKercher and Gregoire (2015):

"**Arizona**: Populations are established in San Bernadion Wildlife Refuge in Cochise county, Leslie Canyon National Wildlife Refuge in Cochise county, and Buenos Aires National Wildlife Refuge in Pima County (USFWS, 2005)."

"**California**: American Bullfrogs are established in Pixley National Wildlife Refuge-Tulare county, Colusa National Wildife Refuge [Sacramento region] - Colusa county, Kern National Wildlife Refuge - Kern county, Humboldt Bay National Wildlife Refuge -Humboldt county, San Diego National Wildlife Refuge- San Diego county, and Guadalupe-Nipomo Dunes National Wildlife Refuge - San Luis Obispo county, and the Trinity River - Trinity County (USFWS, 2005; Fuller et al. 2011)."

"**Colorado**: Specimens are established in Two Ponds National Wildlife Refuge (outside Denver) - Jefferson county (USFWS, 2005)."

"**Hawaii**: Populations are established in Oahu Forest National Wildlife Refuge (in Haleiwa) and James Campbell National Wildlife Refuge, both in Honolulu county (USFWS, 2005)."

"**Iowa**: Established in Desoto National Wildlife Refuge (Located along the Missouri River, 25 miles north of Omaha) in Harrison county (USFWS, 2005)."

"**Massachusetts**: Stocked in Nantucket, the Vineyard, and the Wellfleet Bay Sanctuary, but now established only in Wellfleet Bay Sanctuary, Massachusetts.Established in Nomans Land Island National Wildlife Refuge (In the Atlantic Ocean 3.5 mi SW of Squibnocket Point; Martha's Vineyard; Town of Chilmark) - Dukes county and Assabet River National Wildlife Refuge (formerly referred to as the U.S. Army's Fort Devens Sudbury Training Annex)-Middlesex county (USFWS, 2005)."

"**Nebraska**: Established in Boyer Chute National Wildlife Refuge - Washington county (USFWS, 2005).New Jersey: Established Cape May National Wildlife Refuge - Cape May county (USFWS, 2005)."

"**Nevada**: Established in Pahranagat National Wildlife Refuge, reservoirs in Lincoln county (USFWS, 2005)."

"**Oregon**: Established in Ankeny National Wildlife Refuge - Marion county, Baskett Slough National Wildlife Refuge - Polk county, Cold Springs National Wildlife Refuge - Umatilla county, Tualatin River National Wildlife Refuge - Clackamas county, William L. Finley National Wildlife Refuge - Benton county, Umatilla National Wildlife Refuge - Marrow county (USFWS, 2005)."

"**Utah**: Established in Fish Springs National Wildlife Refuge - Juab county (USFWS, 2005)."

"**Washington**: Established in Conboy Lake National Wildlife Refuge - Klickitat county, Hanford Reach National Monument/Saddle Mountain National Wildlife Refuge - Grant county, Julia Butler Hansen Refuge for the Columbian White-tailed Deer - Wahkiakum county,   Lewis and Clark National Wildlife Refuge - Wahkiakum county, Franz Lake National Wildlife Refuge (Along the Columbia River, 2.2 km (1.4 mi) WSW of Skamania)- Skamania county, McNary National Wildlife Refuge - Walla Walla county, McKay Creek National Wildlife Refuge, Nisqually National Wildlife Refuge, Toppenish National Wildlife Refuge - Yakima county, Pierce National Wildlife Refuge - Skamania county, Steigerwald Lake National Wildlife Refuge - Clark county, Ridgefield National Wildlife Refuge and Columbia National Wildlife Refuge (USFWS, 2005)."

Means of Introductions in the United States

From McKercher and Gregoire (2015):

"The original mode of introduction [to new areas] was probably through accidental introduction with fish stocking; however, other means of introduction have also contributed to the spread of this species in the western states."

Remarks

From McKercher and Gregoire (2015):

"Frost et al. (2006) revised the genus *Rana* and most of the North, Central and South American "true frogs" were seperated [*sic*] from this taxon and placed into the new genus *Lithobates* (Frost et al., 2006; Crother, 2008; Collins and Taggart, 2009). Scientific and standard English names follow Crother (2008)."

"Based on a study in western Washington, conservation of ephemeral wetlands will halt range expansions of bullfrogs. Permanently inundated wetlands are more likely to house nonindigenous species."

From ITIS (2017):

"Synonym(s): *Rana catesbeiana* Shaw, 1802"

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2017):

"Kingdom Animalia
  Subkingdom Bilateria
    Infrakingdom Deuterostomia
      Phylum Chordata
        Subphylum Vertebrata
          Infraphylum Gnathostomata

Superclass Tetrapoda
Class Amphibia
Order Anura
Family Ranidae
Genus *Lithobates*
Species *Lithobates catesbeianus* (Shaw, 1802)"

"Taxonomic Status: valid"

Size, Weight, and Age Range

From GISD (2009):

"*L. catesbeianus* are a large frog reaching up to 20cm in snout-to-vent length (SVL) and up to 800g in weight. […] Longevity for wild bullfrogs is estimated to be eight to 10 years, although a captive specimen survived for nearly 16 years (Oliver 1955a, Goin and Goin 1962, in Casper and Hendricks 2005)."

Environment

From Lorvelec and Détaint (2006):

"Where introduced, it occupies any type of habitat that is lentic or with slowly moving water, especially if aquatic and bank vegetation are abundant."

From GISD (2009):

"Areas having high precipitations during both summer and winter, high maximum temperature, high human pressure, and intermediate minimum annual temperature were those with the highest predicted suitability for bullfrogs (Ficetola et al. 2007b)."

"Bullfrogs are sometimes found in temporary water bodies hundreds of meters from permanent water (Santos-Barrera et al. 2009). However, they are typically found in permanent ponds, whereas most other amphibians inhabit temporary ponds. […] Bullfrogs are often excluded from temporary ponds because they have larval periods exceeding one year, although they can reach metamorphosis in a single season (MDB Pers. Obs., Pechmann et al. 2001 in Boone [et al.] 2004). Bullfrogs will hibernate at the bottom of water bodies or in secluded places on land (CABI Bioscience 2005)."

Climate/Range

From GISD (2009):

"Native to a more temperate climate, bullfrogs have become introduced in over 40 countries. Their huge range is vastly growing with current climate changes that provide suitable habitats all around the world."

Distribution Outside the United States

Native

From CABI (2015):

"[…] native to eastern North America, ranging naturally from Nova Scotia, southern Quebec and Ontario in Canada, down through the eastern United States and Mississippi drainage, and southward along the east coast of Mexico."

Introduced

From GISD (2009):

"*Lithobates catesbeianus* has been introduced in over 40 countries and four continents over the last century (Lever 2003 in Ficetola et al. 2007b). Bullfrogs are broadly invading western United States and have also been introduced in Mexico, western Canada, Hawaii, Japan, Italy, the Netherlands, Cuba and Jamaica (Green 1978, Stebbins 1985, Stumpel 1992 in Adams et al. 2003)."

From Lorvelec and Détaint (2006):

"It is currently established in […] southern British Columbia, as well as in several countries of South America, some islands of the Greater Antilles, Asia, […] and Europe. In Europe, it has been introduced in Germany, Italy, United Kingdom, Spain, the Netherlands, Greece, Belgium and France."

Means of Introduction Outside the United States

From GISD (2009):

"*Aquaculture:* Bullfrogs will disperse from artificial water bodies into natural water bodies using seasonal water corridors (Govindarajulu 2004). […]
Biological control: In some cases, bullfrogs have been deliberately introduced to control agricultural insect pests. This pathway has been of limited importance in the second half of the 20th century.
For ornamental purposes: In British Columbia, Canada they are sold in aquatic garden supply stores for the enhancement of ornamental ponds.
Landscape/fauna "improvement": They have been deliberately introduced as an aesthetically pleasing wildlife.
Natural dispersal: Movements of 2.8 km and more have been documented but bullfrogs are generally philopatric (Bury and Whelan 1984 in Adams et al. 2003). […]
Pet/aquarium trade: Translocations into private wetlands as a pet or source of food (Albertini 1970; Yiming et al. 2006, in Ficetola et al. 2007a) can substantially increase the rate of expansion of this invasive species. Interviews of local people confirmed that, within a study area in France, translocations were performed at least in one case (Ficetola et al. 2007a).
Smuggling: Some bullfrogs continue to be smuggled into some European Union states (following legislation prohibiting the import of the species); arrests aiming to curtail this activity have been made and tens of thousands of animals have been seized (Fiore and Avanzo 2002, Dupré et al.

2006 in Kraus 2009).
Stocking: Species such as *R. catesbeiana* have been introduced into new locations with the intention of establishing new food sources for human consumption (Kraus 2009). Although this pathway has been of limited importance in the second half of the 20th century although it is still important in many developing counties (Kraus 2009)."

From CABI (2015):

"In the late 19th and early 20th centuries bullfrogs were translocated from the eastern United States to […] western Canada (Orchard, 1999), the Caribbean (Kairo et al., 2003; Kraus, 2009), western Europe (Ficetola et al., 2007[a]; Lanza, 1962; Veenvliet and Veenvliet, 2003, 2004; Nehring and Klingenstein, 2008), South America (Hanselmann et al., 2004; Giovanelli et al., 2008; Laufer et al., 2008; Kraus, 2009) east Asia (Fei et al., 1999; Hirai, 2004; Wu et al., 2005; Wang et al., 2008) and southeast Asia (Hardouin, 1997). There have also been introductions to western and central Mexico, from the eastern USA and north-eastern Mexico. Historically the primary motive for moving bullfrogs from place to place has been to profitably cultivate them for human consumption, but there have also been many releases for less obvious reasons. There are currently websites offering to ship bullfrog tadpoles anywhere in the United States ostensibly to enliven backyard ponds. The development of irrigation networks, reservoirs, sewage settling ponds, golf course ponds, farm ponds, and man-made ponds in public parks will permit bullfrogs to take hold in many urban and semi-urban situations and this also facilitates their subsequent dispersal."

Short Description

From GISD (2009):

"They have a robust body with a wide flat head and smooth skin with no wrinkles, warts or spikes (Flores 2005). Dorsal color is pale green to dark olive and can have brown spots. Ventral side is white, grey or yellowish (N.D. LeClere). As sexual maturity approaches in males the upper abdomen temporarily turns yellowish in color (Flores 2005). American bullfrogs have conspicuous tympanic membranes (eardrums). Mature males have tympanums twice the diameter of the eye, while mature females have tympanums about the same diameter as the eye (National Research Council 1974). Males are also slightly smaller than females and have darkly pigmented thumb pads in contrast to the more delicate streamlined thumb of the female (National Research Council 1974). Bullfrogs, in contrast to the similar green frog, do not have dorsolateral ridges (National Research Council 1974, N.D. LeClere). Tadpoles are greenish yellow with small spots, growing up to 15 cm."

Biology

From GISD (2009):

"Several authors suggest that bullfrogs may have a preference for highly artificial and highly modified habitats, such as millponds, livestock grazing ponds and reservoirs (Wright and Wright 1949, Bury and Luckenbach 1976, Jennings 1988, Zampella and Bunnell 2000 in Adams et al. 2003, Doubledee et al. 2003, Ficetola et al. 2007b). Hayes and Jennings (1986, in Cook and Jennings 2007) pointed out that human-driven habitat modification, such as changes in hydrology from seasonal to permanent water, removal of emergent vegetative cover, and elevation of water temperatures from increased sunlight all favor the establishment of bullfrogs. Yiming et al. (2005) concluded from their study that the ease with which bullfrogs have invaded islands of the Zhoushan archipelago relative to the mainland has little to do with biotic resistance but results from variation in factors under human control. Habitats that are highly modified by human activity are typically characterized by a decrease or complete lack of habitat complexity (Doubledee et al. 2003). In such environments bullfrogs are expected to have high attack rates (the attack rate is a measure of bullfrog search efficiency, specifically the length of shoreline that is kept clear of prey items by a bullfrog in a given time interval). Bullfrogs are expected to be less efficient at keeping a complex shoreline choked with cattails and bulrushes clear of prey items than they would be along a shoreline devoid of such vegetation (Doubledee et al. 2003). In other words human-modified habitats probably enhance habitats for bullfrogs by providing optimum conditions for bullfrogs to find and devour their prey."

"Bullfrog tadpoles are mainly herbivorous and consume algae, aquatic plant material and some invertebrates (Treanor and Nichola 1972, Bury and Whelan 1984, in Casper and Hendricks 2005). Their efficient gill filters allow them to feed on an impressive diversity of algal species (Kenny 1969, Wassersug 1972 in Pryor 2003) and their labial teeth (which bear a striking resemblance to the radulae of herbivorous snails; Stenick and Watling 1982, Pers. Obs. in Pryor 2003) allow them to graze periphyton (Wassersug 1984; Kupferberg et al. 1994; Kupferberg [1997]; Altig and McDiarmid 1999 in Pryor 2003). Bullfrog tadpoles will also prey on the tadpoles of other species (Kiesecker and Blaustein 1997, in Blaustein and Kiesecker 2002). Adult bullfrogs are gape-limited opportunistic predators that employ a sit-and-wait approach to feeding (Bury and Whelan 1984, Schwalbe and Rosen 1988, in Casper and Hendricks 2005). Bullfrogs essentially eat whatever they can fit into their mouths (Roach 2004), including crayfish, dragonfly nymphs, aquatic hemipterans and water beetles and small vertebrates such as fish, frogs, turtles, snakes, birds, bats, and weasels (Hirai 2004 and references therein). They have also been known to eat other bullfrogs. In fact, in southern Arizona the most common vertebrate found in bullfrog intestines were other bullfrogs (C. Schwalbe pers. comm. in Roach 2004)."

"Sexual maturity in bullfrogs usually occurs at one to two years in males, and at two to three years in females (Howard 1981, in Casper and Hendricks 2005). Bullfrogs breed in the vegetation-choked shallows (Pope 1964a, in Casper and Hendricks 2005) of permanent bodies of water. Bullfrog breeding is restricted to warmer periods during spring and summer (Cook and Jennings 2007). In southwest France, the breeding period begins in May and lasts until early September and tadpole development takes one to two years (Lorvelec and Détaint 2006)."

"Eggs: Eggs are laid in thin sheets on the water surface, covering 0.5 to 1 m^2, and hatching in three to five days (Bury and Whelan 1984, in Casper and Hendricks 2005). The egg batch forms a floating raft attached to vegetation (CABI Bioscience 2005). Bullfrogs are extremely prolific, producing up to 20 000 eggs per clutch (Schwalbe and Rosen 1999, in Casper and Hendricks 2005). The number of zygotes sired by successfully mating males ranged from 5,000 to 59,000 (mean 11,000), with the number of resultant hatchlings ranging from 300 to 29,000 (mean 5,600; Howard 1978b, in Casper and Hendricks 2005). Females may lose up to 27% of their body mass during oviposition (Judge et al. 2000, in Casper and Hendricks 2005)."

“Larvae/Metamorphosis: Tadpoles favor warm water environments (24°C to 30°C; Brattstrom 1962b, in Casper and Hendricks 2005). The time to metamorphosis varies from a few months (in the south) to three years (in Michigan and Nova Scotia) (Collins 1979, Bury and Whelan 1984). The length of the larval period is negatively correlated with mean length of the frost-free period (Collins 1979, Crawshaw et al. 1992, in Casper and Hendricks 2005).”

Human Uses

From GISD (2009):

“Used as biological control agents, ornamental purposes, landscape improvements, pets and also as a food source […]”

Diseases

From GISD (2009):

“Chytridiomycosis, caused by the fungus *Batrachochytrium dendrobatidis*, is an emerging disease of amphibians responsible for population declines and even extinctions globally (Hanselmann et al. 2004). Introduced populations of *Lithobates catesbeianus* can harbor reservoirs of the fungal agent without showing significant clinical disease symptoms themselves (Hanselmann et al. 2004).”

From CABI (2015):

“Ranavirus is another pathogen associated with bullfrogs that has been implicated in > 90% mortality rates in free-ranging non-bullfrog amphibians (Daszak et al., 1999; Schloegel et al., 2009) and > 50% mortality amongst bullfrogs in an American ranaculture facility (Miller et al., 2007). […] There have been significant mortality events reported from bullfrog farming operations involving a variety of pathogenic bacteria (Pasteris et al., 2006). The bacterium *Aeromonas hydrophila* commonly infects bullfrogs in farms and in nature and the symptomatic syndrome is often called ‘red leg disease’ (Kong et al 1997).”

“Other pathogens associated with American bullfrogs in recent studies include iridoviruses (*Ranavirus*), and the bacterium *Mycobacterium marinum* (Ferreira et al., 2006). Also of interest is the fact that when Kiesecker and Skelly (1999) infected bullfrog tadpoles with the debilitating pathogen *Asterotremella humicola* (*Candida humicola*), they found that healthy bullfrog tadpoles avoided infected conspecifics, presumably to reduce the risk of infection. Limb malformations in frogs, including bullfrogs, have garnered considerable media attention largely due to the initial suspicion that they might be related to deteriorating water quality with potential human health implications (Souder, 2000; Lannoo, 2008). Subsequent research has shown that in many cases these malformations are the result of natural infections by the trematode *Ribeiroia*, though the incidence of these infections seems to have recently increased (Johnson et al.,2003).”

“Also, bullfrog tadpoles and metamorphs have been shown to be suitable hosts for the pathogenic bacterium *Escherichia coli* (Gray et al., 2007). In Japan it was found that 92% of the bullfrogs sampled were highly infected with *Blastocystis*, a single-celled parasite that infects the gastrointestinal tract of hosts including humans (Yoshikawa et al., 2004). The skinning of bullfrogs has been implicated in rare cases of nematode infection of humans (Quirks and Quarks, CBC Radio, Canadian Broadcasting Corporation). Studies are currently under way looking into whether bullfrogs could play a role in transmission of West Nile virus (WNV), because the virus has been isolated in many amphibian-feeding species of mosquitoes (Klenk and Komar, 2003; Danner & Phillips, 2008). An investigation of a cholera outbreak in Hunan, China, in 2006 concluded that aquatic products such as snapping turtles and bullfrogs constituted the major causes of cholera (Deng et al., 2008)."

Infection with *Batrachochytrium dendrobatidis* (chytrid fungus) and infection with ranavirus are OIE-reportable diseases.

Threat to Humans

From CABI (2015):

"The summer chorusing of dense aggregations of large male bullfrogs is sometimes identified as a source of noise pollution. However, if this is having a negative effect on real estate values or tourism the damage has yet to be quantified. Aggregations of large bullfrog tadpoles and juveniles at lake edge swimming areas are psychologically disturbing to some people, but it is not clear whether these people will lobby for the funds to have the problem fixed or they simply go swimming elsewhere."

"There have been cases of severe allergic reaction in some people who ingest the meat of bullfrogs (Hilger et al.,2002). Also, bullfrog tadpoles and metamorphs have been shown to be suitable hosts for the pathogenic bacterium *Escherichia coli* (Gray et al., 2007). In Japan it was found that 92% of the bullfrogs sampled were highly infected with *Blastocystis*, a single-celled parasite that infects the gastrointestinal tract of hosts including humans (Yoshikawa et al., 2004). The skinning of bullfrogs has been implicated in rare cases of nematode infection of humans (Quirks and Quarks, CBC Radio, Canadian Broadcasting Corporation). Studies are currently under way looking into whether bullfrogs could play a role in transmission of West Nile virus (WNV), because the virus has been isolated in many amphibian-feeding species of mosquitoes (Klenk and Komar, 2003; Danner & Phillips, 2008). An investigation of a cholera outbreak in Hunan, China, in 2006 concluded that aquatic products such as snapping turtles and bullfrogs constituted the major causes of cholera (Deng et al., 2008)."

3 Impacts of Introductions

From GISD (2009):

"Threat to Endangered Wildlife: In the USA the bullfrog is known to prey on the following endangered amphibians: Amargosa Toad (*Anaxyrus nelsoni*) (Jones et al. 2003 in Kraus 2009); California tiger salamander (*Ambystoma californiense*); Chiricahua leopard frog (*Lithobates chiricahuensis*); the California red-legged frog (*Rana draytonii*); and the Oregon spotted frog (*Rana pretiosa*)

Ecosystem change: Several field studies portray tadpoles as ''ecosystem engineers'' that alter the biomass, structure and composition of algal communities (Dickman 1968, Seale 1980, Osborne

and McLachlan 1985, Kupferberg [1997], Flecker et al. 1999, Peterson and Boulton 1999, in Pryor 2003).
Modification of Nutrient Regime: High food intake (Wassersug 1984, in Pryor 2003) and high population densities (up to thousands of individuals per m^2; Alford 1986, in Pryor 2003) suggest that tadpoles have considerable impact on nutrient cycling and primary production in freshwater ecosystems.
Predation: Tadpoles of *L. catesbeianus* feed upon eggs and larvae of the endangered Razorback Sucker (*Xyrauchen texanus*) in laboratory conditions (Mueller et al. 2006, in Kraus 2009), and their densities in artificial habitats can depress fish larvae recruitment (Kraus 2009).
Competition: Introduced bullfrogs compete with endemic species (Kupferberg 1997, Kiesecker and Blaustein 1997 in Hanselmann et al. 2004). Unlike many other frogs, bullfrogs can coexist with predatory fish (Hecnar 1997 in Casper and Hendricks 2005), giving bullfrogs a competitive advantage.
Interaction with other Invasive Species: In Oregon, the invasion of bullfrogs appears to have been facilitated by the presence of the non-native sunfish (Adams et al. 2003)."

From Li et al. (2011):

"Bullfrog invaded sites had lower native frog density and species richness, higher submerged vegetation cover and greater frequency of repairs to the water body than did non-invaded sites. […] Both native frog density and species richness were negatively related to post-metamorphosis bullfrog density […] The results suggested that post-metamorphosis bullfrogs had impacts on native frog communities in the [Zhoushan Archipelago, China], and that the extents of these impacts are proportional to post-metamorphosis bullfrog density."

From CABI (2015):

"Bullfrogs are prolific and aggressive competitors for space and voracious predators of a very wide variety of organisms, so displacement of native species is the primary problem that they create (Bury and Whelan, 1984; Lannoo, 2005; Santos-Barrera et al., 2009). They have a much higher critical thermal maximum than most other frogs, meaning that they are able to thrive in higher water temperature, and have a longer breeding season and a higher rate of pre-metamorphic survivorship, which also allows them to be more successful than other frogs. (They also do well with changes in the environment that have occurred due to human modification)."

"Consequently, their invasions are routinely identified as a principal cause of declining populations of native amphibians (Fisher and Shaffer, 1996; Hecnar and M'Closkey, 1997; Adams, 2000; Kats and Ferrer, 2003; Lannoo et al., 1994; Moyle, 1973; Hammerson, 1982), but questions have been raised about the certainty of some of these claims, as habitat modifications and the introduction of exotic predatory fish and crayfish (Mueller et al., 2006) were concurrent events which can make isolating the effects of invasive bullfrogs difficult to impossible (Hayes and Jennings, 1986). Lannoo et al. (1994) repeated an amphibian survey conducted in 1923 in Dickinson County, Iowa, USA, and concluded that the most immediate threat to the existing populations of native amphibians came from the impact of the introduced bullfrog. Bullfrogs may be a primary predator of several federally endangered waterfowl in Hawaii (Pitt et al., 2005). Schwalbe and Rosen (1988) concluded that bullfrogs negatively impact populations of native amphibians and reptiles, and at least two species of endangered fish in southeastern Arizona. The presence of bullfrog tadpoles has been shown to reduce survivorship in both California red-legged frog (*Rana draytonii*, also known as *R. aurora draytonii*) tadpoles (Lawler et al., 1999) and Columbia spotted frog tadpoles (Monello et al., 2006). Kiesecker and Blaustein (1998) found that the red-legged frog *Rana aurora* was negatively impacted by bullfrog larvae and adults. Hecnar and M'Closkey (1997) found that *Rana clamitans* populations increased greatly after bullfrog extirpation at a site in Ontario. Under laboratory conditions bullfrog tadpoles, in concert with the non-native red swamp crayfish (*Procambarus clarkii*), have also been shown to eat the eggs and larvae of the endangered razorback sucker (*Xyrauchen texanus*) in the western United States (Mueller et al., 2006)."

"The results of Kupferberg (1997) suggest that invasive bullfrog tadpoles can exert differential effects on native ranid and hylid frogs and perturb aquatic community structure, and Kiesecker et al. (2001) had similar findings when looking at interactions between non-native bullfrog tadpoles and tadpoles of a native ranid. However, Kiesecker et al.(2001) also suggested that human-induced habitat alteration was a key factor in properly interpreting the results. Pearl et al.(2004) confirmed differential effects of introduced bullfrogs on two species of native ranid frogs in the western United States. In Brazil there are no studies on the consequences of bullfrog introduction, although there is news that in several regions bullfrogs have been seen in the wild, near frog farms (Jim, 1995)."

4 Global Distribution

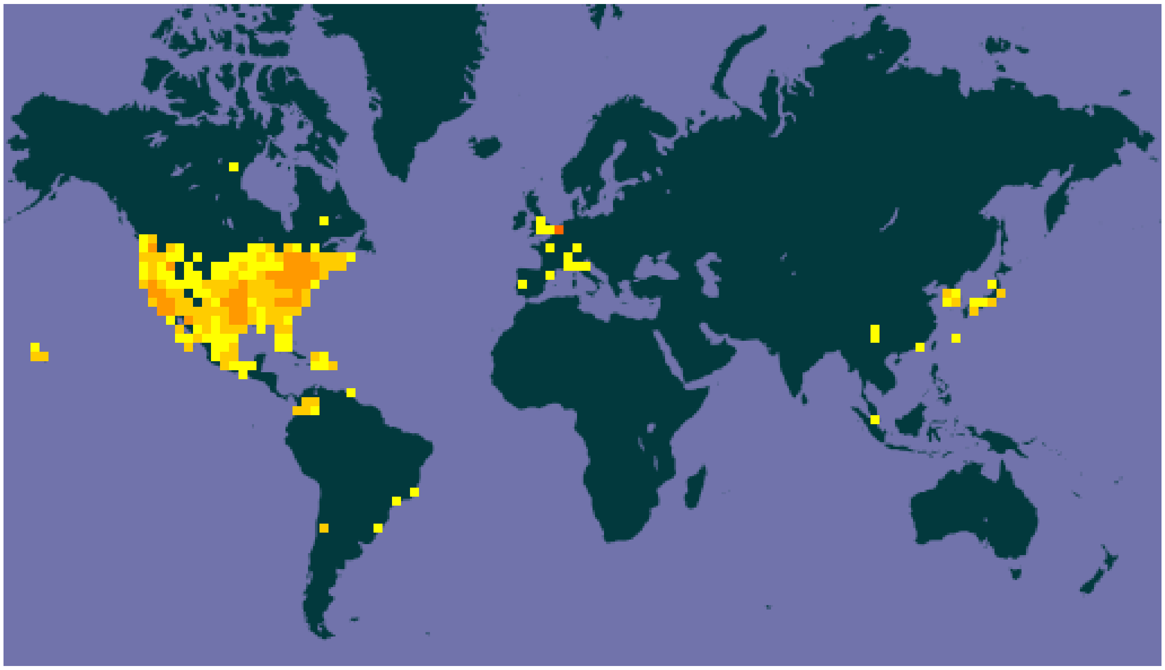

Figure 1. Global distribution of *Lithobates catesbeianus*. Map from GBIF (2016). Locations in Nunavut and southern Quebec, Canada, and Trinidad and Tobago are not supported by other sources and were not included in climate matching.

5 Distribution Within the United States

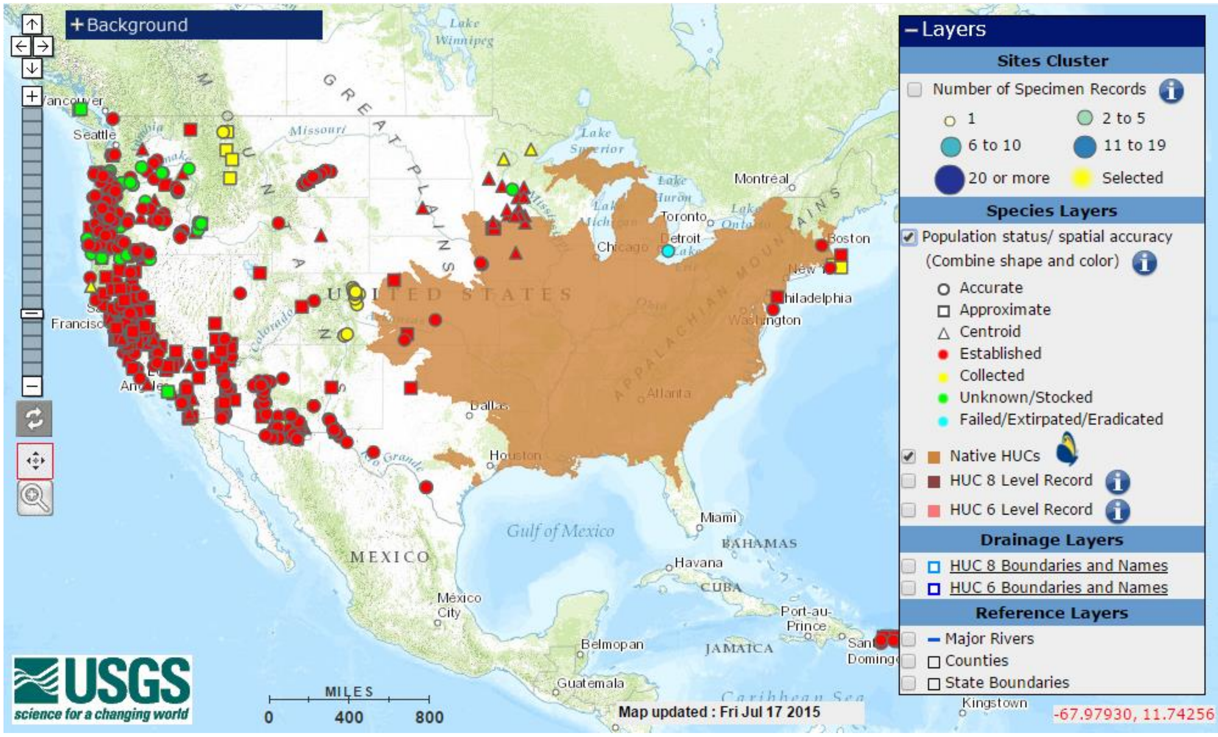

Figure 2. Native and nonnative distribution of *Lithobates catesbeianus* in the United States. Map from McKercher and Gregoire (2015).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) yielded a Climate 6 score of 0.995 for *L. catesbeianus*. The established range of scores indicating a high climate match is 0.103 and greater. Thus, the contiguous U.S. has a very high climate match with established *L. catesbeianus* populations. High climate matches are observed across almost the entire contiguous U.S., except for moderate matches in the Pacific Northwest and parts of the Rocky Mountains.

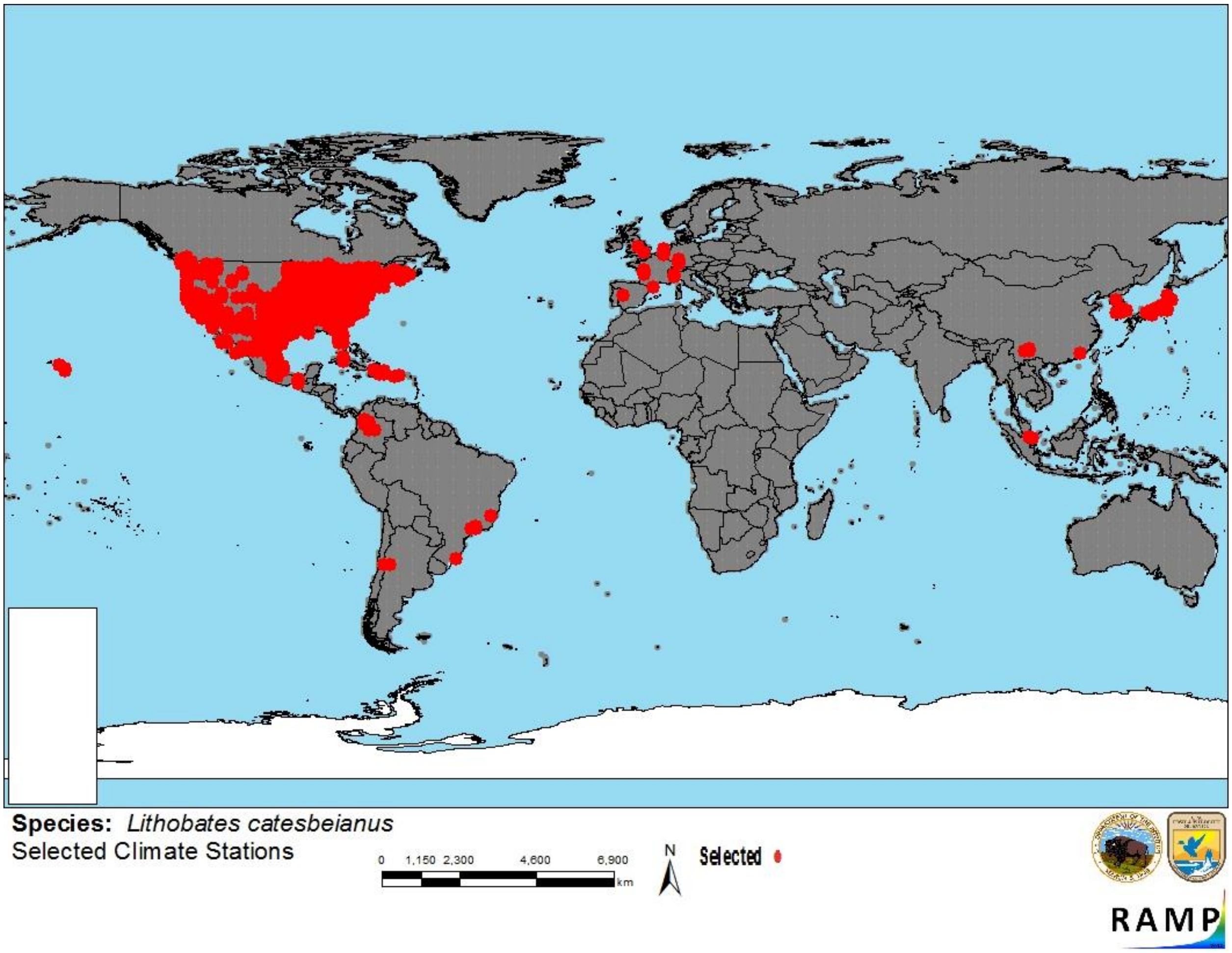

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Lithobates catesbeianus* climate matching. Source locations from GBIF (2016).

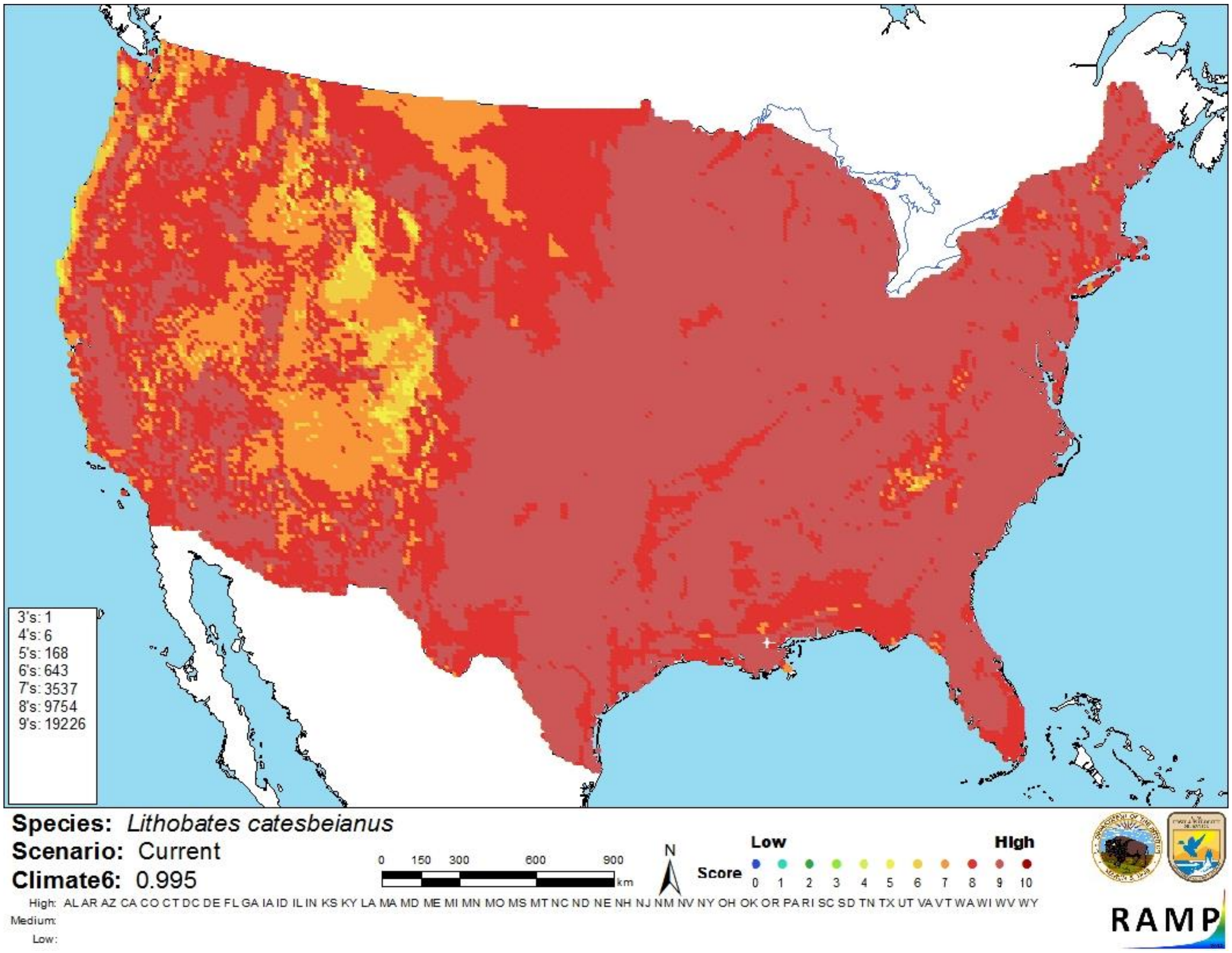

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Lithobates catesbeianus* in the contiguous United States based on source locations reported by GBIF (2016). 0=Lowest match, 10=Highest match. Counts of climate match scores are tabulated on the left.

The “High”, “Medium”, and “Low” climate match categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

Information on the biology, invasion history and impacts of *Lithobates catesbeianus* is readily available from a substantial body of peer-reviewed literature. No further information is needed to evaluate the negative impacts the species is having where introduced. The certainty of this assessment is high.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Lithobates catesbeianus, a frog native to eastern North America, has become established across the United States and in many other countries as well via intentional and accidental introductions. Numerous authors have described the effects of *L. catesbeianus* on novel ecosystems; these include outcompeting or preying on native species, altering nutrient cycling, and spreading disease. Nearly all locations in the contiguous U.S. provide suitable climate for this species. Overall risk posed by this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information: Susceptible to two OIE-reportable diseases.**
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

CABI. 2015. *Rana catesbeiana* (American bullfrog) [original text by S. Orchard]. Invasive Species Compendium. CAB International, Wallingford, UK. Available: http://www.cabi.org/isc/datasheet/66618. (July 2015).

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