GLOBAL INVASIVE SPECIES DATABASE

FULL ACCOUNT FOR: ***Lithobates catesbeianus***

Lithobates catesbeianus 简体中文 正體中文 **System:** Freshwater_terrestrial

Kingdom	Phylum	Class	Order	Family
Animalia	Chordata	Amphibia	Anura	Ranidae

Common name Ochsenfrosch (German), North American bullfrog (English), Stierkikker (Dutch), Rana toro (Spanish), Grenouille taureau (French), Bullfrog (English)

Synonym *Rana catesbiana* ,Shaw, 1802

Similar species *Rana clamitans, Rana ridibunda*

Summary
The American bullfrog (*Lithobates catesbeianus* (=*Rana catesbeiana*)) is native to North America. It has been introduced all over the world to over 40 countries and four continents. Many introductions have been intentional with the purpose of establishing new food sources for human consumption. Other populations have been established from unintentional escapes from bullfrog farms. Consequences of the introduction of non-native amphibians to native herpetofauna can be severe. The American bullfrog has been held responsible for outbreaks of the chytrid fungus found to be responsible for declining amphibian populations in Central America and elsewhere. They are also important predators and competitors of endangered native amphibians and fish. The control of this invasive in Europe partly relies upon increasing awareness, monitoring and education about the dangers of releasing pets into the wild. Strict laws are also in place to prevent further introductions. Eradication is achieved largely by physical means including shooting, spears/gigs, bow and arrow, nets and traps.

[view this species on IUCN Red List]

Species Description

L. catesbeianus are a large frog reaching up to 20cm in snout-to-vent length (SVL) and up to 800g in weight. They have a robust body with a wide flat head and smooth skin with no wrinkles, warts or spikes (Flores, 2005). Dorsal colour is pale green to dark olive and can have brown spots. Ventral side is white, grey or yellowish (LeClere, n.d.). As sexual maturity approaches in males the upper abdomen temporarily turns yellowish in colour (Flores, 20005). 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; LeClere, n.d.). Tadpoles are greenish yellow with small spots, growing up to 15 cm.

Notes

At least 322 species of reptiles and amphibians have been naturalised across the globe; of these 14 species have had ecological impacts demonstrated or reasonably inferred (Kraus, 2009) and of these only three (brown tree snake (*Boiga irregularis*), cane toad (*Rhinella marina*) and *L. catesbeianus*) are even moderately well studied (Kraus, 2009).
Hobson and colleagues (1967 in Casper & Hendricks, 2005) reported that adult bullfrogs have a state of rest characterised by alertness without a loss of reactivity, aiding in predator avoidance. Upon disturbance, adults retreat to deeper water with a series of long leaps with a great deal of splashing (Smith, 1961 in Casper & Hendricks, 2005). Bullfrogs usually squawk when fleeing, often setting off a mass bullfrog exodus from a shoreline into deeper waters (Schwalbe & Rosen, 1999 in Casper & Hendricks, 2005). Bullfrogs may emit a piercing scream when seized, which may startle a predator enough to allow escape (Harding, 1997; Casper & Hendricks, 2005). It has been suggested that bullfrog larvae may be able to recognise cues of novel predators, which could contribute to their success as a native species in a region (Pearl *et al*., 2003). \r\n
The bullfrog is mainly nocturnal, but a loud deep pitched bellow, can be heard during the day (CABI Bioscience, 2005). The mating call has one note that lasts 0.8 seconds at a frequency of 1.0 kHz (Encyclopedia of Life, 2009). To hear the mating call of the American bullfrog please go to Sounds of North American Frogs: The Mating Call of the Bullfrog or AmphibiaWeb.
Currie and Bellis (1969 in Casper & Hendricks, 2005) found bullfrogs to have a mean activity radius of 2.6 meters in an Ontario pond. Their data suggest that home range size is reduced at higher densities and increases as the size of an individual increases, and that males have a larger home range than females.
Finally, the ongoing climatic changes at global scale can modify the suitability of some areas; for example, global warming can cause an expansion of suitable areas towards higher latitude (Roura-Pascual *et al*., 2004; Thuiller *et al*., 2007 in Ficetola *et al*., 2007b).

Lifecycle Stages

Longevity for wild bullfrogs is estimated to be eight to 10 years, although a captive specimen survived for nearly 16 years (Oliver 1955a, Goin & Goin 1962, in Casper & Hendricks 2005).
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 & Whelan 1984, in Casper & 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 & Rosen 1999, in Casper & Hendricks 2005). The number of zygotes sired by successfully mating males ranged from 5000 to 59 000 (mean 11 000), with the number of resultant hatchlings ranging from 300 to 29 000 (mean 5600; Howard 1978b, in Casper & Hendricks 2005). Females may lose up to 27% of their body mass during oviposition (Judge *et al*. 2000, in Casper & Hendricks 2005).
Larvae/Metamorphosis: Tadpoles favor warm water environments (24°C to 30°C; Brattstrom 1962b, in Casper & 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 & Hendricks 2005).\n

Uses

Bullfrogs have been intentionally introduced to new habitats as a food resource for humans (Moyle, 1973; Jennings & Hayes, 1985) or for biological control of insects (Jennings & Hayes, 1985; Lawler *et al*., 1999). They have also been introduced to some areas for farming. However frogs are difficult to farm and farming operations are often unsuccessful (Helfrich *et al*., 2009; Laufer *et al*., 2008).

Habitat Description

Bullfrogs are described as occupying a wide range of aquatic habitats including lakes, ponds, swamps, bogs and backwaters (Conant, 1975; Stebbins, 1985 in Adams *et al*., 2003), as well as reservoirs, marshes, brackish ponds (in Hawaii), streams (Santos-Barrera *et al*. 2009), irrigation ponds and ditches (Govindarajulu, 2004). Adult bullfrogs prefer warmer, lentic habitats such as vegetated shoals, sluggish backwaters and oxbows, farm ponds, reservoirs, marshes, and still waters with dead woody debris and dense and often emergent vegetation (George, 1940; Holbrook, 1842; Bury & Whelan, 1984 in Casper & Hendricks, 2005). In a seasonal marsh in Sonoma County, California, bullfrogs selected spikerush habitat in winter and spring, and aquatic buttercup in summer (Cook & Jennings 2007). Bullfrogs bred in spring and summer in deep areas with dense cover, predominantly smartweed (Cook & Jennings, 2007). 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).
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 & Wright, 1949; Bury & Luckenbach, 1976; Jennings, 1988, Zampella & Bunnell, 2000 in Adams *et al*., 2003; Doubledee *et al*., 2003; Ficetola *et al*., 2007b). Hayes and Jennings (1986, in Cook & 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 characterised 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 give time interval). Bullfrogs are expected to be less efficient at keeping a complex shoreline choked with cat-tails 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.
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. Pond hydroperiod is known to regulate some amphibian communities (e.g., Semlitsch *et al*. 1996, in Boone 2004) and may mediate the impact bullfrogs have on amphibians. 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 2004). Bullfrogs will hibernate at the bottom of water bodies or in secluded places on land (CABI Bioscience, 2005).

Reproduction

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 & Hendricks 2005). Bullfrogs breed in the vegetation-choked shallows (Pope 1964a, in Casper & Hendricks 2005) of permanent bodies of water. Bullfrog breeding is restricted to warmer periods during spring and summer (Cook & 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 & Détaint 2006).
Bullfrogs are highly territorial and have a polygynous mating system, with the largest males in a population controlling the highest quality oviposition (egg-laying) sites (Howard 1978a b, in Casper & Hendricks 2005). Males defend roughly circular territories two to five meters in diameter (Harding 1997, in Casper & Hendricks 2005). Male bullfrogs will aggressively defend sites by pushing, shoving and biting (Ryan 1980, in Casper & Hendricks 2005). Most physical encounters are won by larger males by engaging in wrestling, shoving, and pouncing (A.P. Blair 1963, Durham & Bennet, 1963, in Casper & Hendricks 2005).
Females select a mate by entering his territory (Ryan 1980, in Casper & Hendricks 2005). Female mate choice becomes more discriminating with age, with older females consistently selecting the oldest, largest males as mates (Howard 1978a, in Casper & Hendricks 2005). Older females sometimes vocalize within male choruses, which may elicit higher levels of male to male competition and assist females in selecting high-quality males (Judge *et al*. 2000, in Casper & Hendricks 2005). Embryo mortality depends on female choice of the oviposition site, the best of which are controlled by the largest males and where water temperatures do not exceed 32°C, over which developmental abnormalities occur (Howard 1978b, in Casper & Hendricks 2005). Bullfrog embryos have the highest critical thermal maximum of any North American frog at 32°C and the lower temperature limit for normal embryonic development is 15°C (Moore 1942, in Cook & Jennings 2007).

Nutrition

Bullfrog tadpoles are mainly herbivorous and consume algae, aquatic plant material and some invertebrates (Treanor & Nichola, 1972; Bury & Whelan, 1984 in Casper & 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 & Watling, 1982 Pers. Obs. in Pryor, 2003) allow them to graze periphyton (Wassersug, 1984; Kupferberg *et al*., 1994; Kupferberg, 1997a; Altig & McDiarmid, 1999 in Pryor, 2003). Bullfrog tadpoles will also prey on the tadpoles of other species (Kiesecker & Blaustein, 1997 in Blaustein & Kiesecker, 2002).

Adult bullfrogs are gape-limited opportunistic predators that employ a sit-and-wait approach to feeding (Bury & Whelan, 1984, Schwalbe & Rosen, 1988 in Casper & 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).

Introduced crayfish red swamp crayfish (*Procambarus clarkii*) make up the majority of the bullfrogs' diets in many regions (eg. Colusa National Wildlife Refuge, California (USA); Wylie *et al*. 2003). Stomachs analysis of adult bullfrogs (N=100) collected on the lower Colorado River, Arizona-California by Clarkson and deVos (1986) revealed crayfish (*P. clarki*) accounted for the highest volume of food material. Wolf spiders (Lycosidae) were the next most voluminous taxon. Other relatively frequently occurring items included long-horned earwigs, sowbugs, German cockroaches, crickets and plant material. Found less frequently were diverse items such as a young muskrat, rattlesnake, kingsnake, and soft-shelled turtle (carapace length 45 millimeters), several species of fish, an Asiatic clam, a scorpion, and numerous insect species, primarily coleopterans.

Hirai (2004) analysed stomach contents of bullfrogs in the Mizorogaike Pond (Kyoto, Japan) and found that adult bullfrogs feed predominantly on crayfish (*P. clarkii*), and juveniles feed on a diverse range of arthropods. Adult bullfrogs (N=42) were found to contain diverse arthropods and slugs, along with plant materials and minerals. Arthropoda contained five classes (Insecta, Arachnida, Crustacea, Chilopoda, and Diplopoda). Insecta contained seven orders. The most important and one of the largest food items was the crayfish (43.0 to 89.3 millimeters). Beetles, spiders and hemipterans were also commonly consumed. Aquatic prey were as follows: three water-striders, one dragonfly nymph, 62 crayfish and one freshwater shrimp. Food of the juvenile bullfrog (N=79) included a wide variety of anthropods, slugs, pond snails, leeches, earthworms and fish. Arthropoda contained five classes. Insecta contained nine orders. The two most frequently consumed food items were ants and spiders. Ants and spiders were numerically important, but not volumetrically because of their small body size. Dipterans, caterpillars, beetles, and woodlice were also common food items. Volumetrically, crayfish were again the most important food item. The second largest proportion was occupied by beetles As aquatic prey, one water beetle, 13 maggots, four waterstriders, six nymphal dragonflies, two crayfish, 11 freshwater shrimps, seven amphipods, 18 pond snails, one leech and one bluegill were found.

General Impacts
Disease Transmission: 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 harbour reservoirs of the fungal agent without showing significant clinical disease symptoms themselves (Hanselmann *et al*., 2004).
Native North American amphibians which may be affected by bullfrogs include: the Pacific chorus frog (*Pseudacris regilla*); the Northern red-legged frog (*Rana aurora*); the plains leopard frog (*Lithobates blairi*); the northern leopard frog (*Lithobates pipiens*); the lowland leopard frog (*Lithobates yavapaiensis*); and the entire suite of central Californian amphibians (Kraus, 2009).
Similar declines in native species concurrent with the introduction of bullfrogs have been noted in Europe, in Germany (C.R. Boettger, 1941; Thiesmeier *et al*., 1994 in Kraus 2009), Florence (Italy) (native *Rana*; Touratier. 1992b in Kraus 2009) and in the Aquitaine of southwestern France (native fish; Touratier, 1992a in Kraus, 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 & McLachlan, 1985; Kupferberg, 1997a; Flecker *et al*., 1999; Peterson & 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 m²; 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 & Blaustein, 1997 in Hanselmann *et al*., 2004). Unlike many other frogs, bullfrogs can coexist with predatory fish (Hecnar, 1997 in Casper & 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).
For a detailed account of the environmental impacts of *L. catesbeianus* please read: *Lithobates catesbeianus* Impacts Information.

Management Info
For a detailed account of the management and control options to prevent the spread of *L. catesbeianus* please read: *Lithobates catesbeianus* (American Bullfrog) Management Information. The information in this document is summarised below.
Careful monitoring is necessary for the early detection and management of newly established frog populations (Ficetola *et al*. 2007a). The successful eradication of *Lithobates catesbeianus* from Great Britain (Fisher & Garner, 2007) is an exception to the general pattern of eradication failure because the programmes were placed in the hands of conservation-management professionals (Kraus, 2009).
Preventative Measures: The presence of the emerging *Batrachochytrium dendrobatidis* chytrid fungal pathogen (which is responsible for declines in amphibians world-wide) suggests that trade and introduction of amphibians should be monitored (Hanselmann *et al*., 2004). Hanselmann and colleagues suggest that traded amphibians be made subject to veterinary surveillance and quarantine guidelines developed by the International Union for the Conservation of Nature (IUCN) and the Office Internationale des Epizooties (OIE) (Cunningham *et al*. 2001, in Hanselmann *et al*. 2004). In relation to control of the chytridiomycosis disease in amphibians, please see Control Strategies for Diseases in Wild Amphibians.
European legislation prohibits new introductions of *L. catesbeianus* and environmental agencies promote eradication plans (Ficetola *et al*. 2007a), however, a coordinated effort in the European Union to address invasive species of any kind has not been made (Kraus 2009). Actions are currently are restricted to isolated activities by member states (Kraus, 2009). Genovesi & Scalera (2007 in Kraus, 2009) have proposed a coordinated system of lists covering approved, prohibited, or requiring further study for importation. Doing so would make prevention programs for alien herpetofauna in the European Union more proactive (de Groot & Gerrits, 2002 in Kraus, 2009).
L. catesbeianus is listed as an A1 species by the Belgium Invasive Species Forum (BISF) meaning it represents a high environmental hazard and is present in isolated populations (Etienne *et al*., 2007). Please see BISF definitions for more information. According to the Invasive Species Environmental Impact Assessment (ISEIA) this species earns a score of 12 (out of 12) which puts it in the black list (A category) (Etienne *et al*. 2007).
Physical Control: Adult *L. catesbeianus* may be killed by shooting, spears/gigs, bow and arrow, clubs, nets, traps, angling or by hand. They can be located using torchlight which also temporarily stuns them (P. Veenvliet Pers. Comm. 2003). *L. catesbeianus* can be controlled using a reptile-proof fence to catch the neonates and traps in the ground to catch them as they leave the pond. Collecting egg masses can be effective in combination with killing frogs and tadpoles.
Knowledge and Research: Studies of actual and potential ecological impacts should be conducted (Santos-Barrera *et al*. 2009).
Education and Awareness: Ficetola and colleagues (2007a) suggest the promotion of educational programs to reduce the risk of new introductions in Europe.

Pathway
In British Columbia, Canada they are sold in aquatic garden supply stores for the enhancement of ornamental ponds.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.They have been deliberately introduced as an aesthetically pleasing wildlife.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 centBullfrogs will disperse from artificial water bodies into natural water bodies using seasonal water corridors (Govindarajulu, 2004). Dispersals of at least 3.2 km from the home pond have been recorded, with dispersal distances of seven to eight kilometers likely (Schwalbe & Rosen, 1999 in Casper & Hendricks, 2005). Maximum movement distances of up to 1600 meters (mean 402 meters), as well as homing, were reported by Ingram and Raney (1943 in Casper & Hendricks, 2005) in New York.

Principal source: Scalera, 2007; Kraus, 2009; Santos-Barrera *et al*., 2009

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ALIEN RANGE

[2] ARGENTINA
[1] ASIA
[1] BELGIUM
[3] BRAZIL
[4] CANADA
[1] CHILE
[3] CHINA
[1] COLOMBIA
[1] COSTA RICA
[2] CUBA
[1] DOMINICAN REPUBLIC
[2] ECUADOR
[1] EUROPE
[1] FRANCE
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[1] GUATEMALA
[1] HAITI
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[1] JAMAICA
[2] JAPAN
[1] KOREA, DEMOCRATIC PEOPLE'S REPUBLIC OF
[1] KOREA, REPUBLIC OF
[1] LAO PEOPLE'S DEMOCRATIC REPUBLIC
[1] MALAYSIA
[2] MEXICO
[1] NETHERLANDS
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[1] PORTUGAL
[2] PUERTO RICO
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[1] THAILAND
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[2] UNITED KINGDOM
[25] UNITED STATES
[1] URUGUAY
[2] VENEZUELA
[1] VIET NAM

Red List assessed species 43: EX = 1; CR = 4; EN = 9; VU = 5; NT = 4; DD = 2; LC = 18;

Allobates ranoides **EN**
Alytes obstetricans **LC**
Ambystoma velasci **LC**
Anaxyrus californicus **EN**
Anaxyrus nelsoni **EN**
Ansonia inthanon **DD**
Aromobates mayorgai **EN**
Aromobates meridensis **CR**
Atelopus carbonerensis **CR**
Boana pulchella **LC**
Bolitoglossa spongai **EN**
Bufo bufo **LC**
Centrolene quindianum **VU**
Crossodactylus schmidti **NT**
Dendropsophus mathiassoni **LC**
Dendropsophus meridensis **EN**
Epipedobates espinosai **DD**
Erinna newcombi **VU**
Lithobates fisheri **EX**
Lithobates onca **EN**
Lithobates palmipes **LC**
Lithobates pipiens **LC**
Lithobates subaquavocalis **CR**
Lithobates tarahumarae **VU**
Lithobates vaillanti **LC**
Lycodon rufozonatus **LC**
Nidirana pleuraden **LC**
Opisthotropis kikuzatoi **CR**
Pelophylax cretensis **EN**
Pseudacris regilla **LC**
Pseudis minuta **LC**
Rana aurora **LC**
Rana boylii **NT**
Rana draytonii **NT**

Rana pretiosa **VU**
Salamandra salamandra **LC**
Scinax squalirostris **LC**
Thamnophis atratus **LC**
Thamnophis rufipunctatus **LC**
Rhaebo caeruleostictus **EN**
Scinax granulatus **LC**
Spea hammondii **NT**
Thamnophis gigas **VU**

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133 references found for **Lithobates catesbeianus**

Managment information

Adams, M.J., Pearl, C.A. and Bury, R.B. 2003. Indirect facilitation of an anuran invasion by non-native fishes. *Ecology Letters*. 6 (4): 343-351.
Summary: Report on a field experiment designed to test the predictions that: (1) non-native fish (bluegill, *Lepomis macrochirus* Rafinesque) lower the abundance of native dragonfly nymphs, (2) native dragonfly nymphs reduce the survival of bullfrog tadpoles and (3) survival of larval bullfrogs improves when a nonnative fish is present.
Berroneau, Matthieu; Detaint, Mathieu ; Coic, Christophe. 2007. First Results of the Telemetry Study of Bullfrogs in Gironde (September 2004-June 2005), *Bulletin de la Societe Herpetologique de France 121*: 21-33.
Summary: American bullfrogs (N=25) were followed by Berroneau, Detaint and Coic (2007) using telemetry near Fronsac, Gironde to determine over-wintering habitats, home range and dispersion trends. Results should help in formulating eradication strategies for Bullfrogs, by helping to define the periods and the places of intervention.
Bomford, M., 2003. Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia. Bureau of Rural Sciences, Canberra.
Summary: Available from: http://www.feral.org.au/wp-content/uploads/2010/03/PC12803.pdf [Accessed August 19 2010]
Centre for Environment, Fisheries & Aquaculture Science (CEFAS)., 2008. Decision support tools-Identifying potentially invasive non-native marine and freshwater species: fish, invertebrates, amphibians.
Summary: The electronic tool kits made available on the Cefas page for free download are Crown Copyright (2007-2008). As such, these are freeware and may be freely distributed provided this notice is retained. No warranty, expressed or implied, is made and users should satisfy themselves as to the applicability of the results in any given circumstance. Toolkits available include 1) FISK- Freshwater Fish Invasiveness Scoring Kit (English and Spanish language version); 2) MFISK- Marine Fish Invasiveness Scoring Kit; 3) MI-ISK- Marine invertebrate Invasiveness Scoring Kit; 4) FI-ISK- Freshwater Invertebrate Invasiveness Scoring Kit and AmphISK- Amphibian Invasiveness Scoring Kit. These tool kits were developed by Cefas, with new VisualBasic and computational programming by Lorenzo Vilizzi, David Cooper, Andy South and Gordon H. Copp, based on VisualBasic code in the original Weed Risk Assessment (WRA) tool kit of P.C. Pheloung, P.A. Williams & S.R. Halloy (1999).
The decision support tools are available from:
http://cefas.defra.gov.uk/our-science/ecosystems-and-biodiversity/non-native-species/decision-support-tools.aspx [Accessed 13 October 2011]
The guidance document is available from http://www.cefas.co.uk/media/118009/fisk_guide_v2.pdf [Accessed 13 January 2009].
Daszak, P; Strieby, A. ; Cunningham, A. A. ; Longcore, J. E. ; Brown, C. C. ; Porter, D. 2004. Experimental Evidence That the Bullfrog (*Rana catesbeiana*) is a Potential Carrier of Chytridiomycosis, an Emerging Fungal Disease of Amphibians, *Herpetological Journal 14*(4): 201-207.
Summary: These results from Daszak and colleagues (2004) provide the first experimental evidence that American bullfrogs can be infected by *Batrachochytrium dendrobatidis*, but are relatively resistant to the disease chytridiomycosis, which is lethal to many other amphibian species.
Diego A. Barrasso, Rodrigo Cajade, Santiago J. Nenda, Gabriel Baloriani, Ra�l Herrera. 2009. Introduction of the American Bullfrog *Lithobates catesbeianus* (Anura: Ranidae) in Natural and Modified Environments: An Increasing Conservation Problem in Argentina, *South American Journal of Herpetology 4*(1): 69-75.
Summary: Diego and colleagues (2009) reported on the American bullfrog for the first time in the province of Buenos Aires, Argentina in the locality of 9 de Julio.
Doubledee, R.A.; Muller, E.B. and Nisbet, R.M. 2003. Bullfrogs, disturbance regimes, and the persistence of California red-legged frogs. *Journal of Wildlife Management*. 67 (2): 424-438.
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General information

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La lista de especies del Sistema de informaci�n sobre especies invasoras de m�xico cuenta actualmente con informaci�n aceca de nombre cient�fico, familia, grupo y nombre com�n, as� como h�bitat, estado de la invasi�n en M�xico, rutas de introducci�n y ligas a otros sitios especializados. Algunas de las especies de mayor riesgo ya tienen una liga directa a la p�gina de alertas. Es importante resaltar que estas listas se encuentran en constante proceso de actualizaci�n, por favor consulte la portada (http://www.conabio.gob.mx/invasoras/index.php/Portada), en la secci�n novedades, para conocer los cambios.
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Summary: An online database that provides taxonomic information, common names, synonyms and geographical jurisdiction of a species. In addition links are provided to retrieve biological records and collection information from the Global Biodiversity Information Facility (GBIF) Data Portal and bioscience articles from BioOne journals.
Available from:
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Summary: The Global Amphibian Assessment (GAA) is the first-ever comprehensive assessment of the conservation status of the world s 5,918 known species of frogs, toads, salamanders, and caecilians. This website presents results of the assessments, including IUCN Red List threat category, range map, ecology information, and other data for every amphibian species.
Available from: http://www.globalamphibians.org/ [Accessed 5 November 2006].
Jung, R.E., Bonine, K.E., Rosenshield, M.L., de la Reza, A., Raimondo, S. and Droege, S. 2002. Evaluation of canoe surveys for anurans along the Rio Grande in Big Bend National Park, Texas. *Journal of Herpetology*. 36 (3): 390-397.
Summary: This paper outlines the distribution of bullfrogs in Big Bend National Park, Texas, USA.
Kats, L.B. and Ferrer, R.P. 2003. Alien predators and amphibian declines: review of two decades of science and the transition to conservation. *Diversity and Distributions*. 9 (2): 99.
Summary: This article discusses the impacts of alien species in North America, including the bullfrog.
Kiesecker, J.M.; Blaustein, A.R. and Miller, C.L. 2001. Potential mechanisms underlying the displacement of native red-legged frogs by introduced bullfrogs. *Ecology*. 82 (7): 1964-1970.
Summary: This paper gives detailed information about the competition between bullfrogs and native red-legged frogs (*Rana aurora*) in Oregon, USA.
Kupferberg, S. J. 1997. Bullfrog (*Rana catesbeiana*) invasion of a California river: the role of larval competition. Ecology 78(6): 1736-1751.
Summary: Native yellow-legged frogs, *Rana boylii*, were almost an order of magnitude less abundant in reaches where bullfrogs were well established. Competition from large overwintering bullfrog larvae significantly decreased survivorship and growth of native tadpoles.
Laufer, G., Canavero, A., Nunez, D. & Maneyro, R. 2008. Bullfrog (*Lithobates catesbeianus*) invasion in Uruguay. *Biological Invasions 10*: 1183-1189.
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Summary: This paper compares the effects of bullfrogs and mosquitofish (*Gambusia affinis*) on the declining California red-legged frog (*Rana aurora draytonii*).
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Lopez-Flores, M.; Cruz-Burgos, J.A. and Vilella, F.J. 2003. Predation of a white-cheeked pintail (*Anas bahamensis*) duckling by a bullfrog (*Rana catesbeiana*). *Caribbean Journal of Science*. 39 (2): 240-242.
Summary: This short note gives details about an incident of a bullfrog preying on the duckling of a white-cheeked pintail (*Anas bahamensis*) in Puerto Rico.
Lorvelec, Olivier & Mathieu D�taint. 2006. *Lithobates catesbeianus*. Delivering Alien Invasive Species Inventories for Europe.
Summary: Available from: http://www.europe-aliens.org/pdf//Lithobates_catesbeianus.pdf [Accessed 23 December 2009]
Mahon R, Aiken K (1977) The establishment of the North American bullfrog, Rana catesbeiana (Amphibia, Anura, Ranidae) in Jamaica. Journal of Herpetology 197-199.
Marland, Ian., Scottish Press Association, 19th Oct 2003. Giant Bullfrogs Still Being Imported
Summary: Species account in Europe.
Merovich, C.E. and Howard, J.H. 2000. Amphibian use of constructed ponds on Maryland s eastern shore. *Journal of the Iowa Academy of Science*. 107 (3-4): 151-159.
Summary: This paper gives the results of a study of amphibian assemblages in constructed ponds in Maryland, including the presence of bullfrogs.
Minowa, Shun; Senga, Yutaro ; Miyashita, Tadashi., 2008. Microhabitat Selection of the Introduced Bullfrogs (*Rana catesbeiana*) in Paddy Fields in Eastern Japan. Current Herpetology. 27(2). DEC 2008. 55-59
Summary: Introduction of the bullfrog *Rana catesbeiana* is considered detrimental to native fauna. However, methods for controlling bullfrog populations have not yet been established. Managing habitats to resist invasion is important for alien species that are difficult to control directly. We surveyed habitat characteristics of paddy fields in eastern Japan inhabited by bullfrogs and analyzed their microhabitat selection. Our results suggest that adult bullfrogs prefer microhabitat with deep water. Therefore, it may be possible to prevent invasion of adults by keeping water shallow. Managing local habitats to prevent immigration may reduce the spread of bullfrogs on larger spatial scales.
National Research Council. 1974. Amphibians. Guidelines for the breeding, care and management of laboratory animals. Washington, D.C.: National Academy of Sciences.
Orchard, S. A., 1992. Amphibian population declines in British Columbia. Occasional paper. Canadian Wildlife Service. Ottawa
Summary: Nine families of the class Amphibia are represented in British Columbia. Eighteen species are native, and at least two nonnatives have become established. Among the native species are a number of habitat specialists whose declines are clearly attributable to habitat destruction through human disturbance. It is suggested that predation and competition from increasing populations of introduced fish and bullfrogs (*Rana catesbeiana*), as well as from managed populations of native waterfowl, may have contributed to the decline of these species.
Pearl, C.A.; Adams, M.J.; Bury, R.B.; and McCreary, B. 2004. Asymmetrical effects of introduced Bullfrogs (*Rana catesbeiana*) on native ranid frogs in Oregon. *Copeia*. 2004 (1): 11-20.
Summary: This paper discusses the impacts introduced bullfrogs have has on native frogs in Oregon.
Pearl, C.A.; Adams, M.J.; Schuytema, G.S. and Nebeker, A.V. 2003. Behavioral responses of anuran larvae to chemical cues of native and introduced predators in the Pacific Northwestern United States. *Journal of Herpetology*. 37 (3): 572-576.
Summary: This paper discusses the responses of native and introduced anurans to predator cues.

Pryor, G.S. 2003. Growth rates and digestive abilities of bullfrog tadpoles (*Rana catesbeiana*) fed algal diets. *Journal of Herpetology*. 37 (3): 560-566.
Summary: Contains information about the digestive abilities of tadpole bullfrogs.
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Summary: Available from: http://news.nationalgeographic.com/news/2004/09/0928_040928_bullfrog.html [Accessed 7 March, 2010]
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Summary: Available from: http://www.iucnredlist.org/apps/redlist/details/58565/0 [Accessed 23 December 2009]
Smith, G.R. 1999. Microhabitat preferences of bullfrog tadpoles (*Rana catesbeiana*) of different ages. *Transactions of the Nebraska Academy of Sciences*. 25 (0): 73-76.
Summary: This paper gives the results of an investigation into the habitat preferences of bullfrog tadpoles.
Smith, H.M. and Chiszar, D. 2003. Distributional and variational data on the frogs of the genus *Rana* in Chihuahua, Mexico, including a new species. *Bulletin of the Maryland Herpetological Society*. 39 (3): 59-66.
Summary: This paper gives details about the *Rana* spp. occurring in Chihuahua, Mexico.
Stumpel, A. H. P., 1992. Successful reproduction of introduced bullfrogs *Rana catesbeiana* in northwestern Europe: A potential threat to indigenous amphibians. Biological Conservation. Vol. 60, no. 1, pp. 61-62. 1992.
Summary: In The Netherlands, Belgium, and Germany, bullfrog (*Rana catesbeiana*) larvae are imported on a large scale for trade in pet shops. Many of them survive the goldfish bowl and are then released in the wind as larvae or freshly metamorphosed juveniles. Since many records exist of full-grown bullfrogs, the animals clearly can reach adulthood in the wild. Nature conservationists have great concern about the potential threat to indigenous amphibians, and particularly to green frogs Rana esculenta complex, which occupy more or less the same niche. Examples of bullfrogs expelling other species have been shown by Dumas (1966), Moyle (1973) and Hammerson (1982). In The Netherlands there is no legislation that prevents this trade. Until recently, reproduction of bullfrogs has not been recorded in The Netherlands. In 1991, it became clear that reproduction had taken place since 1989 in a large garden pond in the city of Breda (central-south Netherlands).
Virginia Museum of Natural History (VMNH), 2005. More Bryozoan Information. VMNH Virginia, USA.
Summary: An overview of the biology and problems caused by bryozoans.
Wylie, G.D.; Casazza, M.L. and Carpenter, M. 2003. Diet of bullfrogs in relation to predation on giant garter snakes at Colusa National Wildlife Refuge. *California Fish and Game*. 89 (3): 139-145.
Summary: This paper outlines the relationship between bullfrog predation on giant garter snakes (*Thamnophis gigas*), and vice versa, in Colusa National Wildlife Refuge, California, USA.
Wylie, Glenn D. ; Casazza, Michael L. ; Carpenter, Mike., 2003. Diet of bullfrogs in relation to predation on giant garter snakes at Colusa National Wildlife Refuge. California Fish & Game. 89(3). Summer 2003. 139-145.
Summary: To evaluate predation by bullfrogs, *Rana catesbeiana*, on giant garter snakes, Thamnophis gigas, at Colusa National Wildlife Refuge (NWR) we collected 99 bullfrogs during three field seasons from 2000-2002. Crayfish, Procambarus clarkii, were in 90% of the bullfrogs and were usually the only food item. We found four neonate giant garter snakes in three bullfrogs. We estimated the total annual predation of bullfrogs to be about 22% of neonate production, a value similar to the 20% tail loss we documented for giant garter snakes on the Refuge as another index of bullfrog predation pressure. Even with mortality from bullfrogs and other predators, snake size classes indicate sustainable recruitment into the Colusa NWR giant garter snake population. Smaller bullfrogs and bullfrog tadpoles are also food for giant garter snakes, so further studies are needed to determine the net effect of bullfrog removal for local giant garter snake populations.
Zampela, R.A. and Bunnell, J.F. 2000. The distribution of anurans in two river systems of a coastal plain watershed. *Journal of Herpetology*. 34 (2): 210-221.
Summary: This paper gives details about the distribution of anurans in the New Jersey Pinelands.
Zhou Wei ; Li Ming-hui ; Zhang Xing-yu ; He Jia-fei., 2005. Food comparison between tadpoles of *Rana catesbeiana* and *R. chaochiaoensis* collected from the same habitat. Zoological Research. 26(1). FEB 05. 89-95
Summary: adpoles of *Rana catesbeiana* and R. chaochiaoensis were collected from the same pond in the northeast suburb of Kunming. Their foods were analyzed. The results showed that food items of R. catesbeiana were eight types and 51 categories in tadpole stage I, and eight types and 33 categories in tadpole stage II. Food items of R. chaochiaoensis were six types and 30 categories in tadpole stage II. Bacillariophyta, Chlorophyta, Cyanophyta were main items of food components in two species. However, there was a remarkable difference of food categories between tadpole stage II of R. chaochiaoensis and stage I of R. catesbeiana, and there was not difference of food categories between tadpole stage II of R. chaochiaoensis and R. catesbeiana. Comparisons among tadpole stage II of R. chaochiaoensis with stage I and II of R. catesbeiana, food niche overlap indexes were 0.6952 and 0.6887; biomass of unit body weight (food biomass/average weight) were 10.96 times and 15.48 times of two stages of R. catesbeiana; the indexes of percentage similarity of food (PS) were not high, i.e. 54.95% and 58.11%. Comparisons between the same body weight tadpoles of R. chaochiaoensis and R. catesbeiana, the tadpole of R. chaochiaoensis has greater food quantity. The biomass needed for survival by the tadpole of R. chaochiaoensis was higher than the tadpole of R. catesbeiana. The results both in this text and observed in the field indicated that there was a drastic competition between tadpoles of R. catesbeiana and R. chaochiaoensis in food. Tadpoles of R. chaochiaoensis were in a disadvantageous position