The Invasive North American Bullfrog (*Rana catesbeiana*)

**Diagnostic Information**

**Scientific Name:** *Rana catesbeiana* belongs to the order Anura and the family Ranidae.

**Common Names:** North American Bullfrog, American Bullfrog, Bullfrog

**Photos:**

![Rana catesbeiana](www.dkimages.com)

**Identification**

Bullfrogs are the largest frog species in North America and are measured to have an average length of 180 mm in males and 200 mm in females. Dorsal coloration ranges from dull green to brown to almost black with dark spots present on juveniles and mottling on adults. The ventral side of the bullfrog is white to yellow in color and is often stippled with grey. A distinguishing characteristic of this species of *Rana*, aside from its size, is its lack of dorsolateral
ridges. Males may be distinguished from females by examining the size of their tympanic membrane (eardrum), which is approximately the same size of the eye on females and noticeably larger on males. Other distinctive features of the male are its yellow-toned throat and enlarged thumbs (Bury 1; Wright 79).

Overview

*Rana catesbeiana*, the North American Bullfrog, has been classified as one of the world's 100 worst invasive species by the Invasive Species Specialist Group and has spread to nearly every continent on the planet. The ecological characteristics of the bullfrog have provided it with an efficient and reliable way to establish and spread throughout many of the regions to which it has been introduced. This paper explores the invasive nature of this species by examining its history in respect to human introductions, its ecological traits and life history, and the process by which it invades a new territory. It is only through understanding these fundamental aspects of this invasive species that one can hope to learn to manage and control it effectively.

Origin and Distribution

History of Invasiveness

The bullfrog, once found only in the Eastern half of the United States, is now one of the most notorious invasive species in the world (Lowe 6). The native range of this species is thought to have stretched from as far south as central Florida to Nova Scotia in the North, with populations extending westward across the Great Plains. Within this range, bullfrogs were limited to areas most suitable to their ecological needs and accessible by their natural means of dispersal. It is difficult for researchers to determine the exact extent of the natural range and
original distribution of the species, however, due to the extensive number of introductions that have taken place over the past century (Bury 2).

The western United States saw the introduction of bullfrogs as a food source starting in the late 19th century. The first bullfrogs were brought to California in 1896 to combat the over harvesting of native Rana species (Hayes 492) and since then populations have spread to nearly every county in that state (Bury 2). Throughout the 20th century, repeated introductions all along the west coast and Rocky Mountains helped facilitate the establishment in those states (Hayes 492). The first recorded bullfrog introduction in Oregon occurred in 1914 when specimens from Idaho were released in the Rogue River valley. By the 1930s, Washington had its own established population due to repeated introduction attempts throughout the previous decade (Whitman 439).

The market for frog legs led to bullfrog introductions in other regions of the globe just as quickly. After being introduced to Japan in 1918, the bullfrog managed to establish itself in many of the country’s rivers, ponds, and rice fields (Hirai 1). Several introduction events in Europe throughout the 20th century led to established populations in Italy, Holland, and France by the 1990s, and the species has spread even more in recent years (Ficetola 768). Today, populations of bullfrogs can be found in all parts of the world, with extensive ranges throughout South America, Mexico, and Cuba as well as parts of Asia (Adams 343; Hanselmann 115).

Current Distribution in the Pacific Northwest

In Washington State the bullfrog has become established in nearly every county and is now present in many waterways and wetlands. It is most densely populated in the Puget Sound Lowland and Columbia Basin, with fewer established habitats in the regions of higher altitude and drier climates.

What about Oregon, Idaho, and British Columbia? Any introduction?
Native Range: Shaded
Non-Native Range:
Cross-Hatch & Dots

*Rana catesbeiana* North American range (Bury 4)

*Rana catesbeiana* habitat in Washington State (http://depts.washington.edu/natmap/maps)
Shaded areas represent known areas of establishment
Life History and Basic Ecology

Life Cycle

Like all amphibians, *Rana catesbeiana* begins its life as an egg and must undergo metamorphosis to achieve its adult form. A female will usually lay her eggs between June and July, and those eggs will hatch approximately four days after being laid. The larva, known as tadpoles, have an oval shaped body dark green in color and a tail that is about twice the length of the body (Wright 83). By fall, the hatchlings can reach a body length of over 32 mm, though their growth rate is limited by a number of factors including food availability, oxygen levels, and water temperature (Bury 11; Willis 39). The larval stage can last several seasons in northern environments where tadpoles may overwinter for one or more years; in warmer regions metamorphosis typically occurs after one winter or less (Boone 684; Bury 11; Wright 85). The three causal factors attributed to this overwintering behavior are: “abiotic factors correlated with climatic variation that affect length of growing season; biotic factors that negatively or positively affect growth rates of individual larvae; and variation in the timing, duration, and number of annual breeding periods” (Bury 11).

The size of the tadpole at the time of transformation can differ widely between individuals depending on their environment, and thus the size of juvenile adults will vary as well (Wright 86). After metamorphosis is complete, a bullfrog must wait until it has reached the appropriate size before breeding. Typically, this will take anywhere from one to four years, with the time interval increasing as one goes from south to north. During the winter months the bullfrog goes into hibernation, reemerging in the spring only when the temperature is satisfactorily warm (Willis 36). The bullfrog continues to grow for its entire life, which can last for up to seven to nine years in the wild (Wright 87).
Feeding Habits

Bullfrogs are voracious consumers during all stages of their lives, and it is largely because of this that they have become such destructive invaders. As a tadpole, the bullfrog feeds primarily on aquatic plants, although they have been known to consume some small invertebrates and even small tadpoles of other species (Bury 4). They are heavy consumers of primary production and thus play a significant role in ecosystem function. Under certain circumstances algae is consumed, but only some species can be digested and this behavior is less likely when other plant matter is readily available (Pryor 554).

Adult bullfrogs hunt by sitting still for long periods of time and waiting for prey to come within attack range (Bury 4). In a study that explored the stomach contents of juvenile and adult bullfrogs in Japan, a wide range of foods were found to be part of their diet. In this environment, crayfish comprised the majority of the volume of prey consumed, with beetles, spiders, slugs, and some vegetation making up the rest of the diet. Juveniles were found to contain a more diverse array of prey items, which indicates a greater dependence on crayfish for adults compared with juveniles (Hirai 377). Feeding habits are not limited to the scope of small arthropods and insects, however, and there are numerous examples to illustrate this point. A bullfrog may attempt to eat nearly any live animal smaller than itself if it comes into range, and this commonly includes other bullfrogs. In some regions, various frog species may comprise close to 80% of the diet volume. Bullfrogs are also notorious for consuming some relatively large animals such as birds, rodents, bats, ducklings, snakes, and fish (Bury 4; Hirai 379).

Reproductive Strategies

Bullfrogs first emerge from their winter hibernation when temperatures start becoming warm enough to warrant breeding. This is Two to three weeks later, the aquatic habitats in
which they dwell become boisterous with the call of males. In order to attract a female, the male bullfrog will find a prominent perch and bellow loudly whilst defending the position against other males. It is not known how this perching behavior affects a male's reproductive success, and there is no evidence for any hierarchal structure in respect to breeding (Wright 79; Willis 31).

In order to increase reproductive success, the bullfrog has evolved to produce a very large number of eggs per mating season. Depending on the size of the female she may lay anywhere from 1,000 to over 40,000 eggs per breeding. These eggs are laid in a large mat near the surface of the water which usually covers about 0.5 to 1 m². Due to the large surface area of this structure the eggs are more likely to receive sufficient levels of oxygen. The positioning of the mat near the surface ensures a more optimal temperature for development. In some regions with longer breeding seasons females have been known to produce multiple clutches in the same season (Bury 11).

Environmental Optima and Tolerances

*Rana catesbeiana*’s habitat ranges from areas of continental climate to that of Mediterranean and semi-tropical, and from sea level to elevations of greater than 1,900 meters. In order to survive and reproduce, bullfrogs require a permanent source of water. They appear to favor areas with high levels of vegetation and slow moving water, but are also found in more open waters such as the edges of canals, reservoirs, and intermittent streams (Bury 3). Both pH and temperature range of the water are important limiting factors for bullfrog habitation. Acidic waters can cause abnormalities in bullfrog tadpoles and temperatures outside the optimal range of 15-32°C can cause malformations in embryonic development (Bury 4, 11).

The bullfrog excels most in areas where it has little or no predation pressure. A study by Adams et al. examined the positive association of bullfrogs with a sunfish found in their native
range. The study showed that when these fish are present they readily consume dragonflies, a major predator of bullfrog tadpoles. When the fish is not present, however, dragonflies decimate bullfrog populations making such environments much less habitable (347).

**Biotic Associations**

Bullfrogs are hosts to a wide variety of bacteria, pathogens, and parasites which can have destructive effects on their non-native habitats. Some examples of these include the parasite *Eustrongylides wenrichi*, red leg disease, and Lucke tumor herpesvirus (Bury 13). Recently there has been a great deal of concern over an emerging pathogen known as Chytridiomycosis, a fungal disease of amphibians that has been attributed to global population declines. When bullfrog populations from around the globe were tested for this pathogen, only those in Japan and eastern Canada showed no sign of contagion (Garner 456). While mortality rates for most amphibians infected with Chytridiomycosis are high, infected bullfrogs show little to no symptoms. Bullfrogs are commonly transported around the world, and because it is so difficult to determine the likelihood that an individual is infected, this pathogen is spreading rapidly (Hanselmann 116; Mazzoni 997).

**Invasion Process**

**Pathways, Vectors, and Routes of Introduction**

The primary pathways for the introduction of bullfrogs into foreign habitats have been aquaculture, fish stocking, and the pet and aquarium trade. Frog legs are often harvested as a food source, leading to the importation of bullfrogs into foreign regions for the purpose of a wild food source, sport hunting opportunities, and for commercial food production in frog farms (Whitman 439). It is fairly common for them to escape from these farms and enter the wild,
escapes are especially prevalent during flood events (Mazzoni 996). Fish stocking can become an introduction pathway when tadpoles are unintentionally transferred along with hatchery fish to a new region. If a hatchery has an abundance of tadpoles, then it is fairly likely that some of them will be accidentally stocked into non-native fishing grounds (issg.gov). The pet and aquarium trade introduces the bullfrog into regions for the purpose of being aesthetically pleasing. This leads to the intentional release of these pets once the owner grows tired of them (Willis 37)

Factors Influencing Establishment and Spread

Both biotic and abiotic factors can affect the probability that Rana catesbeiana will establish in a new region. Biotic factors include the presence of predators, the abundance of prey, local pathogens, and competition with local species for resources (Lockwood 107). As was mentioned earlier, the presence of bluegill sunfish can increase the probability of establishment by decreasing predation pressure on bullfrog tadpoles (Adams 343). Abiotic factors that can affect establishment success have to do with the physical suitability of the habitat. Water temperatures must be within the correct range and pH levels must not be too acidic in order to support embryonic development (Bury 11).

The spread of bullfrogs is more likely in regions with extensive water networks through which individuals may travel. Bullfrogs can also travel considerable distances over terrestrial environments, especially during times of heavy rains. Flooding can promote spread since it disperses larvae to new regions and connects waterways for adults to travel through (Bury 4; Willis 37).
Potential Ecological and/or Economic Impacts

Many areas in which the bullfrog has established have had negative impacts on native amphibian diversity and abundance. One of California’s native *Rana* species, the red-legged frog, has been steadily decreasing in population size since the introduction of the bullfrog to that state. While causality has not been solely linked to the presence of bullfrogs, it is believed that the combined effects of predation on and competition for resources with the native species has had some effect (Kiesecker 1967-1969).

A study done by Sarah Kupferberg examined the impacts of competition between non-native bullfrog tadpoles and those of native frog species. She found that the presence of bullfrog larvae significantly decreased the survivorship and metamorphosis of native species of yellow-legged frogs and Pacific treefrogs. This was due largely to competitive exclusion by bullfrog tadpoles over the benthic algae resource. Because this ultimately decreases recruitment of native species, Kupferberg concludes that these populations will continue to decline where bullfrogs are present. Also, the effects of tadpole grazing, which are made more prominent by overwintering, are likely to cause changes in primary production that could have substantial results on an ecosystem (1736-1749).

Despite the ecological drawbacks of a *Rana catesbeiana* invasion, there are some economic advantages to their increased abundance. Frog meat is a popular dish in many regions of the world including the United States, which in 1979 imported 3 million kilograms of frog legs. Bullfrogs are also a valuable research and education tool and are used for experiments in many areas of life science. However, the benefit of these economic rewards is often outweighed by other economic costs such as revenue lost from decreased native species or predation on hatchery fish (Bury 16).
Management Strategies and Control Methods

Because bullfrogs have been so broadly established for so long, it is not likely that an attempt at widespread eradication would be successful, nor would it be economically feasible. Instead, resources should be focused on preventing further spread and limiting the detrimental effects on populations of native species. Control efforts should be directed toward negating the negative effects of bullfrog invasion in areas that are most vulnerable or the most valuable and cost effective to protect. Preventing the further spread of *R. catesbeiana* should be a high priority in order to protect those regions not already infiltrated. Identifying key areas, those which would greatly facilitate spread if they were to become established, is an essential aspect of prevention.

Management of bullfrog populations has traditionally focused on either eradication at the larval/egg stage or the removal of adults. One current way of controlling established populations is through egg removal (Doubledee 425). The by-hand removal of the large egg mats has been shown to effectively decrease the presence of bullfrogs in a region (Wright 81). Sometimes ponds may be drained to destroy bullfrog larva, but this practice is somewhat destructive and cannot be applied to most areas. Adults may be controlled either by capture or through hunting practices to reduce their abundance and biotic effects on an ecosystem (Doubledee 425). The best way to capture or shoot bullfrogs is by hunting them at night with a flashlight (Wright 78), and unregulated hunting of bullfrogs has been known to drastically reduce population size (Bury 17). A study done at the University of California, Santa Barbara suggests that disturbance through flooding regimes might be an effective way to control bullfrog populations while promoting the proliferation of native *Rana* species (Doubledee 436).
Works Cited


Lowe S., Browne M., Boudjelas S., De Poorter M. (2000) 100 of the World’s Worst Invasive Alien Species: A selection from the Global Invasive Species Database. The Invasive Species Specialist Group


Websites Referenced


http://depts.washington.edu/natmap/maps/


True-Frogs/North-American-Bullfrog/

Missin sections

Section 8. Other key sources of information

Section 9. Current research and management strategies in the PNW.

Export contact information?