The Invasive North American Bullfrog (Rana catesbeiana)

The Invasive North American Bullfrog, American Bullfrog, Bullfrog

FISH 497A
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Scientific Name: Rana catesbeiana belongs to the order Anura and the family Ranidae.

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.

\[ \text{Rana catesbeiana (www.dkimages.com)} \]
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 has become a new invasive species. It is only through understanding these aspects of this invasive species that one can hope to learn to manage and control it effectively.
In Washington, 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 populations in the regions of higher altitude and other climates. Washington, Oregon, Idaho, and Alaska as well as parts of Asia (Adams 343; Hanselman 115).

Current Distribution in the Pacific Northwest

South America, Mexico, and Cuba as well as parts of Asia (Hanselman 115). Populations of bullfrogs can be found in all parts of the world, with extensive ranges throughout Europe throughout the 20th century led to established populations in Italy, Holland, and France. Europe introduced 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 (Ficicola 764). Today, Europe introduced the 20th century led to established populations in Italy, Holland, and France. Europe introduced the 20th century led to established populations in Italy, Holland, and France.

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 Japan led to bullfrog introductions in other regions of the globe just as quickly.

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The first recorded bullfrog introduction in Oregon occurred in 1914 when specimens from the west coast and Rocky Mountains helped establish the establishment in those states (Hayes 492). The first recorded bullfrog introduction in Oregon occurred in 1914 when specimens from the west coast and Rocky Mountains helped establish the establishment in those states (Hayes 492). The first recorded bullfrog introduction in Oregon occurred in 1914 when specimens from the west coast and Rocky Mountains helped establish the establishment in those states (Hayes 492).

The western United States saw the introduction of bullfrogs as a food source starting in 1914, when specimens from the west coast and Rocky Mountains helped establish the establishment in those states (Hayes 492). The first recorded bullfrog introduction in Oregon occurred in 1914 when specimens from the west coast and Rocky Mountains helped establish the establishment in those states (Hayes 492). The first recorded bullfrog introduction in Oregon occurred in 1914 when specimens from the west coast and Rocky Mountains helped establish the establishment in those states (Hayes 492).

By the late 19th century, the first bullfrogs were brought to California in 1896 to combat the overharvesting of native bullfrogs (Hayes 492). By the late 19th century, the first bullfrogs were brought to California in 1896 to combat the overharvesting of native bullfrogs (Hayes 492). By the late 19th century, the first bullfrogs were brought to California in 1896 to combat the overharvesting of native bullfrogs (Hayes 492).
Shaded areas represent known areas of establishment.

*Rana catesbiana* habitat in Washington State (http://depts.washington.edu/natmap/maps)

Shaded areas represent known areas of establishment.

*Cross-Hatch & Dots* Non-Native Range: Native Range: Shaded

*Giffin*
Life History and Basic Ecology

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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 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 individuals depending on their environment, and thus the size of juvenile adults will vary as well.

The size at the time of metamorphosis can differ widely between annual breeding periods (Bury 11; Bury 64; Bony 11; Wight 85). The increase in size and duration, and number of individuals in the larval stage can last several seasons in northern environments where tadpoles may overwinter for one or more years in warmer regions. Water temperature (Wight 83). The larval stage can last several seasons in northerm environments where tadpoles may overwinter for one or more years in warmer regions. Water temperature (Wight 83). By fall, the larvae that can reach a body length of over 32 mm, through their growth rate is limited by a number of factors including food availability, oxygen levels, and play a role in their growth rate is limited by a number of factors including food availability, oxygen levels, and play a role in their growth rate.
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 because of this.

Feeding Habits

Juvenile bullfrogs 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 crayfish, comprising the majority of the volume of prey consumed, with beetles, spiders, snails, and some vegetation making up the rest of the diet. 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, 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

Reproductive Strategies

Large animals such as birds, rodents, bats, ducks, snakes, and fish (Bury 4; Hirai 379). Bullfrogs are also notorious for consuming some relatively close to 80% of the diet volume. Bullfrogs are also noted for consuming some relatively this commonly includes other bullfrogs. In some regions, various frog species may compete bullfrog may attempt to eat nearly any live animal smaller than itself if it comes into range, and anthropods and insects, however, and there are numerous examples to illustrate this point. A

in this environment, within attack range (Bury 4). In a study that explored the stomach contents of juvenile and adult bullfrogs both by taking still for long periods of time and waiting for prey. In Japan, a wide range of foods were found to be part of their diet. In this environment, 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

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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 hierarchical 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). If the surface of the water is turbulent, it may cause the eggs to be destroyed.

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 ranges of the water are important limiting factors for bullfrog habitation. Acidic and temperature range of the water 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 habitat.
The study showed that when these fish are present, they readily consume dragonflies, a major predator of bullfrog tadpoles. However, dragonflies decline in range. When the fish is not present, dragonflies consume tadpoles, making such environments much less habitable.

Biotic Associations

Bullfrogs are commonly transported around the world, and because it is so difficult to determine the likelihood that an individual has been infected, this pathogen is spreading rapidly. Bullfrogs are hosts to a wide variety of bacteria, pathogens, and parasites which can have destructive effects on their native habitats. Bullfrogs are hosts to a wide variety of bacteria, pathogens, and parasites which can have destructive effects on their native habitats.

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 pet and aquarium trade. Frog legs are often harvested as a food source, and bullfrogs are consumed in foreign habitats.

Environmental conditions, fish stocking, and the pet and aquarium trade. Fish legs are often harvested as a food source, and bullfrogs are consumed in foreign habitats. The study showed that when these fish are present, they readily consume dragonflies, a major predator of bullfrog tadpoles. However, dragonflies decline in range. When the fish is not present, dragonflies consume tadpoles, making such environments much less habitable. Bullfrogs are hosts to a wide variety of bacteria, pathogens, and parasites which can have destructive effects on their native habitats.
dispersal events do not necessarily lead to new regimes and connect waterways for adults to travel through (Bury 4). Environments, especially during times of heavy rains. Flooding can promote spread since it which individuals may travel. Bullfrogs can also travel considerable distances over terrestrial

The spread of bullfrogs is more likely regions with extensive water networks though

support empirical development (Bury 11).

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impresses must be within the correct range and pH levels must not be too acidic in order to affect establishment success have to do with the physical suitability of the habitat. Water

by decreasing predation pressure on bullfrog tadpoles (Adams 343). Abiotic factors that can mentioned earlier, the presence of bluegill sunfish can increase the probability of establishment

local pathogens, and competition with local species for resources (Lockwood 107). As was established in a new region, abiotic factors include the presence of predators, the abundance of prey,

both biotic and abiotic factors can affect the probability that Rana catesbeiana will

Factors Influencing Establishment and Spread

pleasing. Thus leads to the unintentional release of these pests once the cover grows high on them

aquarium trade introduces the bullfrog into regions for the purpose of being aesthetically

them will be accidentally stocked into non-native fishing grounds (Iss-Gov). The pet and

in a new region. If a hatchery has an abundance of tadpoles, then it is fairly likely that some of

an introduction pathway when tadpoles are unintentionally transferred along with hatchery fish

eeswings are especially prevalent during flood events (Mazzoni 996). Fish stocking can become

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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 and competition for resources with the native species has had some effect (Kiesecker 1996). There has been steadily decreasing 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 and competition for resources with the native species has had some effect (Kiesecker 1996).
Management Strategies and Control Methods

Because bullfrogs have been so broadly established for so long, it is not likely that an
"Management of bullfrog populations has traditionally focused on either eradication or
prevention."

Priority in order to protect those regions not already infested. Identifying key areas, those
which would readily facilitate spread if they were to become established, is an essential aspect of
prevention. Prevenuing the further spread of R. catesbeiana should be a high
cost effective to protect. Preventing the further spread of R. catesbeiana should be a high
effectiveness of bullfrog invasion in areas that are most vulnerable to the most valuable and
effects on populations of native species. Control efforts should be directed toward negating the
invasive. Resources should be focused on preventing further spread and limiting the detrimental
impact a widespread eradication would be successful, not would it be economically feasible.
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