American Bullfrogs as Invasive Species: A Review of the Introduction, Subsequent Problems, Management Options, and Future Directions.

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Introduction

Bullfrogs (*Rana Catesbeiana*) have been introduced throughout the western United States and the world. Originally native to the eastern United States, bullfrogs have been largely implicated in the reduction of various populations of native species in their introduced ranges. The native geographic range of bullfrogs included the eastern United States extending into the Great Plains region. During 1900–1940 bullfrogs were widely introduced to California and other western states, primarily as a food source, where they remain today (Witmer and Lewis 2001, Boersma et al. 2006). Bullfrogs have been able to out-compete various native *Rana* species throughout Western North America, and have become a persistent challenge to control (Hecnar and M'Closky 1997, Díaz De Pascual and Guerrero 2008). The general lack of an economic impact generated by bullfrogs as an invasive species had kept managers searching to find resources for controlling bullfrog populations (Adams and Pearl 2007).

Subsequent Problems

Both tadpoles and adult frogs are voracious feeders and can consume benthic algae and the eggs or offspring of many species of native invertebrates and vertebrates (including fishes, reptiles, amphibians, water birds, and even small mammals). It is also believed that bullfrogs, once established, can compete directly with native birds, reptiles, amphibians and fishes for limited food resources. In some cases, they also may have significant effects on aquatic vegetation. Despite these conflicting reports, direct and indirect effects from bullfrogs have indeed been shown to occur on native species, such as competition, predation, and habitat displacement (Boone et al. 2004, Pearl et al. 2004, others reviewed in Kiesecker 2003).

Bullfrogs may also be carriers of pathogens, which can adversely affect native frog populations. Some recent research has implicated introduced bullfrogs as reservoir hosts of the chytrid fungus, *Batrachochytrium dendrobatidis*, which when transmitted to some indigenous amphibians can be severely pathogenic (Hanselmann et al. 2004, Pearl and Green 2005, Garner et al. 2006).

Management Options

Management of bullfrog populations is difficult, in part because bullfrogs are interspersed with sensitive, native species in aquatic habitats. Adult frogs are removed by trapping or hand captures and tadpoles are destroyed by draining ponds or chemical treatment with limited success (Bury and Whelan 1984, Moler 1994, Pitt et al. 2005). In some cases, habitat manipulation can be used (Adams and Pearly 2007). Because bullfrogs are extremely difficult to control and nearly impossible to eliminate, they pose a very serious challenge to restoration and conservation efforts (Boersma et al. 2006).

Future Directions

Newly devised control methods potentially include (but are not limited to) chemical control and newly designed traps specifically for bullfrogs.

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A field evaluation of a multiple capture trap for invasive bullfrogs

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Introduction

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Methods

We conducted 2 field trials along the Front Range of Colorado to investigate if a newly designed trap could capture a bullfrog, or multiple bullfrogs. During each trail we tested 2 identical traps that have been developed for capturing cane toads in Australia. We placed the traps near or in ponds where bullfrogs were known to exist. Three sides of each trap had a one-way door comprised of clear-plastic strips that hung from the top of the entry. Frogs could push through the hanging strips to enter the trap, but could not push the strips outward to exit the trap once captured. The traps were set out in the evening shortly before dark. The traps were checked after daylight the next morning. To place the traps in the water, we attached Styrofoam flotation devices to the underside of the traps so that the entry doors were level with the surface of the water.

Methods (Continued)

Traps were re-located every evening so a new area was trapped every night. The traps were at least 20 m apart so that they were not likely to influence each other or frogs near the other trap. Traps were always placed in locations where bullfrogs had been previously viewed or heard. We used various attractant types and combinations of attractant types inside each of the traps. We placed live crickets inside clear plastic containers in the traps. We used fly-fishing fly lures tied with monofilament line so they hung inside the trap. We fashioned a headlamp with LED light bulbs onto the top of the trap. We oriented the LED lights into 2 different positions; either pointing the light up or down. One night we tied a yellow glow-stick to the top of the traps so that they hung inside the trap. We recorded bullfrog captures along with the trap attractant, date, and location. Bullfrogs were held and released on-site after the trial, or euthanized. Any non-target animals that were captured were released nearby.

Efficacy of Removal on Bullfrog Abundance

We conducted audio and visual survey counts to estimate the abundance of bullfrogs in the pond following the methodologies explained by Thompson et al. (1998). In the following 5 nights we trapped for bullfrogs and continued the abundance surveys to determine if any removal of bullfrogs had any effect on abundance. On the last night of removal, we attempted to hand-net all bullfrogs possible in 2 passes around the pond. Finally, we conducted survey counts 2 days after all methods of removal had ceased. For the audio counts, we recorded the total amount of bullfrog calls heard in a 10 minute period. For visual counts, we recorded the total amount of bullfrogs seen using a spotlight from 1 complete pass around the entire pond on foot. Both types of counts were conducted 2 times each night.

Results

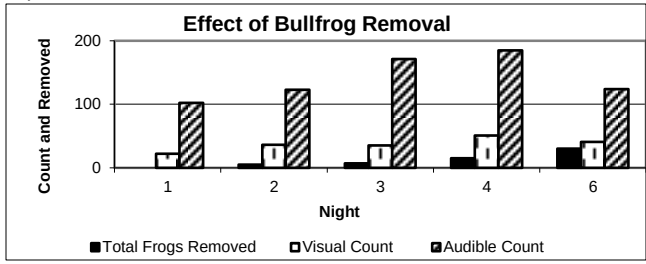
Multiple Capture Trap Pueblo Pond

Two traps were rotated to different positions in the pond for 5 consecutive days. In 10 trap nights, 18 bullfrogs were captured and 0 non-targets (Table X). The amounts of bullfrogs captured ranged from 0–7 per trap. The only attractant type that did not capture any bullfrogs was the LED light pointed up, but was only tested for 1 night in 2 traps. All other attractant types captured at least 1 bullfrog, but the fishing lures seemed best for catching the highest numbers.

Efficacy of Removal on Bullfrog Abundance

In 5 nights we removed 31 total bullfrogs from the pond near pueblo (18 with trapping, 12 with net captures, and 1 with spearing). On night 4, after removing 16 bullfrogs the visual counts were at their highest observed (Table X). After the last night of removal where we had initiated the technique of attempting to net every bullfrog we saw during 2 passes around the pond, both visual and audio counts were slightly reduced.

Toxicant (Concentration)	No. Bullfrogs	% Mortality (No./Group Size)
Citric acid (16%)	5	0 (0/5)
Sodium bicarbonate (15%)	5	0 (0/5)
Caffeine (10%)	5	100 (5/5)
Calcium hydroxide (6%)	5	0 (0/5)
Permethrin (4.6%)	5	40 (2/5)
Control (tapwater)	5	0 (0/5)



Discussion

The multiple capture traps were effective at capturing more than 1 bullfrog per night. The numbers of bullfrogs captured were likely affected by the type(s) of attractants used in the traps, and trap placement. Traps were observed to capture bullfrogs during the day and the night, although most captures happened at night.

We surmised that we did not yet find an extremely attractive stimulus for getting bullfrogs to enter the traps. However, during 1 occasion we observed some outside interest from surrounding bullfrogs toward a trap that already captured 3 bullfrogs, including 1 known female. Therefore, we suggest using a live bullfrog as an attractant inside the traps might be effective. We observed some evidence that removing bullfrogs using multiple capture traps for 5 nights, and 1 night of netting seemed to reduce the abundance of bullfrogs.

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