

advantage to invasive species that are more tolerant of such conditions (Rossetti et al., 2017). These pollutants can degrade habitat quality, making it more challenging for native species to survive and thrive, thereby facilitating invasions.

The presence of environmental stressors like pollution can also interact with diseases such as *Batrachochytrium dendrobatidis* (Bd), exacerbating their impact on amphibian populations. Fragmented habitats can increase the spread and severity of diseases by creating isolated populations that are more susceptible to outbreaks (Fallaschi et al., 2020). The combination of pollution and disease can lead to significant declines in native amphibian populations, further opening niches for invasive species to exploit.

## 6 Case Analysis: The American Bullfrog (*Lithobates catesbeianus*) Invasion

### 6.1 Case background: spread and impact

The American bullfrog (*Lithobates catesbeianus*) is a highly invasive species that has spread across multiple continents, significantly impacting native amphibian populations. In Uruguay, the bullfrog was initially introduced for farming purposes in 1987, but has since established feral populations, particularly in areas like Rincón de Pando, Canelones, where they are displacing native amphibians and altering community structures (Laufer et al., 2008). In Mexico, the bullfrog's invasion poses a threat to 82 endemic frog species (Figure 1) due to its ability to adapt to new environmental conditions through niche shifts (López et al., 2017). In Europe, the bullfrog's potential distribution is expected to increase due to climate change, threatening native species within the Natura 2000 network (Johović et al., 2020). In South Korea, the bullfrog's spread is exacerbated by climate change, posing a significant threat to the critically endangered Suwon treefrog (Koo and Choe, 2021).

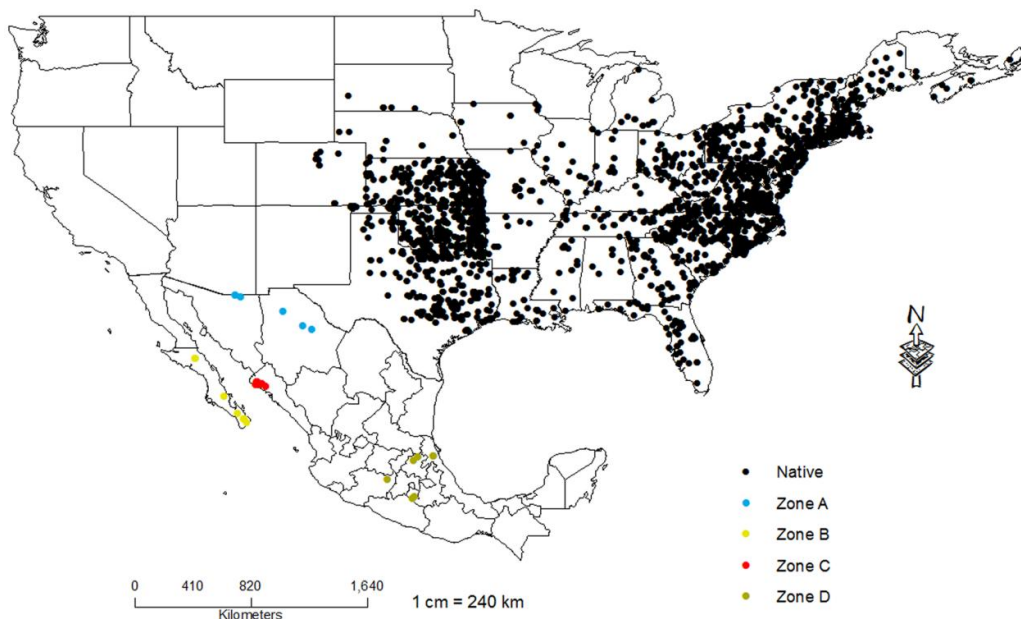


Figure 1 Distribution of *Lithobates catesbeianus* native and invaded ranges (Adopted from López et al., 2017)

Image caption: The black dots indicate the native distribution of *L. catesbeianus* in the United States. The dots in yellow, blue, red and green represent the invaded distribution of bullfrogs in Mexico (Adopted from López et al., 2017)

### 6.2 Role of habitat fragmentation in bullfrog invasion

Habitat fragmentation plays a crucial role in facilitating the spread of the American bullfrog. In the Colorado Front Range, landscape-level factors such as topographic complexity and wetland density are significant predictors of bullfrog occurrence, indicating that fragmented landscapes may facilitate their dispersal. In Uruguay, the bullfrog's presence in fragmented pond networks has led to reduced native anuran richness, with certain species like *Pseudis minuta* being more affected due to increased encounter rates with the invader (Laufer et al., 2023). The bullfrog's ability to thrive in fragmented habitats is further supported by its reproductive characteristics, such as reduced size at reproductive maturity, which enhances its colonization and spread (Urbina et al., 2020).