Nicole Stahl
Professor Chris Jensen
Ecology
1 March 1, 2017

Project Proposal: The Ecological Effects of Cane Toads on Australian Snakes

Since the introduction of cane toads in 1935, they have created countless ecological problems for Australia and its native species. The cane toad was brought to Australia from Hawaii in hopes that it would help control the cane beetles which were destroying the sugar cane crops in North Queensland. On June 22nd, 1935, 102 cane toads arrived at Gordonvale. The cane toads multiplied, spreading across Queensland and much of Australia. The cane beetles were not affected to the degree many had hoped by the cane toads, but the same cannot be same cannot be said for many other native Australian Species. Because the cane toads were introduced over 80 years ago, many studies have been conducted on their devastating effects, including studies on the long term repercussions on their introduction on Australian Ecosystems. Because their effects have been thoroughly researched, I believe that they are a great cautionary example against transplanting certain species. This term project will serve as a call to action, displaying many of the negative long term effects on species brought on by the introduction of the cane toad. (Lewis)

Many invasive species are blamed with losses of biodiversity, however, these claims are not always true. According to ecologists Jessica Gurevitch and Dianna Padilla, "to date, there has been insufficient critical evaluation of overall global patterns of the extent to which invasion is implicated in extinctions, or the conditions and circumstances under which invasions are most likely to lead to extinctions." (Gurevitch, Padilla 1) This is because while many invasive species *contribute* to a loss of biodiversity, in many cases, they are just one of many factors which cause the extinction of native species. In many cases, the cause of an extinction or threat to a species is "anecdotal, speculative, or based upon limited observation." (Gurevitch, Padilla 1) Extinctions may be the cause of any number of factors, including habit alteration, decline of native plants, invasive species, climate change, or many others. Although non-native plants and animals are often blamed for extinctions of and threats to native species, scientists often lack the evidence to prove that these nonnative species are the strongest forcing on a species' population. In many cases, other contributing factors may be the primary cause of extinction or threat to a native species.

One example of a species wrongly blamed for a loss in biodiversity is in the case of zebra mussels. Zebra mussels are currently considered to be a major threat to North American fresh water bivalves. However, the extent to which these non native species are contributing to the decline of threatened and extinct native bivalves is unclear. Even before the introduction of zebra mussels, native bivalves were on the decline as a result of habitat destruction. In fact, it is believed by many ecologists that no species has gone extinct as a direct result of zebra mussels. Many recent studies have questioned if invasions are major cause of extinction. However, although invasive species worldwide may not be a major cause of extinction, that does not mean that specific cases may be devastating to an ecosystem. Species such as brown tree snakes and cane toads have caused major destruction of the native habitats which they have invaded. Species such as the cane toad, which indiscriminately kill many native species, are likely to have a much greater effect on native species than zebra mussels.(Gurevitch, Padilla 2).

Although many invasive species have caused relatively minor effects to native fauna, cane toads are an exception. Cane toads have affected a variety of species including everything from invertebrates to fish to crocodiles. What makes cane toads so devastating to native Australian fauna? Richard Shine, Australian evolutionary biologist and ecologist (and expert on reptiles and amphibians) has extensively researched the cane toad and its effects on many native faunae. According to Shine, "The paratoid (shoulder) glands of cane toads contain bufogenis, bufotoxins, and other substances but the constituents of cane toad toxins differ from those of Australian native frogs. The cane toad is toxic throughout all of its life stages (ie. Eggs, tadpoles, metamorphs, and adults)" (253). Cane toads are highly toxic, and Australian native fauna is not well adapted to deal with these toads. Because of this, many predators (including freshwater crocodiles) are found dead with their mouths still wrapped around a cane toad- the poison is so potent that they die before even swallowing the toads. there have been over 27 native terrestrial vertebrate species (as well as dogs, cats, and humans) in which individual predators have died as a direct result of mouthing cane toads. (Shine 263)

In his article on the effects of cane toads on native populations, Shine summarizes and compares the effects on many native species. In some cases, the effects of the cane toad are stronger than others. For example, bluetongue lizards have been highly effected by the invasion of the cane toads. This is because they are highly vulnerable to toad toxins, and have been dying off in large numbers as a result of consuming these toxic toads. However, some species see a vastly different effect as a result of the toads. Some species of snake, including the keelback and slatey-grey snake have actually seen population increases since the introduction of the cane toad. This is because unlike their competition, they rarely consume toads. Since the toads lead to a staunch decline in their competition, these snakes have been able to flourish, actually benefiting from the invasion of the cane toad. (Shine 260)

Because the cane toads were introduced over 80 years ago, it is possible to study not only the short term effects that the toads had on certain populations, but also the long term effects. In addition to decreasing many populations, the toads have also forced many species to adapt to their presence over many generations. One such species is the black snake. The changes have occurred very rapidly- over less than 23 snake generations- but they have been substantial. The arrival of cane toads potentially imposed selection on at least three traits: "physiological resistance to toad toxin, prey preference (the tendency to eat toads), and the morphology of impacted snake species (relatively small headed snakes are less likely to be capable of consuming a toad dose)" (Phillips, Shine 1545). One native species that has evolved as a result of cane toads is the red-bellied black snake. In a study by Ben L. Phillips and Richard Shine, populations of red-bellied black snakes that had been exposed to cane toads were compared to populations which had not. They found that populations that had been exposed to cane toads would not eat a toad when left alone with it for 24 hours (the toads were pre-killed with their poison glands removed) while snakes that had not been exposed to toads would eat the toad half of the time. Phillips and Shine also found that toad-exposed populations had developed a resistance to the toads toxins.

Another species that has evolved in response to cane toads is the freshwater crocodile. Since the introduction of cane toads, consumption of these poisonous toads has lead to a massive mortality event in freshwater crocodile species. However, according to research by Ruchira Somaweera, populations of freshwater crocodiles are recovering via adaptions in their hatchlings' behavior. Because hatchling freshwater crocodiles only consume young metamorph toads, they often consume a smaller amount of the toxin. This amount is often not enough to kill

them, but it is enough to influence them not to consume any more of the poisonous toads. According to a study by Somaweera, hatchlings that are exposed to cane toad metamorphs often develop an aversion to consuming cane toads, allowing them to avoid being killed by their toxins as they age. This learning could lead to an eventual recovery of freshwater crocodiles. (Shine, Wiens 254)

Through this term project, I plan to create an illustrative painting which details the many effects that cane toads have caused on native species. This piece will illustrate that cane toads and similar invasive species can have a major effect on the biodiversity of the ecosystems they invade. I hope to illustrate this change in biodiversity as well as the adaptations that certain species, (such as snakes) have shown. Specifically, the message that I hope to convey (which is drawn from my research) is that species such as cane toads, which kill other species indiscriminately, can have a major effect when transplanted to a new environment.

This piece will be painted with mixed media (acrylics, oils, and digital mounted elements) blended seamlessly and applied to a wooden cutout of a cane toad silhouette. The cutout will be created using a laser cutter. The illustrative elements will show the many species that have been impacted by the toads, from small species that they consume to larger predator species unfortunate enough to try to eat the poisonous toads. It will also display some changes that have gone on within species as a result of the cane toad. This piece will particularly focus on the changes in freshwater crocodile hatchlings and red-bellied black snacks as a result of exposure to cane toads.

This piece will serve as an informative illustration as well as a piece of fine art. The toad shaped canvas will be filled with many images which inform the viewer of the many effects that cane toads have caused in their over 80 years of wreaking havoc on native Australian fauna. Through the creation of this piece I plan to make every effort to make the piece both visually engaging and readable enough that it can be easily understood by someone with a limited knowledge of the subject matter. Most of all, I plan to create a work of art that serves as a call to action for conservation of biodiversity in Australian ecosystems and mitigation of problems brought forth by the introduction of the cane toad.

Annotated Works Cited

Brown, Gregory P., et al. "Invasion, Stress, and Spinal Arthritis in Cane Toads." *Proceedings of the National Academy of Sciences of the United States of America*, vol. 104, no. 45, 2007, pp. 17698–17700., www.jstor.org/stable/25450305.

A study was conducted on Cane Toads which are an invasive species in Australia; this study revealed that invasive cane toads in Australia have a much higher risk of spinal arthritis than native Cane Toads. While many studies are conducted on the environments which invasive species effect, not many studies are conducted on the effects of invading on a species. This study revealed that the process of rapidly invading Australia was also not beneficial for the Cane Toad species, since the rapid colonization selected for frogs which could move quickly with long legs, which is a trait which often accompanies spinal arthritis in frogs.

Phillips, Ben L., and Richard Shine. "An Invasive Species Induces Rapid Adaptive Change in a Native Predator: Cane Toads and Black Snakes in Australia." *Proceedings: Biological Sciences*, vol. 273, no. 1593, 2006, pp. 1545–1550., www.jstor.org/stable/25223486.

Invasive species have long been a threat to biodiversity, but in this article, scientists studied the possibility of species evolving to accommodate invasive species. In the case of this study, scientists studied populations of red-bellied black snakes in Australia which have been affected by cane toad populations. After generations of being exposed to the toxic toads, some snakes had evolved a resistance to the toxin or learned to not eat the toads. This evolution over many generations shows some hope for native species adapting to invasive species.

Shine, Richard, and JohnJ. Wiens. "The Ecological Impact of Invasive Cane Toads (*Bufo Marinus*) in Australia." *The Quarterly Review of Biology*, vol. 85, no. 3, 2010, pp. 253–291., www.jstor.org/stable/10.1086/655116.

Cane toads were introduced to Australia in 1935. Because there has been so much time since their introduction, Scientists have been able to study the long term effects of their introduction on Australian Ecosystems. Cane toads have impacted many species in Australian ecosystems including a decrease in abundance and diversity of many beetles, termites, and ants (Cane toads have been eating many of these species, thus causing a major effect on their populations). There are many charts and diagrams in this article which detail specific changes in populations, especially on pages 258-260. Cane toads also compete with many native species including native tadpoles and toads. This has caused a decrease in native toad populations. The toads have also affected many populations through lethal ingestion; since they are toxic, many predator species, including saltwater crocodiles, have been negatively impacted by the introduction of the cane toads.

Gurevitch, Jessica and Padilla, Dianna. "Are invasive species a major cause of extinctions?" *TRENDS in Ecology and Evolution*, vol. 19, no. 9, 2004, pp. 470-474, http://www.des.ucdavis.edu/faculty/grosholz/InvasionReadings.pdf.

This article analyzes data to determine whether or not invasive species are a major cause for extinction. This article recounts that, although invasive species are often blamed for decline of native species, there is not enough data to prove that every case of invasive species is the cause of extinction. Although invasive species *sometimes* cause extinction, in many cases, there are many other contributing factors to a loss of biodiversity, and the invasive species are blamed despite not being the sole cause. One example of this is the zebra mussels. Although the introduction of zebra mussels coincided with the decline of several native bivalve species, factors such as water diversion, erosion, and pesticides had a greater effect on native bivalves than the invasive zebra mussels.

Lewis, Mark. *Cane Toads: An Unnatural History*. Sydney: Film Australia, 1987.

This documentary discusses the history of cane toads within Australia and the effects that they have had not only on the native fauna but also on the native people. Many interviews are conducted with experts as well as natives who live alongside countless toad invaders. The history of the introduction of these toads is particularly detailed in this documentary.

Phillips, Ben L., and Richard Shine. "the Morphology, and hence impact, of an invasive species (The cane toad): Changes with time since colonization" *Animal Conservation,* vol. 8, 2005, pp. 407-413., https://www.researchgate.net/profile/Richard_Shine/publication/227793632_The_morphology_and_hence_impact_of_an_invasive_species_the_cane_toad_Bufo_marinus_Changes_with_time_since_colonisation/links/0fcfd50502b173c82d000000.pdf

Since colonizing Australia, cane toads have successfully evolved to suit their environment. Specifically, a study has found that over many generations, cane toads have evolved to be smalle rand less poisonous. This also suggests that the toads will have the largest impact on an area when they first arrive, with a diminishing impact as generations pass. Scientists believe that it is possible that this selection is occurring because size and large poison glands are costly features, or it is possible that they are adapting to a new environment where the size of poison glands and the size of a toad gives no advantage or disadvantage. This is an interesting study because it shows that after generations of cane toads living in Australia, they are becoming less poisonous and may therefore become less of a threat to native predators.

Somaweera, Ruchira, et al. "Hatchling Australian Freshwater Crocodiles Rapidly Learn to Avoid Toxic Invasive Cane Toads." *Behaviour*, vol. 148, no. 4, 2011, pp. 501–517., www.jstor.org/stable/23034331.

This article discusses a study done on hatchling crocodiles. This study revealed that while adult freshwater crocodiles sometimes eat cane toads (and die as a result because of their low resistance) the populations are recovering due to the fact that the young hatchling crocodiles are learning to avoid the toads. This is because older crocodiles have likely already reproduced, therefore their deaths are not nearly as impactful as the deaths of hatchling crocodiles. As long as most hatchlings avoid the toads, enough fresh water crocodiles are able to survive and reproduce.