Effects of *Coffea canephora* removal on plant community structural composition

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Abstract

Invasive plant populations pose a threat to biodiversity in tropical forest ecosystems. This study aimed to assess the impact of invasive plant removal efforts on plant structural community composition over time, focusing on *Coffea canephora* removal projects at La Selva Biological Reserve over a period of 5 years. Using stem size distribution data sampled from plots in both 2019 and 2024, the study assessed the differences in stem size distribution pre- and post-invasive removal; no significant difference in stem size distribution were found between the initial sampling and subsequent resampling. Though these findings do not demonstrate a change in plant structural community composition following invasive plant removal projects, suggestions were made to expand and improve the study for further inquiries into how invasive removal projects impact plant communities and how they recover following these removal projects.

Keywords: Tropical forest succession, disturbances, invasive species management

Introduction

Non-native and invasive species can detrimentally impact the health and biodiversity of an ecosystem, taking up large amounts of space and resources that would otherwise facilitate the growth of native species. Once introduced to an ecosystem, non-native plant species have the potential to spread rapidly, creating distinct monospecific patches with spreading borders which can transform ecosystems irrevocably (C. M. D'Antonio, S. E. Hobbie, 2005). The impact of invasive species on the biodiversity of tropical forest ecosystems has rapidly increased in recent decades (Millennium Ecosystem Assessment 2005). Invasive species present a unique challenge in land management strategies, as some species may have the ability to alter the conditions of the ecosystems they colonize making it no longer viable for native plants to thrive, in addition to the challenge of continued upkeep following invasive removal projects to prevent the establishment of other invasive species in the newly open/disturbed areas where these projects have taken place (Chapin et al. 2008).

Protected land is no exception when it comes to the threat of invasive species to biodiversity. Despite its location in a protected area, La Selva Biological Reserve's diverse land-use history pre-conservation status includes the introduction of several non-native species since its creation. In the 1950's, Dr. L Holdridge introduced the coffee species *Coffea canephora* in an effort to establish an agroforestry plantation. This plantation land has since been allowed to return to its natural state, but the

population of *C. canephora* still thrives. Part of *C. canephora*'s reproductive strategy includes producing a large number of seedlings which then rapidly grow to cover the forest floor beneath the parent plant, hoarding large amounts of space and nutrients that would otherwise be utilized by other species. Under the management of the Organization for Tropical Studies, efforts have been made to remove remaining populations of *Coffea canephora* to allow for native plant communities to recover in the absence of this dominant introduced species.

The goal of this study was to evaluate how these removal projects have impacted plant community structural composition over a period of 5 years. I hypothesized that the removal of a dominant species creates room on the forest floor for other plants to thrive, predicting that plots where *C. canephora* was removed would have a greater proportion of plants with smaller diameters.

Materials & methods

This study took place on the SOC trail at La Selva Biological Station in the Heredia province of Costa Rica. La Selva Biological Station is situated at the north end of the larger Braulio Carrillo National Park and hosts a lush landscape of lowland tropical rainforest.

In 2019, exotic plant removal projects were carried out by a number of volunteer groups, including the removal of *Coffea canephora* from several transects along the SOC trail. Volunteers (facilitated by OTS Director of Science, Orlando Vargas) collected data detailing the abundance and stem size of plant species situated in several $5m^2$ plots along the transects. All *C. canephora* plants were subsequently removed from the plots.

In 2024, Orlando brought me to two of these transects where I resampled data of the stem size distribution of all plants from three of the $5m^2$ plots using a caliper to measure DBH of the woody plants. I formatted my data collection to correspond with the data taken from these plots in 2019 in order to use that data as a baseline for comparison of stem size distribution before (2019) and after (2024) *C. canephora* removal. Both the 2019 and 2024 data was categorized as follows:

Table 1: Categories of stem size used in data collection

≥20cm height + <1 cm DBH	1-2.5 cm DBH	2.5-5 cm DBH	5-10 cm DBH	10+ cm DBH
#	#	#	#	#

In accordance with the 2019 data, plants with heights less than 20 cm were excluded and herbaceous plants were categorized as "≥20 cm height + <1 cm DBH". I then combined all plots into 2 distributions: "Before Removal [of *C. canephora*]" and "After Removal [of *C. canephora*]".

To assess whether the distributions of stem size distribution and abundance in the plots differed before and after removal of *C. canephora* treatment, I ran a Kolmogorov-Smirnov test.

Results

While there was a higher abundance of the smallest category of plant after removal of *Coffea canephora,* I found that stem size distribution in the plots measured did not significantly differ in 2024 from their distributions in 2019 (Figure 1).

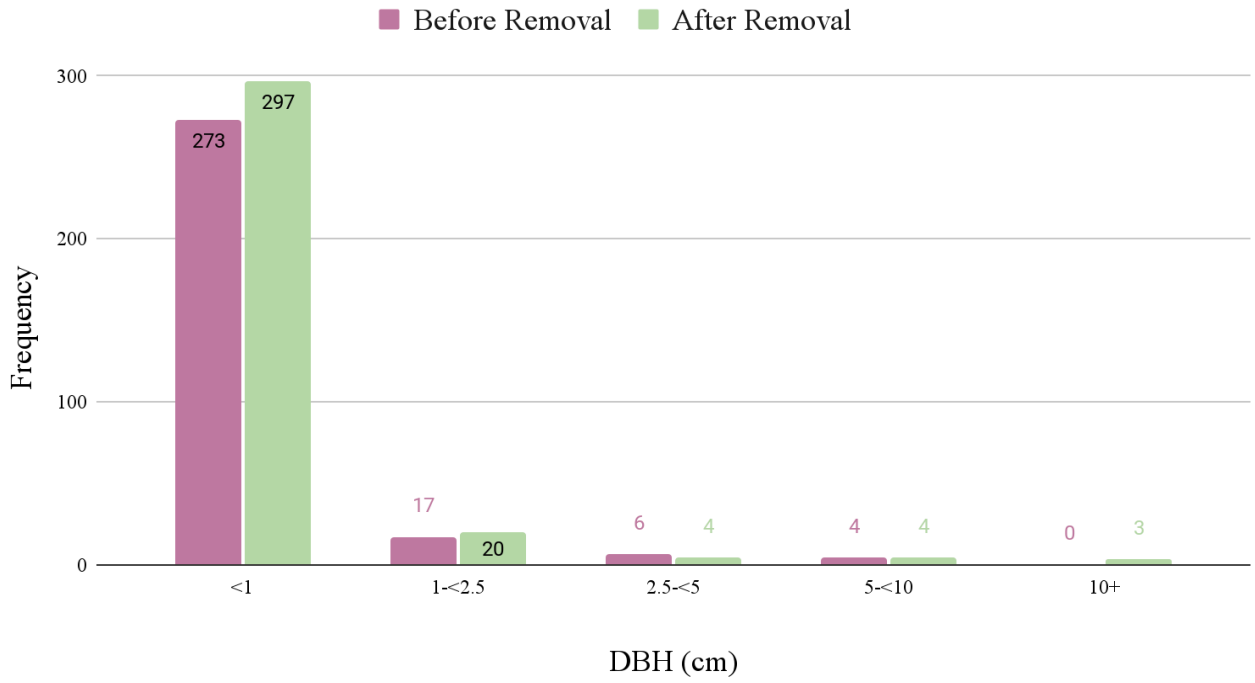

Figure 1: Side by side comparison of stem size distribution in all combined plots before and after the removal of *C. canephora* (P = 0.844)

Discussion

During resampling, I observed a visual distinction between the forest composition within the treatment area and outside of the treatment area, suggesting that removal of *Coffea canephora* may have shaped the forest composition in ways that were not tested in this study. However, there are many possible combinations of factors which may have contributed to the lack of significant change in stem size distribution between the initial data collection in 2019 before removal treatment and my resampling in 2024 post-removal treatment. The majority of the plots resampled presented evidence of recent disturbance by storms; this compounded with the lack of detailed information over the several years

which passed between samplings, making it difficult, if not impossible to differentiate the impacts of *C. canephora* removal from those of natural disturbances, or the simple passing of time.

Based on the slight increase of abundance of small plants in the removal plots, it is possible that the community composition of pre-removal surveys was a baseline to which the plots have now returned, with an increase in the youngest recruits that will not necessarily survive into adulthood. This may suggest that the plots have a specific baseline community capacity that was not limited by the populations of *C. canephora* that were removed. Studies of invasive removal in tropical ecosystems have not necessarily shown an increase in native species over periods of years, suggesting that relatively stagnant native populations are not necessarily indicative of resurgence of invasive populations (Ostertag 2009).

Conversely, it is also possible that without persistent and repeated removal efforts, the coffee plant populations were able to recover to their pre-removal amounts, as in other woody species' invasive removal studies, invasive population counts were able to rebound for several years following removal, even with consistent annual removal efforts (Cutway 2017). Because *C. canephora* is able to reproduce sooner in its lifespan than many tropical species, it would make a good candidate for recolonization from adjacent untreated plots, especially if removal only occurred once (Richardson and Rejmánek 2011). Additionally, *C. canephora* has been shown to be aggressive in its growth in both disturbed and undisturbed tropical ecosystems (Joshi et al 2009), potentially suggesting that the lack of change observed in this study between pre- and post-removal surveys may be a result of the reestablishment of *C. canephora* populations in the plots.

It is important to acknowledge that similar studies of the impact of invasive removal projects on native species generally take place in substantially larger areas of study over several years of detailed monitoring which includes species-level data to account for shifts in species composition, richness, abundance, etc. in monitored plots (Ostertag et al. 2009, Joshi et al. 2009, Cutaway 2017, Raymundo et al. 2018).

Future expansions of this study could include a detailed account of species diversity within and outside of the treatment plots (as well as in separate plots which historically had no populations of *Coffea canephora*) taking into account the different habits and dispersal methods utilized by these plant communities to gain insight into the processes of succession in this protected tropical forest ecosystem and reestablishment of native plant communities in the wake of human impacts. Future expansions of the study may also include more frequent, more detailed sampling of data from plots across a wider range of treated areas, ensuring that the impact of events such as storms could be separated from the effects of non-native plant removal projects.

Data collected from future expansions of this study could be valuable in the development of non-native and invasive species management programs, informing planners of the types of native plants

that occupy areas where invasive management projects are to be carried out, and whether native populations require human intervention to reestablish to avoid the proliferation of invasive species. This data could also be utilized for creating information resources to inform both funding sources and volunteers of the long-term impacts of invasive removal and restoration projects they are considering being involved in, creating a broader understanding of the importance of these projects and how they impact native plant communities following human disturbances.

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