FINAL PROJECT REPORT 4:

Deer browsing, native vegetation, and camphor invasion on Jekyll Island, Georgia

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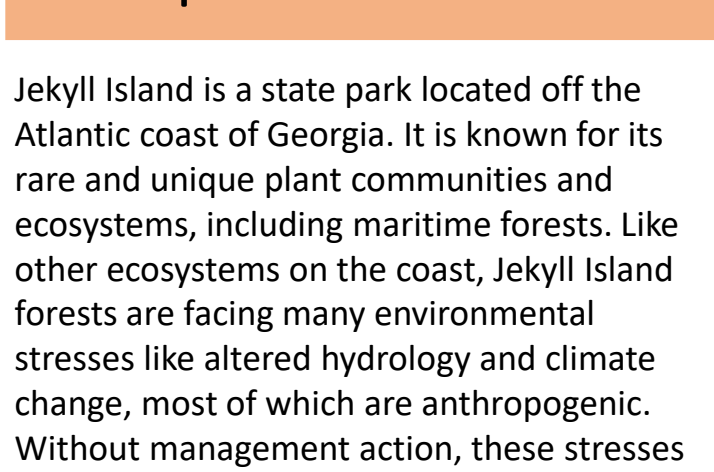
About this report: This preliminary report explores two environmental stressors, the Asian camphor tree and deer herbivory, that may negatively affect the native plant vegetation on Jekyll Island, a Georgia barrier island. We present our study in four sections:

Camphor Tree and Deer Herbivory as Environmental Stressors → Study Site, Experimental Design, and Methods → Preliminary Results → Implications for Jekyll Island Management

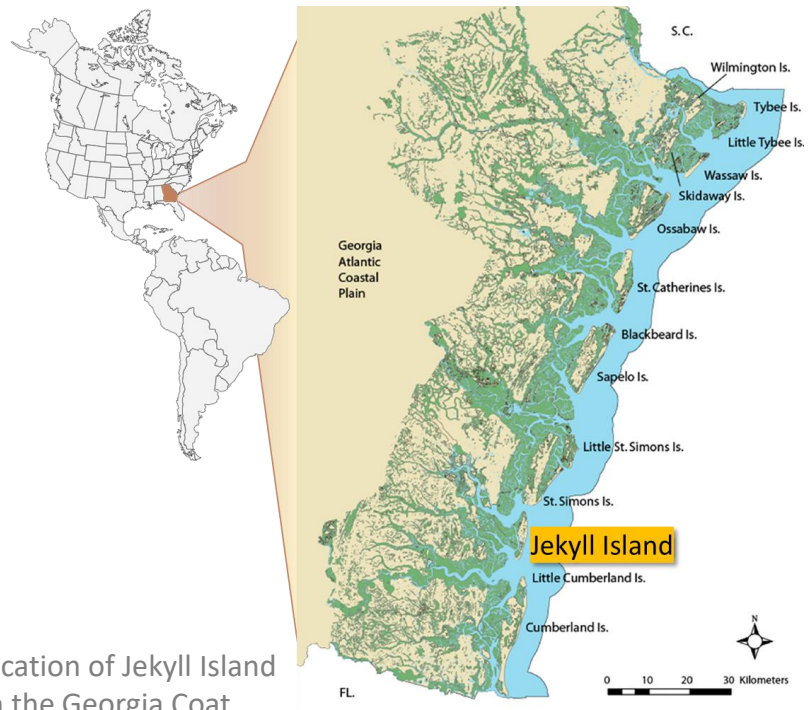
Camphor Tree and Deer Herbivory as Environmental Stressors

Jekyll Island is a state park located off the Atlantic coast of Georgia. It is known for its rare and unique plant communities and ecosystems, including maritime forests. Like other ecosystems on the coast, Jekyll Island forests are facing many environmental stresses like altered hydrology and climate change, most of which are anthropogenic. Without management action, these stresses can have undesired effects on the future condition of these forests including loss of valued tree or plant species and diminishing diversity. Stressors of greatest concern on Jekyll Island are dense **white-tailed deer** populations and **invasive plant species**, both of which can alter plant community structure and ecological functions.

Deer pose a critical constraint on tree seedling establishment and survival to maturity (Jekyll Island Authority (JIA) 2014). Also, deer can reduce the abundance and diversity of native understory plants. Native vegetation is ecologically important because it may help suppress invasive plants by competitively excluding weedy invaders, which often thrive in open or disturbed areas (Averill et al. 2017).



Maritime live oak forest on Jekyll Island.



Location of Jekyll Island on the Georgia Coat

Andrus & Thompson (2012) *J. Archaeol. Sci.*

Competitive exclusion is when one species outcompetes another species for the same resources and displaces it.

Invasive plant species are a growing concern on Jekyll Island. JIA is especially concerned with camphor (*Cinnamomum camphora*), an Asian evergreen tree that was introduced to to the southeastern United States over 100 years ago and is naturalized in many areas. In recent decades, however, camphor has become increasingly abundant on Jekyll Island. Fast-growing and with prolific seed production, its establishment may threaten native plant biodiversity. **Is the suppression of native vegetation by deer allowing camphor to proliferate?**

Non-native or exotic plant species are introduced to a new environment and live outside their native range.

Invasive plant species are non-native plants that have begun proliferating and displacing native plant species.

Naturalized species are non-natives that persist in a new environment, but are not invasive.

Study Site and Research Questions

Camphor has now invaded a few natural areas on Jekyll Island including a 10-ha forest off Shell Road consisting of oak, pine, and other hardwood species. This forest also has a nearly continuous saw palmetto (*Serenoa repens*) shrub layer that excludes almost all other plant species, resulting in greatly reduced plant diversity. However, throughout the site, there are distinct clearings within the saw palmetto, typically 3-12m across, that have thick leaf litter, little herbaceous or shrub vegetation, and evidence of intense deer utilization.

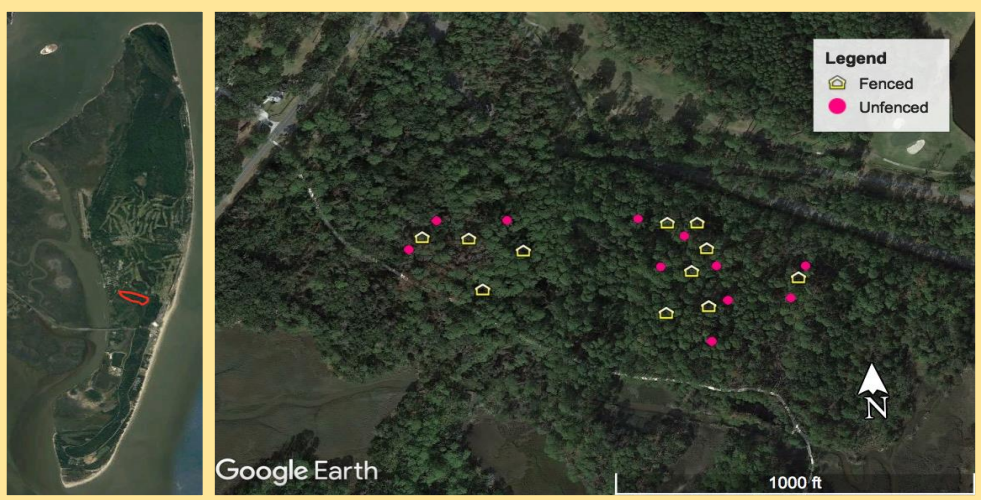
It is within these clearings that the JIA conservation team began treating mature and juvenile camphor trees with herbicide in 2016 and 2017. However, camphor seedlings are emerging within these clearings, which raises concerns about how to keep camphor under control and preserve the native plant population, especially when native plants and tree seedlings are also facing another stress with deer herbivory. To help JIA conservation staff manage the area for invasive control and native plant diversity restoration, we sought to explore whether deer herbivory is affecting the native understory plant community and camphor seedling regeneration.

The camphor tree (*Cinnamomum camphora*) has become naturalized on Jekyll Island and could potentially outcompete native vegetation, including chain fern (*Woodwardia virginica), pictured above.*

Research Questions: How does deer exclusion affect:
(a) Native herbaceous vegetation cover?
(b) Native hardwood tree seedling abundance?
(c) Camphor seedling survival and growth?

Experimental Design and Plot Location

We are manipulating deer herbivory across an elevation gradient in the forest south of Shell Road. In March 2018, we surveyed the entire site to identify clearings in the saw palmetto understory that had similar understory vegetation composition and density. We randomly selected 22 clearings, each at least 6m x 6m in size, from a pool of 32 potential sites, in which to establish plots. We randomly chose 11 sites to build deer exclosure fences and 11 sites where deer would have access. Each 6m x 6m site contains a 5m x 5m plot. There are 22 plots total.



The study site is a 10ha forest south of Shell Road. There are 22 plots total, including 11 fenced deer exclosures (yellow) and 11 unfenced plots, open to deer herbivory (pink).

Experimental methods

Each of the 22 5m x 5m plots contains 25 1m x 1m subplots. Immediately before the fences were built, each plot was surveyed for baseline vegetation and camphor seedlings in April 2018. For vegetation surveys, we recorded total and species percent cover and counted the number of native hardwood tree seedlings less than 1.5m tall within each subplot. Vegetation surveys were conducted in April 2018 for the baseline survey and again in September 2018, May 2019, and May 2020.

For camphor surveys, we tagged each plot's seedlings in May 2018 and measured their height, counted the number of leaves, and noted mammal or insect damage. We recorded presence or absence of the same seedlings and remeasured them in July 2018, September 2018, May 2019, and May 2020. In September 2018, we also tagged and measured all recently emerged seedlings. We revisited and remeasured these seedlings in May 2019 and May 2020.

In May 2019 and May 2020, we also recorded soil moisture and temperature for each of the 22 plots using an EC-350 Aquaterr Digital probe.

PhD student Dessa Dunn measures camphor seedlings in a fenced plot.

For each 5m x 5m plot, we took 12 moisture and 3 temperature measurements. Soil moisture was recorded in a consistent array of points in each plot, and temperature was taken at three random points within each plot. These measurements will help us assess the effects of the moisture gradient on all herbaceous vegetation, and tree seedlings, and on camphor seedling performance.

1

2

Flags mark locations of small camphor seedlings, which are often difficult to find. Flagged seedlings in (1) April 2018 within a deer exclosure plot and under a treated mature camphor tree and (2) underneath grape vines growing on the forest floor.

Research Questions: How does deer exclusion affect:

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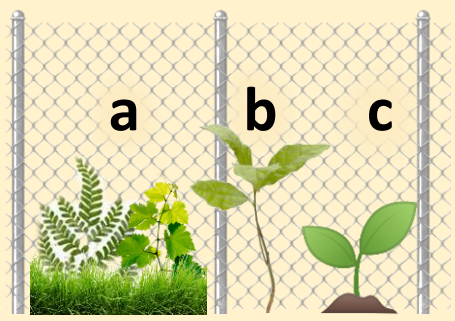
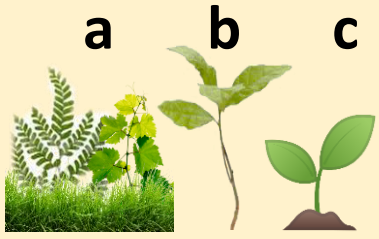


11 fenced plots



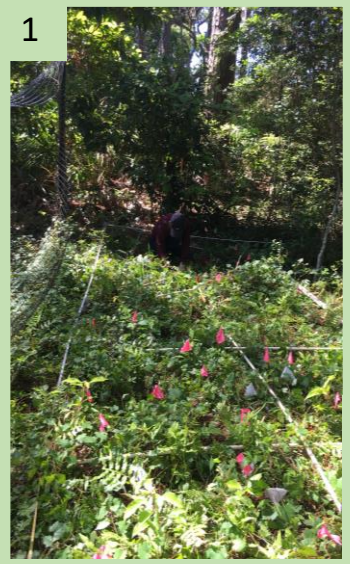
11 unfenced plots

Preliminary results:
Excluding deer improves native herbaceous plant growth, but may also enhance camphor performance

Herbaceous plant cover and number of native tree hardwood seedlings were recorded for two years for each of the 22 plots. For both Spring '19 and Spring '20, excluding deer promoted native herbaceous growth (Graph 1 below). Deer exclusion did not affect native tree seedling abundance for either year (Graph 2 below).

In April 2018, all camphor seedlings in all plots were found, tagged and their height measured. Then all seedlings were found and remeasured in July 2018, September 2018, May 2019, and May 2020.

We found that after two years, excluding deer improved camphor seedling survival (Graph 3 below) and growth (Graph 4 below).

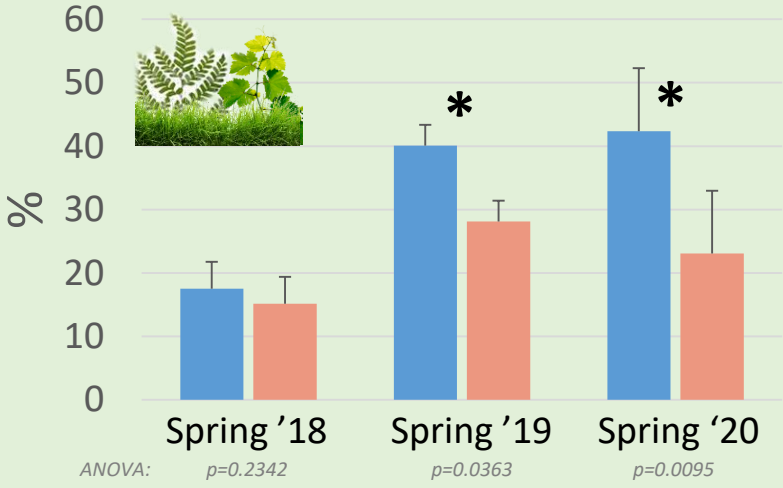


Excluding deer increased native herbaceous plant abundance (1). Unfenced plots had significantly less native plant abundance (2).

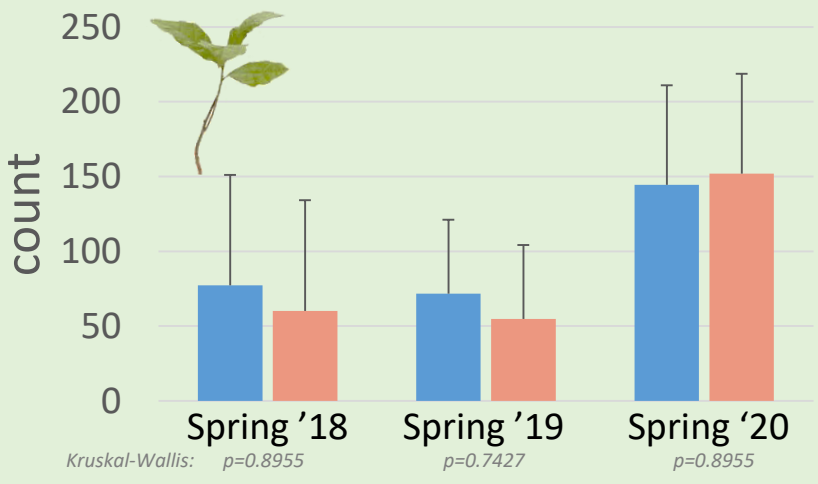
Results after the first and second year:

Fenced Unfenced

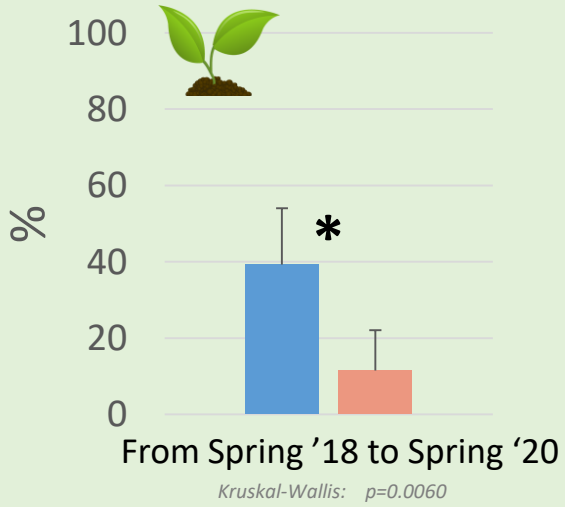
(1) Herbaceous plant cover



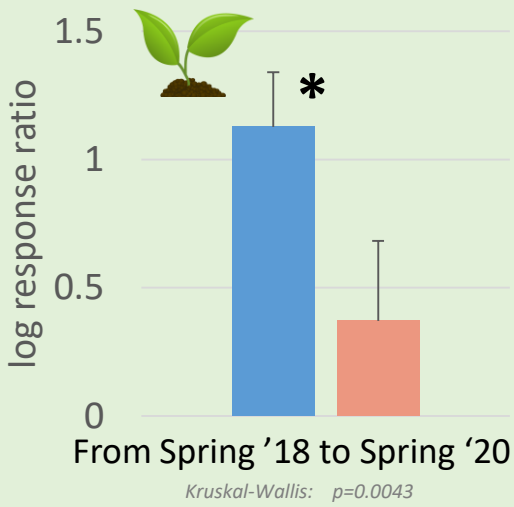
(2) Native tree seedling abundance



(3) Camphor survival



(4) Camphor growth



Excluding deer:

(a) Promotes native herbaceous vegetation cover

(b) Does not directly affect native hardwood tree seedling abundance

(c) Improves camphor seedling survival and growth

* Indicates statistically significant difference between fenced and unfenced plots

Implications for Jekyll Island Management

Excluding deer promotes native herbaceous plant abundance, but it also improves camphor performance. We do not yet know whether native plants or camphor will "win" in the long run when deer are excluded. **Jekyll Island management may need to explore other restoration efforts to reduce camphor performance.**

A combined strategy may be needed, for instance using deer fences in target areas to increase native plants, as well as herbicide application or manual removal of larger camphor seedlings.

Another stressor in Jekyll Island plant communities is decades of **fire suppression**. This has led to a heavy accumulation of litter in this mixed pine-oak forest where camphor is spreading, and may explain the thick shrub layer of saw palmetto. Fire is an important disturbance agent that maintains forest biodiversity by creating fluctuations in resource availability and preventing competitive exclusion (Kerns and Day 2017**). Fire suppression creates an additional stress for the herbaceous layer and for tree species** that rely on periodic litter and shrub reduction to regenerate and reach above the shrub layer. Use of controlled burns could reduce camphor abundance and allow native herbaceous plants to regenerate, but this has not been tested. JIA has begun implementing small control burns around its golf course.

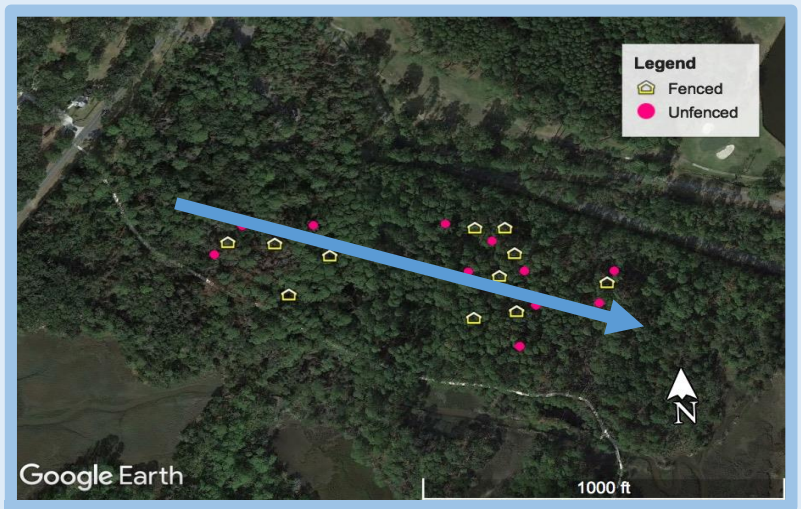
An adaptive management plan with burns would help reduce dangerous and stressful litter accumulations, while also testing whether fire can help control camphor proliferation and/or facilitate native vegetation and tree seedlings.

Jekyll Island Association began implementing control burns near the island's golf course after decades of fire suppression (JIA 2019).

Future Directions:

The findings to date show that deer exclosures are having a positive effect on understory vegetation but are also benefitting camphor growth and survival. Longer term studies are needed to understand which species benefit more in the long run, and to determine if increased camphor performance has a negative effect on native tree seedling abundance.

The forest where this study was conducted lies on an elevation gradient. Initial measurements indicate that soil moisture and temperature vary with elevation. Understanding which local environmental conditions favor the native species, and which favor the invasive, will help JIA conservation staff manage the area for invasive control and native plant diversity restoration.



The study site generally slopes downhill in the direction of the arrow. Preliminary findings indicated that soil moisture increases, and soil temperature decreases, along the downslope gradient

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