

FINAL PROJECT REPORT 1:

Live Oaks, Laurel Oaks, and Environmental Stressors in a Maritime Forest on Jekyll Island, Georgia



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RESEARCH FUNDED BY:



About this report: This report explains a study of the spatial distribution of live oaks and laurel oaks of different size classes, along elevation and soil moisture gradients in a maritime live oak forest on Jekyll Island. We found that live oaks and laurel oaks had different distributions on the elevation gradient. Also, laurel oak seedlings and mature trees had different distributions. We explored hypotheses that could explain the observed patterns. We present our study in four sections:



Background and Rationale

Maritime Forest Stressors

Maritime live oak (MLO) forests found on the barrier islands along Georgia's coast are dominated by live oak (*Quercus virginiana*) trees, sometimes interspersed with other tall canopy tree species such as laurel oak (*Q. hemisphaerica*), water oak (*Q. nigra*), and loblolly and slash pines (*Pinus taeda* and *P. elliotii*). These forests are globally rare, and valued by residents and tourists for the habitat and ecosystem services they provide, as well as their beauty and recreational value. Maritime live oak (MLO) forests also help stabilize islands, which in turn buffer the mainland coast from the effects of powerful storm events.

While there is widespread support for the conservation and preservation of maritime live oak forests along the Georgia coast, there are growing concerns among land managers regarding the state of live oak recruitment and regeneration. **Live oak recruitment is severely limited on many islands, with very low numbers of small trees and saplings observed.** Deer herbivory may be limiting live oak seedling success, but managers also cite other environmental stressors as potential reasons.

Recent changes in freshwater availability on the barrier islands is one possible limiting factor. With industrial development on the mainland over the last century, the level of the Upper Floridian aquifer below Jekyll Island decreased by about 50 ft (Barlow 2003). On island, the surficial water table is further affected by historic and current land use practices (over 300 residential wells today) and changing rainfall patterns. It now averages about 5 ft above sea level, with seasonal fluctuations that invite saltwater intrusion (Gordon & Torak 2016).



Figure 1: Typical Maritime Live Oak (MLO) forest and location of study site on Jekyll Island.

(Photo and map from JIA Conservation Plan, 2014)

Each tree species has a range of environmental conditions under which it is able to survive, thrive, and compete with other trees. The composition of a forest reflects this through the slow process of trees dying and being replaced in the canopy by younger trees. If hydrological conditions have shifted to become less favorable for live oaks, the mature forest composition may shift over time as well.

We know of no studies that have examined effects of changing groundwater levels on vegetation in MLO forests. Studying these effects directly would require decades of monitoring data of hydrology and tree responses. But spatial ecology studies can reveal patterns and preliminary insights, which point to plausible hypotheses for future research.

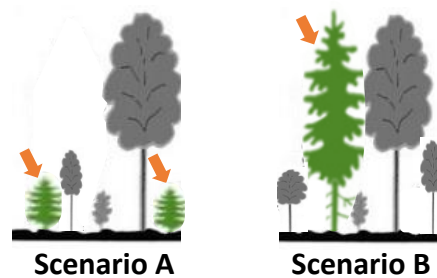
Environmental Stressors and Landscape Patterns

Landscape ecology methods, along with existing knowledge of species' environmental tolerances, can be used together to analyze spatial patterns of vegetation to make inferences about environmental stressors that structure the composition of a forest.

The relative abundances of juvenile versus adult trees along environmental gradients can suggest two different kinds of ecological processes (Figure 2).

First, in the "**filter hypothesis**," environmental conditions may impose **limiting effects at different life stages** of trees – seedlings, saplings, and mature trees. Environmental characteristics, such as the availability of light and water, can act as "filters", which limit the ability of individuals to transition between life stages, winnowing the number of trees as they age. Ecological filtering, in a fairly constant environment over time, is often the default assumption, and can explain why we may see many seedlings at a site, but few or no adults. If, however, we see adults at a site but no seedlings, the constant filter hypothesis alone cannot explain this.

Second, in the "**environmental change hypothesis**," comparisons of small and large tree distributions can be used to make inferences about **environmental change over time**. In this scenario, the presence of adults may indicate sites that had favorable environmental conditions in the past, and presence of seedlings and saplings may indicate the sites where conditions are favorable today. This may explain either seedlings occurring without adults at a site, or adults occurring without seedlings.



Size distribution (species in green)	Seedlings present; Adults absent	Adults present; Seedlings absent
Environmental Change Hypothesis:	Site has become favorable to green species. Adults are expected in future.	Site is no longer favorable for green species. Adults not expected in future.
Filter Hypothesis:	Environment filters out green species before adulthood. Adults are not expected in future.	[Cannot explain pattern]

Figure 2: Diagrams and table explaining how the abundance of adults and seedlings of the green tree species (marked with arrows) could be interpreted.

It is important to emphasize that distributional data alone, taken at a single point in time, cannot always distinguish between the two possible explanations, but instead can identify plausible hypotheses about how environmental change and filter effects may both affect current and future forest composition.

The lack of live oak seedlings and saplings on Jekyll Island is an example of Scenario B in Figure 2. The environmental change hypothesis is consistent with this pattern. Deer herbivory is suspected, but hydrology also changed over time. **If hydrology is involved, we would expect recruitment patterns to differ with elevation**, which is a useful proxy for soil water availability on barrier islands. Higher sites tend to be drier, and lower elevation sites are wetter, even grading into freshwater wetlands.

Laurel oaks also occur in MLO forests, and seem to be more common at higher elevations. This is consistent with existing knowledge about live oak and laurel oak distributions on gradients of soil moisture. Live oaks tend to be associated with moister soils, while laurel oaks are more common in drier sites (Figure 3; Cavender-Bares et al. 2004). **If trees are sensitive to the lowering water table, lower sites that once favored live oaks could become more suitable for laurel oaks.**

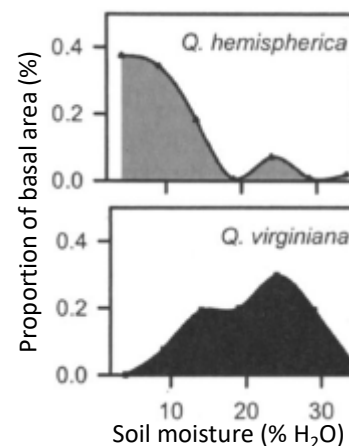


Figure 3: Comparison of laurel oak (top) and live oak (bottom) abundances associated with different soil moisture conditions in north Florida. From Cavender-Bares et al. 2004.

Light availability is a filter on both live oak and laurel oaks. Seedlings and saplings can tolerate shade for some years, yet both species can grow rapidly in response to light in a canopy gap (Spector and Putz 2007). Interestingly, at higher soil moistures, young live oaks can grow faster than laurel oaks (Cavender-Bares et al. 2004). The competitive balance shifts between older trees, however. Live oak canopies need ample light. Laurel oaks can actually shade out and eventually kill live oaks (Spector and Putz 2007).

In this study, we use elevation on Jekyll Island as an environmental gradient along which to examine the distribution and abundances of live oak and laurel oak seedlings, saplings, and adults. From our observations, we can make inferences about the interacting effects of filters and environmental change.

Study Objectives

In a tract of mature maritime live oak forest on the north end of Jekyll Island, anecdotal observations indicated that live oak (*Quercus virginiana*) seedlings were very uncommon, and saplings appeared to be totally absent. Yet there was a great abundance of laurel oak (*Q. hemisphaerica*) seedlings and numerous saplings.

Our specific concern is that as live oak recruitment is declining, hydrological conditions may now favor laurel oaks, and they may come to dominate this forest in the future.

In contrast to the iconic live oak, laurel oak is a shorter-lived and less-valued species, from both an aesthetic and ecosystem services perspective.

This study analyzes the distribution of live oak and laurel oak with respect to different spatial and environmental conditions in order to generate hypotheses and draw inferences about factors that limit plant success and shape the forest composition.

While inferences drawn from this study cannot prove what factors are affecting these two oak species, they help identify plausible explanations, and this is an important first step towards understanding of the future of this small, but highly valued forest.

We compared the distribution of live oaks and laurel oaks to answer the following questions:

- What is the current distribution of live oak and laurel oak trees of various life stage classes, along an elevation gradient on Jekyll Island?
- Do laurel and live oak seedling patterns differ from the distribution of adult trees along the elevation gradient?
- Are seedling distributions predicted by elevation and/or other environmental factors, such as canopy openness or proximity to adult trees?
- What plausible mechanisms of life stage filtering and environmental change are consistent with the observed spatial distribution patterns of live oaks and laurel oaks?
- What are the implications for forest management and conservation?

Figure 4: Left: Typical forest community found at mid-elevation in the study area, with both laurel oaks (white diamonds on trunks) and curved trunks of live oak trees (red diamonds) intermixed. Right: Laurel oak seedlings dominate understory in some areas, sometimes forming dense patches (dashed lines are approximate patch outlines).



Research Design and Methods

We surveyed two 2-hectare (4.4 acre) areas, referred to as “macroplots”, within a maritime live oak forest on the north end of Jekyll Island, located between the Horton House site and Horton Pond. Each macroplot was aligned to span an elevation gradient of approximately 2 meters. We mapped the location and size of all trees, including live oaks, laurel oaks, and other species such as American holly (*Ilex opaca*), water oak (*Quercus nigra*), pines (*Pinus elliotti/taeda*), and cabbage palms (*Sabal palmetto*). mature trees and saplings. Trees with stem diameters greater than 10cm were classified as mature trees. Saplings had stem diameters less than 10 cm and were greater than 1.2m tall.

In the east macroplot, we also set up a stratified random sampling scheme of 200 small 50x50 cm plots in which to assess live oak and laurel oak seedling abundance, average height, and cover. Seedlings were defined as less than 1.2 m tall, with stem diameters less than 10cm. We recorded the GPS location of each seedling plot. We also took digital hemispherical photographs at each seedling plot and used image analysis software to quantify the canopy density as percent canopy closure (the percentage of the sky that was blocked by canopy foliage).

Elevation was used as a proxy for soil moisture availability in our analyses. We used fine-scale LIDAR digital elevation maps to determine the elevation throughout the macroplots. This allowed us to associate an elevation with each mature tree, sapling, and seedling plot in the study. For analysis, we divided up each macroplot into 5 elevation zones, following contours from the LIDAR maps. In the West macroplot, each zone spanned 0.3m of elevation change, and in the East macroplot, each zone covered 0.5 m of elevation change.

Because the total area in each zone was different, we could not simply compare the number of trees in each zone. Instead, we calculated the density of mature and sapling trees (tree count divided by the area covered by each zone). In our analyses, we compared the density of mature live oak vs. laurel oak trees, and live vs. laurel oak saplings, within each elevation zone. We also calculated and compared basal area/ha for mature trees to assess spatial changes in species dominance in the forest composition.

We compared seedling abundance as the proportion of small plots in each zone that had seedlings present. We also compared the average ground cover of seedlings of each species.

We used regression analyses to identify correlations between seedling abundance and three other environmental variables --elevation, proximity to other trees, and canopy density -- to infer which of these variables may be influencing the abundance of seedlings. These were conducted using percent cover of seedlings in the small 50x50 cm plots as the response variable. We combined data from both macroplots, and also analyzed them separately.



Above: Student volunteers emerging from forest surveys onto access road through study area.

Findings

Figure 5: Location and elevation gradients in two macroplots, each 100 x 200m, or 2ha, located near the north end of Jekyll Island. Horton House, a historic site on Jekyll island’s western shoreline, is labeled on the far left of the image, and provides a point of reference. Macroplots were located and aligned to elevation gradients using a coarse elevation map of the general study area. Elevations shown in color contours were later derived from high-resolution lidar digital elevation models available from NOAA. Arrows point uphill. (Aerial image: Google Maps)



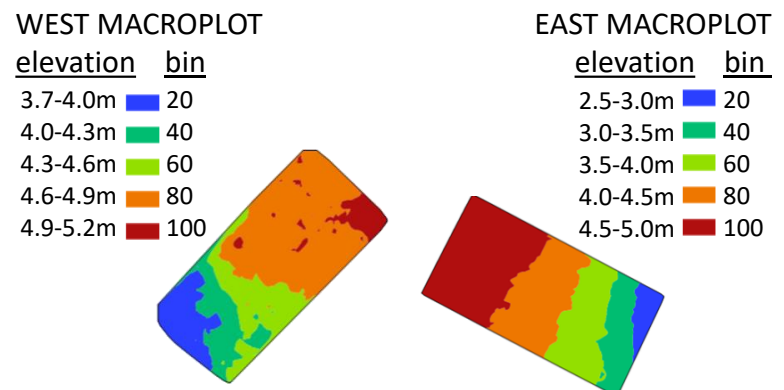
Elevation gradients in macroplots

The elevation gradients in each macroplot basically followed the orientation of the plots. The upper extent of both macroplots are located on a (relatively) high elevation, broad ridge of MLO forest. They both sloped downhill, away from the middle of the study area. In Figure 5, elevations in both plots are shown using the same color scheme to indicate the similarity and differences in the elevation ranges. The East macroplot spanned a larger elevation gradient (a total of 2.5m, while the West macroplot spanned a gradient of 1.5m).

The two macroplots are sloping in different directions, with different hydrological conditions at the lower ends of their slope. Just below the East macroplot there is a freshwater wetland draining into Clam Creek, which becomes a brackish marsh and thus experiences some tidal influence. On the west side, there is a moist hammock at the lower extreme of the West macroplot, separated from salt marshes by a hundred meters or so. Since we do not fully understand the implications of the underlying hydrology on either side, we did not want to assume that a given elevation above sea level in one macroplot was ecologically equivalent to the same elevation in the other plot. Thus, we analyzed the distribution of trees separately of each of the two macroplots.

To analyze the distribution of live oaks and laurel oaks across the elevation gradients, each macroplot was divided into 5 elevation zones, such that each zone (or bin) spanned 20% of the total elevation change in that macroplot. Each zone in the West macroplot covered 0.3m of the total 1.5m elevation change; each zone in the East macroplot covered 0.5m of the total 2.5m elevation change (Figure 6).

Figure 6: Macroplot elevation zones and bin codes used in analyses



Distribution patterns of MATURE live oaks and laurel oaks (Figure 6)

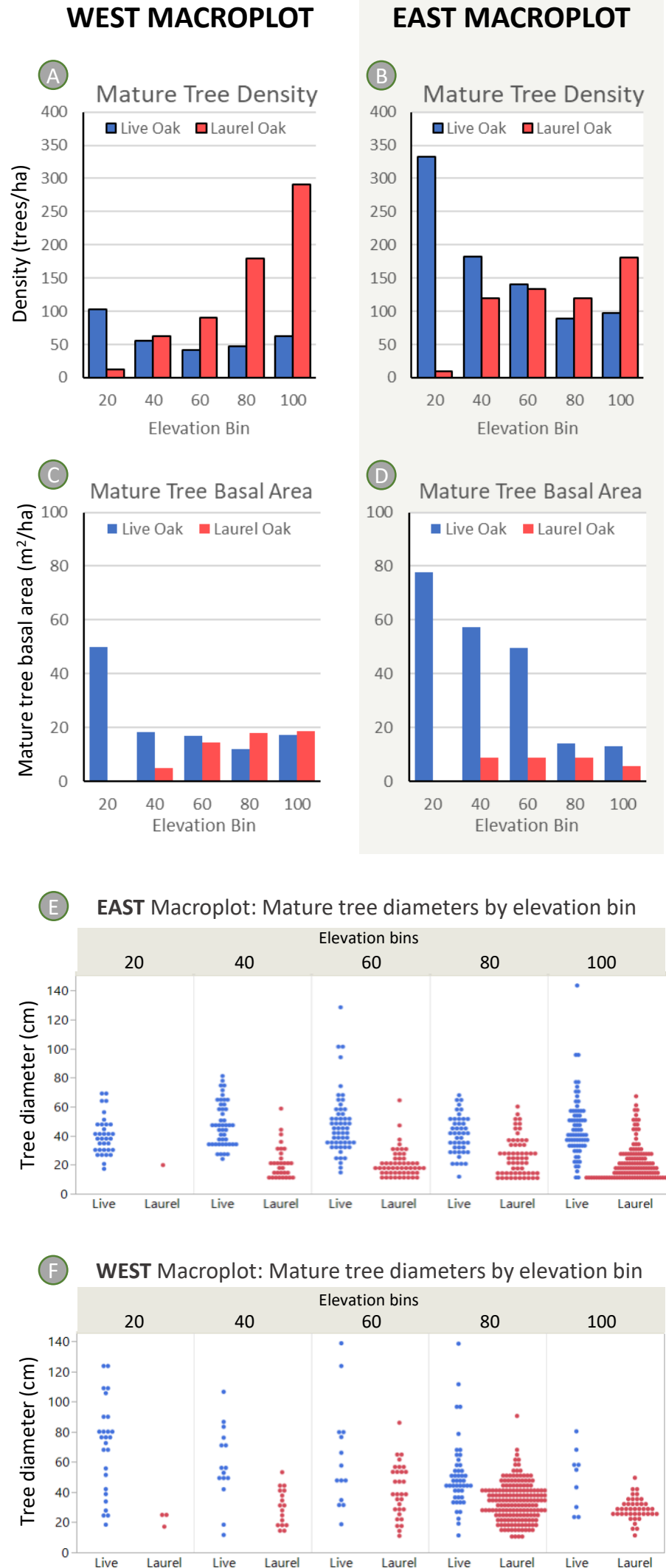
(A) (B) These graphs show mature tree density, or number of individuals per hectare. Mature live oak and laurel oak trees had different distribution patterns along the elevation gradients in each macroplot. Live oaks were more abundant at lower elevations in both plots, and their abundance decreased with elevation. Mature laurel oaks were rare at the lowest elevations in both plots, and showed different patterns of increasing density with elevation in the two plots. Based on known habitat differences between the species (see Figure 3 from Cavender-Bares et al. 2004), **the patterns are consistent with the idea that large soil moisture gradients are associated with elevation in both plots.**

(C) (D) These graphs show the basal area of each tree species. Calculated as the sum of the cross sectional areas of every tree's trunk, basal area is often used to assess the relative dominance of different species in a forest. Live oaks are clearly dominant at lowest elevations, then decrease in basal area to become co-dominant with laurel oaks at higher elevations. Comparing dominance to density (graphs A and B), laurel oaks were numerous at higher elevations, but not dominant, indicating that many of the higher-elevation laurel oaks are smaller trees.

(E) (F) These graphs show the diameter size of mature live oaks and laurel oaks that occurred in each elevation bin. Graph E is from the East macroplot, where we saw the large discrepancy between laurel oak density and basal area. At all elevations, but especially in the highest bin, most laurel oaks were indeed smaller trees. This is in clear contrast to the size distribution of mature live oaks. Smaller diameter mature live oaks are quite uncommon.

We observed that smaller diameter trees had rarely reached full canopy height, and were still quite prone to mortality when taller trees shaded them out. The pulse of smaller laurel oaks bodes well for some of them reaching the canopy one day. The lack of smaller live oaks provides a dwindling pool of candidates to replace today's large canopy trees.

Graph F is for the West macroplot. We do not see a pulse of smaller laurel oaks, and live oaks are especially uncommon. When canopy gaps open, most canopy replacement will need to recruit from smaller size classes of trees, the saplings or seedlings.



Distribution of live oak and laurel oak SAPLINGS (Figure 7)

A B These graphs are the mature tree distribution results from Figure 6 on previous page, provided again for visual comparison

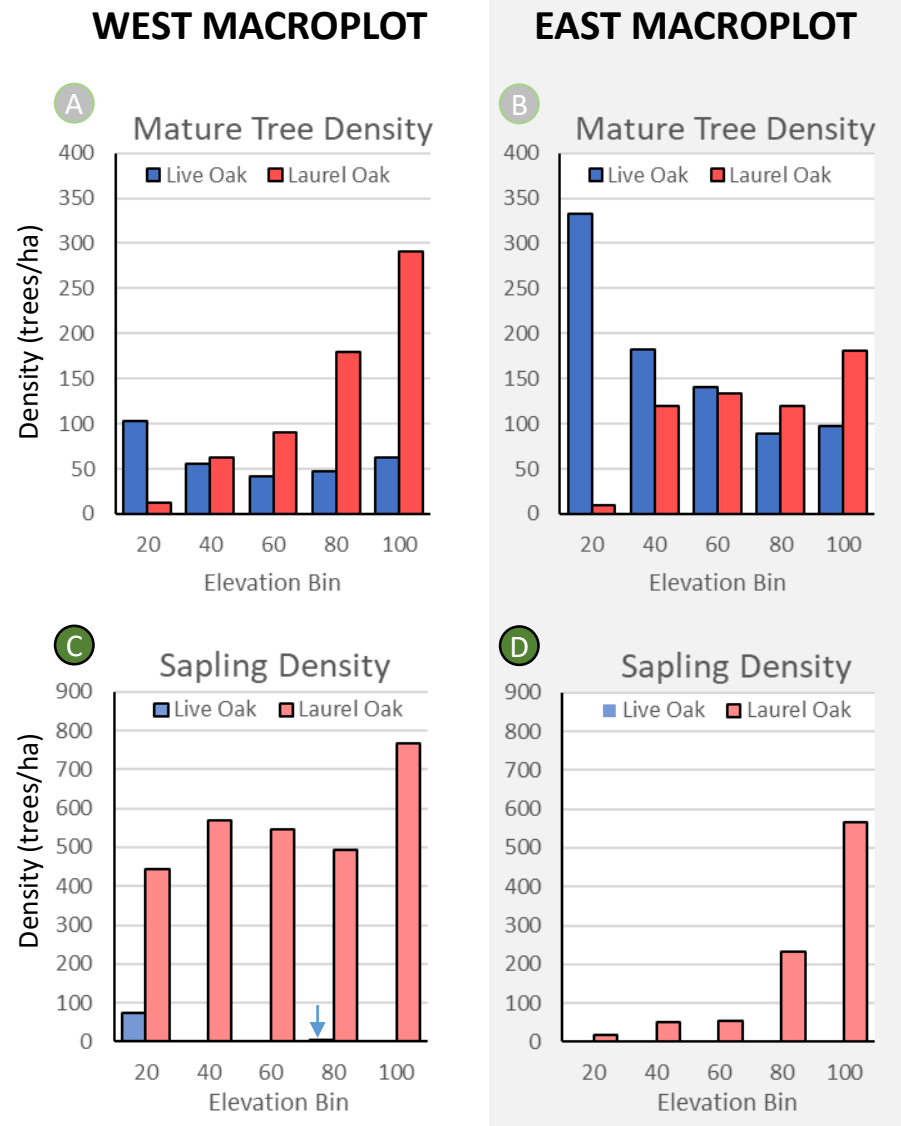
C D These graphs show the distribution of live oak and laurel oak saplings, greater than 1.2 m tall but less than 10cm diameter. The presence and abundance of saplings indicate where seedlings have experienced favorable conditions to grow out of the seedling stage.

The only live oak saplings were in the West macroplot, where we found 19 in the lowest elevation zone, and 2 in the 80% zone (indicated with arrow in C). No live oak saplings were found in the East macroplot. The overall lack of live oak saplings in the macroplots, despite numerous mature trees across the site, suggests that environmental conditions are variable or have shifted over time. **The conditions that allowed today's mature live oaks pass through the sapling stage and ascend to the canopy are currently not allowing very many live oaks to reach the sapling stage.**

The laurel oak saplings show different patterns. In the West macroplot, there were abundant saplings in all zones, even at lower elevations, where mature laurel oaks are less abundant. In the East macroplot, however, sapling density was dramatically reduced in the lower three elevation zones. We do not have a strong hypothesis to explain this spatial pattern. We did not find explanatory correlations with average canopy denseness, live oak density and basal area, or understory vegetation density. Saltwater intrusion or periodic water table rises are possible causes, yet to be explored.

Overall, the suite of observed patterns suggests that environmental conditions are now different than they were when the current mature trees ascended from saplings. Those differences could be long term trends, or of shorter term effects of droughts, storms, etc. **Point-in-time landscape studies such as this can generate likely hypotheses, but are rarely sufficient to actually test mechanisms.**

Based on this study and other sources of information, we propose that water availability is the most likely ecological mechanism generating these spatial patterns. The relationship between elevation and soil moisture conditions is well known in barrier island natural history. Also, findings from the



few available studies of these species' growth and performance, indicate that soil moisture can also affect the outcome of competition between live oaks and laurel oaks (Spector & Putz 2006, Cavender-Bares et al. 2004).

Both species, but especially live oaks, require ample sunlight to grow to reach the sapling stage. Young live oaks have the physiological potential to grow faster than laurel oaks (and most other oaks in fact), *but only with high soil moisture availability*. Competition for light gaps is paramount in forest dynamics, and these relationships are thought to give live oaks the competitive ability to dominate moister sites. In drier sites, laurel oaks may be able to grow faster and outcompete live oaks in light gaps to reach the sapling stage.

In most of the forest, there are currently no live oak saplings "in waiting" to ascend to the canopy if a gap forms. Given the lack of live oak saplings, laurel oak saplings appear poised to ascend to the canopy if a gap forms now.

If this trend persists, it may lead to longer-term shifts in forest competition to become more laurel oak dominated.

Distribution of live oak and laurel oak SEEDLINGS (Figure 8)

A B C D These graphs are the mature tree and sapling distribution results from Figure 7 on previous page, shown again for visual comparison.

E F The graphs show the proportion of 50 x 50cm subplots in each elevation zone that contained any seedlings of each species. There were 200 subplots in each macroplot, placed to ensure coverage across the extent of the macroplot

The first pattern to note is that live oak seedlings are quite rare, but at least some were found in every elevation zone except the highest in the West macroplot. We found a total of 76 live oak seedlings, 34 in the West and 42 in the East.

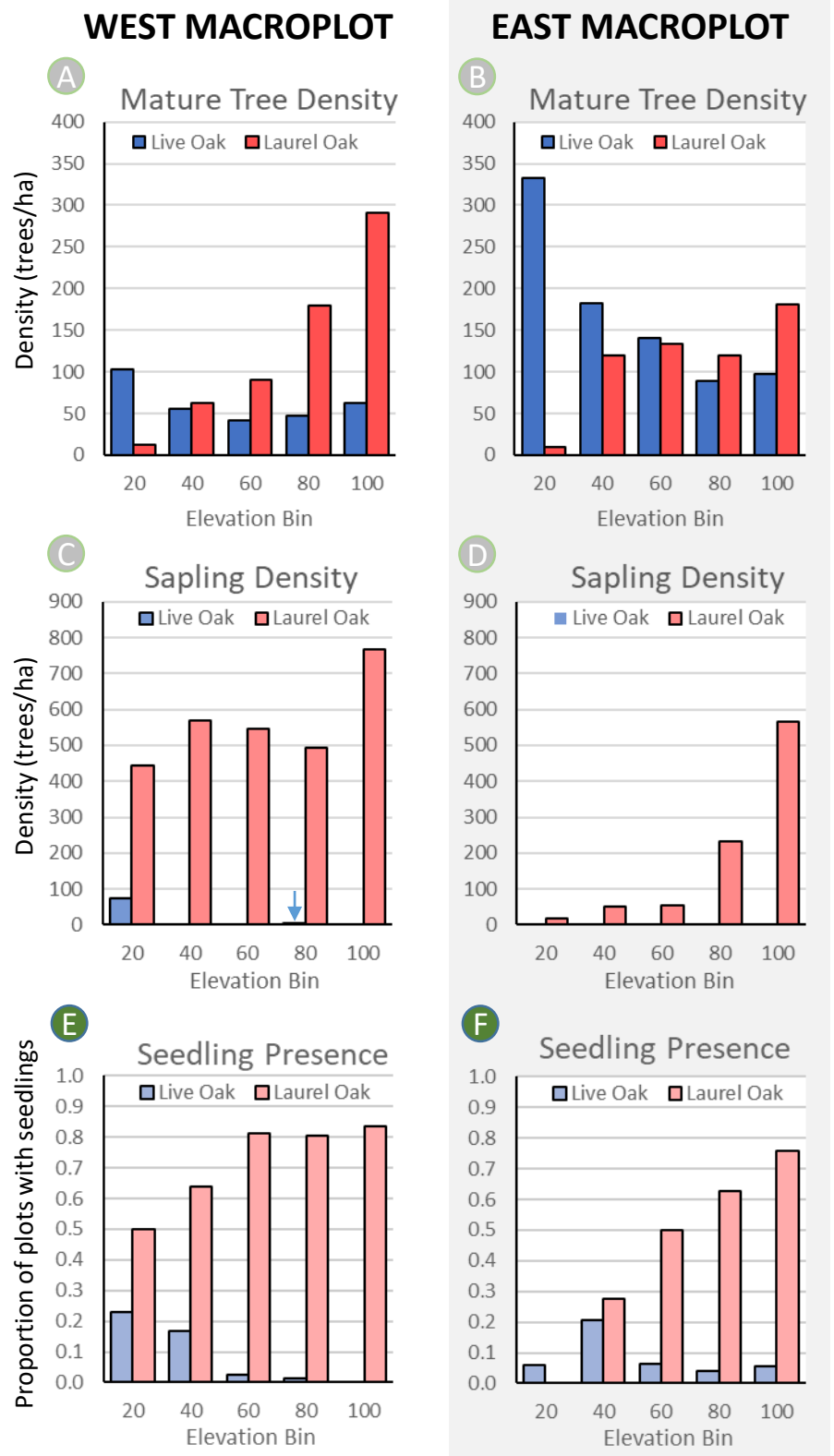
The second thing to note is that live oak seedlings tended to be more frequent in lower elevation zones, which aligns with the distribution of mature trees and with ecological expectations. There was no noticeable shift, expansion, or contraction in seedling distribution across elevations relative to adults.

Laurel oak seedlings were much more common in general, and especially with increasing elevation. We roughly estimated numbers of seedlings in subplots; they totaled to about 1100 in the West and 600 in the East macroplot.

In the West, laurel oak seedlings and saplings tended to be more evenly distributed across elevations as compared to mature trees. But in the East, seedlings and saplings were less evenly distributed, and were more concentrated toward higher elevations. **As previously discussed for saplings, it is not clear what conditions may be particularly limiting for laurel oaks at lower elevations on the East side.**

We further investigated what factors may contribute to the local density of laurel oak seedlings. We found that local canopy density and elevation at each subplot were the most meaningful variables in explaining differences in laurel oak densities *between subplots*. But when tested at the macroplot-scale, they did not help explain patterns in laurel oak seedling abundance across .

Taken together, live oaks seedlings showed no elevational shift relative to mature trees. Laurel oak seedlings showed potential range expansion to lower elevations in the West, but possible range contraction in the East. The implications for future forest composition will depend on subsequent filtering effects on the seedlings.



A final, important note is that **almost all, and perhaps all, live oak “seedlings” were actually sprouts off the roots of mature trees, not actual seedlings that grew from acorns.** This was determined by excavating many seedlings until we found their connection to a mature tree root or trunk, and learning to recognize their root growth without fully excavating. **This is a potential game-changer for seedling success,** because these “seedlings” can draw on their maternal plant’s resources and thus do not face environmental stressors “alone.” **However, the serious scarcity of saplings would suggest that parental support is not enough to overcome environmental stressors on young live oaks to reach the sapling stage or beyond.**

Conclusions and Management Implications

Maritime Live Oak (MLO) Forest Regeneration

The next generation of mature canopy trees will arise from the suite of seedlings and saplings that are growing wherever light gaps are created by falling trees.

Ultimately, we wish to know if the young trees we see today – given the environmental stressors they face – can sustain the forest’s live oak populations.

But so little is known about the environmental conditions and ecological interactions that affect regeneration rates, it is not yet possible to make such predictions.

This study is a preliminary step toward building our understanding. **We use observations of landscape patterns to identify plausible hypotheses about regeneration. This study does not test those hypotheses.** Its findings cannot tell us what processes are, or are not, actually happening. That will require future, targeted research. Instead, the findings can help:

- **document existing patterns in forest composition,**
- **identify hypotheses that could explain such patterns,**
- **motivate future research to test hypotheses,** and
- **recommend starting points and considerations for adaptive management.**

Elevation, Soil Moisture, and Regeneration

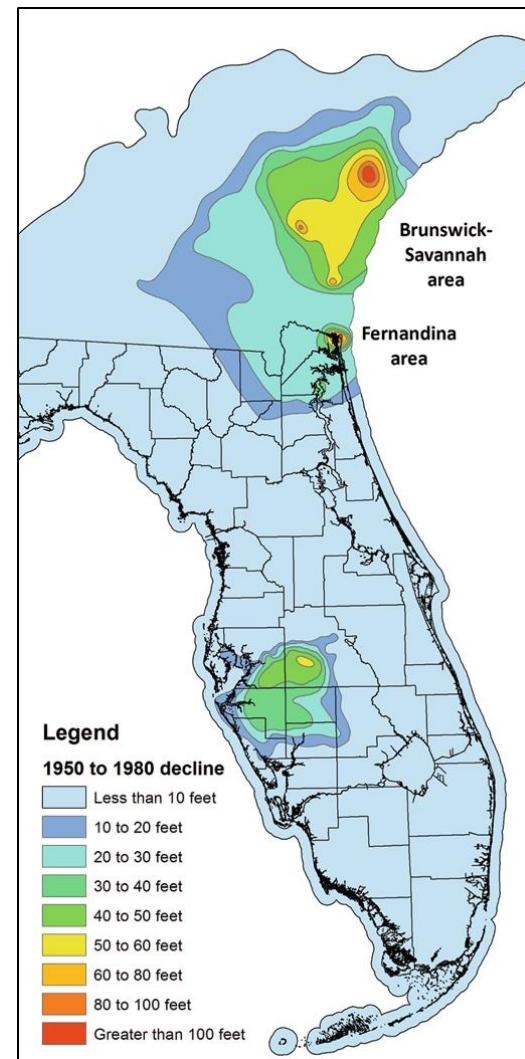
We assessed the distribution of young live oak and laurel oak trees, in relation to mature trees and elevation gradients. We interpret the observed in light of ecological principles and other data sources to infer plausible mechanisms at work.

Within the study forest, elevation had a significant impact on the distribution of mature live oaks and laurel oaks. **Live oaks dominate lower elevations, and the two species are co-dominant at higher elevations.**

Based on oak ecology and barrier island natural history, **this pattern is likely due to responses to soil moisture differences along the elevational gradient.** The two species have contrasting abilities to compete under high and low soil moisture availability. With enough light, live oaks can grow very fast and outcompete laurel oaks at lower, wetter sites. Laurel oaks have a competitive advantage at drier sites.

Over the lifetime of Jekyll Island’s grand live oaks, the island has seen declines in surface and deeper aquifers (e.g., Figure 9). The surficial water table is strongly affected by rainfall and extraction, and fluctuates near cusp of falling below sea level (Gordon & Torak 2016).

Figure 9: Changes to groundwater level in the Upper Floridan Aquifer, which underlies Georgia’s barrier islands (image from Upchurch et al. 2019)



These conditions may affect soil moisture availability in MLO forests, and make it harder for the next generation live oaks to recruit in the higher elevation zones where mature live oaks are found today

However, we found that **live oak seedling distributions did not show a clear downslope range shift** as compared to mature live oak abundance distributions. But with so few seedlings, and even fewer reaching the sapling stage, **we cannot conclude that the few existing live oak seedlings at higher elevations will actually be able to compete, grow, and reach the canopy.** **Longer term studies that track the fate of seedlings and saplings are needed to understand how, and at what stage, water availability acts as a filter on tree regeneration.**

Laurel oak seedlings and saplings appear to have expanded their abundance at lower elevations, but only on the West side of the study area. The success of laurel oaks at lower, moister sites is thought to be limited by the competitive environment created by dominant live oaks. But since young live oaks were very rare in both macroplots, **competition with young live oaks seems implausible as an explanation of the East vs. West difference. Competition with mature trees, or differences in some other environmental variable may be more likely. The East vs. West differences in young laurel oak abundance pose a potentially very informative context for ongoing research.** If future research can identify what is different between the sites, we can then begin to understand factors that limit laurel oaks from expanding into areas that are currently heavily dominated by live oaks.

Notable issues and knowledge gaps

What about herbivory?

Deer, rabbits, and squirrels are known to consume young live oaks, and are thought to prefer live oaks to laurel oaks. This study did not assess herbivore abundance or damage to plants, so **the findings have not motivated specific hypotheses about their role in generating spatial patterns of forest regeneration.**

However, all of the hypotheses that have been suggested by this study focus on success rates of young trees, which herbivory can certainly affect. **Future research should include treatments that monitor or manipulate herbivory whenever possible.** This is needed to build our understanding of when herbivory matters, and how it can change the effects of other stressors.

One avenue for strengthening adaptive management would be to **coordinate forest tree research with other wildlife research on the island**, to maximize the knowledge gained about how herbivores affect outcomes for vegetation, and also to understand how vegetation affects wildlife ecology and outcomes.

Water availability and plant stress

Elevation is a useful, but indirect proxy for soil moisture or water availability for plants, but there are many confounding factors. Having measures that directly correlate to plant water stress is critical. **Further research on hypotheses regarding forest regeneration will benefit from more direct measurements of hydrological conditions.** Measuring soil moisture as it varies across both space and time is often costly, though.

For vegetation ecology research, one of the most informative data products is a spatial map of average soil moisture conditions. We are collaborating with Dr. Trenton Franz, a hydro-geophysicist at the University of Nebraska – Lincoln, to generate a spatial map of integrated soil moisture using electromagnetic induction (EMI) surveys. With the surveys now completed, we are still conducting additional soil testing to calibrate and validate the maps. **Once generated, this map can be used in management. For instance, in restoration planning, it can be used to target plantings in sites that are most conducive to success.**



Figure 11: Dessa Dunn carrying the EMI instrument to map soil electrical conductivity, which is used to calculate an indicator of plant available soil moisture.

Saltwater intrusion

We do not know the salinity of surficial groundwater at the study site, or whether it has increased in recent decades or years due to saltwater intrusion. **We recommend initiating proactive research to investigate salinity in MLO forest groundwater now**, for two reasons. First, with early detection, it may still be possible to mitigate its effects. Second, with sea level rise, the risk and likelihood of saltwater intrusion also rise. It will almost certainly become a widespread concern for MLO forests all along the Georgia coast. Beginning studies now can provide strategies for effectiveness stewardship. **JIA's capacity for coupling research and adaptive management, plus the public value for Jekyll's live oak forests, makes it an ideal site for such work.**

Live oak “seedlings” aren’t really seedlings

One important observation made was that **almost all, if not all, of the live oak seedlings found in this study were growing as root sprouts from mature trees, not as seedlings from acorns.** This changes our entire understanding of competition, tree distributions, and regeneration cycles. These vegetative sprouts are not reliant on a seedling’s modest root to acquire water and nutrients, but may benefit from the parental tree’s vast root system. They may even receive carbon for fuel and growth from their parental tree, rather than having to acquire it themselves from carbon dioxide and sunlight (through photosynthesis). **If so, live oak root sprouts may be quite resilient to abiotic stress such as drought and low light levels.**

Studies of acorn-grown seedlings of many species show that juvenile trees may die back to the ground multiple times and survive. Indeed, oak “seedlings” in temperate forests can actually be decades old. If root sprouts can draw on parental tree resources to regrow after defoliation, they may be able to withstand even higher levels of herbivory. Alternatively, if root sprouts do not invest energy storage in their own root, they may be less resilient than an acorn-grown seedling. **We know of no studies that have compared the ability of acorn-derived seedlings versus root sprouts to tolerate herbivory. Understanding how much herbivory a “seedling” can withstand, under what environmental conditions, is an important consideration when developing management strategies.**



Figure 12: Left: a planted, 2 year old acorn-grown seedling that has been browsed by deer. The next month, it lost its remaining leaf area during a drought. However, it grew back from its base with new leaves within months. Right: a naturally occurring “seedling” on St. Catherine’s Island, which could be a root sprout or acorn-grown. It is about 12 cm tall, with a thick, woody stem. This seedling is likely more than 10 years old.



The Precautionary Principle and Forest Restoration

In the field of conservation biology, the “Precautionary Principle” acknowledges that we often lack the detailed ecological knowledge necessary to know just how endangered a species or an ecosystem may be, or exactly what it would take to ensure its persistence. But if we wait until enough knowledge is available, it may be too late, or much more expensive, to take appropriate action.

Jekyll’s Maritime Live Oak forests present just such a scenario. Surprisingly little previous work has been conducted on the forest ecology of these systems. Forest dynamics are extremely difficult to study in short-term research projects. JIA’s four-year support of this study shows forward-thinking commitment to evidence-based management. Yet our findings are still quite provisional and partial. We do not want to claim that our research has provided more certain findings than it actually has.

In the face of uncertain ecological dynamics and uncertain future environmental conditions, Precautionary Principle management coupled with adaptive management are considered best practices for the objectives of reducing risks and sustainably conserving biodiversity. Adaptive management uses the best existing knowledge to set management strategies, but also conducts research so that the outcomes can be continuously updated. The JIA Conservation Program is well-positioned to implement this approach in MLO forest management, and we have endeavored to provide some fruitful avenues to address in doing so.

Acknowledgements: We are indebted to Ruth Cumberland, Project Coordinator, who performed all of the tree mapping, seedling surveys, and canopy photography. Clint Moore provided technical consultation and project planning support. We gratefully acknowledge the assistance of the JIA Conservation staff, including Ben Carswell, Joseph Colbert, and Yank Moore. We also thank the numerous volunteers from University of Georgia, AmeriCorps, and other surrounding communities for their time, effort, and help.

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