USING A CONTROLLED ENVIRONMENT TO TEST PORCELAIN BERRY (AMPELOPSIS BREVIPEDUNCULATE) SHADE TOLERANCE IN COMPARISON TO LIGHT LEVELS IN A NATURAL HABITAT

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ABSTRACT

The anthropogenic introduction of invasive species has posed an ecological threat to the native ecosystems of the eastern United States. Understanding the properties of these species is an important part of trying to maintain them. Ampelopsis brevipedunculata (porcelain berry) is a plant from eastern Asia and has become a more common invasive in eastern North America. This species may pose a threat to stands of young forests, replacing the biome with a secondary successional ecosystem which is mostly composed of Ampelopsis. This plant does well in many parts of forests and our experiment tested one property: light exposure. By figuring out a limiting factor of porcelain berry an effective removal strategy can be better determined. We exposed samples from the Purchase College campus woods to three different light settings. We found that porcelain berry continues to grow in the three light settings we tested, but high and medium did not differ as much as expected considering the large difference in the levels. Porcelain berry shows adaptive abilities and should be further studied and contained.

Keywords. Invasive, Growth rate, Limiting Factors, Light

INTRODUCTION

Human activities are altering habitats on a global level. The warming of the earth is moving species to areas they were never capable of colonizing because harsh winters wouldn't permit their growth (Walther et al. 2009). Changes in temperature can harm native species because they are adapted to lower temperatures and invasive species use elevated temperatures to their advantage when competing with native plants by increasing their chlorophyll contents (Song 2017). Milder winters now allow ornamental species that would die under cold conditions to survive through the winter (Walther et al. 2009). Many invasive species do better in non-ancestral regions because the new habitat may have variant qualities compared to its native niche such as more pollinators that allow them to create more flowers and spread faster (Petanidou et al. 2018).

The eastern United States has a history of agriculture which altered the original landscape (Robertson et al. 1994). Post-agricultural land that consists of new forests tend to have more invasive species which alter the herbaceous and woody ratios, and natives become more sporadic due to their inability to compete against non-natives (Kuebbing et al. 2014). In these sites, diversity, soil pH, carbon and nitrogen content, and soil makeup are different compared to undisturbed areas (J.L Dupouey et al.

2002). One example of an invasive that benefits from post-agricultural forest characteristics is porcelain berry (*Ampelopsis brevipedunculata)*.

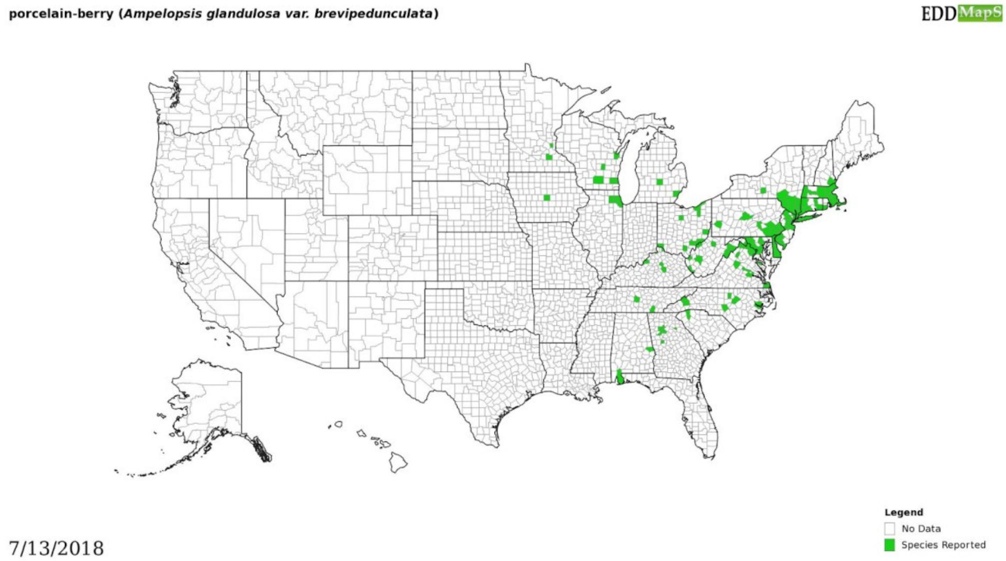

Image 1. Porcelain berry distribution in the United States (Center for Invasive Species and Ecosystem Health).

This invasive has become more prevalent in the eastern part of the United States (Image 1). *A. brevipedunculata* is a climbing vine native to Eastern Asia that was brought to America for its pastel colors and ability to curtain a landscape (Waggy 2009). As urbanization increases more edge habitats exist from roads and like many invaders porcelain berry benefits from increased sunlight. Porcelain berry has a shade-tolerance that allows for the plant to expand its distribution. Its abilities to grow in versatile habitats result in out-competing natives like Virginia creeper (Emerine et al. 2013).

The purpose of this study is to test porcelain berry under different light conditions. This invader is common in Purchase College's young woods. We wanted to understand which parts of the woods the plant has a higher growth rate in. Porcelain berries abilities to survive in shade and along the edges is an increasing problem and its decreasing biodiversity (Emerine et al. 2013). Since these plants are both present in low and high light areas there is a need for understanding where it does better. Exposing porcelain berries to a different level of light will show whether or not this is a limiting factor in its growth rate. This data can then be used in a removal strategy where a weakness is targeted and to either focus on shaded areas or edge habitats. We predict that the leaf and stem growth rate will be higher at stronger light exposure and slowest at low light exposure.

METHODS

To conduct this experiment, on 10/18/2018 we started off by collecting our 12 samples of young porcelain berries and placed them into our 18x15 plastic pots. Our collection site was located in the woodlot behind the science building at Purchase College Campus (Figure 1). We used hand shovels to carefully dig up our porcelain berries and placed each individually into our pots filled with ¾ of soil. We placed a piece of tape on each pot and labeled them accordingly; low 1, 2, 3, 4, medium 1, 2, 3, 4 and high 1, 2, 3 and 4. To obtain porcelain berry natural habitat light levels, we measured light intensities every 2m for 10m along a transect tape in the woods under a hardwood canopy located next to alumni village at Purchase College Campus (Figure 1). We started our measurements at a patch of porcelain berry that had invaded the understory and went from there, 10m out, using a transect tape and PAR (Photosynthetically Active Radiation) meter, which measures in micro-mole per meter squared per second (μmol/s-m2), for the light intensities (Table 1). We followed up by placing our pots into an incubator, in which we had a total of 4 pots for each 3 different light exposures; 4 pots were under high, 4 pots were under medium and 4 pots were under low light levels. Multiple pots were assigned to each light level to account for human error. The 3 different light exposures spanned on the observed light intensities measured along the transect tape. Our high exposure corresponded to 86.7 μmol/s-m2, our medium exposure corresponded to 15.1 μmol/s-m2 and our low exposure corresponded to 2.4 μmol/s-m2. Lastly, our porcelain berries were under the constant temperature of 26.7° Celsius and were watered every 2 days with 100 ml of water. We collected data every 5 days over the two weeks with the exception of our last data set which was taken on the 4th day (October 18, 23, 28 and November 1st 2018).

Additionally, to study the effect of the abiotic factor light on our invasive porcelain berry we measured the length (in centimeters) of the stem on every porcelain berry using a ruler. We also chose a leaf on each porcelain berry to measure their growth over the 2 weeks. To do so, we placed each leaf against a ruler, serving as the scale, and took a picture which was later analyzed using ImageJ. ImageJ is an image processing program that allowed us to measure the length (in centimeters) of each leaf. Each set of 4 porcelain berries were statistically recorded by how much stem and leaf growth occurred between each collection date throughout the 2 weeks. This data was analyzed into figures and tables which would then be compared to each other to display differences and/or possible similarities between growth under each controlled light level and furthermore to its natural habitat light levels.

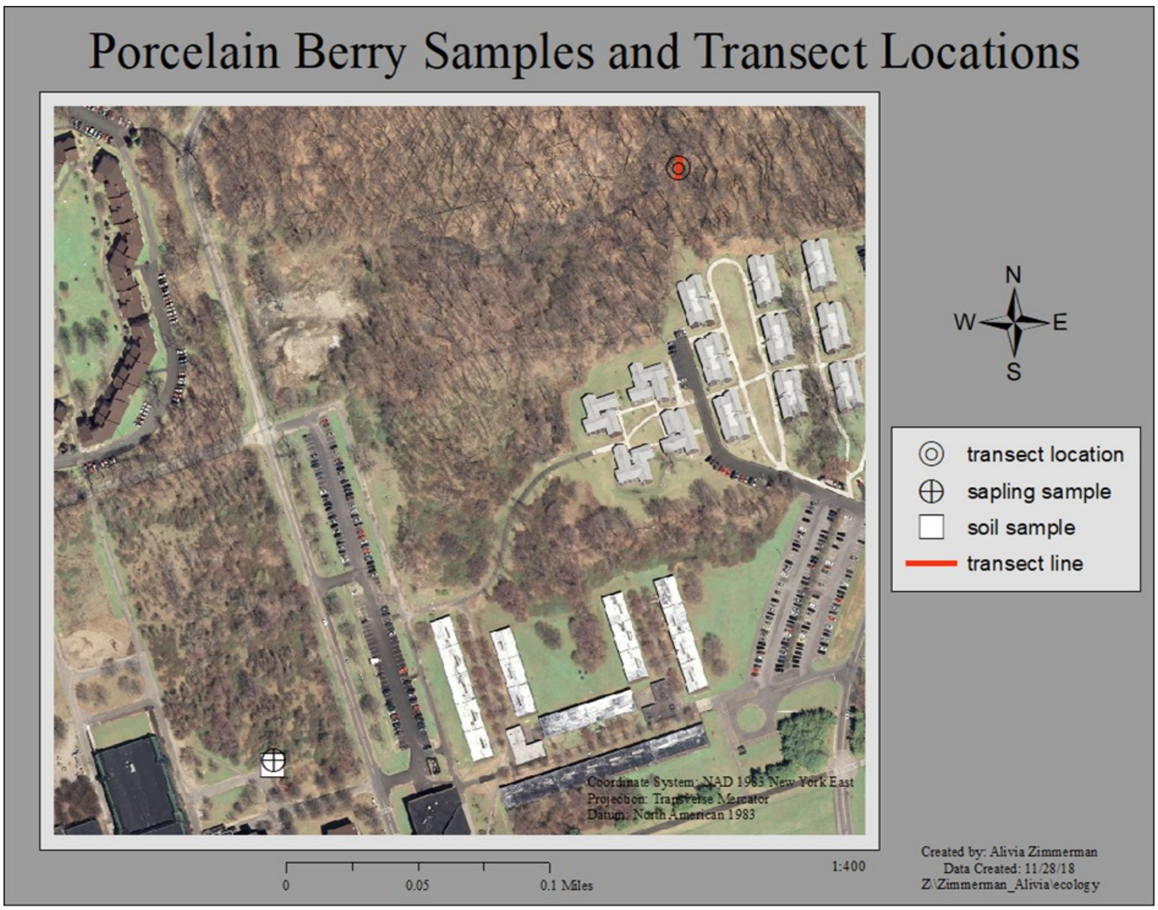

Figure 1. Transect, sapling and soil sample locations at Purchase College Campus

RESULTS

Transect Tape. Throughout the 10m along the transect tape the light intensities fluctuated every 2m (Table 1).

Table 1. PAR meter measurements, µmol/s-m2, in relation to distance from porcelain berry.

Distance From Porcelain Berry (meters)	µmol/s-m^2 Observed
10m	19.15
8m	41.38
6m	21.62
4m	17.23
2m	34.88
0m	40.3

Stem Growth. All stem lengths had different starting points, however all increased under the different light exposures throughout days 0-14 (Figure 2). Stem growth averages increased through each light level and differed more between low and high exposures (Figure 3). Medium exposure shows only 3 datasets because medium 3 died prior to day 10, therefore its measurements were excluded from both figures.

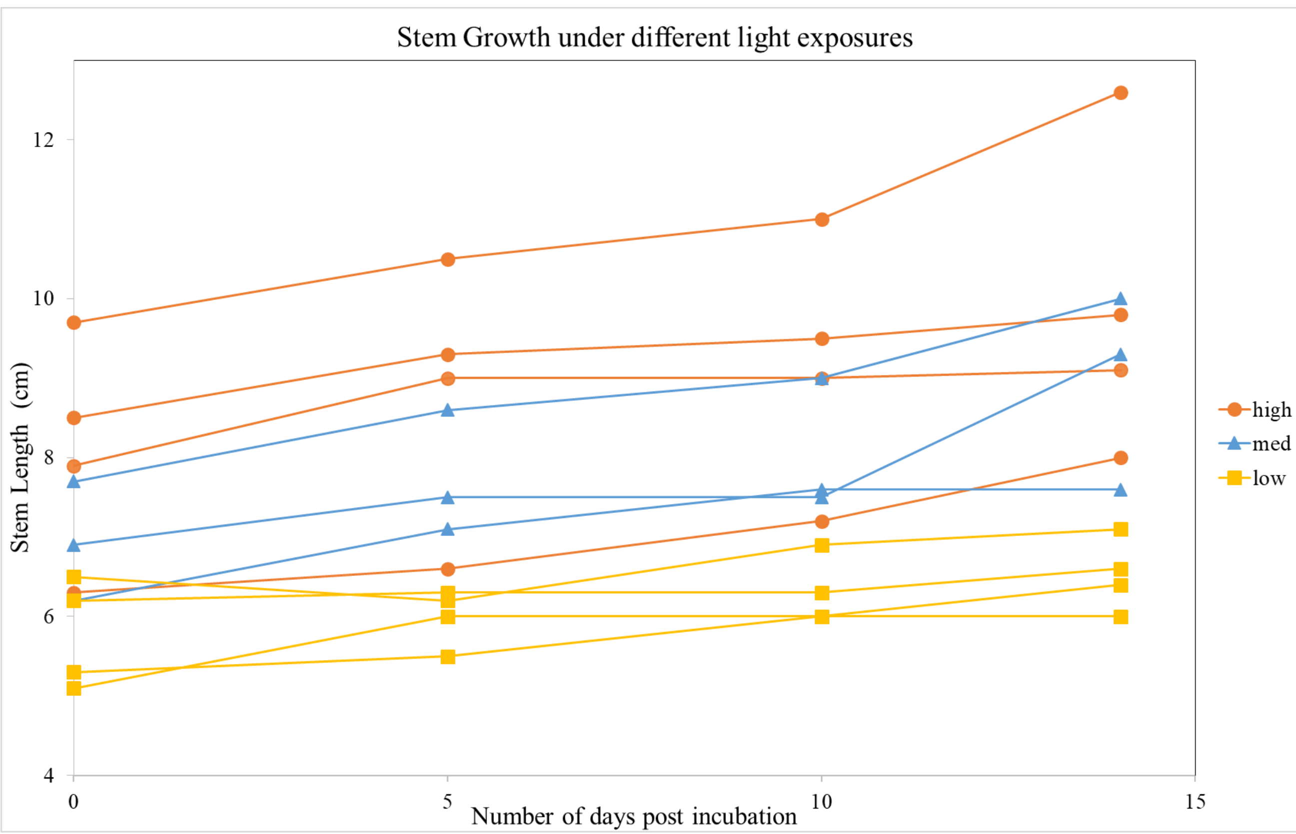

Figure 2. Stem lengths (cm) under high, medium (exclusion of medium 3) and low light exposures throughout days 0 to 14.

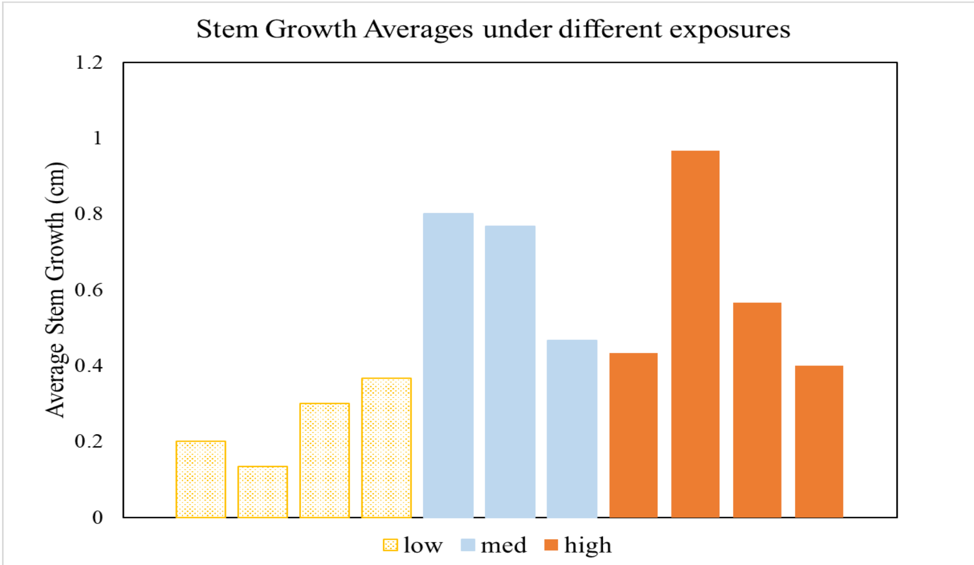

Figure 3. Stem growth averages for each porcelain berry under high, medium (exclusion of medium 3) and low light exposures. Standard deviation for stem growth averages varied from 0.2 to 0.9.

Leaf Growth. Overall leaf growth displayed the same relationship as stem growth; leaf lengths had different starting points and increased throughout days 0-14 (Figure 4). Leaf growth averages differed more between medium and low/high exposures. Additionally, medium exposure measurements were excluded from both figures 4 and 5 due to the same reason stated for its exclusion from stem growth and averages.

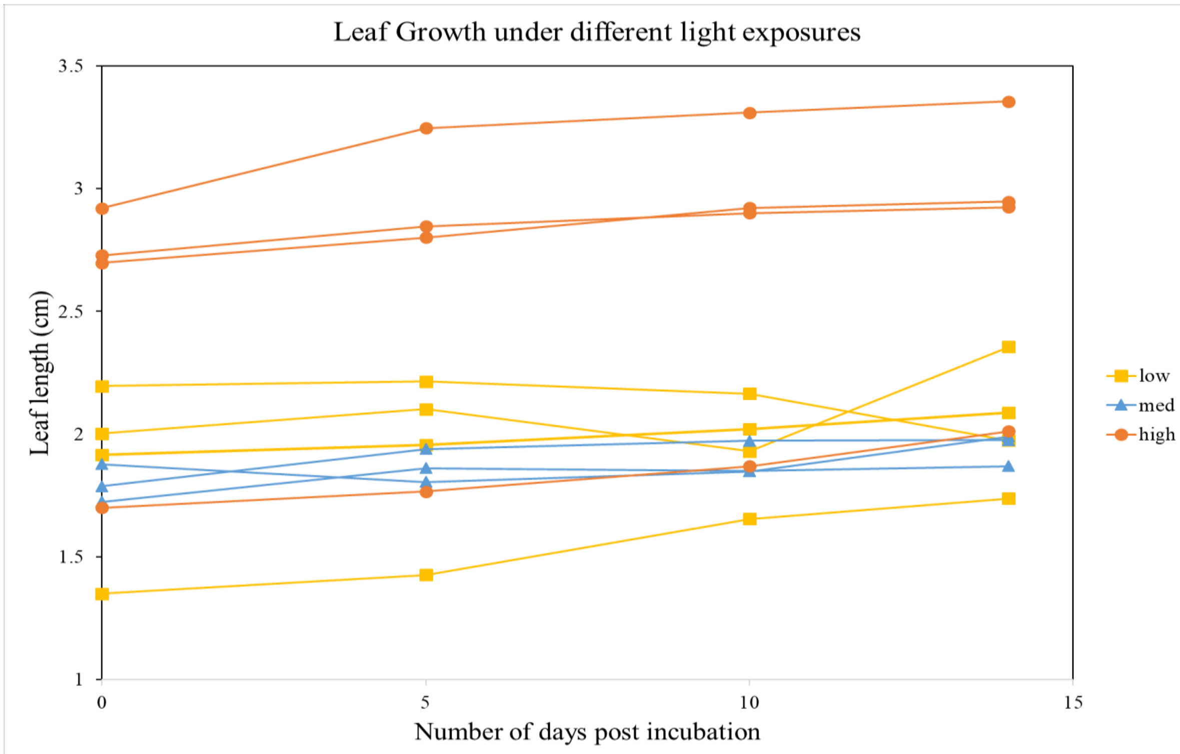

Figure 4. Leaf lengths (cm) under high, medium (exclusion on medium 3) and low light exposures throughout days 0 to 14.

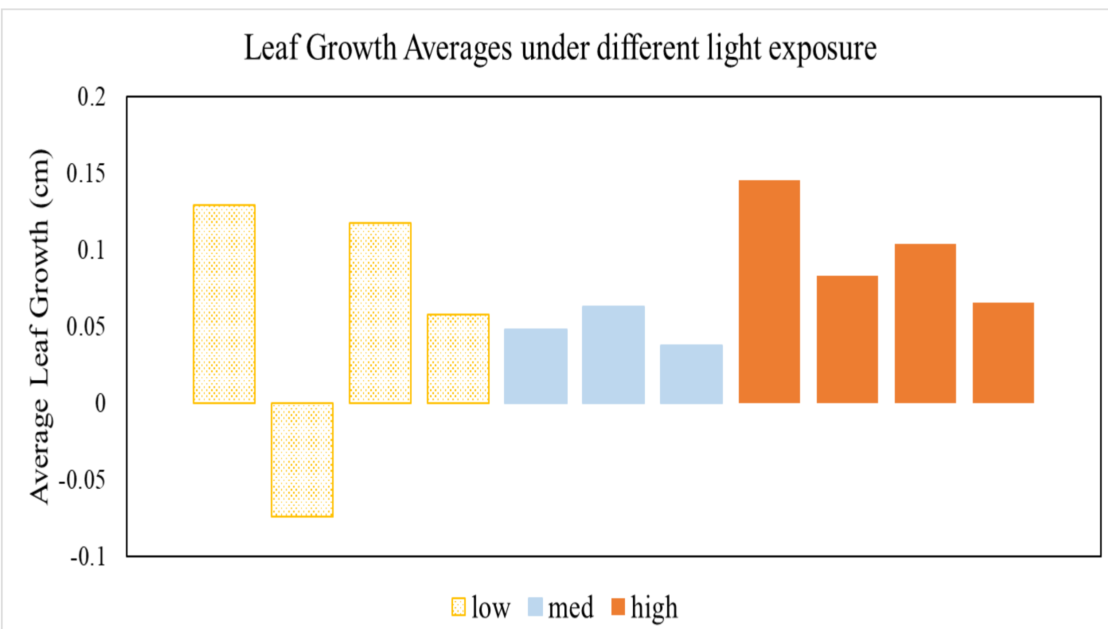

Figure 5. Leaf growth averages under low, medium and high light exposures; with the exclusion of medium 3. Standard deviation for leaf growth averages varied from 0.01 to 0.30.

DISCUSSION

Our results show a consistent rate of growth for saplings subjected to all three differing light levels. In our hypothesis, we expected saplings exposed to low levels of light to exhibit no growth over time or potentially to die during the course of the experiment. Instead, the specimens exhibited a consistent average rate of growth which only differed about three centimeters from the average growth rate of specimens subjected to high light levels.

On average, stem growth rose at a faster rate than leaf length. Light intensity appeared to have a stronger effect on average stem growth differences than average leaf length differences.
On days 10 and 14, we did not record data on the leaf length or stem growth of 'Medium 3' due to its apparent senescence. We extrapolated the death of this specimen due to frayed leaves which quickly fell off when touched. However, on day 14 new sprouts were observed extending out of the stem. Despite the fact that the specimen had continued to live, we were not able to gather leaf length data from the specimen. While we cannot state an exact reason as to why Medium 3 exhibited such dramatic changes, it is within reason to assume that a transplanting error caused significant health problems for the specimen. As demonstrated in all figures, specimens subjected to a medium light intensity show a much steadier rate of growth when 'Medium 3' is removed from the model.

When analyzed individually, consistency in growth rate varied depending on specimen and light intensity. While the leaf and stem length of most saplings ended up higher than at the start of the experiment, some specimens displayed negative rates of growth at different points in the experiment. One of these instances (low 3 in ImageJ) can be attributed to human error. On day 10, a different leaf was measured than the leaf which had been sampled on day 1 and day 5. Despite this mistake, the average growth in leaf length of saplings exposed to low light intensity rose consistently.

Comparison to Natural Light Levels. Saplings exposed to medium light intensity were subjected to 15.1 µmol/s-m^2. This level of light was significantly closer to the "low" light intensity than it was to the "high" light intensity. In our transect, the average µmol/s-m^2 recorded was 29.08 µmol/s-m^2. This level is almost twice the µmol/s-m^2 saplings in the 'medium' category were exposed to in our experiment. This data presents the possibility that porcelain berry plants in the wild may grow at a faster rate than the samples exposed to 'medium' µmol/s-m^2 levels in our experiment. Other research suggest that the light levels which had recorded in the field and in the lab were considerably lower than potential areas of open canopy in different seasons, areas, and times of day. Field studies of light levels in other projects which have measured shade tolerance have tested the effects of light levels up to 1500 µmol/s-m^2 (Dlugos et al. 2015, Kuehne et al. 2014).

Limits of Experimental Setup and Suggestions Going Forward. Conducting an experiment on transplanted saplings requires a high sample size in order to achieve significant results. The need for adequate sample size limited the range of abiotic conditions we could test on our saplings. With a larger amount of samples, it would be useful to test other limiting factors on transplanted saplings such as moisture or temperature.

It is also important to note limitations caused by using a controlled environment to conduct experiments on *A. brevipedunculata*. Comparison between transplanted lab samples and non-transplanted wild specimens may be useful to determine the effects transplantation may have on growth rate. When replicating this experiment more time for recovery should be allotted allowing the plant to recuperate after transplant (Coughlan et al. 2018). Our plants may have experienced a period of time where growth was stunted due to the shock of changed environments.

Other invasive shrubs local to southern New York have had their shade tolerance tested in more extensive, longer term studies. A project examining the shade tolerance of *Rosa multiflora* included an experimental indoor component as well as an outdoor component which observed the invasives in forest and forest edge habitats. This project, which was undertaken from spring until the end of fall in 2013, was able to consider additional variables such as fertility (fecundity) of the plants in a variety of shade environments. Although their sample size and range of light treatments was considerably larger than ours, indoor lab results showed a greater difference in growth rate between different levels of light than was showed with our *A. brevipedunculata* samples. In the field, fecundity of *R. multiflora* specimens was found to increase in areas with higher light. The differences in fecundity depended on light level to a greater degree than *R. multiflora* leaf area ratio, which did not show considerable differences in their results (Dlugos et al. 2015). This demonstrates that the leaf and stem measurements we took in our experiment could show a smaller connection between light and species success than a field study might, or than another variable may demonstrate (such as fecundity). Furthermore, comparing *A. brevipedunculata* shade tolerance to *R. multiflora* shade tolerance may be useful in the future. If *A. brevipedunculata* shows a greater level of shade tolerance than *R. multiflora*, that information can be used in consideration for management priorities.

The effects of light on *A. brevipedunculata* could also be also compared to saplings of a similar native species, such as *Parthenocissus quinqhefola* (Virginia creeper) and even other nonnative species in the *Ampelopsis* family such as *Cayratia japonica* (bushkiller) (Emerine et al. 2013). Comparison between porcelain berry and Virginia creeper may show how competitive the porcelain berry is to Virginia creeper. Emerine et al. found that porcelain berry had less effect on Virginia creeper than bushkiller. When porcelain berry was grown in competition with Virginia creeper it grew more buds, but both had a similar growth rate. They concluded that when these plants were grown together there could be an increased growth rate since they are competing with each other. These plants grow alongside each other in the woods and compete with each other for light and other resources; including them in an experiment could result in more realistic results.

Other studies have focused on invasives species in their original range to examine whether shade tolerance is the limiting factor that controls the dominance of the organism in their natural habitat. Some researchers have predicted that shade and light conditions could lead to genetic differences in abilities to tolerate low-light environments (Dewalt et al. 2013). Others have suggested that certain species are born in forests amongst other plant species which provide darker canopies. (Kuehne et al. 2014) *A. brevipedunculata* should be further examined in its native range to better understand the natural conditions which regulate the spread of the organism.

Despite the scale of our experiment, data from projects such as ours could eventually be compiled in order to make a model projecting areas which may have a high risk of *A. brevipedunculata* invasion. A model may also be able to give a projection of the speed which *Ampelopsis* could overtake a given area of land depending on different ecological features such as the presence or lack of a canopy. Although conventional wisdom may dictate shaded areas to be 'lower risk' of invasion than open fields, our results suggest that shade my not by a significant factor in the limitation of the spread of *A. brevipedunculata.*

CONCLUSION

Although significantly limiting light levels in a lab incubator did slow the growth of transplanted porcelain berry saplings, all but one of the specimens continued to grow throughout the experiment. It is possible that in a natural habitat, even under the shade of a canopy, much more light would be available to wild porcelain berry species than in our experiment. As porcelain berry rapidly increases its geographical range in the United States, there is much work to be done within the field of invasion science to better understand the speed in which it can spread through different biomes and ecosystems. A larger sample size and the addition of other abiotic factors may be useful to other researchers who would like to better understand the limiting factors of Ampelopsis.

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