University of Zurich[UZH]

Assessing Coralita (Antigonon Leptopus) Dynamics on St. Eustatius: Spatio-Temporal Spread and Efficacy of Successive Removal Strategies

ESS 510 Master's Thesis

Author
Zoelle Kwan Ying Ying
21-738-729

Supervised by
Dr. Maarten Eppinga

Faculty representative
Prof. Dr. Maria J. Santos

29.07.2024
Department of Geography, University of Zurich

Acknowledgements

Throughout the writing of this thesis, a number of people have stood by me to provide me with guidance and support, making the completion of this thesis possible.

I want to express my deepest appreciation and gratitude to my supervisor, Dr Maarten Eppinga, for guiding and joining me to set up the fieldwork in St. Eustatius. You truly provided me with an eye-opening and exciting experience for which I am greatly thankful. Your expertise in this topic was something I truly respected. You also provided me with a clear understanding of the direction of this research topic and was ready to clarify any doubts I had along the way, as well as provide stimulating discussions to sharpen my thinking, bringing my work to a higher level and helping me through this journey.

I am also sincerely grateful to Professor Maria J. Santos, who helped financed this project to make it possible.

I would also like to express my gratitude to STENAPA, the national parks organisation of St. Eustatius, for allowing us to conduct the fieldwork and experiments on the island.

Most importantly, none of this could have happened without my family and friends. I would like to thank everyone for their unceasing encouragement and support, as well as happy distractions to rest my mind throughout the course of my study.

I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture.

Declaration

The author declares that except for commonly understood ideas and concepts, or where specific reference is made to the work of other authors, the contents of this report are original and include only the outcome of work done solely by the author.

This thesis has not been previously submitted, in part or in whole, to any other University or Institution for any degree, diploma, or other qualification. This thesis contains approximately 17800 words, 25 tables, 69 figures, and 68 references.

Zoelle Kwan Ying Ying

Abstract

The rapid spread of the invasive vine Coralita (*Antigonon leptopus*) on the Caribbean island of St. Eustatius poses significant risks to the local biodiversity. This study builds upon previous research, including Haber et al. (2021) and Eppinga et al. (2020), by updating Coralita's spatial distribution using Sentinel-2 imagery instead of Worldview-2 and evaluating the effectiveness of repeated above-ground removal as a management strategy for controlling Coralita population. Field surveys conducted from March to May 2023, along with Sentinel-2 imagery and 166 Coralita and 259 non-Coralita ground-truthing points, were used in Support Vector Machines (SVMs) to estimate Coralita distribution. Comparison between Worldview-2 and Sentinel-2 imagery from 2015 demonstrated Sentinel-2's suitability for monitoring changes in Coralita cover over time. Results also indicate a 7% increase in Coralita coverage since 2015, emphasizing its growing threat to biodiversity and ecosystem health. Concurrently, fieldwork evaluated the impact of repeated removal sessions over a 9-week period, with 30 plots measuring 4 m^2 selected for removal every 3 weeks. Qualitative and quantitative methods involved observation of images captured during the removal process and the measurement of various determinants of plant vitality and development, such as stomatal conductance, leaf size, and biomass. Both these methods assessed Coralita's response, revealing that frequent removal intervals significantly reduced its growth and health, with a more pronounced effect observed with increased removal frequency, highlighting the importance of consistent removal efforts. However, Coralita's dynamic growth and resilience present ongoing management challenges. While repeated removal shows promise, logistical and environmental considerations are essential. Overall, this study provides valuable insights for managing Coralita and preserving St. Eustatius's biodiversity.

Contents

Abbreviations

EVI	Enhanced Vegetation Index
GPS	Global Positioning System
LMM	Linear Mixed Model
NDVI	Normalised Difference Vegetation Index
RGB	Red Green Blue
STENAPA	St. Eustatius National Parks
SVMs	Support Vector Machines

Nomenclature

°C	degree Celsius
g	grams
km^2	square kilometre
m	metre
μmol	micro-mole
nm	nanometre
%	percent
s	seconds
m^2	square metre

List of Figures

List of Tables

Chapter 1

Introduction

Invasive alien species (IASs) represent one of the paramount catalysts of biodiversity decline, ranking among the top five direct drivers, as highlighted by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (IPBES, 2023). These species are non-native, originating from regions beyond their natural habitats and are introduced accidentally or deliberately into ecosystems due to human activities (Hui and Richardson, 2017). While not all non-native species become invasive, a subset successfully establishes and proliferates, emerging as primary contributors to global biodiversity loss (McNeely, 2000). Once introduced, they overcome biogeographical barriers and proliferate extensively over vast distances, unleashing a cascade of detrimental effects (Hui and Richardson, 2017; IPBES, 2023). On a global scale, IASs can disrupt the intricate web of interactions among native species in the local ecosystem, which could affect other trophic levels in the food chain, ultimately altering competition dynamics, and influencing native species populations (Russell et al., 2017; Shuvar, Ivan et al., 2021). The alteration of the structure, composition, and distribution of biota can lead to the homogenisation of flora and fauna, resulting in biodiversity loss and the extinction of species (Russell et al., 2017; Shuvar, Ivan et al., 2021).

Globally, as of 2023, statistics reveal that IASs account for 60% of documented animal and plant extinctions, with at least 218 species driving over 1,200 local extinctions

(IPBES, 2023). Their negative influence permeates various aspects of life with 85% of their effects on native species and nearly 80% on ecosystem services registering as detrimental (IPBES, 2023). Furthermore, IASs serve as vectors for diseases like malaria, amplifying health risks and compromising livelihoods (Minakawa et al., 2012). The decline of fisheries in Lake Victoria due to the proliferation of invasive water hyacinth also affects both the local economy and food security (Albright et al., 2004; Kateregga and Sterner, 2009).

Most negative impacts of IASs are reported on land (about 75%), and interestingly, its impacts are the most damaging to islands compared to continental regions, with 90% of global extinctions on islands attributed mainly to IASs (IPBES, 2023; Russell et al., 2017; Sax and Gaines, 2008). The number of alien plants now has exceeded the number of native plants on more than 25% of all islands IPBES (2023). The unique attributes of islands, characterised by their limited size and isolation, have resulted in a relatively high proportion of endemic species and a unique contribution to biodiversity as evolution unfolds (Eppinga et al., 2022; Kier et al., 2009; Russell et al., 2017; Veron et al., 2019). Evolutionary distinctiveness, species impoverishment, and taxonomic disharmony, coupled with the absence of certain functional groups, render islands more vulnerable to the impacts of IASs (Russell et al., 2017). Hence, we observe higher rates of extinction on islands compared to continental regions (IPBES, 2023; Sax and Gaines, 2008). Interestingly, according to Sax and Gaines (2008), the extinction rates across the different taxonomic groups are vastly different, with more bird species being lost compared to plants. However, reports in recent years have found that the number of plants which had disappeared from the wild is more than twice the number of extinct birds, mammals and amphibians combined (Carrington, 2019; Humphreys et al., 2019; Stokstad, 2019; The Royal Botanic Gardens, Kew, 2019). Yet again, it is emphasised by Briggs (2019); Humphreys et al. (2019); Sax and Gaines (2008) that the highest rates of plant extinction are on islands, especially in the tropics with a Mediterranean climate where these regions are home to a large biodiversity of many unique species. Although the impacts of invasive plant species have been well documented, especially in New Zealand, specific impacts of smaller subtropical islands have been studied less in comparison (Eppinga et al., 2022; Sax and Gaines, 2008).

Some of these smaller subtropical islands can be found in the Caribbean region (Eppinga et al., 2022). The Caribbean region is an important ecological site as it is renowned as one of the 25 global biodiversity hotspots (Jesse et al., 2020; Myers et al., 2000; Sloan et al., 2014). These islands hold immense ecological significance despite covering only a fraction of the Earth's land surface (Heger and van Andel, 2019; Mitchell et al., 2019). The Caribbean Islands are also notably vulnerable to plant invasions due to the conducive climatic conditions for lianas and vines to thrive (Eppinga et al., 2022; Schnitzer and Bongers, 2011; Schnitzer et al., 2005). These functional vegetation groups pose a threat to native vegetation as they can form extensive cover over the native vegetation, smothering them, and contributing to forest disturbance, adversely affecting the growth and survival of native trees (Eppinga et al., 2022; Harron et al., 2020; Ward et al., 2020). These vines are also recognised for their ability to influence nutrient dynamics (Eppinga et al., 2022; Ward et al., 2020). For example, the invasive vine, Kudzu (*Pueraria montana*) influences nitrogen fixation in soils, thereby altering overall soil chemistry. This modification in soil conditions contributes to a reduction in native biodiversity, carrying significant economic consequences, with damages reaching up to $100 million per year in the United States (Harron et al., 2020).

Among these islands, St. Eustatius stands out as a crucial site, facing significant challenges posed by the invasive Coralita (*Antigonon leptopus*) vine (Burke and DiTommaso, 2011). The rampant spread of Coralita presents a pressing concern for St. Eustatius, jeopardising the region's rich biodiversity, hence providing a valuable case study to understand the growth dynamics of an invasive vine, such as the Coralita vine (Burke and DiTommaso, 2011; Haber et al., 2021).

The invasive Coralita is a Mexican herbaceous perennial vine that was initially introduced as an ornamental plant in the mid-nineteenth century and was extensively cultivated due to its attractive pink or white flowers, enabling its anthropogenic introduction across the global tropics (Burke and DiTommaso, 2011) (Figure 1.1). However, when left unattended, the Coralita vine exhibits a rapid overgrowth, extending not only over other vegetation and tall structures, as illustrated in Figure 1.2, but also beyond its initially introduced area (Burke and DiTommaso, 2011). The pervasive and "creeping" growth habit of Coralita, as described by Haber et al. (2021), has rendered it so highly dominant on St. Eustatius that extensive patches of Coralita have spanned over substantial portions of the island (Figure 1.4, smothering vegetation and contributing to the decline of the undergrowth (Burke and DiTommaso, 2011).

Figure 1.1: Coralita vine with flowers (Photo taken by: Zoelle Kwan Ying Ying)

Figure 1.2: Overgrown Coralita shrouding a tall structure (Photo taken by: Zoelle Kwan Ying Ying)

(a) Tuberous roots of the Coralita vine

(b) Inside of the tuberous roots of the Coralita vine

Figure 1.3: Tuberous roots of the Coralita vine (Photo taken by: Zoelle Kwan Ying Ying)

Figure 1.4: A vast patch of Coralita on St. Eustatius smothering vegetation (Photo taken by: Zoelle Kwan Ying Ying)

Moreover, Coralita poses a threat to global diversity as it also homogenises local and regional communities (Eppinga et al., 2022; Jesse et al., 2020). Jesse et al. (2020) reveal a significant increase in arthropod abundance due to Coralita invasion, causing biotic homogenisation in invaded habitats. Further insights from Eppinga et al. (2022) indicated that plots invaded by the Coralita vine exhibited a 40-50% reduction of plant species richness and lower evenness, with negative impacts intensifying as Coralita cover increases, resulting in higher levels of homogeneity in species composition. Besides the environmental impacts, N.Huisman et al. (2021) have also delved into the economic impacts that Coralita poses. According to N.Huisman et al. (2021), in scenarios where baseline Coralita cover is at 3%, there is an annual economic loss of five ecosystem services (tourism, non-use value, carbon sequestration, archaeology and local cultural and recreational value) in St. Eustatius amounting to $39,804 — this number rises to $576,704 when Coralita cover is at 36%. Hence, it becomes apparent that the invasive characteristics of Coralita pose a considerable concern, affecting both native biodiversity and leading to substantial economic losses. The majority of research conducted on Coralita focuses on its impacts, with a notable absence of information or studies assessing the effectiveness of mitigation strategies implemented to eradicate Coralita in St. Eustatius. Eradicating the Coralita vine is especially challenging once established as it can reproduce sexually through seed dispersal and asexually by spreading and persisting through underground tuberous roots (Figure 1.3), enabling accelerated vegetative propagation (Burke and DiTommaso, 2011). The report by IPBES (2023) also noted that eradicating IASs would pose greater challenges due to the potential for their seeds to remain dormant in the soil for extended periods.

Prior research, such as that conducted by Lin et al. (2018); Martínková et al. (2021); Ye et al. (2023), has investigated plant regrowth following removal, predominantly in controlled environments like greenhouses or laboratories, using single removal sessions. While Eppinga et al. (2020) have examined the spatial aspects of Coralita patches and their influence on management strategies, their study primarily relied on simulations rather than on-site removal efforts. Hence, understanding Coralita's regrowth capabilities and response to injury on-site still remains limited.

This research aims to explore the effects of repeated removals on Coralita's health and growth, aiming to improve the development of effective management strategies for controlling its population. While various invasive plant control methods exist, including mechanical, chemical, and biological approaches, considering the rich biodiversity of St. Eustatius, employing mechanical control, specifically physical eradication, emerges as the most viable option. This approach minimises disruption to native biodiversity while effectively targeting Coralita. Thus, the study will focus on physically removing Coralita above ground repeatedly to assess its impact on health and growth. Qualitative image observations and quantitative measurements of plant traits such as stomatal conductance, leaf size, and biomass will be utilised to gauge the damage inflicted on Coralita's vitality and development across removals. Drawing on findings by (Martínková et al., 2021), which demonstrated reduced regrowth capacity and biomass following injury to Barbarea vulgaris, we hypothesise that Coralita's regrowth potential will diminish with successive removals, leading to overall reduced health and growth. Therefore, we anticipate observing reduced stomatal conductance, smaller leaf size, and lower biomass as indicators of Coralita's diminished health and growth.

Nevertheless, in order to carry out the on-site removal of Coralita on St. Eustatius, it is imperative to first comprehend the current extent of Coralita spread across the island. As of 2014, earlier ground estimates indicated that Coralita covered 15-33% of the island, whereas satellite imagery indicated that only 3.18% of the island was covered by Coralita (Berkowitz, 2014; Ernst and Ketner, 2007; Haber et al., 2021). While these studies were done at different points in time, different methodologies were also used. Ernst and Ketner (2007) used topographical maps, field surveys, aerial photos and up-to-date Google Earth images to recognise and identify Coralita cover. A follow-up study was done by Berkowitz (2014), where they mapped Coralita cover by using a ground survey and recording standardised Global Positioning System (GPS) locations through a combination of walking and driving through the main and secondary roads in St. Eustatius. On the other hand, Haber et al. (2021) employed field surveys to establish ground-truthing points for Coralita and integrated these points with high spatial-resolution data from Worldview-2 sensors. Subsequently, they utilised Support Vector Machines (SVMs) in R (version 3.3.1) to distinguish between pixels representing Coralita and those that do not, thereby generating a spatial distribution map of Coralita. The different methods employed to study Coralita cover make it difficult to infer temporal dynamics due to the disparate nature of these estimates, which also exhibit a wide range of variability. Moreover, the existing data from 2014 is outdated, hence driving the need for a fresh mapping survey on St. Eustatius.

To monitor the recent and ongoing spread of Coralita and to overcome the challenges associated with assessing its spread across different methodologies and timeframes, this research aims to undertake a new mapping survey on St. Eustatius. Building upon the methodology outlined in Haber et al. (2021), this research will transition from utilising Worldview-2 images to Sentinel-2 images to improve mapping efficiency. However, the spatial resolution of Sentinel-2 is larger than Worldview-2, which may pose a problem in monitoring some invasive species, but given that large patches of Coralita form in St. Eustatius, these challenges may be partly circumvented. Nonetheless, the broader availability and accessibility of Sentinel-2 images make it a more valuable tool. This methodological refinement serves as a foundational step in analysing the past, present, and future spread of Coralita, thereby offering invaluable insights into the temporal dynamics of its expansion over time. As noted above, a critical point until now is the different methodologies used to assess Coralita cover, which has led to very different estimates that are difficult to compare. With the launching of the Sentinel-2 satellites, there is now a large potential to monitor vegetation changes at a relatively high level of temporal resolution, and importantly, in an internally consistent methodological manner.

Over the past years, Sentinel-2 has been effectively utilised to detect and monitor the spread of various invasive plant species, such as Japanese knotweed (*Fallopia japonica*) and water hyacinth (*Eichhornia crassipes*). Japanese knotweed is notorious for its rapid growth and potential to damage infrastructure, while water hyacinth invades aquatic environments, forming dense mats on water surfaces that disrupt ecosystems and water flow (Fennell et al., 2018; Mouta et al., 2023; Pádua et al., 2022; Smerdu et al., 2020). By analysing the spectral signatures captured by Sentinel-2, along with vegetation indices like NDVI (Normalised Difference Vegetation Index) and EVI (Enhanced Vegetation Index), researchers can identify and map the extent of these infestations. The high-resolution multispectral data from Sentinel-2 facilitates the differentiation of Japanese knotweed from surrounding vegetation, aiding in early detection and management efforts. The satellite's multispectral capabilities, particularly in the near-infrared and red-edge bands, are also effective in detecting and mapping the floating mats of water hyacinth, providing crucial information for controlling their spread (Pádua et al., 2022). However, challenges such as cloud cover can obstruct the satellite's view, limiting the availability of usable imagery. Additionally, invasive plant species may have spectral signatures similar to native vegetation, complicating accurate identification.

Therefore, field validation, such as the field survey of Coralita on St. Eustatius, is necessary to confirm the presence of these species. Despite these challenges, Sentinel-2 remains a valuable tool for detecting invasive plant species, demonstrating its significant contribution to environmental monitoring and management. Its ability to provide high-resolution, multispectral data over large areas with frequent revisit times helps identify, map, monitor, track, and address invasive species, ultimately supporting conservation and biodiversity efforts.

Through this new mapping survey, the research aims to provide updated and more accurate data regarding the distribution and extent of Coralita on the island. Additionally, it seeks to evaluate the Coralita cover at various time intervals, facilitating the assessment of the recent proliferation of this invasive species. This research will also ascertain whether Coralita has proliferated since 2015 and to what extent. By doing so, it seeks to determine the current presence and level of concern posed by Coralita on the island and its impact on local economic losses. Ultimately, this endeavour will yield critical insights into the growth dynamics of Coralita, aiding in the formulation of effective management strategies tailored to specific localised areas.

In a nutshell, our goals for this study are to: (1) assess the current distribution of Coralita using Sentinel-2 imagery, (2) compare the spread of Coralita since 2015 and investigate its potential extent, (3) evaluate the impact and extent of repeated above-ground removals on Coralita's health and growth through image observation and plant traits analysis, and (4) assess the effectiveness of above-ground removal as a management strategy for controlling Coralita populations. Therefore, the study evaluates the impact of repeated removals on Coralita's health and growth directly on-site in St. Eustatius and its efficacy as a potential management approach.

Ultimately, this multifaceted approach aims to deepen our understanding of Coralita's growth dynamics, as well as Coralita's response to removal efforts, informing the development of targeted and effective management strategies to control its population on St. Eustatius. By integrating insights from previous studies and conducting on-site evaluations, we aim to contribute to the broader scientific knowledge base on invasive species management and ecological conservation. Through these efforts, we hope to pave the way for more robust and sustainable management practices in the future.

Chapter 2

Methodology

2.1 Study area

St. Eustatius is a volcanic island in the Dutch Caribbean, situated between 17°28' and 17°32' N latitude and between 62°56' and 63°00' W longitude, covering a relatively small surface area of 21 km^2 (de Freitas et al., 2012; Haber et al., 2021). The average air temperature hovers around 26.9 °C, and the island receives an annual average rainfall of 986 mm (de Freitas et al., 2012). Positioned to the southeast of the island is the dormant Quill volcano, which has remained inactive for over 1600 years (de Freitas et al., 2012). This stratovolcano is 600 m tall, marking the island's highest point (de Freitas et al., 2012). St. Eustatius experiences a tropical savannah climate characterized by a distinct dry season, during which rainfall typically measures less than 60 mm at lower elevations (de Freitas et al., 2012). Dry evergreen forests, (semi-)evergreen, and deciduous seasonal forests are prevalent on the lower mountain slopes, while (secondary) rainforest dominates the higher slopes (de Freitas et al., 2012; Eppinga and Pucko, 2018). Coralita is commonly found on the lower slopes of the Quill volcano, particularly in open or disturbed areas. It is also prevalent in urban and suburban areas, frequently along roadsides and pathways.

2.2 Overview of framework

Figure 2.1 offers a comprehensive overview of the methodology framework, illustrating the sequential steps undertaken to address the two distinct research questions.

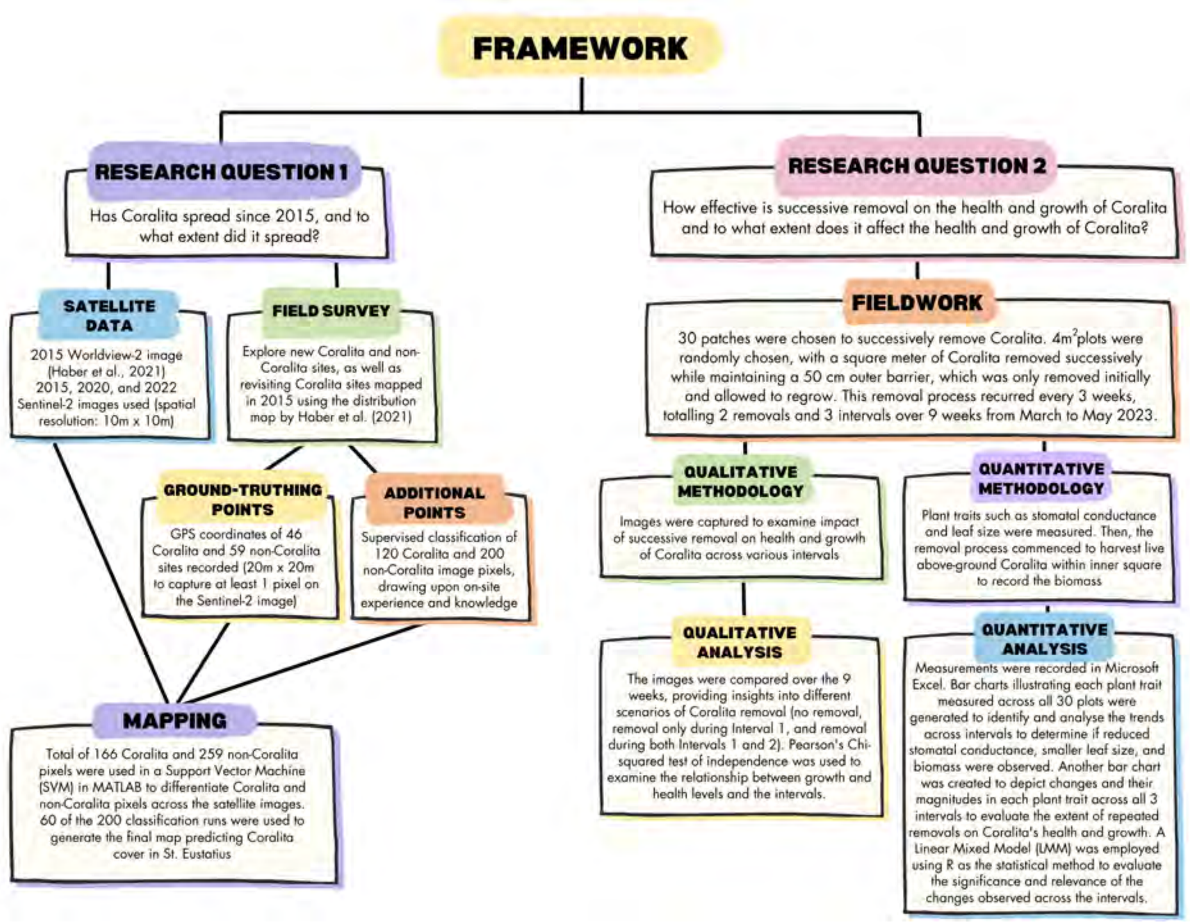

Figure 2.1: Flowchart showing the overview of the methodology framework

2.3 Research question 1: Field survey and mapping

A comprehensive field survey and mapping of Coralita was conducted to address the primary research question: has Coralita spread since 2015, and to what extent did it spread? Spanning two months, from March 2023 to May 2023, the field survey, involved exploring both new Coralita and non-Coralita sites, as well as revisiting Coralita sites mapped in 2015 using the distribution map by Haber et al. (2021) (Figure 2.2). The non-

Coralita sites encompass different types of land cover including grasslands, shrublands, coastal areas, and predominantly urban areas.

Following that, we mapped the spatial distribution and proliferation of Coralita on St. Eustatius using 20 meter by 20 meter resolution ground-truthing points. These ground-truthing points involved using a Trimble TDC150 Handheld Data Collector device to record the GPS coordinates (Figure 2.3). These ground-truthing points included 46 Coralita and 59 non-Coralita sites. Recognising the insufficiency of this dataset for ground-truthing purposes, an additional 120 Coralita and 200 non-Coralita points were complemented by using supervised classification of image pixels, drawing upon the knowledge and experience gained from on-site observations during the field survey on the island. In total, 166 Coralita and 259 non-Coralita ground-truthing points were utilised to estimate the spread of Coralita on St. Eustatius.

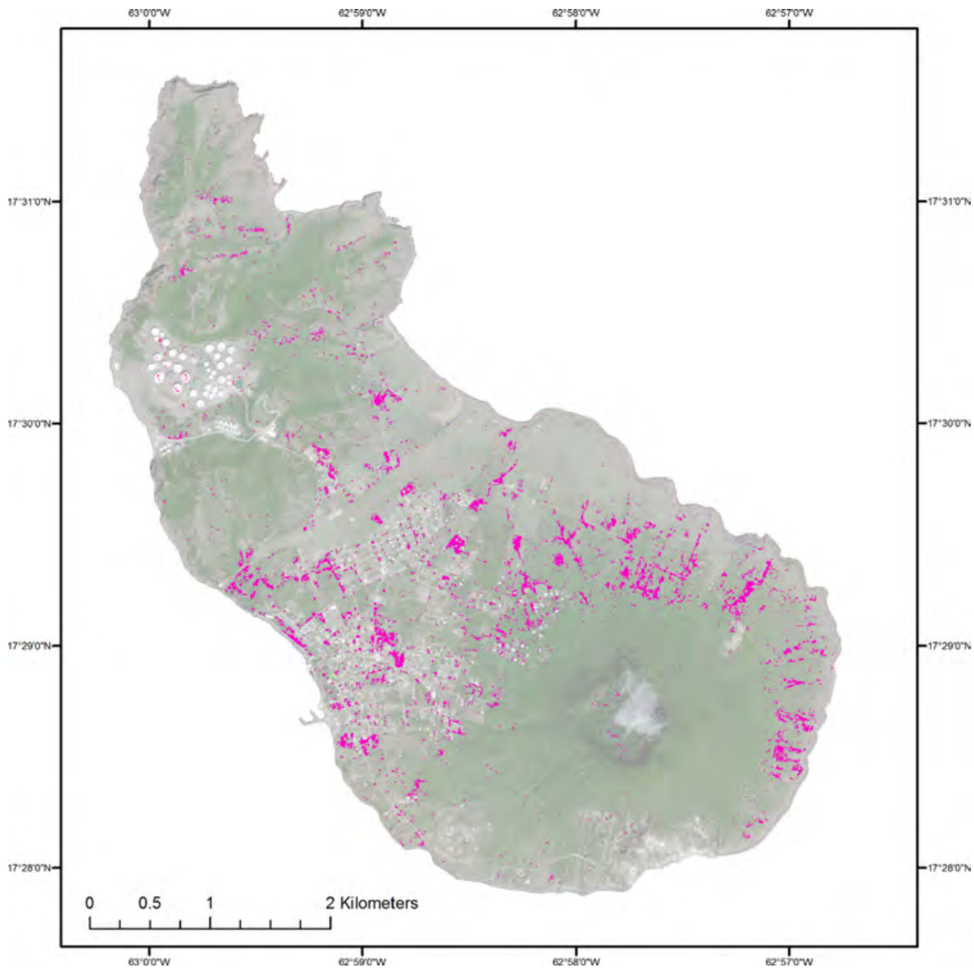

Figure 2.2: Distribution map of Coralita on St. Eustatius in 2015 (Haber et al., 2021)

Figure 2.3: Recording GPS coordinates for Coralita patch (E2) measuring 20 meters by 20 meters

The ground-truthing points were then subsequently utilised to identify Coralita and non-Coralita pixels on a series of Sentinel-2 images, using the methodology described by Haber et al. (2021). However, this research serves as an extension of the work conducted by Haber et al. (2021), but with a notable- shift towards leveraging Sentinel-2 data to generate a time series of images for mapping the spatial distribution of Coralita. This shift from the Worldview-2 image used in 2015 is motivated by the broader availability and accessibility of Sentinel-2 images. Creating a time series also mitigates potential issues related to over or underestimation of a single image, providing a more robust assessment not only of current trends but also of future trends.

However, unlike the Worldview-2 image, which has a spatial resolution of around 2 meters by 2 meters, the Sentinel-2 images used for this research have a larger spatial resolution of 10 meters by 10 meters. By measuring GPS coordinates of 20 meters by 20 meters, we guarantee the inclusion of at least one pixel in the Sentinel-2 image. For example, this can be seen in Figure 2.4, where the 20 meters by 20 meters GPS coordinates for a Coralita plot capture at least 1 pixel on the 2015 Sentinel-2 image.

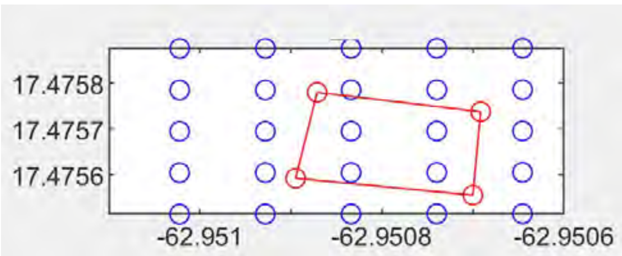

Figure 2.4: The GPS coordinates of a Coralita plot (red) capturing at least one pixel on the 2015 Sentinel-2 image (blue)

The Sentinel-2 satellite captures images with a spatial resolution of 10 meters across 13 spectral bands, of which 10 were utilized in this analysis. These bands include the classical RGB bands (B02, Blue: 490nm, B03, Green: 560nm, and B04, Red: 665nm), the Vegetation Red Edge bands (B05:705nm, B06: 740nm, B07: 783nm, and B8A:

865nm), the Near Infrared band (B08: 842nm), and the Short-Wave Infrared bands (B11: 1610nm and B12: 2190nm) (Sentinel Hub, nd). The RGB bands capture visible light, facilitating water monitoring, vegetation health assessment, and vegetation type identification. Red-edge bands detect light in the red edge region, sensitive to changes in chlorophyll content and plant health, commonly used for vegetation analysis. Near-infrared light aids in vegetation health assessment, water content estimation, and land cover classification. Shortwave infrared is crucial for evaluating moisture content in vegetation and soil European Space Agency (nd). These spectral bands contribute to distinctive bright green colouration in Coralita pixels within Sentinel-2 images (Haber et al., 2021). This unique colour profile serves as the basis for distinguishing between Coralita and non-Coralita pixels. An example of the corresponding Coralita pixel from Figure 2.4 can be seen in Figure 2.5.

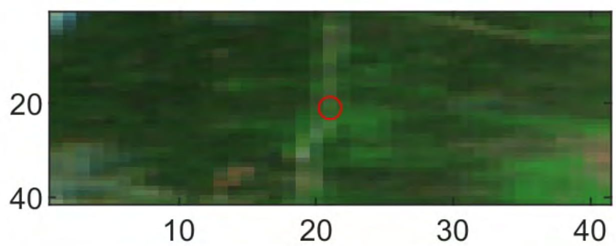

Figure 2.5: Coralita pixel identified on the 2015 Sentinel-2 image

The analysis, following the methodology outlined in Haber et al. (2021), entailed training Support Vector Machines (SVMs) in MATLAB to differentiate between pixels representing Coralita and those that do not. SVMs are supervised non-parametric machine learning algorithms utilised to categorise image data into distinct classes, such as Coralita and non-Coralita in this context (Haber et al., 2021). Known for their efficiency in handling small training datasets with multiple input variables, SVMs often outperform other classification or regression methods (Haber et al., 2021). Hence, an SVM was employed to differentiate between Coralita and non-Coralita pixels in the 2015 Worldview-2 images and the Sentinel-2 images (2015, 2020, 2022). The MATLAB script assigned distinct colours to Coralita and non-Coralita pixels, to differentiate these pixels and those obscured by cloud cover were subsequently excluded from the analysis before SVM execution for Sentinel-2 image analysis.

The SVM underwent 200 classification runs to assign other pixels on the map as either Coralita or non-Coralita, thereby generating 200 different SVM models. The optimised set of support vectors resulting from these runs, indicative of the best performing models, was utilised in the final SVM model to predict the probabilities of Coralita presence across the entire image (Haber et al., 2021). At least 60 of these runs were employed to generate the final map predicting Coralita cover in St. Eustatius.

The results encompass the performance of each SVM model, defined by its ability to accurately classify training data into Coralita and non-Coralita classes. The average accuracy across all 200 runs provides an assessment of how effectively the testing data is predicted by the classification. The results also yield various aspects aimed at demonstrating the suitability of Sentinel-2 as an alternative to Worldview-2 imagery and observing changes in Coralita cover over time. This comparison involved analysing Sentinel-2 images, assessing the extent of cloud cover in these images across multiple years (2015, 2020, 2022), examining the distribution of Coralita in the 2015 Worldview-2 map, mapping the distribution of Coralita in the Sentinel-2 imagery, as well as creating an overlay map depicting both the 2015 Worldview-2 and Sentinel-2 maps. Additionally, a bar chart was generated to illustrate the proportion of pixels classified as Coralita on both the 2015 Worldview-2 map and Sentinel-2 maps, providing insights into trends in

Coralita cover over time.

2.4 Research question 2: Fieldwork to study effects of successive removal on the health and growth of Coralita

2.4.1 Fieldwork

Apart from the field survey and mapping, concurrent on-site data collection of Coralita growth traits was conducted from March 2023 to May 2023. This fieldwork aimed to address the secondary research question: How effective is successive removal on the health and growth of Coralita and to what extent does it affect the health and growth of Coralita? The approach involved thoroughly documenting the health and growth of the Coralita across 30 patches in St. Eustatius.

These 30 patches across the island were meticulously pre-selected by identifying them using the 2015 dataset from Haber et al. (2021) through MATLAB. They range from 400 m^2 to 2000 m^2 to ensure the inclusion of at least one pixel on the Sentinel-2 image. Of these 30 patches, 24 were situated within natural habitats encircling the Quill volcano, exhibiting varying slope orientations. The remaining 6 patches were situated outside the Quill volcano and categorised as urban zones. This deliberate selection process, incorporating patches with varying slope orientations and land covers, introduces spatial diversity and encompasses potential environmental disparities that may influence the observed outcomes. Figure 2.6 illustrates the final map depicting the 30 chosen patches for fieldwork, with 24 located in natural habitats evenly distributed among the four slope aspects (North, South, East, West), and 6 in urban areas.

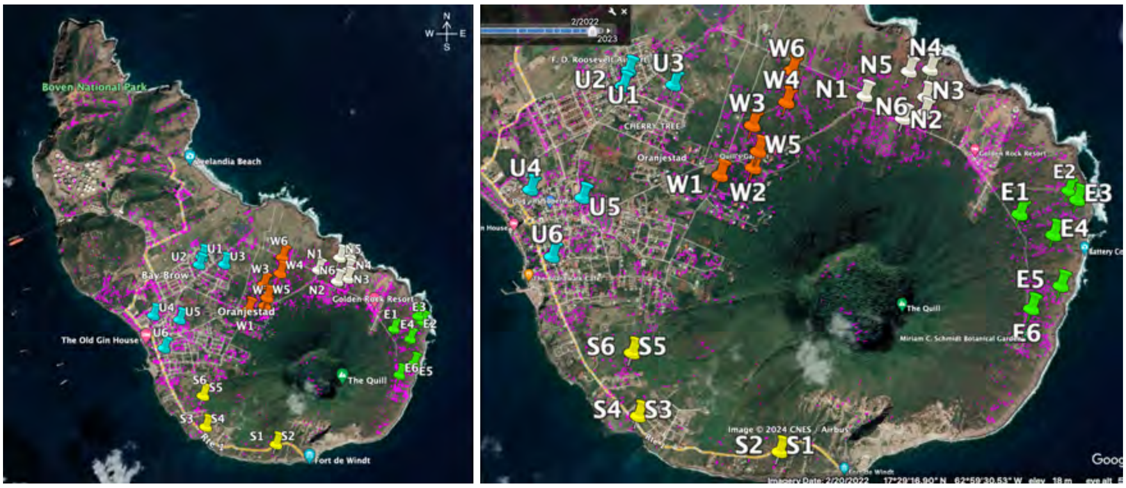

Figure 2.6: Map of the finalised 30 Coralita patches used for the fieldwork (Left) and the zoomed-in version of the map (Right)

Within each of the 30 Coralita patches, a 4 m^2 plot was randomly chosen for sampling. The plots were marked out using four 2-meter rulers to define their perimeter. At each corner, eight sticks were positioned, and paper ribbons were wrapped around them to clearly demarcate the experiment set-up boundaries. Within this 4 m^2 plot, a square meter of Coralita was successively removed, as shown in Figure 2.7, while the outer barrier of 50 cm was only removed during the initial removal (Figure 2.8) and allowed to regrow over the remaining time period. This removal process was then repeated every 3 weeks, amounting to two removals and three intervals over 9 weeks from March 2023 to May 2023.

Figure 2.7: Coralita in the inner square that will be successively removed (plot N6)

Figure 2.8: Coralita in the 50 cm outer barrier removed only during the initial removal (plot N6)

Prior to each removal activity, images were captured and examined to qualitatively assess the impact of successive removal on the well-being and development of Coralita across various intervals. The condition and development of Coralita were then quantitatively measured within the inner square of 1 m^2. It is crucial to note that there is a distinction between the health and growth of Coralita as they pertain to different aspects of the plant's condition.

The health of Coralita refers to the overall condition and vitality of a plant, encompassing various factors such as disease resistance, pest resistance, physiological functioning, and general vigour (Döring et al., 2012; Tian et al., 2022). Conversely, plant growth refers to the irreversible increase in cell number, size, or measurable change in plant dimensions, such as height, width, leaf area, or biomass of a plant over time (Hilty et al., 2021). Growth reflects the plant's ability to accumulate resources and convert them into new plant material (Hilty et al., 2021). While plant health contributes to plant growth, these terms are not interchangeable. A plant may exhibit vigorous growth yet remain susceptible to diseases or pests, indicating compromised health. Conversely, a plant may be healthy but experience limited growth due to unfavourable environmental conditions. Both health and growth are essential indicators of a plant's overall well-being and productivity. Hence, to assess the health and growth of Coralita, three distinct plant traits were measured within the inner square.

The three distinct plant traits that were measured included stomatal conductance (on both the adaxial and abaxial surfaces of Coralita leaves), leaf size (leaf length, width, and thickness), and biomass. Stomatal conductance was assessed by randomly selecting 10 leaves and measuring them using the SC-1 Leaf Porometer. This device measures the vapour flux through the stomata on the leaf by relying on factors like stomata density, size, and degree of stomatal aperture (METER, nd). This allows it to discern between leaves that are actively transpiring or photosynthesising and those that are not. Stomatal conductance was measured on both the upper (adaxial) and lower (abaxial) leaf surfaces due to variations in stomata density between these surfaces. Typically, stomata are more abundant on the lower surface and can respond differently to environmental cues such as changes in light intensity or quality, soil moisture, ambient humidity, and carbon dioxide concentration (Wall et al., 2022; Wang et al., 1998). Nonetheless, stomatal conductance on both leaf surfaces serves as a key indicator of plant health and functionality, specifically in the context of water and gas exchange processes. Increased stomatal conductance signifies a higher rate of carbon assimilation, increased photosynthetic activity, and accelerated growth, all of which significantly contribute to the plant's overall vitality and development (Hasanuzzaman et al., 2023). Additionally, regulating stomatal conductance enables the plant to maintain a balance between water uptake and loss through transpiration (Giménez et al., 2013). Changes in stomatal conductance can also function as an early warning system for environmental stressors such as drought or high temperatures. In response to these stressors, plants may reduce stomatal conductance as a protective measure to minimise water loss (Hasanuzzaman et al., 2023). Therefore, assessing stomatal conductance on both adaxial and abaxial leaf surfaces of Coralita provides valuable insights into its photosynthetic capabilities, water management strategies, responses to environmental stress, and overall physiological well-being.

Using the same 10 Coralita leaves from the stomatal conductance measurements, the size of the leaves, including their thickness, longest length, and width, were also measured using a digital calliper, as depicted in Figure 2.9. Leaf size has a direct impact on photosynthetic efficiency, with thicker leaves typically demonstrating higher photosynthetic activity due to greater photosynthetic biomass per unit leaf area (Smith et al., 2023). Conversely, longer and wider leaves indicate a larger surface area, enhancing the leaf's capacity to capture light, a crucial process for efficient photosynthesis (Jiayan et al., 2020). Therefore, the size of Coralita leaves serves as an important growth metric, as they play significant roles in influencing plant health and fitness.

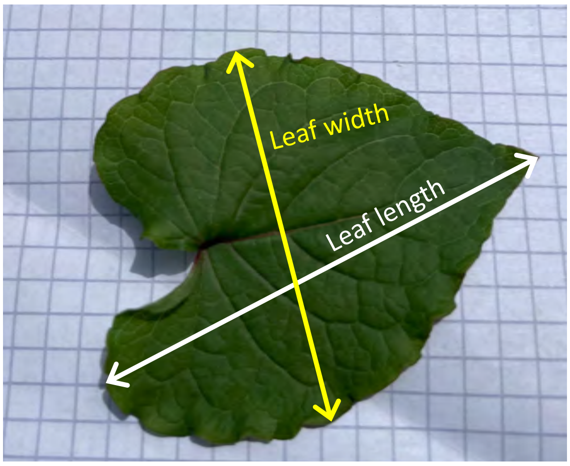

Figure 2.9: Measuring the size of a Coralita leaf

After recording the measurements of stomatal conductance and leaf size, the removal process commenced, and subsequent images were captured. The live Coralita harvested above-ground within the 1 m^2 inner square was collected and placed into ziplock bags. Unfortunately, due to the absence of suitable facilities on the island, we were unable to employ the dry weighing method, which involves drying the plant biomass at a constant temperature of 80°C for 24 to 48 hours, followed by cooling it in a desiccator jar and reweighing it (SERAS, 1994). Consequently, we measured the fresh weight of the Coralita biomass using a weighing scale. Nonetheless, the fresh weight of Coralita biomass is also a crucial indicator of its overall health and fitness, as it represents the total living organic matter within the plant. Greater plant biomass generally signifies more growth and productivity, given that all biomass production relies on the photosynthetic process (Hofius and Börnke, 2007). This metric also reflects the plant's efficiency in converting sunlight, water, and nutrients into organic matter through photosynthesis (McKendry, 2002). Furthermore, the presence of higher biomass in plants indicates an increased pool of resources available for allocation to reproductive structures such as flowers and fruits, thereby enhancing the likelihood of successful reproduction. Hence, greater plant biomass suggests a higher reproductive capacity and overall fitness of the plant (Younginger et al., 2017). In the context of Coralita, higher biomass would also imply the presence of larger tuberous roots (Figure 1.3), facilitating nutrient storage and contributing to its ability to withstand fluctuations in soil nutrients. However, it is important to note that only above-ground Coralita was considered in the measurement of plant biomass. Therefore, we acknowledge that the assessment of plant biomass in Coralita solely considered above-ground components, and further investigations into below-ground biomass, particularly the tuberous roots, would offer a more comprehensive understanding of its nutrient storage capacity and overall resilience in response to soil nutrient variations and regrowth.

After measuring the plant traits and harvesting from the inner square of the experimental plot, Coralita was then left to regrow for the subsequent 3 weeks, and the cycle repeated. Figure 2.10 offers a visual summary of the experimental arrangement over the 9-week period, while detailed images of each plot throughout these 9 weeks can be found in Appendix A. By integrating both the observations from the captured images and the recorded plant traits, both qualitative and quantitative methods are employed to offer a more comprehensive and thorough analysis of the health and growth of Coralita across the intervals. This facilitates the assessment of the effect of successive removal on the health and growth of Coralita to answer the secondary research question.

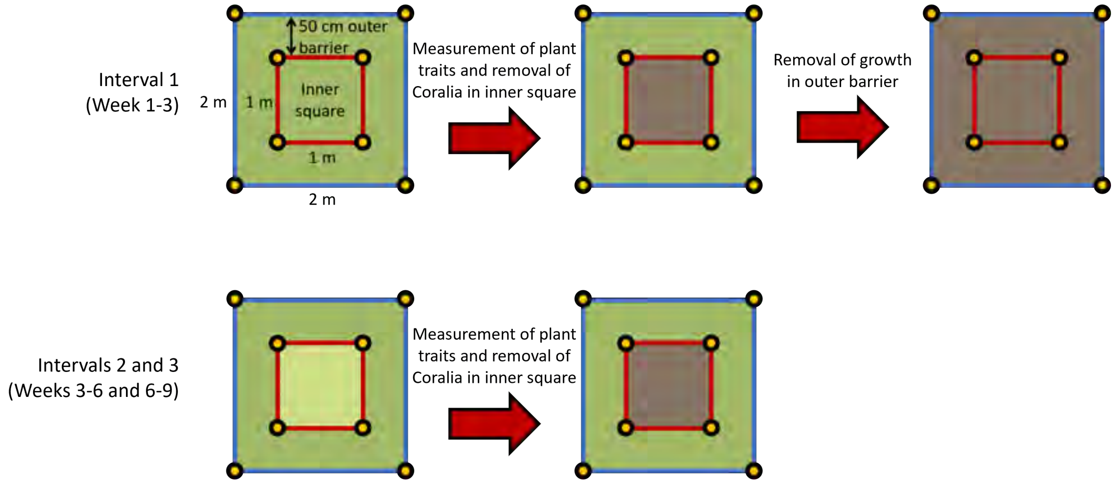

Figure 2.10: Summary of the setup for the fieldwork

2.4.2 Data analysis

2.4.2.1 Qualitative analysis

For the qualitative analysis, observations were conducted individually on the health and growth of the Coralita in each plot by comparing the images captured over the 9-week period. These observations were categorised into three distinct sections of the images: areas outside the experimental plot, within the outer barrier, and within the inner square of the experimental plot. These sections provide insights into different scenarios of Coralita removal: no removal, removal only during Interval 1, and removal during both Intervals 1 and 2, respectively.

The discussion delves into the impact of the removal process on the health and growth of Coralita, and is supplemented by Pearson's Chi-squared test of independence. This statistical method assesses whether the observations drawn across the different intervals hold statistical significance. Pearson's Chi-squared test of independence is a nonparametric test that evaluates whether there is an association between categorical variables and whether these variables are independent or related (Kent State University, 2023). The categorical variables for this research consist of three intervals represented as columns, while the number of plots demonstrating the three categories of growth (most, moderate, and minimal growth) and health (optimal, moderate, and suboptimal health) are arranged as rows. By applying this test, we examine the relationship between growth and health levels and the intervals. Essentially, we investigate whether successive removal affects the health and growth of Coralita. If a statistically significant difference is detected in Coralita's health and growth decline across intervals, it suggests that successive removal effectively impacts the health and growth of Coralita. This analysis underscores the importance of observations made across intervals and helps determine if the observed decrease in health and growth is meaningful. These qualitative findings are then compared with the results obtained from quantitative analysis.

2.4.2.2 Quantitative analysis

The measurements of the plant traits (stomatal conductance, leaf size, and biomass) recorded were entered into Microsoft Excel for subsequent calculations (Appendix B). Considering that 10 leaves were measured in each of the 30 plots, the plant traits for these 10 leaves were averaged to derive consolidated values for further analysis in R (version 4.3.2). This approach simplifies the data representation of plant traits by substituting numerous individual data points with a single value for each plot, facilitating the examination of trends in plant traits across all plots and intervals to ascertain the impact of removal activities on the health and growth of Coralita.

To evaluate if repeated above-ground removals impacted Coralita's health and growth, an overview of measurements collected across the 30 plots throughout all 3 intervals is necessary. Hence, a bar chart illustrating each plant trait measured across all 30 plots was generated. Different intervals were assigned distinct colours to aid in visually distinguishing trends. The purpose of the bar charts is to offer a visual representation of trends over intervals and to recognise patterns such as decreased stomatal conductance, diminished leaf size, and biomass across intervals.

Furthermore, to evaluate the extent of repeated removals on Coralita's health and growth, another bar chart was created to depict changes and their magnitudes in each plant trait across all 3 intervals. A comprehensive table is generated at the end, detailing the average percentage change of all 30 plots between the intervals for each plant trait. It is important to note that the first interval functions as a baseline for comparison with Intervals 2 and 3 as the period of growth differs with the subsequent removals. The table only serves to provide a summary of the overall impact of successive removal on Coralita's health and growth. A significant reduction in stomatal conductance, leaf size, and biomass would indicate diminished Coralita health and growth, suggesting that repeated above-ground removals could be an effective management strategy for controlling Coralita populations.

The graphical representations provide information on the trends observed across all 30 plots and help identify any anomalies in specific locations. Additionally, they enable the assessment of whether different locations impacted the measured results or if variations in environmental conditions existed across these sites.

In order to evaluate the significance and relevance of the changes observed across the intervals (i.e. reduced stomatal conductance, smaller leaf size, and biomass), a Linear Mixed Model (LMM) was employed using R (version 4.3.2) as the statistical method. The LMM is a statistical model that incorporates both fixed effects and random effects to analyse data with nested or hierarchical structures, or repeated measures (UCLA, nd).

Fixed effects within the LMM capture systematic differences or effects in the data using predictor variables. In the LMM model, we used the intervals and sessions of removal as the fixed effect. The fixed effects estimate the disparities between these intervals in terms of their impact on the response variable, which comprises the plant traits. Random effects, on the other hand, account for additional sources of variability in the data that are not of primary interest but are still considered to enhance the model's accuracy. In the LMM model, we used the plot identification number as the random effect to account for variability between plots that might influence the plant trait measurements independently of the interval. This captures the inherent variability between plots that is not explained by the intervals.

To ensure the suitability of the LMM for our dataset, diagnostic tests were conducted to assess whether its assumptions were met. These tests included checking for the normality of residuals using the Shapiro-Wilk test, evaluating the homogeneity of variance through Levene's test, and confirming the independence of observations and linearity. Upon confirming that the assumptions of the LMM were adequately met by the data, the model was applied to assess the significance of the observed changes across the intervals. This thorough validation process ensures the validity of the results obtained from the model. If the observed changes—such as reduced stomatal conductance, smaller leaf size, and biomass—across the intervals are statistically significant, it implies that successive removals effectively affect the health and growth of Coralita, leading to a decline in Coralita's health and growth over intervals when successively removed.

Chapter 3

Results

3.1 Results from the field survey and mapping

This section aims to present the results of the field survey and mapping, illustrating the distribution of Coralita across the years 2015, 2020, and 2022. By comparing the distribution of Coralita over these years, we aim to address the research question regarding whether Coralita has spread since 2015 and to determine the extent of this spread by analysing its distribution over the years.

3.1.1 Results using the Sentinel-2 image in 2015

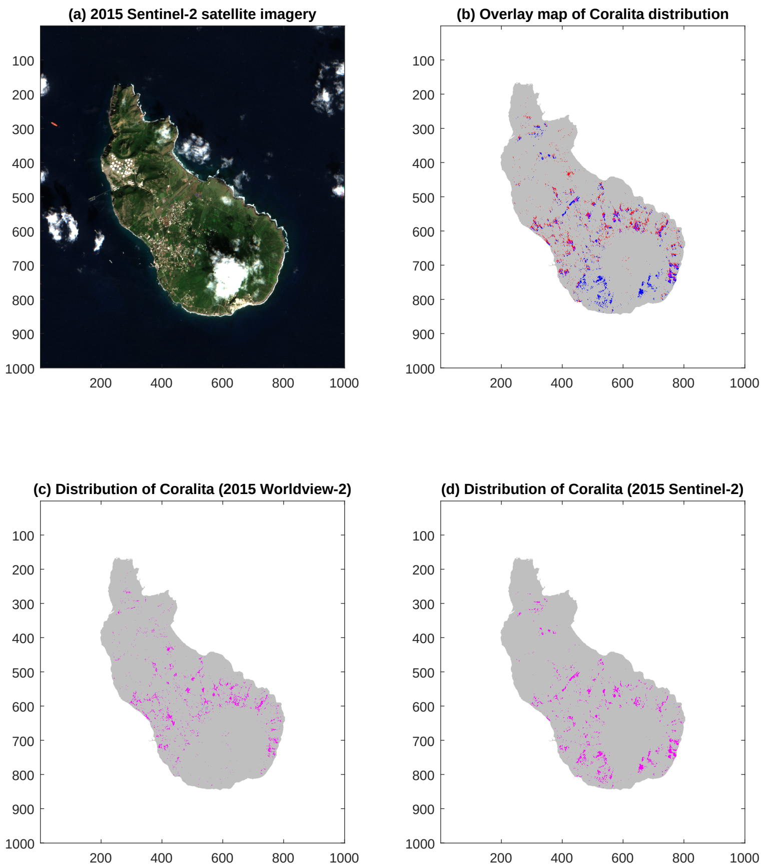

Figure 3.1: (a) 2015 Sentinel-2 satellite imagery, (b) the distribution of Coralita obtained by overlaying the 2015 Worldview-2 map (red) with the 2015 Sentinel-2 map (blue), (c) the distribution of Coralita in the 2015 Worldview-2 map, and (d) the distribution of Coralita in the 2015 Sentinel-2 map

The 2015 Sentinel-2 image utilised for mapping analysis in Figure 3.1 (a) displays relatively clear conditions with minimal cloud cover (11.28%) over the Southern region of the Quill volcano and the Northwest region of St. Eustatius. In Figure 3.1 (c), the distribution of Coralita in the 2015 Worldview-2 map reveals patches in the central urban area and at the base of the Quill volcano, excluding the South of the volcano. Sparse Coralita cover is visible in the North and the Northwest of the island. Similarly, in the Sentinel-2 map of Figure 3.1 (d), Coralita patches are observed around the base of the Quill volcano, with limited cover in the North and Northwest of St. Eustatius. By overlaying these maps in Figure 3.1 (b) and comparing them, a fairly similar Coralita distribution can be observed, with significantly more cover identified in the Sentinel-2 image around the South and Southwest of the Quill volcano.

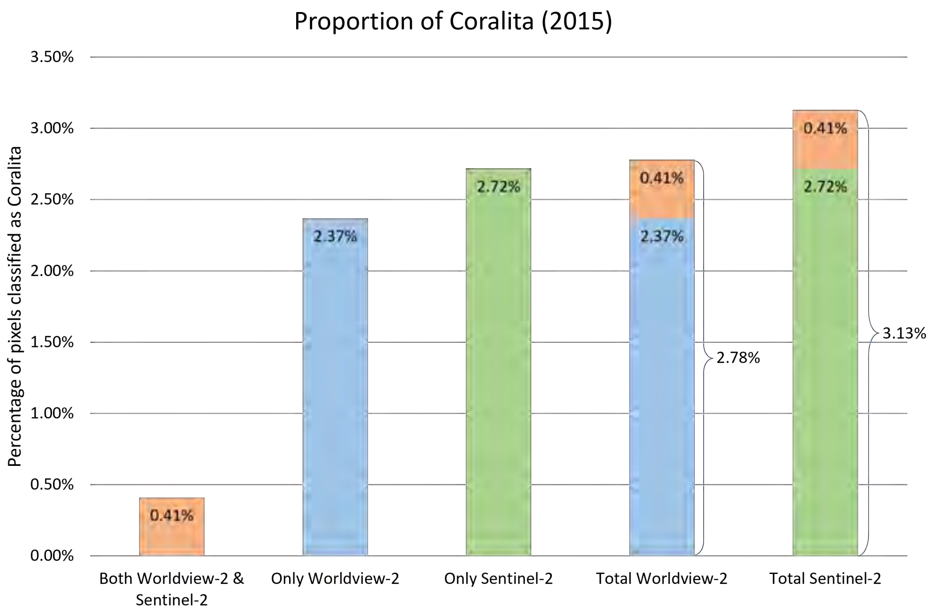

Figure 3.2: Bar chart of the proportion of pixels classified as Coralita on the 2015 Worldview-2 map and Sentinel-2 map

Figure 3.2 presents a bar chart illustrating the proportion of pixels classified as Coralita in both satellite images. The first bar chart reveals some overlap in Coralita patches identified in both images, constituting approximately 0.41% of the image and about 20% of the total Coralita points identified. Despite consistently demonstrating around 3% coverage of Coralita across St. Eustatius, the images display limited overlap in Coralita pixels, implying that different pixels are identified as Coralita between the two images.

Upon closer examination, Coralita pixels in the central region of the island, as well as the North and Northeastern sides of the Quill volcano, exhibit proximity but lack spatial overlap. This discrepancy suggests small spatial shifts in Coralita locations, evident from non-coincident speckling patterns in both images. Clusters of pixels observed in the

Southwestern and Southeastern areas around the Quill volcano seen in Figure 3.3 indicate less likelihood of new large Coralita patches forming within a similar timeframe. This raises the possibility of classification inconsistency, possibly influenced by cloud cover.

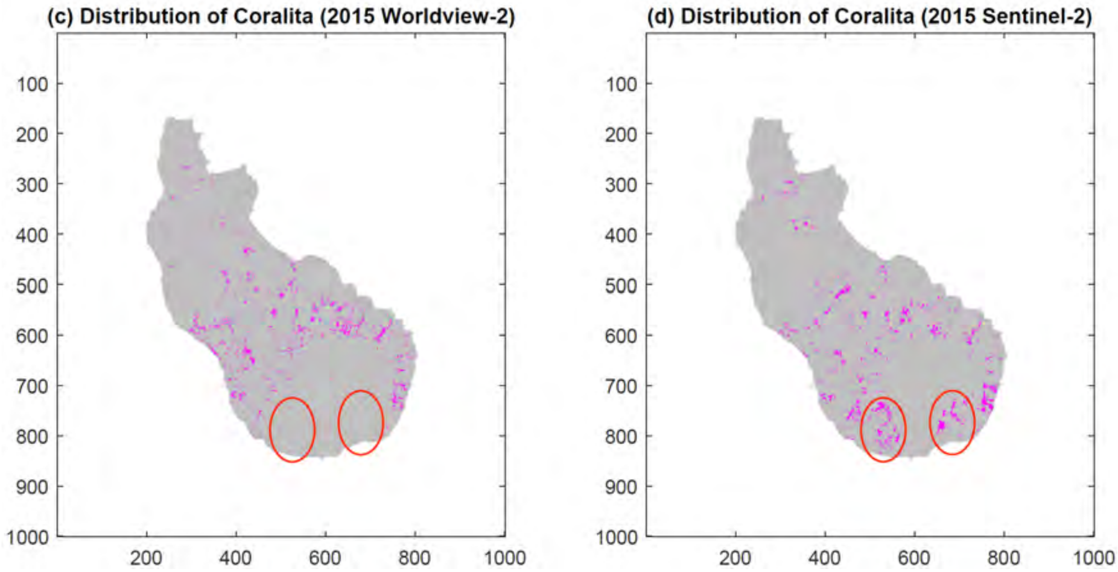

Figure 3.3: Large Coralita patches identified in the 2015 Sentinel-2 map but not the 2015 Worldview-2 map

The SVM model demonstrates a commendable average accuracy of 94.5% across all 200 runs, indicating proficient Coralita classification. However, it is not perfect, and inconsistencies in classification could explain the presence of large Coralita patches, especially in the Southwestern and Southeastern locations around the Quill volcano. Nevertheless, both images exhibited a 3% coverage of Coralita, and consistent patches in the central urban area and at the base of the Quill volcano. This coherence between both images reinforces the Sentinel-2 satellite's efficacy in estimating Coralita cover on the island as well as its suitability as an alternative data source. This is crucial in steering towards the utilisation of Sentinel-2 data, given its broader availability and accessibility. The transition to utilising Sentinel-2 data promises a more comprehensive evaluation of Coralita dynamics over time, enabling high-resolution monitoring of vegetation changes. Adopting a consistent methodology ensures coherence in analyses, laying the groundwork for understanding past, present, and future Coralita expansion trends. Previously, methodological disparities hindered meaningful comparisons, but with the Sentinel-2 satellite, there is now ample opportunity for consistent and effective vegetation monitoring, significantly advancing the ability to track and understand Coralita dynamics.

Given the coherence observed between the 2015 Worldview-2 and Sentinel-2 images of 3% Coralita coverage, it suggests that the 2015 Sentinel-2 image is reliable enough to serve as a baseline for comparison with subsequent years to determine whether Coralita has spread since 2015.

3.1.2 Results using the Sentinel-2 image in 2020

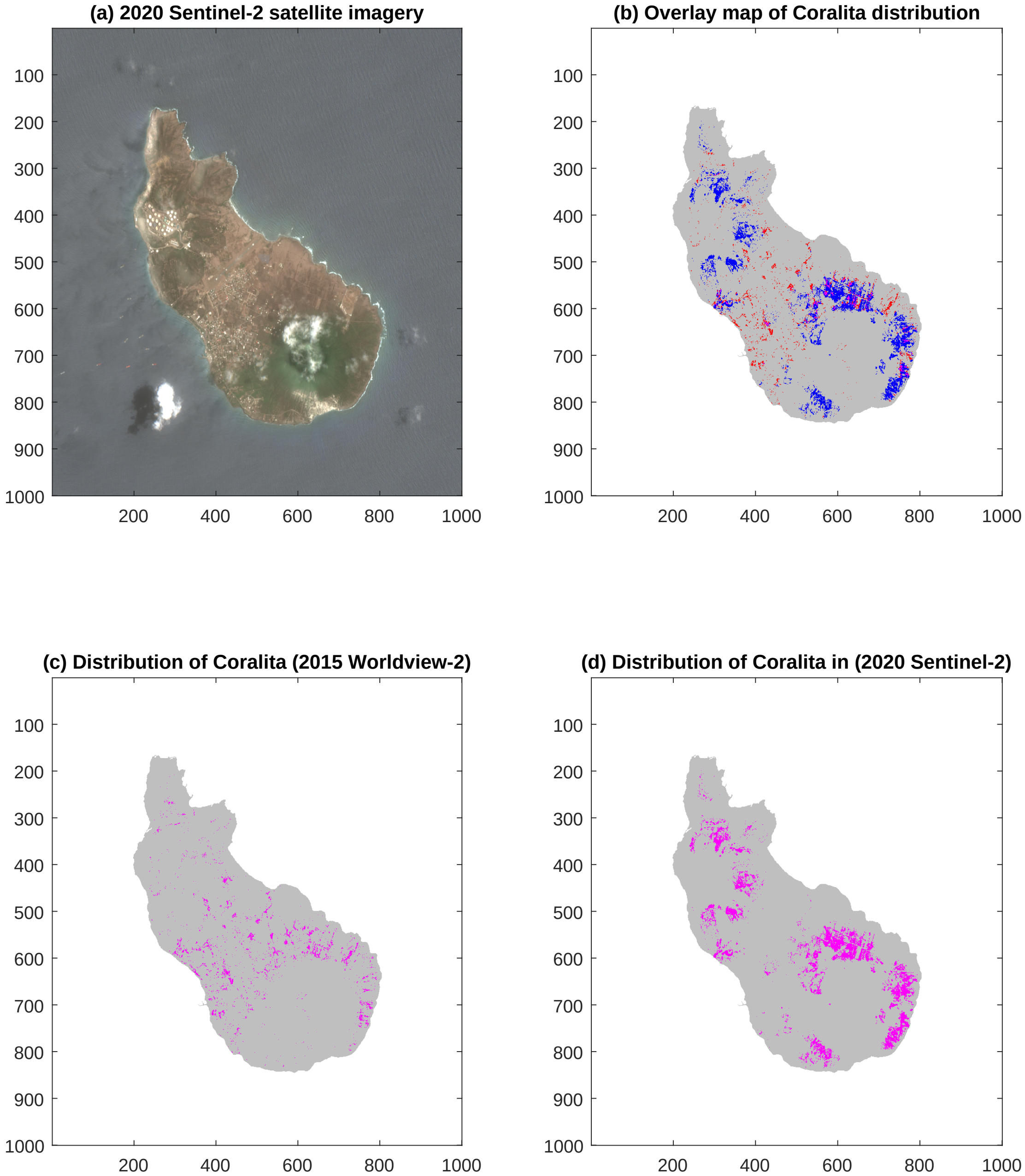

Figure 3.4: (a) 2020 Sentinel-2 satellite imagery, (b) the distribution of Coralita obtained by overlaying the 2015 Worldview-2 map (red) with the 2020 Sentinel-2 map (blue), (c) the distribution of Coralita in the 2015 Worldview-2 map, and (d) the distribution of Coralita in the 2020 Sentinel-2 map

The 2020 Sentinel-2 image in Figure 3.4 (a) exhibits notably thin cloud cover over St. Eustatius, with minimal, denser cloud cover observed over the North and

Northwest regions of the Quill volcano. However, despite the overall impression of ample cloud presence, the estimated cloud cover remains relatively low, accounting for approximately 4.2% of the image. This percentage appears inaccurate as the image reveals an exceptionally thin layer of clouds spread across its entirety, and this subtle cloud cover does not seem to be adequately reflected in the cloud cover estimation.

The same distribution of Coralita is observed in Figure 3.4 (c) and in Figure 3.1 (c) of the 2015 Worldview-2 map. However, a fairly different Coralita distribution is observed in the 2020 Sentinel-2 map depicted in Figure 3.4 (d), differing from both the 2015 Worldview-2 and Sentinel-2 maps in Figure 3.1 (c) and (d). The 2020 Sentinel-2 map displays a denser Coralita cover across St. Eustatius, with concentrated Coralita cover around the base of the Quill volcano and in the North, Northwest, and West regions of the island as Figure 3.5.

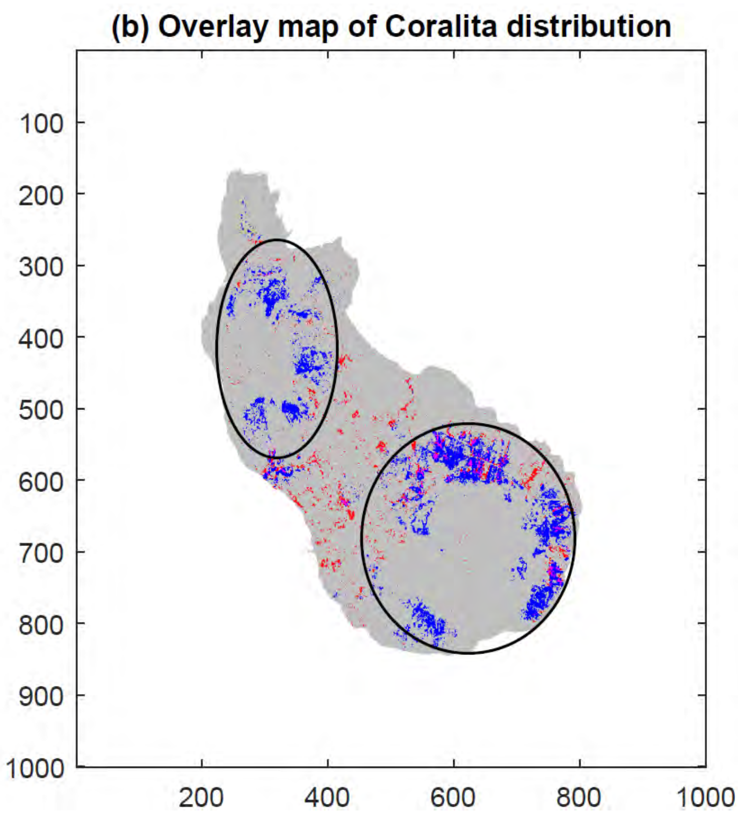

Figure 3.5: Concentrated Coralita cover around the base of the Quill volcano and in the North, Northwest, and West regions of the island

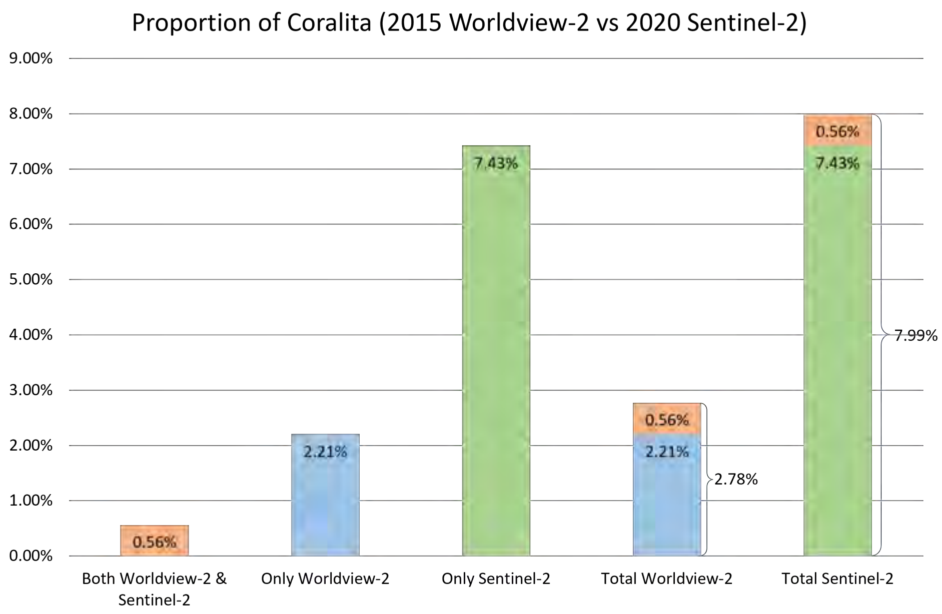

Figure 3.6: Bar chart of the proportion of pixels classified as Coralita on the 2015 Worldview-2 map and 2020 Sentinel-2 map

The first bar chart in Figure 3.6 reveals approximately 0.56% of overlap in Coralita patches identified in both images. This constitutes roughly a fifth of the total Coralita points identified in the Worldview-2 map and only about 7% of the total Coralita points identified in the 2020 Sentinel-2 map. Both images exhibit notably different coverage of Coralita across St. Eustatius, with the 2020 Sentinel-2 map showing approximately 3 times more Coralita patches than the 2015 Worldview-2 image.

It is worth noting that while the overall proportion of Coralita cover in the Worldview-2 map remains constant, the proportion overlapping with the Sentinel-2 images varies. Despite the denser Coralita coverage in the Sentinel-2 image, there is still limited overlap in Coralita pixels between the two, suggesting disparities in pixel identification.

Upon closer inspection, the Coralita pixels lack proximity, indicating that small spatial shifts in Coralita locations are unlikely. Instead, it appears that larger and newer Coralita patches have emerged over time. However, this scenario seems improbable.

Assuming that Coralita has spread since 2015, we would observe new, smaller Coralita patches that are closer to the existing patches identified in the 2015 Worldview-2 image. It is more plausible that the SVM model's reduced accuracy (92.4%) and the exceptionally thin cloud cover across the image could have contributed to inconsistencies in Coralita classification, leading to the emergence of new and larger Coralita patches. Nonetheless, there is still a noticeable increase in Coralita cover in the 2020 Sentinel-2 map compared to both the 2015 Sentinel-2 map and the Worldview-2 map.

3.1.3 Results using the Sentinel-2 image in 2022

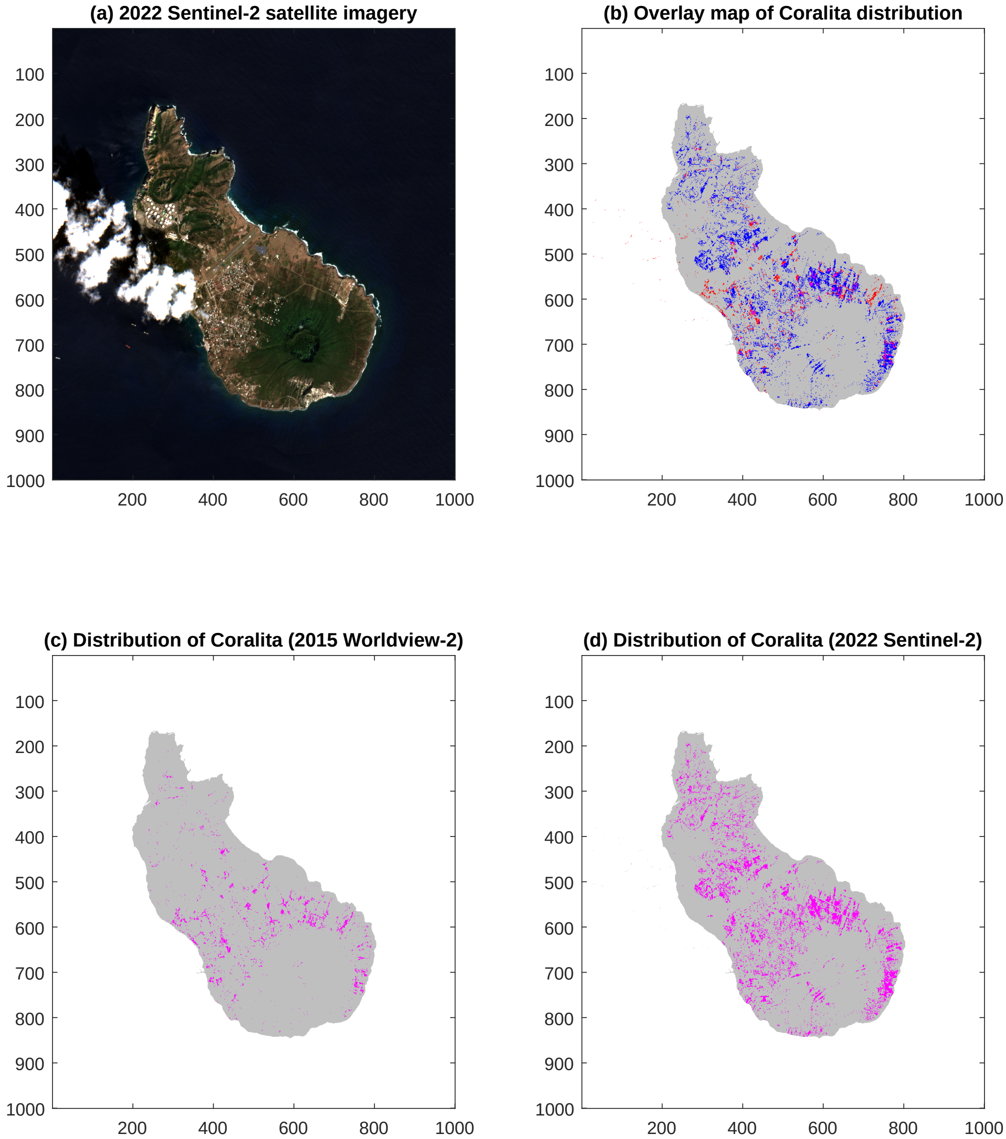

Figure 3.7: (a) 2022 Sentinel-2 satellite imagery, (b) the distribution of Coralita obtained by overlaying the 2015 Worldview-2 map (red) with the 2022 Sentinel-2 map (blue), (c) the distribution of Coralita in the 2015 Worldview-2 map, and (d) the distribution of Coralita in the 2022 Sentinel-2 map

The 2022 Sentinel-2 image in Figure 3.7 (a) displays relatively clear conditions with almost no cloud cover over the island. Nevertheless, 20.64% of the image is covered by thick clouds, especially in the western part and the western tip of the island. In Figure 3.7 (d), a notably different Coralita distribution is observed in the 2022 Sentinel-2 map when compared to the 2015 Worldview-2 map in Figure 3.4 (c). Figure 3.7 (b) highlights a denser and more widespread Coralita cover across St. Eustatius in the 2022 Sentinel-2 map. Increased Coralita cover is particularly noticeable in the Southern part of the Quill volcano, as well as in the Central, Northern and Northwestern regions of the island, as seen in Figure 3.7.

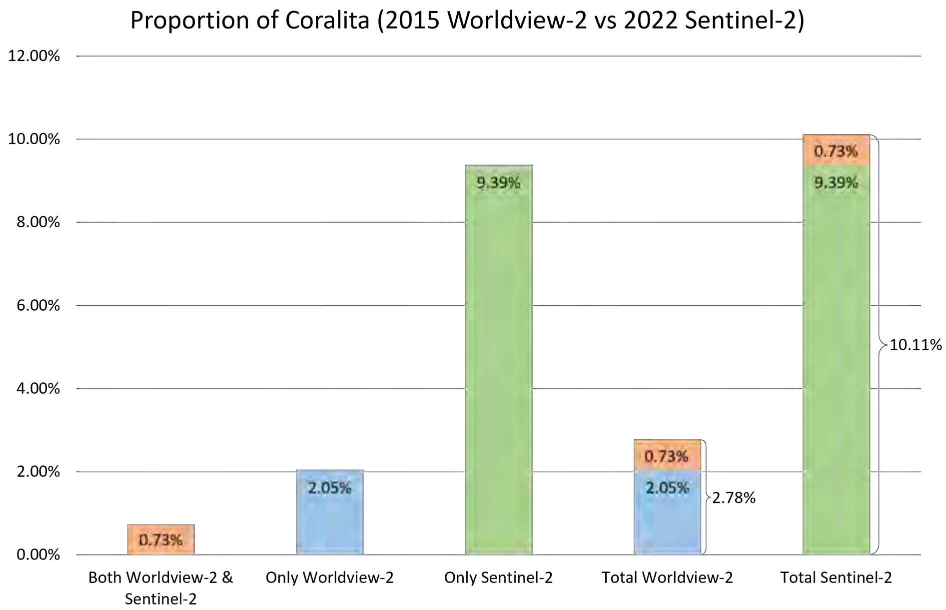

Figure 3.8: Bar chart of the proportion of pixels classified as Coralita on the 2015 Worldview-2 map and 2020 Sentinel-2 map

Figure 3.8 also demonstrates the significant difference in Coralita coverage across St. Eustatius between the two images, with the 2022 Sentinel-2 map revealing approximately 3.5 times more Coralita patches than the 2015 Worldview-2 image. This mirrors the results obtained from the comparison between the 2015 Worldview-2 image and the 2020 Sentinel-2 image in Section 3.1.2.

Despite the denser Coralita coverage depicted in the Sentinel-2 image, there is still limited overlap of approximately 0.73% in Coralita pixels between the two, suggesting disparities in pixel identification. Coralita cover in the Northern and Northwestern regions (within Boven National Park) appears improbable, as no Coralita patches were detected during the field survey.

Upon closer scrutiny, we still note the presence of smaller and newer Coralita patches emerging in close proximity over time, suggesting potential spread since 2015. However, it is crucial to acknowledge that the SVM model's accuracy for Coralita classification in the 2022 Sentinel-2 image is approximately 93.3%, lower than that of the 2015 Sentinel-2 image, underscoring the presence of inconsistencies in Coralita classification.

Nonetheless, there is a documented increase in Coralita cover by 2.12% in the 2022 Sentinel-2 map compared to the 2020 Sentinel-2 map, and an overall rise of 6.98% compared to the 2015 Sentinel-2 map. Additionally, there appears to be a probable spread of Coralita in the North, Northeastern, and Eastern part of the Quill volcano, evidenced by the expansion and emergence of smaller, newer and denser Coralita patches.

3.1.4 Comparison of Coralita distribution over the years

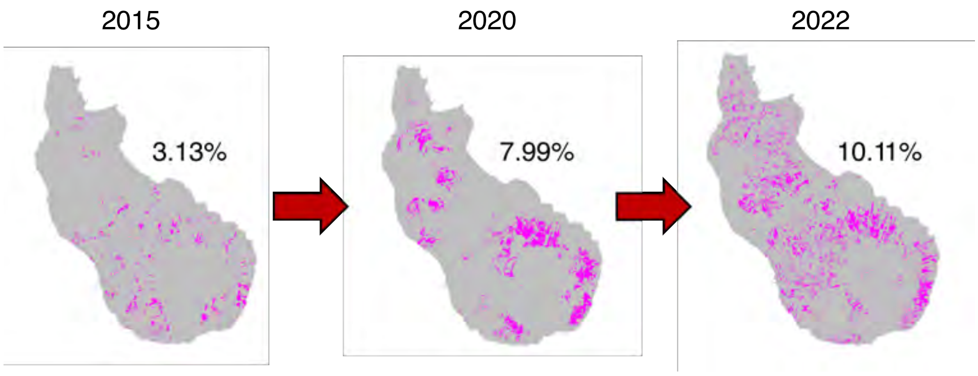

Figure 3.9: Distribution of Coralita across the years

Comparing Coralita distribution and proportion over the years reveals notable trends. In 2015, Coralita coverage in Worldview-2 and Sentinel-2 images was 3%, increasing to 8% by 2020 and reaching 10% by 2022. These results indicate a consistent rise in Coralita coverage, suggesting that Coralita has indeed spread since 2015 by approximately 7% over the years.

However, it is important to note there is also a decline in SVM model accuracy from 94.5% in 2015 to 92.4% in 2020 and 93.3% in 2022. This decline suggests an increase in classification inconsistencies, potentially resulting from an overclassification of Coralita pixels. Particularly in the 2020 Sentinel-2 image, there is subtle yet widespread cloud cover which is likely to be inadequately accounted for in cloud cover estimations. This cover can distort pixel colours, affecting classification accuracy. Moreover, the 2020 Sentinel-2 image depicts drier conditions in St. Eustatius with reduced green foliage and diminished vegetation health compared to 2015 and 2022. Hence, there is a possibility that the colour of other vegetation pixels closely resembles Coralita patches in the 2020 images, given the brown diminished state of all vegetation, including Coralita. This variation in Coralita foliage and health highlights the dynamic nature of its population. These changes may be attributed to seasonal variations inherent in St. Eustatius' tropical climate, characterised by alternating dry and wet seasons, which can significantly impact the growth patterns of Coralita. Further investigation reveals that three months prior to the 2020 Sentinel-2 image, the average temperature and relative humidity were 28.0 °C and 73.3%, respectively, compared to 26.7 °C and 80.7% in 2015, and 26.3 °C and 75.3% in 2022 (Time and Date, nd). These higher temperatures indicate hotter environmental conditions, potentially contributing to the reduced green foliage and diminished vegetation health seen in the 2020 Sentinel-2 image. Similarly, the lower relative humidity implies reduced moisture in the air, leading to increased evaporation and potentially affecting soil moisture levels and Coralita's health.

Recognising the potential impact of cloud cover and diminished vegetation on pixel colours, we carefully reviewed and removed a total of 49 outlier Coralita and non-Coralita ground-truthing points, while also incorporating 93 new points. However, despite these adjustments, misclassification of Coralita persists, evidenced by the emergence of newer, larger, and denser Coralita patches across St. Eustatius, particularly in the Northern and Northwestern regions within Boven National Park. Field surveys conducted recently detected no Coralita presence in these areas, indicating that these patches are likely a result of misclassification. Despite efforts to improve ground-truthing with supplementary data and supervised classification, misclassification remains, indicating a genuine classification error.

In summary, the field survey and mapping efforts have proven that Coralita cover has increased by approximately 7% over the years, indicating that Coralita has indeed spread since 2015. However, it is also crucial to acknowledge the classification inaccuracies in the results. Cloud cover and Coralita dynamics, encompassing growth, spread, and potential changes in vegetation colour could contribute to the inaccuracies in classifying and mapping the distribution and proportion of Coralita cover. Nevertheless, the Sentinel-2 satellite still proves to be a viable alternative to the Worldview-2 satellite. For more accurate results, future research should leverage additional Sentinel-2 images with concurrent ground-truthing points, conduct analyses over extended periods, and consider the impact of seasonality on Coralita dynamics.

3.2 Results from the fieldwork

The first part of this section aims to provide information on the health and growth of Coralita using the different scenarios of Coralita removal (no removal, removal only during Interval 1, and removal during both Intervals 1 and 2) as shown in Figure 3.10. By comparing different images of the plots using different scenarios of Coralita removal, we will be able to evaluate the effectiveness of repeated above-ground removals on

Coralita's health and growth. The second part of this section uses stomatal conductance, leaf size, and biomass to quantitatively evaluate the effectiveness and extent of above-ground removal as a management strategy for controlling Coralita populations. Through both image observation and plant trait analysis, we aim to address the research question regarding how effective successive removal is on the health and growth of Coralita and to what extent it affects Coralita's health and growth.

Figure 3.10: Different scenarios of Coralita removal

3.2.1 Qualitative analysis of the effect of successive removal on the health and growth of Coralita through image observation

Tables 3.1 to 3.8 provide a qualitative summary of the observations of Coralita's health, as well as the growth and spread in each location across the 30 plots around St. Eustatius, based on the images captured over the 9 weeks. Detailed visuals for each plot are available in Appendix A.

3.2.1.1 Scenario 1: No removal of Coralita (outside experimental plot)

Table 3.1: Observations of the growth of Coralita outside experimental plot and the results from Pearson's Chi-squared test

Observation of Coralita growth outside experimental plot	Interval 1	Interval 2	Interval 3
Most growth	12 plots: N2, N3, N4, N5, N6, E1, E4, E6, W1, U3, U5, U6	16 plots: N1, S1, S2, S3, S4, S5, S6, E2, E3, E5, W2, W3, W4, W5, W6, U2	2 plots: U1, U4
Moderate growth	8 plots: S5, E5 ,W2, W4, W5, W6, U2, U4	12 plots: N2, N3, N4, N5, N6, E1, E4, E6, W1, U1, U5, U6	10 plots: N1, S1, S2, S3, S4, S6, E2, E3, W3, U3
Minimal growth	10 plots: N1, S1, S2, S3, S4, S6, E2, E3, W3, U1	2 plots: U3, U4	17 plots: N2, N3, N4, N5, N6, S5, E1, E4, E5, E6, W1, W2, W4, W5, U2, U5, U6
p-value from Pearson's Chi-squared test = 1.27e-04***			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			
Note: There is missing information in plot W6 (refer to Appendix A)			

Table 3.2: Observations of the health of Coralita outside experimental plot and the results from Pearson's Chi-squared test

Observation of Coralita health outside experimental plot	Interval 1	Interval 2	Interval 3
Optimal health	9 plots: N2, N3, N4, N5, N6, E1, W1, U5, U6	19 plots: N1, S1, S2, S3, S4 ,S5, S6, E2, E3, E4, E5, E6, W2, W3, W4, W5, W6, U2, U3	2 plots: U1, U4
Moderate health	9 plots: S1, S5, E4, E5, E6, W2, W6, U1, U4	6 plots: N2, N3, N4, N5, W1, U5	15 plots: N1, N6, S2, S3, S4, S6, E1, E2, E3, W3, W4, W5, U2, U3, U6
Suboptimal health	12 plots: N1, S2, S3, S4, S6, E2, E3, W3, W4, W5, U2, U3	5 plots: N6, E1, U1, U4, U6	12 plots: N2, N3, N4, N5, S1, S5, E4, E5, E6, W1, W2, U5
p-value from Pearson's Chi-squared test = 1.80e-04***			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			
Note: There is missing information in plot W6 (refer to Appendix A)			

No Coralita was removed outside the experimental plot in Scenario 1 and hence it serves as a baseline for comparison with Scenarios 2 and 3. Although no Coralita was removed, the most robust growth and expansion occurred during Interval 2, spanning 16 plots, followed by Interval 1 with 12 plots (Table 3.1). This growth trend corresponds with Coralita's overall health, with 19 plots showing optimal health during Interval 2, compared to 9 plots in Interval 1 (Table 3.2). Interval 2 not only witnessed vigorous growth and spread but also had the highest number of plots with moderate growth levels. As anticipated, the majority of plots with minimal growth were observed in Interval 3, totalling 17 plots. Interestingly, both Intervals 1 and 3 exhibited an equal number of plots indicating suboptimal health. Generally, across the intervals, we observed an even distribution of plots across different growth and health levels at the start of Interval 1. However, in Interval 2, a majority of the plots became healthier, exhibiting the most growth and a decline in Coralita's growth and health is observed in Interval 3.

Generally, with no removal occurrence, a greater number of plots still exhibited the highest growth and optimal health during Interval 2, followed by Interval 1 and then Interval 3. This pattern indicates that more plots experienced a visible improvement in health and growth during Interval 2, only to subsequently deteriorate to a state worse than in Interval 1. Despite the absence of removal activities, we witness a notable shift in Coralita's health and growth within a relatively brief timeframe, highlighting its dynamic nature. This suggests that even without the removal activities, environmental factors exert a significant influence on Coralita's growth and health.

Assuming constant seasonality and environmental conditions throughout the two-month experimental period, one would expect Coralita to continue growing and maintaining similar levels of health. However, this is not observed, as Coralita's health and growth diminishes in Interval 3, characterised by reduced life Coralita plant material and deteriorating health with an increase in brown, dry, and dead leaves, as well as less green foliage.

Furthermore, this observed trend holds statistical significance as the p-values were less than the significance levels, indicating a notable association between Coralita's health and growth levels and the intervals. This also suggests that environmental factors likely impact Coralita's health and growth levels observed across the intervals.

Upon further examination and calculation (Appendix B), we find that the average temperature and relative humidity prior to the removal sessions were 25.7 °C and 73.4%, respectively, during Interval 1, as opposed to 26.4 °C and 76.3% in Interval 2, and 27.7 °C and 74.8% in Interval 3. The heightened humidity levels observed during Interval 2 suggest an increase in atmospheric moisture, potentially resulting in reduced evaporation and greater soil moisture retention, which could positively impact the health and growth of Coralita.

Conversely, the elevated temperatures recorded throughout Interval 3 indicate hotter environmental conditions, likely contributing to the decline in green foliage and diminished vegetation health. However, it is important to note that environmental conditions may vary across different Coralita plot locations, which may not fully explain the variation in trends observed in outlier urban plots U1 and U4. Nevertheless, findings from Scenario 1 demonstrate that environmental factors play a significant role in influencing Coralita's health and growth. Despite the absence of Coralita removal, we observed improved Coralita growth and health during Interval 2, followed by diminished growth and health during Interval 3.

3.2.1.2 Scenario 2: Removal of Coralita only in Interval 1 (in the outer barrier)

Table 3.3: Observations of the growth of Coralita in the outer barrier and the results from Pearson's Chi-squared test

Observation of Coralita growth in the outer barrier	Interval 1	Interval 2	Interval 3
Most growth	16 plots: N1, N2, N3, N4, N5, N6, E4, E6, W1, W6, U2, U3, U4, U5, U6, E1	13 plots: S1, S2, S3, S4, S5, S6, E2, E3, E5, W2, W3, W4, W5	1 plot: U1
Moderate growth	5 plots: E2, E5, W2, W3, U1	6 plots: N2, N3, E4, E6, W1, W6	19 plots: N1, N4, N5, N6, S1, S2, S3, S4, S5, S6, E1, E3, W4, W5, U2, U3, U4, U5, U6
Minimal growth (Extremely little growth*)	9 plots: S1, S2, S3, S4, S5, S6, E3, W4, W5	11 plots: N1, N4, N5, N6, E1, U1, U2, U3, U4*, U5, U6	9 plots: N2, N3, E2, E4, E5, E6, W1, W2, W3
p-value from Pearson's Chi-squared test = 4.32e-05***			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			
Note: In plot E2, there was more spread of Coralita in Interval 3 than Interval 1 although its growth was lower in Interval 3 than in Interval 1. There is missing information in plot W6 (refer to Appendix A)			

Table 3.4: Observations of the health of Coralita in the outer barrier and the results from Pearson's Chi-squared test

Observation of Coralita health in the outer barrier	Interval 1	Interval 2	Interval 3
Optimal health	9 plots: N4, N5, N6, E1, W1, U3, U4, U5, U6	18 plots: N3, S1, S2, S3, S4, S5, S6, E2, E3, E4, E5, E6, W2, W3, W4, W5, W6, U2	3 plots: N1, N2, U1
Moderate health	12 plots: N3, S5, E2, E3, E4, E5, E6, W2, W3, W6, U1, U2	4 plots: N1, N2, W1, U3	14 plots: N4, N5, N6, S1, S2, S3, S4, S6, E1, W4, W5, U4, U5, U6
Suboptimal health	9 plots: N1, N2, S1, S2, S3, S4, S6, W4, W5	8 plots: N4, N5, N6, E1, U1, U4, U5, U6	12 plots: N3, S5, E2, E3, E4, E5, E6, W1, W2, W3, U2, U3
p-value from Pearson's Chi-squared test = 0.00128**			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			
Note: There is missing information in plot W6 (refer to Appendix A)			

With Coralita removal only in Interval 1, the majority of plots in Intervals 1 and 2 exhibited the highest levels of growth, with 16 plots and 13 plots, respectively (Table 3.3). Similarly, a majority of plots in Intervals 1 and 2 demonstrated optimal health, with 9 plots and 18 plots, respectively (Table 3.4). Although fewer plots showed the highest growth in Interval 2 compared to Interval 1, a greater number of plots indicated optimal health. Interestingly, the majority of plots with minimal growth were also from Interval 2, closely followed by Intervals 1 and 3, with 9 plots each exhibiting minimal growth. However, this trend does not align with Coralita's health, as more plots in Interval 3 displayed suboptimal health.

Overall, Interval 1 displayed an even distribution of plots across different growth and health levels. Following the removal in Interval 1, Interval 2 saw both growth and a decline in Coralita's growth, with 13 plots showing the most growth and 11 plots displaying minimal growth. Nevertheless, the majority of plots in Interval 2 still showed improved health. Without the removal of Coralita in Interval 2 and allowing it to continue growing, a decline in growth was observed, with 19 plots displaying moderate growth and 9 plots displaying minimal growth in Interval 3. This trend was also reflected in Coralita's health, with 14 plots exhibiting moderate health and 12 plots displaying suboptimal health.

Generally, in Scenario 2, where Coralita was removed once from the outer barrier during Interval 1, a similar trend to baseline Scenario 1 emerges. Even after a single removal session, a higher number of plots demonstrated optimal health during Interval 2, followed by Interval 1 and then Interval 3. Beyond potential environmental influences, this phenomenon of improved Coralita health in Interval 2 post-removal may be attributed to the tuberous roots of the Coralita plant remaining intact during the experiment. Only above-ground portions were harvested, leaving these roots capable of asexual reproduction and nutrient storage, facilitating rapid resprouting even after above-ground removal (Jesse et al., 2020; N.Huisman et al., 2021).

Furthermore, the removal of Coralita eliminates dead and damaged plant material, allowing Coralita to redirect its energy toward growing new leaves rather than sustaining dying ones. This removal also offers Coralita the opportunity to regrow unhindered by competition for space. Given Coralita's vine-like nature, which may hinder certain leaves from receiving adequate sunlight for photosynthesis, the additional space allows for unimpeded regrowth, fully exposing new Coralita leaves to sunlight and facilitating photosynthesis. Thus, observing an improvement in Coralita health during Interval 2 remains plausible even after just one removal session.

However, unlike in Scenario 1, more plots exhibit the highest growth during Interval 1 in Scenario 2, followed by Interval 2 and then Interval 3. After Coralita removal in Interval 1, one might anticipate less growth than before, considering the Coralita in Interval 1 had been growing for a longer period compared to the shorter growth timeframe before removal in Interval 2. However, this explanation does not entirely account for the trends observed in Interval 3, where both Coralita health and growth reach their lowest levels.

Since no removal occurred in Interval 2 and assuming constant environmental conditions, Coralita should have continued growing, exhibiting more growth than in Interval 3 while maintaining similar levels of health. However, this is not observed, as Coralita's health and growth decline in Interval 3, characterised by reduced plant material and deteriorating health with an increase in brown, dry, and dead leaves, as well as less green foliage. This unexpected outcome suggests that the removal of Coralita in Interval 1 could have a lasting impact on Coralita's health and growth, explaining the diminished health and growth observed only in Interval 3, or that the increase in temperatures and decreased relative humidity had strongly influence Coralita's health and growth, aligning with the trends observed in Scenario 1 and explaining the observed decline.

Nevertheless, findings from Scenario 2 demonstrate the complex interplay, between Coralita removal, environmental conditions, and its subsequent health and growth, suggesting that multiple factors may contribute to observed patterns over time. These patterns, where the highest growth was observed in Interval 1, followed by Interval 2, and then Interval 3, while Coralita health showed optimal levels in Interval 2, followed by Interval 1, and then Interval 3, are statistically significant. The obtained p-values, falling below the significance levels, provide robust evidence supporting a significant association between growth and health levels and the intervals.

3.2.1.3 Scenario 3: Removal of Coralita in both Intervals 1 and 2 (in the inner square)

Table 3.5: Observations of the growth of Coralita in the inner square and the results from Pearson's Chi-squared test

Observation of Coralita growth in the inner square	Interval 1	Interval 2	Interval 3
Most growth	17 plots: N2, N3, N4, N5, N6, E1, E4, E6, W1, W2, W5, U1, U2, U3, U4, U5, U6	12 plots: S1, S2, S3, S4, S5, S6, E2, E3, E5, W3, W4, W6	0 plots
Moderate growth (Extremely little growth/no growth*)	12 plots: S1, S2, S3, S4, S5, S6, E2, E3, E5, W3, W4, W6	18 plots: N1, N2, N3, N4, N5, N6, E1, E4, E6, W1, W2, W5, U1, U2, U3, U4*, U5, U6	0 plots
Minimal growth (Extremely little growth/no growth*)	0 plots	0 plots	29 plots: N1*, N2*, N3*, N4, N5*, N6, S1*, S2, S3*, S4*, S5*, S6, E1*, E2*, E3*, E4*, E5*, E6*, W1*, W2*, W3*, W4*, W5*, U1*, U2*, U3*, U4*, U5, U6
p-value from Pearson's Chi-squared test = 2.2e-16***			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			
Note: There is missing information in plot W6 (refer to Appendix A)			

Table 3.6: Observations of the health of Coralita in the inner square and the results from Pearson's Chi-squared test

Observation of Coralita health in the inner square	Interval 1	Interval 2	Interval 3
Optimal health	7 plots: N3, N4, N6, E1, W1, U4, U5	23 plots: N1, N2, N5, S1, S2, S3, S4, S5, S6, E2, E3, E4, E5, E6, W2, W3, W4, W5, W6, U1, U2, U3, U6	0 plots
Moderate health	21 plots: N2, N5, S1, S3, S4, S5, S6, E2, E3, E4, E5, E6, W2, W3, W4, W5, W6, U1, U2, U3, U6	6 plots: N3, N4, N6, E1, W1, U5	2 plots: S2, U4
Suboptimal health (Because no growth*)	1 plots: S2	1 plot: U4*	27 plots: N1, N2*, N3*, N4, N5*, N6, S1*, S3*, S4*, S5*, S6, E1*, E2*, E3*, E4*, E5*, E6*, W1*, W2*, W3*, W4*, W5*, U1, U2, U3, U5, U6
p-value from Pearson's Chi-squared test = 2.2e-16***			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			
Note: There is missing information in plots N1 and W6 (refer to Appendix A)			

With Coralita removals occurring in both Intervals 1 and 2, distinct trends emerge across various health and growth levels within different intervals. All plots within Intervals 1 and 2 exhibited either the highest growth or moderate levels of growth, with 17 plots displaying the most growth in Interval 1 and 12 plots in Interval 2, while 12 plots in Interval 1 showed moderate growth and 18 plots in Interval 2 (Table 3.5). Similarly, these intervals saw plots displaying optimal health, with Interval 2 showing 16 more plots with optimal health compared to Interval 1 (Table 3.6). It is also noted that there were fewer plots exhibiting moderate health in Interval 2 compared to Interval 1, even though more plots in Interval 2 exhibited moderate growth.

All the plots in Interval 3 exhibited the least growth, with 23 of these plots showing extremely limited or no growth at all. This pattern is also evident in Coralita's health, with the majority of the plots (27) displaying suboptimal health. 18 of these plots were classified as having suboptimal health due to the absence of growth in Interval 3, preventing the proper assessment of leaf colour and overall plant health.

Similar to Scenario 2, a higher number of plots demonstrate optimal health during

Interval 2, followed by Interval 1 and then Interval 3. However, unlike Scenario 2, we observe the full extent of the impact of removal during Interval 2 in Interval 3. In Scenario 3, almost all plots show suboptimal health in Interval 3, contrasting with Scenario 2, where a spread of plots across different health levels is still evident. This indicates that the second removal significantly affected both the health and growth of Coralita.

Additionally, similar to Scenario 2, a greater number of plots exhibit the highest growth during Interval 1, followed by Interval 2 and then Interval 3. This pattern aligns with the expectation that with each removal, Coralita's growth would diminish due to the depletion of reserves stored in its tuberous roots necessary for regrowth.

To contextualise these findings, we can draw parallels with Lin et al. (2018) study, whereby the effects of removals on plant growth and resource allocation were explored, focusing on the common ragwort (*Jacobaea vulgaris*) as an invasive species. Lin et al. (2018) studied the removal of plant shoot material once after 8 and 12 weeks of growth from seed in laboratory conditions. The results indicated that maintaining structural root cells is energetically costly, with larger structural roots consuming greater amounts of stored carbohydrates. Although the extent of reliance on belowground reserves for subsequent above-ground biomass regrowth varies among species, the initial recovery of photosynthetically active biomass after total above-ground removal is heavily dependent on root reserves, as highlighted by Martínková et al. (2021). Despite methodological disparities such as plant species, sample sizes, and environmental conditions, these studies collectively highlight the potential for an intensive consumption of root reserves following removals, explaining the observed minimal Coralita growth in Interval 3, where plots displayed significantly limited growth or none at all.

In general, Interval 1 showed the most growth but with moderate health, whereas

Interval 2 displayed moderate levels of growth with optimal health. In contrast, Interval 3 exhibited the least amount of growth with suboptimal health.

Nevertheless, findings from Scenario 3 demonstrate that when Coralita was removed twice from the inner square during Intervals 1 and 2, a clear correlation emerged between successive removals in both intervals, displaying a decline in Coralita's growth and health over time. This observed trend holds statistical significance as the p-values were less than the significance levels, indicating a robust association between Coralita's health and growth levels and the intervals.

3.2.2 Comparison across different scenarios of removal

Table 3.7: Observations of the number of plots on Coralita growth across all scenarios and the results from Pearson's Chi-squared test

Number of plots observed (in total)	Interval 1	Interval 2	Interval 3
Most growth	45	41	3
Moderate growth	25	36	29
Minimal growth	19	13	55
p-value from Pearson's Chi-squared test = 2.58e-15***			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			

Table 3.8: Observations of the number of plots on Coralita health across all scenarios and the results from Pearson's Chi-squared test

Number of plots observed (in total)	Interval 1	Interval 2	Interval 3
Optimal health	25	60	5
Moderate health	42	16	31
Suboptimal health	22	14	51
p-value from Pearson's Chi-squared test = 2.2e-16***			
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1			

Each of the three scenarios reveals distinct trends in the growth and health of Coralita over time. In Scenario 1, there is an evident improvement in both growth and health during Interval 2. Conversely, Scenario 2 presents a mixed picture, with both improvement and decline in Coralita's growth observed in Interval 2, while only an improvement in health is observed. Similarly, Scenario 3 demonstrates an improvement in Coralita's health during Interval 2, but unlike Scenario 2, it shows a decline in Coralita's growth.

Across all scenarios of removal, we observe that the decline in Coralita's health and growth is particularly pronounced when Coralita was removed in both Intervals 1 and 2. This is evidenced by the increasing number of plots showing minimal growth and suboptimal health in Interval 3. Upon closer examination, it becomes apparent that across the different removal scenarios, the p-values consistently fall significantly below the significance levels. This robust evidence supports a significant association between growth and health levels and the intervals (Tables 3.7 and 3.8). Consequently, the observed trends in growth and health across the different intervals are statistically significant.

Therefore, through image observation, we can conclude that repeated above-ground removals significantly impact the health and growth of Coralita, with the effect being particularly pronounced in the last interval. However, it is worth noting that while the observed trends are similar to the baseline in Scenario 1, where Interval 3 predominantly featured plots with minimal growth and moderate to suboptimal health, it is important to highlight that the extent of diminished Coralita health and growth becomes more pronounced with the increased number of plots displaying minimal growth and suboptimal health.

3.2.3 Quantitative analysis of the effect of successive removal on the health and growth of Coralita

Aside from image observation, we have conducted measurements on several key plant traits, including stomatal conductance (on both adaxial and abaxial surfaces), leaf size (comprising leaf length, width, and thickness), and biomass, at various intervals of the Coralita removal process. Through the quantitative assessment of changes in these traits across intervals, we can comprehensively evaluate the impact and extent of successive removals on Coralita's health and growth. Additionally, we can assess the effectiveness of above-ground removal as a management strategy for controlling Coralita populations.

By analysing these plant traits over time, we gain insights into how Coralita responds physiologically and morphologically to removal events. This approach allows us to quantify the direct effects of removals on Coralita's physiological functioning, leaf morphology, and overall biomass accumulation. Furthermore, it enables us to discern any trends or patterns in trait variation that may indicate the success or limitations of above-ground removal as a means of managing Coralita populations.

Incorporating these quantitative measurements enhances the depth and precision of our understanding, complementing the qualitative insights gained from image observation. Together, these approaches provide a robust framework for assessing the efficacy of removal strategies and informing evidence-based management decisions for controlling Coralita infestations.

3.2.3.1 Effect of successive removal on stomatal conductance

Stomatal conductance on the upper (adaxial) leaf surface

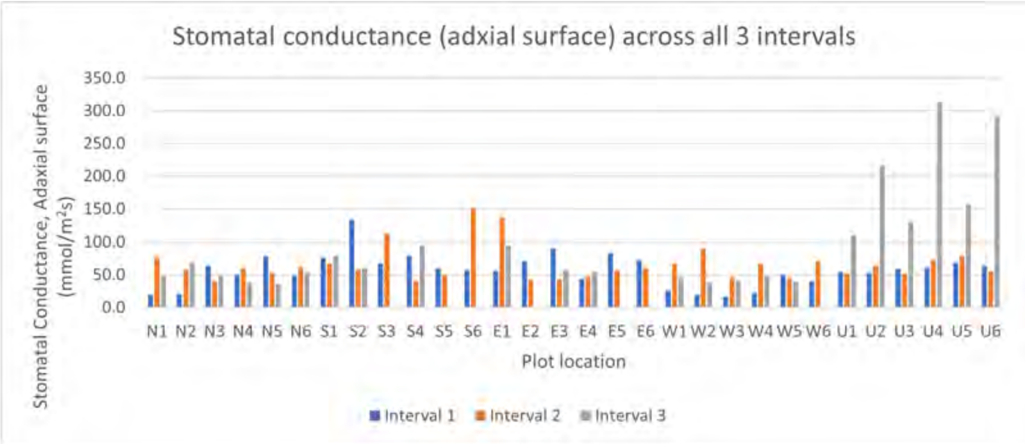

Figure 3.11: Stomatal conductance (adaxial surface) across all 3 intervals

In Figure 3.11, it appears that there is no discernible trend for stomatal conductance on the adaxial surface of Coralita leaves across the intervals, indicating no obvious patterns or consistent higher or lower levels of stomatal conductance. However, it is notable that all 6 plots in the urban area exhibit a distinct trend compared to the other plots, showing significantly higher stomatal conductance in Interval 3 compared to any other interval. Nonetheless, averaging stomatal conductance across all 30 locations reveals that Interval 1 has the lowest average stomatal conductance of 57.0 mmol/m^{2}s, followed by Interval 2 with 66.0 mmol/m^{2}s, and finally Interval 3 with the highest average stomatal conductance of 74.6 mmol/m^{2}s. This result is unexpected, as we hypothesised that the stomatal conductance will decrease over the intervals as a result of compromised health following the removal sessions. However, contrary to our expectations, there is an observed increase in stomatal conductance over the intervals.

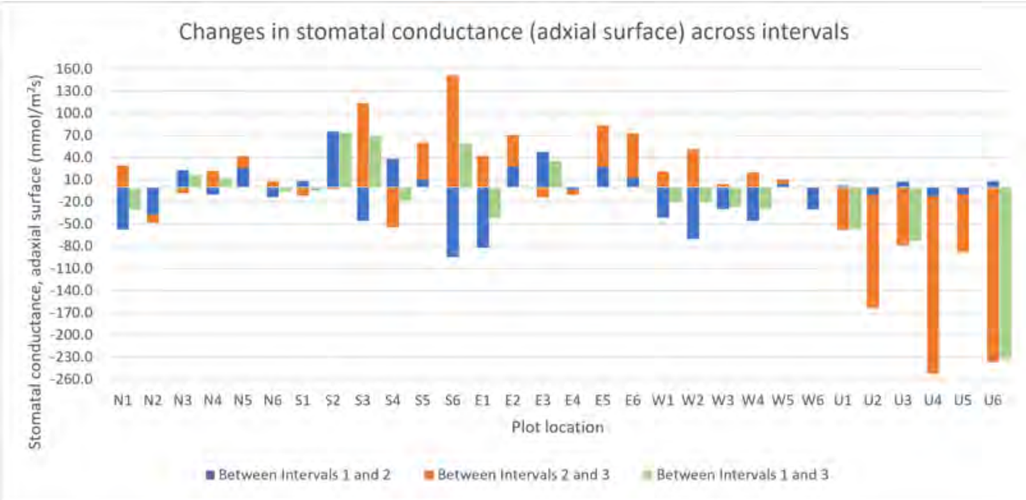

Figure 3.12: Changes in stomatal conductance (adaxial surface) across all 3 intervals

Similarly, in Figure 3.12, there is no clear trend, but an even distribution of plots with both increases and decreases in stomatal conductance across the different intervals is observed. The magnitude of these changes is significantly larger between Intervals 2 and 3 compared to Intervals 1 and 2, with urban area plots showing a substantial increase in stomatal conductance from Intervals 2 to 3. On average, there is a higher increase in stomatal conductance across all 30 plots between Intervals 1 and 2 (9.0 mmol/m^{2}s) than between Intervals 2 and 3 (8.8 mmol/m^{2}s). The total increase in stomatal conductance on the adaxial surface of Coralita leaves between Intervals 1 and 3 is 17.1 mmol/m^{2}s.

Table 3.9: LMM results for stomatal conductance (adaxial surface)

REML criterion at convergence: 928.9				
Scaled residuals				
Min	1Q	Median	3Q	Max
-1.477	-0.5011	-0.1361	0.2125	4.727

Random effects			
Groups	Name	Variance	Standard deviation
ID	(Intercept)	0	0
Residual		2553	50.53
Number of observation: 89, groups: ID, 30			

Fixed effects					
	Estimate	Standard error	df	t value	Pr(>|t|)
(Intercept)	56.96	9.225	86	6.174	2.13e-08 ***
Interval 1 Interval 2	9.047	13.05	86	0.693	0.490
Interval 1 Interval 3	17.69	13.16	86	1.344	0.182
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1					

Correlation of Fixed Effects		
	(Intr)	Intrl2
Interval 1 Interval 2	-0.707	
Interval 1 Interval 3	-0.701	0.496

Analysing the LMM in Table 3.9, a very low p-value (2.13e-08) for the intercept suggests statistical significance, indicating that the baseline level (Interval 1) of stomatal conductance on the adaxial surface of Coralita leaves significantly differs from zero. However, there are high p-values between Intervals 1 and 2 (0.490) and between Intervals 1 and 3 (0.180), indicating statistical insignificance and suggesting that there is no significant difference in stomatal conductance on the adaxial surface of Coralita leaves between these intervals. A positive correlation (0.496) between Interval 2 and Interval 3 is observed, indicating that stomatal conductance at Interval 2 tends to be related to those at Interval 3. Overall, these results suggest that Interval 1 holds statistical significance as a baseline for comparison with Intervals 2 and 3, and that the observed increase in stomatal conductance across the intervals is not statistically significant.

Effect of successive removal on stomatal conductance (abaxial surface)

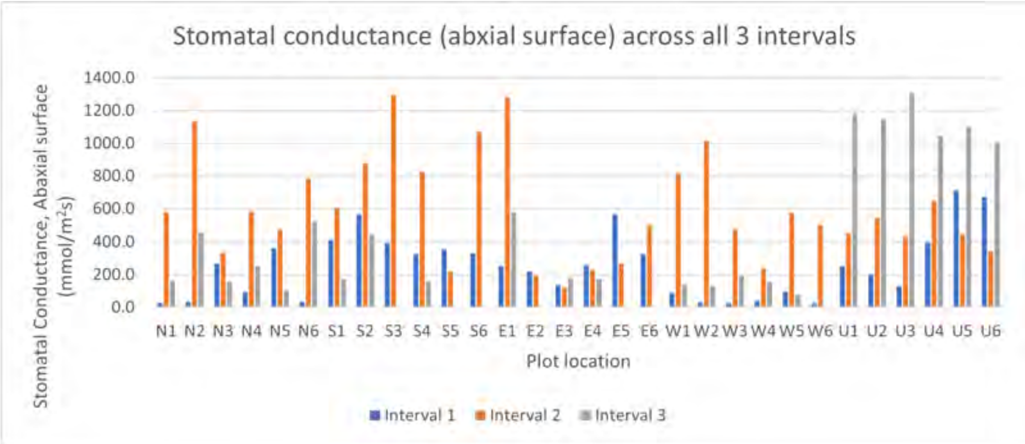

Figure 3.13: Stomatal conductance (abaxial surface) across all 3 intervals

Figure 3.13 show that the majority of the plots exhibit the highest stomatal conductance on the abaxial surface in Interval 2, with an average of 594.8 mmol/m^{2}s across all plots, followed by Interval 3 with 373.8 mmol/m^{2}s, and then Interval 1 at the lowest with 253.8 mmol/m^{2}s. However, the urban plots deviate from this trend, showing the highest stomatal conductance in Interval 3 instead of Interval 2. This result is unexpected, as we hypothesised that the stomatal conductance will decrease over the intervals as a result of compromised health following the removal sessions. However, contrary to our expectations, there is an observed increase in stomatal conductance from Intervals 1 to 2 and a decrease from Intervals 2 to 3.

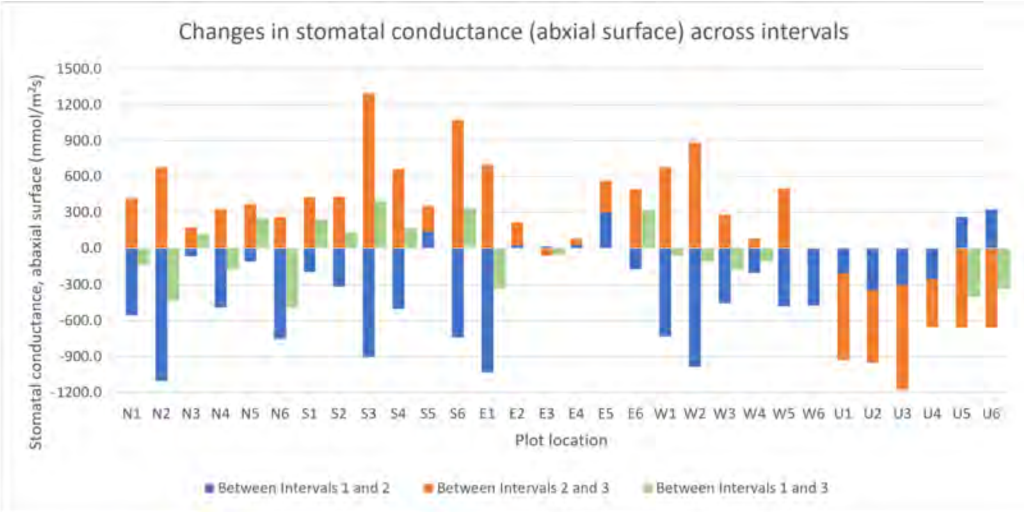

Figure 3.14: Changes in stomatal conductance (abaxial surface) across the intervals

In Figure 3.14, the majority of plots show significant changes in stomatal conductance between Intervals 1 and 2, and between Intervals 2 and 3. Most plots between Intervals 1 and 2 exhibit an increase in stomatal conductance, while a decrease is observed between Intervals 2 and 3. On average, the increase in stomatal conductance across all 30 plots between Intervals 1 and 2 is 341 mmol/m^{2}s, while the decrease between Intervals 2 and 3 averages 224.3 mmol/m^{2}s. Overall, between Intervals 1 to 3, there is a general increase of 112.1 mmol/m^{2}s in stomatal conductance on the abaxial surface of Coralita leaves across all 30 plots.

Table 3.10: LMM results for stomatal conductance (abaxial surface)

REML criterion at convergence: 1250				
Scaled residuals				
Min	1Q	Median	3Q	Max
-1.416	-0.6783	-0.2849	0.4005	2.84

Random effects			
Groups	Name	Variance	Standard deviation
ID	(Intercept)	2467	49.67
Residual		104500	323.3
Number of observation: 89, groups: ID, 30			

Fixed effects					
	Estimate	Standard error	df	t value	Pr(>|t|)
(Intercept)	253.8	59.73	85.91	4.250	2.13e-08 ***
Interval 1 Interval 2	341.0	83.48	57.32	4.084	1.39e-04***
Interval 1 Interval 3	119.7	84.22	57.95	1.422	0.1604
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1					

Correlation of Fixed Effects		
	(Intr)	Intrl2
Interval 1 Interval 2	-0.699	
Interval 1 Interval 3	-0.693	0.496

Analysing the Linear Mixed Model (LMM) Table 3.10, we observe a low p-value of the intercept (5.41e-05) and between Intervals 1 and 2, suggesting statistical significance. This indicates a significant difference in stomatal conductance on the abaxial surface between intervals when compared to the baseline interval (Interval 1) and between Intervals 1 and 2. However, the estimated differences in stomatal conductance between Interval 1 and Interval 3 are not statistically significant, indicating that the changes between Intervals 1 and 3 are not significant. Similar to previous analyses, a positive correlation (0.496) between Interval 2 and Interval 3 is observed, suggesting that stomatal conductance at Interval 2 tends to be related to that at Interval 3. Overall, these results suggest that Interval 1 is statistically significant as a baseline for comparison with Intervals 2 and 3. Additionally, the observed increase in stomatal conductance from Intervals 1 to 2 is statistically significant, while the increase in stomatal conductance from Intervals 1 to 3 is not statistically significant. This indicates that this upward trend is relevant and meaningful only between Intervals 1 and 2, not between Intervals 1 and 3.

Effect of successive removal on stomatal conductance (both leaf surfaces)

Results from the quantitative analysis done within the inner square revealed that stomatal conductance on the abaxial surface of Coralita leaves is highest in Interval 2, followed by Interval 3 and then Interval 1. This trend is similar to the observations drawn from the image observation in the qualitative analysis, whereby optimal health was reported in Interval 2. This similarity in trend proves that Coralita health may be directly linked to the stomatal conductance on the abaxial surface of the Coralita leaves. Just like Hasanuzzaman et al. (2023) described, higher stomatal conductance indicates increased photosynthetic activity, which can contribute to the plant's overall vitality which is seen from the image observations in the qualitative analysis. However, it is notable that stomatal conductance in Interval 3 is higher than in Interval 1, contrary to the expected trend of it being lowest in Interval 3. Despite this observation, the LMM analysis suggests that the change in stomatal conductance between Intervals 1 and 3 is not statistically significant. This implies that the trend of higher stomatal conductance in Interval 3 may not accurately reflect the expected pattern and may not be significant enough to indicate that stomatal conductance should indeed be higher in Interval 3. Nonetheless, it is important to note that younger leaves also generally tend to display higher levels of photosynthesis as compared to older leaves (Freeland, 1952). Hence, it is probable that higher stomatal conductance as a result of higher photosynthesis could occurred in the younger leaves during Interval 3, explaining the higher stomatal conductance result observed in Interval 3 as compared to Interval 1.

Conversely, stomatal conductance on the adaxial surface demonstrates an inverse relationship with the overall trend observed. It peaks in Interval 3, followed by Interval 2, and then Interval 1. This unexpected observation contradicts the anticipated relationship, as high stomatal conductance in Interval 3 would typically indicate increased photosynthetic activity contributing to an overall improvement in Coralita's health during that interval. However, this improvement in stomatal conductance is not observed across the intervals.

Nevertheless, the LMM analysis reveals that the changes in stomatal conductance on the adaxial surface between Intervals 1 and 2, as well as Intervals 2 and 3, lack statistical significance. This suggests that the observed trend may not be sufficiently significant to establish a clear inverse relationship between stomatal conductance on the adaxial surface and the general trend of Coralita's health and growth.

Additionally, the adaxial surface typically possesses fewer stomata compared to the abaxial surface, and these stomata are often smaller and less involved in gas exchange processes, and are less sensitive to environmental signals (Wall et al., 2022; Wang et al., 1998). Consequently, this leads to discrepancies in measurements and trends in stomatal conductance between the two surfaces. Additionally, there seems to be little coherence between adaxial stomatal conductance measurements and observations from qualitative image analysis, as they exhibit different trends.

This inconsistency could also be attributed to variations in timing and weather conditions during stomatal conductance measurements. Factors such as solar radiation, which vary with weather conditions and time of day, directly impact photosynthesis and consequently affect stomatal conductance measurements. Thus, the relationship between stomatal conductance and Coralita health may not be as robust. Nonetheless, from the qualitative results, we can ascertain that Coralita's health is significantly affected by repeated removals above ground.

3.2.3.2 Effect of successive removal on leaf size

Effect of successive removal on leaf length

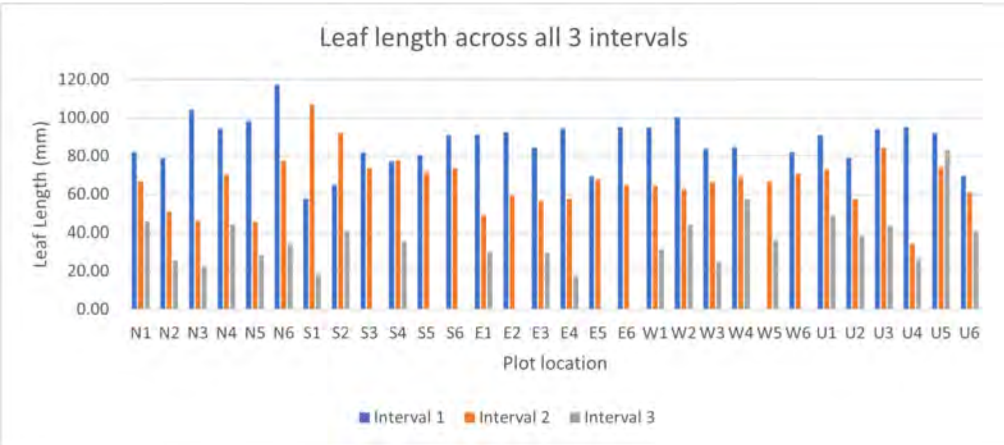

Figure 3.15: Leaf length across all 3 intervals

Figure 3.15 show that the majority of the plots exhibit the highest leaf length in Interval 1, with an average of 86.9 mm across all plots, followed by Interval 2 with 66.4 mm, and then Interval 3 at the lowest with 30.2 mm. However, plots S1 and S2 deviate from this trend, showing the highest leaf length in Interval 2 instead of Interval 1. Nonetheless, this outcome is anticipated, given that leaf length is likely to decrease over the intervals due to compromised growth following the removal sessions.

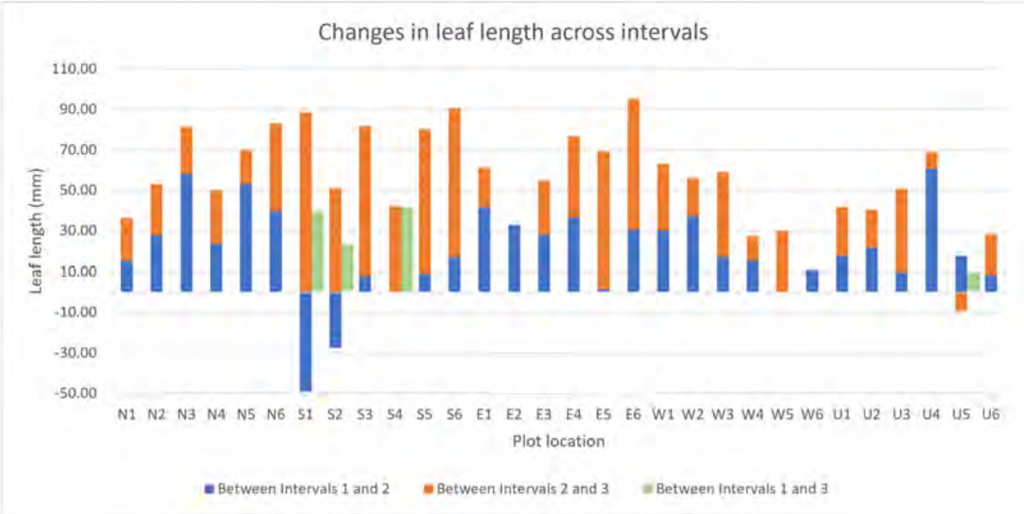

Figure 3.16: Changes in leaf length across the intervals

Furthermore, Figure 3.16 show that the majority of the plots display a significant decrease in leaf length between Intervals 1 and 2, Intervals 1 and 3, and Intervals 2 and 3, except for plots in the South (S1, S2) and plot U5, which exhibit an increase in leaf length between Intervals 1 and 2, and between Intervals 2 and 3, respectively. On average, the decrease in leaf length across all 30 plots is higher between Intervals 2 and 3, with a decrease of 36.2 mm compared to 20.5 mm between Intervals 1 and 2. Between Intervals 1 and 3, there is an average decrease of 56.9 mm in leaf length across all 30 plots.

Table 3.11: LMM results for leaf length

REML criterion at convergence: 709.6				
Scaled residuals				
Min	1Q	Median	3Q	Max
-2.052	-0.4999	-0.0183	0.5020	3.413

Random effects			
Groups	Name	Variance	Standard deviation
ID	(Intercept)	0	0
Residual		242	15.56
Number of observation: 87, groups: ID, 30			

Fixed effects					
	Estimate	Standard error	df	t value	Pr(>|t|)
(Intercept)	86.89	2.889	84	30.08	<2e-16 ***
Interval 1 Interval 2	-20.53	4.051	84	-5.068	2.36e-06***
Interval 1 Interval 3	-56.65	4.122	84	-13.74	<2e-16 ***
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1					

Correlation of Fixed Effects		
	(Intr)	Intrl2
Interval 1 Interval 2	-0.713	
Interval 1 Interval 3	-0.701	0.5

The LMM in Table 3.11 shows a low p-value of the intercept (2e-16), between Intervals 1 and 2 (2.36e-06), and between Intervals 1 and 3 (2e-16), suggesting statistical significance, indicating that there is a significant difference in leaf length between the intervals. A positive correlation (0.5) between Interval 2 and Interval 3 is observed, suggesting that leaf length at Interval 2 tends to be related to that at Interval 3. Overall, the results indicate that the effect of the observed changes in leaf length across the intervals is statistically significant. Overall, these results suggest that Interval 1 holds statistical significance as a baseline for comparison with Intervals 2 and 3, and that the observed decrease in leaf length across the intervals is statistically significant.

Effect of successive removal on leaf width

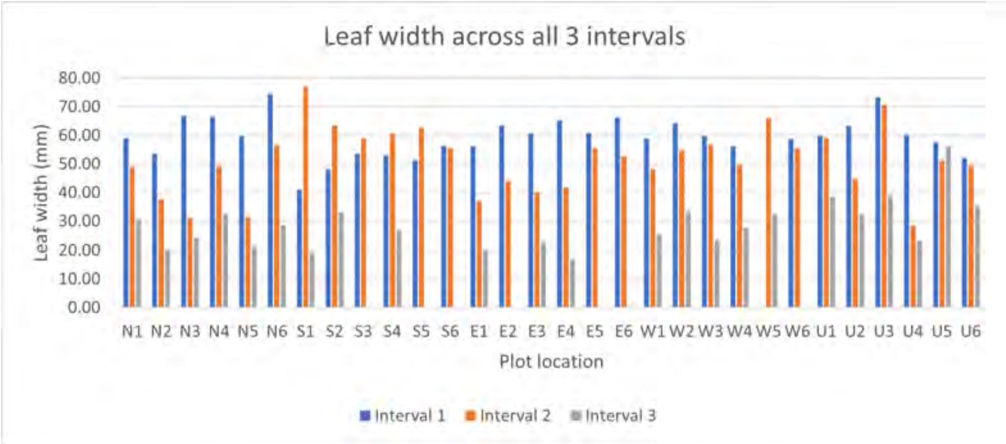

Figure 3.17: Leaf width across all 3 intervals

In Figure 3.17, the majority of plots have the highest leaf width in Interval 1, with an average of 59.3 mm across all plots, followed by Interval 2 with 51.4 mm, and then Interval 3 at the lowest of 22.9 mm. However, the South plots deviate from this trend, showing the highest leaf width in Interval 2 instead of Interval 1. Nonetheless, this outcome is anticipated, given that leaf width is likely to decrease over the intervals due to compromised growth following the removal sessions.

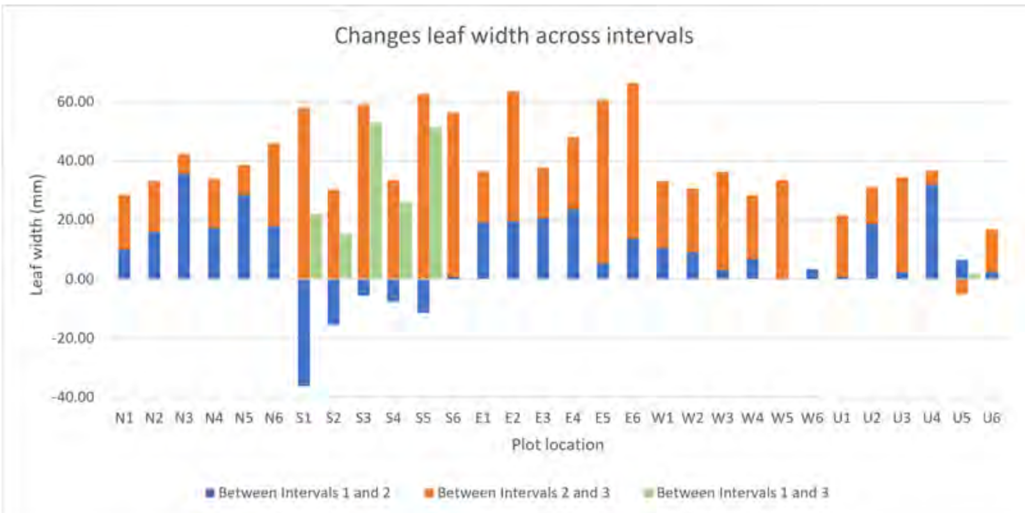

Figure 3.18: Changes in leaf width across the intervals

Furthermore, in Figure 3.18, the majority of plots exhibit a significant decrease in leaf width between Intervals 1 and 2, and Intervals 2 and 3. The decrease in leaf width between Intervals 1 and 2 is lower than between Intervals 2 and 3, with the South plots showing a noticeable increase in leaf width between Intervals 1 and 2. On average, the decrease in leaf width across all 30 plots is higher from Intervals 2 to 3, with a decrease of 28.3 mm compared to only 8.5 mm from Intervals 1 to 2. Between Intervals 1 and 3, there is an average decrease of 36.8 mm in leaf width across all 30 plots.

Table 3.12: LMM results for leaf width

REML criterion at convergence: 664.3					
Scaled residuals					
Min	1Q	Median	3Q	Max	
-2.032	-0.5100	-0.05221	0.6267	2.930	
Random effects					
Groups	Name	Variance	Standard deviation		
ID	(Intercept)	0	0		
Residual		128.8	11.35		
Number of observation: 88, groups: ID, 30					
Fixed effects					
	Estimate	Standard error	df	t value	Pr(>|t|)
(Intercept)	59.35	2.107	85	28.164	<2e-16 ***
Interval 1 Interval 2	-7.983	2.955	85	-2.701	0.00833**
Interval 1 Interval 3	-36.43	2.980	85	-12.223	<2e-16 ***
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1					
Correlation of Fixed Effects					
	(Intr)	Intrl2			
Interval 1 Interval 2	-0.713				
Interval 1 Interval 3	-0.707	0.504			

Analysing the LMM in Table 3.12, we observe a low p-value of the intercept (2e-16), between Intervals 1 and 2 (8.33e-3), and between Intervals 1 and 3 (2e-16), suggesting statistical significance, indicating that there is a significant difference in leaf width between the intervals. A positive correlation (0.504) between Interval 2 and Interval 3 can be seen, suggesting that leaf width at Interval 2 tends to be related to that at Interval 3. Overall, these results suggest that Interval 1 holds statistical significance as a baseline for comparison with Intervals 2 and 3, and that the observed decrease in leaf width across the intervals is statistically significant.

Effect of successive removal on leaf thickness

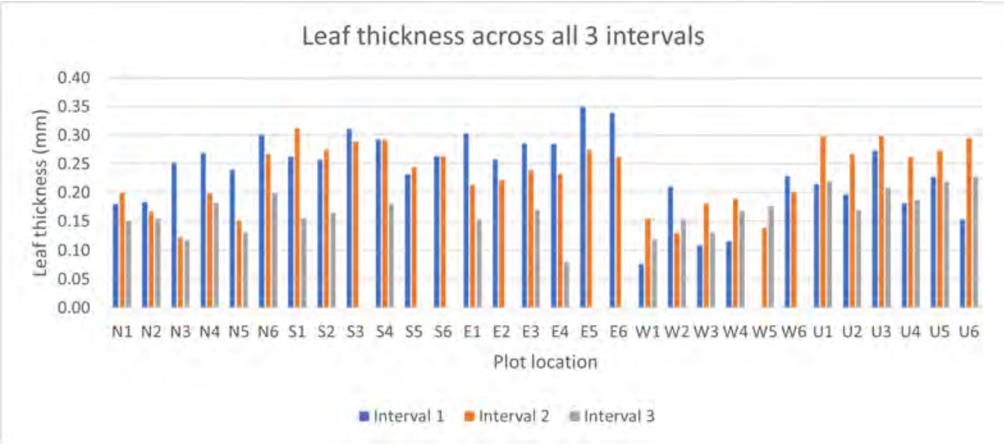

Figure 3.19: Leaf thickness across all 3 intervals

In Figure 3.19, half of the plots in Interval 1 have the highest leaf thickness, with an average of 0.236 mm across all the plots, followed by Interval 2 with 0.231 mm, and then Interval 3 at the lowest with 0.132 mm. However, plot S6 deviate from this trend, showing the same leaf thickness across Intervals 1 and 2. Nonetheless, this result is anticipated, given that leaf thickness is likely to decrease over the intervals due to compromised growth following the removal sessions.

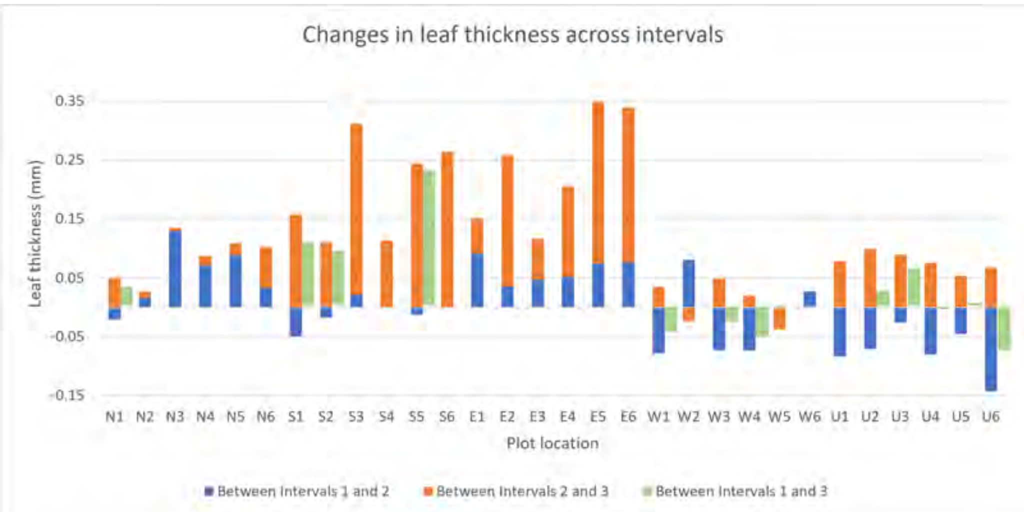

Figure 3.20: Changes in leaf thickness across the intervals

Furthermore, Figure 3.20 shows that the majority of plots exhibit a decrease in leaf thickness between Intervals 1 and 2, and Intervals 2 and 3. Although there were more plots between Intervals 1 and 2 showing an increase in leaf thickness compared to Intervals 2 and 3, the overall trend still indicates a decrease in average leaf thickness across all 30 plots. The average decrease in leaf thickness across all 30 plots is higher in Intervals 2 to 3, with a decrease of 0.0997 mm compared to only 0.0028 mm from Intervals 1 to 2. From Intervals 1 to 3, there is an average decrease of 0.1065 mm in leaf thickness across all 30 plots.

Table 3.13: LMM results for leaf thickness

<table>
<tr><td colspan="6">REML criterion at convergence: -209</td></tr>
<tr><td colspan="6">Scaled residuals</td></tr>
<tr><td>Min</td><td>1Q</td><td>Median</td><td>3Q</td><td colspan="2">Max</td></tr>
<tr><td>-2.392</td><td>-0.5996</td><td>-0.3233</td><td>0.6811</td><td colspan="2">1.6885</td></tr>
<tr><td colspan="6">Random effects</td></tr>
<tr><td>Groups</td><td>Name</td><td colspan="2">Variance</td><td colspan="2">Standard deviation</td></tr>
<tr><td>ID</td><td>(Intercept)</td><td colspan="2">3.053e-26</td><td colspan="2">1.747e-13</td></tr>
<tr><td>Residual</td><td></td><td colspan="2">4.443e-03</td><td colspan="2">6.666e-02</td></tr>
<tr><td colspan="6">Number of observation: 88, groups: ID, 30</td></tr>
<tr><td colspan="6">Fixed effects</td></tr>
<tr><td></td><td>Estimate</td><td>Standard error</td><td>df</td><td>t value</td><td>Pr(>|t|)</td></tr>
<tr><td>(Intercept)</td><td>0.2364</td><td>0.01238</td><td>85</td><td>19.10</td><td><2e-16 ***</td></tr>
<tr><td>Interval 1 Interval 2</td><td>-0.005915</td><td>0.01734</td><td>85</td><td>-0.341</td><td>0.734**</td></tr>
<tr><td>Interval 1 Interval 3</td><td>-0.1046</td><td>0.01751</td><td>85</td><td>-5.978</td><td>5.15e-08 ***</td></tr>
<tr><td colspan="6">Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1</td></tr>
<tr><td colspan="6">Correlation of Fixed Effects</td></tr>
<tr><td colspan="2"></td><td colspan="2">(Intr)</td><td colspan="2">Intrl2</td></tr>
<tr><td colspan="2">Interval 1 Interval 2</td><td colspan="2">-0.713</td><td colspan="2"></td></tr>
<tr><td colspan="2">Interval 1 Interval 3</td><td colspan="2">-0.707</td><td colspan="2">0.504</td></tr>
</table>

From the analysis of the LMM in Table 3.13, we observe a low p-value of the intercept (2e-16) and between Intervals 1 and 3 (5.15e-08), suggesting statistical significance, indicating a significant difference in leaf thickness between the intervals when comparing to the baseline interval (Interval 1) and when comparing between Intervals 1 and 3. On the other hand, the estimated differences in leaf thickness between Intervals 1 and 2 are not statistically significant, indicating that the changes between

Intervals 1 and 2 are not significant. A positive correlation (0.504) between Interval 2 and Interval 3 can be seen, suggesting that there is some tendency for leaf thickness at Interval 2 to be related to those at Interval 3. Overall, these results suggest that Interval 1 holds statistical significance as a baseline for comparison with Intervals 2 and 3, and that the observed decrease in leaf thickness across the intervals is statistically significant.

Summary of the effect of successive removal on leaf size and Coralita growth

The quantitative analysis revealed a consistent decrease in leaf size (length, width, thickness) across the intervals, with the largest measurements recorded in Interval 1, followed by Interval 2 and then Interval 3. This decline can be attributed to the longer growth period in Interval 1 before removal sessions, resulting in larger leaf sizes compared to subsequent intervals. However, notably, the leaf size in Interval 3 is still smaller than in Interval 2. Moreover, this trend closely aligns with observations from the qualitative image analysis, where Coralita growth also diminishes across the intervals. Thus, both the qualitative and quantitative results strongly suggest that Coralita's growth is significantly impacted by repeated removals above ground.

3.2.3.3 Effect of successive removal on biomass

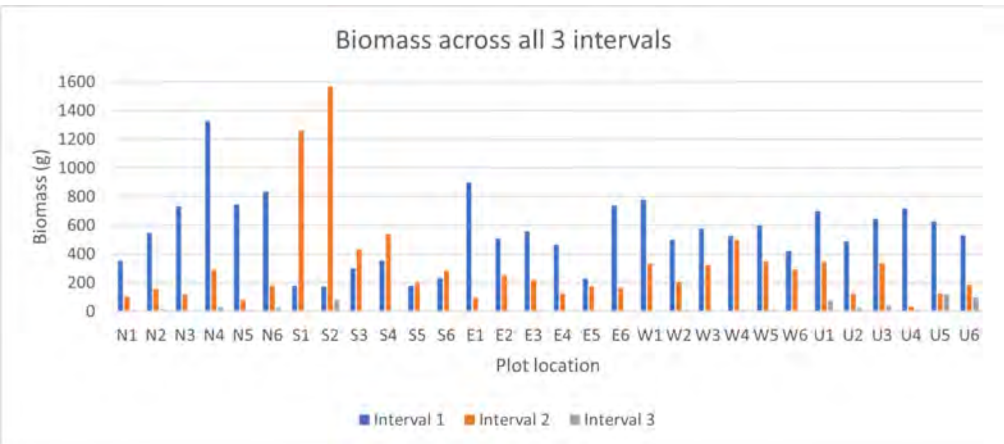

Figure 3.21: Biomass across all 3 intervals

Figure 3.21 illustrates that the majority of plots exhibit the highest biomass in Interval 1, with an average of 549.5 g across all plots, followed by Interval 2 of 314.1 g. Interval 3 displays extremely little biomass, with an average of only 20.4 g across the 30 plots. However, plots S1 and S2 deviate from this trend, showing the highest biomass in Interval 2 instead of Interval 1, and by a significant margin. Nonetheless, this result is expected, as we hypothesised that biomass will also decrease over the intervals as a result of compromised growth following the removal sessions.

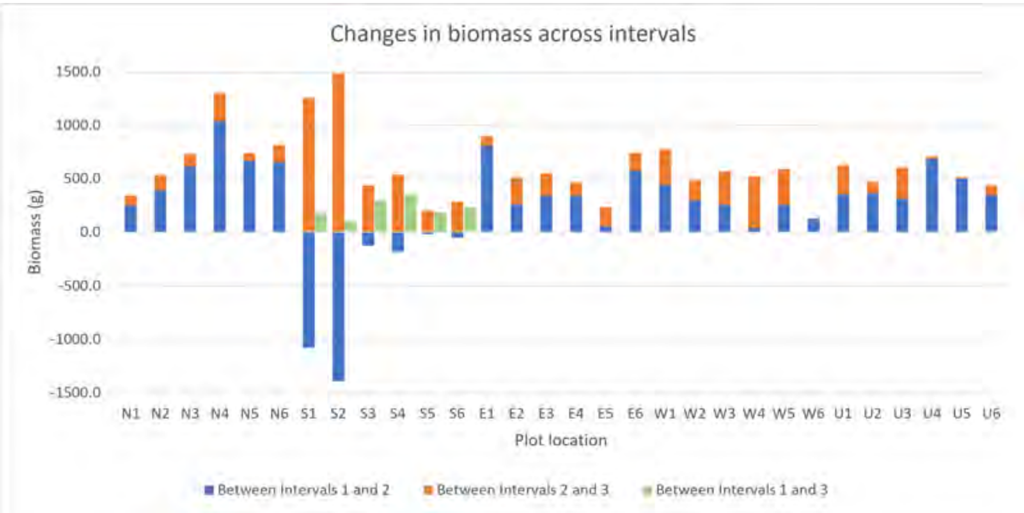

Figure 3.22: Changes in biomass across the intervals

In Figure 3.22, the majority of plots show a substantial decrease in biomass between Intervals 1 and 2, Intervals 2 and 3, and Intervals 1 and 3, except for plots S1 and S2, which show an increase in biomass between Intervals 1 and 2. The average decrease in biomass across all 30 plots is higher between Intervals 2 and 3, with a decrease of 294.4 g compared to 235.4 g between Intervals 1 and 2. All 30 plots display a decrease in biomass between Intervals 1 and 3, with an average decrease of 533.6 g in biomass.

Table 3.14: LMM results for biomass)

REML criterion at convergence: 1197				
Scaled residuals				
Min	1Q	Median	3Q	Max
-1.562	-0.4678	-0.0725	0.1375	5.234

Random effects			
Groups	Name	Variance	Standard deviation
ID	(Intercept)	0	0
Residual		57390	239.6
Number of observation: 88, groups: ID, 30			

Fixed effects					
	Estimate	Standard error	df	t value	Pr(>|t|)
(Intercept)	549.5	43.74	86	12.56	<2e-16 ***
Interval 1 Interval 2	-235.4	61.85	86	-3.806	2.64e-04***
Interval 1 Interval 3	-529.1	62.39	86	-8.481	5.6e-13 ***
Significant levels: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1					

Correlation of Fixed Effects		
	(Intr)	Intrl2
Interval 1 Interval 2	-0.707	
Interval 1 Interval 3	-0.701	0.496

Analysing the LMM in Table 3.14, we observe a low p-value of the intercept (2e-16), between Intervals 1 and 2 (2.64e-04), and between Intervals 1 and 3 (5.6e-13), suggesting statistical significance, indicating a significant difference in biomass between the intervals. A positive correlation (0.496) between Interval 2 and Interval 3 can be seen, suggesting that there is some tendency for biomass at Interval 2 to be related to that at Interval 3. Overall, these results suggest that Interval 1 holds statistical significance as a baseline for comparison with Intervals 2 and 3, and that the observed decrease in biomass across the intervals is statistically significant.

Generally, the quantitative analysis indicates a consistent decrease in biomass across the intervals, with the highest values in Interval 1, followed by Interval 2 and then Interval 3. Notably, biomass is interconnected with morphological traits such as leaf size, encompassing length, width, and thickness. Larger leaf sizes contribute to increased leaf area and volume, resulting in higher biomass per area. This suggests that there is a clear relationship between Coralita growth, leaf size and biomass, as anticipated and explained by Hofius and Börnke (2007). Hence, similarities between leaf size, biomass and Coralita growth are observed. Given the declining trends in both leaf size and biomass, which closely mirror the qualitative image analysis of Coralita growth, it is evident that repeated above-ground removals significantly impact Coralita's growth, as supported by both qualitative and quantitative findings.

3.2.3.4 Effect of successive removal on all the plant traits measured

Different trends were observed across the different plant traits. While stomatal conductance on the adaxial surface displayed no discernible trend across plots, it generally exhibited higher stomatal conductance in Interval 3, followed by Interval 2, and then Interval 1. Moreover, the increase between Intervals 1 and 2 is higher compared to Intervals 2 and 3. On the other hand, stomatal conductance on the abaxial surface tended to be highest in Interval 2, followed by Interval 3, and then Interval 1, with an increase between Intervals 1 and 2 and a decrease between Intervals 2 and 3. Nonetheless, both surfaces showed a general increase in stomatal conductance from Intervals 1 to 3.

In contrast, leaf size (leaf length, width, thickness) and biomass demonstrated similar trends, with the highest values observed in Interval 1, followed by Interval 2, and then Interval 3. Both leaf size and biomass exhibited greater decreases between Intervals 2 and 3 compared to Intervals 1 and 2, with a general decrease observed from Intervals 1 to 3.

In the LMM analysis, we also observed different trends across plant traits. High p-values were noted for stomatal conductance on the adaxial surface between Intervals 1 and 2, and Intervals 1 and 3. Conversely, stomatal conductance on the abaxial surface showed low p-values for Intervals 1 and 2, but high p-values for Intervals 1 and 3. Leaf size and biomass generally displayed low p-values between Intervals 1 and 2, except for leaf thickness, and low p-values between Intervals 1 and 3. This suggests that the effect of removal in Interval 1 impacts the results observed in Interval 2, especially for stomatal conductance (abaxial surface), leaf length, leaf width, and biomass. Removal in Interval 1 also influences the results observed in Interval 3, particularly for leaf size and biomass.

Furthermore, the low p-value for the intercept across all plant traits indicates the presence of a baseline level irrespective of specific conditions or interventions. This baseline level in Interval 1 offers valuable insights into the natural behaviour of plant traits under normal circumstances, crucial for interpreting changes across intervals. Moreover, the positive correlation between Intervals 2 and 3 across all plant traits suggests interrelated changes rather than complete independence between these intervals.

In general, a robust correlation emerges between leaf size, biomass, and Coralita growth, while stomatal conductance on the abaxial surface demonstrates a closer association with Coralita health. Although the plant traits measured in the quantitative analysis align with observations of Coralita's health and growth in the qualitative image analysis, additional growth metrics like the presence and number of flowers, stem length and thickness, number of leaves, and leaf temperature could enhance the accuracy of Coralita's assessment. While some of these traits were measured in Intervals 2 and 3, the absence of data in Interval 1 hindered their inclusion in the quantitative analysis. Nevertheless, both qualitative and quantitative results concur that repeated above-ground removals significantly impact Coralita's health and growth.

However, it is important to note that there are also anomalies observed. Generally across the intervals, a small number of plots, notably the urban plots and South plots, consistently deviate from the overarching trend observed in both qualitative and quantitative analyses. For example, in the qualitative analysis, plot U1 consistently demonstrates the most pronounced growth in Interval 3 across Scenarios 1 and 2. Similarly, in the quantitative analysis, anomalies of substantial regrowth were observed in plots S1 and S2 (Figures A.7 and A.8), characterised by a significant increase in leaf size and biomass, which highlights the remarkable resilience of Coralita. It demonstrates the capacity to rapidly regrow, surpass its previous state, and thrive even after removal. However, despite this regrowth, all plots still experience a significant decline in Coralita's health and growth, as observed in both the qualitative analysis and the leaf size and biomass metrics from the quantitative analysis in Interval 3. This decline highlights the limitations of Coralita's resilience and suggests that prolonged removal can eventually impede its growth and health, despite its regenerative capabilities.

The discrepancy observed in specific plots suggests that location may affect the measured results, as various locations may have been exposed to different environmental conditions impacting the health and growth of Coralita. For instance, urban areas might have experienced the urban heat island effect, potentially affecting the collected data. Although we collected data on environmental conditions, including incoming solar radiation, air temperature, and relative humidity, it was not comprehensive enough to fully elucidate the extent of the influence of location on these environmental conditions and the measured plant traits since these measurements were not taken continuously or simultaneously across all 30 plots.

Nonetheless, despite potential location-specific variations, minimal variability is observed between the plots, as the majority of plots still exhibit similar trends across the intervals. For example, the majority of plots demonstrate that the leaf size and biomass are highest in Interval 1, followed by Interval 2, then Interval 3. While location may indeed exert some influence on the results, its overall impact appears to be minimal. Thus, it is reasonable to infer that there was minimal environmental variation or the absence of a discernible trend in environmental conditions across the 30 plots.

Further research endeavors could involve comprehensive measurements of a diverse array of environmental conditions, conducted continuously over time and simultaneously across various locations. This approach would enable a more exhaustive exploration of the influence of location or environmental factors on the growth and propagation of Coralita. Additionally, these environmental parameters could encompass variables such as soil moisture, levels of rainfall, and soil pH, among others, as they may also exert significant influences on Coralita's health and growth.

For instance, invasive plant species like *Solidago gigantea*, *W. trilobata*, and *Phragmites australis* have been shown to alter soil nutritional conditions by affecting pH values and nutrient availability, such as calcium and nitrogen in invaded soils (Afzal et al., 2023; Si et al., 2013; Teixeira et al., 2020). This alteration can limit the germination and growth of native plants while enhancing the biomass production of the invader species (Teixeira et al., 2020). Invasive plant species like *Microstegium vimineum* have been found to thrive in low soil pH conditions. Similarly, Coralita is known to be adaptable to various soil types and capable of tolerating poor soils and drought conditions (Burke and DiTommaso, 2011). However, the precise impact and extent of these environmental conditions on Coralita's health and growth remain underexplored. Conducting further studies in this area could provide valuable insights into the complex interactions between Coralita and its environment.

Nonetheless, the results from both the qualitative and quantitative analyses show a significant decline in the health and growth of Coralita in Interval 3 as compared to Intervals 1 and 2. This addresses the secondary research question, confirming that successive removal significantly reduces the health and growth of Coralita. Furthermore, the data indicates that this effect becomes more pronounced with increased succession of removal, suggesting that repeated removal impedes Coralita's ability to regrow effectively.

Chapter 4

Discussion

4.1 Discussion of results from the field survey and mapping

The field survey and mapping efforts have confirmed that Coralita has indeed spread since 2015 and has spread by approximately 7% over the years. This means that the rate of Coralita coverage expands by approximately 1% every year in St. Eustatius, equating to an area of 0.21 km^2. As a point of comparison, the Kudzu vine (*Pueraria montana*), renowned as one of the most notorious invasive vines globally, exhibits an annual expansion rate of roughly 0.086% in Oklahoma and 0.00617% across the United States ((Harron et al., 2020; Suszkiw, 2009). The relatively rapid expansion rate of Coralita in St. Eustatius highlights the urgency of effective management strategies to mitigate its impact on native ecosystems. While not yet as pervasive as Kudzu, the steady encroachment of Coralita demands attention and action. Additionally, collaboration between researchers, local authorities, and communities is essential for implementing sustainable management practices that balance conservation efforts with the needs of human populations. As Coralita continues to advance, proactive measures will be vital to safeguard the ecological integrity of St. Eustatius and preserve its unique biodiversity.

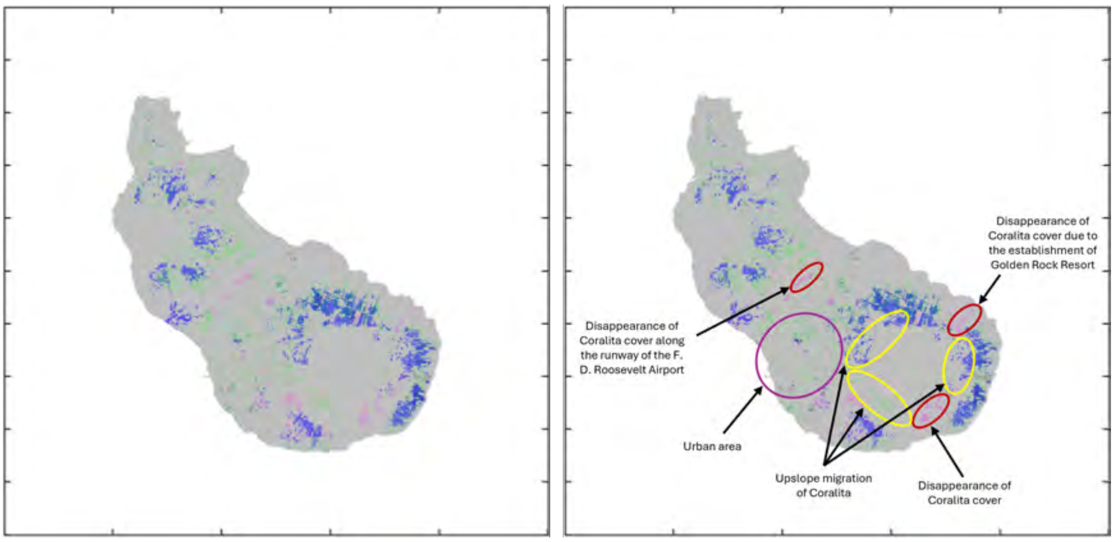

Figure 4.1: An overlap of the map of Coralita distribution across the years (left) and an annotated map of Coralita distribution across the years (right) (magenta: 2015, green: 2020, blue: 2022)

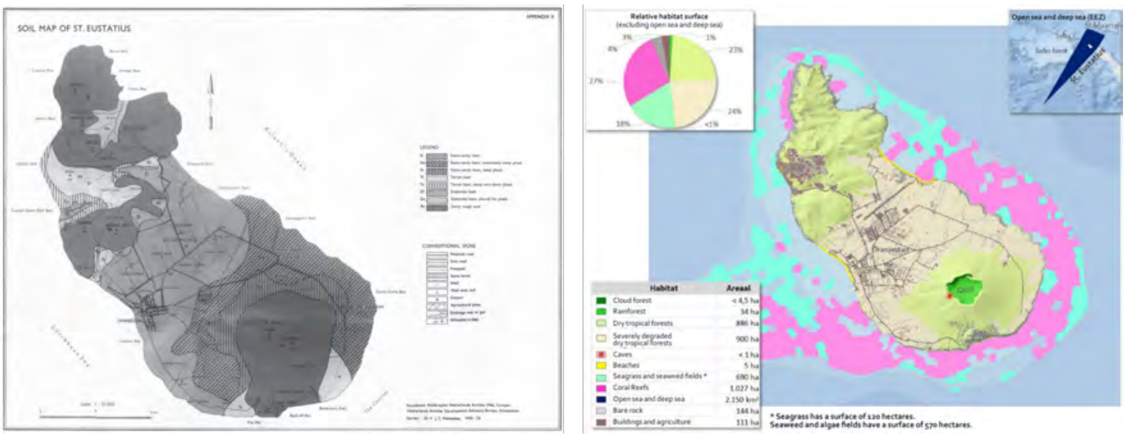

Figure 4.2: Soil map of St. Eustatius taken from de Freitas et al. (2012) (left) and habitats of St. Eustatius taken from DCNA (2019)(right)

Examining the Coralita distribution map in Figure 4.1 reveals the dynamics of Coralita spread in recent years, displaying distinct areas where the vine has experienced the most reduction and expansion. Usually, we expect that anthropogenic factors such as land-use changes and habitat fragmentation would contribute to the proliferation of Coralita, facilitating its encroachment into new areas. However, certain anthropogenic activities, such as the establishment of the Golden Rock Resort in 2021, have contributed to the disappearance of Coralita patches in the Northeast area of the Quill volcano. Nonetheless, it is important to note that land clearing near the resort has also led to the emergence and expansion of new Coralita patches in the surrounding area. Urban areas, though experiencing fluctuations in Coralita cover, exhibit an overall decrease in coverage in recent years. Furthermore, Coralita disappearance along the runway of the F. D. Roosevelt Airport and the Southwest region of the Quill volcano suggests that there may have been localised control efforts or unintentional habitat alterations affecting the vine's presence.

On the other hand, Coralita still exists around the Quill volcano in areas characterised by severely degraded dry tropical forests, with Statia sandy loam soil. The Coralita patches are larger and denser than before, especially in the North, Northeast, and East of the Quill volcano. However, there has been a minor shift, with Coralita spreading into new territories, particularly evident around the upper slopes of the Quill volcano. This trend can be concerning as Coralita patches are now detected higher up the slopes of the volcano, indicating a potential upslope migration facilitated by climate change (Eichel et al., 2023). Rising temperatures, a consequence of climate change, may trigger such vegetation shifts, posing a threat to biodiversity further up the Quill volcano (Eichel et al., 2023). Projections suggest that even modest temperature increases, as outlined by the IPCC for the Caribbean region, could have significant negative impacts on St. Eustatius' habitats and species, exacerbating the vulnerability of already damaged ecosystems, especially those in the rainforest regions atop the volcano (DCNA, 2019).

The fragile state of these habitats renders them less resilient to the effects of both Coralita invasion and climate change. Coralita's ability to reproduce from small fragments poses a considerable challenge to control efforts, particularly in fragile ecosystems

(DCNA, 2019). As such, the biodiversity higher up the Quill volcano faces increased susceptibility to Coralita invasion. While disturbed areas historically provided opportunities for Coralita establishment, recent observations suggest a shift in dynamics, with Coralita encroachment occurring even without significant human-induced disturbances or land-use changes.

4.2 Discussion of results from the fieldwork

4.2.1 Qualitative analysis of the effect of successive removal on the health and growth of Coralita

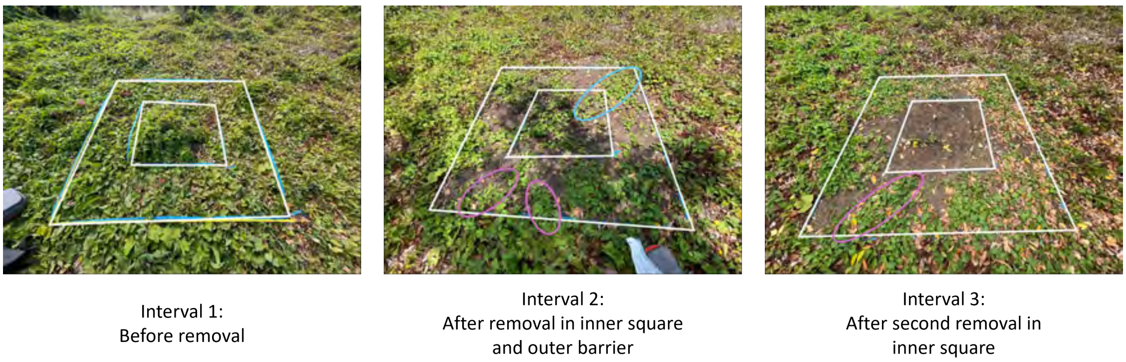

Figure 4.3: Health and growth of Coralita of plot N6 across different intervals

The qualitative analysis of the fieldwork through image observation has confirmed that repeated above-ground removals have a significant impact on Coralita's health and growth. Across the different scenarios of removal, we observe that the decline in Coralita's health and growth is particularly pronounced in the last interval, as seen in the inner square of plot N6 for example (Figure 4.3). Hence, using repeated above-ground removal as a management strategy is effective in controlling Coralita populations.

Upon closer examination, it becomes evident that Coralita's growth manifests in distinct forms. We categorised this as above-ground growth and expansion. Above-ground growth encompasses new growth originating from stems or roots following Coralita removal, while expansion refers to the radial spread of Coralita without removal. Analysis of Figure 4.3 reveals Coralita's expansion from external areas into the outer barrier, filling spaces vacated by removal during the first interval. Notably, in Interval 3, expansion is more pronounced due to minimal above-ground growth in the inner square, resulting in no outward expansion from that area. Additionally, the blue oval highlights Coralita's spread from outside the experimental zone into the inner square.

While repeated above-ground removals effectively diminish Coralita's health and growth, particularly evident in the inner square of experimental plots, the efficacy of this strategy depends on the surrounding environment. Even with removal efforts, Coralita from adjacent areas can infiltrate and colonise cleared zones rapidly due to its vine-like growth and fast propagation. Thus, careful planning of removal boundaries, ensuring the absence of surrounding Coralita, is imperative. Additionally, post-removal revegetation with native plants can provide a competitive advantage against Coralita re-establishment.

While above-ground removal proves effective as a management tactic, additional considerations are necessary to ensure effective control or complete eradication of the Coralita population post-removal. As suggested by Byun et al. (2018), the restoration of native plant cover following control efforts can serve as a valuable measure to prevent or delay re-invasion. However, it is crucial to carefully select and combine native species to maximise ecological resistance (Byun et al., 2018). The effectiveness of plant restoration in controlling invasion has yielded mixed results, highlighting the importance of species selection and combination (Byun et al., 2018). Simply adding species may increase diversity without necessarily enhancing resistance, potentially leading to imbalanced competition and heightened susceptibility to Coralita invasion (Byun et al., 2018).

Furthermore, successful management strategies require a thorough understanding of native taxa and invasion mechanisms (Byun et al., 2018). However, the complex nature of the invasion process poses challenges, rendering research experiments daunting (Byun et al., 2018). Nonetheless, looking ahead, management plans can incorporate diverse strategies, including the integration of native diversity post-removal.

To optimise outcomes, it is essential to explore the temporal effects of repeated removals, determining the most effective intervals for Coralita removal to achieve optimal population control or eradication on St. Eustatius. Thus, such investigations would constitute a valuable addition to management strategies, enhancing their efficacy in combating Coralita infestations.

4.2.2 Quantitative analysis of the effect of successive removal on the health and growth of Coralita

The quantitative analysis conducted during the fieldwork, focusing on the measurement of plant traits such as stomatal conductance, leaf size, and biomass, has confirmed the substantial impact of repeated above-ground removals on Coralita's health and growth. This impact becomes more pronounced with successive removals, indicating that Coralita's ability to regrow effectively is impeded by repeated removals. The extent of this effect on the plant traits is summarised in Table 4.1.

Table 4.1: Effect of successive removal on plant traits across all the intervals

Plant traits	Removal of Coralita in Interval 1	Removal of Coralita in Interval 2	Removal of Coralita in Intervals 1 and 2
	Change between Intervals 1 and 2	Change between Intervals 2 and 3	Change between Intervals 1 and 3
Stomatal conductance (adaxial surface)	+15.8%	+13.0%	+30.9%
Stomatal conductance (abaxial surface)	+134.4%	-37.1%	+47.3%
Leaf length	-23.6%	-54.5%	-65.2%
Leaf width	-13.3%	-55.5%	-61.4%
Leaf thickness	-2.1%	-42.9%	-44.1%
Biomass	-42.8%	-93.6%	-96.3%

One of the most intriguing aspects in Table 4.1 is the contrasting patterns observed in stomatal conductance between the adaxial and abaxial surfaces. While adaxial stomatal conductance exhibited a steady increase across intervals, abaxial stomatal conductance displayed a more fluctuating trend. Following an initial surge, abaxial stomatal conductance experiences a subsequent decline, ultimately leading to an overall improvement by the end. However, both stomatal conductance suggest that there is an overall improvement in Coralita's health in Interval 3 compared to Interval 1 although this was not observed in the qualitative analysis through image observation. This result highlights the complexity of stomatal conductance and its relationship with plant health as well as its responses to change.

The consistent reductions in biomass, leaf length, width, and thickness across intervals suggest a coordinated adjustment in leaf morphology following Coralita removal, possibly driven by competition for resources or alterations in light availability. The magnitude of these reductions especially between Intervals 1 and 3 highlights the importance of repeating the removal session to significantly yield results in controlling the Coralita population. This result also builds onto Eppinga et al. (2020), indicating that not only is removing Coralita spatially effective in reducing Coralita population, but also removing

Coralita just once is not enough to effectively reduce Coralita population on St. Eustatius. This is especially important if the removal of Coralita is used as a management strategy on St. Eustatius to reduce Coralita population. Hence, to effectively decrease or control the Coralita population, removal efforts should be conducted more frequently with the aim of depleting resources in the Coralita tubers, thus preventing their extensive growth and spread across the island. Although the extent of reliance on belowground reserves for subsequent above-ground biomass regrowth varies among species, the initial recovery of photosynthetically active biomass after total above-ground removal is heavily dependent on root reserves, as highlighted by Martínková et al. (2021). However, there remains uncertainty regarding the extent to which resources are depleted from Coralita tubers, or if these tubers indeed aid in Coralita's rapid recovery. Therefore, further investigation could entail measuring the size or nutrient levels of these Coralita tubers, or assessing the growth rate of Coralita in the absence of tubers. This would provide valuable insights into the role of tubers in Coralita's resilience and regrowth following removals.

Moreover, it is crucial to highlight that the removal experiment exclusively involved Coralita as the sole species within the experimental plot. Exploring the effects of Coralita removal alongside competition from other native species for resources within the same plot would be intriguing. This additional study could elucidate whether native species facilitate Coralita's growth or engage in strong competition, potentially influencing Coralita's access to space and resources.

We also acknowledge that due to resource constraints, our study only involved two removal sessions in Intervals 1 and 2, rather than more frequent removals. However, it is noteworthy that in the final interval, there was minimal to no growth of Coralita observed, suggesting that subsequent removals may lead to further suppression of its growth and the possibility of no data being collected. Nonetheless, conducting more comprehensive research involving a higher frequency of removal activities could yield more data to demonstrate the long-term effects of successive removals on Coralita. This would also affirm that in the subsequent intervals, Coralita growth would be absent. Such information could be valuable in establishing definite eradication timelines and refining Coralita management strategies.

Additionally, measurements within the outside barrier and outside the experimental plot over the different intervals could have been taken for further quantitative analysis on the effect of successive removal on Coralita's health and growth. Investigating repetitive removal using varying time intervals could also be beneficial for optimising the removal approach of Coralita on St. Eustatius and effectively eradicating or controlling the Coralita population. However, it is important to acknowledge the practical challenges associated with using removal as a management strategy for Coralita. The extensive growth and spread of Coralita across the island make removal efforts time-consuming and labour-intensive. Therefore, while removal may be effective, it also presents logistical challenges that need to be carefully considered in any management approach.

Chapter 5

Conclusion

Upon comparing the 2015 Worldview-2 and 2015 Sentinel-2 image, there is a notable coherence in the overall distribution and proportion of Coralita on St. Eustatius. With a 94.5% SVM model accuracy, both images exhibited a 3% coverage of Coralita, and consistent patches in the central urban area and at the base of the Quill volcano. This coherence between both images reinforces the Sentinel-2 satellite's efficacy in estimating Coralita cover on the island as well as its suitability as an alternative data source. This is crucial in steering towards the utilisation of Sentinel-2 data, given its broader availability and accessibility. This shift will open up the potential for a more robust assessment of the past, present, and future trends in Coralita dynamics.

In conclusion, this research has addressed both research questions by offering comprehensive insights into the distribution and growth dynamics concerning Coralita on St. Eustatius. The field survey and mapping efforts have highlighted the effectiveness of using Sentinel-2 imagery to assess Coralita cover. A significant consistency in the overall distribution and proportion of Coralita (3%) on St. Eustatius is evident in both the 2015 Worldview-2 and Sentinel-2 images, accompanied by an SVM model accuracy of 94.5%.

Despite minor discrepancies in Coralita classification, with SVM model accuracies of 92.4% in 2020 and 93.3% in 2022, the field survey and mapping efforts have addressed the initial research question. They have demonstrated that Coralita has indeed expanded since 2015 by approximately 7% over the years. This increase in the growth and spread of Coralita in St. Eustatius over the years proves to be a continuously growing concern since it will persist in posing a significant threat to biodiversity, smothering other vegetation, reducing species richness, and homogenising local communities, as well as increasing the economic loss of ecosystem services in St. Eustatius. The observed increase in Coralita coverage since 2015 also underscores the need for ongoing monitoring and management efforts to mitigate its impact on the island's ecosystem.

Furthermore, the fieldwork and removal efforts undertaken on St. Eustatius have highlighted the remarkable resilience of Coralita in certain plots, particularly in plots S1 and S2, evidenced by its ability to rapidly regrow in Interval 2 even after the removal session in Interval 1. This rapid transformation within a short timeframe highlights the dynamic nature of Coralita's growth, emphasising its ability to rebound quickly under favourable conditions.

Our findings also addressed the second research question, revealing that the successive removal significantly impacts Coralita's health and growth, with a more pronounced effect observed in Interval 3. This is evidenced by a significant decline in Coralita's health and growth during Interval 3, as observed in both qualitative and quantitative analyses, in comparison to Intervals 1 and 2. This suggests that repeated and frequent removal within a short timeframe of three weeks is necessary to effectively suppress its growth. While our study illuminates the efficacy of successive removal as a management approach, logistical challenges and practical constraints necessitate careful consideration during implementation.

Moving forward, it is imperative that research efforts concentrate on refining methodologies and integrating supplementary environmental and growth variables. This approach will enrich our comprehension of Coralita dynamics by investigating the specific influence and magnitude of these environmental conditions on Coralita's health and growth, as well as enhance the precision of Coralita's health and growth assessment. Conducting long-term studies could yield more data to demonstrate the long-term effects of successive removals on Coralita. This information can offer valuable insights into the timeline and duration required for the eradication process, thereby refining and optimising Coralita management strategies.

Overall, these findings contribute valuable insights to the ongoing efforts aimed at preserving the biodiversity and ecological integrity of St. Eustatius, thereby better safeguarding the ecological balance and biodiversity against the invasive threat posed by Coralita.

Bibliography

Afzal, M., Naz, M., Ashraf, W., and Du, D. (2023). The legacy of plant invasion: Impacts on soil nitrification and management implications. Plants, 12(16):2980.

Albright, T., Moorhouse, T., and Mcnabb, A. (2004). The rise and fall of Water Hyacinth in Lake Victoria and the Kagera River Basin, 1989-2001. J. Aquat. Plant Manage, 42:73–84.

Berkowitz, B. (2014). The State of Antigonon leptopus (Coralita on St. Eustatius in 2014). Technical report, STENAPA internal report, St.Eustatius, Caribbean Netherlands.

Briggs, H. (2019). Plant extinction 'bad news for all species'.

Burke, J. M. and DiTommaso, A. (2011). Corallita (Antigonon leptopus): Intentional introduction of a plant with documented invasive capability. Invasive Plant Science and Management, 4(3):265–273.

Byun, C., Blois, S., and Brisson, J. (2018). Management of invasive plants through ecological resistance. Biological Invasions, 20.

Carrington, D. (2019). 'Frightening' number of plant extinctions found in global survey.

DCNA (2019). State of Nature in the Caribbean Netherlands: St. Eustatius.

de Freitas, J., Rojer, A., Nijhof, B., and Debrot, A. (2012). A landscape ecological vegetation map of Sint Eustatius (Lesser Antilles). Technical report, Wageningen Environmental Research Landscape Centre Ecosystemen.

Döring, T. F., Pautasso, M., Finckh, M. R., and Wolfe, M. S. (2012). Concepts of plant health – reviewing and challenging the foundations of plant protection. Plant Pathology, 61(1):1–15.

Eichel, J., Stoffel, M., and Wipf, S. (2023). Go or grow? Feedbacks between moving slopes and shifting plants in high mountain environments. Progress in Physical Geography: Earth and Environment, 47(6):967–985.

Eppinga, M., Baudena, M., Haber, E., Rietkerk, M., Wassen, M., and Santos, M. (2020). Spatially explicit removal strategies increase the efficiency of invasive plant species control. Ecological Applications, 31.

Eppinga, M. B., Haber, E. A., Sweeney, L., Santos, M. J., Rietkerk, M., and Wassen, M. J. (2022). Antigonon leptopus invasion is associated with plant community disassembly in a Caribbean island ecosystem. Biological Invasions, 24(3):353–371.

Eppinga, M. B. and Pucko, C. A. (2018). The impact of hurricanes Irma and Maria on the forest ecosystems of saba and St. Eustatius, northern Caribbean. Biotropica, 50(5):723–728.

Ernst, J. J. and Ketner, P. (2007). Study on the ecology and possible control methods of the invasive plant species Antigonon leptopus (Corallita or Mexican Creeper. Technical report, ABC Research Report.

European Space Agency (n.d.). S2 Applications.

Fennell, M., Wade, M., and Bacon, K. L. (2018). Japanese knotweed (Fallopia japonica): an analysis of capacity to cause structural damage (compared to other plants) and typical rhizome extension. PeerJ, 6:e5246.

Freeland, R. O. (1952). Effect of age of leaves upon the rate of photosynthesis in some conifers. Plant Physiology, 27(4):685–690.

Giménez, C., Gallardo, M., and Thompson, R. (2013). Plant–Water Relations. In Reference Module in Earth Systems and Environmental Sciences. Elsevier.

Haber, E. A., Santos, M. J., Leitão, P. J., Schwieder, M., Ketner, P., Ernst, J., Rietkerk, M., Wassen, M. J., and Eppinga, M. B. (2021). High spatial resolution mapping identifies habitat characteristics of the invasive vine Antigonon leptopus on St. Eustatius (Lesser Antilles). Biotropica, 53(3):941–953.

Harron, P., Joshi, O., Edgar, C. B., Paudel, S., and Adhikari, A. (2020). Predicting Kudzu (Pueraria montana) spread and its economic impacts in timber industry: A case study from Oklahoma. PLOS ONE, 15(3):1–12.

Hasanuzzaman, M., Zhou, M., and Shabala, S. (2023). How does stomatal density and residual transpiration contribute to osmotic stress tolerance. Plants (Basel, Switzerland), 12(3):494.

Heger, W. T. and van Andel, T. (2019). A social-ecological perspective on ecosystem vulnerability for the invasive creeper coralita (Antigonon leptopus) in the Caribbean: A review. Global Ecology and Conservation, 18:e00605.

Hilty, J., Muller, B., Florent, P., and Leuzinger, S. (2021). Plant growth: the What, the How, and the Why. New Phytologist, 232.

Hofius, D. and Börnke, F. A. (2007). Chapter 13 - Photosynthesis, carbohydrate metabolism and source–sink relations. In Vreugdenhil, D., Bradshaw, J., Gebhardt, C., Govers, F., Mackerron, D. K., Taylor, M. A., and Ross, H. A., editors, Potato Biology and Biotechnology, pages 257–285. Elsevier Science B.V., Amsterdam.

Hui, C. and Richardson, D. M. (2017). Invasion Dynamics. Oxford University Press.

Humphreys, A., Govaerts, R., Ficinski, S., Nic Lughadha, E., and Vorontsova, M. (2019). Global dataset shows geography and life form predict modern plant extinction and rediscovery. Nature Ecology & Evolution, 3:1–5.

IPBES (2023). Media Release: IPBES Invasive Alien Species Assessment.

Jesse, W. A. M., Molleman, J., Franken, O., Lammers, M., Berg, M. P., Behm, J. E., Helmus, M. R., and Ellers, J. (2020). Disentangling the effects of plant species invasion and urban development on arthropod community composition. Global Change Biology, 26(6):3294–3306.

Jiayan, H., Gadi, V. R., Mengdi, L., and Peijian, S. (2020). A general formula for calculating surface area of the similarly shaped leaves: Evidence from six Magnoliaceae species. Global Ecology and Conservation, 23:e01129.

Kateregga, E. and Sterner, T. (2009). Lake Victoria fish stocks and the effects of Water Hyacinth. The Journal of Environment & Development, 18:62–78.

Kent State University (2023). SPSS Tutorials: Chi-square test of independence.

Kier, G., Kreft, H., Lee, T. M., Jetz, W., Ibisch, P. L., Nowicki, C., Mutke, J., and Barthlott, W. (2009). A global assessment of endemism and species richness across island and mainland regions. PNAS, 106(23):9322–9327.

Lin, T., Klinkhamer, P. G. L., and Vrieling, K. (2018). Evolutionary changes in growth, regrowth and carbohydrate storage in an invasive plant. Scientific Reports, 8:14917.

Martínková, J., Hájek, T., Adamec, L., and Klimešová, J. (2021). Growth, root respiration and photosynthesis of a root-sprouting short-lived herb after severe biomass removal. Flora, 284:151915.

McKendry, P. (2002). Energy production from biomass (part 1): Overview of biomass. Bioresource Technology, 83(1):37–46. Reviews Issue.

McNeely, J. A. (2000). Global strategy for addressing the problem of invasive alien species. Technical report, IUCN-The World Conservation Union.

METER (n.d.). SC-1 leaf porometer stomatal conductance.

Minakawa, N., Dida, G. O., and Njenga, S. M. (2012). Malaria vectors in Lake Victoria and adjacent habitats in western Kenya. PloS one, 7(e32725).

Mitchell, S. A., Kitson-Walters, K. A., and Mitchell, A. A. (2019). Valuing Caribbean biodiversity knowledge. In Hufnagel, L., editor, Changing Ecosystems and Their Services, chapter 2. IntechOpen, Rijeka.

Mouta, N., Silva, R., Pinto, E. M., Vaz, A. S., Alonso, J. M., Gonçalves, J. F., Honrado, J., and Vicente, J. R. (2023). Sentinel-2 time series and classifier fusion to map an aquatic invasive plant species along a river—the case of Water-Hyacinth. Remote Sensing, 15(13).

Myers, N., Mittermeier, P. A., Mittermeier, C. G., da Fonseca, G. A. B., and Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature, 403:853–858.

N.Huisman, S., M.Jesse, W. A., Ellers, J., and Beukering, P. J. H. (2021). Mapping the economic loss of ecosystem services caused by the invasive plant species Antigonon leptopus on the Dutch Caribbean island of St. Eustatius. One Ecosystem, 6:e72881.

Pádua, L., Duarte, L., Antão-Geraldes, A. M., Sousa, J. J., and Castro, J. P. (2022). Spatio-temporal Water Hyacinth monitoring in the Lower Mondego (Portugal) using remote sensing data. Plants (Basel, Switzerland), 11(24).

Russell, J. C., Meyer, J.-Y., Holmes, N. D., and Pagad, S. (2017). Invasive alien species on islands: impacts, distribution, interactions and management. Environmental Conservation, 44(4):359–370.

Sax, D. F. and Gaines, S. D. (2008). Species invasions and extinction: The future of native biodiversity on islands. PNAS, 105(1):11490–11497.

Schnitzer, S. and Bongers, F. (2011). Increasing liana abundance and biomass in tropical forests: Emerging patterns and putative mechanisms. Ecology letters, 14:397–406.

Schnitzer, S. A., Kuzee, M. E., and Bongers, F. (2005). Disentangling above- and below-ground competition between lianas and trees in a tropical forest. Journal of Ecology, 93(6):1115–1125.

Sentinel Hub (n.d.). Sentinel-2 L2A.

SERAS (1994). Plant biomass determination. Technical report, SERAS.

Shuvar, Ivan, Korpita, Hanna, Shuvar, Antin, Shuvar, Bogdan, and Kropyvnytskyi, Ruslan (2021). Invasive plant species and the consequences of its prevalence in biodiversity. BIO Web Conf., 31:00024.

Si, C., Liu, X., Wang, C., Wang, L., Dai, Z., Qi, S., and Du, D. (2013). Different degrees of plant invasion significantly affect the richness of the soil fungal community. PloS one, 8(12):e85490.

Sloan, S., Jenkins, C. N., Joppa, L. N., Gaveau, D. L., and Laurance, W. F. (2014). Remaining natural vegetation in the global biodiversity hotspots. Biological Conservation, 177:12–24.

Smerdu, A., Kanjir, U., and Kokalj, Z. (2020). Automatic detection of Japanese knotweed in urban areas from aerial and satellite data (Special Issue: Detection and control of alien forest species in a changing world). Management of Biological Invasions, 11:661–676.

Smith, E. N., van Aalst, M., Tosens, T., Ülo Niinemets, Stich, B., Morosinotto, T., Alboresi, A., Erb, T. J., Gómez-Coronado, P. A., Tolleter, D., Finazzi, G., Curien, G., Heinemann, M., Ebenhöh, O., Hibberd, J. M., Schlüter, U., Sun, T., and Weber, A. P. (2023). Improving photosynthetic efficiency toward food security: Strategies, advances, and perspectives. Molecular Plant, 16(10):1547–1563. Special Issue on Climate Change and Food Security: Plant Science Roles.

Stokstad, E. (2019). Twice as many plants have gone extinct than birds, mammals, and amphibians combined.

Suszkiw, J. (2009). Fungus tapped to take on Kudzu.

Teixeira, L. H., Yannelli, F. A., Ganade, G., and Kollmann., J. (2020). Functional diversity and invasive species influence soil fertility in experimental grasslands. Plants, 9(1):53.

The Royal Botanic Gardens, Kew (2019). Almost 600 plants have already gone extinct - Why should we care?

Tian, H., Zhao, Y., Gao, C., Xie, T., Zheng, T., and Yu, C. (2022). Assessing the vitality status of plants: Using the correlation between stem water content and external environmental stress. Forests, 13(8):1198.

Time and Date (n.d.). Past weather in Oranjestad, Sint Eustatius, Netherlands.

UCLA (n.d.). Introduction to linear mixed models.

Veron, S., Haevermans, T., Govaerts, R., Mouchet, M., and Pellens, R. (2019). Distribution and relative age of endemism across islands worldwide. PNAS, 9(1):11693.

Wall, S., Vialet-Chabrand, S., Davey, P., Van Rie, J., Galle, A., Cockram, J., and Lawson, T. (2022). Stomata on the abaxial and adaxial leaf surfaces contribute differently to leaf gas exchange and photosynthesis in wheat. New Phytologist, 235(5):1743–1756.

Wang, X. Q., Wu, W. H., and Assmann, S. M. (1998). Differential responses of abaxial and adaxial guard cells of broad bean to abscisic acid and calcium. Plant physiology, 118(4):1421–1429.

Ward, E. B., Pregitzer, C. C., Kuebbing, S. E., and Bradford, M. A. (2020). Invasive lianas are drivers of and passengers to altered soil nutrient availability in urban forests. Biological Invasions, 22:935–955.

Ye, X., Meng, J., Ma, R., and Wu, M. (2023). Effects of clipping an invasive plant species on the growth of planted plants of two co-occurring species in a greenhouse study. Biology, 12(10).

Younginger, B. S., Sirová, D., Cruzan, M. B., and Ballhorn, D. J. (2017). Is biomass a reliable estimate of plant fitness? Applications in plant sciences, 5(2).

Appendix A

Pictures of the health and growth of Coralita over the 9 weeks

The list below highlights areas where visual documentation is incomplete, either due to specific challenges or the absence of corresponding images.

- N1: There is no image available in Interval 1 before the removal took place. (Figure A.1)
- S3: Images before removal and after removal in Interval 3 are the same since no growth occurred. (Figure A.9)
- S5: Images before removal and after removal in Interval 3 are the same since no growth occurred. (Figure A.11)
- S6: Images before removal and after removal in Interval 3 are the same since no growth occurred. (Figure A.12)
- E2: Images before removal and after removal in Interval 3 are the same since no growth occurred. (Figure A.14)
- E5: Images before removal and after removal in Interval 3 are the same since no growth occurred. (Figure A.17)
- E6: Images before removal and after removal in Interval 3 are the same since no growth occurred. (Figure A.18)

- W6: There are no images available in Interval 3 as plot W6 went missing. It is suspected that the sticks and ribbons used to outline this plot may have been destroyed or consumed by the goats or cows in the vicinity. (Figure A.24, Figure A.24)

A.1 North

A.1.1 N1

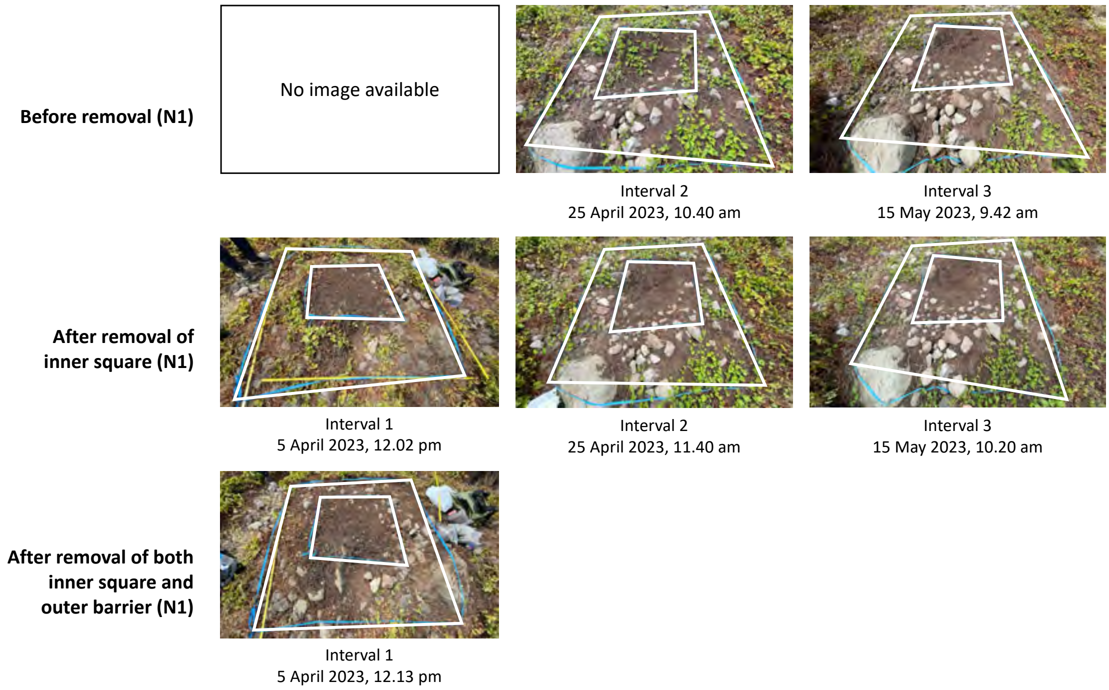

Figure A.1: The health and growth of Coralita in plot N1 over 6 weeks

A.1.2 N2

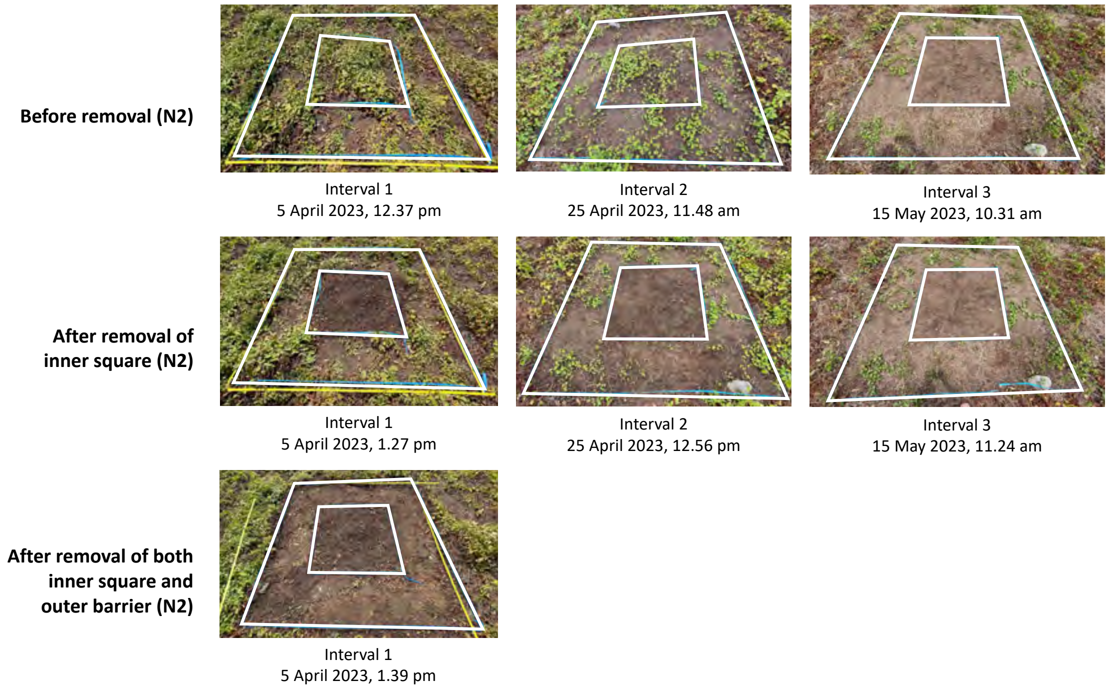

Figure A.2: The health and growth of Coralita in plot N2 over 6 weeks

A.1.3 N3

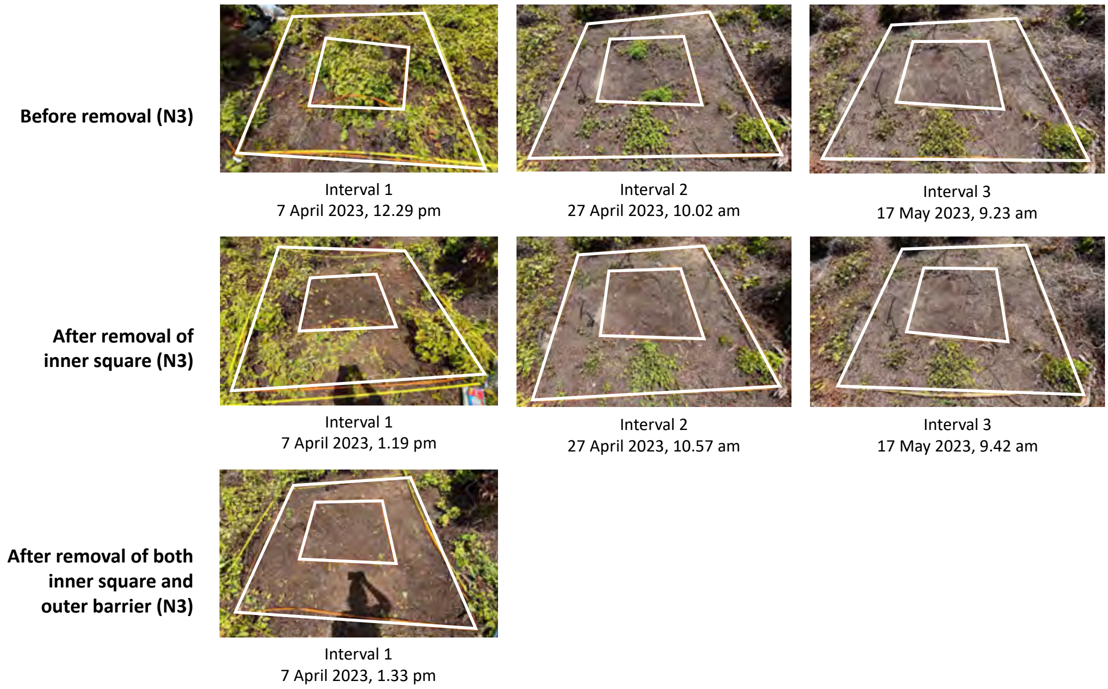

Figure A.3: The health and growth of Coralita in plot N3 over 6 weeks

A.1.4 N4

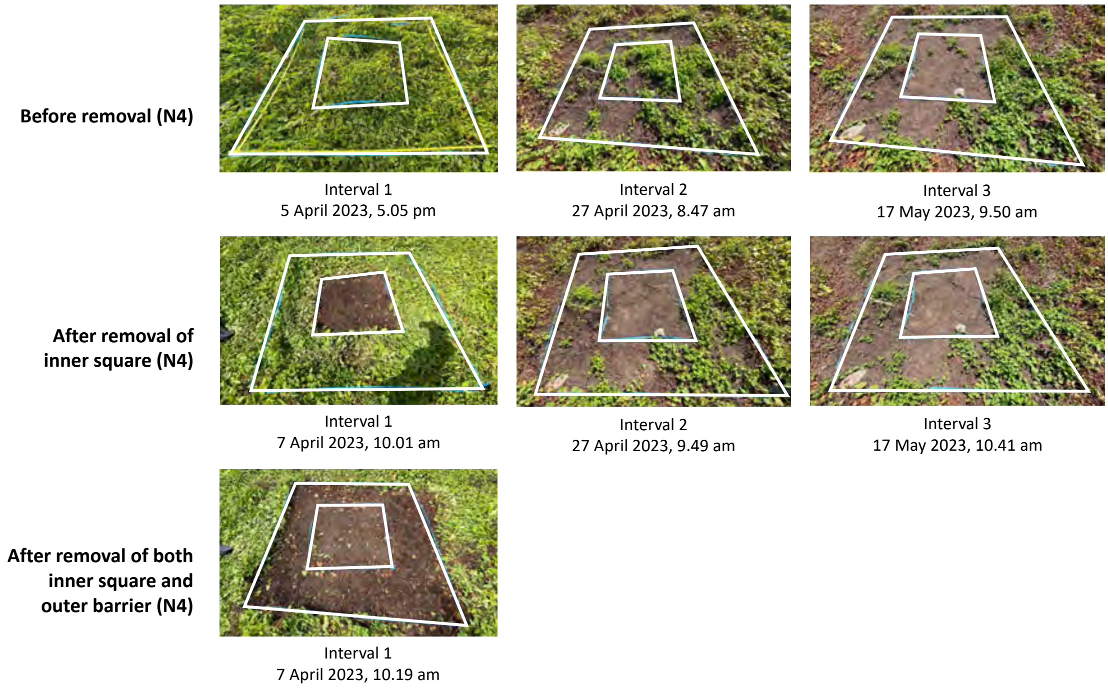

Figure A.4: The health and growth of Coralita in plot N4 over 6 weeks

A.1.5 N5

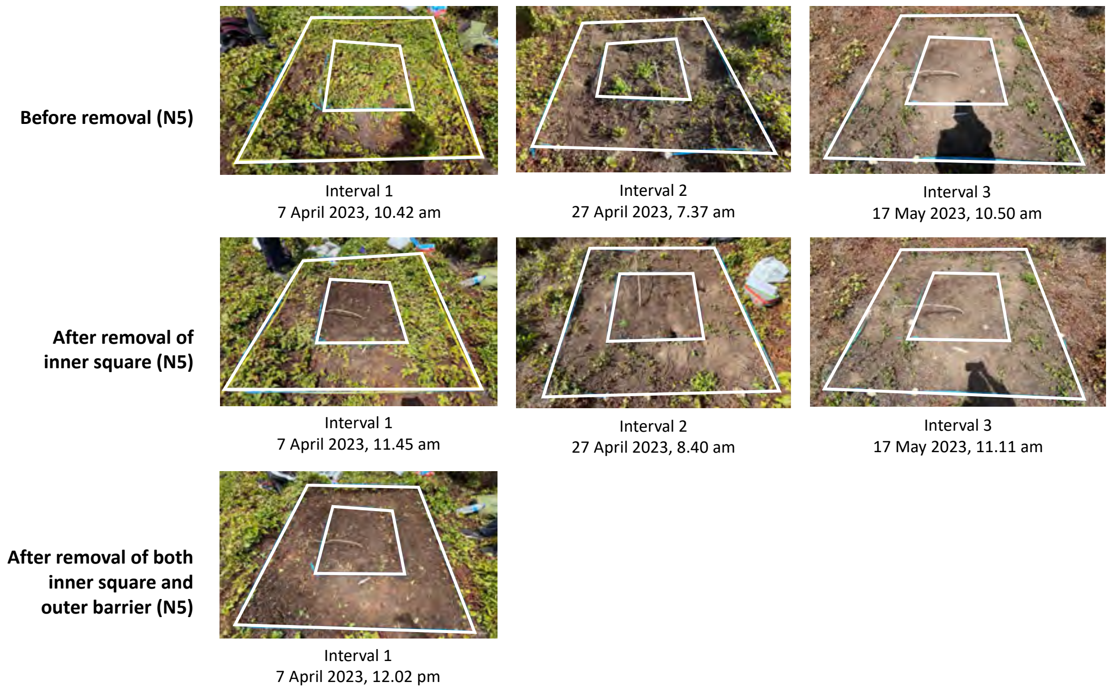

Figure A.5: The health and growth of Coralita in plot N5 over 6 weeks

A.1.6 N6

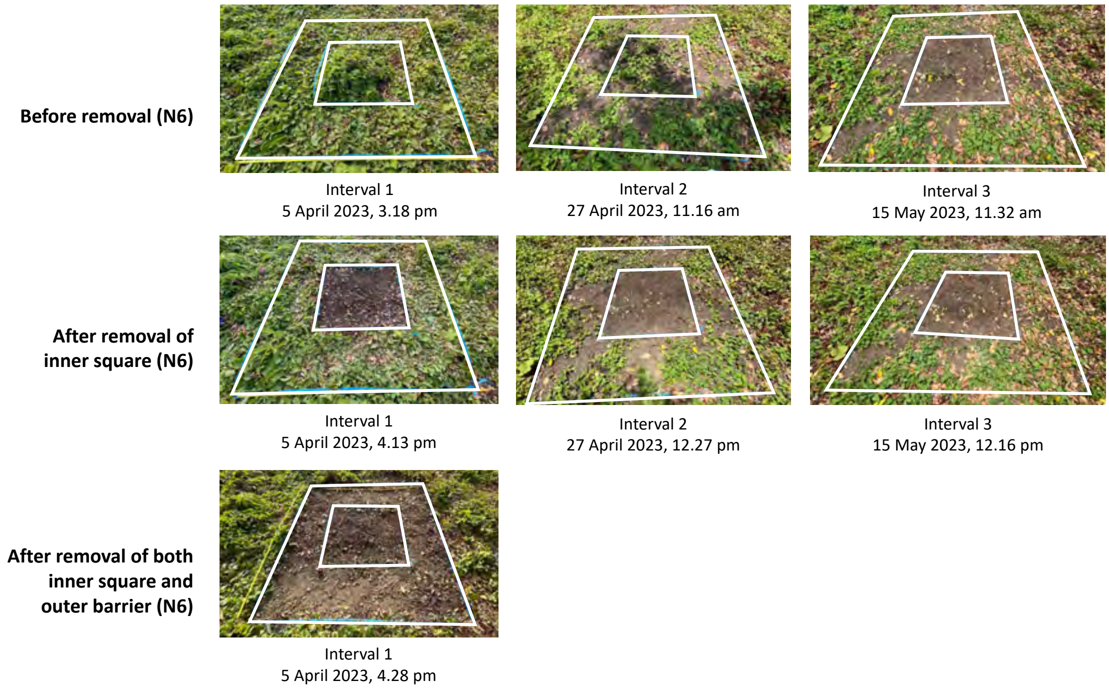

Figure A.6: The health and growth of Coralita in plot N6 over 6 weeks

A.2 South

A.2.1 S1

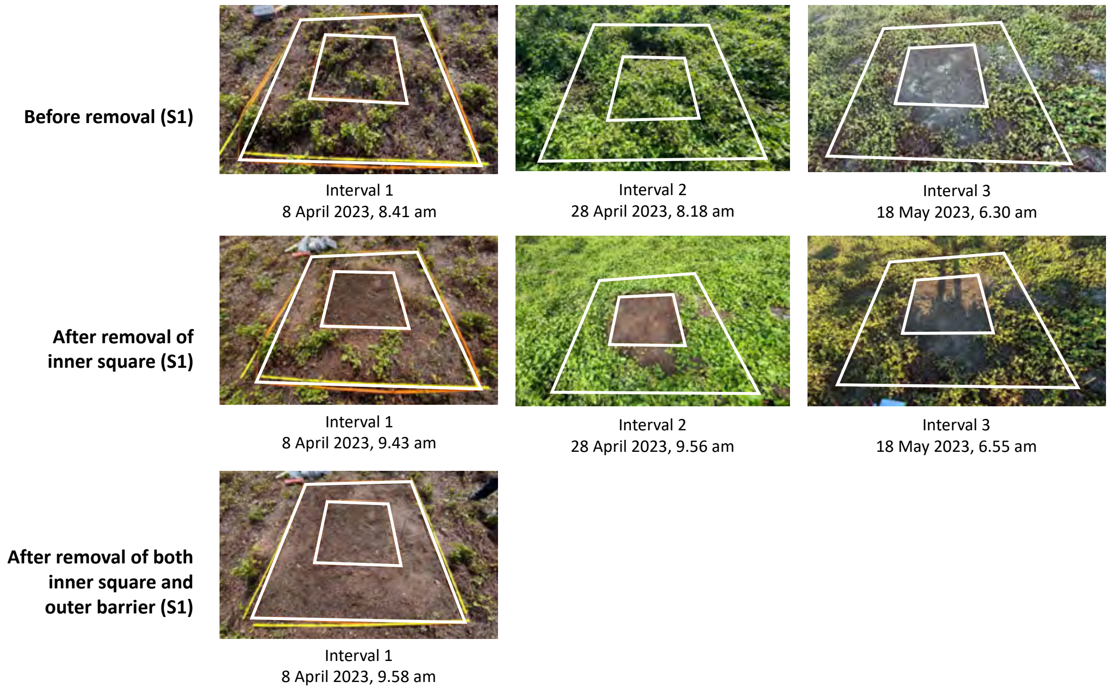

Figure A.7: The health and growth of Coralita in plot S1 over 6 weeks

A.2.2 S2

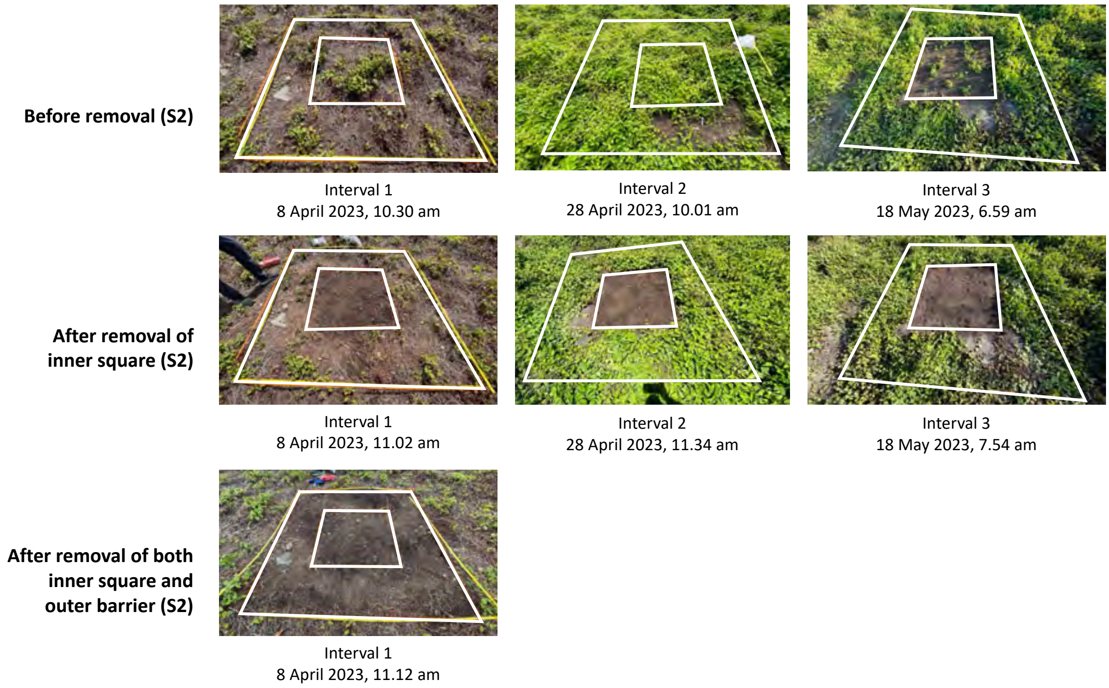

Figure A.8: The health and growth of Coralita in plot S2 over 6 weeks

A.2.3 S3

Figure A.9: The health and growth of Coralita in plot S3 over 6 weeks

A.2.4 S4

Figure A.10: The health and growth of Coralita in plot S4 over 6 weeks

A.2.5 S5

Figure A.11: The health and growth of Coralita in plot S5 over 6 weeks

A.2.6 S6

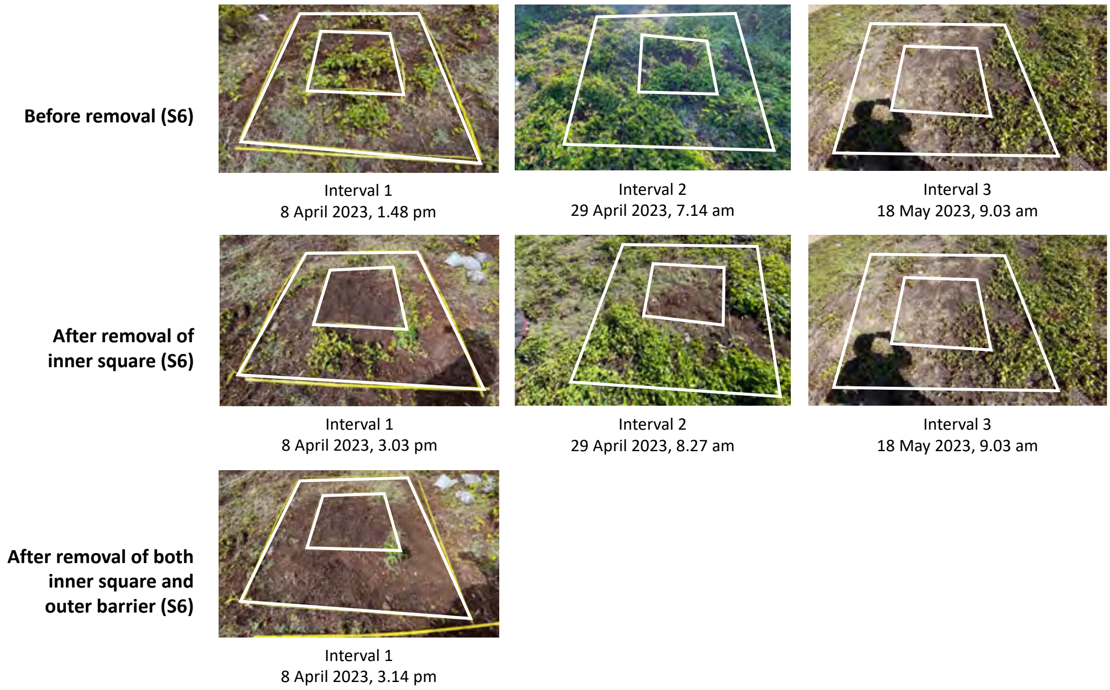

Figure A.12: The health and growth of Coralita in plot S6 over 6 weeks

A.3 East

A.3.1 E1

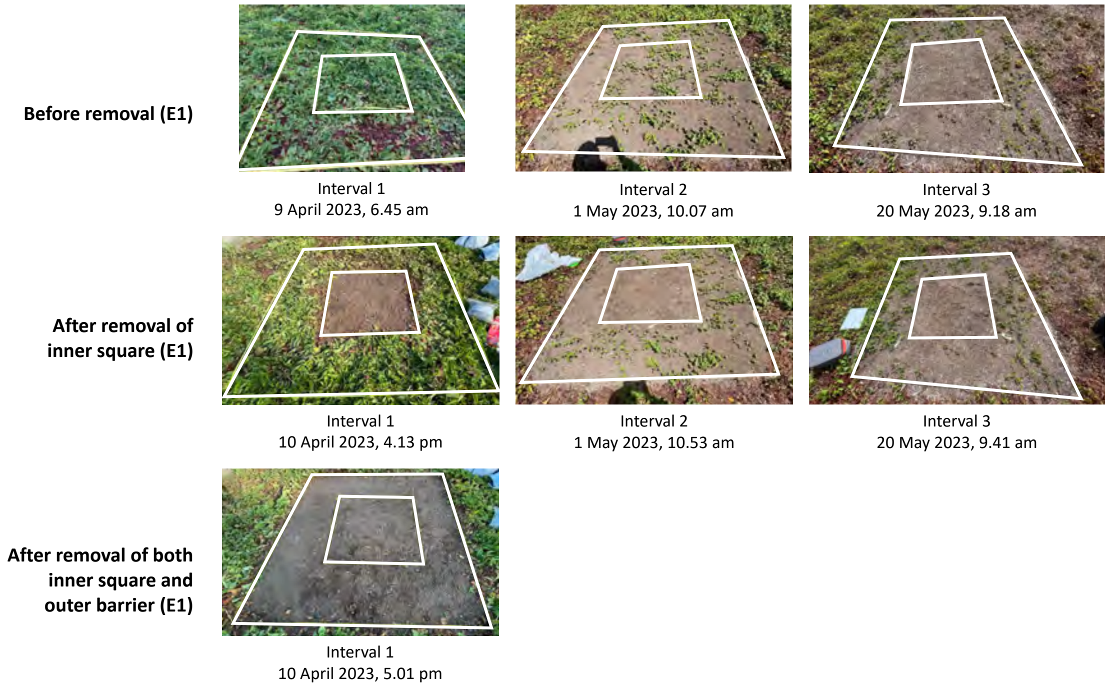

Figure A.13: The health and growth of Coralita in plot E1 over 6 weeks

A.3.2 E2

Figure A.14: The health and growth of Coralita in plot E2 over 6 weeks

A.3.3 E3

Figure A.15: The health and growth of Coralita in plot E3 over 6 weeks

A.3.4 E4

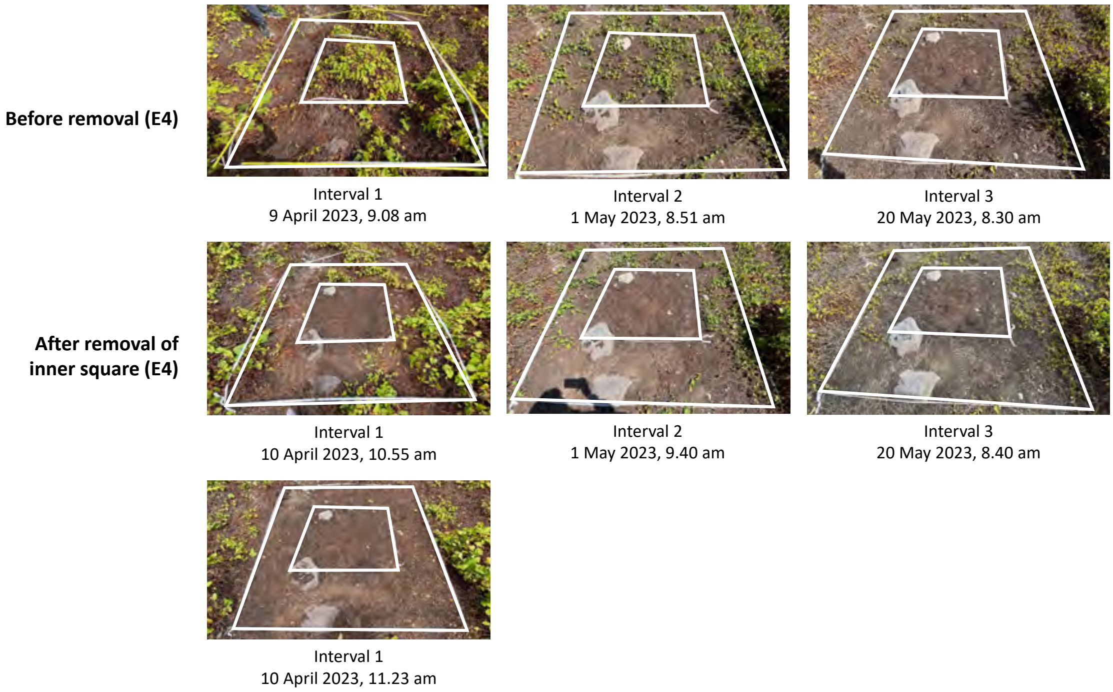

Figure A.16: The health and growth of Coralita in plot E4 over 6 weeks

A.3.5 E5

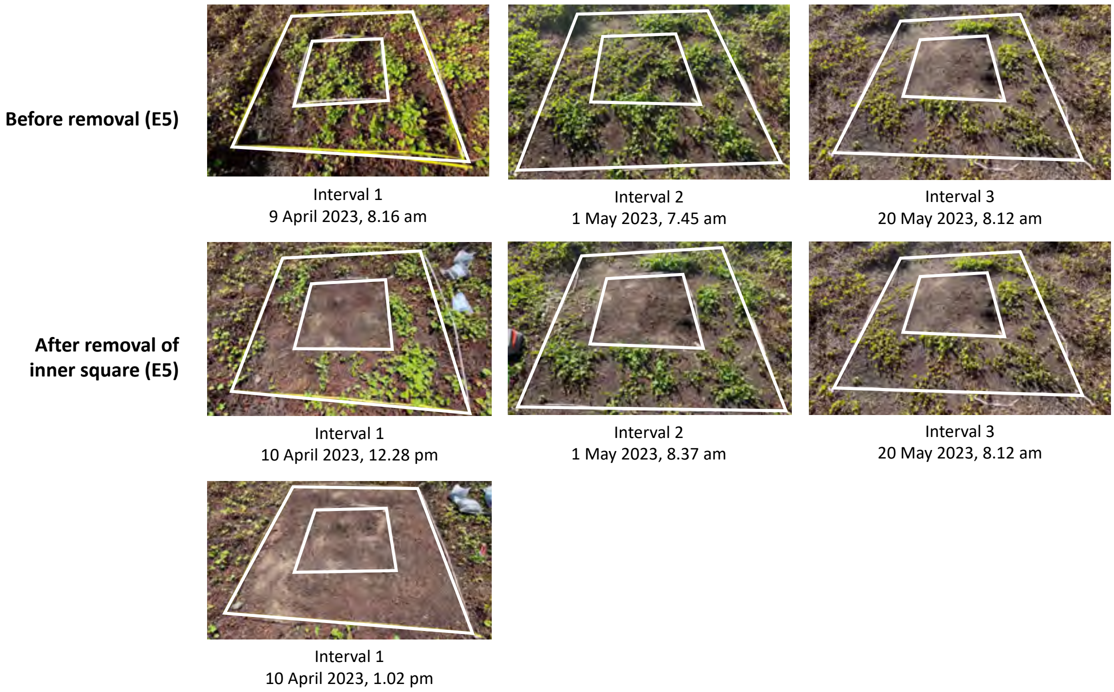

Figure A.17: The health and growth of Coralita in plot E5 over 6 weeks

A.3.6 E6

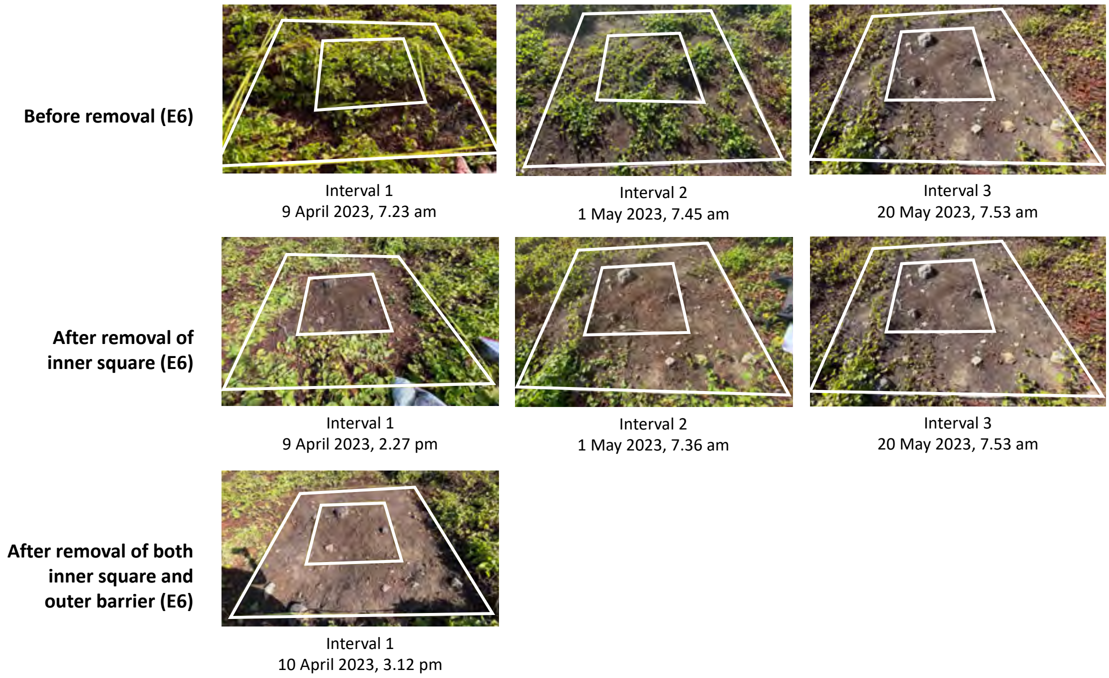

Figure A.18: The health and growth of Coralita in plot E6 over 6 weeks

A.4 West

A.4.1 W1

Figure A.19: The health and growth of Coralita in plot W1 over 6 weeks

A.4.2 W2

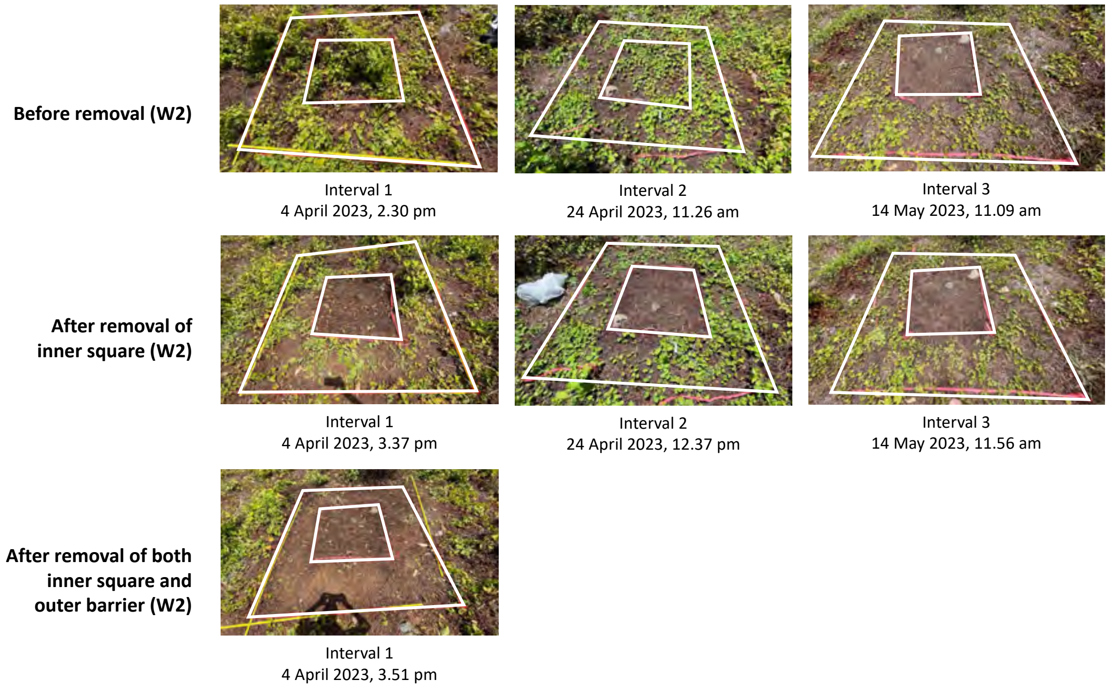

Figure A.20: The health and growth of Coralita in plot W2 over 6 weeks

A.4.3 W3

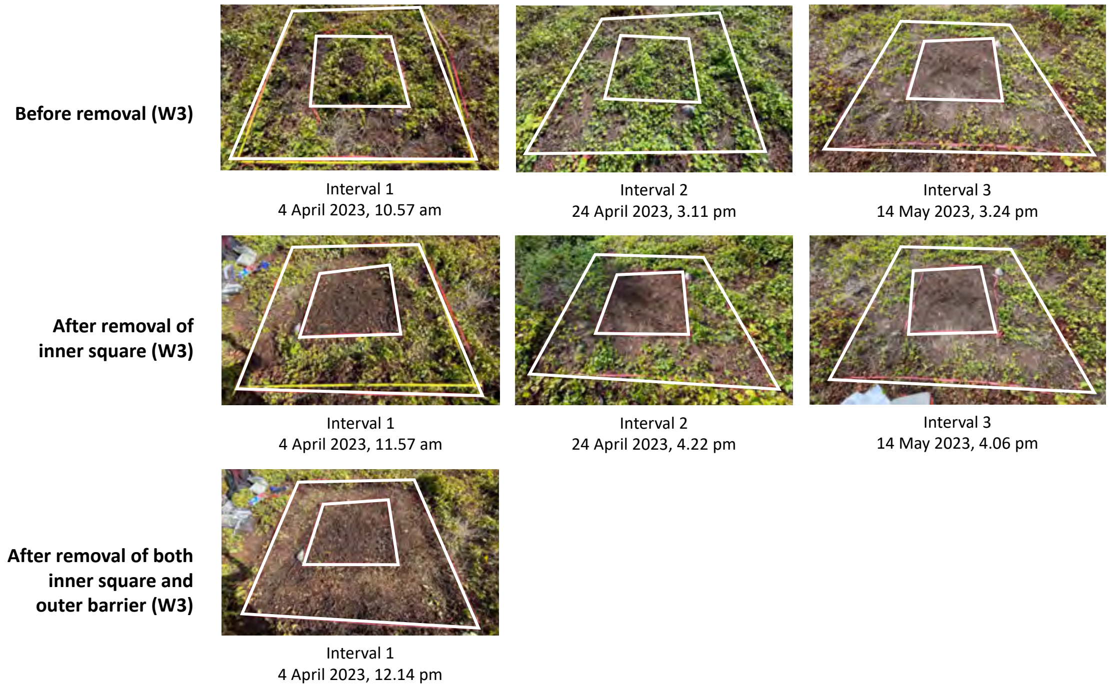

Figure A.21: The health and growth of Coralita in plot W3 over 6 weeks

A.4.4 W4

Figure A.22: The health and growth of Coralita in plot W4 over 6 weeks

A.4.5 W5

Figure A.23: The health and growth of Coralita in plot W5 over 6 weeks

A.4.6 W6

Figure A.24: The health and growth of Coralita in plot W6 over 6 weeks

A.5 Urban

A.5.1 U1

Figure A.25: The health and growth of Coralita in plot U1 over 6 weeks

A.5.2 U2

Figure A.26: The health and growth of Coralita in plot U2 over 6 weeks

A.5.3 U3

Figure A.27: The health and growth of Coralita in plot U3 over 6 weeks

A.5.4 U4

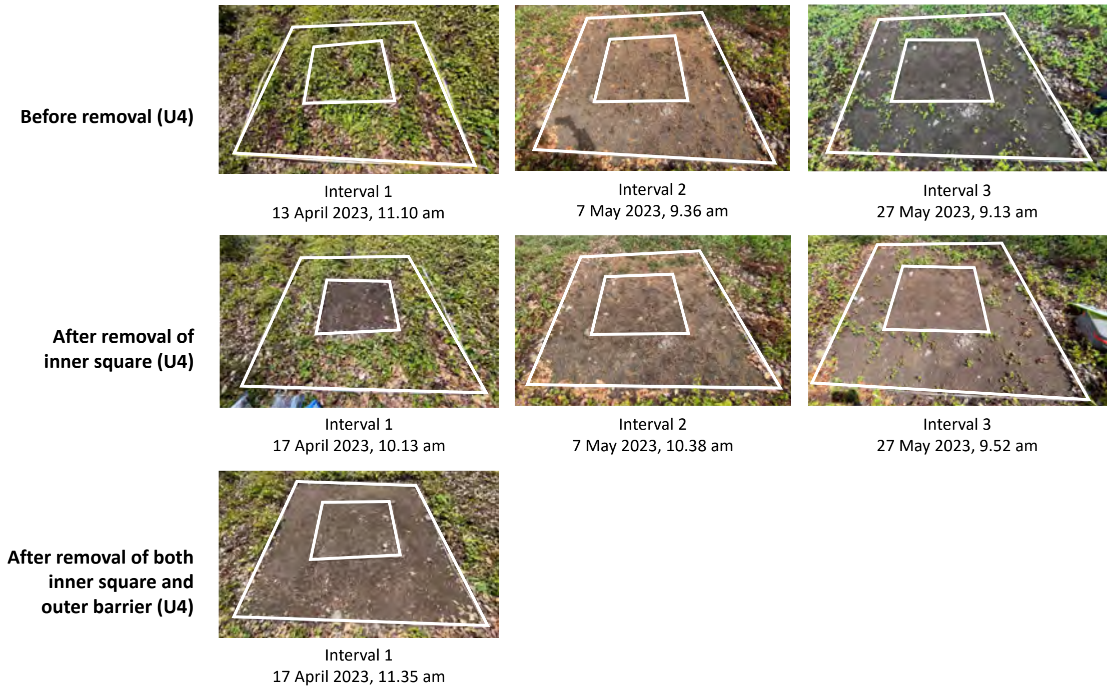

Figure A.28: The health and growth of Coralita in plot U4 over 6 weeks

A.5.5 U5

Figure A.29: The health and growth of Coralita in plot U5 over 6 weeks

A.5.6 U6

Figure A.30: The health and growth of Coralita in plot U6 over 6 weeks

Appendix B

Data and Calculation

B.1 Raw data

The raw data can be found in Tables B.1 to B.3.

Table B.1: Raw measurements obtained during Interval 1

Patch number	Leaf number	Plant traits										Environmental conditions		
		Stomatal conductance (mmol/m^{2}s)		Leaf temperature (°C)		Chlorophyll indicator SPAD	Leaf length (mm)	Leaf width (mm)	Leaf thickness (mm)	Plant biomass (g)		Incoming solar radiation, Qflux (gμmolm^{-2}s)	Air temperature, Hygrothermometer (°C)	Relative humidity, Hygrothermometer (%)
		Top of leaf	Bottom of leaf	Top of leaf	Bottom of leaf					Life biomass	Dead litter			
ZW1	1	75.8	24.4	28.5	29.3	27.0	123.00	69.00	0.09	777	529	670	27.9	63.0
	2	117.0	21.7	29.4	29.4	25.7	93.21	69.04	0.05					
	3	109.2	29.5	29.7	29.8	23.1	73.48	54.77	0.05					
	4	101.0	24.6	29.7	29.5	26.3	64.85	29.59	0.05					
	5	31.9	31.1	29.5	29.6	28.4	90.76	63.55	0.09					
	6					27.2	100	58.74	0.08					
	7					32.3	95.88	64.07	0.09					
	8					25.7	117.56	69.55	0.1					
	9					23.9	102.91	59.81	0.09					
	10					18.6	84.98	49.74	0.08					
ZW2	1	38.3	55.1	40.1	39.9	30.4	144.77	93.47	0.21	499	478	1135	35.0	42.7
	2	20.4	13.7	39.6	39.0	18.9	85.74	48.36	0.20					
	3	35.5	13.2	38.1	37.5	19.7	59.41	48.12	0.17					
	4	67.4	17.0	37.1	37.1	22.0	111.78	64.94	0.16					
	5	19.3	15.0	37.8	37.3	21.7	95.55	53.17	0.19					
	6	19.3	14.2	37.3	37.3	32.2	122.05	82.88	0.27					
	7	18.4	16.6	37.5	37.3	21.1	81.50	51.36	0.26					
	8	18.2	22.7	37.2	37.3	26.0	114.75	87.96	0.29					
	9	31.3	13.6	37.4	37.4	20.5	100.38	53.58	0.18					
	10	31.0	16.0	37.4	37.1	23.5	86.60	57.47	0.18					
ZW3	1	23.1	14.4	33.5	34.0	19.8	67.09	59.41	0.04	576	529	1856	32.7	46.3
	2	27.5	13.9	34.2	34.2	20.9	81.81	54.79	0.06					
	3	17.5	18.6	34.2	34.2	29.8	121.02	84.29	0.13					
	4	23.2	12.4	34.5	34.5	20.5	65.88	50.96	0.03					
	5	21.0	17.3	34.6	34.3	20.4	72.67	42.07	0.14					
	6	23.6	14.6	34.3	34.6	22.3	99.22	82.34	0.16					
	7	31.6	16.6	34.8	35.0	28.1	60.19	41.71	0.14					
	8	21.6	14.3	35.2	35.4	24	122.65	70.38	0.17					
	9	18.5	23.1	35.7	36.0	26.7	76.57	62.48	0.12					
	10	19.9	19.9	36.4	36.8	21.2	69.80	50.12	0.10					
ZW4	1	48.4	20.5	37.1	36.5	19.1	84.16	57.91	0.1	527	585	1001	29.8	56.2
	2	24.3	24.9	35.6	34.8	25.2	93.88	55.12	0.14					
	3	37.0	26.3	34.1	33.9	24.2	91.8	49.93	0.09					
	4	45.2	23.9	33.8	33.6	23.4	77.99	62.93	0.07					
	5	38.8	20.1	33.5	33.3	19.7	82.03	48.76	0.16					
	6	43.6	21.0	34.4	33.5	28.1	99.81	70.54	0.15					
	7	56.7	25.0	33.5	33.7	23.8	66.61	41.30	0.05					
	8	42.6	16.1	33.7	33.7	28.4	94.06	70.64	0.17					
	9	33.4	21.8	33.8	33.9	30.5	64.9	42.05	0.09					
	10	45.8	20.4	33.8	33.3	28.6	90.73	62.38	0.14					
ZW5	1	88.3	51.6	31.7	31.6	21.1				600	631	1229		41.0
	2	61.7	84.0	31.0	30.7	26.8								
	3	110.7	33.3	30.5	30.2	27.6								
	4	136.8	40.0	30.1	29.4	19.7								
	5	82.7	41.1	29.1	29.1	17.0								
	6					27.5								
	7					20.5								
	8					31.9								
	9					24.0								
	10					23.2								
ZW6	1	36.7	20.7	32.5	32.4	26.5	79.03	50.82	0.21	420	392	1772	33.9	47.2
	2	65.7	47.2	32.2	31.9	39.0	107.13	71.67	0.30					
	3	15.8	60.7	31.6	31.8	26.4	83.15	52.89	0.24					
	4	14.3	58.8	34.1	32.3	28.0	81.44	68.47	0.25					
	5	23.2	55.8	33.0	32.1	27.3	72.10	53.62	0.16					
	6	22.7	57.4	32.3	32.6	22.6	84.58	68.44	0.22					
	7	13.7	50.0	33.0	33.5	18.7	92.08	63.01	0.25					
	8	12.2	26.2	33.7	33.9	23.1	87.02	56.65	0.26					
	9	25.7	16.6	34.0	34.3	23.8	81.21	54.98	0.17					
	10	16.1	15.2	31.6	34.9	25.1	53.18	46.95	0.23					
ZN1	1	14.2	15.6	37.1	36.3	23.4	100.43	66.53	0.19	351	407	2212	32.7	53.2
	2	27.2	16.4	36.1	35.9	21.8	79.36	54.84	0.17					
	3	26.2	17.6	36.1	36.3	17.7	71.30	41.75	0.17					
	4	37.0	18.9	35.8	35.0	27.0	99.61	71.72	0.24					
	5	23.2	25.5	34.4	33.6	22.0	69.73	48.57	0.20					
	6	36.7	20.4	33.0	32.6	33.4	82.15	63.72	0.22					
	7	23.2	21.2	33.7	33.7	19.2	70.20	54.99	0.16					
	8	23.1	19.3	32.8	32.6	17.1	66.58	49.08	0.12					
	9	28.6	22.4	32.3	32.0	35.7	100.42	75.75	0.16					
	10	33.9	16.2	32.0	32.4	28.9	80.49	63.24	0.17					
ZN2	1	14.8	16.3	36.0	35.5	35.2	72.97	46.76	0.18	550	507	2209	31.5	56.7
	2	22.8	12.8	35.1	35.2	33.7	96.79	68.16	0.20					
	3	42.4	18.4	35.3	35.5	36.1	91.80	65.79	0.24					
	4	16.8	19.9	35.5	35.5	30.4	73.77	42.30	0.15					
	5	43.9	23.6	35.5	35.6	29.7	63.73	39.32	0.16					
	6	22.5	25.6	35.6	35.0	28.0	66.79	48.77	0.11					
	7	20.7	17.0	39.9	34.5	30.2	58.68	46.46	0.16					
	8	21.3	19.3	34.1	33.9	28.0	86.61	56.58	0.19					
	9	55.8	33.2	33.7	33.5	33.7	91.28	60.87	0.22					
	10	67.3	20.2	33.8	34.1	26.2	85.11	59.84	0.22					
ZN3	1	278.6	39.0	39.0	38.3	20.3	93.25	63.30	0.22	734	807	2341	30.5	64.5
	2	265.0	55.8	37.5	36.8	19.0	81.29	76.99	0.28					
	3	265.3	145.9	36.4	36.5	28.4	97.81	58.30	0.27					
	4	202.0	49.7	36.7	36.8	22.7	86.75	49.47	0.20					
	5	291.6	55.4	36.7	36.7	25.1	119.00	82.74	0.27					
	6	366.1	54.2	36.8	36.6	20.7	106.70	64.83	0.24					
	7	313.7	54.5	36.4	36.3	18.7	115.99	64.15	0.24					
	8	60.8	55.8	36.2	36.1	28.9	88.10	67.20	0.25					
	9	264.3	68.2	36.0	36.3	23.0	131.6	69.55	0.33					
	10	355.8	60.9	36.4	36.1	23.1	121.12	72.11	0.22					
ZN4	1	19.5	15.6	31.0	30.6	35.0	117.54	64.66	0.30	1329	806	1966	33.2	54.8
	2	9.9	31.5	30.2	29.9	34.5	110.39	67.71	0.35					
	3	12.3	26.0	29.7	29.5	26.4	91.04	58.97	0.25					
	4	28.4	18.3	29.3	29.0	34.1	86.82	70.71	0.23					
	5	24.3	17.1	28.7	28.2	30.2	91.31	77.94	0.28					
	6	16.8	17.4	27.7	27.2	35.7	85.88	62.50	0.31					
	7	381.9	93.6	30.7	30.5	39.1	105.64	82.98	0.29					

	8	157.0	89.8	30.7	30.9	32.3	110.89	82.41	0.29					
	9	149.7	120.7	30.8	30.0	22.6	58.15	36.92	0.18					
	10	129.6	70.8	30.2	31.3	29.3	84.57	60.44	0.21					
ZN5	1	385.0	53.9	33.7	33.8	28.5	109.58	67.93	0.24	746	875	2146	30.4	61.2
	2	599.7	54.9	33.7	33.7	26.2	75.48	45.38	0.13					
	3	468.3	33.9	33.8	33.9	25.7	106.60	56.81	0.29					
	4	409.1	185.2	34.1	34.4	39.3	108.95	76.20	0.25					
	5	612.8	100.6	34.3	34.2	31.4	108.08	57.50	0.20					
	6	177.5	53.9	34.2	33.7	31.4	100.38	69.42	0.30					
	7	256.8	74.8	33.4	33.1	31.5	86.80	51.67	0.24					
	8	320.3	62.2	32.8	32.5	32.1	95.43	51.12	0.25					
	9	215.9	87.6	32.6	32.5	30.6	111.44	69.62	0.28					
	10	181.9	77.7	32.6	32.5	27.7	80.51	52.63	0.22					
ZN6	1	61.7	20.4	35.2	34.6	32.8	124.13	94.38	0.28	837	733	293	27.5	65.1
	2	77.5	18.6	34.2	34.4	23.1	74.81	48.68	0.25					
	3	13.0	44.7	33.9	33.5	25.0	118.05	78.70	0.34					
	4	14.1	60.8	33.7	33.7	32.3	151.80	91.26	0.30					
	5	29.5	69.2	33.5	33.4	27.7	140.93	90.86	0.29					
	6	13.4	66.8	33.5	33.3	31.5	104.35	59.69	0.27					
	7	19.5	65.4	33.3	33.2	32.1	95.09	60.67	0.29					
	8	25.1	50.6	33.0	32.6	24.3	102.47	59.22	0.32					
	9	47.1	58.9	32.1	31.8	31.7	114.01	70.96	0.30					
	10	32.5	32.3	31.4	31.1	34.3	147.44	90.62	0.37					
ZE1	1	229.9	51.4	26.1	26.1	29.4	68.79	43.26	0.19	899	451	207	25.2	76.0
	2	265.7	53.8	26.2	26.3	40.3	123.03	75.63	0.46					
	3	261.3	61.8	26.3	26.3	29.7	67.22	40.21	0.25					
	4	170.2	65.1	26.4	26.4	36.4	81.99	49.18	0.25					
	5	168.4	66.4	26.5	26.4	29.6	73.36	40.92	0.21					
	6	226.3	29.7	26.5	26.5	44.0	146.94	97.04	0.41					
	7	274.3	59.0	26.6	26.6	34.5	83.69	52.55	0.31					
	8	420.8	54.2	26.6	26.6	34.7	87.39	52.10	0.30					
	9	279.0	59.5	26.7	26.8	31.9	75.07	46.36	0.30					
	10	204.7	61.7	26.8	26.8	36.6	104.27	65.23	0.36					
ZE2	1	219.1	53.0	32.7	32.2	22.3	125.20	86.10	0.20	508	1310	595	27.8	73.0
	2	274.6	60.0	31.9	32.0	24.9	110.65	71.32	0.25					
	3	108.1	60.3	31.7	31.2	18.4	104.45	61.75	0.26					
	4	177.8	56.2	30.9	31.3	24.2	63.21	43.23	0.15					
	5	381.2	53.4	31.6	31.9	25.8	112.16	65.38	0.27					
	6	257.7	81.2	31.9	31.5	32.3	69.52	51.57	0.37					
	7	144.0	92.7	31.0	30.6	16.9	101.07	80.54	0.18					
	8	255.4	76.8	30.6	30.6	25.4	73.43	55.43	0.35					
	9	120.0	85.8	30.5	30.2	15.7	77.62	55.03	0.20					
	10	246.0	84.6	30.0	29.9	23.1	85.68	65.50	0.35					
ZE3	1	175.4	88.7	28.3	28.0	26.5	66.79	52.63	0.30	557	1457	151	26.7	75.8
	2	134.9	99.9	27.8	27.7	14.1	71.03	59.31	0.33					
	3	153.1	68.4	27.6	27.6	19.0	95.86	76.88	0.22					
	4	96.8	72.3	27.6	27.5	24.9	86.20	54.92	0.27					
	5	152.0	95.9	27.5	27.5	23.4	99.46	54.65	0.23					
	6	110.0	105.0	27.4	27.4	30.7	64.85	55.40	0.32					
	7	135.1	81.1	27.4	27.4	21.5	109.34	72.48	0.33					
	8	188.6	102.5	27.5	27.5	19.5	80.42	57.47	0.23					
	9	132.1	99.4	27.6	27.6	20.9	77.96	57.20	0.25					
	10	81.3	92.8	27.6	27.5	25.0	92.75	66.57	0.38					
ZE4	1	197.7	39.4	33.1	33.6	25.5	87.28	53.70	0.34	464	517	2183	33.3	54.9
	2	303.6	48.8	34.0	34.3	25.9	95.41	80.67	0.27					
	3	357.3	40.5	33.7	33.4	24.8	97.96	66.05	0.36					
	4	211.6	50.1	33.2	33.2	23.5	83.24	60.02	0.18					
	5	151.8	48.5	33.5	33.4	25.4	141.20	84.89	0.29					
	6	95.2	33.4	33.4	33.6	23.6	72.30	46.40	0.21					
	7	202.5	55.5	34.4	34.5	19.2	89.71	60.35	0.20					
	8	325.4	39.6	34.5	34.2	22.5	76.17	55.38	0.36					
	9	541.7	41.0	34.2	33.7	26.7	106.25	74.56	0.33					
	10	165.9	40.3	33.7	33.4	21.7	92.62	70.95	0.31					
ZE5	1	513.6	72.9	31.9	31.9	25.9	61.80	64.96	0.35	231	442	1602	29.6	66.4
	2	715.7	70.0	32.0	32.4	28.4	86.82	73.25	0.36					
	3	564.9	126.7	32.5	32.6	23.0	72.23	59.26	0.35					
	4	499.6	70.8	32.8	33.0	24.1	65.08	59.33	0.36					
	5	700.1	98.2	33.1	33.4	18.6	63.50	53.50	0.33					
	6	616.0	92.5	33.4	33.4	26.1	78.73	66.10	0.32					
	7	444.7	66.0	33.2	33.1	24.3	60.77	49.52	0.31					
	8	586.0	70.2	33.3	33.3	25.8	73.95	63.94	0.30					
	9	529.1	89.2	33.4	33.6	28.2	62.17	56.79	0.39					
	10	494.3	82.0	33.5	33.0	25.2	67.17	61.77	0.42					
ZE6	1	256.8	92.7	27.3	28.3	20.1	73.08	53.29	0.29	740	1257	1104	27.9	67.4
	2	366.2	106.0	29.1	29.7	20.3	102.16	63.73	0.35					
	3	351.5	70.0	30.1	30.3	16.3	93.37	62.40	0.36					
	4	391.3	56.5	30.4	30.4	20.0	83.12	60.63	0.32					
	5	382.6	72.0	30.6	30.6	20.7	122.91	72.97	0.43					
	6	325.7	65.6	30.6	30.3	23.5	69.28	48.57	0.36					
	7	325.9	56.5	30.1	30.0	20.4	114.72	79.79	0.31					
	8	316.7	71.0	30.4	30.9	24.3	84.66	72.76	0.34					
	9	280.5	87.7	31.4	31.7	21.4	119.41	85.86	0.32					
	10	263.6	49.6	31.8	31.9	21.9	90.33	64.39	0.31					
ZS1	1	427.8	138.5	28.9	29.3	26.7	44.29	28.86	0.23	180	1054	1688	29.9	63.4
	2	343.0	82.8	29.6	30.0	30.8	61.04	45.31	0.22					
	3	353.1	70.4	30.3	30.5	34.6	65.70	43.99	0.28					
	4	374.1	67.3	31.0	31.4	38.8	64.51	40.76	0.27					
	5	464.8	72.3	31.7	32.3	35.5	66.70	39.77	0.24					
	6	454.9	70.2	32.5	32.5	27.2	51.12	34.61	0.24					
	7	366.0	61.6	32.5	32.8	31.5	61.58	51.58	0.33					
	8	335.0	64.5	32.7	32.4	28.1	57.80	39.28	0.28					
	9	626.9	62.4	32.5	32.7	29.1	52.87	48.90	0.27					
	10	379.9	69.9	32.8	32.9	29.4	51.98	36.53	0.27					
ZS2	1	476.7	56.4	30.1	30.2	30.9	75.50	56.81	0.29	175	355	2158	30.6	59.3
	2	682.9	54.9	30.7	31.5	41.4	56.84	50.25	0.34					
	3	332.7	54.8	32.4	32.9	32.4	86.41	57.44	0.31					
	4	448.7	70.2	33.1	33.4	34.7	73.10	48.71	0.24					
	5	412.6	114.7	33.8	34.2	27.4	63.70	47.77	0.16					
	6	463.3	404.5	34.4	34.0	32.0	67.42	57.07	0.27					
	7	446.8	238.5	34.1	33.9	33.0	61.01	41.52	0.24					
	8	629.0	72.2	34.3	34.4	27.1	56.87	34.11	0.21					
	9	1070.2	123.0	34.5	34.5	25.4	45.13	43.93	0.25					
	10	685.1	147.2	34.1	33.7	34.6	61.20	43.84	0.27					
	1	196.4	49.1	35.2	35.5	37.4	89.35	57.75	0.35					

	2	458.7	56.5	35.7	36.0	30.0	96.97	68.14	0.31					
	3	462.4	47.6	36.3	36.8	31.0	81.05	49.86	0.22					
	4	488.6	56.8	37.1	37.5	25.1	68.06	41.16	0.31					
ZS3	5	528.4	51.2	37.9	38.1	26.3	91.47	55.59	0.30	302	1138	1405	29.4	67.0
	6	358.5	66.0	37.8	37.5	28.6	79.11	55.60	0.37					
	7	484.4	68.6	37.1	36.9	34.1	63.16	53.01	0.28					
	8	303.7	97.2	36.0	35.0	30.3	69.82	46.80	0.35					
	9	266.6	114.7	34.4	34.3	26.2	79.70	42.55	0.30					
	10	388.3	69.2	37.2	34.4	31.9	100.76	65.21	0.32					
	1	331	72.6	32.7	32.5	22.7	87.51	55.62	0.30					
	2	272.2	75.5	32.6	33.0	30.3	79.18	55.40	0.31					
	3	292.6	58.2	33.5	33.6	27.4	72.57	53.37	0.32					
	4	401.4	65.5	33.7	33.6	31.6	74.63	53.26	0.32					
ZS4	5	260.4	75.8	33.4	33.2	22.6	70.99	47.87	0.28	356	618	1008	28.5	67.2
	6	259.8	67.2	33.1	33.1	30.1	76.57	61.37	0.33					
	7	433.2	79.1	32.9	32.4	25.4	96.82	66.91	0.30					
	8	435.1	93.9	32.0	31.8	21.8	79.95	51.30	0.30					
	9	401.7	76.7	31.6	31.4	21.2	70.75	44.32	0.26					
	10	160.1	126.4	31.2	31.3	26.2	62.81	40.81	0.21					
	1	383.8	51.4	30.1	30.5	35.4	91.16	63.86	0.21					
	2	339.5	78.1	30.8	31.4	35.4	95.35	64.11	0.20					
	3	72.7	48.6	32.1	32.6	35.9	87.31	58.98	0.18					
	4	475.3	74.7	33.4	34.5	32.6	87.28	58.80	0.29					
ZS5	5	879.7	60.7	35.5	36.6	28.0	60.92	37.14	0.23	181	387	1135	33.6	51.5
	6	416.9	42.7	36.6	36.0	26.0	74.06	48.07	0.22					
	7	343.1	60.9	35.5	34.9	26.5	67.90	48.69	0.18					
	8	303.1	51.7	34.2	33.6	29.0	82.13	44.40	0.29					
	9	273.9	71.6	33.1	32.4	21.9	63.40	34.33	0.27					
	10	74.0	65.3	32.1	32.0	24.0	94.78	54.54	0.25					
	1	295.8	42.3	34.6	34.2	28.4	112.70	68.90	0.31					
	2	513.3	58.9	34.8	33.7	25.9	73.81	45.44	0.29					
	3	374.8	41.2	33.7	33.5	21.9	82.73	52.03	0.31					
	4	295.0	64.1	33.7	34.1	20.3	91.27	68.34	0.28					
ZS6	5	425.7	48.7	34.3	34.3	32.7	111.37	69.33	0.36	232	345	897	29.6	64.1
	6	330.0	42.7	34.4	34.1	20.3	63.44	40.17	0.15					
	7	213.5	67.3	33.7	33.3	31.5	100.75	58.44	0.26					
	8	400.8	43.1	32.9	32.7	30.0	103.91	60.13	0.25					
	9	127.2	50.6	32.6	32.6	27.2	85.33	46.51	0.27					
	10	337.3	111.8	32.9	33.1	22.1	81.56	54.86	0.16					
	1	129.2	73.3	29.9	30.9		116.23	77.36	0.28					
	2	231.0	46.5	32.8	33.0		94.43	63.54	0.19					
	3	222.5	58.3	32.9	32.6		99.80	63.91	0.25					
	4	304.4	42.1	32.4	32.4		82.01	55.52	0.24					
ZU1	5	385.5	55.0	32.6	32.6		79.73	55.05	0.20	700	617	1255	30.9	54.5
	6	402.2	46.9	32.6	32.3		104.34	62.42	0.22					
	7	213.0	46.5	32.0	32.0		69.93	49.25	0.17					
	8	235.6	59.8	31.9	31.8		90.86	60.87	0.21					
	9	235.9	63.7	31.7	31.6		97.06	58.67	0.17					
	10	163.5	53.9	31.3	31.2		73.40	53.68	0.22					
	1	169.1	102.4	32.8	33.2		67.31	58.46	0.21					
	2	248.8	42.5	33.9	34.4		72.68	69.93	0.21					
	3	239.7	68.8	34.7	35.0		60.45	50.21	0.18					
	4	234.8	37.7	36.2	36.0		84.45	67.89	0.25					
ZU2	5	164.9	75.4	35.4	35.3		74.39	65.14	0.22	491	502	1190	34.6	46.5
	6	273.2	33.3	35.4	35.0		92.47	54.93	0.20					
	7	88.0	38.7	34.5	34.4		65.32	68.12	0.20					
	8	170.3	47.6	33.9	33.4		103.00	64.93	0.15					
	9	274.6	42.2	33.5	33.5		86.32	81.79	0.19					
	10	121.8	41.9	33.2	33.3		82.78	51.78	0.16					
	1	105.4	45.4	29.7	29.5		85.64	70.23	0.26					
	2	78.4	46.8	29.3	29.2		87.08	56.71	0.21					
	3	91.6	36.8	29.0	28.8		108.64	90.08	0.22					
	4	97.2	64.3	28.5	28.4		72.59	73.79	0.23					
ZU3	5	186.5	55.1	27.9	27.9		121.1	92.69	0.42	647	567	183	28.4	65.2
	6	112.9	66.2	27.8	27.7		97.84	84.16	0.26					
	7	86.0	85.4	27.6	27.4		72.35	57.86	0.21					
	8	247.5	58.8	27.3	27.3		81.77	53.66	0.28					
	9	154.3	68.7	27.3	27.3		87.67	69.14	0.29					
	10	141.6	61.7	27.3	27.3		125.38	85.06	0.35					
	1	136.9	41.6	37.8	41.6		111.34	65.36	0.16					
	2	283.2	35.2	38.5	35.2		83.92	50.68	0.17					
	3	210.2	39.9	37.5	39.9		76.55	59.27	0.15					
	4	527.3	40.4	36.5	40.4		102.73	70.66	0.16					
ZU4	5	533.7	38.4	35.2	38.4		99.29	74.08	0.19	717	844	2162	33.3	48.1
	6	316.3	44.7	35.8	44.7		81.55	50.93	0.15					
	7	537.6	203.5	36.4	42.8		81.44	44.75	0.17					
	8	744.4	42.8	36.3	35.7		84.92	53.06	0.27					
	9	320.1	60.2	36.3	35.9		121.76	67.80	0.21					
	10	356.1	64.8	35.5	35.6		109.52	66.02	0.19					
	1	500.7	145.0	37.2	36.8		97.52	67.78	0.32					
	2	750.6	35.7	35.3	34.6		88.36	55.69	0.21					
	3	659.4	50.9	33.1	32.8		92.26	52.76	0.20					
	4	792.6	49.2	33.0	32.9		76.24	59.22	0.23					
ZU5	5	732.3	76.1	32.8	33.1		94.59	63.39	0.24	627	107	1956	34.1	47.6
	6	694.8	63.9	33.8	33.0		89.60	58.23	0.20					
	7	757.4	50.3	32.3	32.0		90.74	50.33	0.21					
	8	752.6	49.4	32.2	31.8		88.10	49.64	0.26					
	9	607.2	52.8	31.3	30.9		103.41	62.87	0.19					
	10	869.3	115.3	30.8	30.8		98.18	56.29	0.22					
	1	1033.2	44.1	36.0	36.5		74.75	46.59	0.13					
	2	858.6	51.2	36.6	35.6		54.01	42.23	0.12					
	3	880.2	48.3	34.7	34.6		77.42	51.59	0.18					
	4	681.4	46.7	34.5	35.0		73.31	62.42	0.15					
ZU6	5	738.3	112.9	34.6	34.0		60.29	52.55	0.09	531	301	1987	36.0	45.0
	6	507.6	43.9	33.3	32.9		49.31	38.76	0.11					
	7	448.4	33.7	32.7	32.7		89.68	62.29	0.10					
	8	723.2	181.7	32.7	32.7		61.08	51.03	0.20					
	9	555.7	35.7	32.7	32.7		80.47	57.71	0.26					
	10	297.2	40.3	32.6	32.5		74.03	55.58	0.19					

Table B.2: Raw measurements obtained during Interval 2

Patch number	Leaf/Stem number	Plant traits: Stomatal conductance ($mmol/m^2s$) Top of leaf	Bottom of leaf	Leaf temperature (°C) Top of leaf	Bottom of leaf	Leaf length (mm)	Leaf width (mm)	Leaf thickness (mm)	Length of stem (cm)	No. of leaves per stem	Plant biomass (g)	Flowers (Y/N)	Environmental conditions: Incoming solar radiation, Qflux ($g\mu mol m^{-2}s$)	Air temperature, Hygrothermometer (°C)	Relative humidity, Hygrothermometer (%)
ZW1	1	872.4	80.6	28.1	30.2	62.03	48.21	0.20	66.1	7	334	N	1894	30.1	69.5
	2	1011.0	68.2	37.0	37.2	56.67	42.76	0.25	64.7	7					
	3	993.8	25.9	40.2	40.1	56.01	33.59	0.08	48.1	9					
	4	843.0	147.5	42.3	42.1	82.87	68.17	0.21	65.9	9					
	5	838.4	42.3	40.6	39.8	58.98	43.65	0.09	36.9	9					
	6	629.1	34.1	38.4	37.3	78.73	55.06	0.17	60.4	11					
	7	658.8	54.9	37.2	37.8	73.84	47.61	0.10	80.3	8					
	8	924.5	38.3	37.7	38.5	54.85	39.41	0.08	46.5	11					
	9	847.5	139.6	38.5	38.4	53.98	56.02	0.20	87.6	6					
	10	548.7	41.4	38.1	38.1	65.57	49.68	0.17	56.1	8					
ZW2	1	1257.4	97.0	40.7	39.8	68.61	48.18	0.10	101.1	11	204	N	2274	38.9	42.4
	2	1179.6	205.1	38.4	38.0	59.40	74.33	0.15	98.8	12					
	3	1245.9	59.0	39.2	38.5	59.73	47.25	0.14	53.0	10					
	4	889.6	92.7	37.5	37.4	65.01	62.71	0.12	83.1	12					
	5	983.0	52.6	37.0	36.9	51.84	41.92	0.10	95.4	10					
	6	1039.2	169.3	36.1	35.6	53.41	80.13	0.14	76.0	11					
	7	1229.8	64.3	35.3	35.5	62.73	36.67	0.10	50.2	6					
	8	940.8	83.6	35.4	35.1	66.25	52.13	0.19	50.1	8					
	9	1009.8	33.2	35.1	35.4	68.71	51.31	0.15	42.7	8					
	10	376.0	38.8	35.8	36.2	73.01	55.62	0.12	68.9	10					
ZW3	1	885.0	48.6	29.3	30.8	80.97	60.26	0.15	93.4	12	323	N	1785	31.6	52.6
	2	445.6	48.4	34.5	34.8	56.42	45.42	0.14	39.2	7					
	3	624.1	42.8	35.1	35.3	71.87	56.11	0.10	71.0	11					
	4	377.8	55.0	35.4	35.5	56.64	58.23	0.20	35.9	8					
	5	595.7	46.7	36.1	36.4	86.67	64.86	0.22	89.5	14					
	6	200.7	50.7	36.9	37.0	60.46	55.05	0.22	33.1	7					
	7	573.6	43.7	36.9	37.1	66.29	55.46	0.28	60.5	8					
	8	294.9	38.1	37.1	37.1	75.85	67.09	0.19	59.1	9					
	9	425.1	37.0	36.9	37.2	54.11	49.07	0.15	44.9	8					
	10	316.2	47.0	37.1	37.3	55.19	57.13	0.16	53.6	10					
ZW4	1	404.2	166.7	36.0	35.4	52.48	47.43	0.31	53.4	10	495	N	815	32.0	56.6
	2	329.3	46.6	34.5	34.3	68.85	51.51	0.20	68.8	11					
	3	257.6	63.0	33.3	33.3	91.94	66.78	0.21	70.9	10					
	4	129.4	42.0	32.7	32.3	63.88	43.85	0.12	42.5	8					
	5	322.3	55.8	31.8	31.6	81.15	55.73	0.20	53.5	7					
	6	195.7	46.4	31.2	31.1	63.46	48.84	0.17	54.1	8					
	7	176.6	66.1	31.7	31.6	70.86	44.75	0.20	83.1	11					
	8	351.5	55.5	31.3	30.8	63.72	42.50	0.11	72.3	11					
	9	111.8	65.6	30.6	30.6	72.63	48.12	0.19	71.9	13					
	10	115.7	66.8	30.5	30.3	61.62	46.28	0.18	38.1	9					
ZW5	1	769.5	57.9	30.7	30.9	91.21	64.24	0.09	38.1	9	349	N	1751	30.4	61.4
	2	1009.8	52.8	30.8	30.0	68.41	67.83	0.13	56.5	9					
	3	483.0	38.1	30.2	31.3	85.81	68.30	0.12	76.1	11					
	4	582.6	33.2	31.5	31.8	64.19	64.79	0.15	76.5	8					
	5	269.9	33.7	32.1	32.3	39.01	65.95	0.10	57.1	7					
	6	962.9	57.8	32.3	32.6	46.45	67.44	0.20	38.4	7					
	7	210.4	49.5	33.0	33.5	55.37	54.93	0.13	49.8	9					
	8	209.7	35.7	33.7	33.9	72.33	61.75	0.14	23.4	7					
	9	659.2	50.4	33.7	33.7	61.84	68.23	0.13	57.0	9					
	10	595.3	47.3	32.8	32.6	81.82	76.32	0.20	47.3	9					
ZW6	1	301.9	46.3	29.9	30.2	66.31	42.99	0.15	53.0	10	293	N	1831	35.2	63.3
	2	423.2	56.0	31.3	31.4	59.35	52.84	0.22	35.8	5					
	3	467.9	61.8	32.6	33.3	61.07	44.38	0.18	35.4	9					
	4	566.3	166.2	34.0	34.4	87.20	70.94	0.23	34.1	6					
	5	505.4	49.5	34.7	35.3	69.25	50.59	0.21	50.4	7					
	6	463.1	65.9	35.6	35.9	68.78	65.73	0.23	45.9	8					
	7	281.2	54.8	35.8	35.9	74.02	58.98	0.23	77.4	12					
	8	612.1	87.9	36.0	36.4	69.42	54.57	0.15	46.3	8					
	9	870.1	61.3	36.6	36.9	70.12	56.23	0.16	59.0	6					
	10	487.8	55.3	37.1	37.4	82.41	57.83	0.25	45.0	9					
ZN1	1	799.3	145.2	37.5	36.8	47.63	29.30	0.08	54.1	7	104	N	2276	35.4	47.7
	2	803.2	152.1	36.1	35.5	66.37	47.25	0.15	57.0	7					
	3	446.2	66.8	34.6	34.3	58.64	41.13	0.18	69.3	10					
	4	634.8	45.4	34.3	33.9	87.69	60.29	0.28	97.2	14					
	5	629.4	66.3	33.5	33.9	96.25	65.54	0.27	81.7	11					
	6	375.3	41.7	34.6	34.7	68.34	51.40	0.26	66.4	12					
	7	684.6	51.3	34.7	34.3	76.38	65.07	0.28	74.9	14					
	8	409.4	68.4	34.2	34.1	49.35	45.33	0.17	44.1	10					
	9	376.5	69.0	33.7	33.5	60.37	44.35	0.20	36.6	8					
	10	647.3	61.2	33.7	33.8	55.43	42.20	0.13	56.9	9					
ZN2	1	1074.2	47.9	36.0	35.4	61.03	47.83	0.26	82.9	13	159	Y	982	33.2	52.3
	2	1266.2	61.4	34.5	33.6	45.06	30.81	0.11	53.7	11					
	3	962.4	54.0	33.6	33.5	49.82	39.91	0.15	47.2	10					
	4	1241.0	58.3	33.5	33.2	50.88	38.88	0.16	46.2	10					
	5	1199.3	53.5	33.6	33.6	47.35	35.42	0.14	35.1	9					
	6	1250.4	55.7	33.6	33.3	54.24	40.48	0.21	73.8	13					
	7	1296.8	57.1	33.8	33.9	46.46	40.58	0.16	35.0	8					
	8	1267.0	70.0	33.8	33.4	46.32	30.22	0.18	70.1	10					
	9	750.3	55.5	33.5	33.1	43.90	32.02	0.11	24.8	7					
	10	1033.1	61.5	32.9	32.7	62.65	39.91	0.19	86.0	12					
ZN3	1	637.4	41.4	39.4	39.6	46.78	25.25	0.12	57.4	9	121	N	2213	38.7	41.1
	2	116.2	51.1	40.0	39.9	46.60	34.63	0.12	14.5	5					
	3	555.4	46.6	39.8	39.9	41.19	28.32	0.14	66.8	10					
	4	419.0	41.2	39.9	40.1	46.41	27.79	0.11	39.4	10					
	5	369.6	43.8	40.7	40.7	52.33	36.49	0.18	77.5	11					
	6	219.9	34.8	40.4	40.6	48.21	32.91	0.08	11.1	5					
	7	176.4	35.0	41.2	41.2	53.32	31.20	0.14	16.7	5					
	8	296.7	34.2	41.0	40.9	36.72	32.94	0.08	16.2	6					
	9	224.0	42.8	40.7	40.7	39.22	24.91	0.14	47.4	8					
	10	313.4	35.9	41.6	41.7	48.68	37.22	0.12	15.3	5					
ZN4	1	161.6	40.3	36.8	36.9	80.30	56.81	0.21	67.8	12	291	N	1694	35.1	52.3
	2	480.6	56.9	37.5	37.2	60.69	35.67	0.18	51.8	9					
	3	779.7	65.3	36.2	35.8	70.29	55.25	0.18	60.5	10					
	4	662.2	51.7	35.6	35.9	64.78	48.28	0.16	33.5	8					
	5	525.2	84.4	35.4	35.1	72.16	53.84	0.19	42.2	9					
	6	819.2	59.5	34.9	35.3	75.55	46.36	0.22	92.5	14					
	7	982.2	58.1	35.5	35.7	62.54	45.72	0.23	72.4	13					
	8	529.6	53.1	35.7	35.8	78.93	51.89	0.23	72.0	11					
	9	416.4	70.0	35.8	36.1	68.84	45.32	0.15	41.9	7					
	10	461.5	63.8	36.2	36.4	70.21	54.64	0.23	81.5	12					
	1	408.7	44.3	29.3	30.3	36.24	28.56	0.15	30.9	6					
	2	729.1	58.2	31.5	32.3	49.82	31.60	0.15	42.3	10					

ZN5	3	445.8	36.4	32.8	33.5	41.60	34.45	0.16	25.0	7	80	N	1119	30.4	67.8
	4	631.7	56.7	34.0	34.6	46.30	33.66	0.16	28.7	6					
	5	371.2	50.7	34.5	34.9	50.49	37.97	0.16	39.9	9					
	6	489.0	68.0	35.0	35.4	40.04	27.40	0.15	17.9	6					
	7	150.1	44.4	35.5	36.0	55.00	30.35	0.16	46.6	9					
	8	839.4	75.6	36.3	36.6	42.39	28.89	0.13	50.5	9					
	9	422.4	49.2	36.5	36.7	47.70	27.30	0.15	61.2	10					
	10	231.3	43.4	36.7	37.0	42.35	34.61	0.14	52.1	10					
ZN6	1	1039.9	93.5	40.7	39.4	87.91	62.26	0.31	82.4	12	184	Y	1621	35.4	46.2
	2	974.0	43.2	37.6	36.5	94.09	68.23	0.42	157.4	19					
	3	750.3	135.5	35.6	35.2	83.71	66.09	0.24	129.1	15					
	4	764.4	48.5	34.7	34.6	58.63	48.20	0.25	59.6	11					
	5	989.1	56.2	36.0	35.8	78.89	60.74	0.33	56.2	11					
	6	570.3	50.3	35.8	35.7	84.19	60.43	0.26	87.1	15					
	7	627.0	49.4	36.3	36.0	68.86	50.28	0.17	32.3	9					
	8	400.7	42.5	35.7	35.5	86.38	49.79	0.21	87.7	15					
	9	985.7	48.3	35.3	35.3	63.73	54.11	0.25	61.7	11					
	10	732.8	51.1	35.4	35.3	66.87	47.18	0.23	56.1	10					
ZE1	1	1099.5	41.9	39.9	39.9	42.77	38.89	0.22	70.8	12	94	N	2005	36.0	46.0
	2	1436.7	148.8	40.0	39.7	58.73	38.44	0.19	71.6	10					
	3	890.8	75.5	40.1	40.2	48.40	37.50	0.28	55.5	9					
	4	959.6	78.3	40.2	40.3	45.35	33.35	0.19	53.5	8					
	5	1322.5	165.7	40.1	39.8	39.20	30.42	0.20	47.1	9					
	6	1507.3	87.4	39.9	39.3	54.05	36.13	0.18	40.0	9					
	7	1009.3	54.5	39.7	39.6	44.61	35.89	0.16	42.0	8					
	8	1297.3	88.4	39.4	39.2	51.72	37.38	0.24	39.0	7					
	9	1486.8	66.8	39.1	39.4	51.97	37.51	0.22	52.0	9					
	10	1786.0	569.9	39.8	39.7	55.35	45.57	0.25	40.0	8					
ZE2	1	64.6	33.7	34.7	34.4	57.43	50.85	0.31	34.6	8	253	Y	312	31.1	63.9
	2	249.6	38.9	33.7	33.5	67.52	46.47	0.24	83.8	12					
	3	262.4	42.8	33.0	32.8	68.57	49.92	0.19	39.9	10					
	4	251.9	46.8	32.7	33.1	50.40	31.88	0.20	44.1	7					
	5	239.8	42.0	33.0	32.9	52.05	42.99	0.19	30.8	7					
	6	178.3	39.3	32.8	32.9	64.19	44.88	0.28	40.8	9					
	7	60.3	37.8	32.7	32.6	58.24	43.17	0.21	72.3	11					
	8	216.6	64.0	32.7	32.6	55.10	45.61	0.17	42.3	8					
	9	211.9	39.4	32.8	32.5	57.24	41.95	0.20	48.1	10					
	10	180.8	42.3	32.6	32.5	62.02	42.98	0.23	43.4	10					
ZE3	1	105.4	47.3	33.2	33.0	60.29	46.92	0.16	62.0	8	221	N	218	32.3	57.8
	2	80.9	35.3	32.4	32.2	57.60	31.13	0.21	65.9	11					
	3	91.3	35.1	31.9	31.8	57.59	46.83	0.29	27.9	8					
	4	128.7	36.4	31.7	31.6	61.05	44.86	0.28	51.7	9					
	5	110.1	54.2	31.6	31.6	56.44	36.83	0.28	45.1	9					
	6	156.4	36.9	31.6	31.5	51.45	38.56	0.23	65.5	10					
	7	130.4	38.0	31.5	31.4	56.72	36.47	0.25	41.9	9					
	8	203.6	47.9	31.5	31.4	52.35	29.70	0.18	48.9	8					
	9	74.9	54.1	31.4	31.4	75.71	49.11	0.27	106.4	13					
	10	114.4	45.3	31.2	31.2	34.21	42.29	0.24	50.6	7					
ZE4	1	86.8	31.2	35.3	35.7	76.53	49.78	0.30	127.5	17	128	N	1493	34.9	59.8
	2	239.0	70.9	36.5	36.8	47.84	33.71	0.24	57.7	8					
	3	181.8	52.3	37.0	37.2	65.58	50.12	0.28	73.2	12					
	4	163.1	61.3	37.4	37.7	64.97	40.34	0.19	77.4	14					
	5	394.0	38.5	37.9	38.3	51.30	38.05	0.16	58.7	10					
	6	323.2	41.6	38.0	38.2	50.39	36.52	0.21	46.3	11					
	7	249.8	42.2	38.1	38.3	50.23	37.01	0.21	63.5	14					
	8	156.3	41.1	38.1	38.2	56.34	43.60	0.26	42.8	8					
	9	205.2	43.4	37.9	38.2	61.35	41.90	0.19	63.5	14					
	10	278.9	52.3	38.3	38.4	50.56	46.63	0.29	45.5	11					
ZE5	1	171.0	83.0	33.4	33.2	75.79	59.54	0.30	77.0	14	177	Y	1034	32.4	61.5
	2	193.4	53.6	32.0	32.9	80.26	70.42	0.26	98.4	13					
	3	460.9	62.9	32.7	32.6	76.95	58.23	0.24	48.0	10					
	4	153.9	54.3	32.8	32.9	64.52	53.31	0.25	59.0	11					
	5	136.9	48.8	33.0	32.8	69.20	57.17	0.28	79.5	13					
	6	420.5	59.4	32.8	32.9	65.60	53.93	0.31	88.0	11					
	7	402.8	43.6	33.7	33.5	66.91	48.51	0.25	98.2	14					
	8	329.4	52.1	33.8	33.5	60.03	52.00	0.28	65.0	11					
	9	253.6	51.4	33.1	33.0	57.63	51.30	0.28	50.3	9					
	10	154.3	58.6	33.1	33.3	60.39	51.89	0.30	58.6	10					
ZE6	1	525.3	100.5	26.8	27.8	75.03	60.44	0.28	71.3	10	164	Y	433	28.7	77.8
	2	552.2	70.3	29.2	29.9	75.61	58.77	0.31	110.5	12					
	3	304.0	53.7	30.3	30.8	52.09	46.45	0.22	52.0	8					
	4	442.4	52.8	31.0	31.4	49.11	48.93	0.21	103.0	12					
	5	587.2	64.6	31.5	31.8	91.26	68.56	0.33	110.9	12					
	6	589.6	73.0	31.7	31.9	63.12	46.20	0.20	90.0	10					
	7	575.3	53.6	32.3	32.5	67.82	55.84	0.29	117.8	12					
	8	675.7	45.9	32.7	32.9	59.69	47.59	0.24	49.4	6					
	9	317.7	43.0	33.2	33.5	59.61	52.16	0.30	52.6	8					
	10	368.5	43.6	33.5	33.6	53.17	42.60	0.25	40.4	8					
ZS1	1	838.1	69.3	29.1	29.5	120.50	79.46	0.30	50.1	8	1263	Y	1037	29.9	73.3
	2	283.3	81.9	29.8	30.0	95.39	76.80	0.31	73.4	12					
	3	175.4	62.9	30.4	30.7	104.11	69.66	0.27	89.1	22					
	4	598.9	112.5	31.1	31.2	120.92	88.52	0.32	88.6	13					
	5	321.3	50.2	31.8	32.1	100.64	70.99	0.40	126.2	18					
	6	989.2	73.3	32.0	32.1	88.36	65.55	0.29	58.7	11					
	7	418.8	52.7	31.9	31.9	106.97	80.82	0.28	89.5	11					
	8	590.4	48.4	33.1	33.1	113.68	80.28	0.30	113.9	16					
	9	954.2	58.2	32.3	32.4	106.70	76.27	0.29	88.3	14					
	10	864.2	61.7	31.8	31.5	110.48	83.52	0.36	85.9	14					
ZS2	1	120.1	38.0	35.1	35.1	69.96	49.99	0.25	54.2	15	1568	Y	1558	33.7	57.4
	2	1136.9	55.8	34.7	34.7	106.67	78.86	0.39	120.2	20					
	3	1287.5	58.1	34.2	34.0	98.12	73.07	0.28	80.3	14					
	4	1084.8	101.6	33.4	33.5	108.20	70.80	0.30	155.5	18					
	5	344.7	65.7	33.3	33.3	89.30	57.25	0.28	53.9	14					
	6	1018.4	54.3	33.3	33.7	89.76	56.73	0.26	47.4	9					
	7	1383.1	49.6	33.7	33.9	103.32	62.20	0.24	86.4	15					
	8	714.9	50.8	34.2	34.1	88.28	72.15	0.23	93.0	18					
	9	925.8	55.4	33.7	34.0	87.58	59.69	0.24	120.8	17					
	10	761.2	51.7	34.0	34.3	80.07	54.13	0.28	50.4	10					
ZS3	1	1398.9	41.5	40.7	40.8	71.35	54.28	0.26	88.8	10	432	Y	2388	38.5	46.3
	2	1659.8	238.7	40.3	41.0	71.67	62.34	0.31	87.4	9					
	3	1009.6	185.7	41.0	41.5	72.50	61.03	0.29	81.9	9					
	4	1424.1	52.5	41.9	41.6	88.72	57.88	0.33	93.4	13					
	5	1766.0	271.0	41.4	41.2	63.72	52.23	0.31	74.1	8					
	6	1505.3	40.9	41.3	40.8	84.44	64.37	0.33	45.2	9					
	7	1749.6	49.1	40.6	40.8	50.13	40.49	0.26	49.6	9					
	8	246.0	41.8	40.8	41.1	79.23	59.15	0.21	78.1	10					
	9	1498.5	143.3	40.3	40.1	72.81	62.37	0.25	75.2	10					
	10	693.7	68.1	39.9	39.1	85.01	76.52	0.34	102.0	14					

ZS4	1	779.7	55.8	43.6	43.6	59.07	49.81	0.24	50.5	8	541	N	2376	38.5	41.9
	2	1314.7	40.3	44.1	43.8	81.39	64.88	0.37	88.7	11					
	3	1091.1	30.0	49.0	47.7	74.59	61.45	0.34	60.1	9					
	4	1148.2	30.0	43.5	42.6	75.12	51.84	0.37	73.0	13					
	5	763.8	42.9	40.8	39.7	73.31	66.32	0.32	58.5	10					
	6	238.0	38.9	38.4	37.9	74.26	55.89	0.27	46.3	8					
	7	736.8	41.5	37.1	36.7	74.28	65.14	0.31	61.7	8					
	8	1117.9	32.0	36.4	36.3	57.54	50.67	0.16	56.3	9					
	9	519.7	52.8	36.0	35.8	102.14	74.68	0.23	105.2	16					
	10	521.5	40.9	35.3	35.1	104.20	65.84	0.31	89.5	8					
ZS5	1	203.8	50.1	31.1	31.2	67.08	60.96	0.28	18.4	5	202	N	1644	32.7	60.7
	2	137.1	43.0	31.8	31.6	66.15	55.25	0.20	26.1	6					
	3	94.0	51.2	31.6	31.4	81.15	65.80	0.24	36.1	11					
	4	185.1	48.3	31.8	32.6	72.69	85.41	0.18	29.6	6					
	5	273.8	63.2	34.0	34.8	75.72	54.51	0.26	43.2	10					
	6	268.3	48.3	34.9	35.4	72.31	64.22	0.18	16.2	4					
	7	485.5	40.2	35.6	36.0	65.52	47.09	0.22	32.0	6					
	8	132.6	42.5	36.5	36.8	72.68	61.44	0.22	21.0	6					
	9	193.4	38.5	36.5	36.3	73.72	72.37	0.35	51.0	9					
	10	200.8	78.0	36.0	36.2	67.07	60.18	0.31	41.3	7					
ZS6	1	1587.3	162.7	25.8	26.1	76.58	45.71	0.23	41.3	12	286	N	135	25.9	89.9
	2	943.6	181.1	26.6	27.0	70.78	53.80	0.24	26.5	7					
	3	1087.5	541.3	27.4	27.6	86.38	59.64	0.31	30.4	7					
	4	1736.6	87.9	26.1	29.0	73.20	54.90	0.21	39.5	8					
	5	868.8	105.5	29.3	29.3	79.45	57.94	0.27	29.1	7					
	6	713.4	73.1	29.4	29.5	83.85	65.74	0.35	39.1	10					
	7	1154.7	94.7	29.5	29.5	74.01	50.12	0.30	38.1	7					
	8	755.9	78.1	29.5	29.6	41.04	61.75	0.20	22.0	8					
	9	812.5	90.2	29.8	29.9	64.90	37.58	0.23	32.6	8					
	10	1059.3	101.4	29.9	30.1	86.07	68.93	0.30	67.5	17					
ZU1	1	526.6	64.6	29.3	30.9	82.73	61.06	0.30	104.5	14	347	Y	1609	32.8	60.1
	2	614.2	53.8	33.5	34.2	84.11	64.15	0.33	104.1	14					
	3	324.3	81.5	34.6	35.1	85.86	66.04	0.33	145.9	17					
	4	355.5	37.5	35.9	36.6	72.03	63.99	0.25	93.5	12					
	5	275.8	61.4	36.6	36.9	83.47	62.13	0.36	126.1	16					
	6	495.2	48.2	37.0	37.4	53.52	50.61	0.30	68.2	10					
	7	723.1	57.0	37.7	37.8	71.67	55.38	0.25	98.0	11					
	8	394.5	39.7	37.4	37.6	77.90	66.76	0.33	100.0	14					
	9	264.1	41.1	37.3	37.4	57.76	44.08	0.31	46.7	8					
	10	563.5	39.3	37.0	37.1	62.33	57.57	0.22	49.9	8					
ZU2	1	649.6	77.6	26.8	28.0	63.51	45.35	0.27	92.5	14	126	N	951	31.1	65.1
	2	408.1	74.6	28.9	29.5	62.27	42.21	0.30	70.2	13					
	3	1220.4	104.0	30.8	31.6	63.82	48.01	0.30	45.3	9					
	4	422.1	46.1	32.2	32.5	67.39	39.17	0.30	60.2	14					
	5	293.7	47.2	32.7	32.9	55.00	54.27	0.29	43.6	10					
	6	456.3	47.7	32.8	32.8	49.25	39.13	0.25	36.5	7					
	7	670.0	74.0	32.7	32.7	49.11	41.30	0.21	43.3	7					
	8	646.9	51.6	32.7	32.6	51.48	45.73	0.33	36.4	7					
	9	93.8	40.7	32.8	33.6	58.26	48.16	0.20	46.5	7					
	10	570.9	71.9	33.1	33.0	50.90	43.33	0.22	38.5	6					
ZU3	1	518.9	38.0	34.3	34.2	88.44	79.57	0.24	79.6	9	336	Y	1128	33.6	57.2
	2	299.5	42.2	34.5	33.9	77.50	56.33	0.30	59.3	8					
	3	343.0	46.1	33.2	32.7	81.30	65.47	0.34	68.4	10					
	4	366.3	62.5	32.5	32.8	76.27	77.39	0.36	68.5	9					
	5	366.1	64.8	33.1	32.9	96.30	75.65	0.29	97.5	10					
	6	429.9	48.4	32.8	32.7	85.56	81.56	0.33	82.0	7					
	7	357.2	56.2	32.8	32.9	91.62	75.19	0.35	73.2	10					
	8	471.3	42.5	33.3	33.4	81.94	62.44	0.27	56.5	8					
	9	650.7	66.0	34.7	34.7	73.90	58.60	0.28	62.0	8					
	10	518.8	48.8	34.4	34.4	90.88	76.02	0.22	47.1	5					
ZU4	1	685.8	45.5	29.2	30.4	33.90	26.89	0.22	12.2	4	33	N	1654	32.4	50.9
	2	527.0	55.6	31.5	32.0	40.39	30.03	0.29	14.0	5					
	3	634.5	42.9	32.6	32.9	35.61	31.24	0.24	9.4	4					
	4	355.3	62.4	33.3	33.3	28.13	29.17	0.31	8.0	3					
	5	651.9	45.5	33.3	33.4	34.05	26.02	0.23	15.6	4					
	6	729.7	108.8	33.5	33.3	40.44	32.86	0.37	52.7	4					
	7	839.1	154.2	33.2	33.2	34.02	25.59	0.24	36.5	6					
	8	769.6	66.1	33.1	32.9	33.26	24.28	0.20	19.2	5					
	9	501.2	76.5	33.6	34.1	34.83	29.68	0.23	10.1	3					
	10	783.4	77.4	34.4	34.1	29.72	27.33	0.29	6.1	4					
ZU5	1	266.8	37.5	30.0	30.8	60.41	44.55	0.26	44.5	10	127	Y	448	30.6	61.0
	2	422.7	67.4	31.6	31.8	69.49	49.38	0.32	46.7	10					
	3	650.5	46.7	32.6	33.0	56.53	37.40	0.24	39.4	8					
	4	739.7	200.8	33.4	33.6	106.08	71.78	0.34	53.8	14					
	5	480.9	44.1	33.4	33.4	71.07	46.22	0.22	61.5	12					
	6	188.5	101.7	33.3	33.2	75.70	52.73	0.24	31.1	6					
	7	529.4	150.1	32.7	32.7	87.11	64.10	0.35	32.4	6					
	8	622.4	48.7	32.5	32.7	68.39	45.94	0.22	59.8	12					
	9	345.3	51.9	32.7	32.8	79.49	53.33	0.32	63.5	13					
	10	231.3	37.0	33.9	34.0	67.80	46.93	0.22	48.4	10					
ZU6	1	615.5	83.0	32.9	33.8	73.85	57.44	0.31	68.9	12	187	N	1945	34.1	50.7
	2	325.3	59.2	34.2	34.9	64.89	51.92	0.33	35.5	8					
	3	232.7	58.5	36.8	36.6	57.89	53.79	0.33	65.5	9					
	4	70.5	35.9	36.8	37.1	53.21	50.95	0.23	42.1	7					
	5	219.1	36.3	36.9	37.0	62.37	46.50	0.26	56.5	10					
	6	374.3	56.2	36.7	36.8	60.14	46.69	0.32	35.8	7					
	7	594.0	86.2	37.1	37.4	55.29	43.48	0.27	28.6	7					
	8	444.6	37.1	36.9	37.1	64.91	44.72	0.22	44.5	8					
	9	151.8	66.0	37.9	38.0	56.61	45.81	0.29	45.2	8					
	10	439.6	39.0	38.0	38.2	59.77	53.72	0.39	17.0	6					

Table B.3: Raw measurements obtained during Interval 3

Patch number	Leaf number	Plant traits											Environmental conditions		
		Stomatal conductance ($mmol/m^2s$)		Leaf temperature (°C)		Leaf length (mm)	Leaf width (mm)	Leaf thickness (mm)	Length of stem (cm)	No. of leaves per stem	Plant biomass (g)	Flowers (Y/N)	Incoming solar radiation, Qflux ($g\mu molm^{-2}s$)	Air temperature, Hygrothermometer (°C)	Relative humidity, Hygrothermometer (%)
		Top of leaf	Bottom of leaf	Top of leaf	Bottom of leaf										
ZW1	1	118.6	45.9	28.2	29.8	17.32	27.44	0.15	6.5	3	4	Y	2021	37.2	42.5
	2	234.9	51.5	32.1	33.6	37.16	29.92	0.17	19.0	6					
	3	128.5	34.7	34.1	34.4	58.93	41.84	0.09	30.0	7					
	4	155.3	73.4	35.6	36.0	21.76	22.55	0.11	3.6	2					
	5	94.8	69.8	37.0	37.4	14.58	17.61	0.07	3.7	2					
	6	68.0	27.9	37.6	37.6	19.95	17.38	0.10	5.5	2					
	7	137.0	30.2	37.9	37.9	45.02	29.10	0.13	23.5	5					
	8	126.9	53.4	38.1	38.0	36.54	21.35	0.20	23.4	3					
	9	206.2	40.3	37.6	37.4	23.48	23.38	0.09	16.6	2					
	10	125.4	30.4	37.8	37.8	40.28	26.24	0.09	5.5	2					
ZW2	1	248.2	55.3	39.1	39.2	26.09	34.02	0.15	19.3	6	12	N	1998	39.2	38.5
	2	285.5	32.8	39.2	39.1	19.74	20.48	0.10	4.7	4					
	3	57.9	35.2	39.3	39.4	42.08	18.82	0.13	29.6	5					
	4	133.8	36.9	39.1	38.8	46.86	25.75	0.13	24.0	4					
	5	105.8	34.8	38.2	37.8	37.84	19.07	0.09	25.0	4					
	6	78.4	31.9	37.9	37.9	35.49	39.67	0.10	6.0	3					
	7	48.6	34.0	38.4	38.2	50.54	32.88	0.16	13.5	4					
	8	26.4	41.0	37.9	37.8	60.15	45.84	0.15	27.4	8					
	9	86.3	28.7	37.7	37.5	43.71	39.00	0.19	7.5	1					
	10	242.0	51.8	37.1	36.9	78.60	60.35	0.34	43.0	11					
ZW3	1	329.6	42.2	30.7	31.5	25.68	31.95	0.15	7.7	3	9	N	1074	34.4	47.6
	2	107.7	33.5	32.4	32.8	18.51	21.74	0.08	5.7	3					
	3	302.5	36.9	33.4	33.5	29.70	25.36	0.16	7.6	3					
	4	242.9	36.7	33.7	33.9	45.35	33.23	0.15	7.5	4					
	5	107.2	41.8	34.2	34.5	19.84	23.32	0.11	4.8	3					
	6	254.8	34.0	34.7	34.9	22.54	18.24	0.07	4.0	2					
	7	157.1	46.8	35.1	35.1	20.06	20.04	0.22	2.8	2					
	8	232.6	49.6	35.3	35.4	24.67	22.70	0.16	6.3	2					
	9	53.4	32.9	35.5	35.6	18.71	20.47	0.08	6.2	3					
	10	139.7	58.3	35.6	35.5	20.37	18.40	0.14	5.5	2					
ZW4	1	37.6	51.4	34.8	34.6	20.60	27.64	0.26	17.5	4	7	N	652	34.0	50.6
	2	102.6	59.2	34.5	34.6	17.92	12.75	0.05	2.2	2					
	3	250.5	43.4	34.5	34.6	45.50	41.72	0.22	11.6	3					
	4	121.7	55.3	34.4	34.4	26.28	23.51	0.15	4.3	3					
	5	160.8	33.7	34.5	34.4	32.78	33.64	0.14	8.9	3					
	6	191.2	67.8	34.4	34.2	225.38	20.07	0.18	9.7	3					
	7	177.9	35.1	34.0	33.8	44.45	29.31	0.14	16.5	7					
	8	192.4	36.9	33.5	33.2	44.73	33.08	0.21	16.0	6					
	9														
	10														
ZW5	1	63.9	49.3	29.6	30.1	21.27	21.52	0.16	3.4	2	9	N	1188	32.9	53.2
	2	94.9	38.0	30.8	31.0	37.22	35.02	0.25	11.0	3					
	3	50.8	43.4	31.4	31.6	20.38	26.03	0.22	5.9	2					
	4	40.0	39.8	31.8	31.8	45.49	30.38	0.14	28.3	7					
	5	148.5	57.8	31.9	32.0	21.27	27.18	0.19	6.5	2					
	6	56.1	35.4	32.3	32.4	21.71	19.86	0.12	4.0	2					
	7	82.2	40.9	33.1	33.2	31.75	29.63	0.09	10.4	3					
	8	91.8	32.2	33.2	33.1	51.41	43.82	0.26	20.5	5					
	9	59.9	36.2	32.9	32.8	82.05	57.82	0.23	57.5	11					
	10	74.8	24.7	32.7	32.7	31.88	33.97	0.10	10.3	3					
ZW6	1														
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
ZN1	1	123.2	37.1	31.2	31.8	53.01	38.06	0.21	20.8	3	8	Y	1008	31.6	55.8
	2	189.6	48.8	32.5	32.5	51.38	35.02	0.19	27.0	4					
	3	163.0	49.5	32.9	33.0	57.73	28.39	0.11	21.4	6					
	4	193.7	33.3	33.6	33.6	46.66	37.64	0.20	15.5	5					
	5	77.4	59.4	33.5	33.6	26.30	14.50	0.09	8.9	3					
	6	269.9	54.9	33.6	33.4	66.02	43.02	0.16	30.8	5					
	7	124.8	46.7	33.4	33.3	18.97	16.81	0.09	4.7	3					
	8														
	9														
	10														
ZN2	1	604.6	77.2	34.6	35.0	25.98	15.88	0.11	43.5	8	18	N	1455	34.7	48.2
	2	739.0	59.7	36.0	35.9	25.62	18.08	0.15	33.6	8					
	3	777.1	135.8	36.4	36.3	20.14	16.67	0.09	27.8	7					
	4	137.1	56.2	36.4	36.7	19.90	15.65	0.13	3.9	3					
	5	872.3	42.9	36.6	36.7	46.35	34.66	0.23	39.0	15					
	6	211.8	42.1	37.3	37.2	21.25	17.83	0.18	7.4	4					
	7	525.4	109.6	37.8	37.5	16.40	17.06	0.16	3.4	2					
	8	224.1	45.6	38.2	38.4	45.58	30.05	0.19	29.8	13					
	9	258.7	62.5	38.4	37.5	15.80	18.53	0.15	7.9	4					
	10	203.2	54.2	37.1	37.1	18.79	17.74	0.16	7.5	4					
ZN3	1	254.1	63.6	36.4	36.8	17.55	20.12	0.09	9.8	3	2	N	1803	37.8	43.3
	2	176.1	42.8	37.1	37.3	25.25	25.44	0.10	6.5	3					
	3	76.1	52.8	37.3	37.2	21.74	23.10	0.10	3.4	2					
	4	119.3	36.2	37.1	37.0	26.12	29.35	0.18	31.3	8					
	5														
	6														
	7														
	8														
	9														
	10														
ZN4	1	364.6	41.3	38.9	39.1	45.76	30.30	0.18	12.9	6	28	Y	1936	36.5	43.4
	2	109.8	62.6	39.3	39.3	45.33	32.77	0.23	24.3	7					
	3	314.5	36.3	39.7	39.4	66.38	53.13	0.26	66.6	23					
	4	216.0	37.0	39.5	39.4	35.89	31.07	0.16	24.4	10					
	5	359.3	53.1	39.0	38.8	44.63	28.36	0.22	27.5	6					
	6	202.4	49.9	38.5	38.5	39.66	30.38	0.17	9.5	5					
	7	257.2	50.7	38.8	38.7	46.00	33.85	0.16	23.0	8					
	8	275.7	21.3	38.7	38.7	40.03	26.66	0.11	25.4	7					
	9	149.8	16.4	38.4	38.4	34.23	31.57	0.20	37.6	7					
	10	267.6	13.6	38.5	38.5	43.82	27.96	0.13	19.5	4					
	1	138.0	20.0	40.6	40.3	28.63	19.05	0.12	13.8	4					
	2	130.6	76.1	40.5	40.3	18.45	22.56	0.08	9.9	4					

ZN5	3	131.7	54.0	40.1	40.0	17.85	18.81	0.12	7.5	4	7	N	2030	39.3	39.1
	4	66.0	16.7	40.0	39.8	38.52	24.53	0.19	15.4	4					
	5	51.1	15.0	39.8	39.6	37.81	20.97	0.15	15.5	4					
	6														
	7														
	8														
	9														
	10														
ZN6	1	579.9	63.5	37.2	36.8	40.70	30.85	0.15	30.0	7	22	Y	656	36.0	46.4
	2	517.0	48.3	36.6	36.1	34.69	26.57	0.22	10.5	5					
	3	495.3	41.2	35.5	35.0	28.56	27.25	0.23	11.6	5					
	4	705.2	61.5	34.7	34.6	39.50	28.38	0.25	17.6	6					
	5	587.1	45.9	34.5	34.5	29.92	32.43	0.22	19.4	5					
	6	668.9	42.1	34.9	35.2	40.97	27.36	0.18	14.7	6					
	7	272.5	38.2	38.5	35.6	36.06	31.10	0.22	10.9	4					
	8	331.5	40.4	35.7	35.8	35.30	29.11	0.19	8.4	4					
	9	577.1	103.4	35.9	36.0	30.94	29.70	0.17	12.5	4					
	10	480.5	51.1	36.1	36.2	25.99	22.97	0.16	17.1	5					
ZE1	1	129.2	126.0	37.7	37.7	26.27	19.44	0.11	7.1	3	2	N	1996	35.0	48.6
	2	470.3	102.1	38.8	39.2	31.86	15.29	0.13	8.9	3					
	3	1162.2	97.7	40.5	40.8	16.15	16.13	0.13	2.8	1					
	4	271.7	50.4	40.8	40.6	57.23	31.71	0.20	18.9	3					
	5	865.6	98.5	40.3	40.0	17.37	16.96	0.20	2.0	2					
	6														
	7														
	8														
	9														
	10														
ZE2	1										0	N	933	31.1	60.9
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
ZE3	1	115.8	78.6	30.0	30.9	33.58	25.74	0.15	15.9	4	9	N	1136	36.7	45.5
	2	172.6	47.5	31.7	32.4	23.19	19.35	0.18	12.9	5					
	3	250.4	42.7	33.0	33.4	29.02	28.78	0.19	22.8	4					
	4	227.2	33.2	33.8	34.1	40.51	3.56	0.23	10.9	5					
	5	145.7	53.0	34.4	34.7	19.88	19.01	0.10	12.1	4					
	6	165.3	39.7	34.9	35.1	21.20	18.05	0.13	3.9	3					
	7	170.6	123.4	35.3	35.5	19.09	22.12	0.18	10.6	3					
	8	172.1	69.2	35.7	35.8	19.13	15.88	0.12	17.4	4					
	9	253.0	46.1	35.8	35.9	50.00	48.58	0.26	22.3	5					
	10	114.2	37.3	36.0	36.0	40.25	29.24	0.16	43.0	8					
ZE4	1	173.5	54.1	33.4	34.0	17.47	17.12	0.08	8.8	4	1	N	1835	35.7	46.5
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
ZE5	1										0	N	1624	34.4	51.5
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
ZE6	1										0	N	1367	33.1	59.3
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
ZS1	1	190.9	71.9	26.3	26.6	21.97	20.59	0.16	2.8	2	5	N	101	26.7	82.4
	2	210.2	85.5	26.9	27.1	14.21	17.35	0.13	4.0	2					
	3	191.0	86.8	27.4	27.7	20.10	20.91	0.13	2.4	3					
	4	103.4	71.7	27.8	28.0	16.74	17.74	0.20	2.3	2					
	5														
	6														
	7														
	8														
	9														
	10														
ZS2	1	287.2	64.0	28.0	28.2	38.00	35.79	0.16	17.0	5	81	Y	347	27.8	78.9
	2	308.7	72.6	28.5	28.7	38.04	28.68	0.19	17.1	5					
	3	230.4	44.0	28.9	29.2	47.48	33.85	0.18	40.0	7					
	4	746.1	65.6	29.3	29.8	38.91	35.82	0.17	13.1	6					
	5	599.0	70.6	30.0	30.1	44.28	28.10	0.13	10.1	6					
	6	830.2	60.3	30.1	30.5	40.76	29.07	0.20	14.0	6					
	7	265.2	51.3	30.8	30.9	35.35	37.38	0.14	12.0	5					
	8	633.1	60.4	31.1	31.4	42.60	40.70	0.16	26.0	6					
	9	223.3	53.3	31.5	31.6	44.93	32.82	0.15	17.4	5					
	10	332.3	59.0	31.7	31.8	38.59	29.97	0.17	15.5	5					
ZS3	1										0	N	1603	33.5	55.4
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														

ZS4	1	258.1	185.7	32.0	32.2	14.17	18.64	0.19	2.5	3	3	Y	1736	33.1	56.0
	2	93.6	76.0	32.1	32.2	39.23	37.09	0.18	13.7	10					
	3	208.0	66.9	32.3	32.5	43.81	22.78	0.15	16.2	3					
	4	82.8	49.5	32.5	32.6	44.35	30.23	0.20	5.5	2					
	5														
	6														
	7														
	8														
	9														
	10														
ZS5	1										0	N	1520	34.7	49.1
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
ZS6	1										0	N	1737	34.6	50.3
	2														
	3														
	4														
	5														
	6														
	7														
	8														
	9														
	10														
ZU1	1	956.3	81.9	28.2	30.0	53.95	35.41	0.24	78.7	13	74	Y	1981	32.2	54.8
	2	1313.2	112.1	32.6	33.7	50.45	42.40	0.23	63.4	10					
	3	1281.5	178.1	35.1	35.9	39.44	38.40	0.24	24.5	6					
	4	1050.7	138.6	35.0	35.8	43.37	38.03	0.26	24.6	7					
	5	1371.5	68.5	36.8	37.5	51.24	37.09	0.20	58.5	11					
	6	1399.5	64.5	37.8	37.9	54.39	36.43	0.22	58.3	9					
	7	1265.4	260.3	37.5	37.9	43.93	43.95	0.20	35.5	7					
	8	1024.0	66.6	38.3	38.7	48.83	36.42	0.26	52.4	10					
	9	1074.0	73.6	38.6	38.6	55.56	38.43	0.18	41.0	8					
	10	1060.7	58.1	38.8	39.4	47.50	38.21	0.17	44.0	9					
ZU2	1	1264.4	170.0	27.8	29.3	64.76	42.75	0.27	53.3	15	24	N	2149	35.2	53.1
	2	1194.8	204.4	32.4	33.4	43.86	39.94	0.24	20.8	7					
	3	1357.6	286.7	34.6	35.0	40.25	33.03	0.14	14.8	6					
	4	1263.8	273.2	35.2	35.4	32.13	27.32	0.16	21.5	5					
	5	1021.5	82.5	36.0	36.2	37.60	34.74	0.14	13.0	5					
	6	1334.3	374.9	36.3	36.3	26.39	26.45	0.22	16.5	5					
	7	1354.0	157.5	36.6	36.6	29.16	26.65	0.14	11.2	5					
	8	592.5	58.5	36.5	36.5	39.79	30.91	0.10	9.5	4					
	9	1477.0	497.8	36.5	36.4	32.61	29.60	0.11	10.2	4					
	10	623.8	59.9	36.4	36.5	37.63	31.10	0.17	13.0	6					
ZU3	1	1346.8	109.9	32.0	32.8	38.99	39.06	0.21	28.8	5	43	N	1130	32.7	64.9
	2	1447.6	104.2	33.7	34.6	51.86	38.96	0.17	52.3	9					
	3	1514.3	111.6	34.7	34.7	41.98	36.62	0.17	41.2	5					
	4	1554.4	108.8	34.5	34.4	41.47	39.80	0.19	28.5	4					
	5	653.4	82.7	34.2	34.4	77.19	60.92	0.30	37.5	7					
	6	1348.5	148.1	34.8	35.0	38.18	32.47	0.20	41.9	5					
	7	1320.7	117.3	35.7	36.2	40.19	35.31	0.18	24.6	5					
	8	1166.0	142.9	36.4	36.2	38.16	35.03	0.23	29.8	5					
	9	1350.8	213.3	35.9	35.5	30.35	35.81	0.25	23.4	4					
	10	1358.0	162.9	35.0	34.9	33.58	34.31	0.19	15.9	4					
ZU4	1	925.0	471.9	27.5	28.5	27.12	23.67	0.19	5.9	3	12	N	501	29.6	71.9
	2	1129.8	387.6	29.3	29.6	28.40	22.29	0.19	4.7	2					
	3	1013.0	267.9	30.2	30.7	17.72	22.50	0.19	3.7	3					
	4	881.0	461.3	31.3	21.8	16.80	17.80	0.16	3.2	3					
	5	1084.7	226.3	32.5	32.9	36.90	31.18	0.21	4.6	2					
	6	1120.7	142.9	33.2	33.5	36.35	31.21	0.21	18.4	5					
	7	1169.8	236.7	33.7	33.9	20.14	15.76	0.16	2.5	2					
	8														
	9														
	10														
ZU5	1	852.5	140.5	34.8	34.9	123.31	76.88	0.26	101.3	25	116	Y	2289	33.5	55.0
	2	1042.8	81.9	35.2	35.3	78.02	55.25	0.25	87.8	14					
	3	1202.4	121.8	37.0	36.9	83.66	61.33	0.21	60.0	16					
	4	1191.8	294.2	36.6	36.9	84.20	52.68	0.20	81.6	14					
	5	1110.6	129.8	36.8	36.7	67.37	48.29	0.24	42.5	9					
	6	848.6	169.2	36.5	36.5	70.44	43.88	0.16	43.2	10					
	7	1205.8	51.7	36.1	35.8	85.93	53.28	0.22	65.8	9					
	8	1046.3	121.1	35.9	35.7	86.14	54.83	0.22	57.6	14					
	9	1333.6	329.0	35.2	34.9	74.13	60.80	0.20	71.6	15					
	10	1169.4	123.4	34.9	34.5	80.15	54.54	0.23	61.1	15					
ZU6	1	847.9	165.8	30.4	31.2	49.17	34.47	0.22	34.9	6	95	N	2035	34.1	49.0
	2	1163.4	408.2	31.8	31.9	40.72	28.96	0.20	26.7	6					
	3	885.0	288.2	32.1	32.4	55.89	41.04	0.33	43.2	9					
	4	1342.6	304.8	32.5	32.6	37.01	32.46	0.26	21.2	6					
	5	525.5	177.1	32.3	32.3	43.64	37.17	0.21	32.4	7					
	6	413.9	120.2	32.3	32.5	37.56	31.30	0.18	24.1	7					
	7	1179.2	421.9	33.1	33.2	39.22	41.59	0.25	17.0	4					
	8	1365.6	392.6	33.4	33.7	32.49	33.10	0.23	26.0	6					
	9	1148.5	331.9	33.8	33.8	39.30	33.99	0.16	18.8	6					
	10	1146.6	314.9	33.8	34.0	34.72	39.29	0.24	16.2	4					

B.2 Calculation

Measurements were collected for 10 Coralita leaves within each of the 30 plots, although not all 10 leaves were available for measurement due to poor Coralita growth, particularly in Interval 3. Nonetheless, the average values for various plant traits, such as stomatal conductance, leaf length, leaf width, and leaf thickness were calculated using Equation B.1. The resulting averages for each plot are illustrated in Table B.4 in Section B.3.

$$y = \frac{x_1 + x_2 + ... + x_n}{n} \tag{B.1}$$

where:

x: measurement from one corresponding leaf

n: total number of leaves or stems measured in each plot

y: calculated average plant trait value for each plot

B.3 Synthesised data

Tables B.4 and B.3 show the synthesised dataset used for all subsequent graphing and analysis purposes.

Table B.4: Final dataset used for Section 3.2.3.1

Plot	Stomatal conductance, Adaxial surface (mmol/m^{2}s)			Stomatal conductance, Abaxial surface (mmol/m^{2}s)			Leaf length (mm)			Leaf width (mm)			Leaf thickness (mm)			Biomass (g)		
	Interval 1	Interval 2	Interval 3	Interval 1	Interval 2	Interval 3	Interval 1	Interval 2	Interval 3	Interval 1	Interval 2	Interval 3	Interval 1	Interval 2	Interval 3	Interval 1	Interval 2	Interval 3
N1	19.4	76.7	47.1	27.3	580.6	163.1	82.03	66.65	45.72	59.02	49.19	30.49	0.180	0.200	0.150	351	104	8
N2	20.6	57.5	68.6	32.8	1134.1	455.3	78.75	50.77	25.58	53.49	37.61	20.22	0.183	0.167	0.155	550	159	18
N3	63.9	40.7	48.9	266.3	332.8	156.4	104.16	45.95	22.67	66.86	31.17	24.50	0.252	0.123	0.118	734	121	2
N4	50.1	60.3	38.2	92.9	581.8	251.7	94.22	70.43	44.17	66.52	49.38	32.61	0.269	0.198	0.182	1329	291	28
N5	78.5	52.7	36.4	362.7	471.9	103.5	98.33	45.19	28.25	59.83	31.48	21.18	0.240	0.151	0.132	746	80	7
N6	48.8	61.9	53.6	33.3	783.4	521.5	117.31	77.33	34.26	74.50	56.73	28.57	0.301	0.267	0.199	837	184	22
S1	76.0	67.1	79.0	412.6	603.4	173.9	57.76	106.78	18.26	40.96	77.19	19.15	0.263	0.312	0.155	180	1263	5
S2	133.6	58.1	60.1	564.8	877.7	445.6	64.72	92.13	40.89	48.15	63.49	33.22	0.258	0.275	0.165	175	1568	81
S3	67.7	113.3	0.0	393.6	1295.2	0.0	81.95	73.96	0.00	53.57	59.07	0.00	0.311	0.289	0.000	302	432	0
S4	79.1	40.5	94.5	324.8	823.1	160.6	77.18	77.59	35.39	53.02	60.65	27.19	0.293	0.292	0.180	356	541	3
S5	60.6	50.3	0.0	356.2	217.4	0.0	80.43	71.41	0.00	51.29	62.72	0.00	0.232	0.244	0.000	181	202	0
S6	57.1	151.6	0.0	331.3	1072.0	0.0	90.69	73.63	0.00	56.42	55.61	0.00	0.264	0.264	0.000	232	286	0
E1	56.3	137.7	94.9	250.1	1279.6	579.8	91.18	49.22	29.78	56.25	37.11	19.91	0.304	0.213	0.154	899	94	2
E2	70.4	42.7	0.0	218.4	191.6	0.0	92.30	59.28		63.59	44.07	0.00	0.258	0.222	0.000	508	253	0
E3	90.6	43.1	57.1	135.9	119.6	178.7	84.47	56.34	29.59	60.75	40.27	23.03	0.286	0.239	0.170	557	221	9
E4	43.7	47.5	54.1	255.3	227.8	173.5	94.21	57.51	17.47	65.30	41.77	17.12	0.285	0.233	0.080	464	128	1
E5	83.9	56.8	0.0	566.4	267.7	0.0	69.22	67.73	0.00	60.84	55.63	0.00	0.349	0.275	0.000	231	177	0
E6	72.8	60.1	0.0	326.1	493.8	0.0	95.30	64.65	0.00	66.44	52.75	0.00	0.339	0.263	0.000	740	164	0
W1	26.3	67.3	45.8	87.0	816.7	139.6	94.66	64.35	31.50	58.79	48.42	25.68	0.077	0.155	0.120	777	334	4
W2	19.7	89.6	38.2	29.9	1015.1	131.3	100.25	62.87	44.11	64.13	55.03	33.59	0.211	0.131	0.154	499	204	12
W3	16.5	45.8	41.3	22.8	473.9	192.8	83.69	66.45	24.54	59.86	56.87	23.55	0.109	0.181	0.132	576	323	9
W4	22.0	67.5	47.9	41.6	239.4	154.3	84.60	69.06	57.21	56.16	49.58	27.72	0.116	0.189	0.169	527	495	7
W5	50.0	45.6	39.8	96.0	575.2	76.3		66.64	36.44		65.98	32.52		0.139	0.176	600	349	9
W6	40.9	70.5		24.6	497.9		82.09	70.79		58.75	55.51		0.229	0.201		420	293	
U1	54.6	52.4	110.2	252.3	453.7	1179.7	90.78	73.14	48.87	60.03	59.18	38.48	0.215	0.298	0.220	700	347	74
U2	53.1	63.5	216.5	198.5	543.2	1148.4	78.92	57.10	38.42	63.32	44.67	32.25	0.197	0.267	0.169	491	126	24
U3	58.9	51.6	130.2	130.1	432.2	1306.1	94.01	84.37	43.20	73.34	70.82	38.83	0.273	0.298	0.209	647	336	43
U4	61.2	73.5	313.5	396.6	647.8	1046.3	95.30	34.44	26.20	60.26	28.31	23.49	0.182	0.262	0.187	717	33	12
U5	68.9	78.6	156.3	711.7	447.8	1100.4	91.90	74.21	83.34	57.62	51.24	56.18	0.228	0.273	0.219	627	127	116
U6	63.9	55.7	292.6	672.4	346.7	1001.8	69.44	60.89	40.97	52.08	49.50	35.34	0.153	0.295	0.228	531	187	95
Average	57.0	66.0	74.6	253.8	594.8	373.8	86.9	66.4	30.2	59.3	51.4	22.9	0.236	0.231	0.132	549.5	314.1	20.4

Plot	Stomatal conductance, Adaxial surface (mmol/m²s)			Stomatal conductance, Abaxial surface (mmol/m²s)			Leaf length (mm)			Leaf width (mm)			Leaf thickness (mm)			Biomass (g)		
	Between Intervals 1 and 2	Between Intervals 2 and 3	Between Intervals 1 and 3	Between Intervals 1 and 2	Between Intervals 2 and 3	Between Intervals 1 and 3	Between Intervals 1 and 2	Between Intervals 2 and 3	Between Intervals 1 and 3	Between Intervals 1 and 2	Between Intervals 2 and 3	Between Intervals 1 and 3	Between Intervals 1 and 2	Between Intervals 2 and 3	Between Intervals 1 and 3	Between Intervals 1 and 2	Between Intervals 2 and 3	Between Intervals 1 and 3
N1	-57.39	29.64	-27.75	-553.27	417.5143	-135.7557	15.382	20.92071	36.30271	9.833	18.69457	28.52757	-0.02	0.05	0.03	247	96	343
N2	-36.86	-11.09	-47.95	-1101.24	678.74	-422.5	27.982	25.19	53.172	15.879	17.391	33.27	0.016	0.012	0.028	391	141	532
N3	23.26	-8.17	15.09	-66.48	176.4	109.92	58.215	23.281	81.496	35.698	6.6635	42.3615	0.129	0.0055	0.1345	613	119	732
N4	-10.23	22.09	11.86	-488.88	330.13	-158.75	23.794	26.256	50.05	17.146	16.773	33.919	0.071	0.016	0.087	1038	263	1301
N5	25.78	16.33	42.11	-109.14	368.39	259.25	53.132	16.941	70.073	28.349	10.295	38.644	0.089	0.019	0.108	666	73	739
N6	-13.08	8.29	-4.79	-750.08	261.92	-488.16	39.982	43.063	83.045	17.773	28.159	45.932	0.034	0.068	0.102	653	162	815
S1	8.88	-11.865	-2.985	-190.83	429.505	238.675	-49.016	88.52	39.504	-36.228	58.0395	21.8115	-0.049	0.157	0.108	-1083	1258	175
S2	75.54	-2.01	73.53	-312.94	432.19	119.25	-27.408	51.232	23.824	-15.342	30.269	14.927	-0.017	0.11	0.093	-1393	1487	94
S3	-45.57	113.26	67.69	-901.55	1295.15	393.6	7.987	73.958	81.945	-5.499	59.066	53.567	0.022	0.289	0.311	-130	432	302
S4	38.58	-54.015	-15.435	-498.39	662.515	164.125	-0.412	42.2	41.788	-7.629	33.467	25.838	0.001	0.112	0.113	-185	538	353
S5	10.24	50.33	60.57	138.76	217.44	356.2	9.02	71.409	80.429	-11.431	62.723	51.292	-0.012	0.244	0.232	-21	202	181
S6	-94.53	151.6	57.07	-740.62	1071.96	331.34	17.061	73.626	90.687	0.804	55.611	56.415	0	0.264	0.264	-54	286	232
E1	-81.46	42.78	-38.68	-1029.52	699.784	-329.736	41.96	19.439	61.399	19.14	17.202	36.342	0.091	0.059	0.15	805	92	897
E2	27.7	42.7	70.4	26.77	191.62	218.39	33.023			19.515	44.07	63.585	0.036	0.222	0.258	255	253	508
E3	47.55	-14.02	33.53	16.33	-59.09	-42.76	28.125	26.756	54.881	20.481	17.239	37.72	0.047	0.069	0.116	336	212	548
E4	-3.77	-6.62	-10.39	27.46	54.31	81.77	36.705	40.039	76.744	23.531	24.646	48.177	0.052	0.153	0.205	336	127	463
E5	27.08	56.77	83.85	298.73	267.67	566.4	1.494	67.728	69.222	5.212	55.63	60.842	0.074	0.275	0.349	54	177	231
E6	12.66	60.1	72.76	-167.71	493.79	326.08	30.653	64.651	95.304	13.685	52.754	66.439	0.076	0.263	0.339	576	164	740
W1	-41.02	21.53	-19.49	-729.74	677.16	-52.58	30.31	32.851	63.161	10.37	22.735	33.105	-0.078	0.035	-0.043	443	330	773
W2	-69.85	51.32	-18.53	-985.2	883.82	-101.38	37.383	18.76	56.143	9.106	21.437	30.543	0.08	-0.023	0.057	295	192	487
W3	-29.29	4.53	-24.76	-451.12	281.12	-170	17.243	41.904	59.147	2.987	33.323	36.31	-0.072	0.049	-0.023	253	314	567
W4	-45.45	19.6	-25.85	-197.83	85.0725	-112.7575	15.538	11.854	27.392	6.577	21.864	28.441	-0.073	0.02025	-0.05275	32	488	520
W5	4.36	5.87	10.23	-479.19	498.94	19.75		30.201			33.455			-0.037		251	340	591
W6	-29.64			-473.29			11.299			3.242			0.028			127		
U1	2.19	-57.82	-55.63	-201.4	-726	-927.4	17.641	24.272	41.913	0.85	20.7	21.55	-0.083	0.078	-0.005	353	273	626
U2	-10.49	-153	-163.49	-344.66	-605.19	-949.85	21.818	18.681	40.499	18.652	12.417	31.069	-0.07	0.098	0.028	365	102	467
U3	7.37	-78.62	-71.25	-302.03	-873.88	-1175.91	9.635	41.176	50.811	2.516	31.993	34.509	-0.025	0.089	0.064	311	293	604
U4	-12.34	-240.0243	-252.3643	-251.17	-398.5357	-649.7057	60.867	8.230714	69.09771	31.952	4.821857	36.77386	-0.08	0.074857	-0.005143	684	21	705
U5	-9.73	-77.67	-87.4	263.94	-652.63	-388.69	17.693	-9.128	8.565	6.384	-4.94	1.444	-0.045	0.054	0.009	500	11	511
U6	8.11	-236.82	-228.71	325.64	-655.08	-329.44	8.542	19.921	28.463	2.573	14.165	16.738	-0.142	0.067	-0.075	344	92	436
Average	-9.046667	-8.793251	-17.1298	-340.955	224.3012	-112.0905	20.53959	36.21187	56.85398	8.487103	28.29874	36.78902	0.002759	0.099745	0.106486	235.4	294.4138	533.5517

B.4 Temperature and humidity data

Tables B.5 to B.7 show the temperature and humidity dataset used to calculate the average temperature and humidity across the intervals.

Table B.5: Temperature and humidity data for Interval 1

Date	Time	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
14-Mar	00:00	25	24	24.50	83
	06:00	29	25	27.00	74
	12:00	27	26	26.50	71
	18:00	25	24	24.50	81
15-Mar	00:00	24	23	23.50	84
	06:00	28	25	26.50	68
	12:00	29	26	27.50	68
	18:00	26	24	25.00	80
16-Mar	00:00	24	21	22.50	88
	06:00	29	23	26.00	70
	12:00	29	26	27.50	63
	18:00	26	23	24.50	75
17-Mar	00:00	25	23	24.00	80
	06:00	26	25	25.50	77
	12:00	27	24	25.50	75
	18:00	25	24	24.50	70
18-Mar	00:00	24	24	24.00	69
	06:00	28	24	26.00	58
	12:00	28	25	26.50	56
	18:00	25	25	25.00	68
19-Mar	00:00	25	24	24.50	73
	06:00	29	25	27.00	64
	12:00	29	26	27.50	65
	18:00	26	25	25.50	80
20-Mar	00:00	25	24	24.50	81
	06:00	29	26	27.50	68
	12:00	29	27	28.00	65
	18:00	26	25	25.50	77
21-Mar	00:00	25	25	25.00	76
	06:00	29	25	27.00	67
	12:00	29	26	27.50	69
	18:00	25	25	25.00	79
22-Mar	00:00	25	24	24.50	82
	06:00	26	24	25.00	86
	12:00	29	26	27.50	66
	18:00	25	25	25.00	67
23-Mar	00:00	25	24	24.50	73
	06:00	26	24	25.00	76
	12:00	28	25	26.50	73
	18:00	25	24	24.50	75
24-Mar	00:00	24	24	24.00	74
	06:00	28	25	26.50	64
	12:00	29	26	27.50	66
	18:00	26	24	25.00	78
25-Mar	00:00	24	24	24.00	80
	06:00	28	25	26.50	68
	12:00	29	26	27.50	68
	18:00	25	25	25.00	74
26-Mar	00:00	24	24	24.00	78
	06:00	29	25	27.00	63
	12:00	29	26	27.50	55
	18:00	25	25	25.00	67
27-Mar	00:00	25	24	24.50	66
29-Mar	00:00	25	24	24.50	75
	06:00	28	25	26.50	67
	12:00	28	26	27.00	66
	18:00	25	25	25.00	77
30-Mar	00:00	25	24	24.50	76
	06:00	27	24	25.50	75
	12:00	28	26	27.00	72
	18:00	26	24	25.00	74
31-Mar	00:00	25	24	24.50	75
	06:00	29	25	27.00	65
	12:00	28	26	27.00	73
	18:00	25	25	25.00	79
1-Apr	00:00	25	22	23.50	84
	06:00	28	24	26.00	68
	12:00	28	24	26.00	78
	18:00	25	24	24.50	79

Date	Time	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
2-Apr	00:00	25	25	25.00	76
	06:00	29	25	27.00	70
	12:00	29	26	27.50	69
	18:00	25	25	25.00	75
3-Apr	00:00	25	24	24.50	70
	06:00	29	25	27.00	63
	12:00	29	26	27.50	65
	18:00	25	25	25.00	73
4-Apr	00:00	25	24	24.50	75
	06:00	30	25	27.50	67
	12:00	29	26	27.50	65
	18:00	26	25	25.50	76
5-Apr	00:00	25	24	24.50	77
	06:00	28	25	26.50	71
	12:00	28	24	26.00	74
	18:00	25	24	24.50	77
6-Apr	00:00	25	24	24.50	82
	06:00	24	22	23.00	90
	12:00	24	24	24.00	84
	18:00	24	22	23.00	88
7-Apr	00:00	25	24	24.50	81
	06:00	29	25	27.00	73
	12:00	29	26	27.50	71
	18:00	25	25	25.00	77
8-Apr	00:00	25	24	24.50	77
	06:00	28	25	26.50	70
	12:00	28	25	26.50	76
	18:00	25	25	25.00	81
9-Apr	00:00	25	25	25.00	78
	06:00	29	25	27.00	67
	12:00	29	26	27.50	72
	18:00	26	25	25.50	79
10-Apr	00:00	25	24	24.50	82
	06:00	28	26	27.00	72
	12:00	29	26	27.50	68
	18:00	26	25	25.50	78
11-Apr	00:00	24	23	23.50	84
	06:00	29	25	27.00	73
	12:00	29	26	27.50	69
	18:00	25	25	25.00	77
12-Apr	00:00	25	24	24.50	77
	06:00	29	26	27.50	70
	12:00	29	26	27.50	69
	18:00	25	25	25.00	79
13-Apr	00:00	25	24	24.50	79
	06:00	29	25	27.00	70
	12:00	28	26	27.00	71
	18:00	26	25	25.50	78
14-Apr	00:00	25	24	24.50	80
	06:00	28	25	26.50	72
	12:00	28	27	27.50	69
	18:00	25	25	25.00	80
15-Apr	00:00	25	24	24.50	79
	06:00	29	24	26.50	75
	12:00	29	26	27.50	72
	18:00	26	25	25.50	81
16-Apr	00:00	25	24	24.50	80
	06:00	28	25	26.50	72
	12:00	29	26	27.50	67
	18:00	26	25	25.50	79
17-Apr	00:00	25	24	24.50	81
	06:00	28	26	27.00	71
	12:00	29	26	27.50	71
	18:00	25	25	25.00	81
18-Apr	00:00	25	25	25.00	77
	06:00	30	25	27.50	66
	12:00	29	26	27.50	65
	18:00	26	25	25.50	75

Table B.6: Temperature and humidity data for Interval 2

Date	Time	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
3-Apr	00:00	25	24	24.50	70
	06:00	29	25	27.00	63
	12:00	29	26	27.50	65
	18:00	25	25	25.00	73
4-Apr	00:00	25	24	24.50	75
	06:00	30	25	27.50	67
	12:00	29	26	27.50	65
	18:00	26	25	25.50	76
5-Apr	00:00	25	24	24.50	77
	06:00	28	25	26.50	71
	12:00	28	24	26.00	74
	18:00	25	24	24.50	77
6-Apr	00:00	25	24	24.50	82
	06:00	24	22	23.00	90
	12:00	24	24	24.00	84
	18:00	24	22	23.00	88
7-Apr	00:00	25	24	24.50	81
	06:00	29	25	27.00	73
	12:00	29	26	27.50	71
	18:00	25	25	25.00	77
8-Apr	00:00	25	24	24.50	77
	06:00	28	25	26.50	70
	12:00	28	25	26.50	76
	18:00	25	25	25.00	81
9-Apr	00:00	25	25	25.00	78
	06:00	29	25	27.00	67
	12:00	29	26	27.50	72
	18:00	26	25	25.50	79
10-Apr	00:00	25	24	24.50	82
	06:00	28	26	27.00	72
	12:00	29	26	27.50	68
	18:00	26	25	25.50	78
11-Apr	00:00	24	23	23.50	84
	06:00	29	25	27.00	73
	12:00	29	26	27.50	69
	18:00	25	25	25.00	77
12-Apr	00:00	25	24	24.50	77
	06:00	29	26	27.50	70
	12:00	29	26	27.50	69
	18:00	25	25	25.00	79
13-Apr	00:00	25	24	24.50	79
	06:00	29	25	27.00	70
	12:00	28	26	27.00	71
	18:00	26	25	25.50	78
14-Apr	00:00	25	24	24.50	80
	06:00	28	25	26.50	72
	12:00	28	27	27.50	69
	18:00	25	25	25.00	80
15-Apr	00:00	25	24	24.50	79
	06:00	29	24	26.50	75
	12:00	29	26	27.50	72
	18:00	26	25	25.50	81
16-Apr	00:00	25	24	24.50	80
	06:00	28	25	26.50	72
	12:00	29	26	27.50	67
	18:00	26	25	25.50	79
17-Apr	00:00	25	24	24.50	81
	06:00	28	26	27.00	71
	12:00	29	26	27.50	71
	18:00	25	25	25.00	81
18-Apr	00:00	25	25	25.00	77
	06:00	30	25	27.50	66
	12:00	29	26	27.50	65
	18:00	26	25	25.50	75
19-Apr	00:00	25	24	24.50	76
	06:00	27	24	25.50	75
	12:00	28	26	27.00	72
	18:00	26	24	25.00	74
20-Apr	00:00	25	24	24.50	75
	06:00	29	25	27.00	65
	12:00	28	26	27.00	73
	18:00	25	25	25.00	79

Date	Time	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
21-Apr	00:00	25	22	23.50	84
	06:00	28	24	26.00	68
	12:00	28	24	26.00	78
	18:00	25	24	24.50	79
22-Apr	00:00	25	22	23.50	84
	06:00	28	24	26.00	68
	12:00	28	24	26.00	78
	18:00	25	24	24.50	79
23-Apr	00:00	26	25	25.50	88
	06:00	26	25	25.50	81
	12:00	29	26	27.50	74
	18:00	29	27	28.00	74
24-Apr	00:00	26	23	24.50	86
	06:00	29	25	27.00	78
	12:00	29	27	28.00	69
	18:00	26	25	25.50	82
25-Apr	00:00	25	24	24.50	87
	06:00	29	26	27.50	74
	12:00	29	27	28.00	71
	18:00	26	25	25.50	85
26-Apr	00:00	25	24	24.50	87
	06:00	29	26	27.50	74
	12:00	29	27	28.00	74
	18:00	27	26	26.50	83
27-Apr	00:00	26	25	25.50	86
	06:00	30	26	28.00	76
	12:00	31	28	29.50	72
	18:00	27	24	25.50	87
28-Apr	00:00	24	23	23.50	95
	06:00	29	26	27.50	72
	12:00	30	28	29.00	71
	18:00	27	25	26.00	83
29-Apr	00:00	25	24	24.50	92
	06:00	30	26	28.00	74
	12:00	29	28	28.50	74
	18:00	27	27	27.00	83
30-Apr	00:00	27	26	26.50	84
	06:00	31	27	29.00	70
	12:00	30	28	29.00	69
	18:00	27	27	27.00	83
1-May	00:00	27	26	26.50	81
	06:00	31	28	29.50	67
	12:00	30	28	29.00	71
	18:00	27	27	27.00	82
2-May	00:00	27	26	26.50	83
	06:00	31	27	29.00	69
	12:00	31	28	29.50	65
	18:00	27	26	26.50	75
3-May	00:00	26	26	26.00	78
	06:00	31	27	29.00	64
	12:00	30	28	29.00	67
	18:00	27	26	26.50	75
4-May	00:00	26	26	26.00	79
	06:00	30	27	28.50	69
	12:00	31	29	30.00	69
	18:00	28	26	27.00	84
5-May	00:00	26	25	25.50	88
	06:00	29	27	28.00	72
	12:00	30	28	29.00	67
	18:00	27	25	26.00	84
6-May	00:00	26	25	25.50	82
	06:00	31	27	29.00	66
	12:00	30	28	29.00	64
	18:00	27	26	26.50	77
7-May	00:00	26	25	25.50	80
	06:00	31	27	29.00	65
	12:00	30	28	29.00	67
	18:00	27	27	27.00	77
8-May	00:00	27	27	27.00	79
	06:00	30	28	29.00	69
	12:00	30	28	29.00	70
	18:00	28	27	27.50	81

Table B.7: Temperature and humidity data for Interval 3

Date	Time	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
23-Apr	00:00	26	25	25.50	88
	06:00	26	25	25.50	81
	12:00	29	26	27.50	74
	18:00	29	27	28.00	74
24-Apr	00:00	26	23	24.50	86
	06:00	29	25	27.00	78
	12:00	29	27	28.00	69
	18:00	26	25	25.50	82
25-Apr	00:00	25	24	24.50	87
	06:00	29	26	27.50	74
	12:00	29	27	28.00	71
	18:00	26	25	25.50	85
26-Apr	00:00	25	24	24.50	87
	06:00	29	26	27.50	74
	12:00	29	27	28.00	74
	18:00	27	26	26.50	83
27-Apr	00:00	26	25	25.50	86
	06:00	30	26	28.00	76
	12:00	31	28	29.50	72
	18:00	27	24	25.50	87
28-Apr	00:00	24	23	23.50	95
	06:00	29	26	27.50	72
	12:00	30	28	29.00	71
	18:00	27	25	26.00	83
29-Apr	00:00	25	24	24.50	92
	06:00	30	26	28.00	74
	12:00	29	28	28.50	74
	18:00	27	27	27.00	83
30-Apr	00:00	27	26	26.50	84
	06:00	31	27	29.00	70
	12:00	30	28	29.00	69
	18:00	27	27	27.00	83
1-May	00:00	27	26	26.50	81
	06:00	31	28	29.50	67
	12:00	30	28	29.00	71
	18:00	27	27	27.00	82
2-May	00:00	27	26	26.50	83
	06:00	31	27	29.00	69
	12:00	31	28	29.50	65
	18:00	27	26	26.50	75
3-May	00:00	26	26	26.00	78
	06:00	31	27	29.00	64
	12:00	30	28	29.00	67
	18:00	27	26	26.50	75
4-May	00:00	26	26	26.00	79
	06:00	30	27	28.50	69
	12:00	31	29	30.00	69
	18:00	28	26	27.00	84
5-May	00:00	26	25	25.50	88
	06:00	29	27	28.00	72
	12:00	30	28	29.00	67
	18:00	27	25	26.00	84
6-May	00:00	26	25	25.50	82
	06:00	31	27	29.00	66
	12:00	30	28	29.00	64
	18:00	27	26	26.50	77
7-May	00:00	26	25	25.50	80
	06:00	31	27	29.00	65
	12:00	30	28	29.00	67
	18:00	27	27	27.00	77
8-May	00:00	27	27	27.00	79
	06:00	30	28	29.00	69
	12:00	30	28	29.00	70
	18:00	28	27	27.50	81
9-May	00:00	27	27	27.00	83
	06:00	31	28	29.50	68
	12:00	32	28	30.00	63
	18:00	28	27	27.50	78
10-May	00:00	27	26	26.50	80
	06:00	31	28	29.50	64
	12:00	31	28	29.50	63
	18:00	27	27	27.00	72

Date	Time	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
11-May	00:00	27	26	26.50	73
	06:00	31	39	35.00	61
	12:00	30	28	29.00	64
	18:00	27	26	26.50	78
12-May	00:00	26	25	25.50	84
	06:00	30	27	28.50	71
	12:00	30	26	28.00	74
	18:00	27	26	26.50	79
13-May	00:00	27	25	26.00	81
	06:00	30	26	28.00	72
	12:00	30	28	29.00	69
	18:00	27	27	27.00	76
14-May	00:00	27	26	26.50	77
	06:00	30	27	28.50	70
	12:00	31	28	29.50	65
	18:00	27	26	26.50	79
15-May	00:00	27	26	26.50	80
	06:00	30	27	28.50	69
	12:00	30	27	28.50	70
	18:00	27	27	27.00	78
16-May	00:00	26	26	26.00	83
	06:00	31	27	29.00	71
	12:00	31	28	29.50	68
	18:00	27	27	27.00	80
17-May	00:00	27	26	26.50	82
	06:00	31	27	29.00	68
	12:00	30	27	28.50	71
	18:00	28	27	27.50	79
18-May	00:00	27	26	26.50	83
	06:00	31	27	29.00	68
	12:00	31	28	29.50	68
	18:00	28	26	27.00	80
19-May	00:00	26	25	25.50	84
	06:00	31	26	28.50	75
	12:00	31	28	29.50	69
	18:00	27	27	27.00	79
20-May	00:00	27	26	26.50	76
	06:00	31	28	29.50	68
	12:00	29	27	28.00	78
	18:00	27	26	26.50	81
21-May	00:00	27	26	26.50	78
	06:00	31	28	29.50	67
	12:00	31	28	29.50	64
	18:00	27	27	27.00	77
22-May	00:00	27	26	26.50	81
	06:00	30	28	29.00	69
	12:00	30	26	28.00	80
	18:00	26	25	25.50	86
23-May	00:00	26	25	25.50	85
	06:00	30	27	28.50	75
	12:00	30	28	29.00	76
	18:00	27	26	26.50	85
24-May	00:00	27	24	25.50	85
	06:00	30	26	28.00	76
	12:00	29	27	28.00	76
	18:00	27	27	27.00	82
25-May	00:00	26	25	25.50	88
	06:00	30	27	28.50	74
	12:00	29	26	27.50	79
	18:00	27	26	26.50	86
26-May	00:00	26	26	26.00	88
	06:00	31	28	29.50	72
	12:00	31	28	29.50	75
	18:00	28	26	27.00	87
27-May	00:00	27	26	26.50	86
	06:00	31	27	29.00	76
	12:00	30	28	29.00	73
	18:00	28	27	27.50	77
28-May	00:00	27	27	27.00	76
	06:00	30	28	29.00	67
	12:00	30	28	29.00	67
	18:00	27	27	27.00	72

Tables B.8 to B.10 show the calculated average temperature and humidity across the intervals.

Table B.8: Average temperature and humidity data for Interval 1

Duration	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
14-Mar - 3-Apr	26.62	24.66	25.64	72.27
15-Mar - 4-Apr	26.68	24.68	25.68	71.94
16-Mar - 5-Apr	26.66	24.66	25.66	71.92
17-Mar - 6-Apr	26.52	24.65	25.58	72.55
18-Mar - 7-Apr	26.58	24.70	25.64	72.55
19-Mar - 8-Apr	26.60	24.71	25.66	73.23
20-Mar - 9-Apr	26.60	24.73	25.66	73.42
21-Mar - 10-Apr	26.58	24.71	25.65	73.53
22-Mar - 11-Apr	26.57	24.69	25.63	73.69
23-Mar - 12-Apr	26.61	24.71	25.66	73.61
24-Mar - 13-Apr	26.66	24.75	25.71	73.62
25-Mar - 14-Apr	26.65	24.78	25.71	73.87
26-Mar - 15-Apr	26.69	24.77	25.73	74.09
27-Mar - 16-Apr	26.70	24.77	25.73	74.55
28-Mar - 17-Apr	26.73	24.80	25.76	74.73
29-Mar - 18-Apr	26.76	24.82	25.79	74.54
Average			25.68	73.38

Table B.9: Average temperature and humidity data for Interval 2

Duration	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
3-Apr - 23-Apr	28.33	26.56	27.45	75.73
4-Apr - 24-Apr	28.39	26.63	27.51	75.44
5-Apr - 25-Apr	28.44	26.71	27.58	75.15
6-Apr - 26-Apr	28.51	26.79	27.65	74.98
7-Apr - 27-Apr	28.58	26.83	27.71	74.76
8-Apr - 28-Apr	28.62	26.88	27.75	74.50
9-Apr - 29-Apr	28.68	26.93	27.80	74.33
10-Apr - 30-Apr	28.71	26.95	27.83	74.10
11-Apr - 1-May	28.73	26.96	27.85	73.86
12-Apr - 2-May	28.70	26.92	27.81	74.04
13-Apr - 3-May	28.67	26.90	27.79	74.38
14-Apr - 4-May	28.65	26.87	27.76	74.80
15-Apr - 5-May	28.62	26.82	27.72	75.11
16-Apr - 6-May	28.67	26.86	27.76	75.24
17-Apr - 7-May	28.69	26.88	27.79	75.51
18-Apr - 8-May	28.69	26.92	27.80	75.43
Average			26.41	76.34

Table B.10: Average temperature and humidity data for Interval 3

Duration	Highest temperature (℃)	Lowest temperature (℃)	Average temperature (℃)	Humidity (%)
23-Apr - 13-May	28.33	26.44	27.39	75.73
24-Apr - 14-May	28.39	26.51	27.45	75.44
25-Apr - 15-May	28.44	26.60	27.52	75.15
26-Apr - 16-May	28.51	26.67	27.59	74.98
27-Apr - 17-May	28.58	26.71	27.65	74.76
28-Apr - 18-May	28.62	26.76	27.69	74.50
29-Apr - 19-May	28.68	26.81	27.74	74.33
30-Apr - 20-May	28.71	26.83	27.77	74.10
1-May - 21-May	28.73	26.85	27.79	73.86
2-May - 22-May	28.70	26.80	27.75	74.04
3-May - 23-May	28.67	26.79	27.73	74.38
4-May - 24-May	28.65	26.75	27.70	74.80
5-May - 25-May	28.62	26.70	27.66	75.11
6-May - 26-May	28.67	26.74	27.70	75.24
7-May - 27-May	28.69	26.76	27.73	75.51
8-May - 28-May	28.69	26.80	27.74	75.43
Average			27.66	74.83