Photosynthetic Response of Drooping Sheoak (*Allocasuarina verticillata*) to Root-Zone Soil Moisture

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List of Acronyms

A: Assimilation rate

AEST: Australian Eastern Standard Time

ATP: Adenosine Triphosphate

cm: Centimeter

cm^2: Square centimetres

CO$_2$ R: Reference cell Carbon Dioxide

CO$_2$: Carbon dioxide

DEH: Department for Environment and Heritage

G.B.C: Glossy Black-cockatoo

Gt: Gigatonnes

Km/hr: Kilometre per hour

M: Mean value

m: Meter

m^2: Square meters

MJ/day: Mega Joule per day

mm: millimetre

MPa: Mega Pascal

NSW: New South Wales

NADP: Nicotinamide Adenine Dinucleotide

Nr: Reactive Nitrogen

N$_2$: Nitrogen

P: Power of significant

PAR: Photosynthetic active radiation

ppm: Parts per million

PSY: Stem Psychrometers

PWP: Predawn Water Potential

RH_H: Relative humidity in reference cell

Std: Standard deviation

Stm: Transitional models

Tair◦C: Temperature in sample cell

Tr: Transpiration rate

VpdA: Vapour-pressure deficit on air temperature

Ψ_{pd}: Predawn Water Potential

V: Volt

◦C: Degrees Celsius

Summary

Since European settlement in Australia, *Allocasuarina verticillata* (Lam.) L. Johnson (Drooping Sheoak) has undergone regional decline. In South Australia, Drooping Sheoak woodland is considered a threatened ecosystem, and in some areas is listed as vulnerable. Current land-use patterns (such as grazing, fire regimes, weeds and changes to the aquatic environment) have changed this natural woodland ecosystem and put pressure on biodiversity and the viability (or health) of woodland as well as the survival of other dependent flora and fauna. For a prospective conservation plan for Drooping Sheoak, this research focused on the leaf level photosynthetic response to root-zone soil moisture for two reasons: i) photosynthesis rate is the result of mechanical, physical and chemical processes, and thus can reveal the plant's function under internal and external influences; ii) water is necessary for the plant's structure and function; the failure of plant water uptake can result in mortality. In this research, four Drooping Sheoak trees (two male and two female) were selected throughout the period of the experiment, from mid-December 2016 utill the end of April 2017. The predawn stem water potential was measured to demonstrate the root-zone soil moisture at the point when the plant and soil reached equilibrium. In addition, the photosynthesis rate was measured using an LI-6400XT portable photosynthesis system. To eliminate any influential factor on photosynthesis other than soil moisture, the light saturation point was estimated and the assimilation rates after this point were taken as measurements of the response by the plant species to soil moisture. The predawn water potential was thus matched to each photosynthesis measurement, in order to illustrate the photosynthetic response to soil moisture. The results show stable photosynthesis within (0,-2) (MPa) and constant decline of photosynthesis after this point. The assimilation rate reached its lowest point within the range of soil moisture (-3,-4) (MPa), showing a 68% decline. These findings indicate that Drooping Sheoak's function is suffering under soil moisture water stress, which can push the system into further degradation.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Nasrin Sterling

16/10/2017

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Chapter 1 Introduction and Background

1.1 Introduction

Since the pre-industrial era, the major sources of the increased atmospheric concentration of carbon dioxide have been land-use change and the burning of fossil fuels (IPCC, 2014). This change has accelerated and become more destructive over the last fifty years as human populations have increased rapidly and the fast-growing need of the human species for food and water has boosted consumption (Ciais et al., 2014; Erisman, Galloway, Seitzinger, Bleeker, & Butterbach-Bahl, 2011; Klein et al., 2014; Primack, 2006). Carbon dioxide (CO_2) emissions associated with land-use change were expected to be 1.6 [0.5 to 2.7] GtC (5.9 [1.8 to 9.9] Gt CO_2) per year over the 1990s with high levels of uncertainty (Solomon, 2007).

Land-use change, as the second-largest source of anthropogenic CO_2 emissions to the atmosphere, is causing a global reduction in the carbon sink (Ciais et al., 2014). Forests represent the largest percentage of annual carbon exchange with the atmosphere and with global carbon storage (Ballantyne, Alden, Miller, Tans, & White, 2012; Le Quéré et al., 2007; Phillips et al., 1998). Forests have become more vulnerable to deforestation (Bradshaw, 2012; Cramer et al., 2001; Phillips et al., 1998) and to changes of ecosystem structure and function (Cramer et al., 2001; Eldridge & Simpson, 2002; Stritar, Schweitzer, Hart, & Bailey, 2010). Since 1750, anthropogenic land use has expanded, with an additional area of around 50 (million km^2) now used for pasture and cropland (Foley, Monfreda, Ramankutty, & Zaks, 2007; Foley et al., 2011).

Moreover, deforestation and habitat loss are drivers for the extinction of species (Primack, 2006; Wright & Muller-Landau, 2006). The extent of modification and fragmentation has put pressure on biodiversity (Bird, Mutze, Peacock, & Jennings, 2012; R. J. Hobbs & A. Hopkins, 1990; Wright & Muller-Landau, 2006). Clearing of vegetation for purposes such as agriculture or urbanization has left only disconnected patches of native bushland, and has led to further degradation (Bird et al., 2012; R. Hobbs & A. Hopkins, 1990; Primack, 2006; Wright & Muller-Landau, 2006). The results include direct and indirect impacts on flora and fauna (such as loss of feeding habitats, exposure to predators and loss of symbiotic relationships with other species) and also on soil quality and moisture.

Additionally, changes in vegetation structure influence the magnitude of the carbon cycle and the availability of fresh water (run-off), as well as having an impact on climate (Cramer et al., 2001; Foley et al., 2005). Changes to the hydrologic cycle (the cycle between water input [precipitation] and output [evapotranspiration and runoff]) can affect soil moisture. Water, as a primary source of life, is important for plant structure and composition, as well as for the distribution of minerals. Plant water limitation reduces the photosynthesis rate (Katul, Manzoni, Palmroth, & Oren, 2009), and plant hydraulic failure results in mortality (McDowell et al., 2008). Some studies show that the photosynthetic soil moisture-driven changes during progressive drought have a greater impact than respiration on the whole plant carbon balance (Zhao, Hartmann, Trumbore, Ziegler, & Zhang, 2013).

Furthermore, the impacts of projected climate change, through altering abiotic stressors such as temperature, precipitation and water stress, have direct effects on the growth and development rates of organisms, and can alter the habitat range of species. Habitat specialists are more vulnerable to being affected by modified abiotic conditions (Kearney, Shine, & Porter, 2009) and by variables such as species isolation, species richness and composition. The response capacity of terrestrial organisms, populations, communities and ecosystems may not be sufficient to keep up with rapid climate change and allow adaptation to the new situation (Penuelas et al., 2013; Primack, 2006).

1.1.1 Australia's Natural Woodlands

In Australia (since European settlement) many natural woodlands have been cleared or modified dramatically for forestry, agriculture, grazing and urbanization (R. Hobbs & A. Hopkins, 1990; Saunders & Hobbs, 1995). The magnitude of these variables influences fauna responses to habitat change (Watling & Donnelly, 2006; Wright & Muller-Landau, 2006). *Allocasuarina verticillata* (Lam.) L. Johnson (Drooping Sheoak) woodlands in South Australia have been affected by such broad interactions. Drooping Sheoak belongs to the Casuarinaceae family whose members are widely distributed throughout Australia, the Pacific islands and South-East Asia (Johnson, 1982; Turnbull, 1990), with about 46 species native to southern Australia (Johnson, 1982). Drooping Sheoak woodlands are considered a threatened ecosystem in South Australia, with some areas considered as vulnerable (Durant, 2009).

Clearance of Drooping Sheoak woodlands has resulted in the gradual decline of many species including the Glossy Black-cockatoo (Calyptorhynchus lathami halmaturinus) (G.B.C), which since 1992 has been listed as endangered in South Australia. The G.B.C depends primarily on *Allocasuarina* for its food and habitat (Maron & Lill, 2004; P. A. Mooney & Pedler, 2005).

More than 60% of Drooping Sheoaks are on private lands (P. A. Mooney & Pedler, 2005), posing a big challenge for conservation management as well as limiting research opportunities. The impacts on vegetation structure of key factors such as rabbit grazing, weed invasion and soil composition are so great that they can ultimately lead to the loss of Drooping Sheoaks, regardless of other attempts at their conservation (Bird et al., 2012). The recovery plan for the G.B.C since 1995, along with other related studies, has drawn significant attention to Drooping Sheoak as the primary source of food and habitat for G.B.Cs (see: Chapman & Paton, 2006; Crowley & Garnett, 2001; Mooney & Pedler, 2005; Pepper et al., 2000). This research has been useful for building knowledge of Drooping Sheoak. However, only a few direct studies, including ecohydrology perspectives (such as Swaffer, 2014; Wang, 2014; Lees, 2016) and holistic perspectives (Durant, 2009) have been made of Drooping Sheoak. The Wild Eyre project on Eyre Peninsula, South Australia began in 2007 and sought to develop a Conservation Action Plan for Drooping Sheoak woodland by 2009 (Durant, 2009). In this effort, all the key ecological indicators were integrated to allow an overall assessment of the viability of this ecosystem. Ecosystem health is not a matter of whether or not nature can be healthy or unhealthy (Nelson, 1993), the concept of ecosystem health can provide an alternative approach for understanding the extent of ecosystem decline. According to the Wild Eyre reports (Durant, 2009), the viability of Sheoak ecosystems is suffering from multiple stressors on various spatial and temporal scales.

Moreover, an ecosystem has the potential to pass through different altered states accompanied by land degradation (R. Hobbs & A. Hopkins, 1990; Saunders & Hobbs, 1995). In Figure 1.1, transition models (STMs) show hypothetical alternative system states (Hobbs & Norton, 1996) and it's ability to interchange between these states (to state 1, 2 or 3) without passing the theshold (state 4), to a non recoverable state. From the description of each different condition, the decline from one state to another may be noted. When an ecosystem is highly degraded, it becomes so difficult to return it to a previous state that it may pass the threshold to non-recoverable. Returning the system from a highly degraded state requires a great deal of effort and funding.

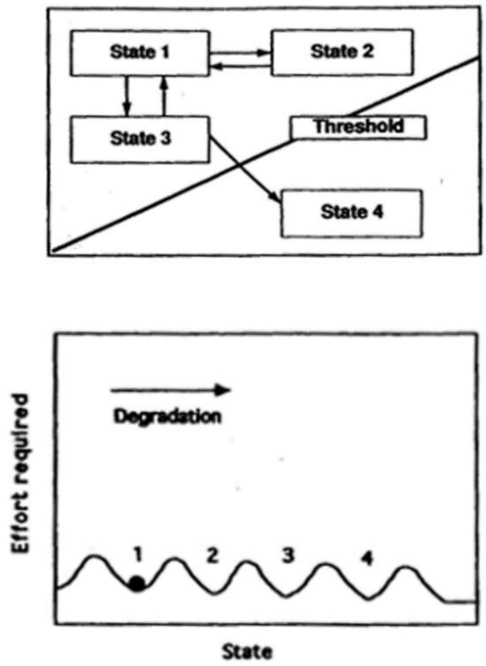


Figure 1.1 Transition models (STMs), hypothetical alternative system states
Top figure: The system state is interchangeable from one state to another one (to state 1, 2 or 3) without passing the threshold and entering to a non-recoverable state (state 4).
Bottom figure: Degradation and decline of system happens along this interchange.

Source: Restoration Ecology, Hobbs and Norton (1996)

The hypothetical breakpoint for Drooping Sheoak resilience has to do with the ability of the trees to absorb change and disturbance while maintaining essentially the same identity, structure and function. The complexity of natural systems means that careful consideration is needed of all the physiological, biophysical and biogeochemical processes involved. Understanding the dynamics of the system requires a better grasp of the key components and their characteristics. Therefore, understanding the vulnerability of the system will make it possible to draw up informed plans for managing the risks, impacts and adaptability

1.2 Study Aims and Objectives

While this thesis uses and builds upon the current findings concerning Drooping Sheoak, and adopts related concepts aimed at achieving holistic conservation advantages, it seeks to address the knowledge gap by investigating the ecohydrological relations in Drooping Sheoak, focusing on the leaf level photosynthetic response to root-zone soil moisture. The complexities of photosynthesis reveal a great deal about internal and external factors that can be adapted for conservation purposes, while also presenting uncertainties and challenges that require further investigation. It is hoped that the outcomes of this research can be used for making overall assessments of Drooping Sheoak ecosystems, and for recognizing the possible threshold beyond which these ecosystems undergo a state change to non-recoverable. Timely conservation actions that suit the conditions of Drooping Sheoak woodland may thus save the system from crossing that threshold.

The objective of this thesis is on measuring photosynthesis in Drooping Sheoak in South Australia, and on determining the response of the species to root-zone soil moisture. The hypothesis is that photosynthetic capacity will reduce under root-zone soil moisture stress. The project aims to develop new insights into Drooping Sheoak function under patch scale disturbances (such as grazing, fire regimes, weeds and changes to the aquatic environment), with a view to these insights being used by managers to improve ecosystem function and services. To achieve the objective of this research, the steps to be taken are:

1) To measure the photosynthesis rate at various light intensities under the natural field conditions encountered during this experiment, from mid-December 2016 until the end of April 2017;

2) To measure water potential proxy for soil moisture from mid-December 2016 until the end of April 2017;

3) To monitor microclimate conditions throughout the duration of the experiment;

4) To monitor the dynamic of sap flow throughout the duration of the experiment;

5) To synthesize the photosynthetic response to root-zone soil moisture.

1.3 Background and Literature Review

Substantial literature exists in regard to the conservation and management of native trees including Drooping Sheoak in South Australia that forms the basis of this thesis. While the literature covers a considerable range of topics in a variety of contexts, for the purpose of the present research this review will address several common key issues. The primary aim of this review is to assess the factors that may prevent the persistence of Drooping Sheoaks.

1.3.1 The importance of *Allocasuarina verticillata* (Drooping Sheoak) Ecosystem

Allocasuarina belongs to the Casuarinaceae family of 96 species (Moncur, Boland, & Harbard, 1997; Turnbull, 1990). The family has a diverse distribution in Australia (Johnson, 1982; Turnbull, 1990). Figure 1.2 shows the distribution of this woodland in 1983 (Chapman, 2009) where the woodlands spread in part of South Australia, Victoria, New South Wales and Tasmania. *Allocasuarina verticillata* woodlands are considered a threatened ecosystem in South Australia, with some parts regarded as vulnerable (Durant, 2009). The *Allocasuarina* habitat range extends from the coasts to arid regions (Morley & Toelken, 1983), and the trees usually grow on soil with poor nutrient value (Johnson, 1982).

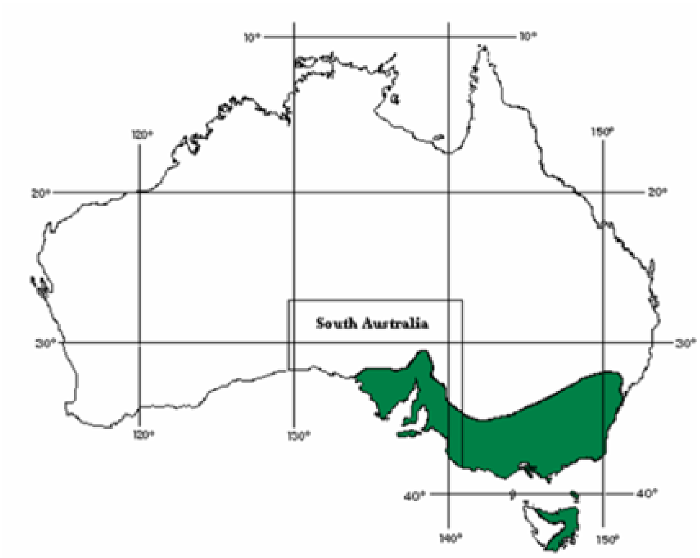


Figure 1.2 Distribution of *Allocasuarina verticillata* (Drooping Sheoak) in 1983.
Allocasuarina verticillata woodlands spread over South Australia, Victoria, New South Wales and Tasmania.

Source: Chapman (2006).

In South Australia, the usual soil formations underlying Drooping Sheoak woodlands are sandy soils (near the coast), and skeletal soils on hills, on limestone flats (mainly on western Eyre Peninsula), or on steep rocky slopes in areas with higher rainfall (e.g. Mount Lofty Ranges). These soils exist throughout the southern agricultural regions of South Australia, commonly within the 350 to 550 mm rainfall zone (Durant, 2009). Ecosystem structure is a composition of individuals and communities of plants and animals, all of which act together as a whole and create ecosystem functions such as climate regulation, nutrient cycling and gas regulation. Any structural change would thus affect the ecosystem services including gas regulating and provisional and supporting services (Daly & Farley, 2011). For the environment to be able to continue its services and to sustain us requires a good interface between every micro and macro-organism in the complex and dynamic ecosystems web.
The ecosystem services provided by Drooping Sheoak woodland include: i) Cycling of water, energy and carbon between land and atmosphere; ii) Cultural value; iii) Biodiversity value.

1.3.1.1 Cycling of Water, Energy and Carbon between Land and Atmosphere

Drooping Sheoak trees are among primary producers, and solar radiation is the primary driver for plant photosynthesis occurring at the leaf level. Photosynthesis is a complex matter, involving mechanical and physical as well as chemical processes. Photosynthesis involves three separate processes: i) diffusion, in which stomata open to allow ambient CO_2 to diffuse into leaves [stomata are small openings on the leaf, and their movements make it possible to change the rate of transpiration and partial pressure of CO_2 (Farquhar & Sharkey, 1982)].; ii) light reactions, in which light energy is converted into chemical energy as in the formation of ATP (Adenosine Triphosphate) and NADP (Nicotinamide Adenine Dinucleotide); and iii) dark reactions, in which chemical energy is used to produce carbohydrates(Bonan, 2015). Solar radiation is a primary driver for plant photosynthesis, and at the leaf level, chlorophyll molecules make use of light energy. In photosynthesis, plants absorb carbon from the atmosphere and lose water through transpiration (i).

$$6CO2 + 6H2O + \text{photons} \rightarrow C6H12O6 + 6O2 \quad \text{(i)}$$

Photosynthesis is a slow cycling of carbon, energy and water between atmosphere and land (Ciais et al., 2014) (Table 1.1).

Table 1.1 Natural processes of CO_2 cycling by land vegetation, with the relative time scale and biochemical reactions involved

Source: IPCC (2014)

Process	Time Scale (years)	Reaction
Land uptake: Photosynthesis -respiration	1–100	$6\ CO_2 + 6H_2O + \text{photons} \rightarrow C_6H_{12}O_6 + 6O_2$ $C_6H_{12}O_6 + 6O_2 \rightarrow 6\ CO_2 + 6H_2O + \text{heat}$

Oxygen is a life-supporting component and a by-product of the photosynthetic process in which atmospheric carbon dioxide combines with water, producing a carbohydrate and oxygen. Biological advantage for plants is gained from the photosynthesis process when the integration of leaf environment, metabolism and stomatal functioning helps to minimize water loss while maximizing carbon uptake. The excess carbon can then be used for growth or defence, or can be stored for future use in non-structural carbohydrate that results in increased biomass (Zhao et al., 2013). For efficient plant functioning, stomatal conductance should be tuned to leaf photosynthetic metabolism, to leaf environment and to the hydraulic features of the plant and soil (Farquhar & Sharkey, 1982).

Tree mortality in response to draught results from two mechanisms: carbon starvation or hydraulic failure (McDowell et al, 2008; Adams et al, 2009). At elevated temperatures, high transpiration rates reduce the soil moisture in most of terrestrial ecosystems. Stomata close (stomatal conductance decline) so as to prevent water loss (Hamerlynck, Huxman, Loik, & Smith, 2000; H. A. Mooney, Björkman, & Collatz, 1978; Schulze, Lange, Evenari, Kappen, & Buschbom, 1974), resulting in a decline of photosynthetic activity. Stomatal movements can change the CO_2 pressure and the rate of transpiration, causing changes in the temperature and water potential of the leaf, all of which can determine the rate of carbon assimilation during photosynthesis (Farquhar & Sharkey, 1982).

Furthermore, photosynthetic rate and stomatal conductance change in response to different CO_2 concentrations (Anderson, Maherali, Johnson, Polley, & Jackson, 2001; Long, Ainsworth, Rogers, & Ort, 2004). Many field experiments suggest increases in leaf photosynthesis with rising CO_2 (the so-called CO_2 fertilization effect), and also increases in water use efficiency (plant carbon gain per unit of water loss via transportation). However, substantial uncertainties remain concerning the extent of the CO_2 fertilization effect (IPCC, 2014). Studies suggest that a short-time increased net photosynthesis under high CO_2 concentrations is often offset by photosynthetic capacity down-regulation, that may reduce Rubisco activity and production (Long et al., 2004).

Moreover, nitrogen is an essential element for all life forms, and plant growth is limited by its availability in soil. Plants use nitrogen to produce proteins and therefore to assemble carbohydrates, which in turn affects the rate of CO_2 fixation (Erisman et al., 2011) and influences photosynthetic acclimation (Gunderson & Wullschleger, 1994). Bacteria-like organisms (Actinomycetes) living in nodules on the roots have a symbiotic relationship with Drooping Sheoak, and are effective in providing the nitrogen required by the tree (Morley & Toelken, 1983). Before the Industrial Era, reactive nitrogen Nr (all nitrogen species other than N2) was produced naturally by lightning and minimizing N_2 fixation. Since the beginning of the Industrial Era, human activities have altered the Nr circulation largely through combustion of fossil fuels and through agricultural biological nitrogen fixation (Ciais et al., 2014), affecting the health of human and ecosystem services.

1.3.1.2 Cultural Value

Information on the past distribution of Drooping Sheoak in South Australia is sparse, but the species is thought to have been common throughout the Fleurieu Peninsula and Adelaide foothills prior to European settlement (Chapman, 2005). The record shows that Aboriginal people continuously occupied the South Australian region during the Holocene and for over 3000 years before European settlement (S. Bickford & Gell, 2005). The young green “cones” of Drooping Sheoak were eaten by Aboriginal people in arid regions of Australia while the stems were used for making spears or other wooden tools (Lawrence, 1967). Moreover, there are Aboriginal pictographs of female Plains-wanderers in the Simpson Desert (Treilibs, 2006) (between the Northern Territory, South Australia and Queensland), suggesting the cultural importance of such species for indigenous Australians.

After European settlement, Drooping Sheoak woodland provided services for agricultural, firewood and ornamental purposes (Chapman, 2005), allowing a productive grazing industry in some parts of South Australia from the 1850s (Durant 2009). *Allocasuarina verticillata* was named “Sheoak” by early settlers (Morley, 1983) since the timber is like oak in appearance. The understory of *Allocasuarina verticillata* woodlands was commonly composed of native species of the Cyperaceae and Poaceae families, and in some places of low shrubs. Apart from 9% of the original native vegetation, the rest has been replaced with introduced grasses and non-native pasture species (S. Bickford & Gell, 2005). These new disturbances of the ecosystem structure have altered the vegetation composition, and have often resulted in land degradation (R. J. Hobbs & A. Hopkins, 1990; Primack, 2006).

1.3.1.3 Biodiversity Value

Where *Allocasuarina* woodlands have been totally or partially cleared, many habitats have been lost, and the ability of dependent fauna to feed or nest has been put under huge pressure. The good quality habitat has mostly replaced by lower-quality habitat; many species cannot persist in an agricultural landscape (Garnett, Szabo, & Dutson, 2011) where the application of fertilizers, pesticides and insecticides affects their existence. Moreover, some species like the G.B.C use nesting hollows, which can take as much as 100 years to emerge (P. A. Mooney & Pedler, 2005). Alterations such as land clearing or changes in fire regime are among the limiting factors that can stop nesting hollows from developing naturally. Drooping Sheoak woodland associated fauna species (other than the G.B.C, that has vanished from the mainland) in South Australia are reported to include reptile species such as the Carpet Python (Morelia spiltoa); mammals such as the Western Grey Kangaroo and the Southern Hairy-nosed Wombat, and ground-dwelling birds such as the Australian Bustard, Bush Stone-curlew and Plains-wanderer, while associated flora species are Mallee Box (Eucalyptus porosa) and Coastal White Mallee (Eucalyptus diversifolia). Many of these species have vulnerable status nationally or within the state. The rate of species extinction in Drooping Sheoak woodland ecosystem is faster than the pace of the reporting system. For example, the Plains-wanderer, that at the time of the report (Durant, 2009) was listed as Vulnerable, Criterion 4 in the red list, had jumped by 2015 to Criterion 1, Critically Endangered (Department of Environment, Australian Government, 2015) (Appendix 1).

It should be noted that the persistence of bioindicators like birds can indicate the health of a living ecosystem since birds are very sensitive to changes in their surroundings. The growth, behaviour and survival rate of birds can be influenced by the synergetic effects of multiple stressors under modified conditions. Changes such as decreases in foraging resources (Pepper et al., 2000; Crowley et al., 2001; Mooney & Pedler, 2005; Chapman & Paton, 2006), decreasing home range size (Baker-Gabb, Benshemesh, & Maher, 1990), or decreases of the camouflage effect for sheltering birds (Johnson & Baker-Gabb 1994, Webster & Baker-Gabb 1994), can affect their vulnerability. An example of the problems caused by degradation of *Allocasuarina verticillata* (Drooping Sheoak) ecosystems appears in the population decline of the G.B.C., which in South Australia is now confined to Kangaroo Island. This decline has occurred over decades, and results from the total or partial loss of Drooping Sheoak as the birds' primary feeding habitat (Mooney & Pedler, 2005). Recorded as "numerous" in the late 1800s, the G.B.C. had vanished from the South Australia mainland by 1977 and was considered "endangered" by 1992 (Chapman, 2006). Research indicates that the long-term survival of the G.B.C population rests on a mainland refuge in the event of a catastrophic development and loss of habitat on Kangaroo Island (Chapman, 2006).

A study by Chapman (2006), showed that revegetation with Drooping Sheoak near nests and an increase in the density of russet cones on female branches through provision of additional slow-released nitrogen leads to an increase in the foraging efficiency of the G.B.C. This can increase the cockatoos' energy intake by 20% (Pepper, Male, & Roberts, 2000), and this energy is available for breeding (Chapman, 2006). The same study also suggests that the G.B.C. prefers to stay close to food sources; the lessened movement appears to save the birds from being seen by predators. The significant decline of the G.B.C. in numbers and breeding potential is not only an indication of insufficient home range and habitat, but also of reduced quality of the food source (Chapman, 2006). This might suggest that changes in the characteristics of Drooping Sheoak stands over decades may have affected the birds' nutrition. Furthermore, the G.B.C. shows a preference for certain trees (Mooney & Pedler, 2005; Chapman & Paton, 2006) with large girths (Pepper et al., 2000; Crowley et al., 2001). Thus, decline in numbers of the G.B.C. may reflect a decline of Drooping Sheoak function compared to the past (when the G.B.C. was more abundant); and or, a failure of Drooping Sheoak trees to reach maximum maturity in their short lifespan of between 60 and 100 years.

1.3.2 Challenges for Persistence of Drooping Sheoak (*Allocasuarina verticillata*)

The regional decline of Drooping Sheoak occurred soon after European settlement (S. Bickford & Gell, 2005). As a result of agricultural practices, the landscapes of the Fleurieu Peninsula in the Mount Lofty Ranges region of South Australia (where *Allocasuarina verticillata* was distributed prior to European settlement) have now changed profoundly (R. J. Hobbs & A. Hopkins, 1990; Kirkpatrick, 1999; M. Williams, 1974).

1.3.2.1 Viability, Extent of Modification and Degradation

Clearance and fragmentation of woodlands and forest are global problems associated with land-use change, changes to water resources and species extinction (Watling & Donnelly, 2006; Wright & Muller-Landau, 2006). Drooping Sheoak ecosystems, composed of individuals and communities of plants and animals, provide a range of services on broad temporal and spatial scales.

The different conditions (states) of Drooping Sheoak in Table 1.2 (including remnant, recoverable and unrecoverable) highlight the nature of the defined ecosystem structures in which these Drooping Sheoak ecosystems can continue to function.

If the Remnant condition is assumed to be the ‘Natural’ state, involving the least disturbed area, State 1 shows a decline with the presence of grazing animals and reduction of the understorey. Comparison between states 1 and 4 highlights the further decline that results from successively greater disturbances.

Current land-use patterns including alteration of vegetation structure and composition, agricultural practices, fire regimes, grazing , weeds and changes to the aquatic environment have put pressure on the viability (or health) of Drooping Sheoak woodlands. Table 1.3 is a viability assessment from Eyre Peninsula of a Sheoak woodland (Durant, 2009) in which all the ecological key within the ecosystem are considered.

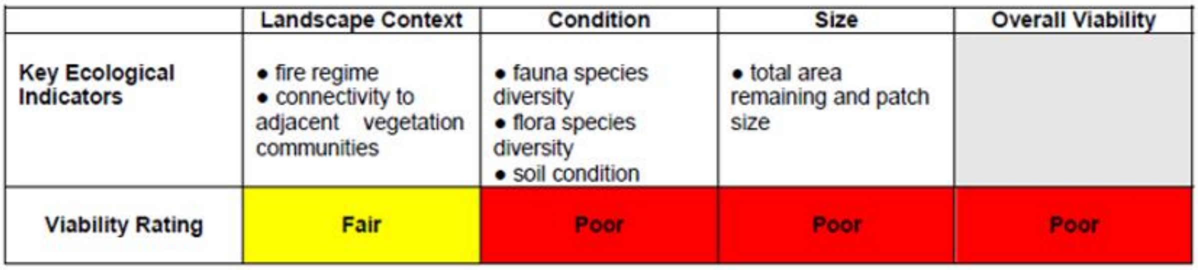
Table 1.2 Drooping Sheoak Woodland Condition on Eyre Peninsula, South Australia

Source: Modified from Durant (2009)

Description of Drooping Trees	Condition	State
Healthy mature trees, evidence of regeneration (several cohorts present), healthy intact understorey. No evidence of stock or feral animal grazing.	Remnant	Natural
Healthy mature trees, some evidence of regeneration, some understorey species present. Under light grazing pressure.	Recoverable	State 1
Mature trees with ability to regenerate, no native understorey remaining. Under heavy grazing pressure.	Recoverable	State 2
Mature trees senescing with ability to regenerate. Under heavy grazing pressure.	Recoverable	State 3
Mature trees sparse senescing to dead with limited or no ability to regenerate. Under heavy grazing pressure.	Non-Recoverable	State 4

Table 1.3 Viability assessment with key ecological indicators.

Source: Durant (2009).



	Landscape Context	Condition	Size	Overall Viability
Key Ecological Indicators	• fire regime • connectivity to adjacent vegetation communities	• fauna species diversity • flora species diversity • soil condition	• total area remaining and patch size	
Viability Rating	Fair	Poor	Poor	Poor

1.3.2.2 Grazing and Exotic Species

The distribution of many species is threatened by introduced species and the reduction of food sources through overgrazing. Reduction of the biomass of grasses through grazing represents a major pressure on species composition and biodiversity.

As well as being grazed by sheep and cattle (Bird et al., 2012; Durant, 2009; Eldridge & Simpson, 2002; Mooney & Pedler, 2005), Drooping Sheoak woodlands are subject to grazing by introduced European rabbits (Bird et al., 2012) by goats and deer (Bird et al., 2012; Durant, 2009; Mooney & Pedler, 2005), and by native herbivores such as kangaroos (Durant, 2009; Eldridge & Simpson, 2002; Mooney & Pedler, 2005) and wombats (Bird et al., 2012; Durant, 2009). An Arial map in 1949 (Local History Service in City of Mitcham) in Figure 1.3, shows the impact of human activities. This area was mainly cleared and was under heavy grazing before the land was purchased by Flinders University.

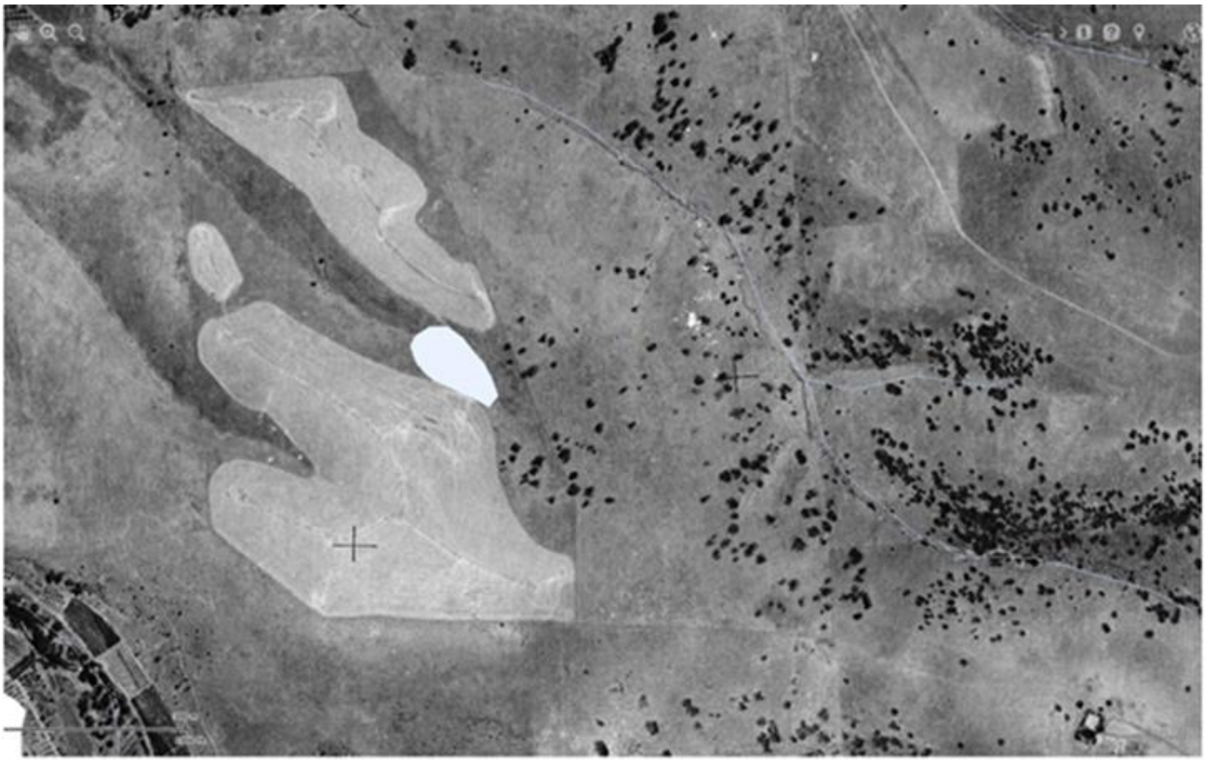


Figure 1.3 Arial Map of Flinders University in 1949. Heavily grazed and scattered patches from clearance.

Source: Local History Service in City of Mitcham, Adelaide (2017).

While the degree of suppression of native plants by exotic herbivores is much greater than by native herbivores (Parker, Burkepile, & Hay, 2006), research nevertheless shows that an increase in the abundance of native herbivores also occurs in response to the availability of food in a low density exotic herbivore environment (Bird et al., 2012). This increases grazing, again affecting recruitment. The speed of regeneration in wooded rangeland also depends on available seeds and post-treatment rainfall (Eldridge & Simpson, 2002). Biotic stressors can change the availability of resources for foraging, altering pathogen populations and conveying phenological mismatches.

European rabbits (Oryctolagus cuniculus L.) first arrived in Australia in 1788 and within a century they occupy extensive areas of southern Australia. Today, they are the major threat to *Allocasuarina* (Durant, 2009; Eldridge & Simpson, 2002; Mooney & Pedler, 2005). Rabbits live in large underground colonies (warrens) with a series of entrances holes (burrows) usually above the warren (mound). The whole area is heavily grazed. Excavation of the warren is an ongoing process with the mound soil being replaced by new excavation, causing extensive and persistent soil disturbance. Annual soil accumulation levels of up to 63 m3 ha–1 are reported (Eldridge & Simpson, 2002). Drooping Sheoak seeds are vastly palatable to most herbivores, and this prevents Sheoak regeneration and seedling establishment (Bird et al., 2012; Durant, 2009; Eldridge & Simpson, 2002), thus influencing the community structure of many species. Rabbits are extremely selective herbivores (Bird et al., 2012; Foran, 1986), and their preferential grazing of native plants (Bird et al., 2012; Durant, 2009) further facilitates the abundance and survival of exotic weeds (Bird et al., 2012). Table 1.4, demonstrates the very high threat posed by the combination of grazing and an abundance of exotic weeds on Eyre Peninsula, South Australia.

Table 1.4 Threats to Sheoak Grassy Woodlands on Eyre Peninsula South Australia.

Source: Durant (2009).

Threats	**Threats Status**
Stock grazing	Very high
Native and exotic species grazing	High
Fragmentation	High
Weeds	High
Overall threats status	Very high

1.3.2.3 Fire regime

Historical clearance of native vegetation (S. A. Bickford, 2001; R. J. Hobbs & A. Hopkins, 1990; Kirkpatrick, 1999; M. Williams, 1974) caused a decline of *Allocasuarina verticillata* in the early period of European settlement, and the trees have been replaced by fire tolerant species (S. Bickford & Gell, 2005). By altering the quantity and structure of fuels (such as organic inputs of leaves and roots), chemical properties and soil water availability (R. J. Williams et al., 2009), the changed distribution of species can alter the ecosystem process and fire regime (Hobbs, 2002; Prieto-Fernández, Acea, & Carballas, 1998; Stritar et al., 2010; R. J. Williams et al., 2009). Fires have been part of the historical ecology of Drooping Sheoak woodlands (Durant, 2009; Mooney & Pedler, 2005) and they can recover from wildfires by germination of surviving seed (Durant, 2009). Fire may be necessary for seed release (Moncur et al., 1997), but it is not significant (Durant, 2009). However, it affects habitat dependent species, especially those with less dispersal ability and species with particular preferences. For example, the habitat preference of the Glossy Black-cockatoo (G.B.C) for Drooping Sheoak (Mooney & Pedler, 2005; Chapman & Paton, 2006) makes the birds more vulnerable when significant areas could be lost in wildfires. Studies suggest that continued grazing after fire (Durant, 2009; Mooney & Pedler, 2005; Stritar et al., 2010), in addition to mechanisms of trampling (Stritar et al., 2010), puts significant pressure on ecosystem recovery.

1.3.2.4 Nutrient Flux, Exotic Plants and Water Variability

Natural river flows have been altered by the construction of dams and weirs and by poor agricultural practices, creating a pattern of reservoirs instead of the natural climatic flow and affecting native fauna and flora. The composition of species is changed as a result of declining flows and the reduced availability of water (Bardsley & Sweeney, 2010). Changes in rainfall patterns, as well as causing further erosion and desertification, may influence river flows and the availability of water for irrigation or flushing the soil (Van Leeuwen et al., 2009). Water scarcity is a global issue that has outcomes such as reduction of primary production that leads to increases in atmospheric CO_2.

The hydrologic cycle can be affected by invasion of exotic plants (Doody et al., 2015; Sala & Tenhunen, 1994), with resulting changes to the ecosystem and biodiversity (Doody et al., 2015). Drooping Sheoaks are a dominant overstorey species and they may occur with other species such as Coastal White Mallee (Eucalyptus diversifolia) or Mallee Box (Eucalyptus porosa) (Durant, 2009) in which their abundance over groundwater recharge area, became more by grazing (Swaffer, 2014). Boxthorn (Lycium ferocissimum) is a common weed within Drooping Sheoak woodlands, and increases in the absence of grazing (Durant, 2009). Removing grazers through the use of fences results in increased regeneration of trees and native grasses coverage, as well as reducing exotic species and soil compaction. However, results from a study on a southern New South Wales farm show that using fences to end stock grazing does not always lead to increased re-establishment of native species. This suggests that some other ecological barriers are inhibiting further recovery (Spooner & Briggs, 2008).

Other reported weeds are: Aleppo Pine, Wild Turnip, Bridal Creeper, Horehound, and Lincoln Weed. A study of exotic tree species and karstic groundwater systems on Eyre Peninsula, South Australia, shows that plantation of non-native Aleppo pine (Pinus halepensis), originally as a wind break, has invaded this water limited environment and caused further water scarcity issues. It has been suggested that its removal may bring about an annual water saving of ~ 50 mm (Swaffer, 2014).

In some experiments, plant nutrient limitation has been hypothesized as the primary cause for a lack or reduction of CO_2 fertilization effects on net primary productivity. Nitrogen and phosphorus very likely play the most significant role in influencing the CO_2 fertilization effect (IPCC, 2014; Luo et al., 2004). Decreases in available nitrogen nutrition may reduce stomatal conductance and carbon assimilation (Caemmerer & Farquhar, 1981; Farquhar & Sharkey, 1982; Wong, Cowan, & Farquhar, 1979). A linear relationship exists between the rate of carbon assimilation and leaf conductance, affected by the different levels of available nitrogen and phosphorus nutrition (Wong et al., 1979).

1.3.2.5 Other Conservation Challenges

Other conservation challenges of the species include the following:

i) A major gap exists regarding the protection of remnant areas on private lands and the willingness of private landowners to assist in these efforts. Only 45% of Drooping Sheoak are within Department for Environment and Heritage (DEH) reserves or are protected in Heritage Agreements for feeding or nesting habitat (P. A. Mooney & Pedler, 2005). The status of Drooping Sheoak (as a threatened species in some researched areas) might suggest a lack of suitable conservation efforts within the existing dynamic.

ii) The relatively short lifespan of Drooping Sheoak, between 60 and 100 years (Durant, 2009), makes conservation more challenging for two reasons: 'lagging' effects on the environment may not surface for years after the original causes (Primack, 2010), and conservation programs are needed to observe the functioning of ecosystems and species communities over the long term, while allowing time for management to evolve around the findings. Meanwhile, cultural changes in management thinking may only occur over decades, generations, or in some instances, centuries (Elkington, 2004).

iii) Some natural phenomena, such as nesting hollows, need time to emerge. However, most of the old trees were lost in the huge historical clearance (Mooney & Pedler, 2005; Durant, 2009), and the clearance of Drooping Sheoak left remnants in very small isolated patches.

iv) The decline or disappearance of birds has important consequences for Drooping Sheoak seed dispersal that is carried out mainly by birds. Younger sites with little native vegetation may not be able to sustain bird species, and this can affect the regeneration of Drooping Sheoak. A study of replanted woodlands on the floodplain of the Murray River shows that these areas have little value for bird breeding success, possibly because the trees are too young to be recognised by bird species (Nally, De Vries, & Thomson, 2010). Also of importance may be the lack of different plant groups, and young trees, compared to adults, follow different patterns of extinction (Rigueira, da Rocha, & Mariano-Neto, 2013).

v) Grazing, weeds and fire are continuous threats to the persistence of Drooping Sheoak on a temporal and spatial scale. However, for an appropriate conservation outcome, every woodland category (remnant or recoverable), needs to be assessed separately, presenting major challenges given the restricted availability of funds and appropriate human resources.

vi) Finally, climate change is putting species and habitats at risk (Albouy et al., 2014; Hannah, Midgley, & Millar, 2002; Prentice et al., 1992; Sykes, Prentice, & Cramer, 1996), as well as altering the composition of species and trophic structure within ecosystems (Albouy et al., 2014). Together, these factors can be expected to cause further species extinctions. The extent to which Drooping Sheoak is resilient to ongoing climate warming and other environmental changes is largely unknown.

Chapter 2 Methodology

The research started from 14 of December 2016 until end April 2017; on four Drooping Sheoak tree under the natural field conditions. The duration of the experiment covered the South Australian summer season (December – February) and the first two months of autumn (March-April). Drooping Sheoak foliage includes conjoined drooping long branchlets (cladodes), with 4-13 teeth (1-4 cm and 0.7-1.5mm diameter) per whorl (Jossop et al., 1986) and with longitudinal ridges (phyllichnia) that conceal the stomata (Morley , 1983; Jossop et al., 1986). To avoid any confusion; the term “leaf/leaves” is used.

To determine photosynthetic response of Drooping Sheoak to root-zone soil moisture, the conducted measurements included photosynthesis, water potential, sap flow and microclimate condition measurements. Furthermore, in this experiment, the term "photosynthesis'' is understood as CO_2 exchange at the leaf level and “assimilation” is understood as the net photosynthesis in which leaves absorb CO_2 during the photosynthetic process and release CO_2 in respiration.

2.1 Site description

The campus of Flinders University (Kaurna Land) is located at (138o34’28”E, 35o01’49”S). It is among the private lands that have belonged to Flinders University, South Australia, since the 1960s. While the university has taken steps to conserve the area through measures such as revegetation and exclusion of grazing (Flinders University Landscape Review, 1981), there are now only a few patches of Drooping Sheoaks, with some Casuarina (small tree), Acacia (understorey; bush-small tree), Melaleuca bush and some weeds. The area has a Mediterranean climate with precipitation of approximately 546 mm per year, and the soil formation is characterised as sandy loam. The study trees are on a slope and in a patch of about 100 m^2, very close to the road (Ring Rd) and to one of the Flinders University car parks (Figure 2.1). A dirt road separates the two parts of the slope, giving access to pedestrians and to permitted vehicles. Two of the study trees (trees 2 and 4) are close to the edge of the slope and close to the dirt road. The patch includes at least 20 additional Drooping sheoak of different height and maturity, in addition to 8-10 dead *Allocasuarina* trees and a few with one or two live branches. Rabbits were observed (personally) around the area and on the site at various times during the course of the experiment.

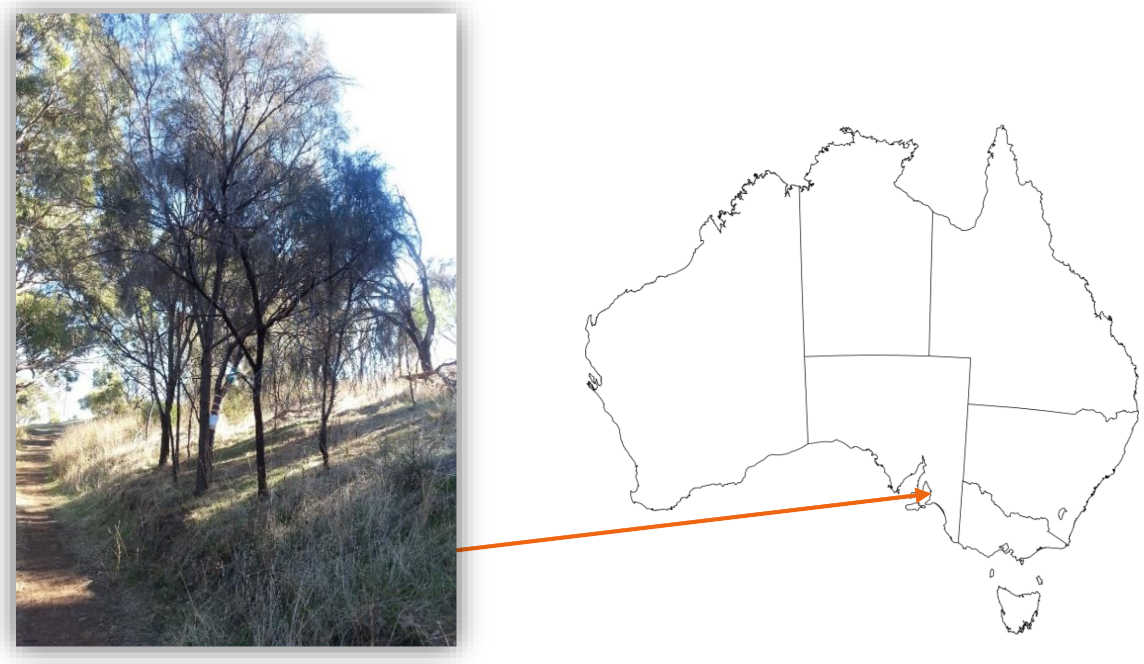


Figure 2.1 The study Site for Drooping Sheoak. Tree number 4, close to the dirt road (access by permitted vehicles). Arrow shows the approximate location in Adelaide, South Australia.

Source: Australia Map from Clker.com (2007)

The experiment was conducted on four trees of different sizes, two female and two male, within a small area, (the two closest trees were approximately 5m apart, and the most distant, 22m from the next).

2.2 Microclimate data

From December 2016 until April 2017, micrometeorological data were collected from an automatic weather station located on top of the Earth Sciences Building at Flinders University about 150m away from the research site, during the same time that the biotic data were collected. Climatological data obtained included air temperature and humidity (with hourly intervals), while solar radiation and wind speed were recorded daily. Additional data were obtained from the closest Bureau of Meteorology (BoM) weather station when the collected data were not sufficient.

2.3 Sap flow measurement

A set of heat-pulse sap flow sensors (SFM1, ICT International Pty Ltd., Australia) was installed on one sample tree, mainly to observe the daily dynamic of transportation/flow of sap in the plant at 30-minute intervals, using uncorrected sap flux measurement. The set included one heat probe and two measuring temperature probes. Three holes were drilled approximately 70 cm above the ground and two measuring temperature probes were placed in sapwood, above and below the heat release probe (10 mm downstream and 5 mm upstream). The set was insulated properly and the logger battery (12-v battery) was supported by an external battery that was charged by a solar panel during the experiment period.

2.4 Stem water potential

To measure the stem water potential in this experiment, Stem Psychrometers (PSY, ICT International Pty Ltd., NSW, Australia) developed by Dixon and Tyree (Dixon & Tyree, 1984) were used. The devices were installed on the stems of four trees with the chambers sealed tightly and the sensors in touch with the exposed sapwood surface. The measurements began on 14 December 2016 and continued until 30 April 2017, at 30-minute intervals. The range of PSY recorded was from -0.01 to -10 MPa, with a resolution of 0.002 MPa and with an accuracy of +/-0.01 MPa. Water potential measurements were calibrated prior to installation using sodium chloride solution (Lang, 1967). Research indicates that the soil-plant continuum reaches equilibrium before sunrise; thus, predawn stem water potential (Ψpd) was used to represent the root zone soil water potential (Sala & Tenhunen, 1994; Yang et al., 2013). Predawn stem water potential in this experiment was determined by an average calculated between 4 and 5 am when soil and plant water potential reached an equilibrium in the absence of water flux. The missing observed data were filled where required by estimating value using a regression analysis.

2.5 Photosynthesis measurement

Measurments were made in order to determine the Drooping sheoak photosynthesis light response to environmental conditions, using an LI-6400XT portable photosynthesis system (LI-6400, LI-COR Inc., Lincoln, NE, USA) fitted with a 2x6 cm needle chamber suitable for sheoak leaves. Air temperature and humidity in the LI-6400XT system are controlled so as to be the same as the external temperature and humidity. Under field ambient condition, reference cell CO_2 concentration (CO_2 R) was fluctuated between 332-411 ppm. Photosynthetic active radiation (PAR), transpiration rate (Tr), Assimilation rate (A), relative humidity in reference cell (RH_R), and temperature in sample cell (Tair◦C) were recorded along with other measurements. Field experiments were conducted during the experiment period (14/12/2016 until 30/04/2017), on Drooping sheoak in ambient conditions and on four trees. Due to the environmental fluctuation in the field, the measurements were obtained on dry and sunny days (when this was possible) to minimise the impacts of other factors on photosynthetic performances on soil moisture. Due to the weather conditions from the start of experiment, measurements were conducted once a week and changed to regular times (8am, 12 md, 4 pm AEST) from mid-January until the end of April 2017. Photosynthesis measurements were carried out on three trees at each time of day. For each tree, three sets of two mature leaves were randomly picked from within arm's reach, and this was restricted to one branch for tree number one. The difference between the leaf areas for each tree was considered in the overall of photosynthesis rate using the LI-6400XT system by calculating an average diameter of 10 random leaves (for each tree) and the area for the individual tree

(Table 2.1). Two leaves from each tree were placed in the chamber, waiting till the photosynthesis reading ceased to fluctuate appreciably, with three logging efforts.

Table 2.1 Characteristics of sample trees in the experiment.

Sample tree	Height(m)	Average Leaf area (cm^2)
Tree 1, female	7	1.7
Tree 2, female	6	1.9
Tree 3, male	6	1.9
Tree 4, male	5	1.9

An effort was made to avoid prolonging this time, so as to prevent condensation inside the chamber or any possible damage to the leaf. Before measurements were begun on each tree, the chamber was matched for accuracy. Additionally, for photosynthesis measurements, an average photosynthesis was calculated from each set of three reading logs. The light response curve provides important points for photosynthesis. However, the challenge presented by the absence of steady-state conditions in the field (with rapid changes of PAR), could lead to some insights concerning the light response characteristics of plant species under field ambient light conditions. Accordingly, the assumed light saturation point in this experiment is 340 (μmol m^{-2} s^{-1}), the average PAR of the four trees at maximum photosynthesis where the light intensity is no longer a limiting factor for the overall rate of photosynthetic response. This eliminates the impact of other factors on photosynthesis measurement apart from the effect of soil moisture conditions. From the sum of 290 photosynthesis measurments, 112 measurments occurred after saturation point.

For demonstrating the relationship between assimilation rate and predawn regardless of the time of measurement and where the circumstances (RH_R, Tair◦C) were similar, photosynthesis was averaged again. The related predawn water potential of each tree (including observed, estimated and in a few cases the figure from the closest date in the vicinity of two days) was added to the date measurement. Thus, the results from four trees were used for investigating the photosynthetic response to soil moisture.

Chapter 3 Results and Discussion

The measurements for photosynthetic response of Drooping Sheoak to root-zone started from 14 of December 2016 and ceased by end April 2017 (South Australian summer season [December – February] and the first two months of autumn [March-April]). The conducted measurements under the natural field conditions were included:

i) Microclimate measurements including air temperature and humidity (with hourly intervals), daily record of solar radiation and wind speed. The data collected from a weather station located about 150m away from the research site, and some data from the closest Bureau of Meteorology (BoM) weather station to recover the missing data;

ii) Sap flow measurements (only on Drooping Sheoak Tree 2) to observe the daily dynamic of transportation/flow of sap during day and night throughout the period of the experiment, using a set of heat-pulse sap flow sensors (SFM1, ICT International Pty Ltd., Australia);

iii) Stem water potential measurements (on four Drooping Sheoak sample trees) using Stem Psychrometers (PSY, ICT International Pty Ltd., NSW, Australia) at 30-minute intervals. Because the stem water potential is variable to evaporative demands (measured by vapour pressure deficit/VPD), predawn water potential was chosen for study and analysis. Since, soil water stores over the root zone and the soil-plant continuum reach equilibrium before sunrise, predawn stem water potential determined by an average calculated between 4 and 5 am; and the missing observed data were filled where it was required by using a regression analysis; and

iv) Photosynthesis measurements were conducted on three trees (from four Drooping Sheoak sample trees) at each time of day and once a week (from mid-January until the end of April 2017 on regular times [8am, 12 md, 4 pm AEST]) using the LI-6400XT system and under natural conditions. Drooping Sheoak foliage includes conjoined drooping long branchlets, with 4-13 teeth (1-4 cm and 0.7-1.5mm diameter) per whorl. For each sets of three logging effort, two separate (but close) mature leaves were chosen randomly from each tree. The size of leaves needed to exceed the 6 cm length of the chamber (needle chamber 2x6 cm) without being detached or damaged without extending the time, to inhibit condensation inside the chamber. An average photosynthesis was calculated from each set of three reading logs.

Additionally, an average diameter of 10 random leaves (for each tree) was calculated and the leaf areas for each tree was calculated accordingly, thus being reflected in the photosynthesis rate (Chapter 2, Table 2.1). With rapid changes of PAR under field ambient light conditions, the light saturation point was assumed 340 (µmol m^{-2} s^{-1}) in which it was calculated from the average of maximum PAR in photosynthetic rate in the four trees. Thus, the limiting factor on photosynthesis measurements after saturation point would be the effect of soil moisture conditions rather than light intensity. Within 112 measurements occurred after saturation point (out of 290 measurements), photosynthesis was averaged again to show the relationship between predawn and assimilation rate where the situations were similar (RH_R, Tair ◦C). Related predawn water potential was cited for each assimilation rate sometimes using the closest date (in vicinity of two days) where the result could be used for photosynthetic response to soil moisture.

3.1 Microclimatological Condition and Stem Water Potential

The microclimate condition during the experiment period is shown in Figure 3.1.

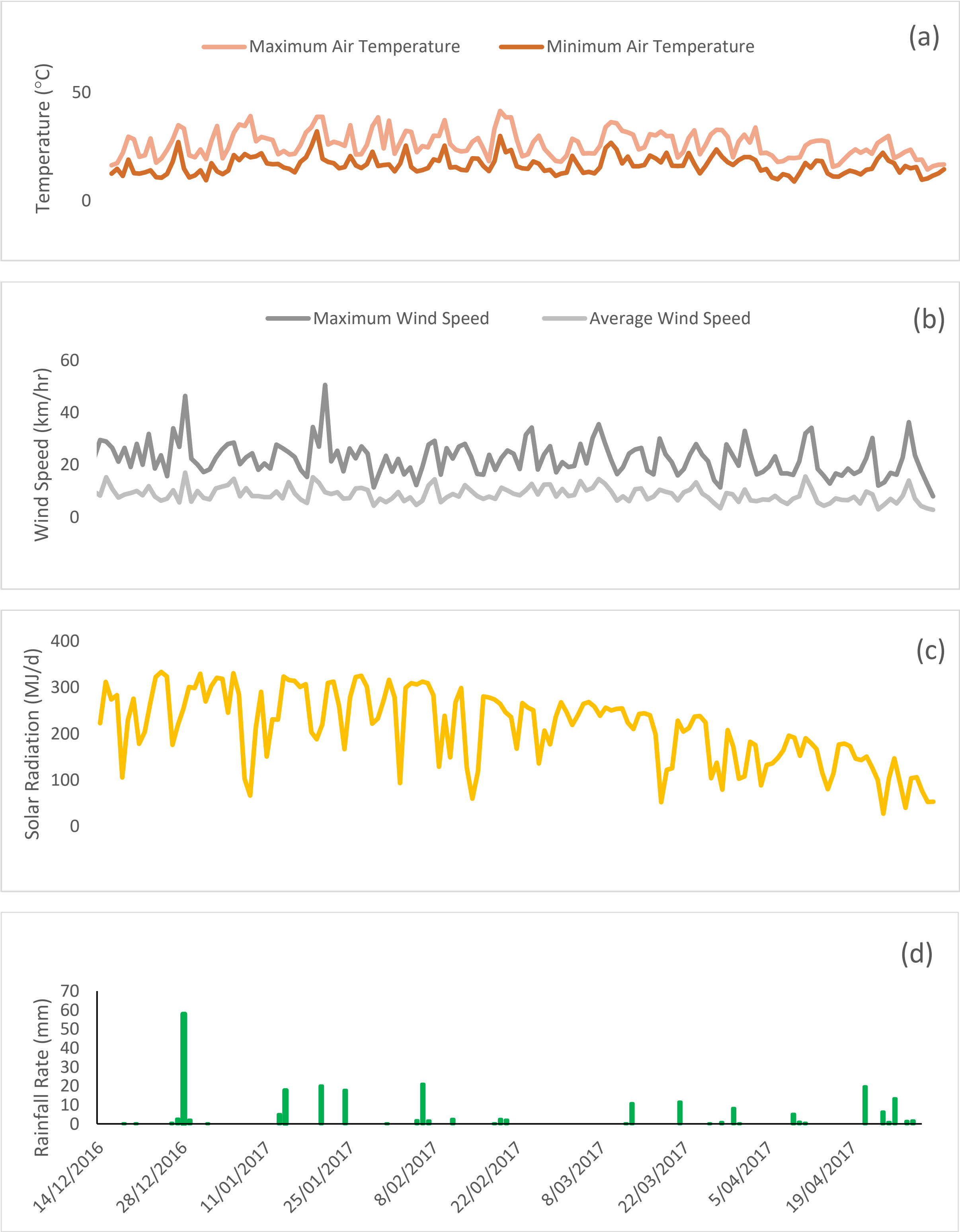


Figure 3.1 Meteorological data through the measurement period from 14 December 2016 to 30 April 2017.

(a) Maximum and minimum temperature (◦C), (b) maximum and average wind speed (km/hr), (c) daily solar radiation (MJ/d), (d) daily rainfall rate (mm).

The temperature reached a maximum of 41.5 (◦C) in February and a minimum of 8.9 ◦C in April, and solar radiation was between 27.3 and 330 (MJ/day). During the summer months there was a total of 50 days with maximum temperatures above 25 (◦C), including 25 days above 30 (◦C). Total precipitation during the period of the experiment was 252 (mm) (Appendix 2).

3.2 Sap flow measurements

The sap flux shown in Figure 3.2, is the uncorrected sap flux density (cm/hr). Accordingly, the sap flow dynamic reached its maximum during the day, and was at a minimum during the night. This showed Drooping Sheoak actively transporting water during the day and the activity of the plant diminished or ceased during the night.

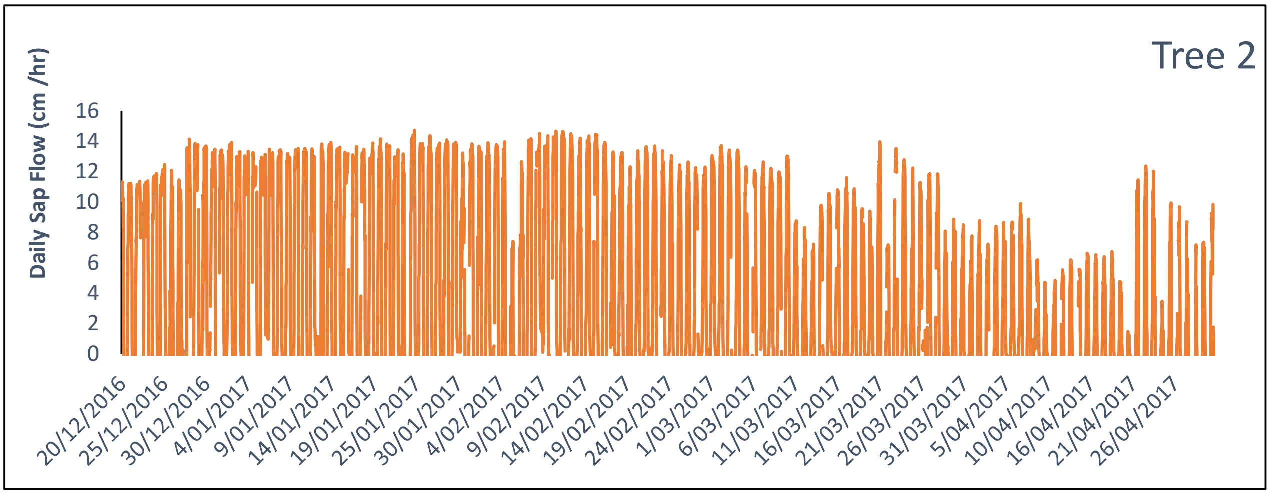


Figure 3.2 Sap flow measurement for tree 2, during 20/12/16 till 30/04/2017.

The uncorrected sap flux density (cm/hr), showing active transportation of water during the day and the ceasing of activity during the night.

After eleven days with average maximum temperatures of 31 ◦C (from 28/02/17 till 11/03/17), the average sap flow decreased to an average of 2 (cm/hr) at the end of April. During this time, the sap flow increased on 21/04/17 following precipitation of 11.6 (mm). The photosynthetic response to CO_2 may be influenced by nutrient availability (Field, Jackson, & Mooney, 1995; Gunderson & Wullschleger, 1994) and by reduced electron transport capacity (Farquhar & Sharkey, 1982). Furthermore, evapotranspiration or ET (the sum of the transpiration of water moving through the plant and of evaporation from the plant and from the soil surface) depends on leaf conductance and response to CO2 on the larger scale (Field et al., 1995). Some research suggests that temperature alone is sufficient to affect photosynthetic acclimation (Mooney et al., 1978).

3.3 Stem Water Potential Measurements

Stem Water Potential (SWP) for the four trees is shown below (Figure 3.3 for tree 1, 2; and Figure 3.4. for tree 3, 4). Some data for tree 4 were missing while the rest of the data show consistency. Observed SWP for the four trees shows a drop after sunrise and during the daytime due to transpiration and plant water loss. SWP recovered to some degree at night and reached its equilibrium around 4 to 5 am (Predawn water potential or Ψ_{pd}).

However, the experiment showed different Ψ_{pd} for each tree, with tree 1 showing average Ψpd of -1.3 (MPa) and tree 2 average Ψpd of -2 (MPa), while Ψ_{pd} for tree 3 reached to average -3.3 (MPa) and for tree 4, average of -2.3 (MPa), the overall of average Ψpd of -2.4 (MPa), (Appendix 3). The predawn water potential in trees 1 and 2 (female trees) and trees 3 and 4 (male trees) shows similar trend patterns, with a linear regression model used to estimate predawn water potential for tree 1 (from 28/12/16 until 11/01/17) and tree 4 (from 13/2/17 until 18/04/17 and from 21/04/17 until 25/04/17). On this basis, the relationship between the observed predawn water potential of tree 1 and tree 2 with R^2 value of 0.94 (Figure 3.5) is estimated. Similarly, the relationship between the observed predawn water potential of tree 3 and tree 4 with R^2 value of 0.58 (Figure 3.6) was estimated and used to compare trees 3 and 4. A comparison between the predawn water potential of tree 1 and tree 2 (Figure 3.5) shows a similar trend pattern. However, the predawn water potential for tree 1 decreases to -3.1 (MPa) while for tree 2 it decreases to -4.3 (MPa). A comparison between the predawn water potential for trees 1, 2, 3 and 4 (Figure 3.7) during the experiment shows maximum Ψpd of -5.3 for tree number 3.

Total rainfall between 14 December and 30 January amounted to 124.4 mm. The relationship between rainfall and predawn water potential was more obvious during March and April than during December and January. The average predawn water potential for the four trees was -1 (MPa) in December and January, and became less negative following rainfall events (e.g. rainfall of 17.8 mm on 14/01/17). A more obvious shift toward less negative predawn water potential occurred on 22/03/17 following rainfall of 11.6 (mm). Similarly, when the sum of rainfall on 24, 25 and 26 April reached 20.6 (mm), predawn water potential changed greatly (e.g. for tree 1 it changed from -3.19 MPa on 19/04/17 to -0.63 MPa on 26/04/17) (refer to Appendix 3).

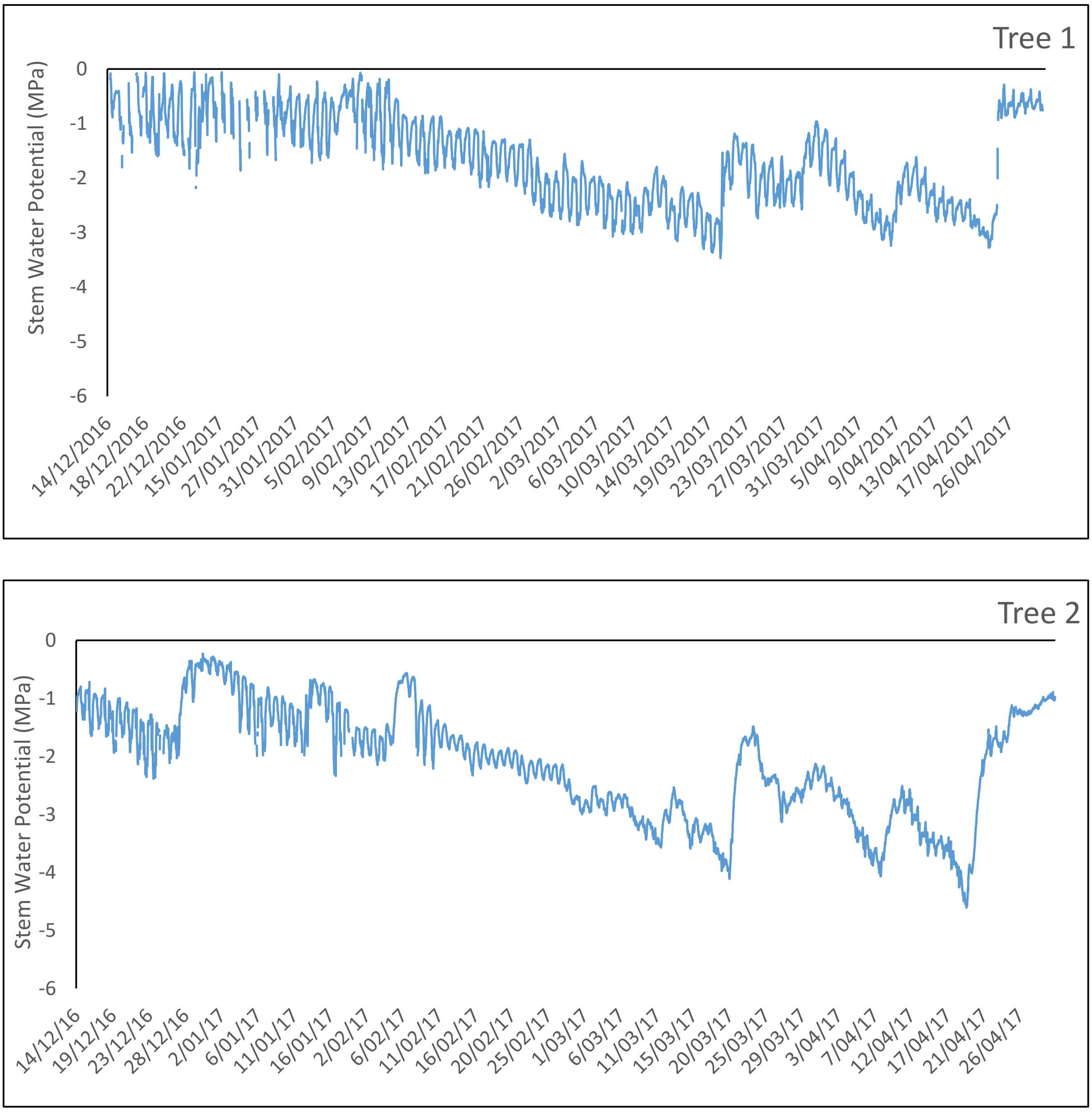


Figure 3.3 Stem water potential (MPa) for trees 1 and 2 from 14 December 2016 until 30 April 2017. The average Ψpd (Predawn water potential) is -1.3 (MPa) for tree 1, and -2 (MPa) for tree 2.

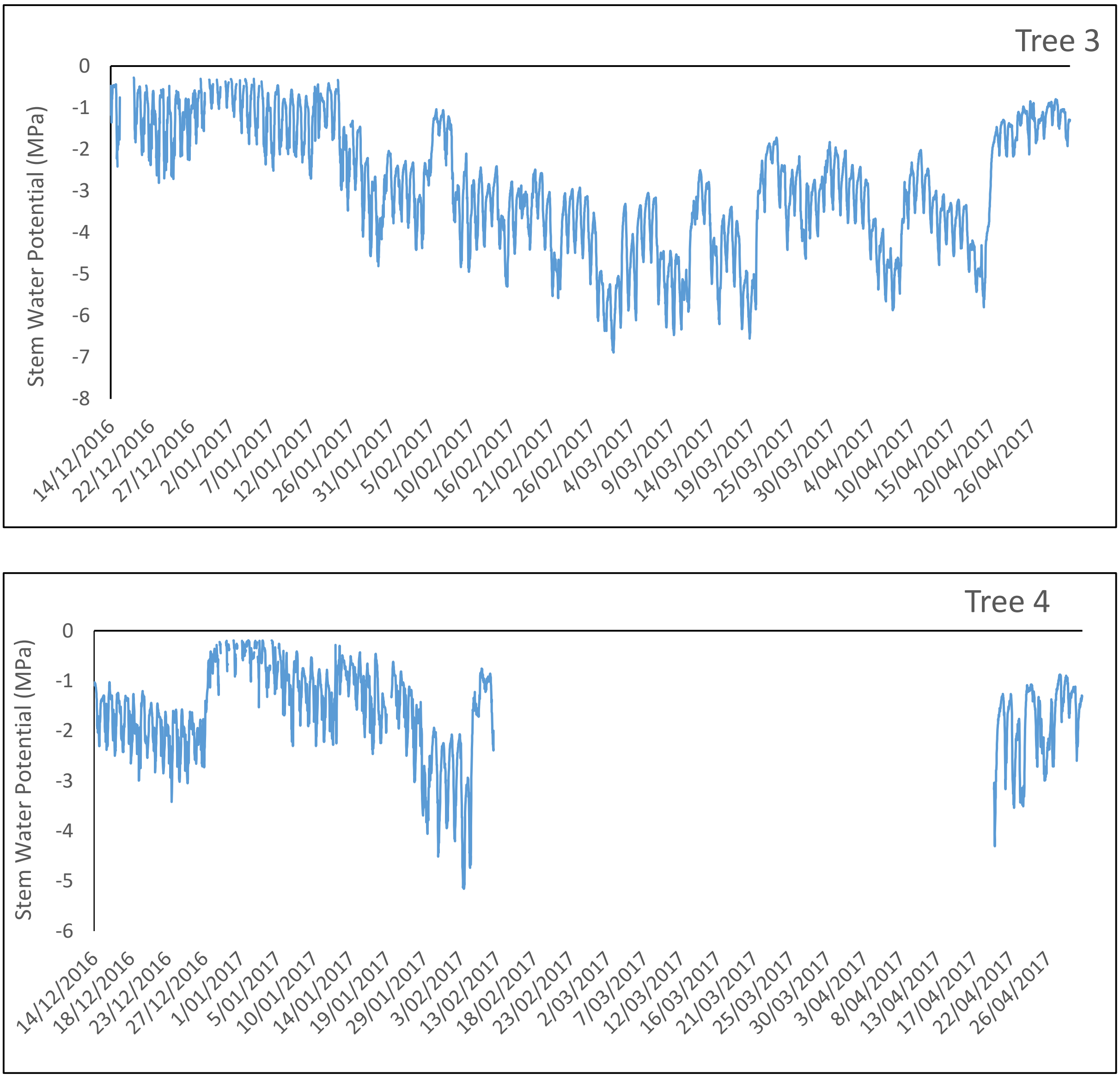


Figure 3.4 Stem water potential (MPa) for trees 3 and 4 from 14 December 2016 until 30 April 2017. The average Ψpd (Predawn water potential) is -3.3 (MPa) for tree 3, and -2.3 (MPa) for tree 4.

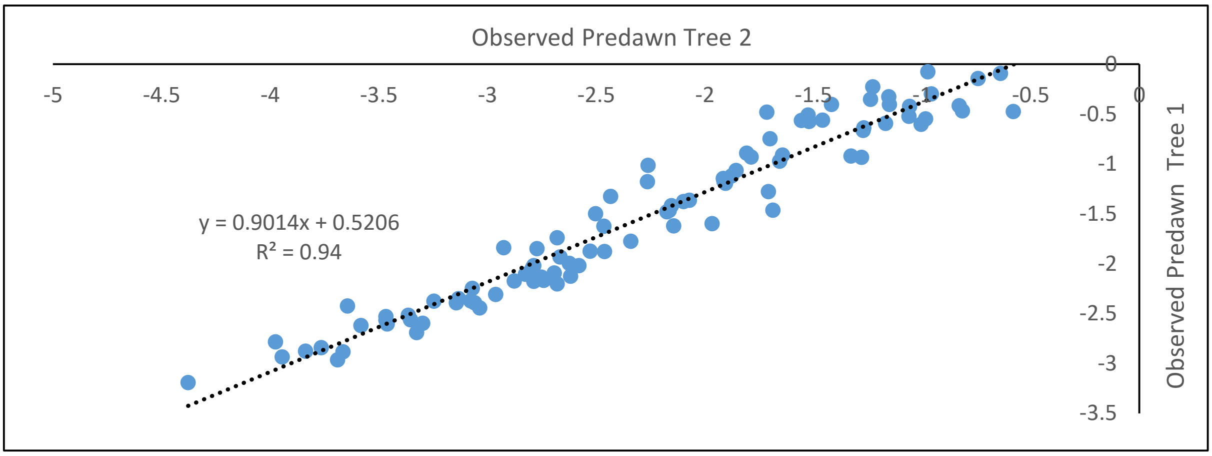


Figure 3.5 Relationship between the observed predawn water potential of tree 1 and tree 2 using a linear regression model

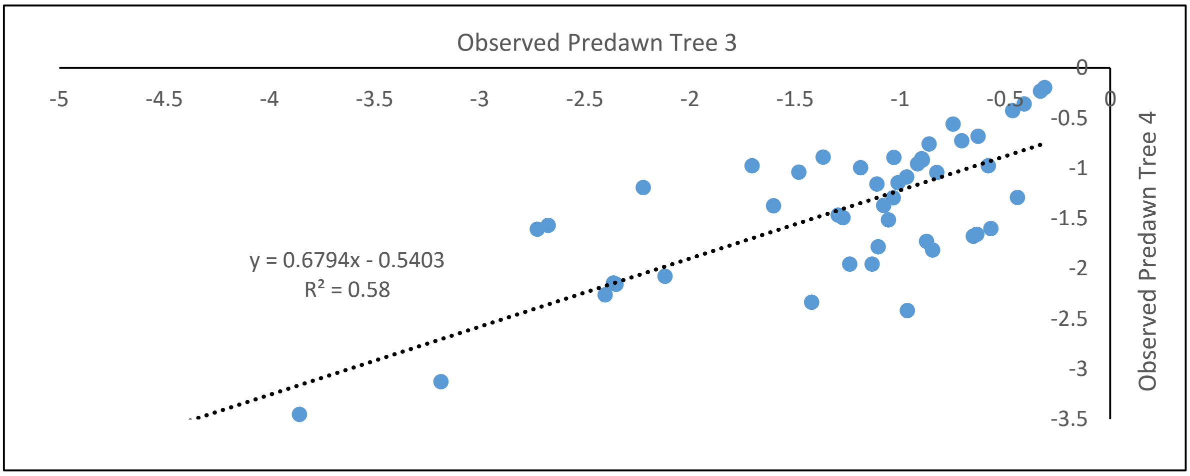


Figure 3.6 Relationship between the observed predawn water potential of tree 3 and tree 4 using a linear regression model.

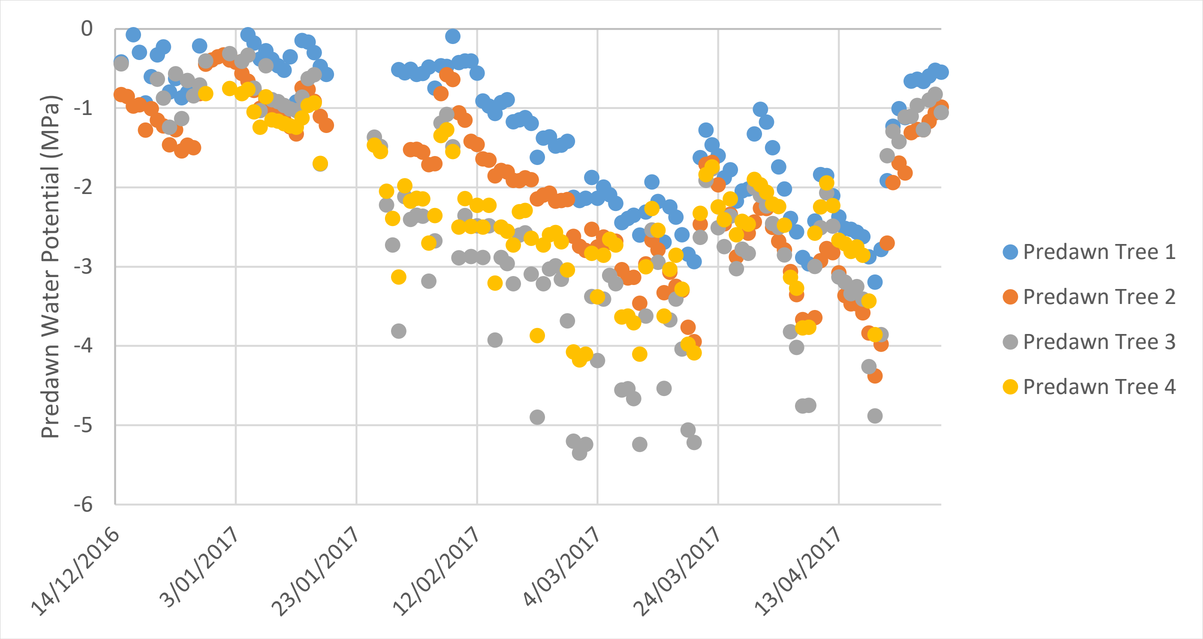


Figure 3.7 A comparison between the predawn water potential for trees 1, 2, 3 and 4 during the period from 14/12/16 until 30/04/17.

3.4 Photosynthesis Measurements

Accordingly, the overall photosynthesis light response curve for the four trees during the experiment period is shown in Figure 3.8 where 290 photosynthesis measurements collected (Appendix 4). The photosynthetic activity within the experiment shows more intensity when PAR is between 50 and 100 (µmol m^{-2} s^{-1}). The early morning measurements taken during April showed PAR mostly no greater than 150 (µmol m^{-2} s^{-1}). The assimilation rate for the sample trees started from PAR of 11 (µmol m^{-2} s^{-1}), reached a light saturation point around 340 (µmol m^{-2} s^{-1}) (the photosynthesis rate did not change as the light intensity increased) and continued to approximately PAR 1400 (µmol m^{-2} s^{-1}). The light saturation point was thus estimated as the average PAR at which each tree reached the maximum assimilation rate (PAR=340).

The average assimilation rate for all the trees was estimated at 2.3 (µmol CO2 m^{-2} s^{-1}) with PAR 340-1400 (µmol m^{-2} s^{-1}). Within this range, the average maximum photosynthetic rate reached to 3.9 (µmol CO2 m^{-2} s^{-1}) for all trees [3.9 (µmol CO2 m^{-2} s^{-1}) for trees 1, 2 and 3 in different light intensities (335, 384 and 312 [µmol m^{-2} s^{-1}]) and 3.6 (µmol CO2 m^{-2} s^{-1}) in PAR 329 (µmol m^{-2} s^{1}) for tree 4].

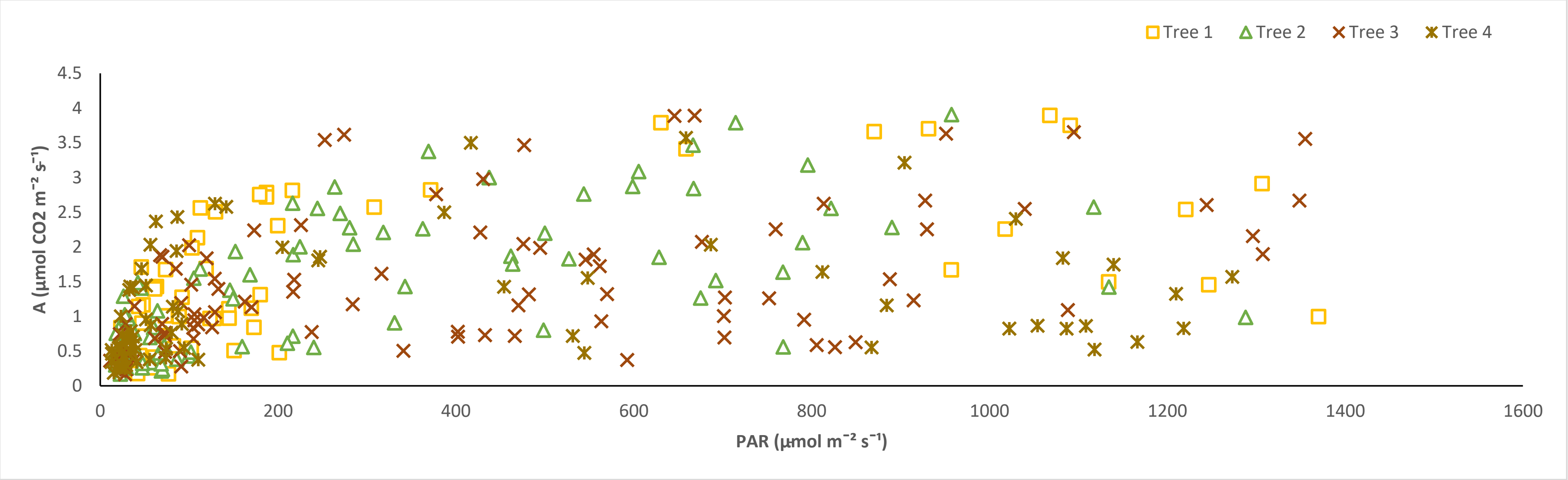


Figure 3.8 Light response curve of four trees (tree 1, 2, 3 and 4), under field ambient light condition, PAR between 0- 1400 (µmol m^{-2} s^{-1}) from 14/12/16 to 30/04/17.
From 290 photosynthesis measurements for four trees, the average maximum assimilation rate (A) reached to 3.8 (µmol CO2 m^{-2} s^{-1}).

3.5 Carbon Assimilation in Response to Predawn Water Potential

The average assimilation rates and predawn water potential with PAR (0-1400) (µmol m^{-2} s^{-1}) was estimated for each tree. These findings for tree 1 revealed an average of A=1.7 (µmol CO2 m^{-2} s^{-1}) and predawn water potential of -1.3 (MPa), tree 2 revealed an average of A=1.4 (µmol CO2 m^{-2} s^{-1}) and predawn water potential of -2 (MPa), tree 3 revealed an average of A=1.2 (µmol CO2 m^{-2} s^{-1}) and predawn water potential of -3.3 (MPa), and tree 4 revealed an average of A=1.1 (µmol CO2 m^{-2} s^{-1}) and predawn water potential of -2.3 (MPa). The findings indicate that the soil moisture for trees 1 and 2 (female trees) are relatively higher than trees 3 and 4 (male trees). Similarly, the assimilation rates for trees 1 and 2 are higher than trees 3 and 4. Moreover, the comparison between the predawn water potentials of trees 1 and 2, given their locations within the canopy (tree 2 on the edge of the dirt road and tree 1 away from road), shows a lower predawn water potential for tree 2. However, these findings are not applicable for trees 3 and 4 due to where tree 3 is located (in the middle of the study patch) compared to tree 4 (on the edge of the road)(refer to Figure 2.1). These findings indicate the possible existence of factors (other than erosion and runoff) that are causing the lowest predawn water potential for tree 3. Additionally, to confirm the female Sheoaks' characteristic towards water loss would require further research as the result of this study are not conclusive.

Figure 3.9 demonstrates the relationship between leaf carbon assimilation and the root zone soil moisture with PAR (0-340) (µmol m^{-2} s^{-1}) where most of the photosynthetic activities took place. The result of 185 measurements where the maximum average assimilation rate of 1.4 (µmol CO2 m^{-2} s^{-1}) occurs within predawn (0, -2) (MPa) with average PAR of 116 (µmol m^{-2} s^{-1}). The average assimilation rate of 0.7(µmol CO2 m^{-2} s^{-1}) occurs in average PAR of 70 (µmol m^{-2} s^{-1}) within predawn (-2,-3) (MPa) and within predawn equal to and less than -3 (MPa) with average PAR of 67 (µmol m^{-2} s^{-1}). The average assimilation rate of 0.7 (µmol CO2 m^{-2} s^{-1}) stays unchanged even when the predawn water potential falls to (-3,-4) and (-4, -5) (MPa) (Appendix 5).

To demonstrate a clear visual figure, thirty seven average points are calculated from 112 phothosynthesis measurements with light saturation point (PAR=340 µmol m^{-2} s^{-1}). Since the light intensity very ocasionally exceeded 340 (µmol m^{-2} s^{-1}), remaining measurements include

12 midday and 4pm rates. An average of assimilation rates is made from measurments with close PAR and where the circumstances (RH_R, Tair◦C) were similar (regardless of the time) (Appendix 6). According to the figure 3.10, a good deal of activity and higher assimilation rates occurs in predawn (0,-1) and (-1, -2) (MPa). Less activity and assimilation rates are evident within predawn (-2,-3) (MPa) and equal to and less than -3 (MPa), with occasional high assimilation rates within predawn (-2,-3) (MPa).

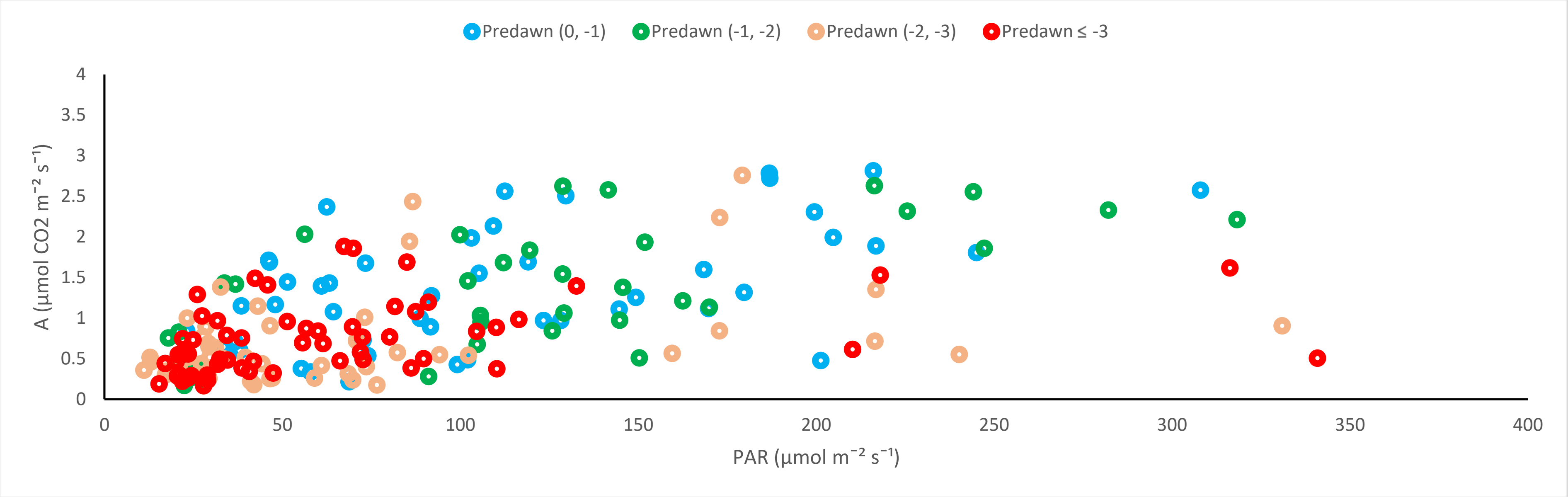


Figure 3.9 Leaf Assimilation rate (A) and predawn water potential (4-5 am) before light saturation point (PAR= 340 µmol m^{-2} s^{-1}).
The result is from 185 photosynthesis measurements for four trees. The maximum assimilation rate occurs in higher soil moisture (0,-1) (-1,-2) (MPa) and spread more comparing to the lower soil moisture (-2,-3) (MPa). The drier soil moisture, predawn equal to and less than -3, presents with lower assimilation rate.

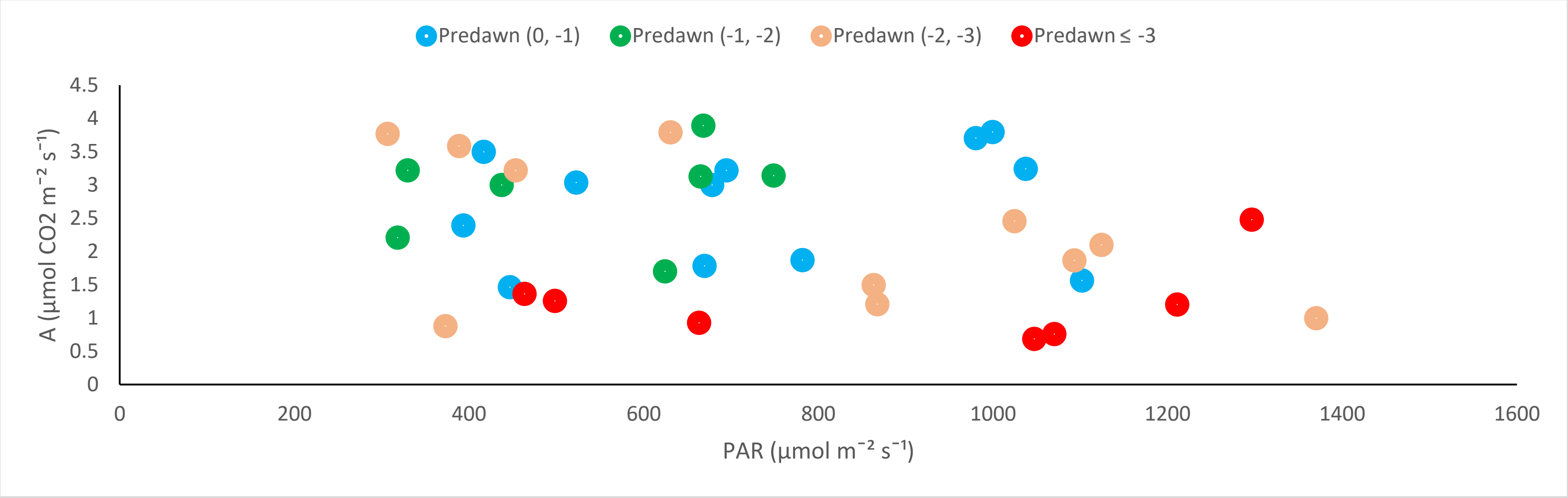


Figure 3.10 Relationship between leaf Assimilation rate and predawn water potential (4-5 am) after light saturation (PAR= 340 µmol m^{-2} s^{-1}). Presented circles are the result of average from 112 photosynthesis measurements. Each circle is an average of assimilation rate made from measurments with close PAR and where the circumstances (RH_R, Tair◦C) were similar (regardless of the time). Predawn (0,-1) (-1, -2) (MPa), show higher assimilation rates and predawn ≤ -3 show lower assimilation rate. The assimilation rate mostly are low, showing higher rates occasionally.

Figure 3.11, below, shows the assimilation response from 94 measurements (out of 112 original measurement after light saturation point), to soil moisture water potential. The maximum average assimilation rate of 2.1 (µmol CO2 m^{-2} s^{-1}) occurs with predawn water potential between (0, -1) (-1, -2) (MPa). Then it decreases to 1.7 (µmol CO2 m^{-2} s^{-1}) with predawn water potential between (-2,-3) (MPa), 0.9 (µmol CO2 m^{-2} s^{-1}) with predawn water potential between (-3,-4) (MPa) and of 1.3 (µmol CO2 m^{-2} s^{-1}) when water potential is equal to or greater than -4 (MPa) (Appendix 7).

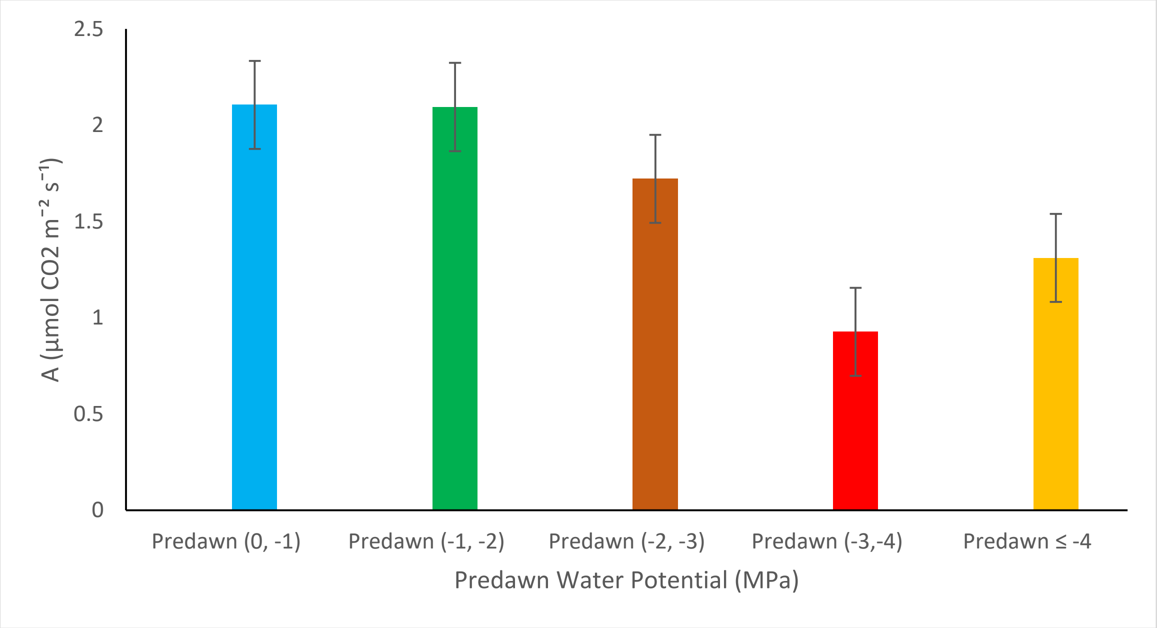


Figure 3.11 Assimilation response to predawn water potential.
From left to right, the columns are labelled: A′, B, C, D and E. Mean value (M) and Standard deviation (Std) for samples calculated as: A′ (M=2.1, Std=0.76); B (M=2.1, Std=0.62); C (M=1.7, Std=0.72); D (M=0.9, Std=0.44); and E (M=1.3, Std=0.73)

The assimilation rate stayed unchanged with predawn water potential within (0,-2) (MPa), then showed a decline of 11% within (-2,-3) (MPa). It reached its lowest point, a decline of 68%, within (-3,-4) (MPa), and the decline was 38% when predawn water potential was equal to and less than -4 (MPa). This assimilation decline of 38% within a dryer root-zone soil moisture (Predawn ≤ -4) (MPa) is only the result of measurements from one sample tree (Tree 3, Appendix 7). The lack of sufficient data from more than one sample tree suggests an error/unreliability, and the result is not conclusive at this point.

Standard deviation (Std) was calculated at this point to measure the dispersion of the sample values. The results for samples (from left to right from Figure 3.11) were: A′ (M=2.1, Std=0.76);

B (M=2.1, Std=0.62); C (M=1.7, Std=0.72); D (M=0.9, Std=0.44); and E (M=1.3, Std=0.73). Furthermore, an analysis of two population means was run through a t-Test using online computing and the comparative statistical model VassarStats. The comparison took place in three stages. First, sample A' within predawn (0,-1)(MPs) was used as the point of reference; thus, the assimilation rates for each array size n of samples B, C, D, E for sequential predawn from (-1- ≤ -4) (MPa)] were compared and tested. Since the mean assimilation rate for size n of sample A' was the same as for B (with 0.01 difference), the test was repeated for size n of samples D and E and with size n of sample C. Finally, the test was repeated for size n of sample E and sample C. The test results (Appendix 8), indicate a significant difference (p-value ≤ 0.001) within the range of (-3, -4) (MPa) compared to reference samples of A' and C.

The rate of photosynthesis and stomatal conductance can change in different CO_2 concentrations but since the concentration of CO_2 during the experiment was almost constant, the decline of assimilation rate was not caused by different CO_2 concentration. By knowing that one third of the photosynthesis measurements were collected at 12 midday–12:30 pm [all of these were used to demonstrate the plant's photosynthetic response to soil moisture after the light saturation point (59 out of a sample size of 94)], the assimilation decline might be caused by midday stomatal closure to conserve water. Extreme midday closure under natural conditions can be explained by the influence of the temperature and humidity-controlled stomatal response for the regulation of the gas exchange processes (Schulze et al., 1974), which gradually becomes less extreme in autumn (Losch et al., 1981). However, the degree of stomatal response to humidity and temperature needs further investigation.

Chapter 4 Conclusion

Photosynthetic activity is necessary for the plant's growth, defence and storage of biomass; and on the other hand, water is essential to plant's structure and function. In order to investigate the ecohydrological relations in Drooping Sheoak, this thesis focused on the leaf level photosynthetic response to root-zone soil moisture. During the experimental period (mid-December 2016 till the end of April 2017), a total of 290 photosynthesis measurements was taken from four Drooping Sheoak trees. The photosynthetic rate from saturation point onward (PAR=340 µmol m^{-2} s^{-1}) was considered to represent the response to soil moisture. This made it possible to avoid the impact of other factors on photosynthesis measurement. Additionally, the stem predawn water potential (average between 4–5 am) for four Drooping Sheoak was used as a proxy for soil moisture where the plant and soil water potential reached equilibrium. Some missing data were estimated using a linear regression model. The average predawn water potential during the experiment period amounted to -2.4 (MPa), where the two female trees demonstrated a higher soil moisture than the two male trees. At this point, related predawn water potential was matched to the day of photosynthesis where the higher assimilation rates were observed in less stressed soil moisture. The findings showed a decline in the plant species photosynthesis within (-2, -4) (MPa). The assimilation rate reached its lowest rate within the range of soil moisture (-3,-4) (MPa). This decline confirm that Drooping Sheoak photosynthetic capacity reduces under root-zone soil moisture stress. Considering the status of Drooping Sheoak as a threatened species in most parts of its South Australian range, a decline of photosynthetic activity in order to conserve water in drier root-zone soil moisture conditions can result in further degradation and eventual mortality of the species. The outcome of this thesis must highlight the vulnurebility of Drooping Sheoak's and the importance of timley conservation plans for adaptability of this ecosystem to ongoing threats.

4.1 Future study

The Characteristics of Drooping Sheoaks are unknown as there has been no published research on the matter before the present study. The scope of this thesis did not extend to a deeper understanding of the complexities of photosynthesis. However, it aimed to set a benchmark for future study.

As the current research has revealed, assimilation declined considerably (68% of assimilation rate in non-stressed water potential) within (-3,-4) (MPa) (Figure 3.11). Soil moisture of (-3,-4) (MPa) could be the hypothetical break point at which further restriction of water loss overrides the benefits of increasing photosynthesis. Additional investigation is needed to define the hydraulic failure point based on the stem hydraulic conductivity decline under seasonal drought and increasing water stress. Drooping Sheoak resilience may be built up around this point.

Possible further research includes i) photosynthetic response to controlled irrigation within predawn stem water potential (-3,-4) (MPa) and beyond; and ii) photosynthetic response to additional slow released nitrogen within predawn stem water potential (-3,-4) (MPa) and beyond. The findings of Chapman (2006) suggest that adding some slow released nitrogen to Drooping Sheoak may benefit the female trees by contributing to the maturity of russet cones. Nitrogen nutrition can decrease stomatal conductance and carbon assimilation, thereby, adding nitrogen and measuring photosynthesis through the hypothetical break point might show an increase in photosynthesis function under the same soil water stress. Taking these points together, an additional line of research iii) might study photosynthetic response to a combination of additional slow released nitrogen and irrigation within predawn stem water potential (-3,-4) (MPa) and beyond. Still more research iv) might investigate whether the nitrogen fixing bacteria-like organisms (Actinomycetes) that live in nodules on the roots of male and female Drooping Sheoak (Chapman's [2006] experiment was on female trees), remain in a symbiotic relationship with the trees.

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Chapter 6 Appendix

1. Associated bird species in the Drooping Woodland ecosystem

Associated Birds in Drooping Woodlands and their status, Eyre Peninsula, South Australia (Modified from Durant, 2009) ; changes to this status have been caused by habitat loss within the Drooping Woodland ecosystem. It is important to note that

Species Name	Red list Status
Plains-wanderer (Pediononus torquatus)	Nationally Vulnerable
Australian Bustard (Ardeotis australis)	State Vulnerable
Bush Stone-curlew (Burhinus garllarius)	State Vulnerable
Chestnut Quailthrush (Cinclosoma castanotum)	State Vulnerable
Painted Button-quail (Turnix varia)	State Vulnerable
Diamond Firetail (Stagonopleura guttata)	State Vulnerable

2. Temperature and rainfall rates during December 2016 and April 2017

Months	**Daily Maximum Temperature between 25-30 ◦C**	**Daily Maximum Temperature between 30.1-41.5 ◦C**	**Total Monthly Rainfall mm**
December	9 days out of 31	7 days out of 31	77.8
January	9 days out of 31	12 days out of 31	61
February	7 days out of 28	6 days out of 28	31.4
March	7 days out of 31	14 days out of 31	32
April	8 days out of 30	Non out of 30	49.8

3. Predawn Water Potential for tree 1, 2, 3 and 4.

Tree 1	Ψ_{pd} (MPa)		Tree 1	Ψ_{pd} (MPa)		Tree 1	Ψ_{pd} (MPa)
9/12/2016	-0.03		15/02/2017	-1.06667		28/02/2017	-2.12667
13/12/2016	-0.2		18/02/2017	-1.17333		1/03/2017	-2.16667
15/12/2016	-0.416667		19/02/2017	-1.14667		2/03/2017	-2.13667
17/12/2016	-0.075		20/02/2017	-1.12		4/03/2017	-2.13667
18/12/2016	-0.296667		21/02/2017	-1.19333		6/03/2017	-2.09333
19/12/2016	-0.933333		22/02/2017	-1.62		7/03/2017	-2.20333
20/12/2016	-0.603333		23/02/2017	-1.37667		8/03/2017	-2.44333
21/12/2016	-0.326667		24/02/2017	-1.36333		9/03/2017	-2.39333
22/12/2016	-0.226667		25/02/2017	-1.48		10/03/2017	-2.35
12/01/2017	-0.353333		26/02/2017	-1.46667		11/03/2017	-2.60333
13/01/2017	-0.92		27/02/2017	-1.42		12/03/2017	-2.31
14/01/2017	-0.143333		3/03/2017	-1.87667		14/03/2017	-2.17667
30/01/2017	-0.513333		5/03/2017	-1.99667		15/03/2017	-2.69
31/01/2017	-0.553333		13/03/2017	-1.93333		16/03/2017	-2.24667
1/02/2017	-0.51		21/03/2017	-1.62333		17/03/2017	-2.37667
2/02/2017	-0.573333		22/03/2017	-1.27667		18/03/2017	-2.59667
3/02/2017	-0.563333		23/03/2017	-1.46333		19/03/2017	-2.84333
4/02/2017	-0.48		24/03/2017	-1.6		20/03/2017	-2.93667
5/02/2017	-0.746667		25/03/2017	-1.88		27/03/2017	-2.17333
6/02/2017	-0.466667		26/03/2017	-1.77667		28/03/2017	-2.04333
7/02/2017	-0.473333		30/03/2017	-1.32667		29/03/2017	-2.02
8/02/2017	-0.093333		31/03/2017	-1.01333		4/04/2017	-2.02
9/02/2017	-0.423333		1/04/2017	-1.17667		5/04/2017	-2.39333
10/02/2017	-0.403333		2/04/2017	-1.5		6/04/2017	-2.56333
11/02/2017	-0.403333		3/04/2017	-1.74		7/04/2017	-2.88333
13/02/2017	-0.91		10/04/2017	-1.84		8/04/2017	-2.96333
14/02/2017	-0.973333		11/04/2017	-1.85		9/04/2017	-2.42333
16/02/2017	-0.93					12/04/2017	-2.10667
17/02/2017	-0.893333					13/04/2017	-2.37333
26/04/2017	-0.636667					14/04/2017	-2.51667
27/04/2017	-0.663333					15/04/2017	-2.53
28/04/2017	-0.593333					16/04/2017	-2.56667
29/04/2017	-0.523333					17/04/2017	-2.62
30/04/2017	-0.546667					18/04/2017	-2.87667
						20/04/2017	-2.78333
						Tree 1	Ψ_{pd} (MPa)
						19/04/2017	-3.19333

Tree 2	Ψ_{pd} (MPa)
15/12/2016	-0.82893
16/12/2016	-0.85315
17/12/2016	-0.97424
18/12/2016	-0.95694
28/12/2016	-0.81855
29/12/2016	-0.44491
30/12/2016	-0.39301
31/12/2016	-0.3515
1/01/2017	-0.32728
2/01/2017	-0.39301
3/01/2017	-0.42069
4/01/2017	-0.56254
5/01/2017	-0.65941
6/01/2017	-0.77704
8/01/2017	-0.88428
14/01/2017	-0.74244
15/01/2017	-0.7632
16/01/2017	-0.91196
6/02/2017	-0.81509
7/02/2017	-0.57983
8/02/2017	-0.63865
30/04/2017	-0.98462

Tree 2	Ψ_{pd} (MPa)
19/12/2016	-1.27869
20/12/2016	-1.00537
21/12/2016	-1.15414
22/12/2016	-1.22679
23/12/2016	-1.46205
24/12/2016	-1.27523
25/12/2016	-1.54162
26/12/2016	-1.46897
27/12/2016	-1.50011
7/01/2017	-1.00191
9/01/2017	-1.00537
10/01/2017	-1.09532
11/01/2017	-1.1576
12/01/2017	-1.23717
13/01/2017	-1.32712
17/01/2017	-1.10224
18/01/2017	-1.21641
1/02/2017	-1.52432
2/02/2017	-1.52086
3/02/2017	-1.55546
4/02/2017	-1.7146
5/02/2017	-1.70077
9/02/2017	-1.05727
10/02/2017	-1.15068
11/02/2017	-1.41707
12/02/2017	-1.45859
13/02/2017	-1.64195
14/02/2017	-1.65579
15/02/2017	-1.85645
16/02/2017	-1.78726
17/02/2017	-1.80802
18/02/2017	-1.91181
19/02/2017	-1.91527
20/02/2017	-1.87721
21/02/2017	-1.90489
22/03/2017	-1.70769
23/03/2017	-1.68693
24/03/2017	-1.96716
22/04/2017	-1.93948
23/04/2017	-1.69385
24/04/2017	-1.81839
25/04/2017	-1.30982
26/04/2017	-1.26831
27/04/2017	-1.27177
28/04/2017	-1.16798
29/04/2017	-1.06073

Tree 2	Ψ_{pd} (MPa)
22/02/2017	-2.1436
23/02/2017	-2.09863
24/02/2017	-2.07095
25/02/2017	-2.17474
26/02/2017	-2.16436
27/02/2017	-2.15398
28/02/2017	-2.61758
1/03/2017	-2.74213
2/03/2017	-2.79402
3/03/2017	-2.52763
4/03/2017	-2.7525
5/03/2017	-2.6245
6/03/2017	-2.69369
7/03/2017	-2.67985
12/03/2017	-2.96354
13/03/2017	-2.66601
14/03/2017	-2.7871
21/03/2017	-2.46535
25/03/2017	-2.46189
26/03/2017	-2.3408
27/03/2017	-2.87705
28/03/2017	-2.79402
29/03/2017	-2.57952
30/03/2017	-2.43422
31/03/2017	-2.26123
1/04/2017	-2.26469
2/04/2017	-2.50341
3/04/2017	-2.67985
4/04/2017	-2.7871
10/04/2017	-2.92549
11/04/2017	-2.77326
12/04/2017	-2.82516
21/04/2017	-2.70407

Tree 2	Ψ_{pd} (MPa)
8/03/2017	-3.0362
9/03/2017	-3.14345
10/03/2017	-3.13307
11/03/2017	-3.46174
15/03/2017	-3.32681
16/03/2017	-3.07079
17/03/2017	-3.24724
18/03/2017	-3.29913
19/03/2017	-3.76619
20/03/2017	-3.94609
5/04/2017	-3.06042
6/04/2017	-3.35449
7/04/2017	-3.66586
8/04/2017	-3.69007
9/04/2017	-3.6451
13/04/2017	-3.07771
14/04/2017	-3.36487
15/04/2017	-3.46866
16/04/2017	-3.46866
17/04/2017	-3.58282
18/04/2017	-3.83884
20/04/2017	-3.97723

Tree 2	Ψ_{pd} (MPa)
19/04/2017	-4.37855

Tree 3	Ψ_{pd} (MPa)		Tree 3	Ψ_{pd} (MPa)		Tree 3	Ψ_{pd} (MPa)
9/12/2016	-0.39647		23/12/2016	-1.23976		28/01/2017	-2.22199
13/12/2016	-0.46432		25/12/2016	-1.13314		29/01/2017	-2.72602
15/12/2016	-0.44171		7/01/2017	-1.02975		31/01/2017	-2.11859
21/12/2016	-0.63557		12/01/2017	-1.01036		1/02/2017	-2.40292
22/12/2016	-0.87466		13/01/2017	-1.03298		2/02/2017	-2.35123
24/12/2016	-0.56771		17/01/2017	-1.70503		3/02/2017	-2.36415
26/12/2016	-0.65172		26/01/2017	-1.36577		5/02/2017	-2.67433
27/12/2016	-0.84558		27/01/2017	-1.48209		9/02/2017	-2.88757
28/12/2016	-0.70665		6/02/2017	-1.18807		10/02/2017	-2.35446
29/12/2016	-0.40616		7/02/2017	-1.07821		11/02/2017	-2.87142
2/01/2017	-0.31247		8/02/2017	-1.48532		12/02/2017	-2.4837
4/01/2017	-0.4094		22/03/2017	-1.91181		13/02/2017	-2.88434
5/01/2017	-0.33185		23/03/2017	-1.76642		14/02/2017	-2.4837
6/01/2017	-0.74865		21/04/2017	-1.60163		16/02/2017	-2.88434
8/01/2017	-0.46432		22/04/2017	-1.29469		17/02/2017	-2.96189
9/01/2017	-0.89405		23/04/2017	-1.4207		19/02/2017	-2.60324
10/01/2017	-0.91666		24/04/2017	-1.11052		20/02/2017	-2.57417
11/01/2017	-0.96836		25/04/2017	-1.10406		25/02/2017	-2.98773
14/01/2017	-0.86174		27/04/2017	-1.27207		13/03/2017	-2.53862
15/01/2017	-0.6291		30/04/2017	-1.0556		14/03/2017	-2.94573
16/01/2017	-0.58064					21/03/2017	-2.62909
26/04/2017	-0.96513					24/03/2017	-2.50955
28/04/2017	-0.89728					25/03/2017	-2.74864
29/04/2017	-0.82619					26/03/2017	-2.36415
						28/03/2017	-2.77772
						29/03/2017	-2.83265
						30/03/2017	-2.00228
						31/03/2017	-2.09921
						1/04/2017	-2.23491
						2/04/2017	-2.45785
						3/04/2017	-2.50631
						4/04/2017	-2.85203
						9/04/2017	-2.99743
						10/04/2017	-2.50955
						11/04/2017	-2.0669
						12/04/2017	-2.49016

Tree 3	Ψ_{pd} (MPa)
30/01/2017	-3.81487
4/02/2017	-3.18482
15/02/2017	-3.92795
18/02/2017	-3.21713
21/02/2017	-3.09436
23/02/2017	-3.21713
24/02/2017	-3.02974
26/02/2017	-3.15898
27/02/2017	-3.6824
3/03/2017	-3.37545
5/03/2017	-3.40776
6/03/2017	-3.11051
7/03/2017	-3.21713
12/03/2017	-3.62424
16/03/2017	-3.67271
17/03/2017	-3.41099
27/03/2017	-3.02651
5/04/2017	-3.82133
13/04/2017	-3.1299
14/04/2017	-3.19452
15/04/2017	-3.33991
16/04/2017	-3.25268
17/04/2017	-3.40776
20/04/2017	-3.85687

Tree 3	Ψ_{pd} (MPa)
22/02/2017	-4.90049
4/03/2017	-4.1832
8/03/2017	-4.558
9/03/2017	-4.53861
10/03/2017	-4.66462
15/03/2017	-4.53538
18/03/2017	-4.04104
6/04/2017	-4.01842
7/04/2017	-4.75832
8/04/2017	-4.74863
18/04/2017	-4.26075
19/04/2017	-4.88433

Tree 3	Ψ_{pd} (MPa)
28/02/2017	-5.2042
1/03/2017	-5.34959
2/03/2017	-5.24297
11/03/2017	-5.24297
19/03/2017	-5.06204
20/03/2017	-5.22035

Tree 4	Ψ_{pd} (MPa)		Tree 4	Ψ_{pd} (MPa)		Tree 4	Ψ_{pd} (MPa)
8/12/2016	-0.5442		7/12/2016	-1.21154		31/01/2017	-2.0771
28/12/2016	-0.7259		9/12/2016	-1.13886		1/02/2017	-2.26211
2/01/2017	-0.19732		10/12/2016	-1.05627		2/02/2017	-2.15639
3/01/2017	-0.33277		11/12/2016	-1.13556		3/02/2017	-2.14318
4/01/2017	-0.3592		12/12/2016	-1.15868		23/04/2017	-2.33479
5/01/2017	-0.23035		13/12/2016	-1.59807		26/04/2017	-2.41738
6/01/2017	-0.56072		14/12/2016	-1.10913			
7/01/2017	-0.89109		15/12/2016	-1.29083			
8/01/2017	-0.42527		16/12/2016	-1.30735			
9/01/2017	-0.91752		17/12/2016	-1.58816		Tree 4	Ψ_{pd} (MPa)
10/01/2017	-0.95386		18/12/2016	-1.37012		30/01/2017	-3.7851
14/01/2017	-0.75894		19/12/2016	-1.88549		4/02/2017	-3.12437
15/01/2017	-0.67965		20/12/2016	-1.32387		20/04/2017	-3.45143
16/01/2017	-0.97368		21/12/2016	-1.65754			
17/01/2017	-0.97368		22/12/2016	-1.72692			
18/01/2017	-0.71269		23/12/2016	-1.95487			
26/01/2017	-0.88778		24/12/2016	-1.60138			
6/02/2017	-0.9935		25/12/2016	-1.95487			
28/04/2017	-0.9043		26/12/2016	-1.67736			
			27/12/2016	-1.81281			
			11/01/2017	-1.086			
			12/01/2017	-1.14217			
			13/01/2017	-1.29413			
			19/01/2017	-1.53861			
			27/01/2017	-1.03975			
			28/01/2017	-1.19172			
			29/01/2017	-1.60798			
			5/02/2017	-1.56834			
			7/02/2017	-1.37012			
			21/04/2017	-1.37342			
			22/04/2017	-1.46593			
			24/04/2017	-1.15538			
			25/04/2017	-1.78308			
			27/04/2017	-1.49235			
			29/04/2017	-1.04306			
			30/04/2017	-1.51548			

4. Assimilation rate and related predawn water potential, PAR 0-1400 (µmol m^{-2} s^{-1})

Tree 1, 2, 3, 4, tree 1 (blue), tree 2 (red), tree 3 (green) and tree 4 (purple) within PAR 0-1400 (µmol m^{-2} s^{-1}) and 290 photosynthesis measurements.

tree 1	HHMMSS	PAR (µmol n	A (µmol CO2	Trmmol (n	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa)	Ψ_{pd} (MPa)
22/12/2016	11:48:30	129.6829	2.504416	1.330342	3.39	23.24543	389.3451	41.17227	1.551170607	-0.226667
22/12/2016	11:50:13	112.55641	2.562406	1.237684	3.39	23.25741	389.2494	40.45779	1.597622286	-0.226667
22/12/2016	11:52:16	23.088871	0.838324	1.028146	3.39	23.40139	388.7716	40.25545	1.625290895	-0.226667
23/12/2016	14:13:29	1246.6781	1.455356	2.808895	3.39	32.92077	387.3752	27.99231	3.441082559	-0.797291
23/12/2016	14:15:30	957.04626	1.670426	3.03076	3.39	33.41695	387.1496	26.78196	3.598154222	-0.797291
5/01/2017	17:02:15	144.64803	1.10904	2.72486	3.39	35.81829	393.9869	33.50265	3.646337142	-0.073789
11/01/2017	0.635671	63.233738	1.428842	1.545881	3.39	25.56762	332.1017	41.86807	-1.246064627	-0.522859
11/01/2017	0.63706	73.396347	1.67384	1.279796	3.39	25.58708	332.1375	41.89784	-1.229943129	-0.522859
11/01/2017	0.639132	60.982777	1.393951	0.933794	3.39	25.59514	332.0304	42.00374	-1.212210531	-0.522859
16/01/2017	0.589178	308.00923	2.573384	3.299246	3.39	38.5634	385.6083	16.22777	11.44211658	-0.301443
16/01/2017	0.589722	201.34012	0.475415	3.166956	3.39	38.66106	385.4096	15.87351	11.52962944	-0.301443
31/01/2017	08:19:07	109.34027	2.132132	0.566923	3.39	18.56912	386.4251	57.72931	1.5844164	-0.553333
31/01/2017	08:20:31	88.757235	0.99513	0.25542	3.39	18.56535	386.4684	57.79793	1.615713218	-0.553333
31/01/2017	08:21:58	91.962588	1.273014	0.558038	3.39	18.64669	386.0034	57.48397	1.6152682	-0.553333
31/01/2017	15:58:49	186.84534	2.784303	1.238414	3.39	24.09497	380.9352	42.08543	2.830504265	-0.553333
31/01/2017	16:01:31	187.00411	2.721077	0.821203	3.39	24.04272	381.0859	42.36644	2.858958806	-0.553333
31/01/2017	16:02:16	103.13943	1.985653	0.806629	3.39	24.06644	380.7891	42.56397	2.860514722	-0.553333
7/02/2017	12:13:22	119.11221	1.689725	2.384088	3.39	28.87714	396.5189	40.91656	4.100936072	-0.553333
7/02/2017	16:03:37	46.174652	1.712349	0.934251	3.39	32.70642	386.4112	37.17387	6.295271158	-0.473333
7/02/2017	16:06:18	48.026201	1.165657	0.368996	3.39	32.45705	386.2582	37.77204	6.088112037	-0.473333
7/02/2017	16:07:53	179.76991	1.313625	1.40551	3.39	32.28438	385.6197	38.24622	5.94921458	-0.473333
13/02/2017	12:12:56	216.11536	2.813601	0.700912	3.39	21.58698	379.1585	49.07171	2.18052923	-0.91
13/02/2017	12:13:39	199.56367	2.306807	0.777037	3.39	21.60776	378.9254	48.95789	2.188528835	-0.91
21/02/2017	12:10:15	1306.4648	2.911724	1.034065	3.39	30.61678	384.3083	22.77881	5.646219637	-0.91
21/02/2017	12:14:38	371.4794	2.820316	1.329521	3.39	31.84966	383.6972	21.18457	6.536673	-1.193333
21/02/2017	16:00:16	150.3102	0.507909	0.76153	3.39	31.5812	386.4917	23.05873	6.371492535	-1.193333
21/02/2017	16:00:56	144.78548	0.973536	0.650109	3.39	31.60721	386.0654	23.1302	5.90054868	-1.193333
28/02/2017	08:23:51	46.532768	0.253813	0.153821	3.39	32.6933	389.7581	19.68005	6.514119028	-2.126667
28/02/2017	12:09:23	1370.1265	0.996645	0.683215	3.39	41.30057	385.2224	13.85112	14.36983292	-2.126667
8/03/2017	12:20:04	179.24361	2.755543	0.787031	3.39	32.86579	390.0631	25.94211	3.682084996	-2.443333
8/03/2017	16:07:42	43.122665	1.144133	0.383742	3.39	31.31184	385.696	24.24959	3.370659225	-2.443333
8/03/2017	16:08:23	46.536289	0.902995	0.304045	3.39	31.17072	385.5385	24.29925	3.340418657	-2.443333
8/03/2017	16:09:41	59.05201	0.258834	0.039179	3.39	30.95838	384.9858	24.61671	3.318787129	-2.443333
6/04/2017	08:24:44	41.107845	0.220551	0.297125	3.39	24.86693	390.0237	24.62683	2.329610539	-2.093333
6/04/2017	08:25:34	44.296989	0.436886	-0.08772	3.39	24.93655	390.4309	24.9675	2.342888651	-2.093333
6/04/2017	08:26:42	41.997452	0.177062	0.211425	3.39	25.04227	389.9979	24.29411	2.361019376	-2.093333
6/04/2017	12:24:49	76.605457	0.172943	0.378792	3.39	31.31515	386.0128	17.33202	3.684147274	-2.093333
6/04/2017	12:26:36	61.001123	0.411583	0.098754	3.39	30.82966	385.9105	17.55262	3.587043824	-2.093333
6/04/2017	12:27:32	82.303065	0.572821	0.290085	3.39	30.62683	386.0663	17.57548	3.543476708	-2.093333
12/04/2017	12:09:09	172.85954	0.842811	0.233373	3.39	22.61596	382.7426	46.16602	1.43511504	-2.093333
12/04/2017	12:10:06	70.848618	0.720524	-0.071951	3.39	22.65367	382.5016	46.50319	1.44607552	-2.106667
12/04/2017	12:10:59	73.137917	1.007184	0.043794	3.39	22.68494	382.515	46.34314	1.444453913	-2.106667
18/04/2017	12:01:39	1134.0098	1.496626	0.466589	3.39	30.66247	386.2397	39.95498	2.625830913	-2.876667
18/04/2017	12:02:26	1017.7657	2.255714	0.657179	3.39	30.73164	385.9619	39.86341	2.631745744	-2.876667
18/04/2017	12:03:09	1220.6454	2.541374	0.566987	3.39	30.8047	386.081	39.77055	2.649089583	-2.876667
18/04/2017	12:05:52	102.31637	0.540716	0.58424	3.39	31.29533	385.9137	38.04931	2.806455807	-2.876667
30/04/2017	12:09:58	128.23515	0.96928	0.372218	3.39	19.2956	386.7701	44.92141	1.174945509	-0.546667
30/04/2017	12:10:48	123.393	0.969969	0.327233	3.39	19.28265	386.453	44.5065	1.186610898	-0.546667
30/04/2017	12:11:23	169.7583	1.115206	0.273507	3.39	19.25805	386.3253	44.50347	1.186141684	-0.546667
16/01/2017	12:14:35	931.53857	3.702984	5.466779	3.39	39.83991	383.7059	15.64172	12.11309614	-0.301443
16/01/2017	14:07:08	1067.9178	3.89467	3.199135	3.39	38.34328	386.0239	16.55996	11.03823896	-0.301443
24/01/2017	12:13:38	1090.8134	3.753357	1.281399	3.39	24.03449	382.7737	41.45866	2.763441464	
24/01/2017	16:03:36	870.43044	3.66061	1.135457	3.39	23.40136	383.0488	42.76546	2.710687864	
21/02/2017	12:12:27	658.66022	3.414053	1.107848	3.39	31.26412	384.5573	22.14301	6.230457911	-1.193333
8/03/2017	12:19:08	630.54675	3.790529	0.910773	3.39	32.73494	390.0418	25.98226	3.646064647	-2.443333

tree 2	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
5/01/2017	16:37:30	957.4864	3.90752	1.989313	3.88	36.98681	394.2553	31.30635	4.140742	-0.65941
11/01/2017	15:25:27	666.6396	3.466674	1.023617	3.88	25.71646	381.9975	47.44978	1.672743	-1.1576
24/01/2017	12:02:31	714.6784	3.790836	0.665503	3.88	25.04724	385.2192	41.80233	2.759739	
7/02/2017	16:00:08	437.4482	2.998842	1.742208	3.88	32.40853	386.7791	37.33544	6.02494	
7/02/2017	16:00:09	369.1856	3.375918	1.748281	3.88	32.41026	386.7655	37.33169	6.046784	-0.57983
5/01/2017	16:33:35	1117.327	2.573644	1.436291	3.88	37.21253	395.7104	30.52758	4.303212	-0.65941
5/01/2017	16:34:55	216.8334	1.888222	1.287134	3.88	37.19553	394.9993	30.62483	4.272979	-0.65941
11/01/2017	0.646678	890.4644	2.278755	0.03092	3.88	25.76325	381.9773	47.23727	1.741204	-1.1576
11/01/2017	0.665706	605.4138	3.083803	1.187594	3.88	27.1118	380.161	43.00306	1.965857	-1.1576
11/01/2017	0.666725	667.3364	2.840494	1.497614	3.88	27.17535	380.1352	42.84874	1.942077	-1.1576
11/01/2017	0.667477	598.8388	2.869538	1.375565	3.88	27.08367	379.9547	42.92157	1.922259	-1.1576
16/01/2017	10:27:14	57.97476	0.334765	0.844362	3.88	28.29715	406.6481	34.42117	2.426896	-0.91196
16/01/2017	0.596111	795.6324	3.180806	1.585664	3.88	38.88795	330.0304	12.58116	-0.03951	-0.91196
16/01/2017	12:21:38	767.9918	0.557951	1.143879	3.88	38.24114	384.4841	16.78898	10.43981	-0.91196
24/01/2017	08:26:37	64.34903	1.078174	0.46686	3.88	19.50733	386.8118	66.49846	1.479493	-0.91196
24/01/2017	08:27:54	68.7244	0.213023	0.245499	3.88	19.49927	386.7326	66.09911	1.529884	-0.91196
24/01/2017	16:07:53	821.9245	2.55606	0.844422	3.88	23.24827	382.5251	42.17704	2.700652	-0.91196
24/01/2017	16:09:00	461.8109	1.865932	0.655598	3.88	23.40989	382.4769	42.13808	2.789955	-0.91196
31/01/2017	12:10:37	151.8863	1.932943	1.361837	3.88	26.08428	380.3675	35.4414	3.639248	-1.52432
31/01/2017	16:15:01	216.355	2.628594	0.610289	3.88	23.50454	381.9486	44.6053	2.757906	-1.52432
31/01/2017	16:15:52	263.6995	2.862973	0.556084	3.88	23.46086	381.8934	44.63662	2.716686	-1.52432
7/02/2017	12:20:47	168.4177	1.596722	0.814653	3.88	28.39155	398.9447	42.66622	4.07817	-0.57983
7/02/2017	12:22:06	224.5453	2.000641	0.963751	3.88	28.25541	398.3233	43.15582	4.252516	-0.57983
7/02/2017	12:23:25	362.7648	2.259291	0.598918	3.88	28.12177	395.198	42.89156	4.230554	-0.57983
7/02/2017	15:57:36	543.7118	2.760731	1.284042	3.88	32.21064	388.6317	37.2645	5.777815	-0.57983
7/02/2017	16:00:08	437.4482	2.998842	1.742208	3.88	32.40853	386.7791	37.33544	6.02494	-0.57983
7/02/2017	16:01:09	499.8419	2.195801	1.832425	3.88	32.54524	386.7047	37.31265	5.824824	-0.57983
13/02/2017	12:04:32	284.4472	2.039411	0.373674	3.88	20.77194	380.8559	51.6625	1.929112	-1.64195
13/02/2017	12:05:38	318.2866	2.209523	0.445465	3.88	20.8363	380.382	51.14851	1.949576	-1.64195
13/02/2017	12:06:23	280.4996	2.276886	0.607696	3.88	20.87628	380.3807	50.97773	1.933947	-1.64195
13/02/2017	15:59:32	269.9196	2.485023	0.443296	3.88	23.24123	381.6488	45.45594	2.424996	-1.64195
21/02/2017	12:02:56	692.3488	1.514352	0.298485	3.88	29.20615	385.4887	24.92251	4.889086	-1.90489
21/02/2017	12:03:53	527.1432	1.828182	0.846042	3.88	29.44978	385.119	24.44347	4.942514	-1.90489
21/02/2017	12:05:05	342.6927	1.430791	0.526356	3.88	29.66446	384.7647	24.04968	5.166151	-1.90489
21/02/2017	16:22:56	789.7325	2.062285	0.563943	3.88	31.09181	385.3259	23.19123	5.789621	-1.90489
21/02/2017	16:23:36	628.5167	1.851672	0.780061	3.88	31.22425	385.2569	22.9929	5.844114	-1.90489
21/02/2017	16:24:49	463.7959	1.751456	0.839789	3.88	31.49549	384.9476	22.73861	5.992878	-1.90489
21/02/2017	16:26:14	675.1687	1.262453	0.795751	3.88	31.77242	385.1534	22.63701	6.002263	-1.90489
21/02/2017	16:26:14	767.7504	1.634731	0.795751	3.88	31.77242	385.1534	22.63701	6.002263	-1.90489
28/02/2017	12:04:59	331.0075	0.904724	1.034434	3.88	40.91692	385.2153	13.60833	14.09495	-2.61758
28/02/2017	12:06:14	498.4879	0.800604	2.355478	3.88	40.92402	384.8399	13.65515	13.93323	-2.61758
28/02/2017	16:05:07	240.2112	0.550956	1.11991	3.88	38.95272	383.918	16.29406	11.90236	-2.61758
28/02/2017	16:05:47	216.5661	0.713886	0.767734	3.88	38.93726	383.9185	16.24765	12.07909	-2.61758
28/02/2017	16:07:20	159.5791	0.561782	1.088587	3.88	38.86849	383.9795	16.32139	12.32563	-2.61758
8/03/2017	08:20:57	31.80547	0.966958	0.014964	3.88	24.812	401.3403	41.37	1.808184	-3.0362
8/03/2017	08:23:31	38.57593	0.751609	0.053376	3.88	25.0248	399.6825	41.68907	1.817757	-3.0362
8/03/2017	08:24:35	45.86044	1.406361	0.034232	3.88	25.11393	399.5592	41.40001	1.839177	-3.0362
8/03/2017	08:27:47	42.37224	1.487358	0.211408	3.88	25.55187	399.7008	40.00333	1.932034	-3.0362
8/03/2017	08:29:16	86.19003	0.382298	0.16502	3.88	25.79135	399.1276	39.26746	2.00998	-3.0362
8/03/2017	16:02:09	60.03032	0.836858	0.239775	3.88	31.6571	387.3782	25.15662	3.449604	-3.0362
8/03/2017	16:03:26	41.92084	0.465442	0.604633	3.88	31.61021	386.567	24.69576	3.437459	-3.0362
8/03/2017	16:04:10	55.74033	0.695364	0.372816	3.88	31.57415	386.3802	24.63239	3.45958	-3.0362
22/03/2017	08:16:50	22.45764	0.167955	-0.06265	3.88	19.78637	388.8484	72.31176	0.603206	-1.70769
22/03/2017	08:19:49	20.89803	0.823502	-0.01333	3.88	19.8565	389.5333	71.75091	0.614448	-1.70769
22/03/2017	08:20:47	17.96344	0.753687	-0.01469	3.88	19.82681	389.3564	71.68047	0.617137	-1.70769

tree 2	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
22/03/2017	12:15:29	244.1838	2.554589	0.331727	3.88	20.86462	384.4176	66.02784	0.785485	-1.70769
22/03/2017	12:16:27	112.123	1.679944	0.334968	3.88	20.88421	384.3564	65.72875	0.790442	-1.70769
22/03/2017	12:17:27	145.6975	1.375916	0.19811	3.88	20.87072	384.1181	65.76867	0.796934	-1.70769
27/03/2017	08:17:21	69.80832	0.235629	0.068365	3.88	21.49405	381.7221	61.15883	0.950043	-2.87705
27/03/2017	08:17:44	68.49944	0.313147	-0.04632	3.88	21.47562	381.6125	61.08894	0.962236	-2.87705
27/03/2017	08:18:14	47.23661	0.258188	0.01432	3.88	21.45786	381.6741	60.96223	0.955041	-2.87705
27/03/2017	16:19:50	27.25952	0.436291	0.206795	3.88	22.93637	383.59	45.36607	1.455201	-2.87705
27/03/2017	16:20:26	31.2317	0.632576	0.169408	3.88	22.74664	383.1899	45.98255	1.425383	-2.87705
6/04/2017	16:12:49	26.09512	1.289669	0.075178	3.88	28.22335	391.7467	18.76806	3.055718	-3.35449
6/04/2017	16:14:16	27.44399	1.022847	0.121732	3.88	28.24366	391.0625	18.84104	3.052188	-3.35449
12/04/2017	08:15:39	29.36262	0.254657	0.025691	3.88	19.54851	386.7748	57.38177	0.940855	-2.82516
12/04/2017	08:16:59	27.78276	0.768335	-0.03954	3.88	19.63845	386.326	57.32922	0.950433	-2.82516
12/04/2017	16:08:48	17.14995	0.299154	0.065615	3.88	20.83304	384.5609	49.10155	1.212433	-2.82516
12/04/2017	16:09:35	17.48661	0.34304	0.101037	3.88	20.80838	384.5984	49.13046	1.206742	-2.82516
18/04/2017	08:14:34	66.19981	0.473379	0.108844	3.88	23.84385	388.7249	35.21125	1.878868	-3.83884
18/04/2017	08:15:23	71.96874	0.580249	0.115767	3.88	23.8962	388.4898	35.25195	1.881969	-3.83884
18/04/2017	12:09:50	1134.255	1.421836	0.629453	3.88	31.89687	385.4679	36.62622	2.958798	-3.83884
18/04/2017	12:12:13	1287.969	0.983424	0.402099	3.88	32.175	385.3166	35.6855	3.093052	-3.83884
18/04/2017	12:13:13	210.298	0.61145	0.188854	3.88	32.23083	385.2191	35.13889	3.07293	-3.83884
18/04/2017	15:56:38	17.07657	0.438605	0.049784	3.88	28.51261	384.9239	21.50442	3.020197	-3.83884
18/04/2017	15:57:48	20.16922	0.460546	0.101542	3.88	28.41944	385.0916	21.55316	3.002842	-3.83884
18/04/2017	15:58:46	47.42412	0.320553	0.128333	3.88	28.39406	384.8993	21.5926	2.997575	-3.83884
30/04/2017	08:22:11	99.18063	0.427122	0.05889	3.88	19.67097	392.7768	52.11689	1.049951	-0.98462
30/04/2017	08:22:59	102.0723	0.485758	0.151869	3.88	19.63544	392.7643	52.11911	1.040178	-0.98462
30/04/2017	08:23:55	149.3377	1.252503	0.267867	3.88	19.59928	392.7859	52.1578	1.026659	-0.98462
30/04/2017	12:17:36	105.2871	1.551226	-0.1921	3.88	19.58859	385.9854	43.765	1.26311	-0.98462

tree 3	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
22/12/2016	11:54:54	1354.944	3.556921	1.223928	3.84	31.58094	392.1227	29.81015	3.197246	
22/12/2016	12:02:09	951.1956	3.630079	1.725984	3.84	33.57791	389.5244	27.16914	3.691056	
22/12/2016	12:05:31	1094.898	3.655084	1.825914	3.84	33.9747	388.4426	27.50071	3.68842	
22/12/2016	12:06:56	645.6377	3.888307	1.939246	3.84	34.22451	388.4497	26.64653	3.766753	
31/01/2017	12:18:57	476.6714	3.465968	0.556769	3.84	26.325	380.468	35.62624	3.729209	-2.11859
7/02/2017	12:01:40	668.5096	3.890669	0.723549	3.84	27.50941	393.4609	42.16021	3.508316	
13/02/2017	12:16:48	274.2172	3.617114	0.495772	3.84	21.82024	379.102	48.95479	2.246692	
13/02/2017	16:12:37	252.4234	3.542061	0.553371	3.84	22.25762	379.7161	48.24267	2.240494	
15/12/2016	15:35:15	38.50583	1.147276	1.56632	3.84	21.1852	389.7715	44.0388	1.254479	-0.87466
22/12/2016	12:07:57	377.6811	2.757734	1.932066	3.84	34.262	388.1434	26.52657	3.780541	-0.87466
5/01/2017	16:19:33	427.4767	2.207308	1.498452	3.84	35.36817	398.8304	32.93936	3.715685	-0.33185
5/01/2017	16:24:44	466.1721	0.716425	1.055026	3.84	36.13757	398.3773	31.64987	3.999886	-0.33185
16/01/2016	0.387859	72.68017	0.72627	1.062023	3.84	26.85932	411.3335	38.56584	2.077059	-0.58064
16/01/2016	0.504549	813.7483	2.621438	2.371728	3.84	41.20492	384.3708	15.03565	13.66943	-0.58064
16/01/2016	0.582569	805.7762	0.587581	1.682365	3.84	37.08568	386.0995	17.13565	9.753399	-0.58064
16/01/2016	0.583264	887.9205	1.533492	2.046044	3.84	37.23032	385.9609	17.0404	9.843558	-0.58064
16/01/2016	0.583889	1039.671	2.546062	2.394468	3.84	37.31182	386.1162	17.09767	9.82899	-0.58064
16/01/2016	0.584815	283.9867	1.17423	2.464653	3.84	37.54511	386.028	17.65175	10.01395	-0.58064
24/01/2017	08:20:01	119.5387	1.834768	0.089007	3.84	19.31312	386.9456	67.13129	1.48098	-1.36577
24/01/2017	08:20:47	102.124	1.455063	0.131743	3.84	19.28705	386.8404	67.14743	1.473221	-1.36577
24/01/2017	08:21:29	99.95063	2.024399	0.158384	3.84	19.30313	386.6725	66.95602	1.486753	-1.36577
31/01/2017	12:18:57	430.4593	2.977454	0.556769	3.84	26.325	380.468	35.62624	3.729209	-2.11859
31/01/2017	12:19:50	216.8665	1.352309	0.736493	3.84	26.25104	380.6832	35.42043	3.63016	-2.11859
7/02/2017	12:02:16	225.6258	2.314821	0.811784	3.84	27.64203	393.0588	42.11204	3.584857	-1.18807
13/02/2017	16:11:56	172.9455	2.23837	0.47264	3.84	22.23072	379.4913	48.31463	2.360123	-2.88434
21/02/2017	16:37:29	482.073	1.315258	1.02872	3.84	32.66766	386.8768	21.67813	6.581534	-3.09436
21/02/2017	16:38:38	475.9668	2.043892	0.911932	3.84	33.00173	386.8676	21.35744	6.915443	-3.09436
21/02/2017	16:41:40	432.61	0.730284	1.072661	3.84	33.80843	386.6441	19.76343	7.300041	-3.09436
28/02/2017	12:16:35	914.827	1.230399	1.128117	3.84	42.01524	384.3733	13.22713	15.54418	-5.2042
28/02/2017	12:20:03	561.6694	1.724458	1.470371	3.84	42.26028	384.1287	13.14588	16.13635	-5.2042
28/02/2017	12:21:16	470.1631	1.157318	1.269424	3.84	42.41931	384.1513	12.9793	16.56672	-5.2042
28/02/2017	12:21:56	563.3805	0.929996	0.83798	3.84	42.47095	384.3421	12.99994	16.59891	-5.2042
28/02/2017	12:25:05	592.6117	0.373027	1.521011	3.84	42.44251	384.0186	12.87061	16.40826	-5.2042
28/02/2017	15:54:03	826.2853	0.554198	0.655004	3.84	39.2699	384.2313	15.75463	12.25812	-5.2042
28/02/2017	15:54:48	791.542	0.952753	1.216302	3.84	39.34815	384.0456	15.68589	12.42959	-5.2042
28/02/2017	15:55:37	402.0974	0.777233	1.687363	3.84	39.49665	383.986	15.6245	12.59404	-5.2042
28/02/2017	15:56:54	849.5076	0.627381	0.643607	3.84	39.64669	383.72	15.51429	12.89776	-5.2042
8/03/2017	08:12:38	21.93218	0.218823	0.295057	3.84	23.70102	406.846	43.86332	1.599033	-4.558
8/03/2017	08:13:56	24.47424	0.288893	0.229352	3.84	23.89287	405.2303	43.05158	1.648389	-4.558
8/03/2017	08:15:15	28.82904	0.294796	0.135732	3.84	24.10102	404.2389	42.21325	1.70432	-4.558
8/03/2017	08:16:34	28.99392	0.234446	0.117345	3.84	24.30545	403.2149	41.44962	1.749707	-4.558
8/03/2017	08:17:44	27.90391	0.164825	0.166532	3.84	24.48046	403.2921	40.90989	1.780425	-4.558
8/03/2017	12:05:11	759.4382	2.252911	0.546487	3.84	30.03162	396.0205	31.31545	2.911195	-4.558
8/03/2017	12:06:08	494.68	1.986347	0.658078	3.84	30.25017	394.7706	30.96562	2.957554	-4.558
8/03/2017	12:08:00	676.6614	2.071245	0.575053	3.84	30.72888	393.2295	29.83769	3.087468	-4.558
8/03/2017	12:10:54	340.9009	0.504421	0.241018	3.84	31.29957	391.2917	28.97012	3.232251	-4.558
8/03/2017	16:11:57	72.73855	0.48681	0.609595	3.84	30.90302	385.4219	24.92361	3.268903	-4.558
8/03/2017	16:12:32	132.6771	1.393466	0.756467	3.84	30.78583	385.3646	25.1301	3.221989	-4.558
8/03/2017	16:12:59	218.0159	1.527898	0.163418	3.84	30.73324	385.4233	25.25312	3.256997	-4.558
8/03/2017	08:06:40	22.01078	0.743897	0.057585	3.84	20.14581	392.7668	71.42594	0.632733	-4.558
8/03/2017	08:07:31	23.48992	0.260244	0.053726	3.84	20.09966	392.9004	71.74052	0.626195	-4.558
8/03/2017	08:08:58	23.54411	0.556241	0.056302	3.84	20.05663	393.5209	72.23289	0.608708	-4.558
8/03/2017	08:10:34	21.00552	0.297383	0.006122	3.84	20.0134	394.218	72.88162	0.593049	-4.558
8/03/2017	12:21:34	116.439	0.982725	0.164099	3.84	20.83559	383.4917	65.55061	0.804338	-4.558
8/03/2017	12:22:24	110.1546	0.883459	0.230353	3.84	20.82012	383.4707	65.61733	0.801068	-4.558

tree 3	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
8/03/2017	12:23:15	104.6005	0.833645	0.209471	3.84	20.83536	383.4844	65.7613	0.799931	-4.558
8/03/2017	16:10:22	85.02811	1.686508	0.158692	3.84	21.57119	383.062	62.69911	0.919488	-4.558
8/03/2017	16:11:13	69.91938	1.859226	-0.05457	3.84	21.4878	383.0948	62.95358	0.923455	-4.558
8/03/2017	16:12:13	67.36386	1.879779	0.182487	3.84	21.46036	383.2765	62.99186	0.907596	-4.558
8/03/2017	08:13:08	89.7409	0.49774	0.029569	3.84	21.58855	382.6742	61.66448	0.955354	-4.558
8/03/2017	12:18:55	545.857	1.818558	0.212804	3.84	23.03642	382.7978	45.55185	1.49166	-4.558
8/03/2017	12:19:51	316.2873	1.615407	0.33328	3.84	23.09744	382.7287	45.68916	1.480242	-4.558
8/03/2017	12:20:32	554.9251	1.892232	0.25111	3.84	23.14232	382.7316	45.68132	1.498784	-4.558
8/03/2017	12:21:42	701.2217	1.004376	0.37002	3.84	23.3075	382.1721	44.90398	1.535089	-4.558
8/03/2017	16:08:54	752.1685	1.258148	0.341816	3.84	22.84289	383.2538	47.04137	1.429167	-4.558
8/03/2017	16:11:11	701.8592	0.696193	0.358362	3.84	23.22886	383.1833	46.75696	1.468233	-4.558
8/03/2017	16:11:41	702.3728	1.272212	0.312673	3.84	23.28762	383.1164	46.67895	1.47713	-4.558
6/04/2017	08:18:17	38.68408	0.383254	0.107457	3.84	24.19796	393.1066	26.20362	2.194282	-4.01842
6/04/2017	08:20:10	34.62804	0.482672	-0.03296	3.84	24.35781	393.9041	26.32238	2.218954	-4.01842
6/04/2017	12:10:36	237.7008	0.773384	0.31127	3.84	30.33446	387.1471	17.51996	3.544295	-4.01842
6/04/2017	12:11:14	402.2453	0.707296	0.329022	3.84	30.40415	387.094	17.43534	3.551328	-4.01842
12/04/2017	16:12:12	21.20182	0.4314	0.005526	3.84	20.64345	384.647	49.66965	1.180092	-2.49016
12/04/2017	16:13:53	20.78549	0.397094	-0.02993	3.84	20.55604	384.698	49.96095	1.160883	-2.49016
12/04/2017	16:15:44	11.14422	0.358642	0.067686	3.84	20.5146	384.7831	50.2931	1.154372	-2.49016
12/04/2017	12:13:30	1088.224	1.090994	0.193437	3.84	23.05742	382.8049	45.46666	1.530963	-2.49016
12/04/2017	12:15:38	929.8652	2.255186	0.5118	3.84	23.30978	382.6344	44.1296	1.569405	-2.49016
12/04/2017	12:16:14	927.6464	2.668427	0.379552	3.84	23.42403	382.6071	43.69131	1.601784	-2.49016
12/04/2017	12:17:11	570.0503	1.318403	0.287656	3.84	23.6146	383.275	43.07207	1.628636	-2.49016
12/04/2017	12:18:14	1307.436	1.894678	0.258653	3.84	23.78326	383.0558	42.58304	1.683819	-2.49016
12/04/2017	08:07:43	28.59711	0.890235	0.113203	3.84	18.99172	389.8875	58.07869	0.886968	-2.49016
12/04/2017	08:09:25	29.63588	0.514839	0.151068	3.84	19.14672	388.7633	57.30265	0.910838	-2.49016
12/04/2017	08:10:03	23.66216	0.51626	0.172488	3.84	19.18892	388.462	57.07757	0.916438	-2.49016
18/04/2017	08:10:58	69.75383	0.891609	0.06203	3.84	23.51037	388.3716	35.77736	1.8356	-4.26075
18/04/2017	08:11:37	61.44038	0.683851	0.192539	3.84	23.58748	388.2201	35.31453	1.846822	-4.26075
18/04/2017	08:12:25	72.52905	0.763952	0.261841	3.84	23.68981	387.8916	35.03129	1.858859	-4.26075
18/04/2017	12:15:59	1348.514	2.669467	0.908774	3.84	32.45322	385.3241	34.28461	3.144645	-4.26075
18/04/2017	12:16:41	1296.203	2.156142	0.732821	3.84	32.53452	385.2138	34.2892	3.172848	-4.26075
18/04/2017	12:17:21	1244.331	2.604248	0.795783	3.84	32.65442	385.1377	34.38251	3.17917	-4.26075
18/04/2017	12:18:04	91.06811	1.193648	0.751544	3.84	32.74781	385.0399	34.42912	3.155867	-4.26075
18/04/2017	16:02:49	32.47187	0.491861	0.108317	3.84	28.10498	385.6042	22.21768	2.901589	-4.26075
18/04/2017	16:03:35	31.84497	0.429827	0.041782	3.84	28.05622	385.2197	22.26908	2.892131	-4.26075
30/04/2017	08:15:46	105.6591	1.029665	0.294085	3.84	19.48869	395.4945	52.00799	1.028135	-1.0556
30/04/2017	08:16:13	105.8231	0.944619	0.308933	3.84	19.50026	397.282	51.93584	1.029672	-1.0556
30/04/2017		104.7752	0.675547	0.427397	3.84	19.58896	395.9205	51.88119	1.029526	-1.0556
30/04/2017	08:19:44	91.09778	0.278034	0.351718	3.84	19.61092	394.4722	51.73217	1.035653	-1.0556
30/04/2017	12:19:43	170.0183	1.132214	0.230841	3.84	19.66425	385.7708	43.43245	1.245544	-1.0556
30/04/2017	12:20:39	162.5906	1.209906	0.17842	3.84	19.74501	386.5363	44.08909	1.241351	-1.0556
30/04/2017	12:21:58	125.8648	0.841306	-0.06697	3.84	19.72004	385.7936	43.31962	1.266642	-1.0556
30/04/2017	12:23:00	128.7805	1.541263	0.079298	3.84	19.70541	386.5283	43.00602	1.259748	-1.0556
30/04/2017	12:23:47	129.1303	1.061267	0.11302	3.84	19.70134	386.2413	43.05787	1.259888	-1.0556

tree 4	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
5/01/2017	14:37:12	416.7519	3.49796	1.270609	3.84	26.54982	380.6149	45.17316	1.779969	-0.23035
24/01/2017	12:02:15	658.7491	3.571599	0.850313	3.84	26.27174	380.7245	34.92379	3.588197	-0.88778
23/12/2016	16:04:13	247.2682	1.858166	0.763482	3.84	32.13012	394.9756	27.9093	3.349017	-1.95487
5/01/2017	16:11:05	204.7954	1.992027	1.602655	3.84	33.63944	399.9752	34.75763	3.292536	-0.23035
5/01/2017	16:14:34	245.1145	1.806024	1.50459	3.84	34.43642	397.0102	34.22558	3.480589	-0.23035
5/01/2017	14:38:20	38.0085	0.599435	1.165676	3.84	26.42976	380.6508	45.34966	1.754108	-0.23035
5/01/2017	15:05:16	1082.713	1.838159	0.376978	3.84	25.48614	382.6948	47.79557	1.681116	-0.23035
5/01/2017	15:06:36	91.63802	0.89155	0.293079	3.84	25.65278	382.3699	47.19334	1.71646	-0.23035
5/01/2017	9:35:24	686.7009	2.031924	0.599316	3.84	30.72779	404.4874	32.52438	2.91634	-0.23035
5/01/2017	9:37:25	51.43649	1.443908	1.469386	3.84	31.15922	403.2441	29.9535	3.006545	-0.23035
24/01/2017	08:03:59	33.4714	0.640795	0.583268	3.84	20.10925	400.7494	61.60706	1.528694	
24/01/2017	08:06:20	46.36025	1.686587	0.308045	3.84	20.01423	393.7726	62.44703	1.530782	
24/01/2017	08:07:34	62.51745	2.366733	0.333754	3.84	20.01946	391.5342	62.94278	1.519589	
24/01/2017	12:17:49	386.831	2.499824	0.901985	3.84	24.17479	381.7935	43.19045	2.82424	
24/01/2017	12:03:01	36.68925	0.707146	0.726676	3.84	26.39313	380.7485	34.87345	3.641825	
24/01/2017	16:07:00	74.08629	0.533244	0.576343	3.84	23.84623	380.0435	43.41595	2.833774	
24/01/2017	16:09:48	55.35265	0.378558	0.338932	3.84	23.74771	380.5501	43.95444	2.781667	
7/02/2017	08:05:48	27.59571	0.250573	0.551072	3.84	19.27721	400.1629	59.34506	1.653926	-1.37012
7/02/2017	16:10:41	33.69429	1.430278	0.188609	3.84	31.89752	386.2648	38.98211	5.961649	-1.37012
7/02/2017	16:11:34	36.83117	1.415797	0.137629	3.84	31.7251	385.9092	39.11194	5.301971	-1.37012
7/02/2017	16:12:21	56.30712	2.032634	0.510089	3.84	31.59774	385.577	39.11008	5.604244	-1.37012
13/02/2017	16:16:17	85.74039	1.941372	0.156969	3.84	22.07675	380.3358	48.96418	2.352417	-2.49992
13/02/2017	16:17:09	86.63364	2.432294	0.197568	3.84	21.96939	380.3146	49.43961	2.318825	-2.49992
21/02/2017	08:05:20	32.6828	1.381778	0.522133	3.84	22.37358	405.5862	43.50165	2.21838	-2.64261
21/02/2017	08:06:32	23.29278	0.998541	0.632545	3.84	22.49594	407.3375	43.71885	2.223864	-2.64261
21/02/2017	12:18:28	1209.9	1.323951	0.879156	3.84	32.26868	383.292	21.27503	6.693084	-2.64261
21/02/2017	12:20:01	812.1167	1.640986	0.791378	3.84	32.53171	383.002	21.2861	6.930235	-2.64261
21/02/2017	12:21:02	548.2382	1.554491	0.681466	3.84	32.71413	383.1012	20.86516	7.091518	-2.64261
21/02/2017	12:22:22	1218.448	0.828507	0.372965	3.84	32.70753	383.4704	20.84393	7.045464	-2.64261
21/02/2017	12:23:17	531.5028	0.717593	0.60132	3.84	32.8082	383.7409	20.7046	7.041242	-2.64261
21/02/2017	12:26:11	884.4026	1.158586	0.600871	3.84	33.37817	383.6776	19.87247	7.376626	-2.64261
28/02/2017	08:11:57	40.69624	0.34183	0.789724	3.84	30.74303	389.0933	22.16737	5.350066	-4.07603
28/02/2017	16:01:30	110.256	0.374672	0.673808	3.84	39.05282	383.7542	15.91041	11.95813	-4.07603
8/03/2017	08:07:48	34.36715	0.787249	0.242452	3.84	22.99283	409.96	45.1921	1.496016	-3.637
8/03/2017	08:09:12	51.36986	0.956448	0.116006	3.84	23.18347	408.2134	44.70814	1.537711	-3.637
8/03/2017	08:10:03	56.71564	0.871887	0.183588	3.84	23.31008	407.8224	44.56482	1.550124	-3.637
8/03/2017	12:30:41	867.4865	0.552343	0.353868	3.84	33.9319	388.1375	24.10753	4.01291	-3.637
8/03/2017	12:31:59	1166.324	0.632136	0.29404	3.84	34.17705	387.7207	23.90504	4.095253	-3.637
8/03/2017	12:33:09	1108.358	0.862438	0.360168	3.84	34.48007	387.7259	23.80496	4.165376	-3.637
8/03/2017	12:34:10	544.2136	0.473152	0.323025	3.84	34.75902	387.7529	23.39892	4.233037	-3.637
14/03/2017	08:33:45	39.59717	0.512748	0.334233	3.84	24.40323	399.5164	59.97449	1.176668	-2.54163
22/03/2017	08:02:58	25.70261	0.419781	-0.02599	3.84	20.37172	390.771	70.08714	0.678763	-1.83918
22/03/2017	08:03:54	23.91153	0.480464	-0.02825	3.84	20.32589	390.7532	70.40681	0.669411	-1.83918
22/03/2017	08:04:27	24.29776	0.263463	-0.0338	3.84	20.28752	390.5385	70.58613	0.663067	-1.83918
27/03/2017	08:04:43	73.61875	0.40031	-0.00171	3.84	21.30786	383.8586	61.50364	0.944092	-2.59651
27/03/2017	08:05:50	94.20934	0.545655	-0.04524	3.84	21.31398	383.4064	61.67049	0.943392	-2.59651
27/03/2017	12:26:19	904.3276	3.212422	0.515678	3.84	24.29792	381.8381	44.10544	1.685934	-2.59651
27/03/2017	12:27:30	1029.81	2.4045	0.218738	3.84	24.55652	381.8348	43.99234	1.727779	-2.59651
27/03/2017	12:29:04	1139.547	1.744495	0.194995	3.84	24.79659	381.6488	43.17603	1.785138	-2.59651
27/03/2017	16:19:02	33.69677	0.493383	0.235459	3.84	23.13637	383.1169	44.67905	1.499898	-2.59651
27/03/2017	16:19:51	29.4134	0.644494	0.334319	3.84	22.93182	383.5735	45.38413	1.45345	-2.59651
6/04/2017	08:07:57	24.91776	0.729459	0.107397	3.84	23.33579	392.131	27.89085	2.045751	-3.27042
6/04/2017	08:08:43	22.49229	0.556823	0.070643	3.84	23.45612	392.2314	27.66306	2.068738	-3.27042
6/04/2017	12:14:17	1118.043	0.521637	0.169321	3.84	30.87879	386.6039	17.5343	3.682146	-3.27042
6/04/2017	12:14:58	1086.795	0.822263	0.260961	3.84	30.95296	386.3323	17.56997	3.67898	-3.27042

tree 4	HHMMSS	PAR (μmol	A (μmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (μm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
6/04/2017	12:15:55	1054.077	0.86316	0.359864	3.84	31.0934	386.3706	17.4844	3.709724	-3.27042
6/04/2017	12:16:35	1022.344	0.824934	0.24509	3.84	31.21373	386.4421	17.44568	3.726873	-3.27042
12/04/2017	08:02:39	29.23722	0.683912	0.066234	3.84	18.807	389.3315	58.07174	0.87125	-2.23211
12/04/2017	08:03:32	29.11136	0.295422	0.016504	3.84	18.8104	388.7208	58.16706	0.871172	-2.23211
12/04/2017	12:20:37	1273.042	1.567802	0.242141	3.84	24.43194	383.0176	42.09	1.77431	-2.23211
12/04/2017	12:22:24	454.0817	1.423904	0.065573	3.84	24.66699	383.2628	42.64735	1.753778	-2.23211
12/04/2017	16:16:24	13.06906	0.460166	-0.03216	3.84	20.51964	384.8098	50.33726	1.159626	-2.23211
12/04/2017	16:17:09	12.83078	0.514532	0.063195	3.84	20.52295	384.9903	50.41889	1.152477	-2.23211
12/04/2017	16:17:41	12.71365	0.340236	0.012876	3.84	20.53101	385.0512	50.38699	1.156404	-2.23211
18/04/2017	08:08:01	87.44356	1.075053	0.037213	3.84	23.21333	389.2849	36.53934	1.781796	-3.43505
18/04/2017	08:08:30	80.18861	0.766117	0.093909	3.84	23.25579	389.1655	36.28234	1.790104	-3.43505
18/04/2017	08:09:06	81.66973	1.140767	0.000393	3.84	23.30728	388.9375	36.03738	1.808935	-3.43505
18/04/2017	16:08:03	20.7331	0.545348	-0.04321	3.84	27.77107	386.1383	23.10402	2.820182	-3.43505
18/04/2017	16:08:45	20.48249	0.286611	0.005064	3.84	27.74339	385.6185	23.11626	2.816331	-3.43505
18/04/2017	16:10:46	15.35867	0.18782	0.027431	3.84	27.65371	385.7474	23.32959	2.791684	-3.43505
30/04/2017	08:10:18	141.5973	2.57606	0.089724	3.84	19.27643	395.2954	53.79391	0.995269	-1.51548
30/04/2017	08:11:46	128.8606	2.621977	0.089557	3.84	19.35635	394.9211	52.99644	1.015629	-1.51548

5. Assimilation rate and different predawn water potential, PAR 0-340 (µmol m^{-2} s^{-1})

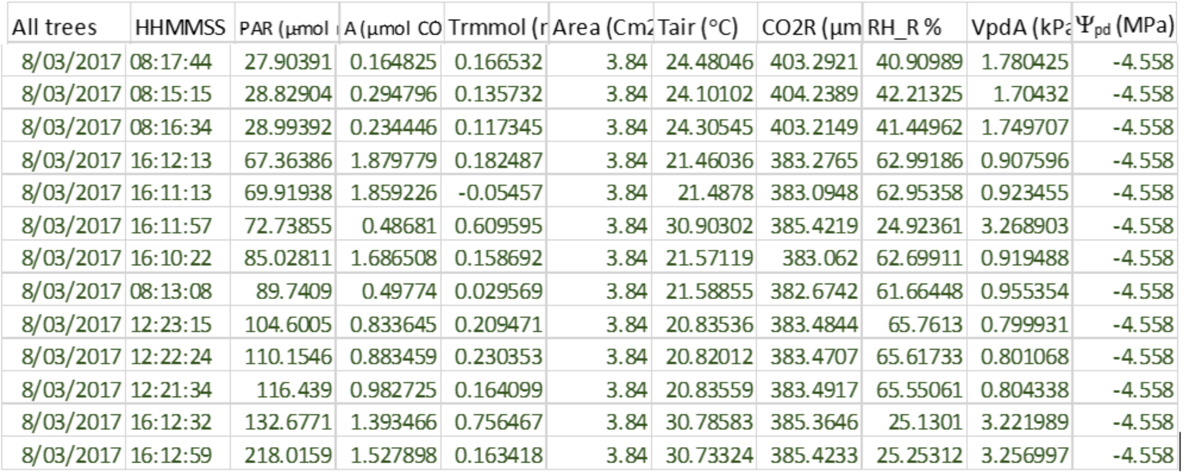
Total photosynthesis measurements of 185, within PAR 0-340 (µmol m^{-2} s^{-1}) for tree 1 (blue), tree 2 (red), tree 3 (green) and tree 4 (purple).

All trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
5/01/2017	17:02:15	144.648	1.10904	2.72486	3.39	35.81829	393.9869	33.50265	3.646337	-0.07379
22/12/2016	11:52:16	23.08887	0.838324	1.028146	3.39	23.40139	388.7716	40.25545	1.625291	-0.22667
22/12/2016	11:50:13	112.5564	2.562406	1.237684	3.39	23.25741	389.2494	40.45779	1.597622	-0.22667
22/12/2016	11:48:30	129.6829	2.504416	1.330342	3.39	23.24543	389.3451	41.17227	1.551171	-0.22667
5/01/2017	14:38:20	38.0085	0.599435	1.165676	3.84	26.42976	380.6508	45.34966	1.754108	-0.23035
5/01/2017	9:37:25	51.43649	1.443908	1.469386	3.84	31.15922	403.2441	29.9535	3.006545	-0.23035
5/01/2017	15:06:36	91.63802	0.89155	0.293079	3.84	25.65278	382.3699	47.19334	1.71646	-0.23035
5/01/2017	16:11:05	204.7954	1.992027	1.602655	3.84	33.63944	399.9752	34.75763	3.292536	-0.23035
5/01/2017	16:14:34	245.1145	1.806024	1.50459	3.84	34.43642	397.0102	34.22558	3.480589	-0.23035
16/01/2017	0.589722	201.3401	0.475415	3.166956	3.39	38.66106	385.4096	15.87351	11.52963	-0.30144
16/01/2017	14:08:25	308.0092	2.573384	3.299246	3.39	38.5634	385.6083	16.22777	11.44212	-0.30144
7/02/2017	16:03:37	46.17465	1.712349	0.934251	3.39	32.70642	386.4112	37.17387	6.295271	-0.47333
7/02/2017	16:06:18	48.0262	1.165657	0.368996	3.39	32.45705	386.2582	37.77204	6.088112	-0.47333
7/02/2017	16:07:53	179.7699	1.313625	1.40551	3.39	32.28438	385.6197	38.24622	5.949215	-0.47333
11/01/2017	0.639132	60.98278	1.393951	0.933794	3.39	25.59514	332.0304	42.00374	-1.21221	-0.52286
11/01/2017	0.635671	63.23374	1.428842	1.545881	3.39	25.56762	332.1017	41.86807	-1.24606	-0.52286
11/01/2017	0.63706	73.39635	1.67384	1.279796	3.39	25.58708	332.1375	41.89784	-1.22994	-0.52286
30/04/2017	12:10:48	123.393	0.969969	0.327233	3.39	19.28265	386.453	44.5065	1.186611	-0.54667
30/04/2017	12:09:58	128.2352	0.96928	0.372218	3.39	19.2956	386.7701	44.92141	1.174946	-0.54667
30/04/2017	12:11:23	169.7583	1.115206	0.273507	3.39	19.25805	386.3253	44.50347	1.186142	-0.54667
31/01/2017	08:20:31	88.75724	0.99513	0.25542	3.39	18.56535	386.4684	57.79793	1.615713	-0.55333
31/01/2017	08:21:58	91.96259	1.273014	0.558038	3.39	18.64669	386.0034	57.48397	1.615268	-0.55333
31/01/2017	16:02:16	103.1394	1.985653	0.806629	3.39	24.06644	380.7891	42.56397	2.860515	-0.55333
31/01/2017	08:19:07	109.3403	2.132132	0.566923	3.39	18.56912	386.4251	57.72931	1.584416	-0.55333
7/02/2017	12:13:22	119.1122	1.689725	2.384088	3.39	28.87714	396.5189	40.91656	4.100936	-0.55333
31/01/2017	15:58:49	186.8453	2.784303	1.238414	3.39	24.09497	380.9352	42.08543	2.830504	-0.55333
31/01/2017	16:01:31	187.0041	2.721077	0.821203	3.39	24.04272	381.0859	42.36644	2.858959	-0.55333
7/02/2017	12:20:47	168.4177	1.596722	0.814653	3.88	28.39155	398.9447	42.66622	4.07817	-0.57983
16/01/2016	0.387859	72.68017	0.72627	1.062023	3.84	26.85932	411.3335	38.56584	2.077059	-0.58064
5/01/2017	16:34:55	216.8334	1.888222	1.287134	3.88	37.19553	394.9993	30.62483	4.272979	-0.65941
15/12/2016	15:35:15	38.50583	1.147276	1.56632	3.84	21.1852	389.7715	44.0388	1.254479	-0.87466
24/01/2017	08:03:59	33.4714	0.640795	0.583268	3.84	20.10925	400.7494	61.60706	1.528694	-0.88778
24/01/2017	12:03:01	36.68925	0.707146	0.726676	3.84	26.39313	380.7485	34.87345	3.641825	-0.88778
24/01/2017	08:06:20	46.36025	1.686587	0.308045	3.84	20.01423	393.7726	62.44703	1.530782	-0.88778
24/01/2017	16:09:48	55.35265	0.378558	0.338932	3.84	23.74771	380.5501	43.95444	2.781667	-0.88778
24/01/2017	08:07:34	62.51745	2.366733	0.333754	3.84	20.01946	391.5342	62.94278	1.519589	-0.88778
24/01/2017	16:07:00	74.08629	0.533244	0.576343	3.84	23.84623	380.0435	43.41595	2.833774	-0.88778
13/02/2017	12:13:39	199.5637	2.306807	0.777037	3.39	21.60776	378.9254	48.95789	2.188529	-0.91
13/02/2017	12:12:56	216.1154	2.813601	0.700912	3.39	21.58698	379.1585	49.07171	2.180529	-0.91
16/01/2017	10:27:14	57.97476	0.334765	0.844362	3.88	28.29715	406.6481	34.42117	2.426896	-0.91196
24/01/2017	08:26:37	64.34903	1.078174	0.46686	3.88	19.50733	386.8118	66.49846	1.479493	-0.91196
24/01/2017	08:27:54	68.7244	0.213023	0.245499	3.88	19.49927	386.7326	66.09911	1.529884	-0.91196
30/04/2017	08:22:11	99.18063	0.427122	0.05889	3.88	19.67097	392.7768	52.11689	1.049951	-0.98462
30/04/2017	08:22:59	102.0723	0.485758	0.151869	3.88	19.63544	392.7643	52.11911	1.040178	-0.98462
30/04/2017	12:17:36	105.2871	1.551226	-0.1921	3.88	19.58859	385.9854	43.765	1.26311	-0.98462
30/04/2017	08:23:55	149.3377	1.252503	0.267867	3.88	19.59928	392.7859	52.1578	1.026659	-0.98462

All trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
30/04/2017	08:19:44	91.09778	0.278034	0.351718	3.84	19.61092	394.4722	51.73217	1.035653	-1.0556
30/04/2017	08:18:20	104.7752	0.675547	0.427397	3.84	19.58896	395.9205	51.88119	1.029526	-1.0556
30/04/2017	08:15:46	105.6591	1.029665	0.294085	3.84	19.48869	395.4945	52.00799	1.028135	-1.0556
30/04/2017	08:16:13	105.8231	0.944619	0.308933	3.84	19.50026	397.282	51.93584	1.029672	-1.0556
30/04/2017	12:21:58	125.8648	0.841306	-0.06697	3.84	19.72004	385.7936	43.31962	1.266642	-1.0556
30/04/2017	12:23:00	128.7805	1.541263	0.079298	3.84	19.70541	386.5283	43.00602	1.259748	-1.0556
30/04/2017	12:23:47	129.1303	1.061267	0.11302	3.84	19.70134	386.2413	43.05787	1.259888	-1.0556
30/04/2017	12:20:39	162.5906	1.209906	0.17842	3.84	19.74501	386.5363	44.08909	1.241351	-1.0556
30/04/2017	12:19:43	170.0183	1.132214	0.230841	3.84	19.66425	385.7708	43.43245	1.245544	-1.0556
7/02/2017	12:02:16	225.6258	2.314821	0.811784	3.84	27.64203	393.0588	42.11204	3.584857	-1.18807
21/02/2017	16:00:56	144.7855	0.973536	0.650109	3.39	31.60721	386.0654	23.1302	5.900549	-1.19333
21/02/2017	16:00:16	150.3102	0.507909	0.76153	3.39	31.5812	386.4917	23.05873	6.371493	-1.19333
24/01/2017	08:21:29	99.95063	2.024399	0.158384	3.84	19.30313	386.6725	66.95602	1.486753	-1.36577
24/01/2017	08:20:47	102.124	1.455063	0.131743	3.84	19.28705	386.8404	67.14743	1.473221	-1.36577
24/01/2017	08:20:01	119.5387	1.834768	0.089007	3.84	19.31312	386.9456	67.13129	1.48098	-1.36577
7/02/2017	08:05:48	27.59571	0.250573	0.551072	3.84	19.27721	400.1629	59.34506	1.653926	-1.37012
7/02/2017	16:10:41	33.69429	1.430278	0.188609	3.84	31.89752	386.2648	38.98211	5.961649	-1.37012
7/02/2017	16:11:34	36.83117	1.415797	0.137629	3.84	31.7251	385.9092	39.11194	5.301971	-1.37012
7/02/2017	16:12:21	56.30712	2.032634	0.510089	3.84	31.59774	385.577	39.11008	5.604244	-1.37012
30/04/2017	08:11:46	128.8606	2.621977	0.089557	3.84	19.35635	394.9211	52.99644	1.015629	-1.51548
30/04/2017	08:10:18	141.5973	2.57606	0.089724	3.84	19.27643	395.2954	53.79391	0.995269	-1.51548
31/01/2017	12:10:37	151.8863	1.932943	1.361837	3.88	26.08428	380.3675	35.4414	3.639248	-1.52432
31/01/2017	16:15:01	216.355	2.628594	0.610289	3.88	23.50454	381.9486	44.6053	2.757906	-1.52432
13/02/2017	15:59:32	282.1654	2.330148	0.443296	3.88	23.24123	381.6488	48.35943	2.424996	-1.64195
22/03/2017	08:20:47	17.96344	0.753687	-0.01469	3.88	19.82681	389.3564	71.68047	0.617137	-1.70769
22/03/2017	08:19:49	20.89803	0.823502	-0.01333	3.88	19.8565	389.5333	71.75091	0.614448	-1.70769
22/03/2017	08:16:50	22.45764	0.167955	-0.06265	3.88	19.78637	388.8484	72.31176	0.603206	-1.70769
22/03/2017	12:16:27	112.123	1.679944	0.334968	3.88	20.88421	384.3564	65.72875	0.790442	-1.70769
22/03/2017	12:17:27	145.6975	1.375916	0.19811	3.88	20.87072	384.1181	65.76867	0.796934	-1.70769
13/02/2017	12:05:38	318.2866	2.209523	0.445465	3.88	20.8363	380.382	51.14851	1.949576	-1.64195
22/03/2017	12:15:29	244.1838	2.554589	0.331727	3.88	20.86462	384.4176	66.02784	0.785485	-1.70769
22/03/2017	08:03:54	23.91153	0.480464	-0.02825	3.84	20.32589	390.7532	70.40681	0.669411	-1.83918
22/03/2017	08:04:27	24.29776	0.263463	-0.0338	3.84	20.28752	390.5385	70.58613	0.663067	-1.83918
22/03/2017	08:02:58	25.70261	0.419781	-0.02599	3.84	20.37172	390.771	70.08714	0.678763	-1.83918
23/12/2016	16:04:13	247.2682	1.858166	0.763482	3.84	32.13012	394.9756	27.9093	3.349017	-1.95487

All trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
6/04/2017	08:24:44	41.10785	0.220551	0.297125	3.39	24.86693	390.0237	24.62683	2.329611	-2.09333
6/04/2017	08:26:42	41.99745	0.177062	0.211425	3.39	25.04227	389.9979	24.29411	2.361019	-2.09333
6/04/2017	08:25:34	44.29699	0.436886	-0.08772	3.39	24.93655	390.4309	24.9675	2.342889	-2.09333
6/04/2017	12:26:36	61.00112	0.411583	0.098754	3.39	30.82966	385.9105	17.55262	3.587044	-2.09333
6/04/2017	12:24:49	76.60546	0.172943	0.378792	3.39	31.31515	386.0128	17.33202	3.684147	-2.09333
6/04/2017	12:27:32	82.30306	0.572821	0.290085	3.39	30.62683	386.0663	17.57548	3.543477	-2.09333
12/04/2017	12:09:09	172.8595	0.842811	0.233373	3.39	22.61596	382.7426	46.16602	1.435115	-2.09333
12/04/2017	12:10:06	70.84862	0.720524	-0.07195	3.39	22.65367	382.5016	46.50319	1.446076	-2.10667
12/04/2017	12:10:59	73.13792	1.007184	0.043794	3.39	22.68494	382.515	46.34314	1.444454	-2.10667
31/01/2017	12:19:50	216.8665	1.352309	0.736493	3.84	26.25104	380.6832	35.42043	3.63016	-2.11859
28/02/2017	08:23:51	46.53277	0.253813	0.153821	3.39	32.6933	389.7581	19.68005	6.514119	-2.12667
12/04/2017	16:17:09	12.83078	0.514532	0.063195	3.84	20.52295	384.9903	50.41889	1.152477	-2.23211
12/04/2017	16:16:24	13.06906	0.460166	-0.03216	3.84	20.51964	384.8098	50.33726	1.159626	-2.23211
12/04/2017	08:03:32	29.11136	0.295422	0.016504	3.84	18.8104	388.7208	58.16706	0.871172	-2.23211
12/04/2017	08:02:39	29.23722	0.683912	0.066234	3.84	18.807	389.3315	58.07174	0.87125	-2.23211
8/03/2017	16:07:42	43.12267	1.144133	0.383742	3.39	31.31184	385.696	24.24959	3.370659	-2.44333
8/03/2017	16:08:23	46.53629	0.902995	0.304045	3.39	31.17072	385.5385	24.29925	3.340419	-2.44333
8/03/2017	16:09:41	59.05201	0.258834	0.039179	3.39	30.95838	384.9858	24.61671	3.318787	-2.44333
8/03/2017	12:20:04	179.2436	2.755543	0.787031	3.39	32.86579	390.0631	25.94211	3.682085	-2.44333
12/04/2017	16:15:44	11.14422	0.358642	0.067686	3.84	20.5146	384.7831	50.2931	1.154372	-2.49016
12/04/2017	16:15:44	11.14422	0.358642	0.067686	3.84	20.5146	384.7831	50.2931	1.154372	-2.49016
12/04/2017	16:13:53	20.78549	0.397094	-0.02993	3.84	20.55604	384.698	49.96095	1.160883	-2.49016
12/04/2017	16:12:12	21.20182	0.4314	0.005526	3.84	20.64345	384.647	49.66965	1.180092	-2.49016
12/04/2017	08:10:03	23.66216	0.51626	0.172488	3.84	19.18892	388.462	57.07757	0.916438	-2.49016
12/04/2017	08:07:43	28.59711	0.890235	0.113203	3.84	18.99172	389.8875	58.07869	0.886968	-2.49016
12/04/2017	08:09:25	29.63588	0.514839	0.151068	3.84	19.14672	388.7633	57.30265	0.910838	-2.49016
13/02/2017	16:16:17	85.74039	1.941372	0.156969	3.84	22.07675	380.3358	48.96418	2.352417	-2.49992
13/02/2017	16:17:09	86.63364	2.432294	0.197568	3.84	21.96939	380.3146	49.43961	2.318825	-2.49992
14/03/2017	08:33:45	39.59717	0.512748	0.334233	3.84	24.40323	399.5164	59.97449	1.176668	-2.54163
27/03/2017	16:19:51	29.4134	0.644494	0.334319	3.84	22.93182	383.5735	45.38413	1.45345	-2.59651
27/03/2017	16:19:02	33.69677	0.493383	0.235459	3.84	23.13637	383.1169	44.67905	1.499898	-2.59651
27/03/2017	08:04:43	73.61875	0.40031	-0.00171	3.84	21.30786	383.8586	61.50364	0.944092	-2.59651
27/03/2017	08:05:50	94.20934	0.545655	-0.04524	3.84	21.31398	383.4064	61.67049	0.943392	-2.59651
28/02/2017	16:07:20	159.5791	0.561782	1.088587	3.88	38.86849	383.9795	16.32139	12.32563	-2.61758
28/02/2017	16:05:47	216.5661	0.713886	0.767734	3.88	38.93726	383.9185	16.24765	12.07909	-2.61758
28/02/2017	16:05:07	240.2112	0.550956	1.11991	3.88	38.95272	383.918	16.29406	11.90236	-2.61758
21/02/2017	08:06:32	23.29278	0.998541	0.632545	3.84	22.49594	407.3375	43.71885	2.223864	-2.64261
21/02/2017	08:05:20	32.6828	1.381778	0.522133	3.84	22.37358	405.5862	43.50165	2.21838	-2.64261
12/04/2017	16:08:48	17.14995	0.299154	0.065615	3.88	20.83304	384.5609	49.10155	1.212433	-2.82516
12/04/2017	16:09:35	17.48661	0.34304	0.101037	3.88	20.80838	384.5984	49.13046	1.206742	-2.82516
12/04/2017	08:16:59	27.78276	0.768335	-0.03954	3.88	19.63845	386.326	57.32922	0.950433	-2.82516
12/04/2017	08:15:39	29.36262	0.254657	0.025691	3.88	19.54851	386.7748	57.38177	0.940855	-2.82516
18/04/2017	12:05:52	102.3164	0.540716	0.58424	3.39	31.29533	385.9137	38.04931	2.806456	-2.87667
27/03/2017	16:19:50	27.25952	0.436291	0.206795	3.88	22.93637	383.59	45.36607	1.455201	-2.87705
27/03/2017	16:20:26	31.2317	0.632576	0.169408	3.88	22.74664	383.1899	45.98255	1.425383	-2.87705
27/03/2017	08:18:14	47.23661	0.258188	0.01432	3.88	21.45786	381.6741	60.96223	0.955041	-2.87705
27/03/2017	08:17:44	68.49944	0.313147	-0.04632	3.88	21.47562	381.6125	61.08894	0.962236	-2.87705
27/03/2017	08:17:21	69.80832	0.235629	0.068365	3.88	21.49405	381.7221	61.15883	0.950043	-2.87705
13/02/2017	16:11:56	172.9455	2.23837	0.47264	3.84	22.23072	379.4913	48.31463	2.360123	-2.88434
28/02/2017	12:04:59	331.0075	0.904724	1.034434	3.88	40.91692	385.2153	13.60833	14.09495	-2.61758

All trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
8/03/2017	08:20:57	31.80547	0.966958	0.014964	3.88	24.812	401.3403	41.37	1.808184	-3.0362
8/03/2017	08:23:31	38.57593	0.751609	0.053376	3.88	25.0248	399.6825	41.68907	1.817757	-3.0362
8/03/2017	16:03:26	41.92084	0.465442	0.604633	3.88	31.61021	386.567	24.69576	3.437459	-3.0362
8/03/2017	08:27:47	42.37224	1.487358	0.211408	3.88	25.55187	399.7008	40.00333	1.932034	-3.0362
8/03/2017	08:24:35	45.86044	1.406361	0.034232	3.88	25.11393	399.5592	41.40001	1.839177	-3.0362
8/03/2017	16:04:10	55.74033	0.695364	0.372816	3.88	31.57415	386.3802	24.63239	3.45958	-3.0362
8/03/2017	16:02:09	60.03032	0.836858	0.239775	3.88	31.6571	387.3782	25.15662	3.449604	-3.0362
8/03/2017	08:29:16	86.19003	0.382298	0.16502	3.88	25.79135	399.1276	39.26746	2.00998	-3.0362
6/04/2017	08:08:43	22.49229	0.556823	0.070643	3.84	23.45612	392.2314	27.66306	2.068738	-3.27042
6/04/2017	08:07:57	24.91776	0.729459	0.107397	3.84	23.33579	392.131	27.89085	2.045751	-3.27042
6/04/2017	16:12:49	26.09512	1.289669	0.075178	3.88	28.22335	391.7467	18.76806	3.055718	-3.35449
6/04/2017	16:14:16	27.44399	1.022847	0.121732	3.88	28.24366	391.0625	18.84104	3.052188	-3.35449
18/04/2017	16:10:46	15.35867	0.18782	0.027431	3.84	27.65371	385.7474	23.32959	2.791684	-3.43505
18/04/2017	16:08:45	20.48249	0.286611	0.005064	3.84	27.74339	385.6185	23.11626	2.816331	-3.43505
18/04/2017	16:08:03	20.7331	0.545348	-0.04321	3.84	27.77107	386.1383	23.10402	2.820182	-3.43505
18/04/2017	08:08:30	80.18861	0.766117	0.093909	3.84	23.25579	389.1655	36.28234	1.790104	-3.43505
18/04/2017	08:09:06	81.66973	1.140767	0.000393	3.84	23.30728	388.9375	36.03738	1.808935	-3.43505
18/04/2017	08:08:01	87.44356	1.075053	0.037213	3.84	23.21333	389.2849	36.53934	1.781796	-3.43505
8/03/2017	08:07:48	34.36715	0.787249	0.242452	3.84	22.99283	409.96	45.1921	1.496016	-3.637
8/03/2017	08:09:12	51.36986	0.956448	0.116006	3.84	23.18347	408.2134	44.70814	1.537711	-3.637
8/03/2017	08:10:03	56.71564	0.871887	0.183588	3.84	23.31008	407.8224	44.56482	1.550124	-3.637
18/04/2017	15:56:38	17.07657	0.438605	0.049784	3.88	28.51261	384.9239	21.50442	3.020197	-3.83884
18/04/2017	15:57:48	20.16922	0.460546	0.101542	3.88	28.41944	385.0916	21.55316	3.002842	-3.83884
18/04/2017	15:58:46	47.42412	0.320553	0.128333	3.88	28.39406	384.8993	21.5926	2.997575	-3.83884
18/04/2017	08:14:34	66.19981	0.473379	0.108844	3.88	23.84385	388.7249	35.21125	1.878868	-3.83884
18/04/2017	08:15:23	71.96874	0.580249	0.115767	3.88	23.8962	388.4898	35.25195	1.881969	-3.83884
18/04/2017	12:13:13	210.298	0.61145	0.188854	3.88	32.23083	385.2191	35.13889	3.07293	-3.83884
6/04/2017	08:20:10	34.62804	0.482672	-0.03296	3.84	24.35781	393.9041	26.32238	2.218954	-4.01842
6/04/2017	08:18:17	38.68408	0.383254	0.107457	3.84	24.19796	393.1066	26.20362	2.194282	-4.01842
8/03/2017	12:10:54	340.9009	0.504421	0.241018	3.84	31.29957	391.2917	28.97012	3.232251	-4.558
8/03/2017	12:19:51	316.2873	1.615407	0.33328	3.84	23.09744	382.7287	45.68916	1.480242	-4.558
28/02/2017	08:11:57	40.69624	0.34183	0.789724	3.84	30.74303	389.0933	22.16737	5.350066	-4.07603
28/02/2017	16:01:30	110.256	0.374672	0.673808	3.84	39.05282	383.7542	15.91041	11.95813	-4.07603
18/04/2017	16:03:35	31.84497	0.429827	0.041782	3.84	28.05622	385.2197	22.26908	2.892131	-4.26075
18/04/2017	16:02:49	32.47187	0.491861	0.108317	3.84	28.10498	385.6042	22.21768	2.901589	-4.26075
18/04/2017	08:11:37	61.44038	0.683851	0.192539	3.84	23.58748	388.2201	35.31453	1.846822	-4.26075
18/04/2017	08:10:58	69.75383	0.891609	0.06203	3.84	23.51037	388.3716	35.77736	1.8356	-4.26075
18/04/2017	08:12:25	72.52905	0.763952	0.261841	3.84	23.68981	387.8916	35.03129	1.858859	-4.26075
18/04/2017	12:18:04	91.06811	1.193648	0.751544	3.84	32.74781	385.0399	34.42912	3.155867	-4.26075
8/03/2017	08:10:34	21.00552	0.297383	0.006122	3.84	20.0134	394.218	72.88162	0.593049	-4.558
8/03/2017	08:12:38	21.93218	0.218823	0.295057	3.84	23.70102	406.846	43.86332	1.599033	-4.558
8/03/2017	08:06:40	22.01078	0.743897	0.057585	3.84	20.14581	392.7668	71.42594	0.632733	-4.558
8/03/2017	08:07:31	23.48992	0.260244	0.053726	3.84	20.09966	392.9004	71.74052	0.626195	-4.558
8/03/2017	08:08:58	23.54411	0.556241	0.056302	3.84	20.05663	393.5209	72.23289	0.608708	-4.558
8/03/2017	08:13:56	24.47424	0.288893	0.229352	3.84	23.89287	405.2303	43.05158	1.648389	-4.558



All trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm	Tair (°C)	CO2R (µm	RH_R %	VpdA (kP	Ψ_{pd} (MPa)
8/03/2017	08:17:44	27.90391	0.164825	0.166532	3.84	24.48046	403.2921	40.90989	1.780425	-4.558
8/03/2017	08:15:15	28.82904	0.294796	0.135732	3.84	24.10102	404.2389	42.21325	1.70432	-4.558
8/03/2017	08:16:34	28.99392	0.234446	0.117345	3.84	24.30545	403.2149	41.44962	1.749707	-4.558
8/03/2017	16:12:13	67.36386	1.879779	0.182487	3.84	21.46036	383.2765	62.99186	0.907596	-4.558
8/03/2017	16:11:13	69.91938	1.859226	-0.05457	3.84	21.4878	383.0948	62.95358	0.923455	-4.558
8/03/2017	16:11:57	72.73855	0.48681	0.609595	3.84	30.90302	385.4219	24.92361	3.268903	-4.558
8/03/2017	16:10:22	85.02811	1.686508	0.158692	3.84	21.57119	383.062	62.69911	0.919488	-4.558
8/03/2017	08:13:08	89.7409	0.49774	0.029569	3.84	21.58855	382.6742	61.66448	0.955354	-4.558
8/03/2017	12:23:15	104.6005	0.833645	0.209471	3.84	20.83536	383.4844	65.7613	0.799931	-4.558
8/03/2017	12:22:24	110.1546	0.883459	0.230353	3.84	20.82012	383.4707	65.61733	0.801068	-4.558
8/03/2017	12:21:34	116.439	0.982725	0.164099	3.84	20.83559	383.4917	65.55061	0.804338	-4.558
8/03/2017	16:12:32	132.6771	1.393466	0.756467	3.84	30.78583	385.3646	25.1301	3.221989	-4.558
8/03/2017	16:12:59	218.0159	1.527898	0.163418	3.84	30.73324	385.4233	25.25312	3.256997	-4.558

6. Assimilation rate and different predawn water potential, PAR 340-1400 (µmol m^{-2} s^{-1})

Total photosynthesis measurements of 112, within PAR 340-1400 (µmol m^{-2} s^{-1}) for tree 1 (blue), tree 2 (red), tree 3 (green) and tree 4 (purple).

trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm	Tair (°C)	CO2R (µm	RH_R %	VpdA (kP	Ψ_{pd} (MPa)
8/03/2017	12:10:54	340.9009	0.504421	0.241018	3.84	31.29957	391.2917	28.97012	3.232251	-4.558
21/02/2017	12:05:05	342.6927	1.430791	0.526356	3.88	29.66446	384.7647	24.04968	5.166151	-1.90489
7/02/2017	12:23:25	362.7648	2.259291	0.598918	3.88	28.12177	395.198	42.89156	4.230554	-0.57983
7/02/2017	16:00:09	369.1856	3.375918	1.748281	3.88	32.41026	386.7655	37.33169	6.046784	-0.57983
21/02/2017	12:14:38	371.4794	2.820316	1.329521	3.39	31.84966	383.6972	21.18457	6.536673	-1.19333
22/12/2016	12:07:57	377.6811	2.757734	1.932066	3.84	34.262	388.1434	26.52657	3.780541	-0.87466
24/01/2017	12:17:49	386.831	2.499824	0.901985	3.84	24.17479	381.7935	43.19045	2.82424	
28/02/2017	15:55:37	402.0974	0.777233	1.687363	3.84	39.49665	383.986	15.6245	12.59404	-5.2042
6/04/2017	12:11:14	402.2453	0.707296	0.329022	3.84	30.40415	387.094	17.43534	3.551328	-4.01842
5/01/2017	14:37:12	416.7519	3.49796	1.270609	3.84	26.54982	380.6149	45.17316	1.779969	-0.23035
5/01/2017	16:19:33	427.4767	2.207308	1.498452	3.84	35.36817	398.8304	32.93936	3.715685	-0.33185
31/01/2017	12:18:57	430.4593	2.977454	0.556769	3.84	26.325	380.468	35.62624	3.729209	-2.11859
21/02/2017	16:41:40	432.61	0.730284	1.072661	3.84	33.80843	386.6441	19.76343	7.300041	-3.09436
7/02/2017	16:00:08	437.4482	2.998842	1.742208	3.88	32.40853	386.7791	37.33544	6.02494	
7/02/2017	16:00:08	437.4482	2.998842	1.742208	3.88	32.40853	386.7791	37.33544	6.02494	-0.57983
12/04/2017	12:22:24	454.0817	1.423904	0.065573	3.84	24.66699	383.2628	42.64735	1.753778	-2.23211
24/01/2017	16:09:00	461.8109	1.865932	0.655598	3.88	23.40989	382.4769	42.13808	2.789955	-0.91196
21/02/2017	16:24:49	463.7959	1.751456	0.839789	3.88	31.49549	384.9476	22.73861	5.992878	-1.90489
5/01/2017	16:24:44	466.1721	0.716425	1.055026	3.84	36.13757	398.3773	31.64987	3.999886	-0.33185
28/02/2017	12:21:16	470.1631	1.157318	1.269424	3.84	42.41931	384.1513	12.9793	16.56672	-5.2042
21/02/2017	16:38:38	475.9668	2.043892	0.911932	3.84	33.00173	386.8676	21.35744	6.915443	-3.09436
31/01/2017	12:18:57	476.6714	3.465968	0.556769	3.84	26.325	380.468	35.62624	3.729209	-2.11859
21/02/2017	16:37:29	482.073	1.315258	1.02872	3.84	32.66766	386.8768	21.67813	6.581534	-3.09436
8/03/2017	12:06:08	494.68	1.986347	0.658078	3.84	30.25017	394.7706	30.96562	2.957554	-4.558
28/02/2017	12:06:14	498.4879	0.800604	2.355478	3.88	40.92402	384.8399	13.65515	13.93323	-2.61758
7/02/2017	16:01:09	499.8419	2.195801	1.832425	3.88	32.54524	386.7047	37.31265	5.824824	-0.57983
21/02/2017	12:03:53	527.1432	1.828182	0.846042	3.88	29.44978	385.119	24.44347	4.942514	-1.90489
21/02/2017	12:23:17	531.5028	0.717593	0.60132	3.84	32.8082	383.7409	20.7046	7.041242	-2.64261
7/02/2017	15:57:36	543.7118	2.760731	1.284042	3.88	32.21064	388.6317	37.2645	5.777815	-0.57983
8/03/2017	12:34:10	544.2136	0.473152	0.323025	3.84	34.75902	387.7529	23.39892	4.233037	-3.637
8/03/2017	12:18:55	545.857	1.818558	0.212804	3.84	23.03642	382.7978	45.55185	1.49166	-4.558
21/02/2017	12:21:02	548.2382	1.554491	0.681466	3.84	32.71413	383.1012	20.86516	7.091518	-2.64261
8/03/2017	12:20:32	554.9251	1.892232	0.25111	3.84	23.14232	382.7316	45.68132	1.498784	-4.558
28/02/2017	12:20:03	561.6694	1.724458	1.470371	3.84	42.26028	384.1287	13.14588	16.13635	-5.2042
28/02/2017	12:21:56	563.3805	0.929996	0.83798	3.84	42.47095	384.3421	12.99994	16.59891	-5.2042
12/04/2017	12:17:11	570.0503	1.318403	0.287656	3.84	23.6146	383.275	43.07207	1.628636	-2.49016
28/02/2017	12:25:05	592.6117	0.373027	1.521011	3.84	42.44251	384.0186	12.87061	16.40826	-5.2042
11/01/2017	0.667477	598.8388	2.869538	1.375565	3.88	27.08367	379.9547	42.92157	1.922259	-1.1576
11/01/2017	0.665706	605.4138	3.083803	1.187594	3.88	27.1118	380.161	43.00306	1.965857	-1.1576
21/02/2017	16:23:36	628.5167	1.851672	0.780061	3.88	31.22425	385.2569	22.9929	5.844114	-1.90489
8/03/2017	12:19:08	630.5468	3.790529	0.910773	3.39	32.73494	390.0418	25.98226	3.646065	-2.44333
22/12/2016	12:06:56	645.6377	3.888307	1.939246	3.84	34.22451	388.4497	26.64653	3.766753	
21/02/2017	12:12:27	658.6602	3.414053	1.107848	3.39	31.26412	384.5573	22.14301	6.230458	-1.19333
24/01/2017	12:02:15	658.7491	3.571599	0.850313	3.84	26.27174	380.7245	34.92379	3.588197	-0.88778
11/01/2017	15:25:27	666.6396	3.466674	1.023617	3.88	25.71646	381.9975	47.44978	1.672743	-1.1576
11/01/2017	0.666725	667.3364	2.840494	1.497614	3.88	27.17535	380.1352	42.84874	1.942077	-1.1576
7/02/2017	12:01:40	668.5096	3.890669	0.723549	3.84	27.50941	393.4609	42.16021	3.508316	
21/02/2017	16:26:14	675.1687	1.262453	0.795751	3.88	31.77242	385.1534	22.63701	6.002263	-1.90489
8/03/2017	12:08:00	676.6614	2.071245	0.575053	3.84	30.72888	393.2295	29.83769	3.087468	-4.558

trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
5/01/2017	9:35:24	686.7009	2.031924	0.599316	3.84	30.72779	404.4874	32.52438	2.91634	-0.23035
21/02/2017	12:02:56	692.3488	1.514352	0.298485	3.88	29.20615	385.4887	24.92251	4.889086	-1.90489
8/03/2017	12:21:42	701.2217	1.004376	0.37002	3.84	23.3075	382.1721	44.90398	1.535089	-4.558
8/03/2017	16:11:11	701.8592	0.696193	0.358362	3.84	23.22886	383.1833	46.75696	1.468233	-4.558
8/03/2017	16:11:41	702.3728	1.272212	0.312673	3.84	23.28762	383.1164	46.67895	1.47713	-4.558
24/01/2017	12:02:31	714.6784	3.790836	0.665503	3.88	25.04724	385.2192	41.80233	2.759739	
8/03/2017	16:08:54	752.1685	1.258148	0.341816	3.84	22.84289	383.2538	47.04137	1.429167	-4.558
8/03/2017	12:05:11	759.4382	2.252911	0.546487	3.84	30.03162	396.0205	31.31545	2.911195	-4.558
21/02/2017	16:26:14	767.7504	1.634731	0.795751	3.88	31.77242	385.1534	22.63701	6.002263	-1.90489
16/01/2017	12:21:38	767.9918	0.557951	1.143879	3.88	38.24114	384.4841	16.78898	10.43981	-0.91196
21/02/2017	16:22:56	789.7325	2.062285	0.563943	3.88	31.09181	385.3259	23.19123	5.789621	-1.90489
28/02/2017	15:54:48	791.542	0.952753	1.216302	3.84	39.34815	384.0456	15.68589	12.42959	-5.2042
16/01/2017	0.596111	795.6324	3.180806	1.585664	3.88	38.88795	330.0304	12.58116	-0.03951	-0.91196
16/01/2016	0.582569	805.7762	0.587581	1.682365	3.84	37.08568	386.0995	17.13565	9.753399	-0.58064
21/02/2017	12:20:01	812.1167	1.640986	0.791378	3.84	32.53171	383.002	21.2861	6.930235	-2.64261
16/01/2016	0.504549	813.7483	2.621438	2.371728	3.84	41.20492	384.3708	15.03565	13.66943	-0.58064
24/01/2017	16:07:53	821.9245	2.55606	0.844422	3.88	23.24827	382.5251	42.17704	2.700652	-0.91196
28/02/2017	15:54:03	826.2853	0.554198	0.655004	3.84	39.2699	384.2313	15.75463	12.25812	-5.2042
28/02/2017	15:56:54	849.5076	0.627381	0.643607	3.84	39.64669	383.72	15.51429	12.89776	-5.2042
8/03/2017	12:30:41	867.4865	0.552343	0.353868	3.84	33.9319	388.1375	24.10753	4.01291	-3.637
24/01/2017	16:03:36	870.4304	3.66061	1.135457	3.39	23.40136	383.0488	42.76546	2.710688	
21/02/2017	12:26:11	884.4026	1.158586	0.600871	3.84	33.37817	383.6776	19.87247	7.376626	-2.64261
16/01/2016	0.583264	887.9205	1.533492	2.046044	3.84	37.23032	385.9609	17.0404	9.843558	-0.58064
11/01/2017	0.646678	890.4644	2.278755	0.03092	3.88	25.76325	381.9773	47.23727	1.741204	-1.1576
27/03/2017	12:26:19	904.3276	3.212422	0.515678	3.84	24.29792	381.8381	44.10544	1.685934	-2.59651
28/02/2017	12:16:35	914.827	1.230399	1.128117	3.84	42.01524	384.3733	13.22713	15.54418	-5.2042
12/04/2017	12:16:14	927.6464	2.668427	0.379552	3.84	23.42403	382.6071	43.69131	1.601784	-2.49016
12/04/2017	12:15:38	929.8652	2.255186	0.5118	3.84	23.30978	382.6344	44.1296	1.569405	-2.49016
16/01/2017	12:14:35	931.5386	3.702984	5.466779	3.39	39.83991	383.7059	15.64172	12.1131	-0.30144
22/12/2016	12:02:09	951.1956	3.630079	1.725984	3.84	33.57791	389.5244	27.16914	3.691056	
23/12/2016	14:15:30	957.0463	1.670426	3.03076	3.39	33.41695	387.1496	26.78196	3.598154	-0.79729
5/01/2017	16:37:30	957.4864	3.90752	1.989313	3.88	36.98681	394.2553	31.30635	4.140742	-0.65941
18/04/2017	12:02:26	1017.766	2.255714	0.657179	3.39	30.73164	385.9619	39.86341	2.631746	-2.87667
6/04/2017	12:16:35	1022.344	0.824934	0.24509	3.84	31.21373	386.4421	17.44568	3.726873	-3.27042
27/03/2017	12:27:30	1029.81	2.4045	0.218738	3.84	24.55652	381.8348	43.99234	1.727779	-2.59651
16/01/2016	0.583889	1039.671	2.546062	2.394468	3.84	37.31182	386.1162	17.09767	9.82899	-0.58064
6/04/2017	12:15:55	1054.077	0.86316	0.359864	3.84	31.0934	386.3706	17.4844	3.709724	-3.27042
16/01/2017	14:07:08	1067.918	3.89467	3.199135	3.39	38.34328	386.0239	16.55996	11.03824	-0.30144
5/01/2017	15:05:16	1082.713	1.838159	0.376978	3.84	25.48614	382.6948	47.79557	1.681116	-0.23035
6/04/2017	12:14:58	1086.795	0.822263	0.260961	3.84	30.95296	386.3323	17.56997	3.67898	-3.27042
12/04/2017	12:13:30	1088.224	1.090994	0.193437	3.84	23.05742	382.8049	45.46666	1.530963	-2.49016
24/01/2017	12:13:38	1090.813	3.753357	1.281399	3.39	24.03449	382.7737	41.45866	2.763441	
22/12/2016	12:05:31	1094.898	3.655084	1.825914	3.84	33.9747	388.4426	27.50071	3.68842	
8/03/2017	12:33:09	1108.358	0.862438	0.360168	3.84	34.48007	387.7259	23.80496	4.165376	-3.637
5/01/2017	16:33:35	1117.327	2.573644	1.436291	3.88	37.21253	395.7104	30.52758	4.303212	-0.65941
6/04/2017	12:14:17	1118.043	0.521637	0.169321	3.84	30.87879	386.6039	17.5343	3.682146	-3.27042
18/04/2017	12:01:39	1134.01	1.496626	0.466589	3.39	30.66247	386.2397	39.95498	2.625831	-2.87667
18/04/2017	12:09:50	1134.255	1.421836	0.629453	3.88	31.89687	385.4679	36.62622	2.958798	-3.83884
27/03/2017	12:29:04	1139.547	1.744495	0.194995	3.84	24.79659	381.6488	43.17603	1.785138	-2.59651
8/03/2017	12:31:59	1166.324	0.632136	0.29404	3.84	34.17705	387.7207	23.90504	4.095253	-3.637

trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (r	Area (Cm	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
21/02/2017	12:18:28	1209.9	1.323951	0.879156	3.84	32.26868	383.292	21.27503	6.693084	-2.64261
21/02/2017	12:22:22	1218.448	0.828507	0.372965	3.84	32.70753	383.4704	20.84393	7.045464	-2.64261
18/04/2017	12:03:09	1220.645	2.541374	0.566987	3.39	30.8047	386.081	39.77055	2.64909	-2.87667
18/04/2017	12:17:21	1244.331	2.604248	0.795783	3.84	32.65442	385.1377	34.38251	3.17917	-4.26075
23/12/2016	14:13:29	1246.678	1.455356	2.808895	3.39	32.92077	387.3752	27.99231	3.441083	-0.79729
12/04/2017	12:20:37	1273.042	1.567802	0.242141	3.84	24.43194	383.0176	42.09	1.77431	-2.23211
18/04/2017	12:12:13	1287.969	0.983424	0.402099	3.88	32.175	385.3166	35.6855	3.093052	-3.83884
18/04/2017	12:16:41	1296.203	2.156142	0.732821	3.84	32.53452	385.2138	34.2892	3.172848	-4.26075
21/02/2017	12:10:15	1306.465	2.911724	1.034065	3.39	30.61678	384.3083	22.77881	5.64622	-0.91
12/04/2017	12:18:14	1307.436	1.894678	0.258653	3.84	23.78326	383.0558	42.58304	1.683819	-2.49016
18/04/2017	12:15:59	1348.514	2.669467	0.908774	3.84	32.45322	385.3241	34.28461	3.144645	-4.26075
22/12/2016	11:54:54	1354.944	3.556921	1.223928	3.84	31.58094	392.1227	29.81015	3.197246	
28/02/2017	12:09:23	1370.126	0.996645	0.683215	3.39	41.30057	385.2224	13.85112	14.36983	-2.12667

7. Assimilation response from 94 photosynthesis measurements.

Total photosynthesis measurements with PAR 340-1400 (µmol m^{-2} s^{-1}) for tree 1 (blue), tree 2 (red), tree 3 (green) and tree 4 (purple).

trees	HHMMSS	PAR (µmol	A (µmol CO	Trmmol (	Area (Cm2	Tair (°C)	CO2R (µm	RH_R %	VpdA (kPa	Ψ_{pd} (MPa)
5/01/2017	9:35:24	687	2.0	0.60	3.8	31	404	33	2.9	-0.23
5/01/2017	15:05:16	1083	1.8	0.38	3.8	25	383	48	1.7	-0.23
5/01/2017	16:19:33	427	2.2	1.50	3.8	35	399	33	3.7	-0.33
5/01/2017	16:24:44	466	0.7	1.06	3.8	36	398	32	4.0	-0.33
7/02/2017	12:23:25	363	2.3	0.60	3.9	28	395	43	4.2	-0.58
7/02/2017	16:00:08	437	3.0	1.74	3.9	32	387	37	6.0	-0.58
7/02/2017	16:01:09	500	2.2	1.83	3.9	33	387	37	5.8	-0.58
7/02/2017	15:57:36	544	2.8	1.28	3.9	32	389	37	5.8	-0.58
16/01/2016	13:58:54	806	0.6	1.68	3.8	37	386	17	9.8	-0.58
16/01/2016	12:06:33	814	2.6	2.37	3.8	41	384	15	13.7	-0.58
16/01/2016	13:59:54	888	1.5	2.05	3.8	37	386	17	9.8	-0.58
16/01/2016	14:00:48	1040	2.5	2.39	3.8	37	386	17	9.8	-0.58
5/01/2017	16:33:35	1117	2.6	1.44	3.9	37	396	31	4.3	-0.66
23/12/2016	14:15:30	957	1.7	3.03	3.4	33	387	27	3.6	-0.80
23/12/2016	14:13:29	1247	1.5	2.81	3.4	33	387	28	3.4	-0.80
22/12/2016	12:07:57	378	2.8	1.93	3.8	34	388	27	3.8	-0.87
24/01/2017	12:17:49	387	2.5	0.90	3.8	24	382	43	2.8	-0.89
21/02/2017	12:10:15	1306	2.9	1.03	3.4	31	384	23	5.6	-0.91
24/01/2017	16:09:00	462	1.9	0.66	3.9	23	382	42	2.8	-0.91
16/01/2017	12:21:38	768	0.6	1.14	3.9	38	384	17	10.4	-0.91
16/01/2017	14:18:24	796	3.2	1.59	3.9	39	330	13	0.0	-0.91
24/01/2017	16:07:53	822	2.6	0.84	3.9	23	383	42	2.7	-0.91
11/01/2017	16:01:10	599	2.9	1.38	3.9	27	380	43	1.9	-1.16
11/01/2017	15:58:37	605	3.1	1.19	3.9	27	380	43	2.0	-1.16
11/01/2017	16:00:05	667	2.8	1.50	3.9	27	380	43	1.9	-1.16
11/01/2017	15:31:13	890	2.3	0.03	3.9	26	382	47	1.7	-1.16
21/02/2017	12:14:38	371	2.8	1.33	3.4	32	384	21	6.5	-1.19
21/02/2017	12:05:05	343	1.4	0.53	3.9	30	385	24	5.2	-1.90
21/02/2017	16:24:49	464	1.8	0.84	3.9	31	385	23	6.0	-1.90
21/02/2017	12:03:53	527	1.8	0.85	3.9	29	385	24	4.9	-1.90
21/02/2017	16:23:36	629	1.9	0.78	3.9	31	385	23	5.8	-1.90
21/02/2017	16:26:14	675	1.3	0.80	3.9	32	385	23	6.0	-1.90
21/02/2017	12:02:56	692	1.5	0.30	3.9	29	385	25	4.9	-1.90
21/02/2017	16:26:14	768	1.6	0.80	3.9	32	385	23	6.0	-1.90
21/02/2017	16:22:56	790	2.1	0.56	3.9	31	385	23	5.8	-1.90
31/01/2017	12:18:57	430	3.0	0.56	3.8	26	380	36	3.7	-2.12
28/02/2017	12:09:23	1370	1.0	0.68	3.4	41	385	14	14.4	-2.13
12/04/2017	12:22:24	454	1.4	0.07	3.8	25	383	43	1.8	-2.23
12/04/2017	12:20:37	1273	1.6	0.24	3.8	24	383	42	1.8	-2.23
12/04/2017	12:17:11	570	1.3	0.29	3.8	24	383	43	1.6	-2.49
12/04/2017	12:16:14	928	2.7	0.38	3.8	23	383	44	1.6	-2.49
12/04/2017	12:15:38	930	2.3	0.51	3.8	23	383	44	1.6	-2.49
12/04/2017	12:13:30	1088	1.1	0.19	3.8	23	383	45	1.5	-2.49
12/04/2017	12:18:14	1307	1.9	0.26	3.8	24	383	43	1.7	-2.49
27/03/2017	12:26:19	904	3.2	0.52	3.8	24	382	44	1.7	-2.60
27/03/2017	12:27:30	1030	2.4	0.22	3.8	25	382	44	1.7	-2.60
27/03/2017	12:29:04	1140	1.7	0.19	3.8	25	382	43	1.8	-2.60
28/02/2017	12:06:14	498	0.8	2.36	3.9	41	385	14	13.9	-2.62
21/02/2017	12:23:17	532	0.7	0.60	3.8	33	384	21	7.0	-2.64

21/02/2017	12:21:02	548	1.6	0.68	3.8	33	383	21	7.1	-2.64
21/02/2017	12:20:01	812	1.6	0.79	3.8	33	383	21	6.9	-2.64
21/02/2017	12:26:11	884	1.2	0.60	3.8	33	384	20	7.4	-2.64
21/02/2017	12:18:28	1210	1.3	0.88	3.8	32	383	21	6.7	-2.64
21/02/2017	12:22:22	1218	0.8	0.37	3.8	33	383	21	7.0	-2.64
18/04/2017	12:02:26	1018	2.3	0.66	3.4	31	386	40	2.6	-2.88
18/04/2017	12:01:39	1134	1.5	0.47	3.4	31	386	40	2.6	-2.88
18/04/2017	12:03:09	1221	2.5	0.57	3.4	31	386	40	2.6	-2.88
21/02/2017	16:41:40	433	0.7	1.07	3.8	34	387	20	7.3	-3.09
21/02/2017	16:38:38	476	2.0	0.91	3.8	33	387	21	6.9	-3.09
21/02/2017	16:37:29	482	1.3	1.03	3.8	33	387	22	6.6	-3.09
6/04/2017	12:16:35	1022	0.8	0.25	3.8	31	386	17	3.7	-3.27
6/04/2017	12:15:55	1054	0.9	0.36	3.8	31	386	17	3.7	-3.27
6/04/2017	12:14:58	1087	0.8	0.26	3.8	31	386	18	3.7	-3.27
6/04/2017	12:14:17	1118	0.5	0.17	3.8	31	387	18	3.7	-3.27
8/03/2017	12:34:10	544	0.5	0.32	3.8	35	388	23	4.2	-3.64
8/03/2017	12:30:41	867	0.6	0.35	3.8	34	388	24	4.0	-3.64
8/03/2017	12:33:09	1108	0.9	0.36	3.8	34	388	24	4.2	-3.64
8/03/2017	12:31:59	1166	0.6	0.29	3.8	34	388	24	4.1	-3.64
18/04/2017	12:09:50	1134	1.4	0.63	3.9	32	385	37	3.0	-3.84
18/04/2017	12:12:13	1288	1.0	0.40	3.9	32	385	36	3.1	-3.84
6/04/2017	12:09:36	347	0.2	0.17	3.8	30	387	18	3.5	-4.02
6/04/2017	12:11:14	402	0.7	0.33	3.8	30	387	17	3.6	-4.02
18/04/2017	12:17:21	1244	2.6	0.80	3.8	33	385	34	3.2	-4.26
18/04/2017	12:16:41	1296	2.2	0.73	3.8	33	385	34	3.2	-4.26
18/04/2017	12:15:59	1349	2.7	0.91	3.8	32	385	34	3.1	-4.26
8/03/2017	12:10:54	341	0.5	0.24	3.8	31	391	29	3.2	-4.56
8/03/2017	12:06:08	495	2.0	0.66	3.8	30	395	31	3.0	-4.56
8/03/2017	12:18:55	546	1.8	0.21	3.8	23	383	46	1.5	-4.56
8/03/2017	12:20:32	555	1.9	0.25	3.8	23	383	46	1.5	-4.56
8/03/2017	12:08:00	677	2.1	0.58	3.8	31	393	30	3.1	-4.56
8/03/2017	12:21:42	701	1.0	0.37	3.8	23	382	45	1.5	-4.56
8/03/2017	16:11:11	702	0.7	0.36	3.8	23	383	47	1.5	-4.56
8/03/2017	16:11:41	702	1.3	0.31	3.8	23	383	47	1.5	-4.56
8/03/2017	16:08:54	752	1.3	0.34	3.8	23	383	47	1.4	-4.56
8/03/2017	12:05:11	759	2.3	0.55	3.8	30	396	31	2.9	-4.56
28/02/2017	15:55:37	402	0.8	1.69	3.8	39	384	16	12.6	-5.20
28/02/2017	12:21:16	470	1.2	1.27	3.8	42	384	13	16.6	-5.20
28/02/2017	12:20:03	562	1.7	1.47	3.8	42	384	13	16.1	-5.20
28/02/2017	12:21:56	563	0.9	0.84	3.8	42	384	13	16.6	-5.20
28/02/2017	12:25:05	593	0.4	1.52	3.8	42	384	13	16.4	-5.20
28/02/2017	15:54:48	792	1.0	1.22	3.8	39	384	16	12.4	-5.20
28/02/2017	15:54:03	826	0.6	0.66	3.8	39	384	16	12.3	-5.20
28/02/2017	15:56:54	850	0.6	0.64	3.8	40	384	16	12.9	-5.20
28/02/2017	12:16:35	915	1.2	1.13	3.8	42	384	13	15.5	-5.20

8. Power significance

A t-Test using online computing and the comparative statistical model VassarStats.

Sample size	Predawn range (MPa)	Assimilation Mean (μmol CO2 m^{-2} s^{-1})	Probability- One tailed, reference sample=A'	Probability- One tailed, reference sample=C	Probability- One tailed, reference sample=D
A'=22	Predawn (0,-1)	2.1	-	-	-
B=13	Predawn (-1,-2)	2.1	0.4772	-	-
C=22	Predawn (-2,-3)	1.7	0.0444	-	-
D=13	Predawn (-3,-4)	0.9	<.0001	0.0001	-
E=24	Predawn ≤ -4	1.3	0.0004	0.0340	0.0221