



On-Farm Water Demand

DEFINING AGRICULTURAL WATER USE AND ITS VALUE IN
THE WARREN-DONNELLY CATCHMENT



Australian Government
Department of Agriculture,
Fisheries and Forestry



Centre for Crop and
Disease Management



Curtin Biometry and
Agricultural Data Analytics

Curtin University



Department of
Primary Industries and
Regional Development



SWAN
systems
Scheduling water and nutrients



South-West WA
Drought Resilience Adoption
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Acknowledgements

Grateful acknowledgement is made for the information and time committed by the following growers featured in this booklet: The Radomiljac family, Rose Yeoman and Paul Robinson, Mark Bending, Andy and Sheralee Stoddart and Bevan Eatts.

The On-Farm Water Demand project was led by the Centre for Crop and Disease Management at Curtin University. The project team would like to acknowledge the financial support from the Department of Agriculture Fisheries and Forestry, Department of Primary Industries and Regional Development (WA), Southern Forest Food Council, SWAN Systems and Food Agility CRC. Extension of the learnings from this project has been aligned with the South-West WA Drought Resilience Adoption and Innovation Hub through the South-West WA Drought Resilience and Innovation Hub and Grower Group Alliance).

On-Farm Water Demand: Defining agricultural water use and its value in the Warren-Donnelly catchment.

Cover Photo: ©Julia Easton

Project Code: FA022 and RES-61416

ISBN: 978-0-6481940-6-4 (printed) 978-0-6481940-5-7 (online)

Published September 2026

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This case study report has drawn on a number of outputs (including submissions, presentations, progress updates and other materials) generated over the lifespan of the project. Subsequently, this final report is the synthesis of many outputs and the contribution of all project team members and project participants is gratefully acknowledged.

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Introduction

Bevan Eatts is no stranger to promoting the food and its economic importance produced from the Warren-Donnelly catchment in the south-west of WA. In 2012, Bevan was Chair of the Southern Forest Food Council, which was successful in obtaining funding to develop the brand 'Genuinely Southern Forest' to promote the region's produce.

"Margaret River is famous around the world for its wine and within the Southern Forests region we grow a huge range of produce but no one really knew we existed," explains Bevan Eatts.

"Farming was, and still is, a critical part of the region's economy. There were no corporate farms, it was all family farms that were being handed down to sons and daughters.

"We developed a brand that could be used across all the commodities to promote the produce from our region which was very exciting.

"Within three years we got the Genuinely brand recognition up to about 50 percent from surveys we did across the state."

Limits on water use

While the community was working hard to promote its produce, questions were being asked about water use in agriculture across the region.

In the Warren-Donnelly Catchment area, if water is being drawn from a spring or a river a water licence is required. However, if a grower has a dam that's situated off a defined waterway, a licence isn't needed.

"One of the objectives of the Food Council was to grow the value of agriculture," explains Bevan.

"On one hand we were working with the Department of Primary Industry and Regional Development WA (DPIRD) trying to increase agricultural production. However, on the other hand, the messaging from the Department of Water and Environmental Regulation (DWER) indicated that we were approaching a key resource limit.

"This uncertainty contributed to a division in the community where people that had been long lifelong friends stopped talking to each other."

Introducing the Genuinely Southern Forest brand was successful in raising the profile of fruit and vegetables from the Warren-Donnelly Catchment. Photo: Southern Forest Food Council



Farmers believe in not using every last drop of dam water to future proof themselves against future dry years. Photo: Julia Easton



While Bevan recognises the importance of using water efficiently, he believes this fundamental difference in thinking is a real challenge for the industry.

“Farmers try to drought proof ourselves by keeping a reserve in the dams for next year just in case we don’t get a wet winter.

“That means you can still grow some crops and create an income.”

These challenges led the Southern Forest Food Council to think about how they could both help heal the community and also continue to help farmers expand their operations. Bevan then approached Mark Gibberd from Curtin University’s Centre for Crop and Disease Management. Together it was decided the best approach was to independently develop the data sets that allowed both the industry and government agencies to see the true value of an industry.

Defensible data set

When the Southern Forests Food Council started, Bevan believed the value of agriculture in the Shire of Manjimup was \$127 million and it has since grown to about \$247 million. However, future growth faces real headwinds if the value of water used in agriculture in the region is not understood by the broader community.

“While as farmers we are always looking to be more efficient with our water use, we need to continue to grow and keep drought proofing so we can continue to be a food bowl for WA,” Bevan says.

“It is so important to have this data set so we can explain to government departments the value of the water we use in our community.

“Irrigated agriculture means we have families living here, it creates jobs and then you have all the support

businesses, and other supporting jobs like teachers and you have nurses, it keeps the community strong and stops rural communities from dying.

“So the data set that’s coming out will shine a light on how important this region is for horticulture and for food security for both the state and country.

“Hopefully the results from this project allows the Department staff to consider the impact that reducing water licences has on our local and state economy.”

Making better decisions

Aside from this project producing a defensible data set, Bevan believes it will be very useful to help growers

make more informed decisions about what crops they grow both now and into the future.

“If a farmer is considering expanding their business, they will have a better handle on how much water they will need and what the returns on that water will be,” Bevan says.

“The reality is that we are looking at a drying climate and so if we can have information, we can make informed business decisions rather than emotive or speculative decisions. Ultimately this will assist the industry to be more economically sustainable and for farmers to continue to invest and stay on the land hopefully a lot longer.”



Bevan Eatts, Former Chair of Southern Forest Food Council. Photo: Kelly Cussons

Balancing the debate

The government has a responsibility to regulate water use and agriculture has a requirement to remain viable. That was the conundrum faced by the communities of Manjimup and Pemberton when the Southern Forest Food Council approached Mark Gibberd, Director of the Centre for Crop and Disease Management (CCDM) for help.

Understanding the value of water use on farm

“When you consider what we understand about the ‘value’ of water, there’s a lot known about the importance of water for the natural environment, there is a wealth of data and mature models to determine the supply side, including the role of climate, rivers and the importance of wetlands but by comparison there was very little understood about the value of water use on the farm, for this part of the country,” explains Mark Gibberd.

“We were observing a condition whereby there was a mismatch between the volume of information that government and regulators could access that related to decisions around supply.

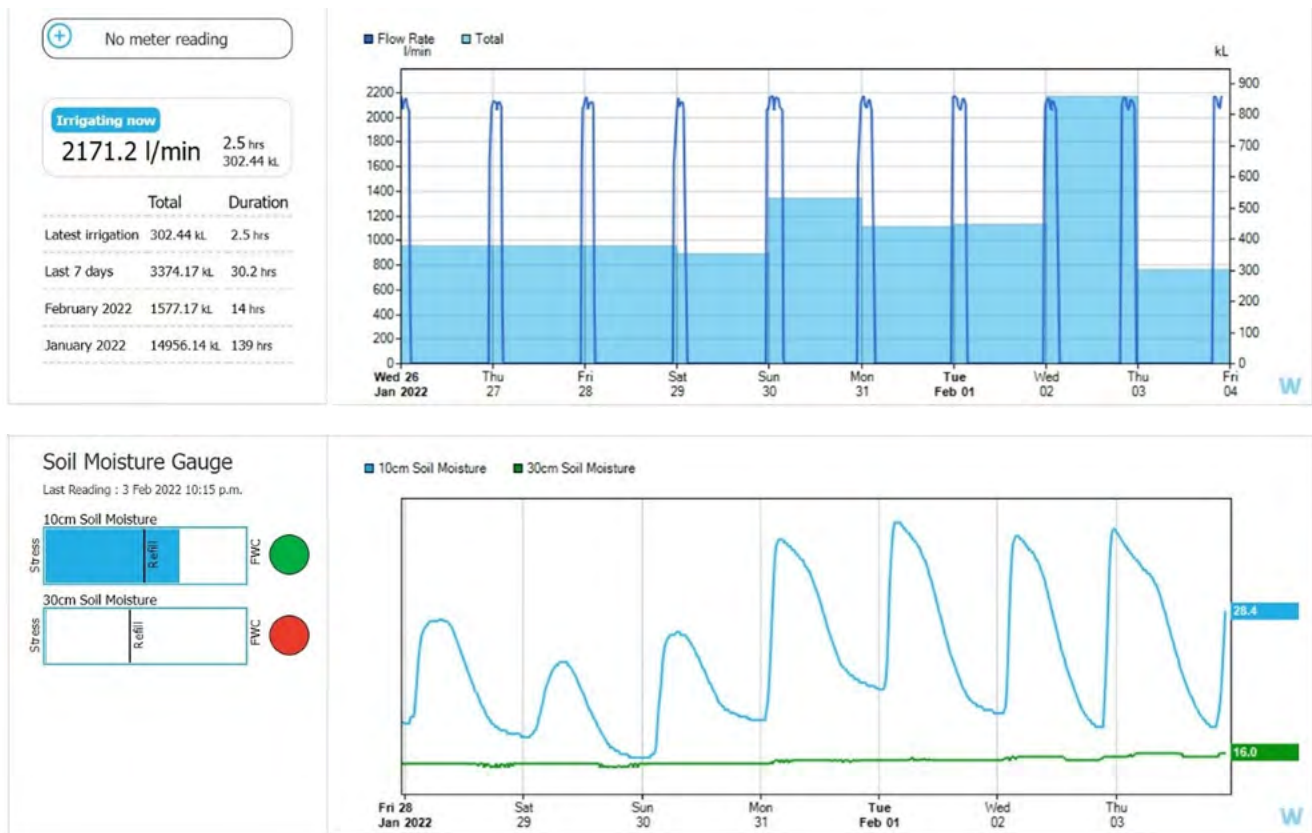
“But there was very little information to balance the debate around the requirement of water for farming and the value of that water to the community and so we sought to help to address that imbalance.

“We certainly don’t criticise the work done in the supply side but for people involved in agriculture, defensible, independent data that allows us to place economic values on options for on farm water use is really important as this allows discussion and decisions to be informed by evidence and hopefully lead to a more balanced outcome.”

A flow meter, soil moisture probes and a IoT data logger was placed on each of the avocado, truffle, apple, potato and wine grape sites. Photo: Danielle Gale



FIGURE 1: Example of output from the WildEye web portal.



Defensible data

The first step the CCDM team made in gathering data on agricultural water use was to understand the planted area of the different commodities and the associated economic value of them.

“In consultation with the Southern Forest Food Council, we picked the top five commodities on the basis of planted area and economic value. Collectively these accounted for over 90 per cent of the irrigated production in the area,” Mark says.

Five to seven growers each of avocados, apples, truffles, potatoes and wine grapes joined the four-year project in 2019. A flow meter, some soil moisture probes and an Internet of Things (IoT) enabled data logger were installed on blocks that represented medium sized businesses across the catchment.

At each site irrigation usage, rainfall, evaporation and soil moisture was measured. Participating farm businesses were able to access their site data using

WildEye and SWAN Systems web portals. The WildEye system provided close to real time irrigation data (See Figure 1) whereas the SWAN Systems portal drew data from the WildEye loggers and weather data from Bureau of Meteorology (BOM) and Department of Primary Industry and Regional Development (DPIRD) (See Figure 2).

Participants in the project also received financial year summaries showing crop demand, or host tree demand in the instance of truffles, versus water applied on a monthly basis (See Figure 3). In addition to receiving data from their own property, they also received data from their cohort showing their individual irrigation quantity compared to their peers in the same crop type (See Figure 4).

Financial information was also confidentially supplied to the CCDM team, so the water productivity and profitability could be compared within a crop type (See Figure 5).

Scaling up

In addition to providing individuals with key water use information, a big part of this project is about understanding agricultural water use and its economic impact across the catchment. Figure 6 highlights the average annual irrigation volumes per crop type over the four years of the project.

The project has created a data set of on-farm water use (irrigation) for 5 crops (apples, avocados, truffles, potatoes and wine grapes) grown in the Warren-Donnelly catchment in the southwest region of WA near Manjimup and Pemberton. Publicly available data (weather observations, crop factors, land use classes etc) have been collated and scaled across the catchment. A model for identifying crop (tree) types using satellite imagery and machine learning was developed to help understand the footprint of each crop across the landscape. Farm and publicly available data was aggregated with sub-catchment scale land use, and landform data, to estimate crop water demand and actual water use. Cost of production has also been

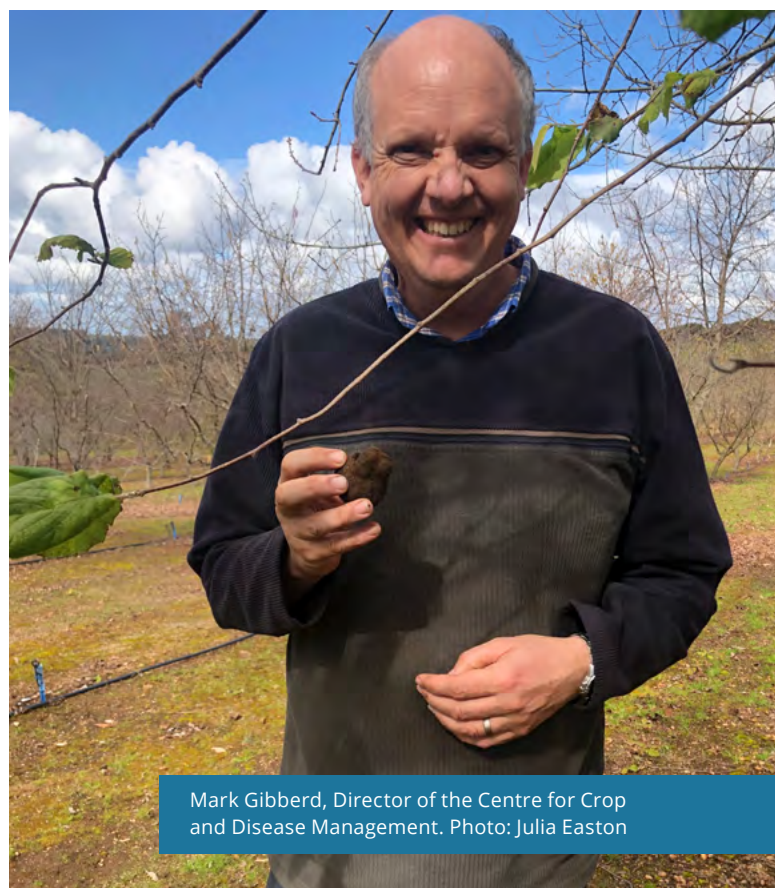
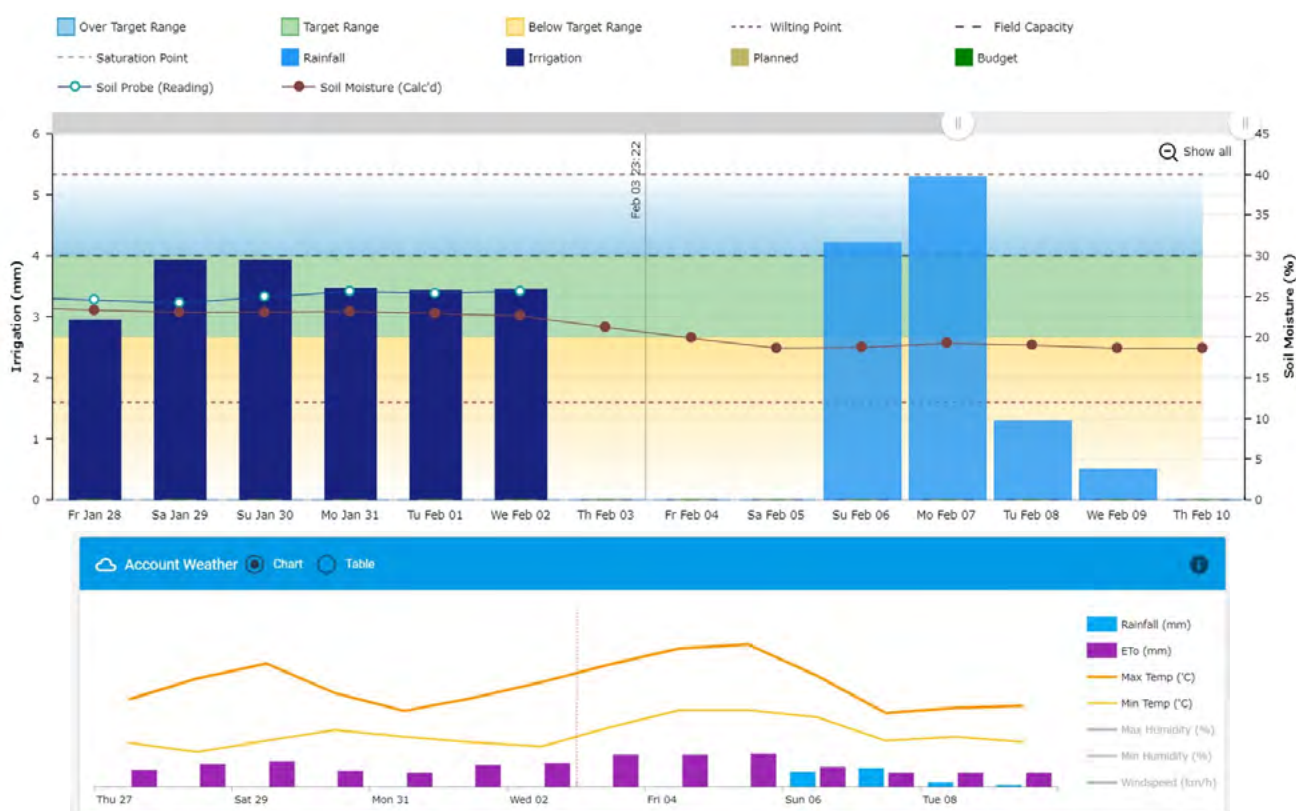


FIGURE 2: Example of output from the SWAN Systems web portal.



assessed in terms of net operating profit per mega-litre of water applied. This will in turn provide data on the net benefit of irrigation to farmers, the Western Australian economy and the flow-on benefits to the community. In addition to the development of the defensible data set of current water use and its economic value, Mark is also interested in what the future looks like.

“I am particularly interested in using the models to see what it looks like in 2050 to understand what adaptations we might need in a future drying climate,” he says.

FIGURE 3: Example of crop water demand (green) compared with evapotranspiration (yellow spots) and total water applied i.e. stacked rainfall (blue) and irrigation (grey). Each data set has been converted to megalitres per hectare (ML/ha)

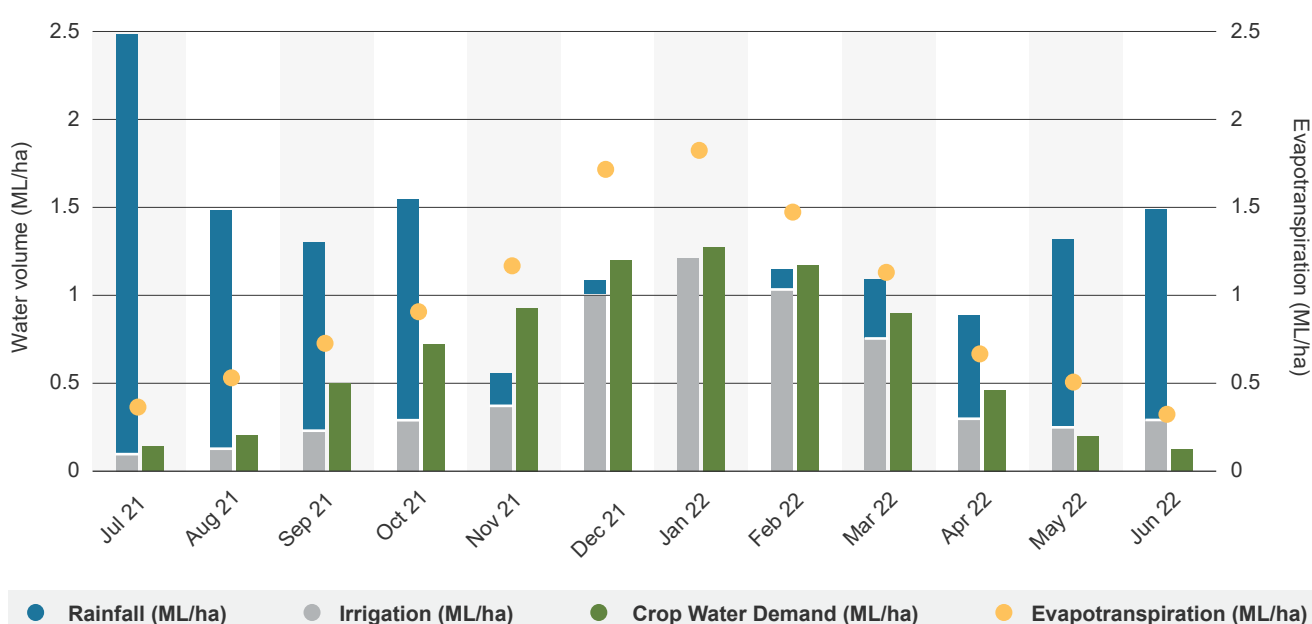


FIGURE 4: Example of monthly applied irrigation across the avocado cohort compared with evapotranspiration (yellow spots).

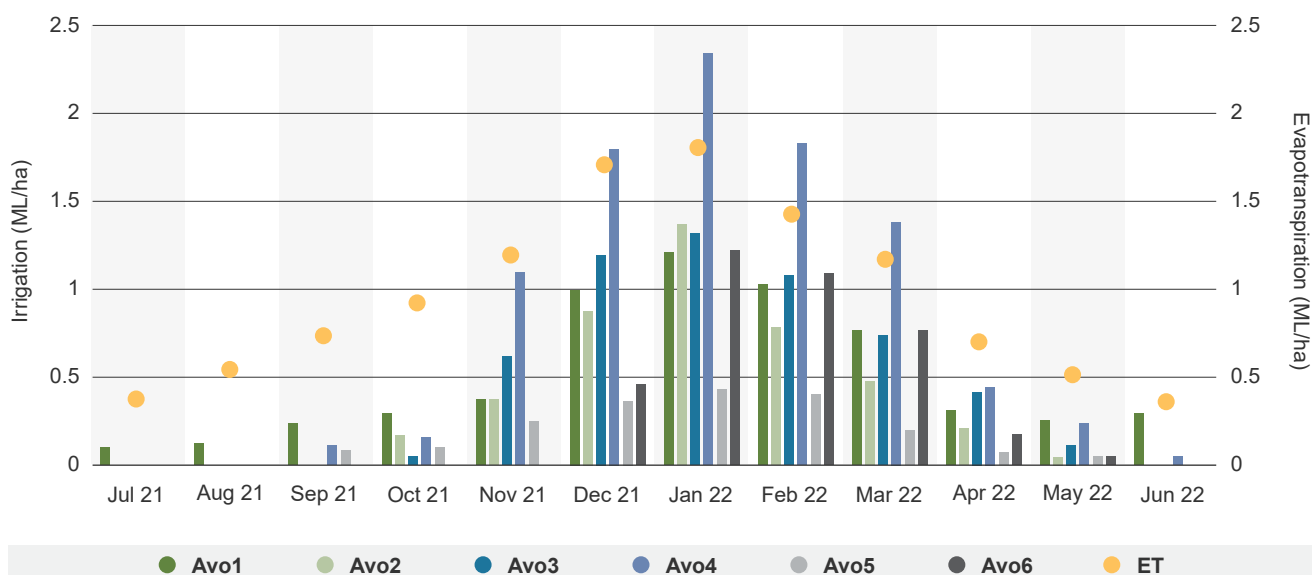
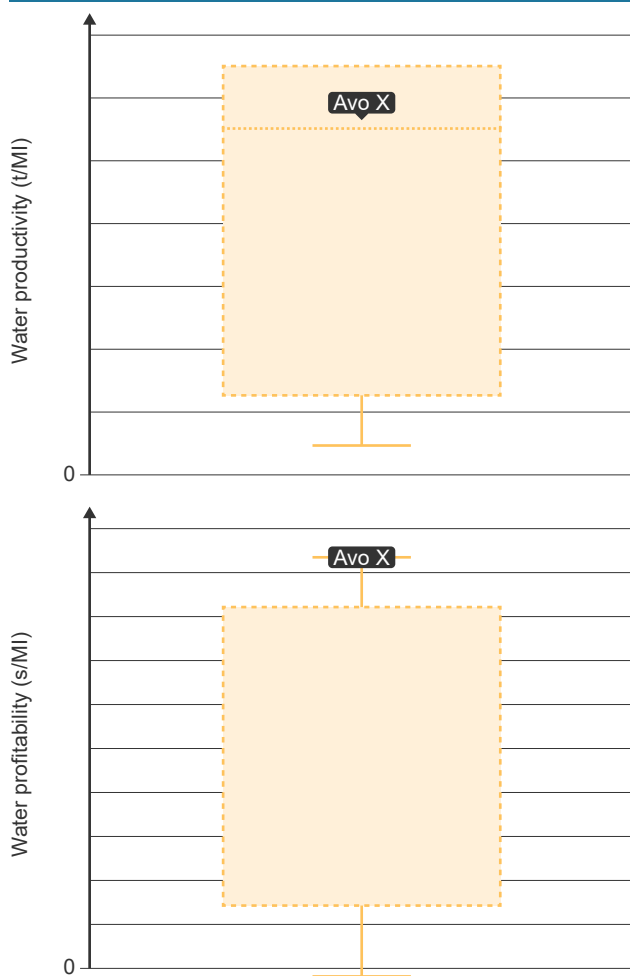
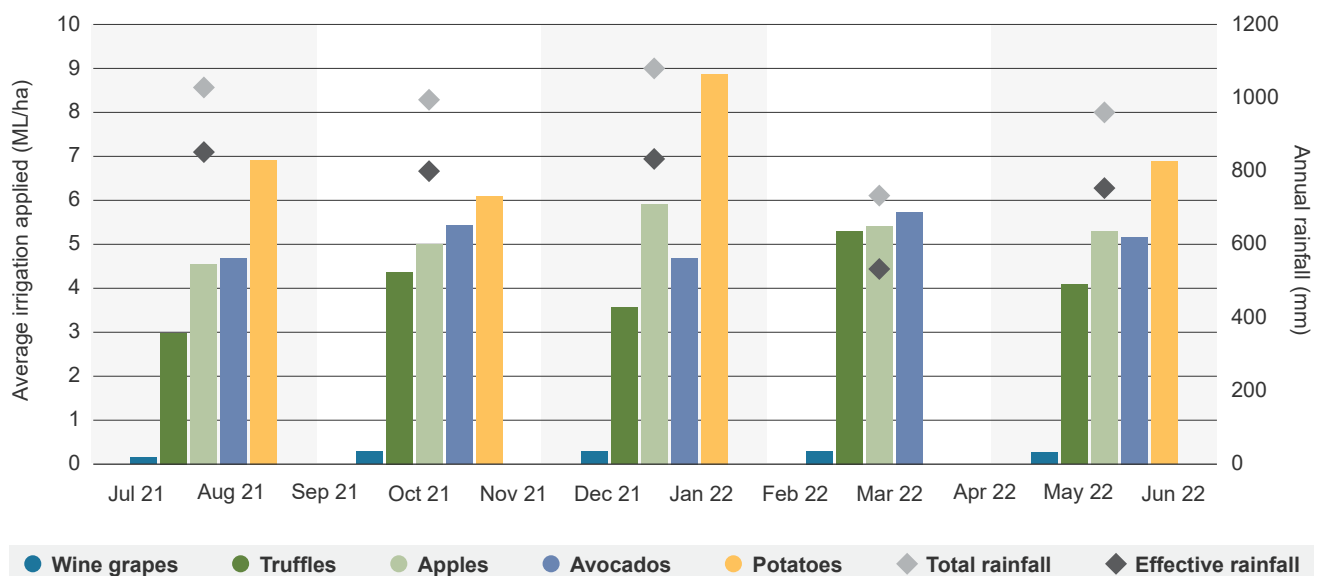


FIGURE 5: Example of water productivity and profitability relative to the cohort.



Developing a defensible data set of estimated crop water demand and actual water use is a key output of this project. Photo: Julia Easton

FIGURE 6: Irrigation volumes (ML/ha) applied and rainfall received for a series of crops (wine grapes, truffles, apples, avocados and potatoes) grown in the Warren-Donnelly catchment near Manjimup in south-west Western Australia, for the 2020 to 2024 growing seasons.



An opportunity to benchmark for Jarnadup Farms

SNAPSHOT

GROWER: Mark Bending, Jarnadup Farms

ENTERPRISE: 3000 avocado trees on 10 ha and finishing beef for Woolworths' Macro Range

SOIL TYPE: Gravel loams

RAINFALL: 1000mm

LOCATION: Manjimup

The opportunity to benchmark the performance of his avocado business against other growers in the region was one of the key reasons why Mark Bending wanted to be involved in the On-Farm Water Demand project.

"The project sounded really interesting to me in terms of the range of different commodities, but also a range of different properties so I could look at what we do here and try and evaluate how we were going across the region," explains Mark Bending.

Pleasingly for Mark, initial data showed that for their water consumption, they are strong performers in terms of both yield and profitability.

Better matching demand

The project has delivered more than just benchmarking. Two soil moisture probes and one flow meter were initially added into one of the avocado blocks and in 2023 this was replicated into another block. Although originally starting with another integrated computerised watering system, Mark switched to the MAIT system which monitors real time water requirements of the orchard as well as tracking its water use.

After considering the water demand and water use data from the first two years of the project, Mark and his Orchard Manager Sheralee Stoddart made the decision to slightly change their approach.



Jarnadup Farms produces avocados and finishes beef for Woolworths' Macro Range. Photo: Kelly Cussons



Andy and Sherallee Stoddart, Farm Managers and Mark Bending, owner of Jarnadup Farms. Photo: Kelly Cussons

"We found we were under watering a little bit through spring and probably over watering a little bit through late autumn, so we've swapped that around," explains Mark.

As a whole, the data generated from the project has meant Mark and Sherallee have better knowledge and are more in control of the decisions they make.

"2024 was a really hot summer so we needed to change our approach and I've tended to do it by gut feeling in the past, whereas now Sherallee can be far more certain that she's making the right choices at the right times, which is really important," Mark says.

Challenging season in 2024

In addition to using the data on a daily basis to inform when to irrigate, Mark and Sherallee will also use the information gathered from previous years to help make decisions when there are similarities in environmental conditions.

"We had such a bad season 2024 as it was so hot and keeping up with irrigation was a bit challenging," Sherallee says.

"So I've been looking back at some of our annual and monthly graphs to determine where I haven't irrigated enough.

"Those graphs are really handy in reflecting on the 2024 season and helping to identify what I can improve on in 2025."

In 2024 yields were down but Mark noted the four previous years saw consistent yields, so he felt they were due for an 'off' year.

"Interestingly it wasn't related to the season so much because the poor fruit set happened back in October or November," Mark says.

In 2025, avocado growers across the region struggled

with early maturing on the trees and fruit drop, which Mark says reflects what happened in 2024.

“So going forward we know that if we see a similar year to 2024, you can be pretty sure that you’re going to suffer the same issues.

“You will just know that come November, the fruit’s going to start dropping and it’s going to go black on the tree.

“Interestingly, we made the decision early in 2024 to pick early so we went to the packing shed and said we need some bins and that was going to be no problem.

“We went back the next week and there were no bins left because everyone had done the same thing,” says Mark.

Importance of defensible data set

Aside from understanding the water use on his own property, Mark is very keen to demonstrate the

importance of water use for agriculture in the Warren-Donnelly catchment.

“We need to demonstrate to the region and others that this is a food bowl for WA and water is fundamental, as it underpins pretty much most of what happens here,” explains Mark.

“Between 50 and 70 per cent of WA’s pome fruits, 50 to 70 percent of potatoes and 70 per cent of the state’s avocados are grown in this region.

“People don’t understand the water that we have here is vital, not just in terms of volume but in terms of quality as well.

“I think that needs to be understood more broadly at the state level, just how important this region is for agriculture.”

Poor fruit set in late spring combined with a really hot summer resulted in lower than average yields in 2024.
Photo: Kelly Cussons





Sheralee Stoddart found using the irrigation data from 2024 really helpful to identify areas for improvement in 2025. Photo: Kelly Cussons

Unlocking the secrets of growing truffles in WA

SNAPSHOT

PAST GROWERS: Rose Yeoman and Paul Robinson

ENTERPRISE: Silverwood Truffles

LOCATION: Manjimup

What do you get when you combine an earth scientist, a biological scientist and a tree crop where there is still so much to learn about? The answer is some very robust discussions!

After purchasing the 32 hectare property in 2008, Rose Yeoman and Paul Robinson planted 2,300 black truffle inoculated oaks and hazels in November 2009. Four years later the first truffles were harvested. Once the trees started producing truffles, they had a period of several years of two- to three-fold annual yield increase. The expectation was this would continue for a further 5 to 8 years before production usually declined.

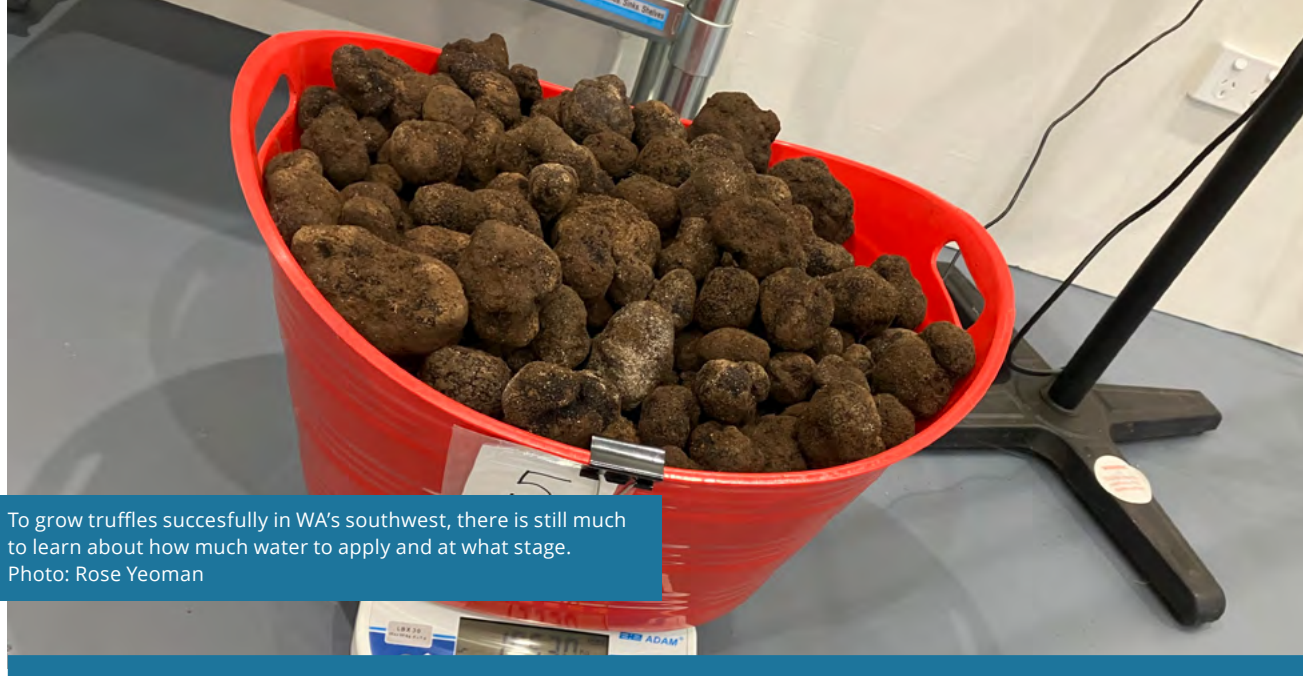
The opportunity to learn more

There is still much to be understood about producing truffles in WA's southwest, including how much water to apply and at what stage. So, when presented with the opportunity to participate in the project, Rose and Paul were keen to be involved.

"For us it wasn't just a matter of how an applied amount of water related to a crop return in dollar value, it was also a matter of benchmarking water applied against yield," explains Rose.



Julia Easton and Paul Robinson are hunting for truffles.
Photo: Rose Yeoman



To grow truffles successfully in WA's southwest, there is still much to learn about how much water to apply and at what stage.
Photo: Rose Yeoman

Understanding the data

Silverwood's truffle orchard is irrigated from two on-farm dams. Irrigation commences in spring and once the summer heat has set in, water is applied to meet the requirements of the host trees as well as maintaining moisture levels for the truffles developing in the soil.

As part of the project, a flow meter was installed in the main irrigation line, and a three-level soil moisture probe was placed in one of the most productive sections of the orchard. The data from the probe sensors and flow meter enabled Rose and Paul to compare the demand of the host trees against the water applied (irrigation plus rainfall). In the first year (Financial Year 2021), over summer, they were applying less than the host tree water demand. They also compared their water use with four other truffle growers in the project and found they were watering significantly less than their peers. As a result, they changed strategy, choosing shorter periods but more frequent watering during summer heat rather than lengthy and deep watering. In autumn, the irrigation was tapered off as days became cooler and rainfall decreased.

Over the four years of the project, the watering of the orchard increased from 15.6 megalitres (ML) in FY2021 to 28.6 ML in FY2024 as a response to drier conditions, increasing size of trees and the need to maintain soil moisture through the dry summer months.

Monitoring water through the profile

For Paul, while understanding how much water they were applying was important, understanding how it moved through the soil profile was just as relevant.

"With deep waterings we saw within 24 hours that the moisture increase "spike" at the 30 centimetres sensor was still quite significant, which meant the water was moving through the profile and being lost to the growing truffles and probably of reduced benefit to the tree," explains Paul.

"So, we changed our strategy to two irrigation periods: a short watering to wet the soil (a "wicking" process) and then a longer watering to replenish the week's moisture lost from soil evaporation and foliage transpiration".

"This results in reduced water wastage."

Variable production

In 2021, Silverwood was in the early stages of its production cycle, producing approximately 300 kilograms (kg) of sold truffle. Production increased to 670 kg in 2022 and approximately 1,240 kg in 2023. However, following an unusually hot summer in 2024, sold truffle production declined to approximately 840 kg.

In 2024 many truffle growers in the southwest region experienced a 30-50 percent decrease in harvest

volume most likely due to the heat stress on the trees.

“One issue for growers is identifying which of the many variables impact production and the reality is that often we just don’t know,” says Rose.

“Our increased production from 300 to 1,240 kg could be attributed to the recognised natural increase for the age of the orchard.

“It could also be other orchard operations or the change in water management, or a combination of these.”

Compared to other truffle orchards, Silverwood’s production was slow to start.

“Whether this was to do with watering or that we have different trees and different tree ratios, we don’t know, but it is possible that our ability to monitor and refine water use has helped to accelerate production,” explains Rose.

Community benefit

For Rose and Paul, aside from learning more about water usage in truffles, they are keen to understand the economic benefit of water across the different crops in the catchment, particularly with diminishing rainfall.

“As farmers we need to consider what crops are best grown in the region and which ones will provide enough return to the grower to continue to grow them,” says Rose.

“It also means as truffle growers we will need to consider more efficient ways of using and delivering water and introduce drought proofing strategies into existing orchards and truffle orchards of the future.”

Aside from the opportunity to learn more about water usage in truffles, Rose Yeoman believes it is important for farmers in the region to understand what crops will provide enough return for growers to continue to grow them. Photo: Rose Yeoman





While truffle production has increased from 300 to 1240 kg at Silverwood Truffles it is difficult to define the key reason for the increase. Photo: Julia Easton

Using data to manage a new wine grapes block removes the guess work

SNAPSHOT

GROWERS: Dave and Monica, Jordan and Tyler Radomiljac

ENTERPRISE: Pemberley of Pemberton; 80 ha wine grapes, 10 ha potatoes, 2 ha truffles, 80 beef cows and marron

RAINFALL: 900-1100 mm

SOIL TYPES: Pemberley site: clay loam, Bellarmine site: gravelly loams

LOCATION: Pemberton

Not many businesses in the Warren-Donnelly catchment have the diversity of enterprise the Radomiljac family does. They grow grapes for their own brand Pemberley of Pemberton and also supply grapes to other vineyards, run a cellar door for wine tastings, often host community events and also grow potatoes, truffles, beef and marron.

As Dave Radomiljac says, “We run a cellar door for wine tastings but we sell the experience of the farm in the food bowl that exists as Pemberley, which essentially is wine but it’s also potatoes, truffles and marron.”

Why be involved?

With much community debate about the value of water, the Radomiljac family were keen to contribute to a defensible data set on the value of water for agriculture use in the region. To be involved in a project that could answer questions like, “What’s the value of water used to irrigate crops?”

As Jordan Radomiljac explains, “With increasing environmental pressure, as farmers we felt we couldn’t answer what the value of water is because there are so many things to take into account such as, How many



Dave (left) and Jordan Radomiljac are keen to know the value of the water used for both their crops and for the benefit it brings to the broader community. Photo: Kelly Cussons



Wine grapes are watered for a four to eight week irrigation window depending on seasonal conditions. Photo: Kelly Cussons

people does it employ? How many school children get taught in town?

“So the original intent of this project was to take a litre of water and say how many jobs does that create in the region and how many tonnes of food does that create in the region and the state?”

Limited irrigation for grapes

The Radomiljac family vineyard focuses on producing really early ripening varieties, which reduces the disease risk as well as limiting the time on the vine to be affected by other agricultural risks such as smoke. Growing early ripening varieties for sparkling wine also reduces the water requirement and produces higher yields.

While some grape growers don't irrigate, the Radomiljac family commonly irrigates from bunch closure to about one week before harvest. Depending on the season, this can mean a four (on a quicker dry season) to eight (on a longer wet season) week irrigation period where the grapes are watered twice per week. Soil moisture probes and flow meters were placed on two sites with different soil types and they were watered for four hours per week on the Pemberly site and 12 hours

on the Bellarmine site, receiving about 14,600 L/hr/site. The sites are connected to a SWAN System so real time water flow is tracked. During the project it was evident from monitoring the real time soil moisture content that the Radomiljacs were able to reduce the Bellarmine irrigating duration from 12 hours a week to only 8 hours a week, reducing the water usage by 25 per cent or 58,400 L each week.

Different seasons

In addition to grapes at Pemberly only having a limited window for irrigation, the four seasons the project has been running have all been very different.

“The first season was so wet that we barely irrigated and then the next season was more of an average season with a standard five to six week watering, but for more than four hours per week,” explains Jordan.

“Then in 2024 it was the hottest we'd ever had so we began watering early and we were watering flat out but we also harvested early.”

Water moves differently in the two blocks

The two sites which had the soil moisture probes and

flow meters are quite different. One site just came into management by the Radomiljacs in 2017 and is a sandy gravelly loam where the vines produce 2-3t/ha. The other site has been managed by the Radomiljacs for 30 years and is more of a clay loam where the vines produce 8-13t/ha.

The data from this project has given the Radomiljacs a greater understanding of the water holding capacity of the different sites. The Bellarmine site that has the gravel soil drains much faster than the other.

"It takes much more water to bring the gravelly soil up to the same soil moisture level and then it has a much quicker drop off," explains Dave.

"The more loamy soil will hold the water for a few days whereas the higher latitude more gravelly soil will drain within a day and a half."

While this information doesn't surprise the Radomiljacs, the data has helped quantify what they expected.

"So now we are reassessing how we best water that gravelly soil site, whether we do it more often and whether we deliver it in larger or smaller doses," adds Jordan.

It is understanding all sites are not the same and require different management is a lesson Dave thinks many could learn from.

"People have just moved sites and replicated what they did before and you just can't," Dave says.

"So we've now got the tool to be able to be one step ahead and we don't have to learn from years of experience.

"We can now just make a more informed decision."

Utilising the information for other crops

At the farm business level, while the flow meters and sensors were placed in two of the Radomiljac's grape blocks, they are keen to learn from the data gathered from the potato growers and especially, the truffle growers in the project. The truffles have been in for eight years and they are about to start production and Dave feels it is difficult to get information about what an efficient watering regime looks like.

"We don't know how much water is too much or not enough or how much we can just get by with," Dave says.

"It does feel like maybe we're not watering enough, but it's not really producing us that much now so can we just keep the trees going and then maybe the truffles will come on later?"

"So in the next 24 months we are going to have to get our heads around what is the optimal system of watering truffles."

The Radomiljac family of Pemberly of Pemberton grow a wide range of crops including grapes (left) and truffles (right). Photo: Kelly Cussons



Next Steps

The project has developed a defensible data set and the research frameworks to collate and analyse these datasets to understand crop water demand and use across the Warren-Donnelly catchment. The work to date has focussed on understanding crop water demand under current and historical conditions, which include declining rainfall and rising temperatures, which are placing increasing pressure on irrigation water supply.

The next step is to look beyond current conditions and assess how water availability for food production may change in the future. By combining the on-farm water use data with long-term climate records and future climate projections, the study aims to better understand how much water key crops will need in the future and where water shortages are most likely to occur.

Importantly, this work provides practical, forward-looking insights for both government and farm businesses. It will deliver tools and maps that estimate future crop water demand and identify potential gaps between water supply and demand across the catchment. This enables more informed decisions about water allocation, crop selection and long-term farm planning, while also supporting regional economic resilience. By linking water use to production systems and future climate risks, the research helps quantify the ongoing value of water for food production and ensures that planning decisions are based on credible, data-driven evidence.

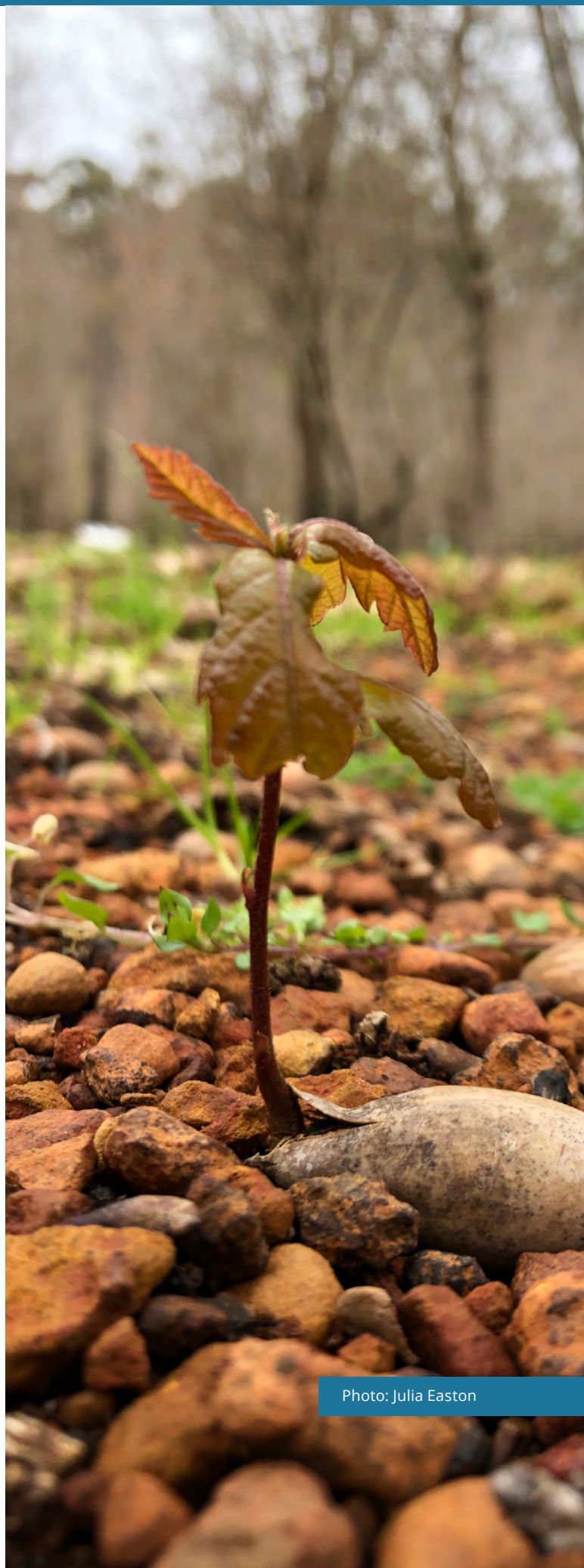
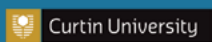


Photo: Julia Easton



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