Drone-Based Multispectral Monitoring of Vegetation Health in Constructed Stormwater Wetlands

Dr Brandon Winfrey, Dr Sabrina Sayers, Liam Pimentel

Monash University

21 October 2025 11:15 AM - 11:35 AM (Session 1)

Water RA Next Water 2025 Conference

Creating Thriving Communities: Water and Liveability

Acknowledgement of Country

Monash University recognises that its Australian campuses are located on the unceded lands of the people of the Kulin Nations, and pays its respects to their Elders, past and present.

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Outline

- Background
- Approach
- Outcome
- Next steps

BACKGROUND

Why do we want to know how vegetation is doing in these wetlands?

Pergamon

Wat. Sci. Tech. Vol. 35, No. 5, pp. 11–17, 1997.
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Printed in Great Britain.
0273–1223/97 $17·00 + 0·00

PII: S0273-1223(97)00047-4

DO MACROPHYTES PLAY A ROLE IN CONSTRUCTED TREATMENT WETLANDS?

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ABSTRACT

The larger aquatic plants growing in wetlands are usually called macrophytes. These include aquatic vascular plants, aquatic mosses and some larger algae. The presence or absence of aquatic macrophytes is one of the characteristics used to define wetlands, and as such macrophytes are an indispensable component of these ecosystems. As the report... constructed wetlands are based on physical and microbial processes... role of the macrophytes has been questioned. This paper summarizes how macrophytes influence the treatment processes in wetlands.

The most important functions of the macrophytes in relation to the treatment of wastewater are the physical effects the plants have on the environment. The presence of the plants stabilizes the bed and provides good conditions for physical filtration and prevent vertical flow systems from clogging. Furthermore, the plants insulate the surface against frost during winter, and provide huge surface area for attached microbial growth. Contrary to earlier belief, the presence of macrophytes does not increase the hydraulic conductivity of the substrate in soil-based subsurface flow constructed wetlands. The macrophytes affect the treatment processes to different extents depending on the type of wetland and the nutrients in question. The quantitative importance in low-loaded systems (surface flow systems) of macrophyte mediated transfer of oxygen to the rhizosphere by leakage from roots increases aerobic degradation of organic matter and nitrification. The macrophytes have additional site-specific values by providing habitat for wildlife and making wastewater treatment systems aesthetically pleasing. © 1997 IAWQ. Published by Elsevier Science Ltd

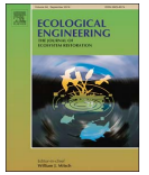
YES!

Ecological Engineering 116 (2018) 80–86

Contents lists available at ScienceDirect

Ecological Engineering

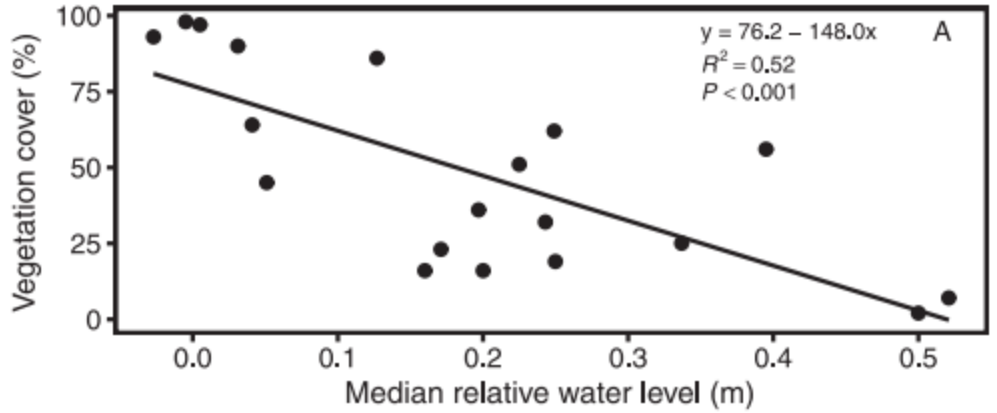
journal homepage: www.elsevier.com/locate/ecoleng



Identifying critical inundation thresholds to maintain vegetation cover in stormwater treatment wetlands

J.J. Robertson[a], T.D. Fletcher[a], A. Danger[b], C. Szota[a,*]

[a] School of Ecosystem and Forest Sciences, The University of Melbourne, Australia
[b] Melbourne Water Corporation, Australia



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BACKGROUND

Water level experiments at Troups Creek Wetland, Narre Warren, VIC

NOVATECH 2023

Activating lazy stormwater wetlands through real-time monitoring and control

Activation des zones humides d'eaux pluviales paresseuses grâce à un suivi et un contrôle en temps réel

Canwei Pang[1], Baiqian Shi[1], Stephen Catsamas[1], Xixi Shi[1], Miao Wang[1], Tim Fletcher[2], Rhys Coleman[3], David Bergmann[4], David McCarthy*[1]

Are there trade-offs when controlling water levels for water quality improvement vs vegetation health using RTC?

Figure 1: (a) Site Map of Troups Creek Wetland and the RTC control points. (b) Cabinet setup for the actuators installed at the control points. The actuator is placed behind the back of the cabinet.

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BACKGROUND

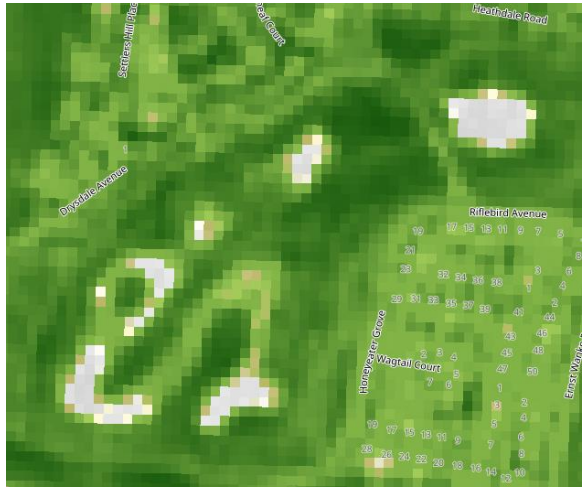
Plant surveys: Fun, but a lot of work!

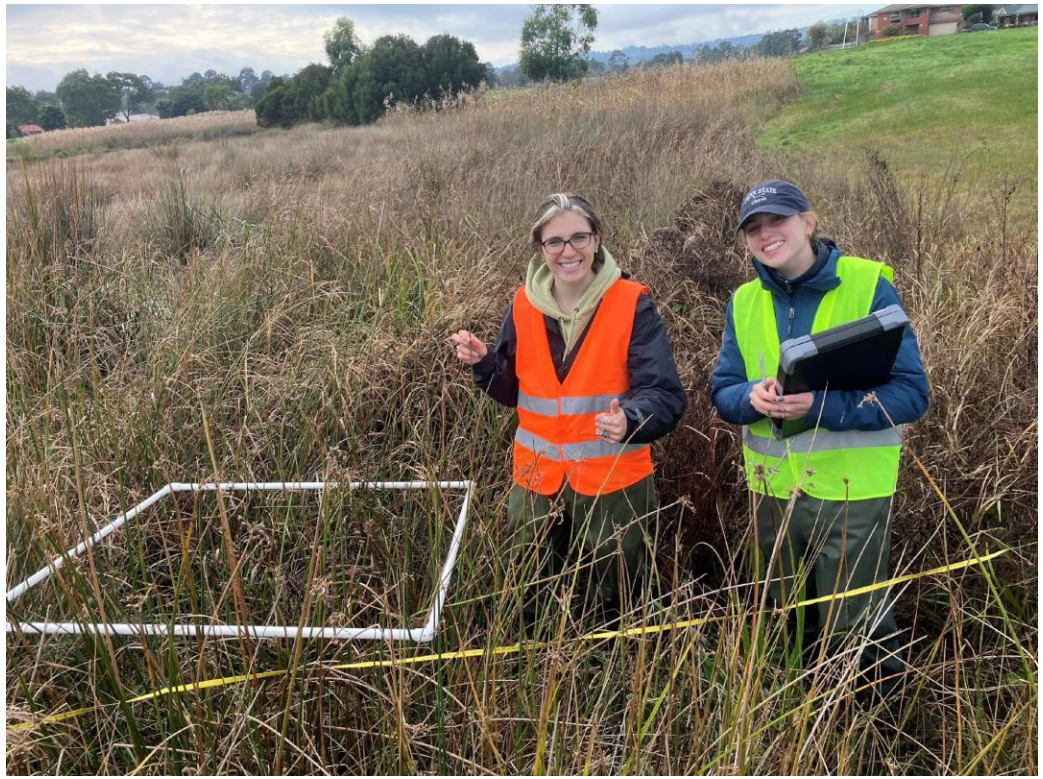
Vegetation cover can be determined from satellite imagery

High resolution drone imagery can increase accuracy

NDVI (Drone)
15/11/2024

NDVI (Sentinel 2)
15/11/2024





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BACKGROUND

How *is* the vegetation doing?

In many stormwater wetlands in Victoria, vegetation is struggling.

Nov 2024 **Mar 2025** **Jul 2025**

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BACKGROUND

What did we want out of this project?

A tool for classifying vegetation cover, health, and type in a constructed wetland undergoing RTC experiments

- Track changes in cover using NDVI and other metrics
- High spatial resolution
- Data that could be used to classify veg health and type

APPROACH

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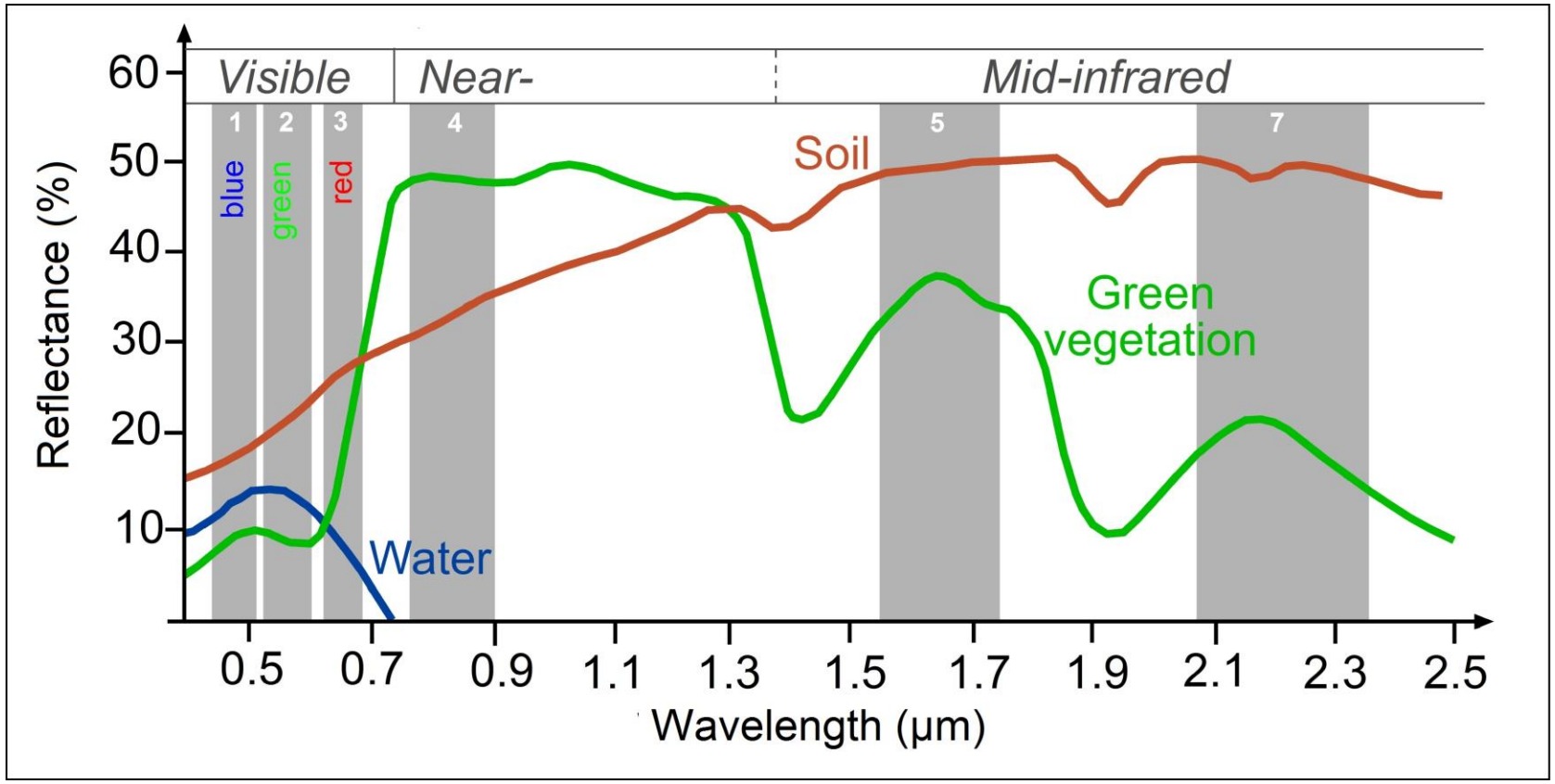
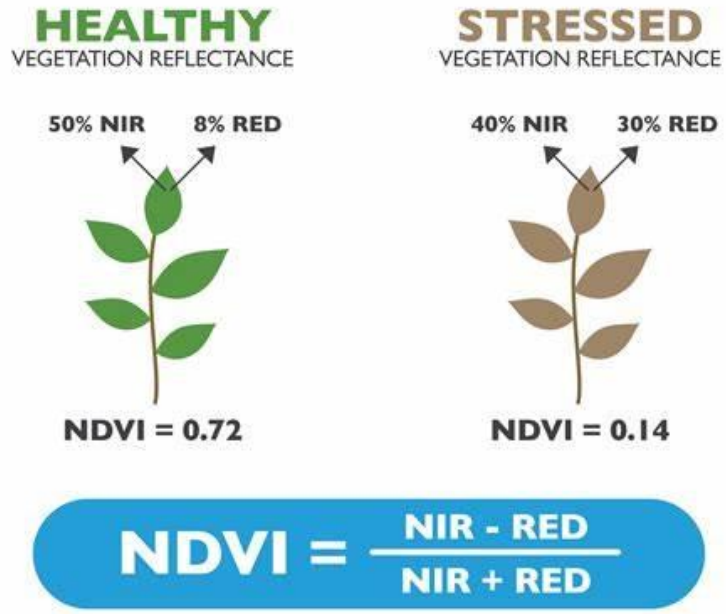
APPROACH

Vegetation reflects light that we can't see with our eyes.





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APPROACH

Drone with multispectral sensors

- Flights across different seasons
- Ground truth data
- Post-processing in Agisoft Metashape Pro
- **Ortho-mosaic** developed
- Calculated NDVI, NDWI ($\frac{Green - NIR}{Green + NIR}$)
- Developed **NDVI**, NDWI, **CIR**, and single band images

DJI Mavic 3M

- G: 560nm± 16nm;
- R: 650nm± 16nm;
- RE: 730nm± 16nm;
- NIR: 860nm±26nm;

- RGB camera

2024

October 2024

S	M	T	W	T	F	S
		1	2	3	4	5
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13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November 2024

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December 2024

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29	30	31				

2025

January 2025

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February 2025

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March 2025

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April 2025

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May 2025

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June 2025

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July 2025

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27	28	29	30	31		

August 2025

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September 2025

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14	[redacted]			17	18	19
21				24	25	26
28						

October 2025

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26	27	28	29	30	31	

November 2025

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December 2025

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7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

APPROACH

Classification of vegetation communities

- A Random Forest machine learning model was used to classify pixels based on a training dataset we developed.
- Training data from Nov 2024 flight data
- Tested on Nov 2024 and Mar 2025 images
- Model trained for 1) plant health and 2) plant type
- Colour infrared maps generated for visual comparison of revegetated zones

Table 6-3 Table Depicting Examples of Vegetation Training Class

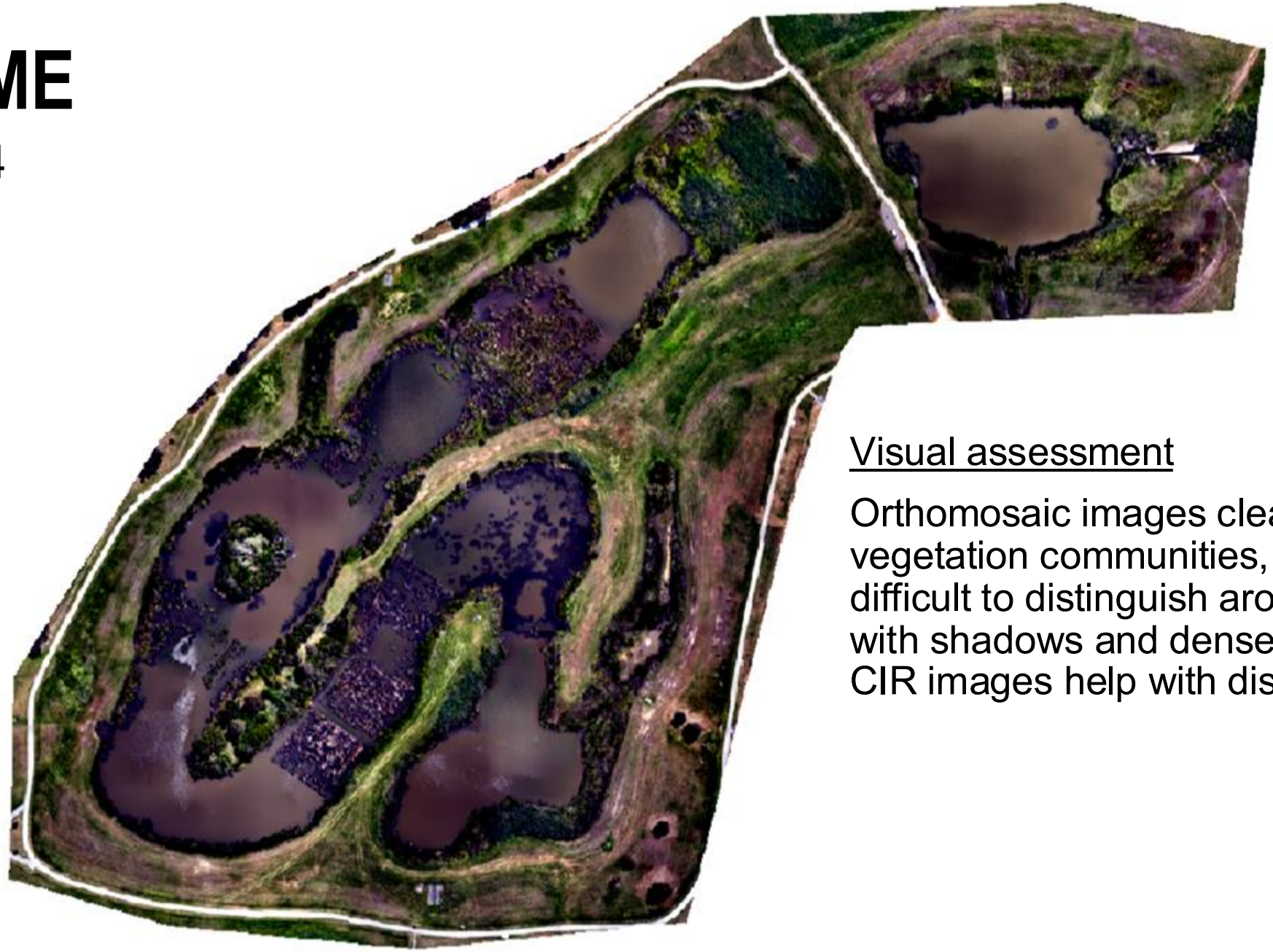
Training Class	Class Description	Example Image
Water/Non-Vegetation	Any non-organic object detected, including water and weir plate	
Submerged/Shallow	Very Shallow Water or Submerged Vegetation	
Wetland Plant Type 1	Reed/Grass-like plants with brown reed	
Wetland Plant Type 2	Leafy green plant with large flat leaves	

Pimentel, L., 2025. Stormwater Wetlands Vegetation Modelling with Dror Imagery and Machine Learning (Honours). Monash University.

OUTCOME

OUTCOME

November 2024

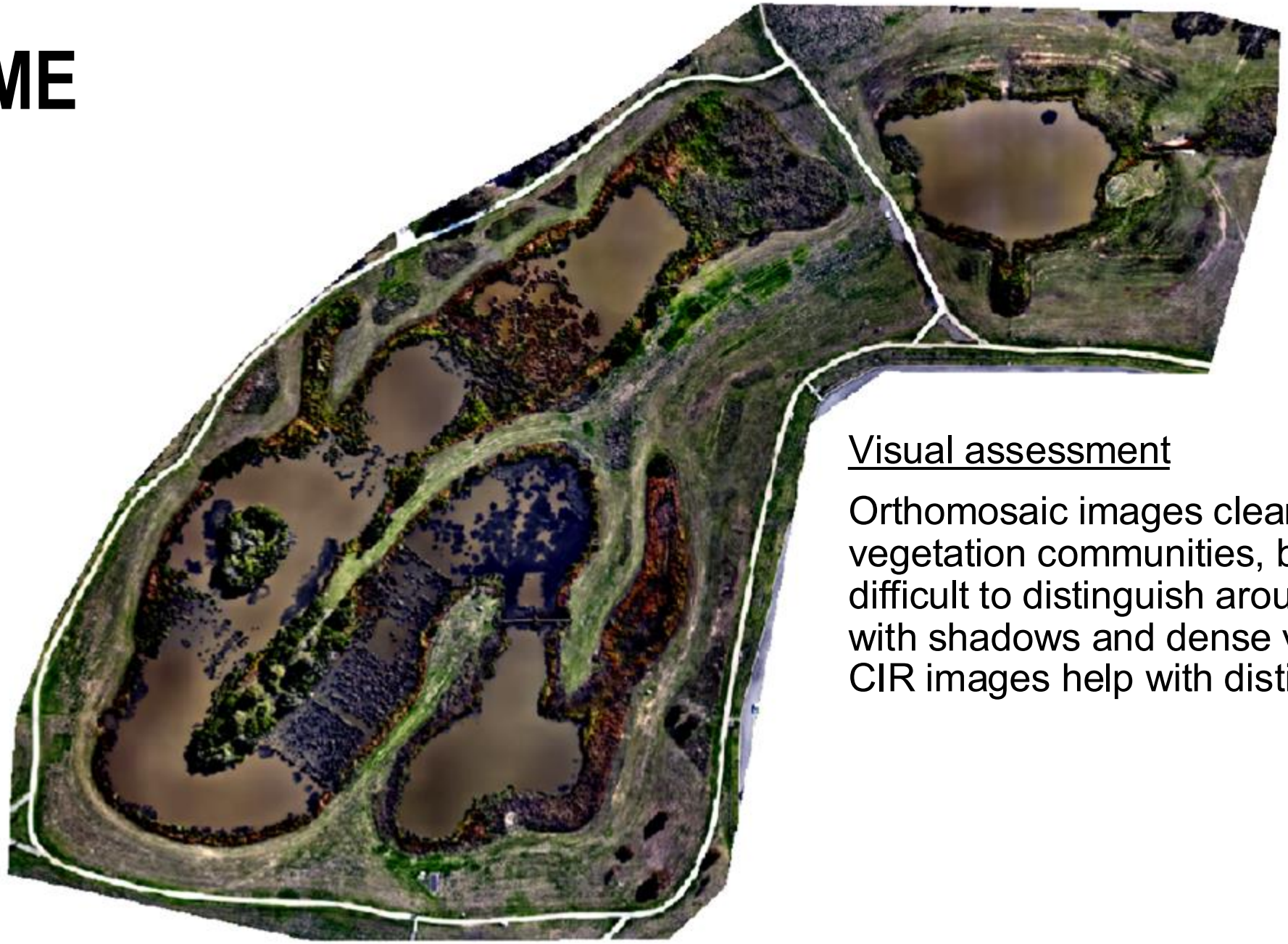


Visual assessment

Orthomosaic images clearly show vegetation communities, but it's difficult to distinguish around areas with shadows and dense vegetation. CIR images help with distinctions

OUTCOME

March 2025



Visual assessment

Orthomosaic images clearly show vegetation communities, but it's difficult to distinguish around areas with shadows and dense vegetation. CIR images help with distinctions

OUTCOME

July 2025

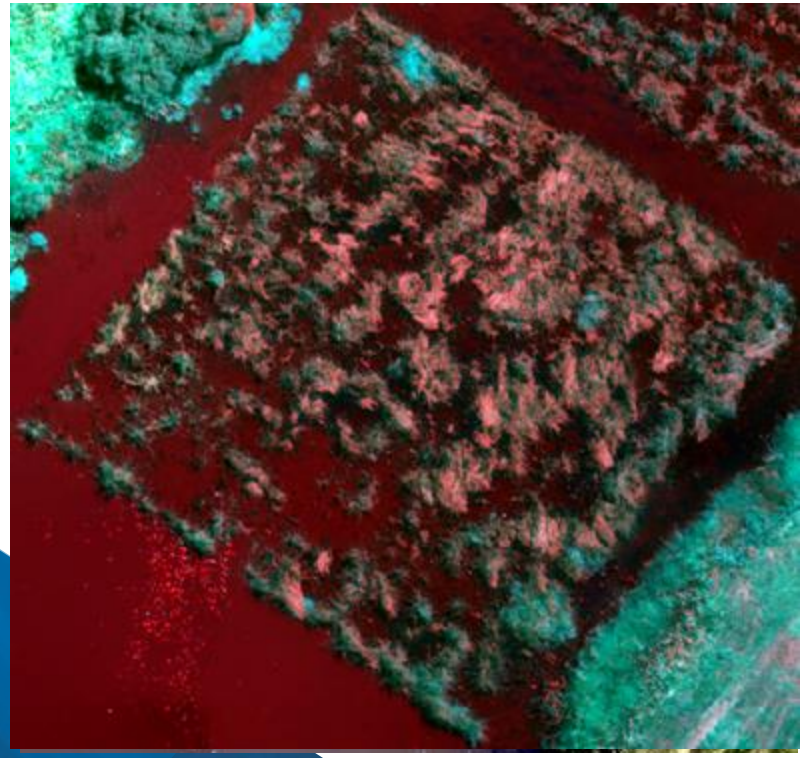
Visual assessment

Orthomosaic images clearly show vegetation communities, but it's difficult to distinguish around areas with shadows and dense vegetation. CIR images help with distinctions

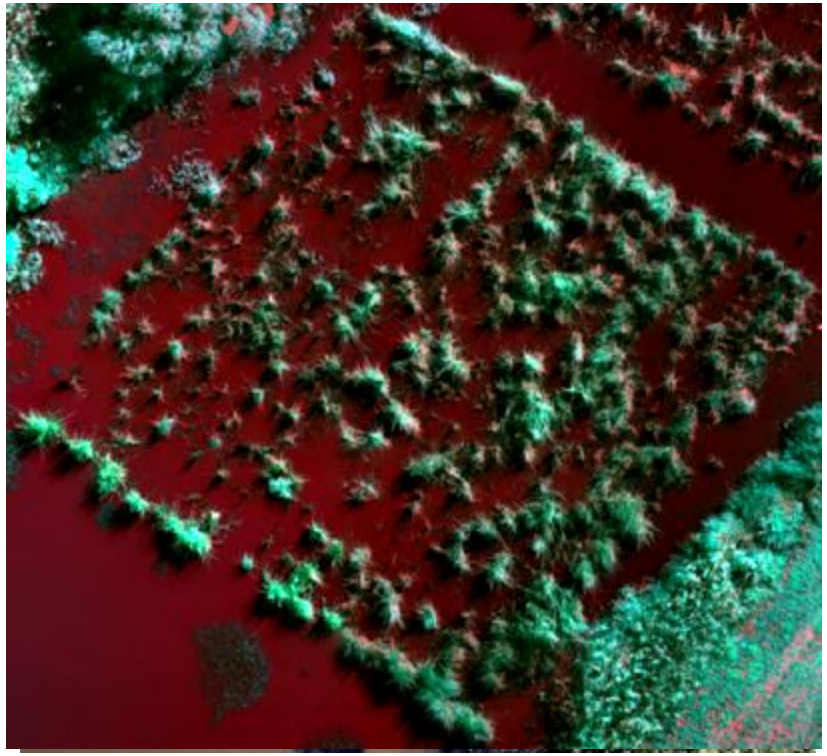
OUTCOME

CIR Images: Revegetation zone

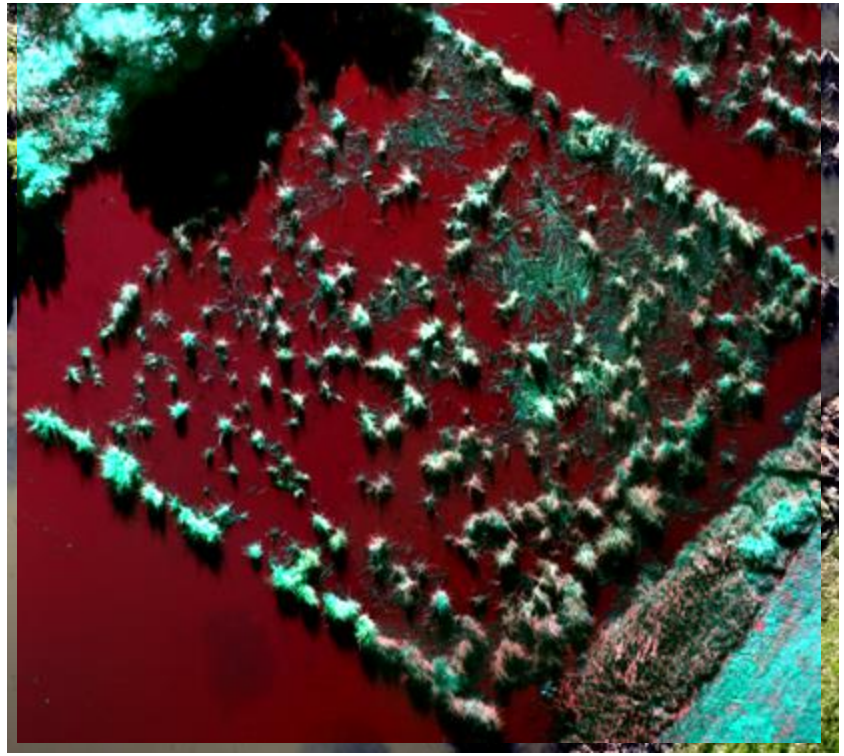
Nov 2024



Mar 2025



Jul 2025



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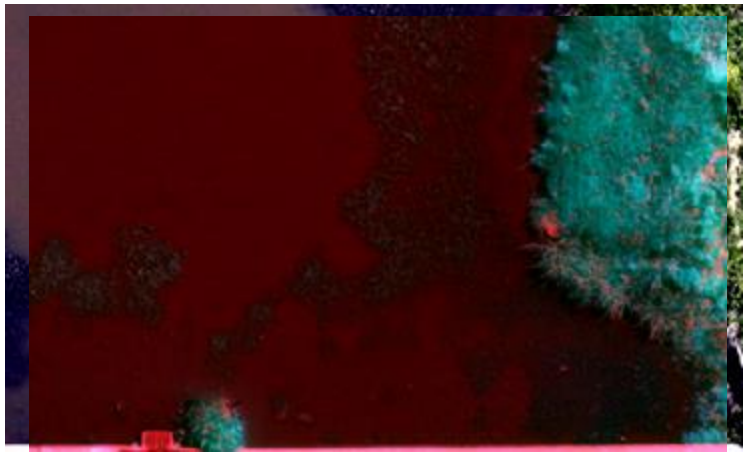
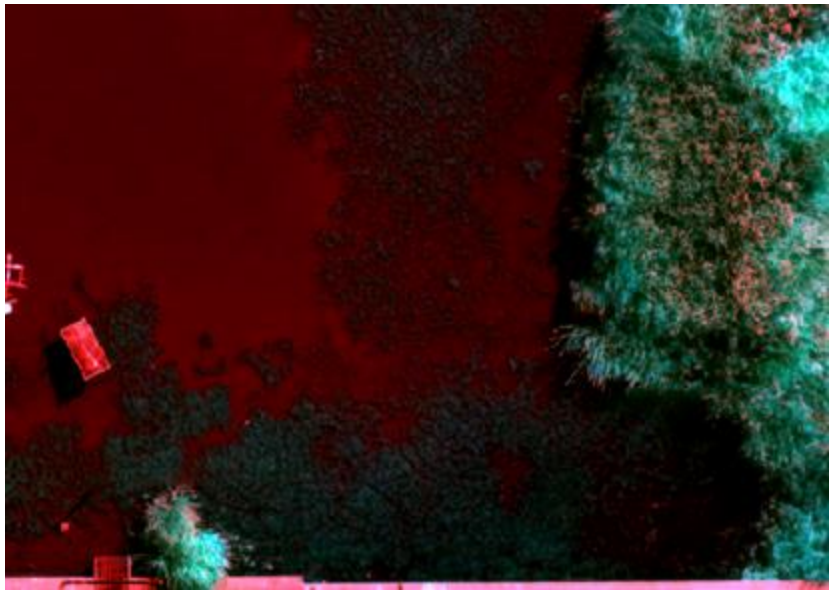
OUTCOME

CIR Images: Submerged vegetation

Nov 2024



Mar 2025



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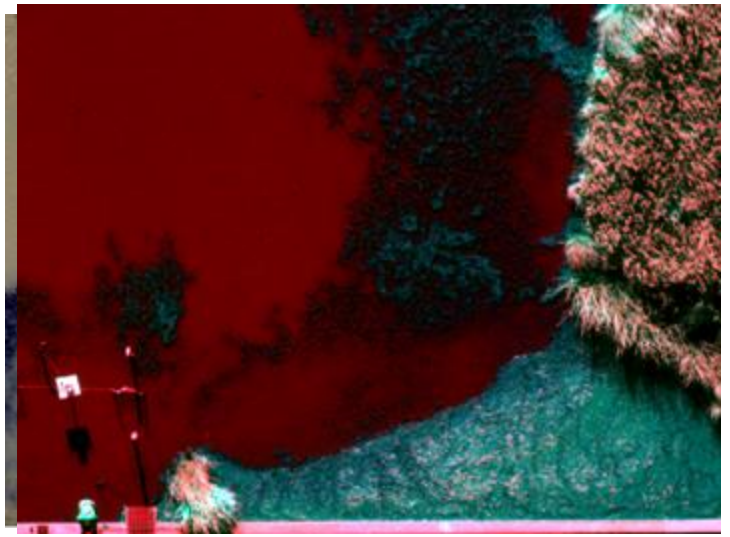
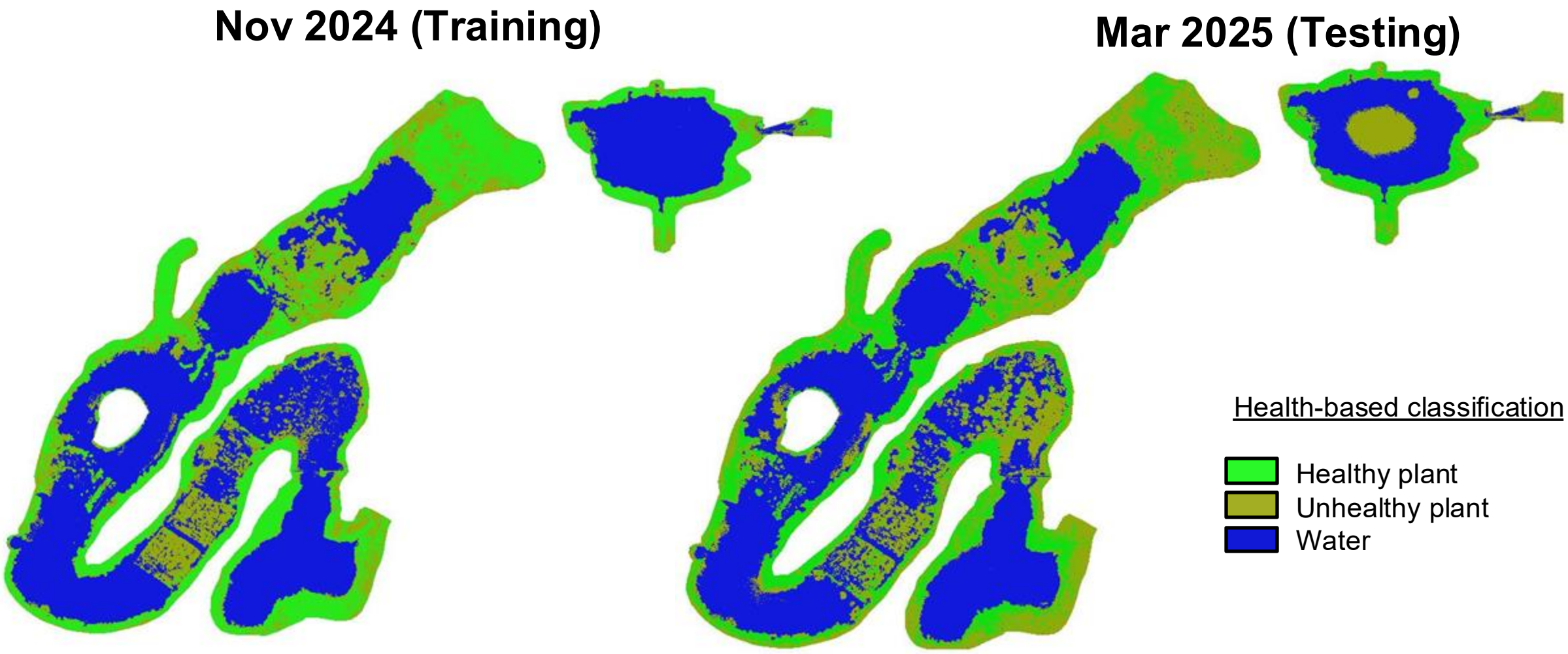


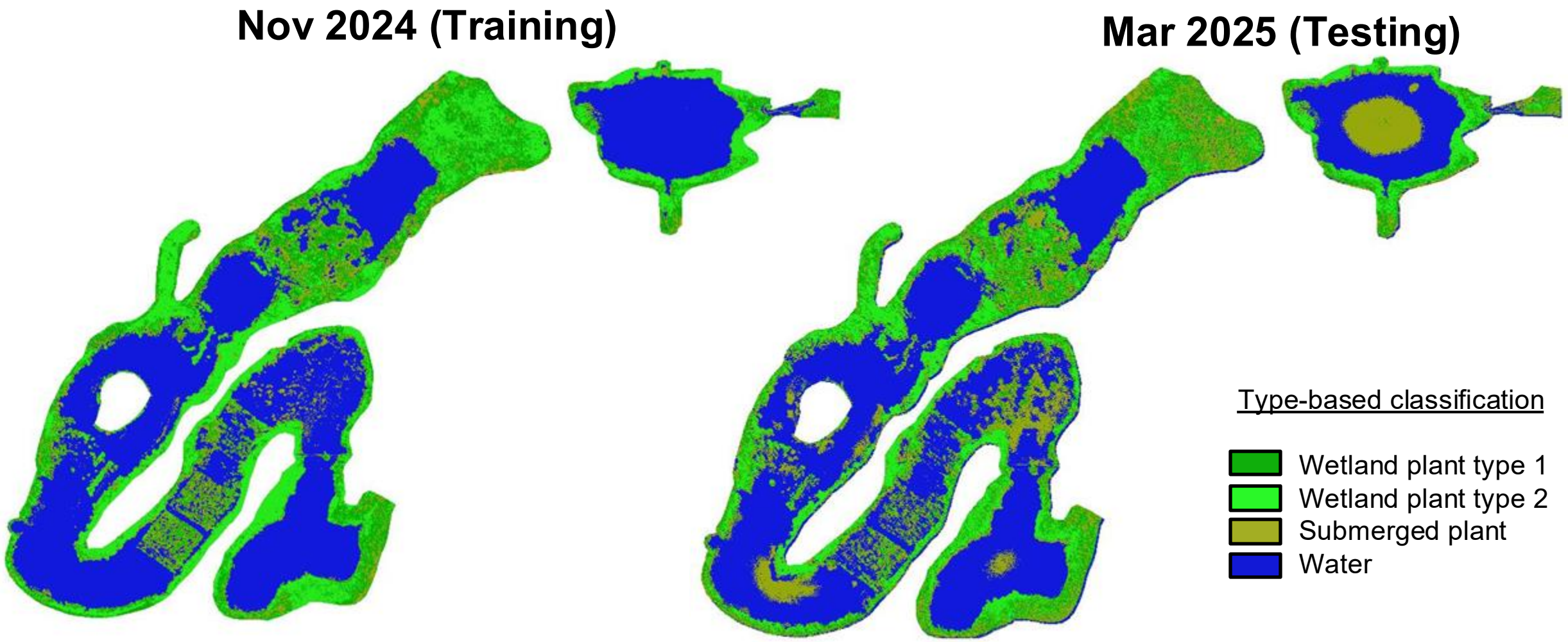
OUTCOME

Machine learning classification - Plant health



OUTCOME

Machine learning classification - Plant type



OUTCOME

Summary

- Visual analysis using different bands helps distinguish veg cover
- Machine learning classification can be applied to quantify cover and can accurately distinguish cover types on images which were not used in training
- Distinction between plant types:
  - Very high accuracy for image used in training for both health (97%) and type (94%) classifications
  - For testing data, health classification remained high (94%), but type classification was reduced (66%)

NEXT STEPS

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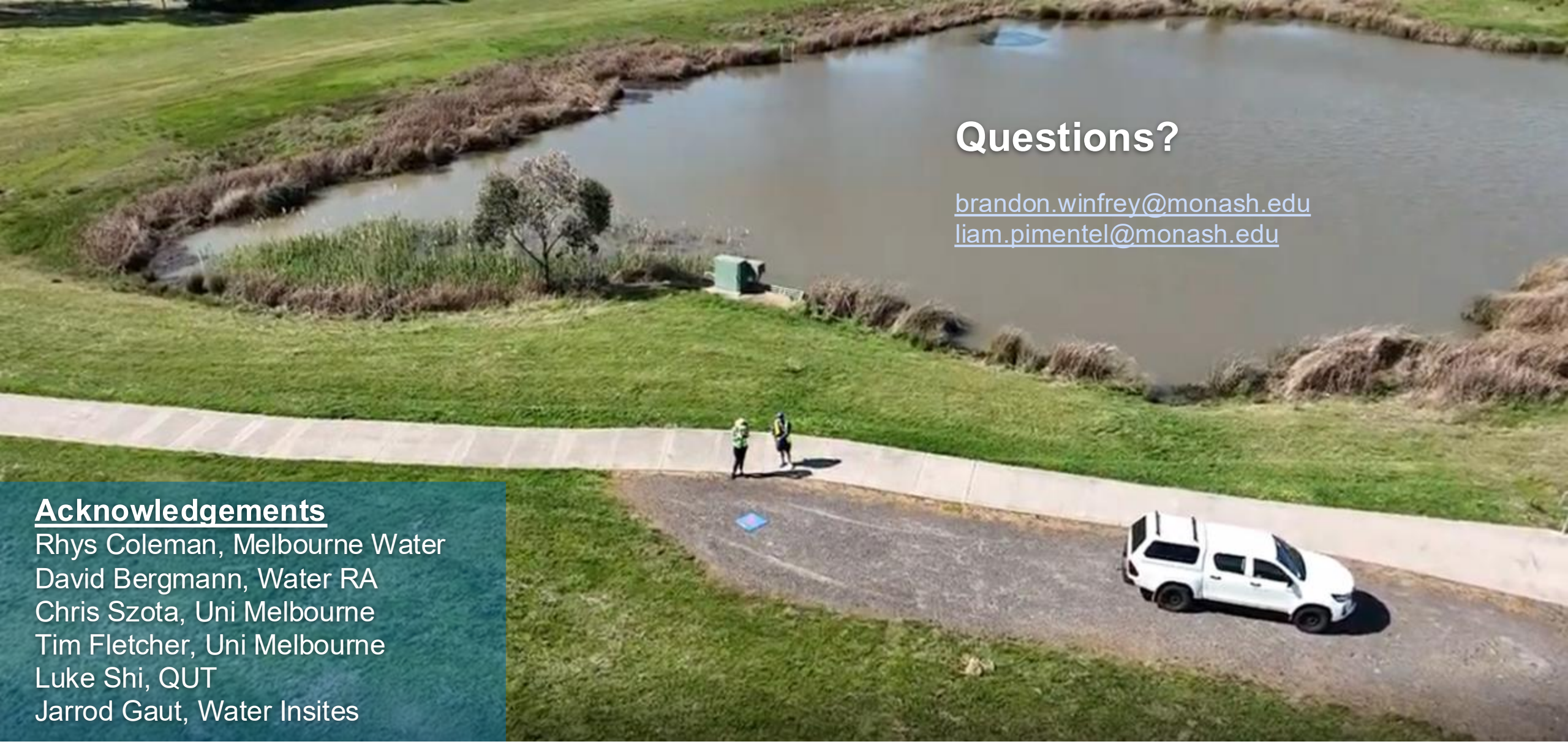
NEXT STEPS

- Machine learning: incorporate additional data sources (DEM, *in situ* spectral measurements)
- Merge satellite (high temporal resolution) and drone (high spatial resolution) data in a model
- Use changes in NDVI and other indices to predict vegetation health ‘direction’
- Evaluate effects of water level drawdown on vegetation cover through RTC trials



Questions?

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Acknowledgements
Rhys Coleman, Melbourne Water
David Bergmann, Water RA
Chris Szota, Uni Melbourne
Tim Fletcher, Uni Melbourne
Luke Shi, QUT
Jarrod Gaut, Water Insites

Australian Government
Australian Research Council

Melbourne Water

South East Water

Work supported by ARC LP210200490

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