DEVELOPING A TOOL FOR WETLAND CHARACTERIZATION USING FRACTIONAL COVER, TASSELED CAP WETNESS AND WATER OBSERVATIONS FROM SPACE

Bex Dunn, Leo Lymburner, Vanessa Newey, Andrew Hicks, Hashim Carey

Geoscience Australia, Canberra

ABSTRACT

Combining observations of open water, wet vegetation, and vegetation fractional cover allows us to observe the spatiotemporal behaviour of wetlands. We developed a Wetlands Insight Tool (WIT) using Analysis-Ready Data available through Digital Earth Australia that combines Water Observations from Space (WOfS), the Tasseled Cap Wetness Transform (TCW) and Fractional Cover into an wetland summary. We demonstrate the tool on three Australian wetlands, showing changes in water and vegetation from bush fires, sand mining and planned recovery.

1. INTRODUCTION

Digital Earth Australia (DEA, formerly the Australian Geoscience Data Cube [1]) is the Australian collection of calibrated, corrected and orthorectified Analysis-Ready Landsat and Sentinel 2 Data, along with the analysis platform used to interrogate the data, and complementary and derived datasets [2]. The Landsat archive (1987 - present) can be utilised to study long-term ecosystem dynamics [3]. Spatial changes in the extent of wetlands can be used to show the impacts of policy decisions impacting on wetland ecosystems [4]. Most wetland monitoring in Australia is conducted by states, with no current national (continental) tool existing that can be used to report on changes in wet vegetation. Nationally, the Water Observations from Space (WOfS) dataset is available to monitor open water dynamics; however the WOfS classifier does not capture mixtures of water and wet vegetation [5] .

2. METHODS AND DATASETS

We developed the Wetlands Insight Tool to provide insight at a glance into wetland dynamics. The WIT is a spatiotemporal summary of an wetland. It is created with a workflow that combines multiple datasets derived from the Australian Landsat archive held within DEA. Fractional cover [6], WOfS [5] and surface reflectance data are retrieved from DEA and combined to produce the WIT. The WIT outputs plots describing the percentage of the wetland polygon as vegetation fractional cover, open water and wet vegetation through time, as well as a results table.

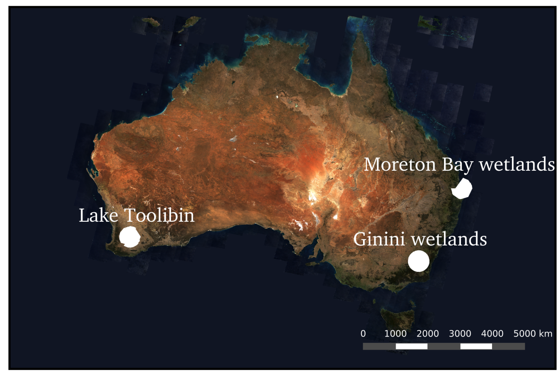

Fig. 1. Wetlands Insight Tool demonstration sites overlaid on the 2017 Australian Landsat 8 geometric median composite [7]

2.1. Fractional Cover

Fractional cover is a product generated using a spectral unmixing algorithm developed by the Joint Remote Sensing Research Program (JRSRP) [6], which breaks each pixel into three fractions based on the spectral signature of the pixel. These fractions represent the proportion of the land surface that is bare soil (BS), photosynthetic vegetation (PV) or non-photosynthetic vegetation (NPV).

2.2. Water Observations from Space

The Water Observations from Space (WOfS) product [5] was used to identify pixels containing open water. The WOfS product uses a regression tree classification of individual bands and band ratios for water detection, trained on samples across Australia. WOfS correctly identifies areas of water 93% of the time [5]. WOfS performs best in areas of open water, and is not recommended for use in areas with mixed water and wet vegetation pixels. We used the TCW for identification of these pixels.

978-1-5386-9154-0/19/$31.00

2.3. Thresholded Tasseled Cap Wetness Index

The Tasseled Cap Wetness Index formulation of Crist(1985) [8] was applied to surface reflectance data to identify pixels containing wet vegetation. Wet vegetation pixels were those pixels (not including open water pixels) exceeding a threshold (-350). This threshold was identified from ongoing work to determine a threshold for the TCW consistent with surface water in Australian wetlands.

2.4. Wetlands Insight Tool

The WIT uses Python code and Digital Earth Australia. The code loads data from polygons within a shapefile and uses the polygon extent to query DEA for WOfS, fractional cover and Landsat surface reflectance. Data is retrieved for timesteps containing more than 90% cloud-free data. The code calculates TCW from surface reflectance as above [8] and takes the maximum Fractional cover fraction per pixel, masking Fractional cover with wetness and wetness with open water. For each pixel inside or overlapping the polygon describing the wetland we calculated the dominant fractional cover type. The fractional cover algorithm calculates the BS, PV and NPV for each pixel as a percentage. The WIT uses code written in Python to select the largest percentage value for each pixel as the dominant fractional cover type. Fractional cover was masked using WOfS and TCW to remove areas of water and wet vegetation from areas where fractional cover is calculated.This is necessary as the fractional cover algorithm erroneously classifies water as green vegetation (PV) [9]. Landsat 7 data after May 31 2003 is removed from the WIT to avoid data collected after the Scan-Line Corrector failure (SLC-off data). Where no good data is available between Landsat 5 and Landsat 8 the output graph is overlaid with a pale hatched box so interpreters will disregard this period. The resulting output is a stacked plot of open water, wet vegetation, photosynthetic vegetation, non-photosynthetic vegetation and bare soil for the wetland polygon through time and an output csv of the data.

3. RESULTS

The Wetlands Insight Tool is able to provide insight into the changing character of wetlands as it provides a simple and understandable visualisation of spatial and temporal variability. Figure 2 demonstrates the WIT on the Ginini wetlands, located in the Namadgi National Park in the Australian Capital Territory. The Ginini wetlands *Spagnum* bogs were seriously affected by wildfires in 2003 [10]. The WIT in Figure 2 shows a drop in green vegetation (PV) and an increase in bare soil and dry vegetation (NPV) in 2003 corresponding to the fire, with the recovery afterward showing higher values of dry vegetation (NPV) during yearly cycles post-2013. This may reflect changing vegetation communities post-fire. A fire bog rehabilitation program is underway at the site. [10]

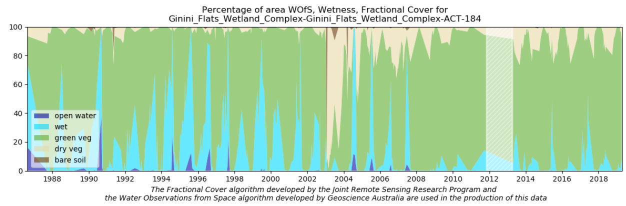

Fig. 2. Percentage of polygon surrounding Ginini wetlands covered by water (WOfS), wet vegetation (TCW), bare soil (BS), green vegetation (PV) and dry vegetation (NPV) 1987-2019. Light box covers area where Landsat archive was affected by SLC-off.

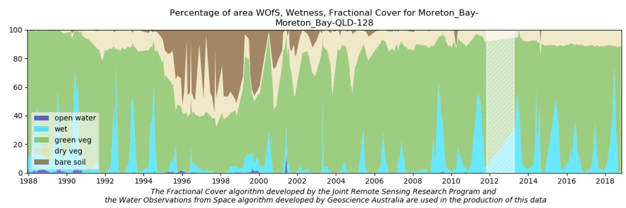

Fig. 3. Percentage of polygon for Moreton Bay wetlands for area of North Stradbroke Island covered by water (WOfS), wet vegetation (TCW), bare soil (BS), green vegetation (PV) and dry vegetation (NPV) 1987-2019. Light box covers area where Landsat archive was affected by SLC-off.

North Stradbroke island in Queensland is part of Australia's Moreton Bay Ramsar wetlands site. The Wetlands Insight Tool was run for a small area in the south of the island (Figure 3). This site was used for mineral sand mining and rehabilitated in 1998 [11]. The WIT in Figure 3 shows the drop in green vegetation (PV) and increase in bare soil (BS) after the onset of sand mining at the site, and the post-rehabilitation increase in green vegetation and wet vegetation.

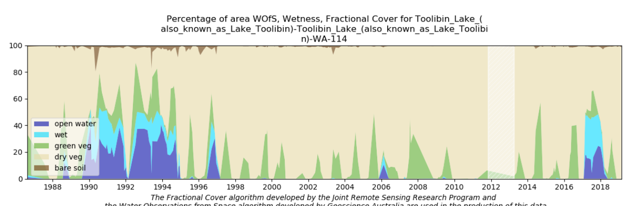

Fig. 4. Percentage of polygon surrounding Lake Toolibin covered by water (WOfS), wet vegetation (TCW), bare soil (BS), green vegetation (PV) and dry vegetation (NPV) 1987-2019. Light box covers area where Landsat archive was affected by SLC-off.

Lake Toolibin in Western Australia is an ephemeral wooded wetland, providing breeding and feeding habitat for migratory waterbirds when water remains in the lake for at least six months [12]. Recovery plans at Lake Toolibin have been active since 1996 to reduce the impacts of clearing-and cropping-induced salinization [12]. The Wetlands Insight Tool for Lake Toolibin in Figure 4 shows the lake filling in February 2017 for the first time in 20 years.

4. CONCLUSIONS

The Wetlands Insight Tool developed using Digital Earth Australia and the Fractional cover, WOfS and TCW datasets is demonstrably useful for monitoring changes in the spatial and temporal behaviour of different types of wetlands. The combination of open water, wet vegetation and vegetation information into one tool allows us to produce a useful overview of changes in wetland ecosystems, with wetland managers able to use the tool to select time periods of interest to investigate further on a local scale, or to demonstrate the effects of rehabilitation programs at sites. The WIT will be used in the future monitoring of Australian sites, with open source code enabling the application of the tool to a larger set of sites with international application potential.

5. ACKNOWLEDGEMENTS

This paper is published with the permission of the CEO, Geoscience Australia. With thanks to Kirill Kouzoubov for the generation of the 2017 Landsat 8 geomedian composite basemap (Figure 1)

6. REFERENCES

[1] Adam Lewis, Simon Oliver, Leo Lymburner, Ben Evans, Lesley Wyborn, Norman Mueller, Gregory Raevksi, Jeremy Hooke, Rob Woodcock, Joshua Sixsmith, Wenjun Wu, Peter Tan, Fuqin Li, Brian Killough, Stuart Minchin, Dale Roberts, Damien Ayers, Biswajit Bala, John Dwyer, Arnold Dekker, Trevor Dhu, Andrew Hicks, Alex Ip, Matt Purss, Clare Richards, Stephen Sagar, Claire Trenham, Peter Wang, and Lan-Wei Wang, "The Australian Geoscience Data Cube — Foundations and lessons learned," *Remote Sensing of Environment*, vol. 202, pp. 276 – 292, 2017.

[2] Trevor Dhu, Bex Dunn, Ben Lewis, Leo Lymburner, Norman Mueller, Erin Telfer, Adam Lewis, Alexis McIntyre, Stuart Minchin, and Claire Phillips, "Digital earth Australia – unlocking new value from earth observation data," *Big Earth Data*, vol. 1, no. 1-2, pp. 64–74, 2017.

[3] Valerie J. Pasquarella, Christopher E. Holden, Les Kaufman, and Curtis E. Woodcock, "From imagery to ecology: leveraging time series of all available Landsat observations to map and monitor ecosystem state and dynamics," *Remote Sensing in Ecology and Conservation*, vol. 2, no. 3, pp. 152–170, 2016.

[4] Kate C. Fickas, Warren B. Cohen, and Zhiqiang Yang, "Landsat-based monitoring of annual wetland change in the Willamette Valley of Oregon, USA from 1972 to 2012," *Wetlands Ecology and Management*, vol. 24, no. 1, pp. 73–92, Feb. 2016.

[5] N. Mueller, A. Lewis, D. Roberts, S. Ring, R. Melrose, J. Sixsmith, L. Lymburner, A. McIntyre, P. Tan, S. Curnow, and A. Ip, "Water observations from space: Mapping surface water from 25years of Landsat imagery across Australia," *Remote Sensing of Environment*, vol. 174, pp. 341 – 352, 2016.

[6] P Scarth, A Röder, M Schmidt, and R Denham, "Tracking grazing pressure and climate interaction—The role of Landsat fractional cover in time series analysis," in *Proceedings of the 15th Australasian Remote Sensing and Photogrammetry Conference, Alice Springs, Australia*. 2010, pp. 13–17, The Remote Sensing and Photogrammetry Commission of the Spatial Sciences Institute Canberra.

[7] D. Roberts, N. Mueller, and A. Mcintyre, "High-Dimensional Pixel Composites From Earth Observation Time Series," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 55, no. 11, pp. 6254–6264, Nov. 2017.

[8] Eric P Crist, "A TM Tasseled Cap equivalent transformation for reflectance factor data," *Remote Sensing of Environment*, vol. 17, no. 3, pp. 301–306, June 1985.

[9] Geoscience Australia Canberra, "Fractional Cover (FC25) Product Description," *GeoCat: #79676*, 2015, retrieved from: https://d28rz98at9flks.cloudfront.net/79676/Fractional_Cover_FC25_v1_5.PDF.

[10] ACT Government, "Ginini Flats Wetland Complex Ramsar Site Management Plan," 2017, retrieved from: https://www.environment.act.gov.au/__data/assets/pdf_file/0016/1060036/Ginini-Flats-Ramsar-Site-Management -Plan-Summary-ACCESS.pdf.

[11] Amanda Gravina, Phill McKenna, Vanessa Glenn, et al., "Evaluating the success of mineral sand mine rehabilitation on north stradbroke island, queensland: comparisons with reference eucalypt communities," *Proceedings of the Royal Society of Queensland, The*, vol. 117, pp. 419, 2011.

[12] Department of Biodiversity Conservation and Attractions, "Toolibin Lake Catchment Recovery Plan 2015–35," *Department of Biodiversity, Conservation and Attractions, Perth*, 2017.