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Our Reference: 15631-21-EOLR-1Rev0_200804

Dylan Asgill-Tucker
Advisor Environment Approvals and Compliance
Roy Hill Iron Ore
5 Whitham Road
Perth Airport WA 6105

Dear Dylan,

Re: Vegetation Cover Used in the Mounding and Salinisation Model Based on MSAVI – Memo

1 Background

Roy Hill Iron Ore (RHIO) has requested clarification on the validation approach used during the determination of vegetation cover based on WordView imagery and the modified soil adjusted vegetation index (MSAVI) (Astron Environmental Services 2020a). RHIO also require the location of the cross-validation areas used for this approach. This memo addresses these requirements. Note that cross-validation through resampling of the visual imagery compares two remote sensing datasets. It does not compare cover to a ground-based estimate.

2 Method

Fifty randomly positioned 400 m^2 areas were selected across the study area (Figure 1). For each area, the percentage cover of all vegetation was determined based on an MSAVI classification threshold of 0.36 ($MSAVI_t$). The percentage cover of all vegetation was also determined from a maximum entropy threshold of the panchromatic image of each area (S_t). The maximum entropy threshold approach is closely related to the Otsu method (Otsu 1979). This algorithm separates pixels into foreground (vegetation) and background (non-vegetation) by minimising the variance in intensity (brightness) within the two classes. The performance of the maximum entropy and Otsu methods is especially appealing when there is a clear bimodal distribution in a greyscale histogram. However, if the foreground object is small compared with the background area, or there is insufficient contrast between the foreground and background, a bimodal distribution is less likely, and the threshold may not accurately estimate vegetation canopy cover. In other words, while S_t will provide an accurate estimate of cover generally, the thresholding approach may be a poor representation of vegetation cover where the canopy is especially sparse or where there is minimal contrast between soil and leaves. However, for the purpose of defining vegetation cover for risk modelling, the maximum entropy threshold was regarded as a useful method to cross-validate MSAVI.

3 Outcome

A comparison of the two methods showed that, on average, percentage cover was similar. The area of vegetation estimated from $MSAVI_t$ was 4% larger than the maximum entropy approach, but there

was considerable variation from location to location, particularly where the estimated cover based on $MSAVI_t$ was greater than 40% (Figure 2). Where $MSAVI_t$ was low (less than approximately 15% cover), it tended to underestimate cover compared to S_t (Figure 2). Visual examples of the two methods are shown below in Figure 3. In general, it is likely that the 'all vegetation' classification used in the Surface Flow Dependent Vegetation model (Astron Environmental Services 2020b), the Life of Mine model (Astron Environmental Services 2019) and the combined model (Astron Environmental Services 2020a) based on $MSAVI_t$ overestimated actual vegetation cover, especially where the actual vegetation cover was relatively high. However, an overestimation of the magnitude detected in this analysis can be considered a feature that is appropriately conservative.

770000 780000 790000 800000 810000 820000 830000

7510000 7500000 7490000 7480000 7470000

Legend

- Cross-validation location *(400m^2; symbol not to scale)*
- Project area
- Roy Hill Tenure
- Extent of model

Vegetation cover (MSAVI) by mapping unit

- Claypan
- Disturbed Areas
- *Eucalyptus victrix/ E. camaldulensis*
- Grassland/Bare
- Marsh
- Mulga
- Mulga Banded
- Mulga Riparian
- Samphire Fringe
- Samphire Marsh

Roy Hill Iron Ore Pty Ltd

Vegetation Cover Used in the Mounding and Salinisation Model Based on MSAVI

Scale: 1:180,000 at A3

Coordinate System: GDA 1994 MGA Zone 50

0 2 4 6 8 10 Kilometres

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Figure 1: Locations used for cross-validaton of vegetation cover thresholds based on MSAVI and the maximum entropy approach

Author: P. Drake | Drawn: T. Pedersen | Date: 03-08-2021 | Figure Ref: 15631-21-BIDR-3RevA_210803_Fig01_CV_Locns

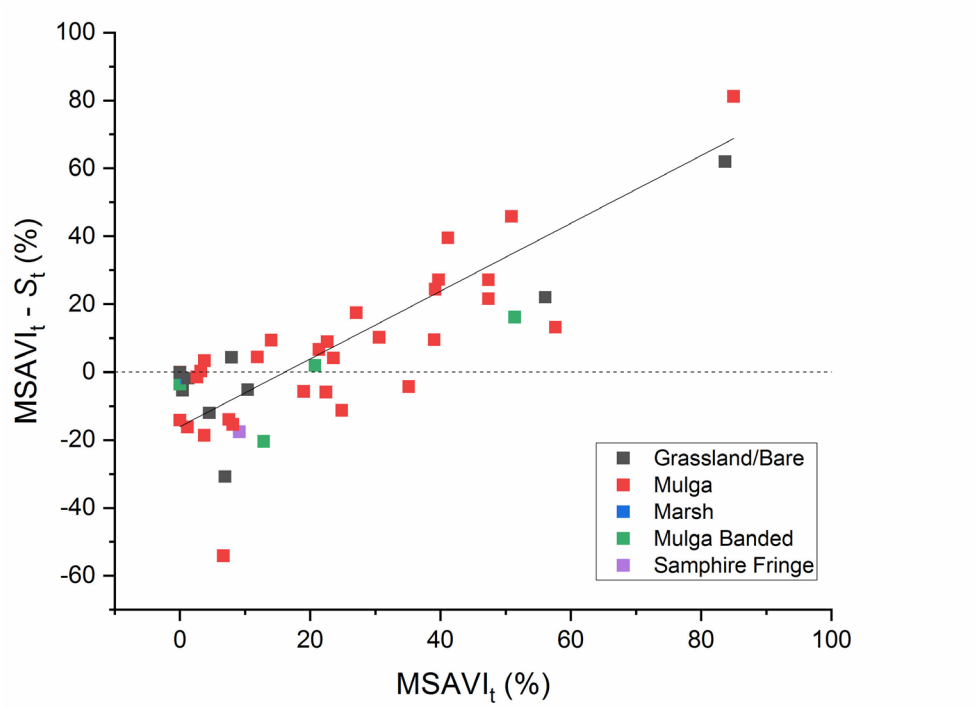

Figure 2: Correlation between the difference in vegetation cover based on the maximum entropy threshold of panchromatic images (S_t) and the modified soil adjusted vegetation index (MSAVI) threshold ($MSAVI_t$) ($MSAVI_t - S_t$) and $MSAVI_t$. The solid line represents a standardised major axis regression model, $r^2 = 0.63$, $P < 0.001$.

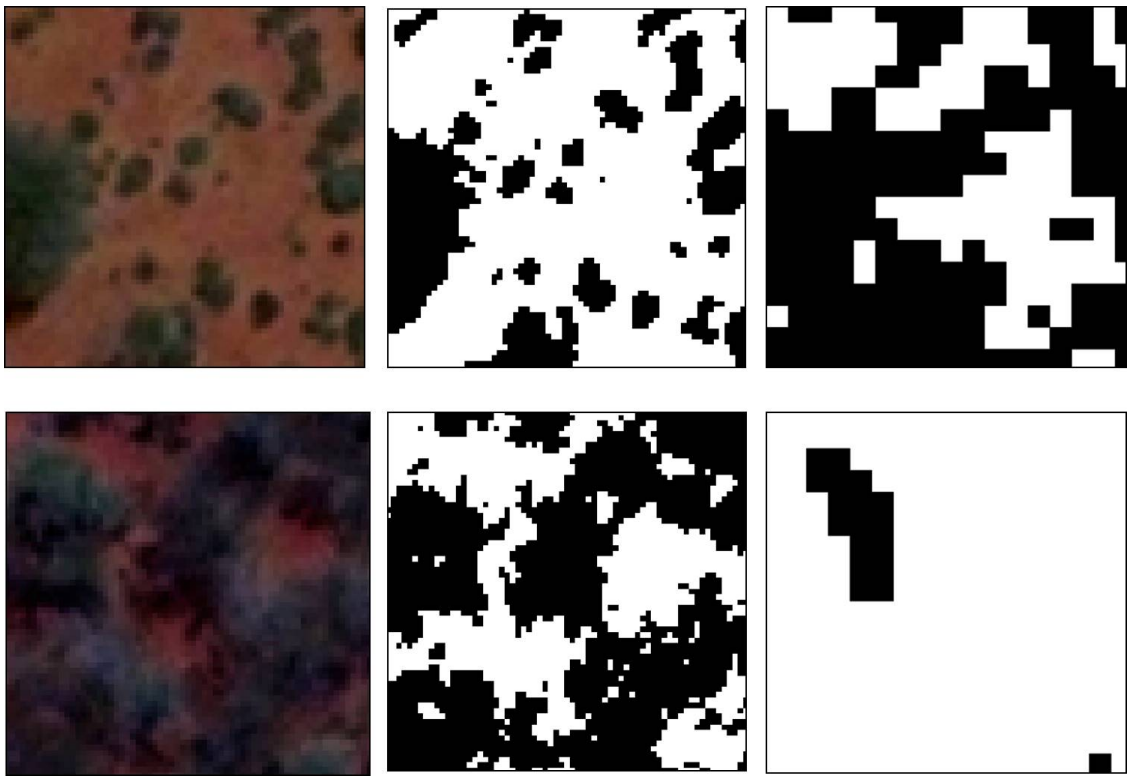

Figure 3: Visual examples of the site based on the natural colour image (left images), the maximum entropy threshold (centre images) and the modified soil adjusted vegetation index threshold ($MSAVI_t$, right images) for two 400 m² locations. Black = vegetation and White = non-vegetated. Note that the maximum entropy threshold is based on the intensity values of the pan-chromatic WorldView imagery (pixel size = 30 cm), whereas $MSAVI_t$ is based on multispectral WorldView satellite imagery (pixel size = 1.2 m).

This memo was prepared by Dr Paul Drake and reviewed by Dr Robert Archibald. Please do not hesitate to contact Paul or Rob should you have any queries.

Yours sincerely
ASTRON ENVIRONMENTAL SERVICES

Jacob Delfos
Manager – Earth Observation

4 References

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