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The Benefits of SWIR Imagery for Archaeological Landscape Analysis: A Case Study from Easter Island (Rapa Nui), Chile

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The Benefits of SWIR Imagery for Archaeological Landscape Analysis: A Case Study from Easter Island (Rapa Nui), Chile

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Introduction

The use of multispectral imagery is particularly effective for mapping the archaeological record of Rapa Nui (Easter Island) due to the island's lack of vegetation and exposed surficial lithic features. In 2010, Flaws demonstrated that near-infrared (NIR) imagery can be used to identify "lithic mulch" gardens, areas of cultivation that are enhanced through the prehistoric addition of broken bedrock. Here, we evaluate newly available, high-resolution short-wave infrared (SWIR) imagery for its potential to provide additional resolution and discrimination in mapping "lithic mulch" features.

What is Lithic Mulch?

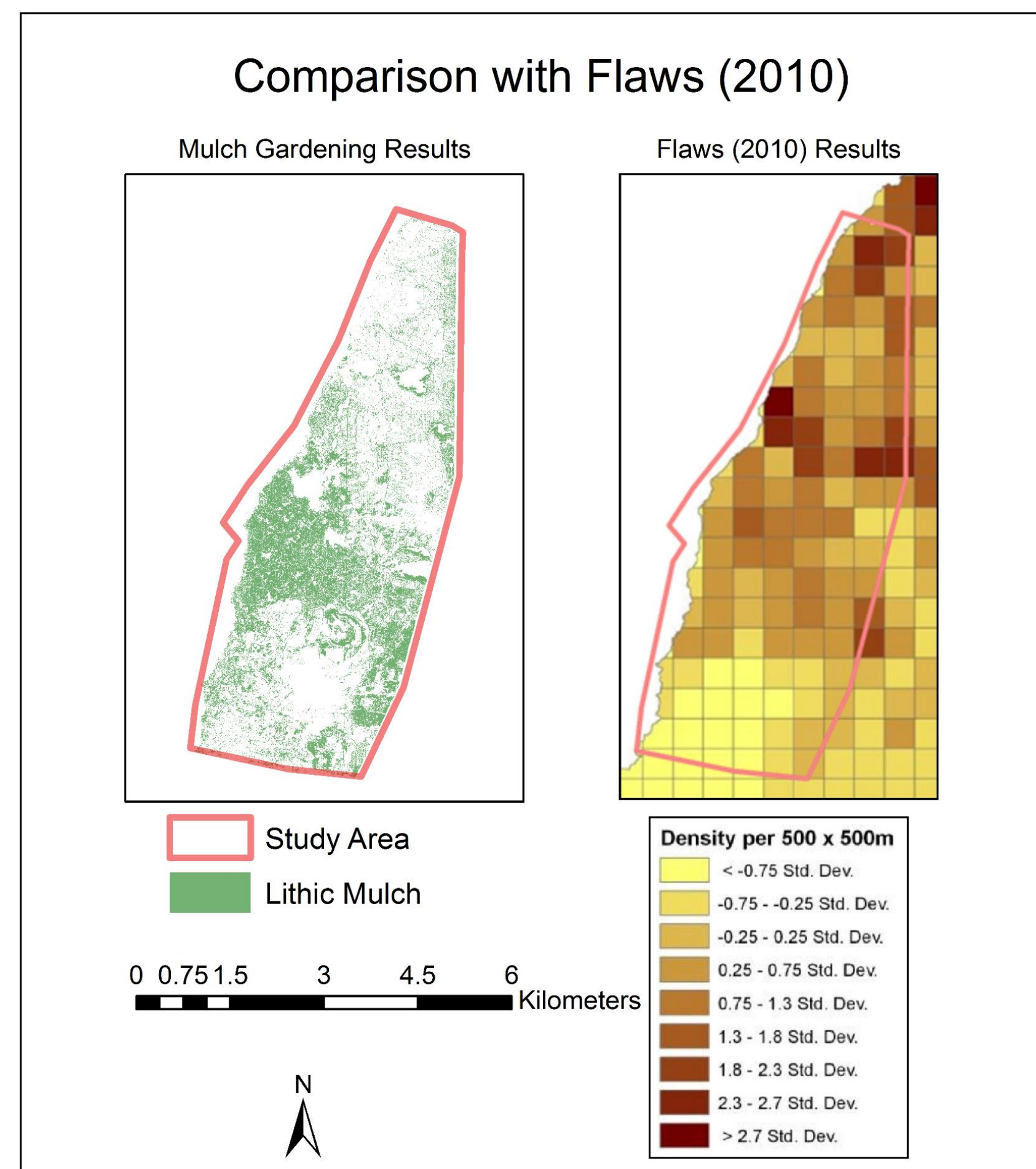
- Lithic mulch is a prehistoric cultivation practice in which broken pieces of bedrock are added to soil.
- On Rapa Nui, mulching increases soil nutrients and moisture to sufficient levels to allow for sweet potato crops.
- Protects crops from prolonged winds, erosion, and temperature variability
- Covers approximately 76 km² of the island (Bork et al. 2004)
- Key part of Rapa Nui subsistence practice.



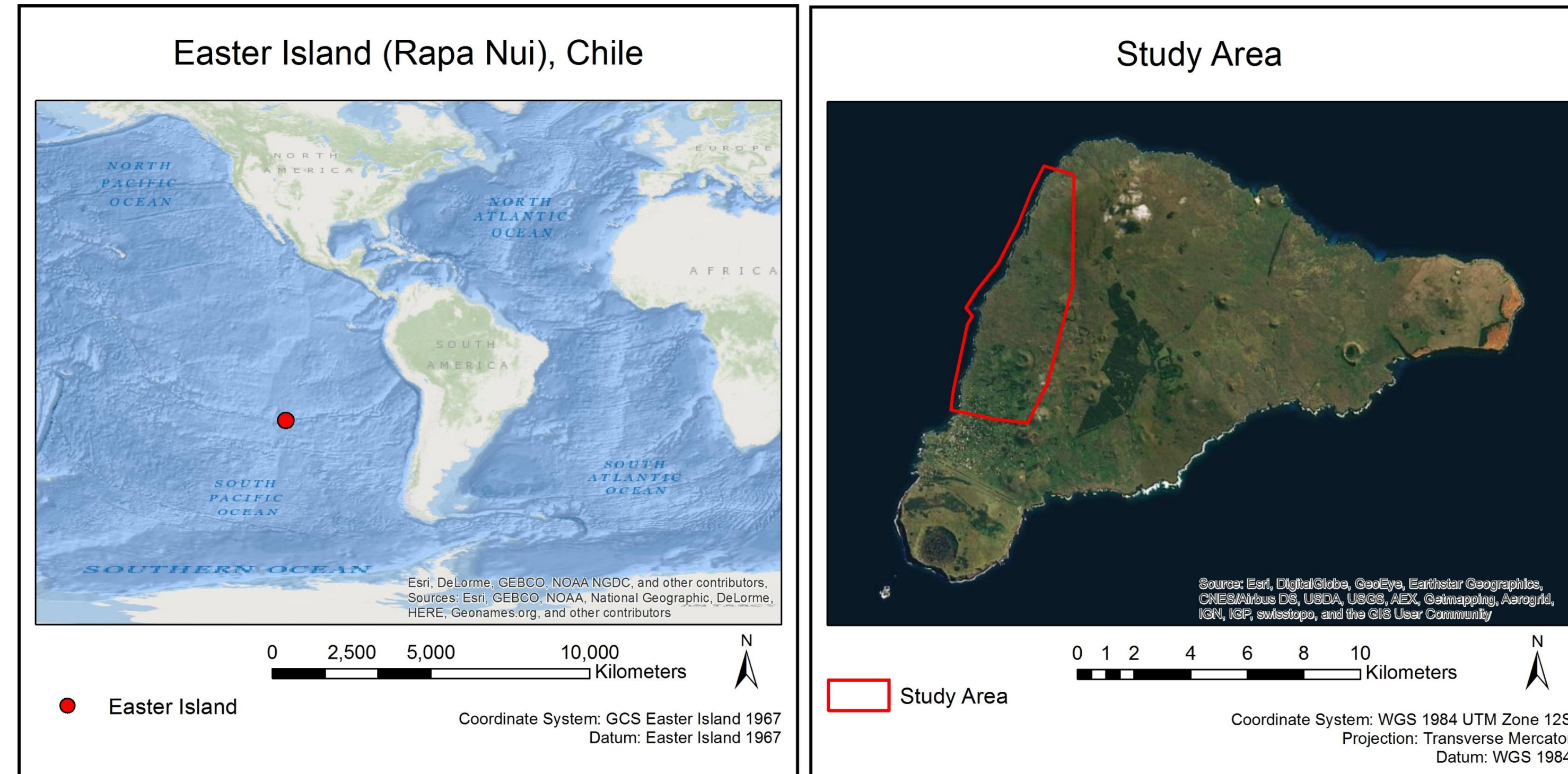
Example of Lithic Mulching as constructed on Rapa Nui

Flaws (2010)

- Use of NIR band (760-1050 nm) from WorldView-2 satellite.
- Identified rock gardening across Rapa Nui using land-based studies by Wozniak (1999)
- Image analysis using Maximum likelihood classification yields an overall accuracy of lithic mulch identification of 65%.
- The success of NIR bands for detecting mulch are based on detection of water absorption in these bands. This suggests that SWIR (1195-2365 nm) can provide greater accuracy in mapping such features



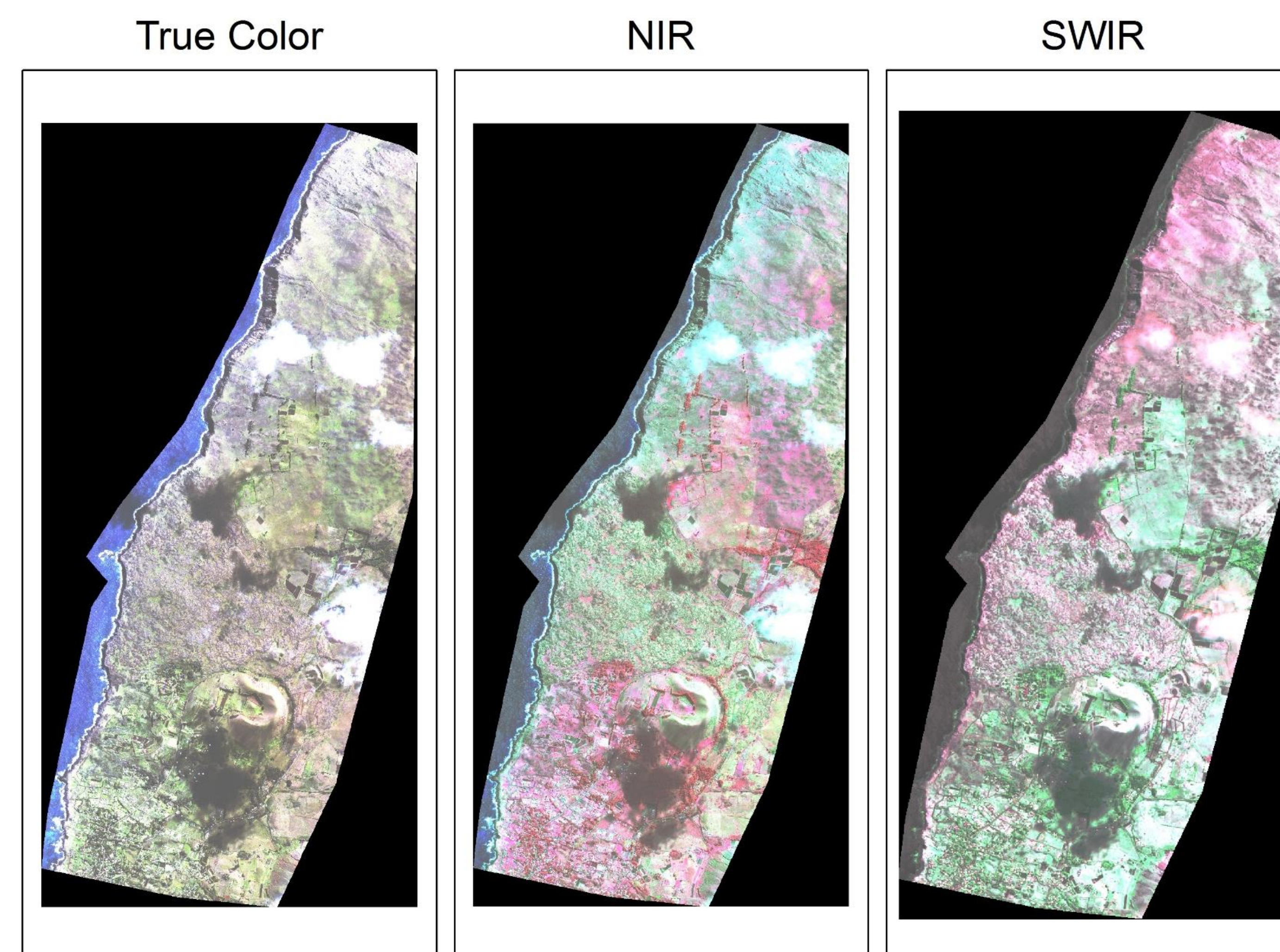
Map shows comparison between SWIR classification and Flaws(2010) NIR classification of Lithic Mulching. Note that the high densities indicated by NIR (Flaws) are actually bedrock as determined by SWIR



Geographic Location of Easter Rapa Nui and the Study Area.

Methods and Analysis

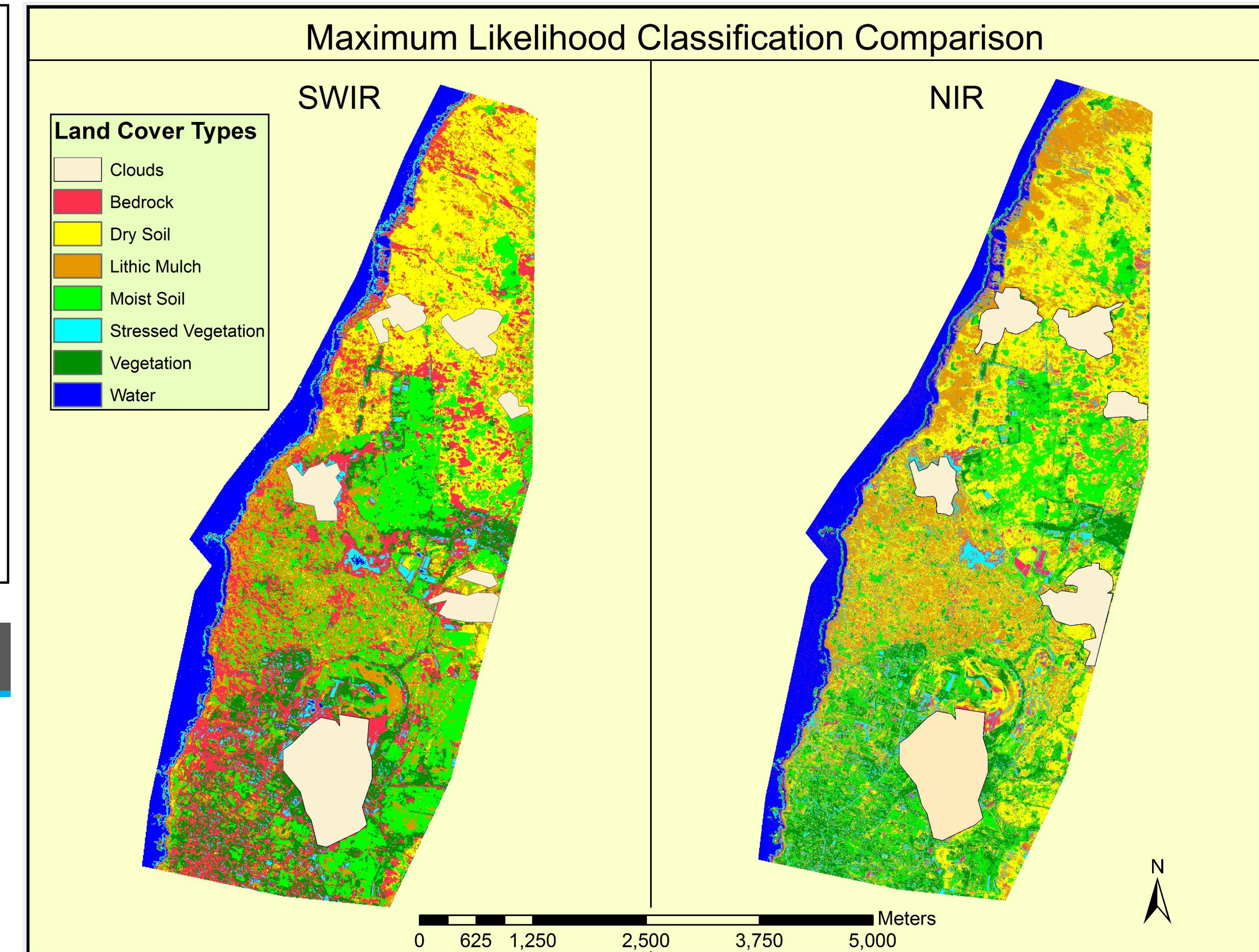
- WorldView-3 Satellite Imagery (1.24 m NIR, 7.5 m SWIR) analyzed using ENVI 4.7
- Composite images were created using bands that best displayed lithic mulching for NIR (bands 7, 5 and 3) and SWIR (bands 6, 1, and 4)².
- Features were classified using a maximum likelihood classification (MLC).
- Accuracy assessment and z-test conducted to determine statistical significance of the classification differences between the images.



Difference in landscape visualization between NIR, SWIR, and True Color

Results

- The difference between the two classifications was statistically insignificant ($z = 0.46, p > 0.05$) despite a 6.26 meter spatial resolution difference between the two images.
- MLC shows that lithic mulch increases soil moisture, as areas between mulched areas have higher amounts of vegetation and increased moisture content compared to areas without lithic mulch.
- Overall accuracy was greater using WorldView-3 than WorldView-2 as conducted by Flaws (2010) (77.05% vs 65%)



Results of MLC. Comparison shows differences between NIR and SWIR in delineating between bedrock and lithic mulch.

Accuracy Test	NIR	SWIR	Difference
Diagonal Sum	77.05%	76.17%	0.88%
User's Accuracy	71.05%	81.83%	10.78%
Producer's Accuracy	76.95%	78.45%	1.50%
Kappa Coefficient	0.7219	0.7089	0.013

Conclusion

- 7.5 meter resolution SWIR imagery is comparable in its accuracy to 1.24 meter resolution NIR imagery despite its lower pixel resolution.
- SWIR provides greater success than NIR imagery in distinguishing between natural rock-outcrops and lithic mulch gardens
- Future work should expand on the progress made here to cover the entire land-area of Rapa Nui, instead of only a small percentage (14.5%) of the island as in this study
- In the future, if SWIR imagery is released to the public at a higher resolution, it will likely be **more accurate** than NIR imagery for land-classification and provide greater degrees of discrimination, especially in terms of rock and minerals.

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Acknowledgements

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