MRes Project Outcomes: Lucy Beese, September 2021

In the last academic year, I was awarded the Lady Emily Smyth Studentship from the Bristol Centre for Agricultural Innovation (BCAI), and I have just recently submitted my final thesis. My project began with the intention to study yield gaps in oil palm over a broad landscape in Sabah Malaysian Borneo. The increasing demand for palm oil has led to a rapid rise in the clearing of tropical forests, particularly in areas of South East Asia.

To ensure that the production of palm oil can occur as sustainably as possible we must understand how oil palm growth varies across tropical landscapes to optimize yields. During my project, I used repeat airborne LiDAR data to map the height growth of over half a million individual oil palms in Malaysian Borneo over a two-year period which coincided with the 2015-16 global El Niño event. I investigated whether oil palms were able to continue growing during this period of uncharacteristically dry and hot weather, and explored which ecological and landscape features contribute most to differences in growth rates across landscapes. Despite the drought conditions, I found that on average oil palms grew 1.61 m yr^{-1} in height, but growth varied substantially among individuals, with smaller oil palms exhibiting the fastest rates of height growth. Landscape features such as the distance of palms from forest edges, elevation, and terrain ruggedness all had significant effects on height growth, as did relative competition with neighbours. Original plans for this research were to travel to the study site in Borneo to obtain information on palm oil production and collect field data for validation. However, these activities were curtailed by the COVID-19 pandemic because of travel restrictions to Malaysia which remain ongoing. Because of this, I focussed solely on the changes in height growth of palms during the project, as I could measure these from existing LiDAR data.

Vertical height growth was able to act to some extent as a proxy for aboveground carbon and yield, but the precise conversion of our experimental data to such metrics could have made our findings more applicable in the context of plantation management. This slight change in original plans taught me to be able to cope under changing circumstances and learn to adapt to new and challenging situations that so often arise when completing research.

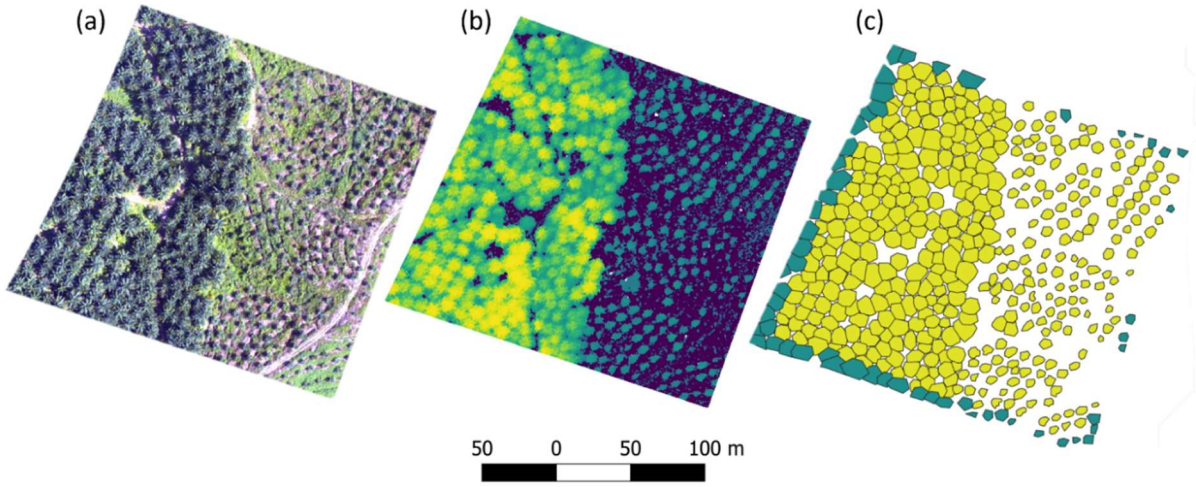

Fig. 1: Manually delineating oil palms to create a training and validation dataset for individual oil palm segmentation. RGB imagery (a) and CHM data (b) from 2014 were used to manually delineate individual oil palm crowns in an area of approximately 4.5 ha. Crowns falling within a 5 m buffer from the edge of this area were excluded (teal polygons in c), leaving a total of 409 manually delineated crowns for training and validating algorithms (yellow polygons in c)

My results highlighted the resilience of oil palms to climate extremes associated with El Niño events and I was also able to show that there is potential scope for improving plantation practices that could increase yield while simultaneously reducing the level of environmental damage caused across the landscape. Some of the most challenging parts of the project, while also being the parts that I enjoyed the most, were learning to code in far greater depth than I ever had before, as well as learning about a whole new area of remote sensing in

ecology. This experience that I picked up enabled me to be accepted onto a PhD course in 'Using multitemporal remote sensing data to map the dynamics and resilience of European forests to global change.' This masters allowed me to be successful in applying to this role, as I was able to illustrate that I had experience in using geographic information systems such as QGIS, had a good knowledge of remote sensing techniques such as LiDAR, and a great amount of experience using the coding language R. These were only achievable to me thanks to the MRes, and the BCAI funding has ensured that I had the skills required to continue my academic journey on to complete a PhD

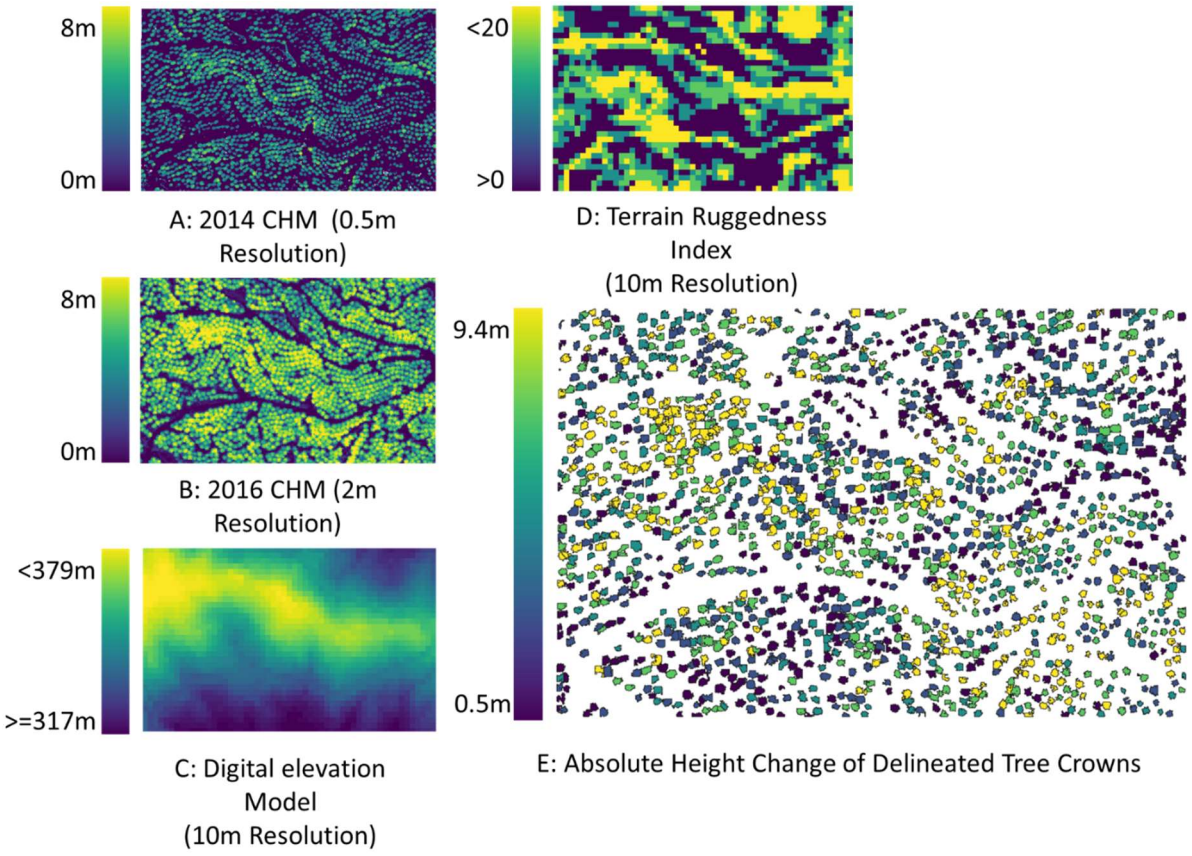

Fig. 2: Maps of a subset of the SAFE landscape showing variation in oil palm canopy height in both 2014 (A) and 2016 (B), and how this maps on to the digital elevation model (C) and terrain ruggedness index (D). The bottom right-hand panel (E) shows the segmented oil palms within this area, colour-coded by their height growth rate, ranging from low (blue) to high (yellow).