Landscape Modelling of a Protected Cultural Landscape: Kura Tāwhiti Conservation Area

Don Royds[1]

[1]Lincoln University, Lincoln/NZ · don.royds@lincoln.ac.nz

Abstract: Protecting culturally significant sites has become an increasingly recognised undertaking as seen with the increase in the number of listed UNESCO World Heritage cultural sites from 563 in 2002 to 897 in 2021. Landscape architects, planners, environmental scientists and other consultants are involved with the management of these resources and creating accurate landscape models of these can contribute to informing decision making. In the Aotearoa, New Zealand context, one of these levels of protection, Tōpuni, is unique and has been designated as such by the indigenous Māori people. This designation has been placed on 14 sites and for this research, Kura Tāwhiti Conservation Area was selected due to its distinct limestone landforms and the risk of negative impact due to increased tourist visitor numbers. An accurate 3D landscape model of the Kura Tāwhiti Conservation Area was created using aerial an UAV survey and land-based 3D laser scanning. The landscape modelling exercise is the first of any tōpuni site and provides a set of tools for decision makers. The benefits of such a landscape model for this culturally significant and protected conservation area include the potential for further analysis by other professionals of the landforms, being used in accurate visualisations for future scenarios, and providing a benchmark for changes over time.

Keywords: UAV, conservation, 3D laser scanning, landscape modelling, cultural landscape, tōpuni.

1 Introduction

Protecting culturally significant sites has become an increasingly recognised undertaking as seen with the increase in the number of listed UNESCO World Heritage cultural sites from 563 in 2002 to 897 in 2021. This paper seeks to place the unique protection of culturally significant sites from Aotearoa, New Zealand into context and discuss the issues and opportunities of creating a 3D landscape model.

The site for this research is Kura Tāwhiti Conservation Area which is located in the Southern Alps of the South Island of New Zealand. It was first gazetted as a 'Reserve for the Protection of Flora and Fauna' in 1954 but has held a significant connection to Māori (the indigenous people of Aotearoa New Zealand) for over 600 years. They gave it the name Kura Tāwhiti meaning 'treasure from a distant land' which refers to the growing of kūmara (sweet potato) in the area. The Conservation Area is managed by the national conservation agency, the Department of Conservation / Te Papa Atawhai (DoC), and also has a layer of legal recognition by having 'tōpuni' status. Tōpuni as a designation does not constitute a planning restriction in terms of development, but rather as a way of being "very public symbols of Ngāi Tahu mana (status) and rangatiratanga (sovereignty) over some of the most prominent landscape features" within Aotearoa New Zealand (TE RŪNANGA O NGĀI TAHU 1997)

This is a recognition of the cultural significance the site has for Ngāi Tahu (Māori tribe for the wider area). This status is to ensure that Ngāi Tahu values are recognised, acknowledged and respected, and allows for them to take an active role in the management of the area (NGĀI TAHU NEGOTIATING GROUP 1997).

Journal of Digital Landscape Architecture, 7-2022, pp. 327-334. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-724-3, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537724032.

Kura Tāwhiti Conservation Area is a popular place to visit for domestic and international tourists and has seen a steady increase in visitor numbers over the last decade. The management of this is now a focus for DoC and Ngāi Tahu as there are no accurate records of visitor numbers to inform decision-making. The impressive limestone tors that protrude out of the rolling landscape are the main attraction for visitors and the area is popular for rock climbing, bouldering and day walkers. The effects that these visitors have on this culturally significant landscape are currently being monitored through visual inspection and there is currently no detailed survey of the area and landforms. There has been little research undertaken regarding the management of tōpuni sites as part of the wider field of protected cultural landscapes. This research seeks to engage with the following questions: What considerations need to be made for the creation of a landscape model of a tōpuni site? What advantages does an accurate 3D landscape model have for a tōpuni site? How can the digital experience of a tōpuni site aid site designers? As UAVs are used widely in landscape architecture, especially to answer questions that require an overview with high-quality imagery (CURETON 2020), UAV options will be used to acquire the large-scale attributes of the site that a terrestrial laser-scanner cannot efficiently gather.

2 Methods

2.1 Data Collection

As UAV flights within the conservation area are prohibited, special permission was required to carry out the research tasks on this site before any physical survey could be undertaken. As the area has both conservation protection and tōpuni status, permission was required from the Department of Conservation and Māori through the local tribe – Ngāi Tahu (and more accurately, Ngāi Tūāhuriri who are the hapū (smallest tribal unit) that has governance over the area). This involved meeting with representatives and discussing the history of the area, issues that Ngāi Tūāhuriri are dealing with at the landscape-scale, and their aspirations for the future.

After a rigorous permission process that spanned 17 months, permission was granted and included conditions such as displaying signage that the UAV flights were permitted and that UAV flights are otherwise prohibited. As the site itself provided challenging terrain with narrow gaps between rocks, close proximity to a state highway and varied altitude changes, it was decided that the best possible result would require using both UAVs and terrestrial laser scanners. Following examples of research with complex terrain (such as JUNJIE et al. 2017 and LIANG et al. 2020), a Leica RTC360 laser scanner was used to survey the more complex central rock outcrops, and a Leica BLK2GO for moving through narrow gaps due its portability. The aerial survey was carried out by a senseFly eBee X and a DJI Phantom 3 Professional UAV. The eBee X is a fixed-wing UAV and was able to cover a larger area for capturing data (the site totalled 128,000 m^2), whilst the Phantom 3 was used for the areas closest to the state highway due to having smaller turnarounds at the end of each pass. Flight management was controlled using eMotion for the eBee X and Pix4DCapture for the Phantom 3. The survey was carried out over the span of three days due to the scale of the site.

2.2 Landscape Model Creation

Once the data were collected, the next phase involved the building of the landscape model. This was achieved using software on a high-performance PC. Register 360 software was used for reviewing and collating point cloud data, and ContextCapture was used for the meshing of aerial survey images with 3D laser scan points to complete the landscape model. The extent of the collated point cloud is shown in Figure 1 which also reveals the missing areas where the UAV data was used to complete the surface of the 3D model.

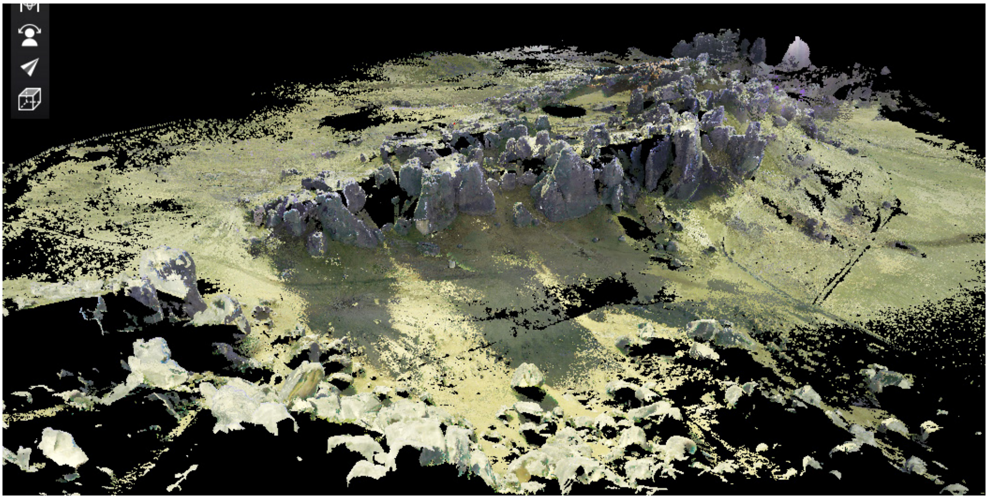

Fig. 1: Point cloud of the terrestrial laser scan data showing the areas that were supplemented by UAV data in order to complete the surface of the 3D model

3 Results

The results from processing the point cloud survey points, and from the merging of the point cloud and UAV survey data were as expected, with high levels of accuracy and resolution given the equipment used. Across the site, a precision of 10 mm was afforded from the 3D laser scanning with ground control points and yielded 1.5 billion points of data. The data collected from the UAV survey added areas to the model that the laser scanner couldn't reach, such as the upper and top faces of the rock formations. A sample of the output is shown in Figure 2 and demonstrates how using multiple UAVs and laser scanners resulted in a high-quality result.

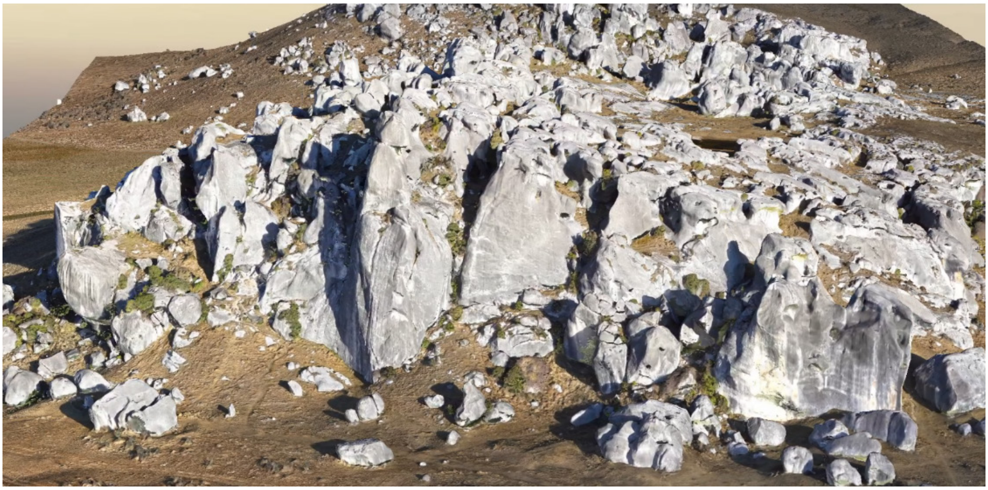

Fig. 2: Completed 3D landscape model (point cloud and photogrammetry combined) showing the complex terrain and altitude variation

4 Discussion

The undertaking of this research exercise raised several items to attention throughout the process. These include the process around gaining permission to undertake it, the experience of using different collection tools, the benefits of collaboration between researchers and land managers, as well as using these models for alternative scenarios and virtual environments.

The process to gain permission to undertake this research required more steps than was expected – especially when compared to obtaining permission for activities in similarly protected areas – and took 17 months. The advantage of going through such a process, encouraged multiple points of contact with those involved with the management and protection of this cultural landscape, and through these discussions they are more aware of the outcomes from this research. This engagement is important and ensures that the research is applicable and of end benefit for decision makers.

The process of collecting the UAV data was very short (<45 mins.) compared to the lengthier process required for the 3D laser scanner (15 hrs. approx.). This variation enabled a comparison to arise from this research which was not expected – site awareness. Through the process of manoeuvring the laser scanner around the site through difficult terrain, the site's features and characteristics became more apparent.

This research made use of a funding grant and educational licences for software to undertake the data collection, the processing and the landscape modelling itself. Furthering this work for other significant cultural landscapes within Aotearoa New Zealand would be of mutual benefit for mana whenua, DoC and researchers through a sharing of the cost-burden. There are many benefits to a 3D landscape model, such as creating a representation that can be used for preservation and remediation from a specific point in time (HOU et al. 2014), through to safety, decision making and innovation (JONES et al. 2020). The 3D landscape model also provides guidance in landscape planning, especially in terms of analysing it further e. g., absorbed energy of solar radiation (URECH et al. 2020).

The landscape modelling such as the research undertaken here, present persons charged with the management of these resources visual tools to assess any proposals for development and infrastructure improvements. Alternative scenarios could also be derived using these accurate landscape models to review and mitigate the impacts from tourism, with LAWSON et al. (2021) showing that such models would already be of benefit to Kura Tāwhiti (Figure 3). The development of alternative scenarios that use highly-accurate 3D landscape models could help to avoid cultural conflicts such as the Te Mata O Rongokako track issue in 2017, where a track was arbitrarily constructed into a site which was of special significance to the local Māori (MORRISON 2020). Whilst a simple photomontage would be a beginning step, using the 3D landscape model can enable better results and more angles.

Fig. 3: Alternative scenarios are a useful tool for decision makers – seen here is Kura Tāwhiti under an 'Intensive Visitation' scenario. Accurate 3D landscape models can help with improving this tool. Image credit: LAWSON et al. (2021) – CC BY 4.0

Finally, using this 3D landscape model in other Virtual Reality (VR) or Augmented Reality (AR) settings would be beneficial as these can be used by decision makers, to have a more immersive experience. One drawback, as identified by OBRADOVIĆ et al. (2020), is that specific skills are required to create the virtual environment and to effectively control the experience of movement throughout the environment – something that could be another benefit of a collaboration arrangement between land managers and researchers. The virtual experience of a sensitive or fragile site also benefits greatly from fewer visitors (Poux et al. 2020). Lawson et al. (2021) showed that visitors would have a more positive experience of the site with less people. With other issues, such as COVID-19 drastically reducing international travel, this 3D landscape model could also be used online for those wanting to visit a virtual site too. Storytelling the history, significance and messages embedded in this landscape, would be an important next step for the use of this data and 3D visualizations, such as point clouds and virtual environments, are key tools to enable this (Thöny et al. 2018).

5 Open Data

Sharing this research has been an important value since the inception of this work. This will be enabled by making it publicly available through https://data.govt.nz (Figure 4) and the 3D files will be stored in the Lincoln University research online portal.

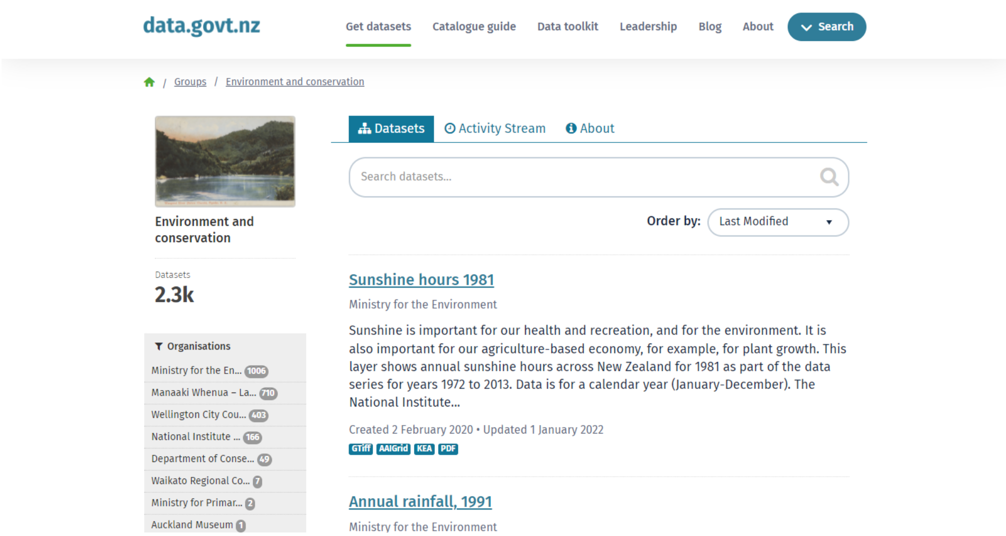

Fig. 4: The 3D landscape model data will be stored on the central government website which has a growing number of datasets following New Zealand's signing up to the International Open Data Charter in 2017

6 Conclusion

While the recognition of cultural landscapes is improving thanks in part to improved technologies and the acknowledgment of their relevance and significance to indigenous communities, the impacts of tourism and climate change requires that these cultural landscapes need more than just protection. They require careful management and the use of detailed landscape models that reveal a snapshot in time and have the potential to then be analysed further to reveal changes over time.

It is clear that the advantages of creating a 3D landscape model of a tōpuni site are several: the monitoring of landscape change; the testing of accurate alternative scenarios; and enabling virtual visits which reduce numbers and protect the site. However, the process to receive permission to create these is currently obstructive, though of mutual benefit to both land managers and researchers.

The process of creating an accurate 3D landscape model of a Tōpuni site was not cost restrictive nor required specialist knowledge or skills to create, and that this example should prompt further 3D landscape models to be created for other Tōpuni sites due to reduced barriers. Some of the remaining 13 sites, such as Aoraki / Mt. Cook (Figure 5), may be difficult for terrestrial laser scanners due to extreme changes in elevation or for UAVs due to below freezing temperatures.

Video data was also collected from this research and will form the basis of a subsequent research paper.

Fig. 5: Other Tōpuni sites, such as Aoraki / Mt. Cook (pictured), would also benefit from the creation of a 3D landscape model (Image credit: Author)

Acknowledgements

This research was undertaken thanks to a Seed Fund grant (#INT1140) from Lincoln University (NZ).

References

CURETON, P. (2020), Drone Futures: UAS in Landscape and Urban Design. Routledge.

HOU, M., ZHANG, X., WU, Y. & HU, Y. (2014), 3D Laser Scanning Modeling and application on Dazu Thousand-hand Bodhisattva in China. ISPRS Annals of Photogrammetry, Remote Sensing & Spatial Information Sciences, 2 (4).

JONES, D., SNIDER, C., NASSEHI, A., YON, J. & HICKS, B. (2020), Characterising the Digital Twin: A systematic literature review. CIRP Journal of Manufacturing Science and Technology, 29, 36-52.

JUNJIE, M., DAN, L. & ZHILONG, L. (2017), Application of 3D Laser Scanning Technology in Complex Rock Foundation Design. 3D Research, 8 (4), 34.

LAWSON, G., DEAN, D., HE, Y. & HUANG, X. (2021), Motivations and Satisfaction of New Zealand Domestic Tourists to Inform Landscape Design in a Nature-Based Setting. Sustainability, 13 (22), 12415.

LIANG, H., LI, W., LAI, S., JIANG, W., ZHU, L. & ZHANG, Q. (2020), How to survey, model, and measure rockeries in a Chinese classical garden: a case study for Huanxiu Shanzhuang, Suzhou, China. Landscape Research, 45 (3), 377-391.

MORRISON, W. (2020), On the Jurisprudence of Wine's Journeys from National Terroirs to a Global Market: Places of Normativity, Mythology and Justice in London and Aotearoa/New Zealand. In: Wine Law and Policy, 593-625. Brill Nijhoff, Leiden.

NGAI TAHU NEGOTIATING GROUP (1997), Te Karaka Special Edition: The Crown's Settlement Offer, Ngai Tahu Publications, Christchurch.

OBRADOVIĆ, M., VASILJEVIĆ, I., ĐURIĆ, I., KIĆANOVIĆ, J., STOJAKOVIĆ, V. & OBRADOVIĆ, R. (2020), Virtual reality models based on photogrammetric surveys – A case study of the iconostasis of the serbian orthodox cathedral church of saint nicholas in Sremski Karlovci (Serbia). Applied Sciences, 10 (8), 2743.

POUX, F., VALEMBOIS, Q., MATTES, C., KOBBELT, L. & BILLEN, R. (2020), Initial user-centered design of a virtual reality heritage system: Applications for digital tourism. Remote Sensing, 12 (16), 2583.

TE RŪNANGA O NGĀI TAHU (1997), Mana Recognition. Te Rūnanga o Ngāi Tahu. https://ngaitahu.iwi.nz/ngai-tahu/the-settlement/settlement-offer/cultural-redress/ownership-and-control/mana-recognition/.

THÖNY, M., SCHNÜRER, R., SIEBER, R., HURNI, L. & PAJAROLA, R. (2018), Storytelling in interactive 3D geographic visualization systems. ISPRS International Journal of Geo-Information, 7 (3), 123.

URECH, P. R., DISSEGNA, M. A., GIROT, C. & GRÊT-REGAMEY, A. (2020), Point cloud modeling as a bridge between landscape design and planning. Landscape and Urban Planning, 203, 103903.