The digital direction of peatland restoration: automation and digital twins

M. P. Wilson, L. Gill, R. Pilkington, & C. Pons

North Pennines AONB Partnership, 1 Martin Street, Stanhope, Bishop Auckland DL13 2UY

Abstract

A key theme of the IUCN UK Peatland Programme Conference 2022 was the need to scale up peatland restoration to meet climate change targets. Another theme of the conference, voiced by restoration practitioners, was how to scale up with only limited, short-term (not decadal) funding grants available to keep staff on and expand teams. These contradictory themes highlight capacity issues peatland restoration faces; do more work with limited additional resources. Part of the solution lies in restoration practitioners embracing the use of digital technologies to improve efficiencies, rather than relying on, for example, labour-intensive fieldwork. Such a technology-driven approach is also being seen more generally across the conservation sector, with a rapidly expanding use of Geographical Information Systems (GIS), coding, artificial intelligence, and Earth Observation (EO), for example via Unoccupied Aerial Vehicles (UAVs), aeroplanes and satellites. This is not to say fieldwork is redundant and unnecessary – there will still be a need to observe sites in person, ground-truth remotely sensed data, and deploy and maintain monitoring equipment. Nevertheless, technology is enabling much more to be achieved in the digital world from behind a desk than previously. In this study we investigated a digitally-led approach to creating an upland peatland restoration plan, whereby fieldwork was only undertaken to carry out an initial UAV survey and ground-truth the restoration interventions planned entirely from the desk. Using remotely sensed data in GIS it is possible to semi-automatically map hagg edges and quantify their heights, map gully systems and their widths, map bare peat and quantify the area, and ultimately combine these outputs with a digital twin (i.e. a digital 3D model) from which field staff can determine restoration interventions.

Methodology

UAV survey
- Mavic 3 Enterprise
- DroneDeploy flight planning
- 120 m altitude → 3.4 cm/px
- Nadir and oblique photos

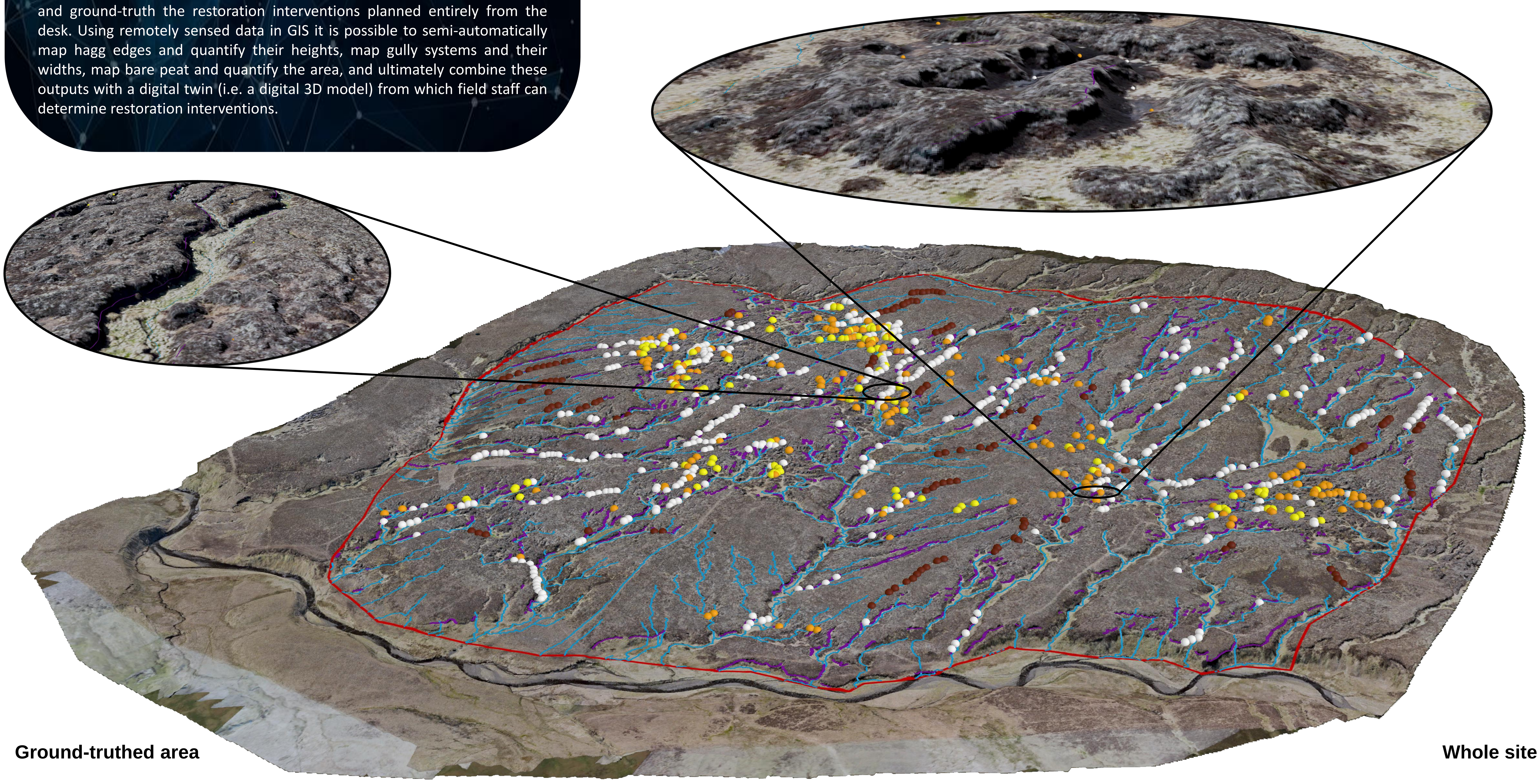
Data processing
- 1,577 UAV photos
- PIX4Dmapper
- Upscale 3.4 cm/px → 10 cm/px
- Output orthomosaic + DSM

Semi-automated mapping
- ArcGIS Pro
- Custom geoprocessing models
- Edges mapped from Environment Agency LiDAR (coarser resolution → less noisy output)

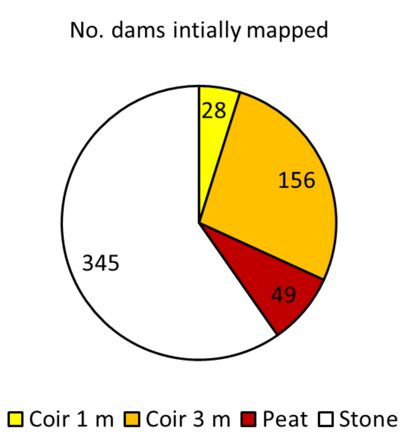
Intervention mapping
- ArcGIS Pro local scene view
- Orthomosaic draped over DSM → Digital Twin (static digital 3D model)
- 3 field staff mapping restoration interventions separately
- QC edges to reprofile and determine dam locations + type

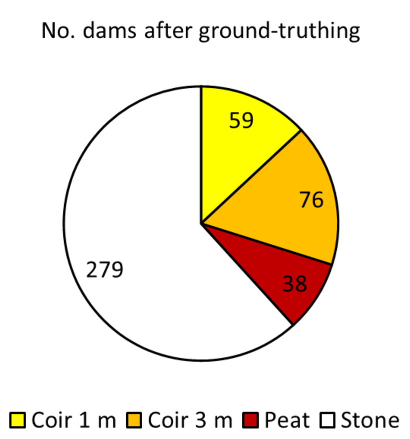
Ground-truth survey
- Transect based
- 578 of 1,004 dam locations checked
- 7,643 m of 14,085 m edges checked
- Trimble TDC600 + ArcGIS Field Maps

"A picture is worth a thousand words, but a digital twin is worth a thousand pictures"



Ground-truthed area

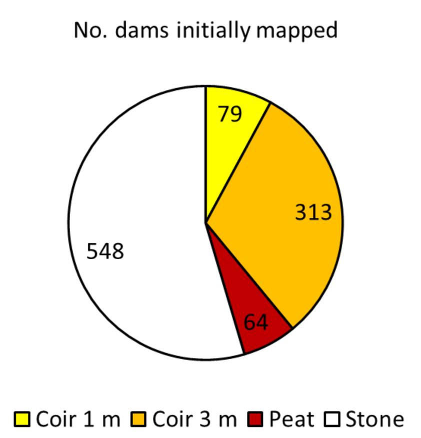


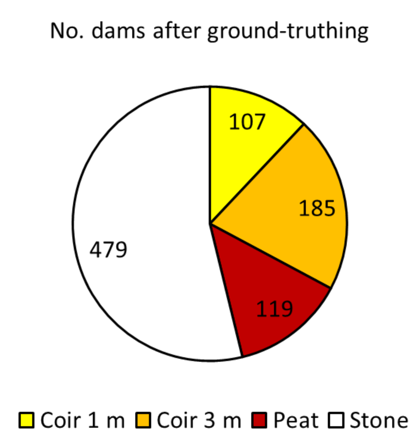


Dams	Coir 1 m	Coir 3 m	Peat	Stone
Number checked	28	156	49	345
Number unchanged	7	43	21	152
Number changed	5	30	2	12
Number removed	16	83	26	181
Number added	52	33	17	127

Edge reprofiling	Length (m)
Desk mapped	14,085
Ground-truthed	7,643
Removed	1,765
Added	987
Final	13,307

Whole site





Advantages

- Year round restoration planning possible (not limited by weather, MOD restrictions, bird nesting, or game shooting)
- Increased efficiency. Semi-automated mapping takes minutes/hours to set up, run and QC compared to days/weeks of manual GIS and field mapping. Outputs are highly accurate and require little and easy manual cleaning
- Choosing dam types and locations across a whole site is quicker digitally than in the field (after initial software familiarisation)
- Lower resolution digital twins possible from freely available datasets (UAV not necessarily required)
- Lone working and remote location risks removed
- Less vehicular travel to sites (reduced carbon footprint)
- Reduced foot presence on sites is better for fauna and flora
- Opportunities for staff equality, diversity and inclusivity (EDI) improvements with desk-based, digital fieldwork roles possible
- Enhanced engagement opportunities with stakeholders. Ability to "visit" sites digitally rather than in person

Disadvantages

- Field staff sometimes struggled to recognise vegetated pixels from bare peat dominated pixels (although only a 10 cm/px resolution was trialled in this study) → Large coir 3 m reduction
- Shadows in imagery can create blind spots, image classification errors, and field staff to question automated outputs (lack of trust in elevation data-driven outputs)
- Inability to remotely measure peat depth is problematic for determining peat and timber dam possibilities
- Even the highest resolution UAV imagery isn't as good as being there in person, e.g. only top vegetation layer captured, overhanging edges not captured
- Considerable ground-truthing can still be required due to staff inexperience and data limitations. For example, deep gullies less than a metre wide which had vegetation covering them were difficult to identify in the digital twin
- Higher performance computing and software needed, which is generally more expensive
- High resolution data from UAVs requires UAV hire or purchase costs, CAA licencing, and specialist processing software

Key learning outcomes

- Initial familiarisation with digital twin and new approach takes time for field staff, but feature and intervention mapping at the site scale is much quicker than in the field
- Effectiveness of digital intervention mapping greatly improves with experience, just as mapping in the field improves with experience
- Data management is important, especially if multiple staff are working on the same digital twin
- If multiple staff are working on the digital twin, it may be useful to assign specific areas within the site so each staff member can better keep track of surveyed areas
- Efficient ground-truthing requires a simple and quick system so that field staff can keep, discard or change interventions and update easily in the digital twin (e.g. ArcGIS Field Maps forms).

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https://www.northpennines.org.uk/what_we_do/peatland-programme/