

# Digital twins for natural landscape management: Opportunities and challenges

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**Abstract:** Digital Twins (DTs), which are dynamic virtual representations of physical objects or systems across multiple stages of their lifecycle, support understanding, reasoning and decision-making about those systems (Jones et al. 2020). Inspired by their success in the management of man-made systems, there has been a recent push towards creating DTs of the natural environment. Examples range from DTs at the farm scale (Moghadam et al. 2020), to the proposed DTs of the Earth (Bauer et al. 2021). The DT technology holds immense potential for the management of environmental systems, particularly to aid informed decision making. DTs can facilitate collaboration among stakeholders with differing or conflicting perspectives by helping them understand (i) the associated processes and interactions, and (ii) potential actions and interventions needed to manage the landscape, by simulating various states of the landscape under multiple management scenarios.

However, successfully applying the DT paradigm to the natural environment is challenging for several reasons. Principal among these are the integration of the human and social components that are vital parts of most natural environments, and the need to integrate the idiosyncrasies and uncertainties of complex, dynamic, living sub-systems within that landscape. While overcoming these challenges is difficult, any DT of the natural landscape will be incomplete without the integration of the dynamic social and biological sub-systems.

We propose to address this using a layered framework, where the DT of the natural landscape is either composed of, or connected to several sub-digital twins and models (see Fig 1). The lower two layers (the landscape/environment and biophysical layers) will form the foundation upon which the social models of the natural landscape will be developed, i.e., these layers will be the environment or context for the socio-cultural DTs. As we move up from the more observable and quantifiable layers to more abstract layers, the DTs will increasingly rely on modelling and simulation. This separation of layers and context in the proposed framework will allow us to create varying sets of scenarios as contextual inputs that apply to either the entirety or a subset of the DT framework.

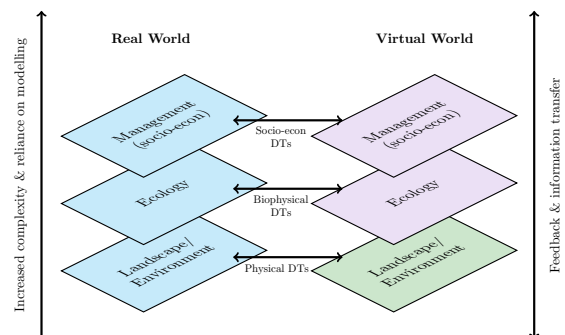
This will enable multivariate testing of various real, probable and hypothetical scenarios and simulating their influence on the underlying landscape.

The initial DTs of the natural landscape will probably focus only on specific aspects of the natural landscape that are being studied. However, we believe the layered modular approach of the proposed framework will provide the opportunity to integrate expertise across multiple scientific fields towards the goal of developing a comprehensive DT of the natural environment. Additionally, such DTs have immense potential in terms of informed, coordinated and collaborative decision-making for sustainable management of the natural landscape.

## REFERENCES

- Bauer, P., Stevens, B. & Hazeleger, W. (2021), 'A digital twin of earth for the green transition', **11**, 80–83.  
Jones, D., Snider, C., Nassehi, A., Yon, J. & Hicks, B. (2020), 'Characterising the digital twin: A systematic literature review', **29**, 36–52.  
Moghadam, P., Lowe, T. & Edwards, E. J. (2020), 'Digital twin for the future of orchard production systems', *Multidisciplinary Digital Publishing Institute Proceedings* **36**(1), 92.

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**Figure 1.** Proposed layered digital twin framework