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Interoperability in Practice: Integrating Natural History Collections with Modern Ecological Data Streams

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Natural history collections are increasingly recognised as critical infrastructure for addressing complex ecological challenges, yet their full potential can only be realised through strategic integration with other ecological data streams. While FAIR principles and the Digital Extended Specimen concept provide theoretical frameworks for data integration, practical implementation requires navigating real-world constraints and trade-offs. This presentation explores two case studies demonstrating pragmatic approaches to collections data integration, highlighting both opportunities and challenges in building interoperable biodiversity data assets.

The first case study demonstrates integration of historical specimen records with climate projection data to forecast flowering phenology responses in Australian Acacia species. By combining specimen data, historical climate records, and phylogenetic information with CMIP6 climate projections, we model potential shifts in flowering patterns under different climate scenarios (high- and low-emissions Shared Socioeconomic Pathways) at 2050 and 2100 horizons. This integration of specimen-based spatiotemporal data with climate projections provides insights into potential ecosystem-level impacts of phenological changes, while highlighting technical challenges in integrating collections datasets and other ecological data layers with projected outputs from modern climate models.

The second case study examines the integration of specimen data from Australian herbaria with the AusTraits database, focusing on practical strategies for linking specimen records with trait measurements. Rather than pursuing universal completeness in metadata and vocabulary overlap, this work emphasises feasible approaches that maximise utility for diverse research applications while maintaining manageable data standards. We discuss key decision points in balancing comprehensive coverage against practical constraints, and present solutions for creating flexible, interlinked data resources that serve multiple research needs.

These case studies illustrate how thoughtful integration of collections data with other ecological data streams can unlock new research capabilities while adhering to FAIR principles. We present practical lessons learned about balancing ideal standards against operational realities, and share suggestions for similar integrative studies. Our experiences demonstrate that successful data integration need not achieve perfect universality to deliver significant scientific value, suggesting pragmatic pathways for expanding the utility of natural history collections in modern ecological research.

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