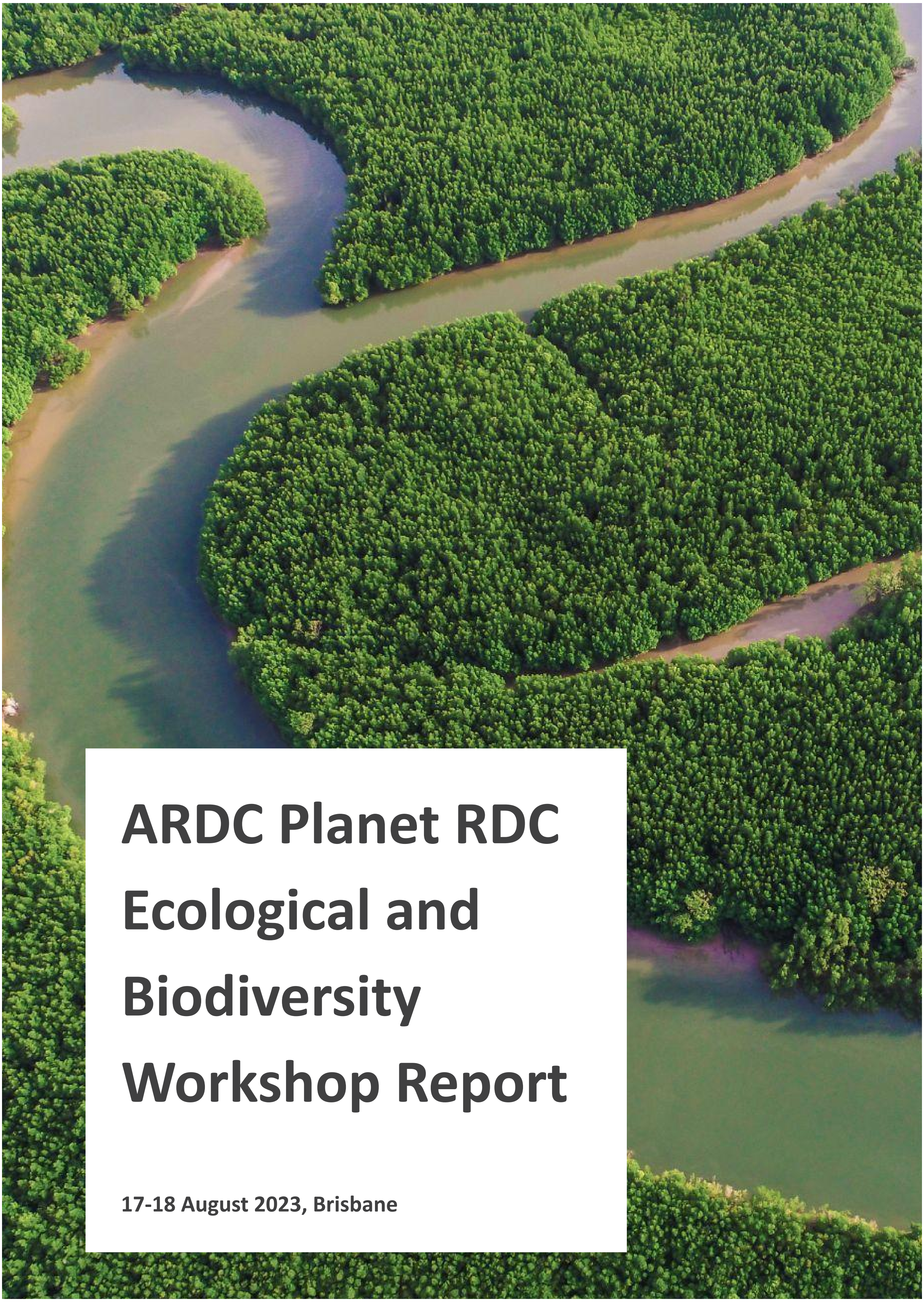

ARDC Planet RDC Ecological and Biodiversity Workshop Report

17-18 August 2023, Brisbane

ARDC
Australian Research Data Commons
NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative
ARDC is enabled by NCRIS

Acknowledgments

Thank you to our many partners across research, government, industry and community for their contributions and for the help of Jo Morris, Kerry Levett, Elisa Bayraktarov, Hamish Holewa, Martin Westgate, Rob Clemens, Brendan Mackey in particular for assistance in compiling this report.

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Acknowledgement of Country

We acknowledge the traditional custodians throughout Australia and their continuing connection to, and deep knowledge of, the land and waters. We pay our respects to Elders both past and present.

Australian Research Data Commons

The Improving Indigenous Research Capability project received investment (doi.org/10.47486/HIR003) from the Australian Research Data Commons (ARDC).

CONTENTS

1. Introduction

Research and decision-making about biodiversity increasingly depends on statistical models, whose function is to infer where and when species are likely to be found.

The ARDC is investigating what digital research infrastructure is needed to support researchers in model development and use, and to foster collaborative networked modelling efforts under the Planet Research Data Commons program.

Access to trusted species distribution models (SDM), related species models and curated environmental datasets, are supported by NCRIS through the Atlas of Living Australia, TERN, IMOS, and the ARDC-supported EcoCommons Australia and Biosecurity Commons platforms.

However, a much larger tool box of ecological models have been developed and are being used by researchers and practitioners such as Bayesian belief models, meta-population dynamics models, process-based species models, landscape habitat patch analysis and connectivity models, as well as spatial conservation planning tools.

Ecological and biodiversity modelling experts gathered in Brisbane on Turrbal and Yuggera Country to discuss the digital research infrastructure needed to support researchers developing and using ecological and biodiversity models.

The workshop was part of a series of consultations underway for the ARDC's Planet Research Data Commons (Planet RDC), which is developing national-scale data infrastructure for earth and environmental research and decision-making.

The workshop participants represented a wide range of organisations, bringing their insights on the needs of terrestrial biodiversity and ecological modelling across academia, government, nonprofits and national infrastructure facilities. The participants came from:

- Government departments: Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW), NSW Department of Planning and the Environment, Queensland Department of Environment and Science
- Universities and government research agencies: CSIRO, Griffith University, Macquarie University, University of Melbourne, University of Queensland, University of New South Wales
- Non-government organisations: The Nature Conservancy
- Research infrastructures: Atlas of Living Australia and ARDC.

2. Objectives

The objectives of the workshop were to:

1. Contribute to the development of Planet RDC's understanding of modelling, analytics and decision support infrastructure of the ecological research and practice community.
2. Provide guidance on the digital infrastructure required to support collaborative, networked modelling.
3. Identify high-priority/national priority trusted ecological models and associated input data that could be supported and made available to a broader community of users.
4. Given the different levels of data science skills of the modelling and user communities, identify the types of infrastructure that are most useful for those users who want to collaboratively develop, test and generate trusted models.

3. Discussion Areas

3.1 Science drivers and needs

Discussion focused on the science needs and opportunities for local, state and national demand for ecological analytics, information and decision support. At a national level, these include:

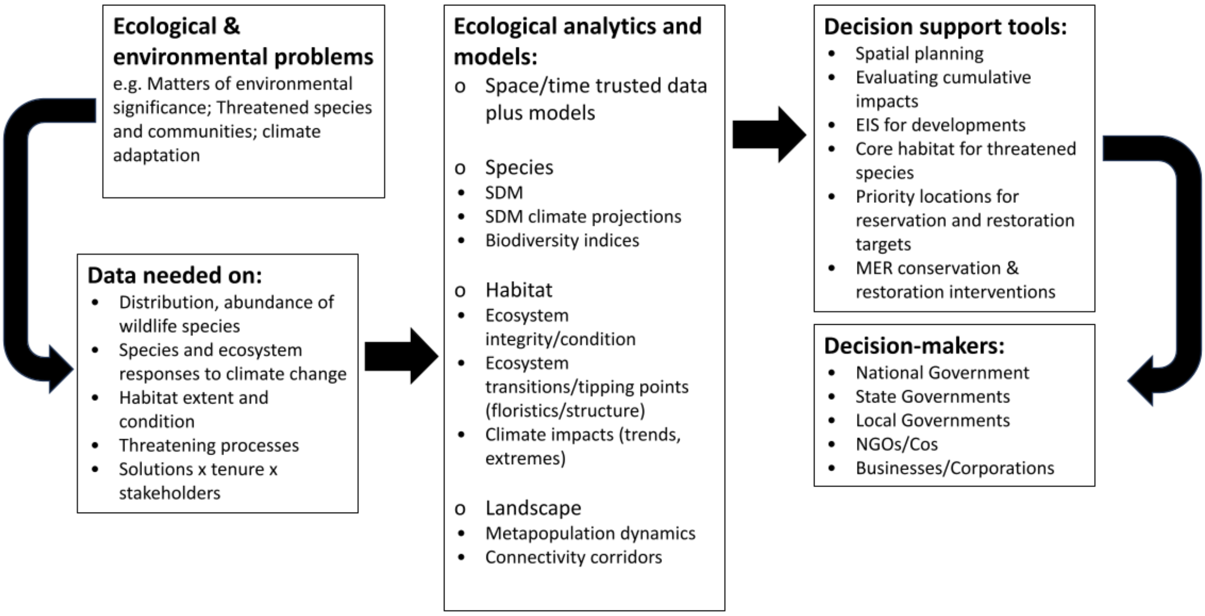
- Matters of National Environmental Significance
    - listed threatened species and communities
    - listed migratory species
    - Ramsar wetlands of international importance
    - Commonwealth marine environment
    - World Heritage properties
    - National Heritage places
    - the Great Barrier Reef Marine Park
    - water resource, in relation to coal seam gas development and large resource developments

State governments also have their complementary lists of threatened species and communities, and related species recovery programs. All levels of government now have a need for and commitment to various kinds of climate adaptation planning and regional planning for biodiversity and environmental matters.

- Climate Adaptation Planning
    - Place based, community-centred, informed and guided by community values

    - Underpinned by science and analysis, including climate risks assessments, to inform decision making, prioritise areas, identify adaptation strategies and option that are feasible and appropriate
    - Needed now to support the protection and management of species, ecosystems and related natural resources
- Regional Planning
    - State governments are increasingly seeking to integrate ecological and environmental factors with interregional planning
    - The Australian Government is currently developed approaches to regional planning in support of reform to the Environment Protection and Biodiversity Conservation Act
    - Regional plans need to provide clear guidance on areas and locations that are important for biodiversity and other matters of environmental significance that must be protected, restored and appropriately managed

There is a need for a set of agreed, fit-for-purpose ecological models that can be used confidently to generate the information needed for regional planning and the associated regulatory decision-making. A chained set of Integrated ecological models and decision support tools is needed to generate the information required to assess biodiversity assets, address matters of national environmental significance, and support climate adaptation and regional planning requirements. As the following diagram illustrates, there must be a program logic that provides decision makers with information needed to address their specific problems, and there is a clear line of sight from data to models and decision support tools (research translation pathways):



3.2 Current Platform Capabilities and Future Potential

In this session, three examples of commercial platforms and four research-driven platforms were presented. Infrastructures listed do not represent all platforms available or are extensive and are provided as an example only. An overview of the platforms and their current capabilities are summarised below:

3.2.1 Commercial Platforms

1. Microsoft's Planetary Computer - released in 2022, is intended as a "global portfolio of applications connecting trillions of data points" and is designed to use artificial intelligence to synthesise environmental data into practical information regarding the Earth's current ecosystems. The Planetary Computer was born from Microsoft's plan to be carbon negative, water positive and zero waste by 2030. It consist of 4 major components:
    a. A Data Catalogue which contains 24 petabytes of earth observation data (e.g., Air Quality, Biodiversity, Biomass/Vegetation, Climate/Weather, Digital Elevation Models, Demographics, Fire, Land use/Land cover etc.), which can be accessed via Azure Blob Storage hosted on Azure and made available to the users free of charge.
    b. APIs allowing users to search for data in the data catalogue

c. The Microsoft Planetary Hub is a JupyterHub engine-powered computing environment where users can run scripts or notebooks to process data on the Azure Cloud
d. And then there are applications that are mostly built by partners and not directly connected to the Hub or to the Data Catalogue. One of Microsoft's main example applications is the Spatial Prioritisation Tool Marxan.

2. Google Earth Engine - is focused on providing users access to satellite imagery data to detect changes, map trends and quantify differences on the Earth's surface. It was first released in 2010 and has been the a popular cloud computing platform for the remote sensing community due to free access. Users sign up with their gmail account and then apply for access. In 2022, Google released a version of the Google Earth Engine as an enterprise-grade service through Google Cloud to businesses and governments. In terms of data, Google Earth Engine has about 600 datasets that span the time interval between 1970 and present day and data products are updated every 15 mins. With regards to analytics, Google offers access through the Earth Engine Code Editor which is a code-base development environment for analyses through the browser. Since 2022, users can also build custom applications in JavaScript and Python. Google is interested in collaborating with partners for the development of new methods for mapping and monitoring and they are specifically interested in land use or land cover, carbon emissions, environmental indicators. While the number of registered Google Earth Engine users is not made publicly available, since launch of the platform in 2010, there have been about 800 scientific publications referring to Google Earth Engine as of 2022.

3. Earth on AWS - planetary-scale application on the cloud consisting of a data-focused platform built by Amazon and released in 2006. Services are focused on Environmental, Social and Governance investing and many of them are paid. From their 4000 data products, 74 contain environmental data. AWS has some geospatial and location-specific applications and they provide cloud credits for researchers. For instance, users can track surface temperature, changes in vegetation coverage and even biodiversity. For many years, AWS was the most popular cloud computing platform for the remote sensing community due to free access. Earth on AWS is available at no cost for nonprofit organisations, research scientists, and other impact users for their non-commercial and research projects.

It was noted that within Commercial platforms there is a paucity of Australian specific environmental data and modelled outputs. Making relevant Australian environmental data available natively to these platforms would facilitate increased adoption and utilisation for research purposes.

3.2.2 Research Driven Platforms

1. The TSX Threatened Species Index, established in 2018, is a tool for tracking threatened species trends in Australia. In collaboration with data custodians, it aggregates data from 230 sources with a coverage of 278 species, and is part of TERN's infrastructure until 2028. In 2023, it became an official well-being indicator for Australia, focusing on biodiversity change. The TSX integrates standardised time-series data from systematic surveys at monitored sites, with data available at tsx.org.au, stored securely on the NeCTAR Research Cloud. There's growing interest in accessing the high-resolution data for applications like Species Distribution Models.

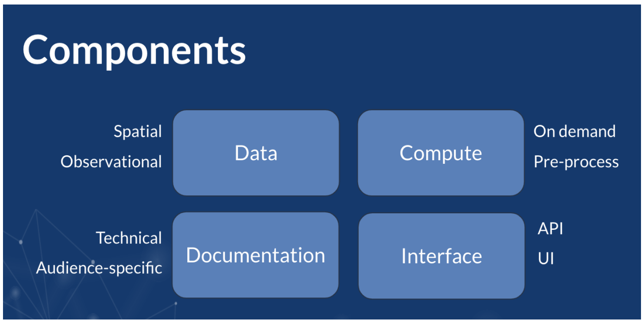
2. EcoCommons Australia offers 19 statistical and machine-learning algorithms for Species Distribution Models and Ensemble Models. It can also run Climate Projections that highlight climate change impacts on biodiversity using point-and-click functionality. It provides a JupyterHub command-line environment for scripted code or notebooks. It includes a data catalogue offering access to 60,000 data collections, and integrates with national and international repositories. Users are able to import their own data. The underlying platform is shared with Biosecurity Commons, serving about 800 users and will be operational until 15/12/2023.

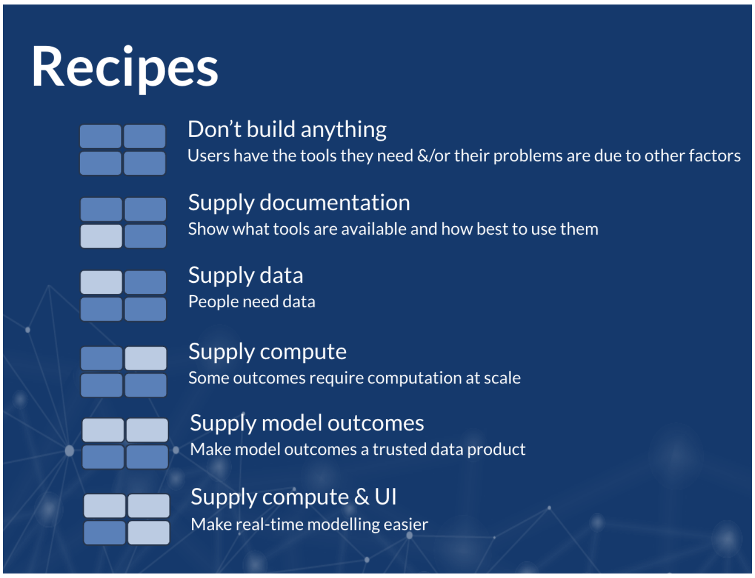
3. Biosecurity commons provides risk and response biosecurity analytics, including risk mapping, dispersal modelling, surveillance design, and proof-of-freedom workflows. The risk mapping workflow estimates where a pest or disease is likely to arrive and establish. Climatic niche models (SDMs) are often used as an input to this workflow, but the methods are incorporating those developed by CEBRA at the University of Melbourne. The dispersal modelling workflow predicts how a disease or pest might spread. It is expected over the next year that a workflow on resource allocation will be developed to optimise where to spend limited resources to control or eradicate pests or diseases. Developed by CEBRA, Griffith University and partners between 2021-2023, it's in a pilot phase aiming to expand its user base. The Commonwealth has funded the pilot that will complete in October 2024 that will build templates, use cases and educational material.

4. Marxan- the Spatial Prioritisation Tool Marxan is widely used for R spatial conservation planning including prioritising areas for conservation, management actions and restoration since 1995. It was originally used to rezone the Great Barrier Reef and since then has been utilised by practitioners internationally in particular in planning for new protected areas. A cloud-based version, Marxan Planning Platform (MaPP), was released in 2022 and complements EcoCommons as the species distribution modelling outputs can be used as input for a spatial prioritisation exercise on MaPP. TNC intends to host MaPP until 2025.

3.3 Infrastructure Requirements to Support Advanced Analysis and Modelling

Infrastructure requirements to support analysis and modelling were discussed using a conceptual framework made up of the components: (1) data (2) compute (or technical infrastructure); (3) documentation and; (4) interfaces; and how improvements in each area (or a combination of areas) could best meet the needs of different end-users.





The infrastructure requirements for each component area discussed were:

3.3.1 Data

- More data needs to be made available
- Data should be well-documented and FAIR
- Data could be made available in real-time, or pre-processed for ease of use, including integrating data from different disciplines/sources
- Model outputs could also be provided as indexed searchable data products
- Data should use national and international standards such as the new Australian Biodiversity Information Standard which intends to harmonise the API-provisioned data from states/territory data repositories into the federal Biodiversity Data Repository, and Darwin (Event) Core.
- Ability to process, filter, merge data and then store that curated data are steps that all researchers take. Biosecurity Commons has started to develop generic toolbox functionality for a

few spatial data processing steps, but there are many opportunities to do more with both spatial data and dataframes.

3.3.2 Documentation, discovery and user support

- Researchers and software engineers look for model code in journal publications or repositories such as CRAN. It is harder for end users from government, NGOs and industry to find models, and hard to know which models will be useful.
- Robust documentation is essential for transparency, reproducibility, and reusability. Documentation should adequately describe the models and their usage, including:
  - The process employed in modelling should be explained, to establish trust and obtain social licence (this can be done in vignettes).
  - The data used (particularly authoritative data sources)
  - ‘Quality’ or ‘fit-for-purpose’ measures, e.g. the level of evidence the model provides (incorporating spatio-temporal resolution, specificity, uncertainty, etc).
- User support is crucial - dedicated data science and SME support is required to help users use any infrastructure or models provided appropriately
- Building use cases with professionalised code in a notebook for how to use models in different scenarios is important to guide people through using them.

3.3.3 Interfaces

- APIs/Command Line Interfaces are preferred by experienced modellers. Most Early Career Researchers and Mid-Career Researchers use R or Python.
- GUIs (Graphic User Interface) certainly help novice researchers and are heavily utilised by governmental users (e.g. over 85% of practitioners in the governmental biosecurity sector require analytics with GUIs). However, GUIs as implemented by EcoCommons also help raise the standard of Specie Distribution Models (SDMs) by: (i) making available to users all the model parameter options which enables sensitivity analysis and exploring alternative model configurations; (ii) facilitating intermodel comparison and ensemble modelling (the later is increasingly seen as best practice); (iii) more robust post modelling diagnostic, especially variable importance and the interactive production of parsimonious models; and (iv) rigorous documentation of work flows and reproducibility of the SDM by other researchers.

3.3.3 Technical Infrastructure/Compute

- Supplying on-demand compute resources, particularly for models needing large-scale compute (HPC, GPUs on cloud - collaborative cloud) can make models available to more users
- Many governments require a reliable and continuing digital research infrastructure that allows them to run nation-wide models with higher resolution than their current 1km standard outputs. Preference is for national analyses with 90m resolution and regional analyses with up to 30m resolution.

- Access to HPC-type and parallel processing is also heavily required for turning large datasets such as imagery (e.g. camera trap images of animals, drone imagery of vegetation cover and change) and acoustic recordings to be converted into fit-for-purpose data products which can be used as inputs to modelling.
- Requirement for systems to store data, workflows and analysis products securely, with restrictions on access (levels of security specific to user requirements).

3.4 Summary

Foundational common infrastructure technology needs that emerged through the discussion included:

1. Support for well documented and maintained JupyterHub, BinderHub and Notebooks in any coding environment (R, Python) and linking those hubs to data sources and stores, e.g. through GitHub or GitLab etc.
2. Development of a modelling catalogue which enables communities to publish and rank and/or recommend models, curated workflows, example workflows with data for instruction, and analytics tools as notebooks or code
3. Spatial data and model output storage, possible indexing with search and visualisation functions;
4. Supplying on-demand compute resources, particularly for models needing large-scale compute (HPC, GPUs on cloud - collaborative cloud).

4. Model prioritisation and development

The workshop participants advanced a vision of a collaborative, well-documented, and technically advanced ecosystem for data-driven modelling and decision support, with a strong emphasis on trust, transparency, varying levels of sharing and user support for reliable regulatory decision-making. The ultimate goal is to provide reliable, trusted models for regulatory decisions. These models should complement existing work and fill existing gaps.

Representatives from the federal Department of Climate Change, Energy, Environment and Water, the Qld Department of Environment and Science and the NSW Department of Planning and Environment discussed their major needs and research questions that ecological and biodiversity models are envisioned to answer.

Many of the research and information needs are either related to the level of an individual species or related to the level of a whole ecosystem. The government representatives need the modelling capability to track change in the state of the environment at the species level and the ecosystem level.

This requires information on past, present and future states that can then be utilised to support decisions. Workshop participants highlighted the ongoing need to understand where things are, how that might change under anthropogenic threats, the quality or condition of habitats or ecosystems, the connectivity of those ecosystems, and the spatial uniqueness of biodiversity across planning areas.

The Qld government reported that species distribution models (SDMs) are most often utilised as a critical starting point for many further analyses. SDMs alone are, however, not enough and they need to be supplemented by auxiliary data on habitat quality e.g. what habitat types provide source or sink populations for a certain species; or what seasonal / temporal differences can impact the distribution of a certain species based on the availability of resources or lack thereof. The government representatives recognised that the question around past, present and future distributions of a species requires different approaches as well as data. Predictions of species distributions under climate change often inform natural resource management planning into the future. Other questions relate to the connectivity of habitat and how species vitality rates might vary based on patch size, corridor length and width, landscape permeability or attractors. Habitat connectivity models when combined with population viability analyses can inform directly on where the most valuable habitats for species or communities are currently, and where they might shift in the future. A better understanding on the threatening processes such as land clearing, bushfires, or exotic species is required to guide the optimisation of management actions, e.g. fire or fuel management, feral cat and fox control, or expansion of protected areas. Mapping of threats and threatening processes spatially can provide useful information for management of species and ecosystems (for context, this national strategy on threatened species action may help: https://www.dcceew.gov.au/sites/default/files/documents/threatened-species-action-plan-2022-2032.pdf)

All models that provide insights into these questions and specifically SDMs in conjunction, habitat condition, connectivity, or quality (source/sink) with spatial threat maps are highly useful to inform conservation planning as they can help prioritise interventions. Spatial prioritisation of intervention can be carried out using a spatial prioritisation tool such as the tools offered by the Marxan Planning Platform (for more context: https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/cobi.13681)

Some challenges were voiced with regards to accessibility to modelling tools but also access to species data and particularly access to sensitive species data such as on the exact locations of threatened species, e.g., the raw restricted-access data housed in the Threatened Species Index database which is controlled by data sharing agreements between TERN and data owners. Having standardised approaches to access and control of this data is critical and exemplified through initiatives such as the ALA lead Restricted Access Species Data program.
https://ardc.edu.au/project/restricted-access-species-data-pathways-from-decision-making-to-research/

Some of the models and their outputs that would need to be included going forward included:

- Species distribution models (where species or groups of species are more likely to be found), generalised dissimilarity models (where are unique groups of species / communities) and occupancy models (where are species based on an understanding of detection probability of current survey efforts).
- Connectivity models and population viability analyses answer questions about the quality of patches of habitat and the importance of corridors. These results not only help prioritise reserve expansion or habitat protection measures but also inform on optimal locations for restoration work to grow patch sizes, or restore connectivity through habitat corridors. Remote sensing data and data products can help provide insights into changes in the availability or condition of habitats.

The following models were identified:

1. Species distribution modelling for suitable species habitat in the past, present and future
2. Models to assess habitat quality
3. Spatial habitat patch analyses.
4. Climate projections to understand the impact of climate change on future distributions of species
5. Mapping threats to species to guide effective decisions for management of these threats (more context: https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002256)
6. Connectivity models to assess the fragmentation of habitat and quality of existing habitat patches or connected networks of habitats
7. Population viability analyses to understand the likelihood of species persistence in the available networks of habitat.
8. Generalised dissimilarity models to understand how community of species change through time or along the distance gradient, where are unique communities found
9. Occupancy models to improve precisions of distribution predictions by including detection probability in the models.
10. Spatial prioritisation of interventions (e.g., Marxan Planning Platform tool). Species distribution modelling outputs can be used as input for a spatial prioritisation exercise on MaPP.

Another need identified was to chain ecological models (SDM + habitat + threat + PVA + connectivity) which can all inform spatial planning tools.

A SDM Hypercube portal was envisaged that could be built upon existing national scale investments and infrastructure that allowed seamless data access, modelling and post modelling functionality, modelled outputs and workflows across species, environments and timescales. The number of potential users is large given the escalating demand for biodiversity information by research, industry and governments at all levels and community organisations.

For governments, functionality could be expanded by developing a decision support portal based around the concept SDM Hypercube – a spatial database for Australian threatened species that contains multiple distribution models for each species based on different predictor variables and modelling algorithms that have been generated using different predictor variables, algorithms, resolutions, and temporal projections. This SDM Hypercube portal would provide researchers, decision makers, and practitioners the functionality to discover, collaborate, share, evaluate and compare SDMs for Australia species. The degree of access could be moderated so that, for example, government agencies responsible for curating threatened species could securely collaborate in building or comparing SDMs. Practitioners could have access to SDMs for species that have been verified as reliable for specified uses, researchers could collaborate in improving models based on new data sources and methods.

The concept of a SDM Hypercube would allow for multiple SDM for the same species to be stored that reflect varying levels of or differences in (1) ecological knowledge, habitat data and biological observations; (2) precision and accuracy of predictor variables; (3) modelling algorithms; and (3) the time horizon (e.g. SDM projected for past or future climates).

Through a SDM Hypercube portal, a collaborative approach could also be taken to peer review and guidance by a scientific advisory group as to the limitations and applications of the SDMs, including recommendations as to the most appropriate SDM for a given use. Guidance could also be provided on workflows e.g. selection of variables for a particular modelling experiment.

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5. Enabling Activities

The focus of this discussion was the development of activities aimed at enabling and enhancing the use of models, their sharing, discoverability, reuse, and 'chaining' in the context of environmental information systems.

The following are priorities, key considerations and activities that participants felt were crucial for this endeavour:

5.1 Standards and quality

- Development and/or adoption of national standards and/or guidance for data and common products such as outputs from Species Distribution Modelling.
- Enhancing model usability and making models more fit-for-purpose, e.g. for environmental decision making and management 'decision-ready,' by addressing uncertainty.
- Establishing data quality feedback loops from data users/wranglers to data sources/providers.

- Common data vocabularies at national and state/territory levels, including common species taxonomies.

5.2 Bringing stakeholders together

- Share approaches and capabilities across jurisdictions and reduce duplication of efforts.
    - Collaboratively review and agree upon the best models.
    - Common data and methods across states are required, with feedback loops to improve models and data quality.
- We need to achieve a shared understanding and agreement on nation-wide and jurisdiction-wide priorities and develop a systematic plan to address collaboratively, e.g. through dedicated working groups.
- Building linkages and integrations between existing and future infrastructure.
- Build a cross-sectoral community of practice involving researchers, government, academia, and NGOs.
- Foster collaboration and alignment among data scientists, domain experts, and end-users:
    - Dedicated development of rigorous workflows by scientists requires highly qualified research employed as staff on projects developing curated analytics as either curated example code or as UI.
    - Translation of those workflows to a broader user group also requires active involvement by researchers familiar with optimal use of the developed methods.
    - Data science support is necessary to assist users in utilising the ecosystem effectively and appropriately. Subject matter experts (SMEs) are crucial for this purpose.
    - For highly curated analytics, data, or data products, staff from the target user community need to be provided from that user community.

5.3 Other considerations

- Ensuring clarity in long-term investment goals for a sustainable system.
- Leverage existing systems and capabilities and enhance them through better interoperability.
- Highlighting the need for continuous resourcing to maintain software and models.

A focus on cross-sector and cross-jurisdictional collaboration, long-term sustainability and funding security were seen as key principles in achieving success in this endeavour.

6. Key Recommendations

Driving factors of the provision of modelling infrastructure should be towards trend analysis and cumulative impact, regional planning and assessment. Ensuring model outputs are able to be linked through defining common approaches and standards and having well described methods were identified as key priorities.

Also recommended is the need to address social infrastructure constraints and provide programs and mechanisms for researchers and practitioners to collaborate and define approaches to complex modelling and analytical questions across domains and disciplines.

Species Distribution Models were identified as a core input to other related species and habitat related modelling and analysis. Standardised approaches and a searchable catalogue of Species Distribution Models is foundation data for other modelling approaches such as habitat quality, climate projections, spatial priority, connectivity models and population viability analysis.

Five key recommendations were identified:

1. Facilitate standardised model approaches, outputs and best practice across research and government sectors by aligning methods, technology and people.
2. Develop a comprehensive set of frequently updated and trusted Species Distribution Models that allow users to search and access associated models and their outputs as a precursor to other environmental related models.
3. Develop a "Species Distribution Modeling Hypercube" – a spatial database for Australian threatened species that contains multiple distribution models for each species based on different predictor variables and modelling algorithms that have been generated using different predictor variables, algorithms, resolutions, and temporal projections.
4. Provide infrastructure to enable a 'Trusted Model Commons' that allows users to find and execute common models; search on products or use cases, link to associated and well described methods in code (Jupyter Notebooks, R, Python), access trusted data and provide retention of modelled outputs and associated data.
5. Identify associated input data that could be supported and made available to a broader community of model users and to commercial platforms.

Appendix 1: Attendees

Name	Role/Project/Organisation
Jorge Alvarez-Romero	Spatial Planning and Strategy Scientist, The Nature Conservancy
Elisa Bayraktarov	EcoCommons Australia Program Manager, Griffith University
Linda Beaumont	Deputy Dean, Faculty of Science and Engineering, Macquarie University
Tom Bruce	Post Doctoral Fellow, Wildlife Observatory, University of Queensland
Rob Clemens	Biosecurity Commons Program Manager, Griffith University
Wes Davidson	Assistant Director - Vegetation and Marine Data, Department of Climate Change, Energy, the Environment and Water (DCCEEW)
Michael Drielsma	Principal Scientist Biodiversity Priorisation, NSW Office of Environment and Heritage
Simon Ferrier	Senior Principal Research Scientist, EcoSystem Sciences, CSIRO
Hamish Holewa	Director Planet RDC, ARDC
Shawn Laffan	Director, Earth and Sustainability Science Research Centre, UNSW
Kerry Levett	Solutions Architect, Planet RDC, ARDC
Sama Low-Choy	Senior Statistician, Associate Professor, Griffith University
Brendan Mackey	Director of the Griffith Climate Action Beacon, Griffith University Queensland
Craig Moritz	Director of the ANU-CSIRO Centre for Biodiversity Analysis, ANU
Jo Morris	Program Manager, Planet RDC, ARDC
Danielle Murphy	Principal Environmental Scientist (Classification and BioMetric Systems), NSW Office of Environment and Heritage (NSW DPE)
Patrick Norman	Research Fellow, Climate Action Beacon, Griffith University
Jo Savill	Senior Science Communicator, ARDC

Stephen Trent	Principal Environmental Officer, QLD Government, Energy Resources Unit
Martin Westgate	Science Team Leader, Science and Decision Support Team, Atlas of Living Australia
Andrew White	Research Data Specialist, ARDC
Brendan Wintle	Director, Melbourne Biodiversity Institute, University of Melbourne
Fiona Woods	Director, Department of Climate Change, Energy, the Environment and Water (DCCEEW)

Appendix 2: Workshop Agendas

Day 1 - Thursday 17 August - Models

Time	Session
0930-1000	**Coffee on arrival**
1000-1015	**Welcome and introductions to all participants** -
1015-1030	**Overview of workshop objectives, and:** - Planet Research Data Commons - SAFE
1030-1100	**Overview of workshop from science perspective** The aim of the workshop is to identify ecological and biodiversity models and data requirements that could be incorporated into the Planet Research Data Commons
1100-1115	**What are the priority use cases?** - e.g. Regional biodiversity planning
1115-1200	**Overview from attendees on current and developing models**: 1. What models are you using or developing? 2. What ecological problems and/or questions can the models address? 3. How do you currently develop, share and make available the models? Who are the main users? 4. What are the barriers and enablers for wider uptake of these models? 5. How do or could these models be used for decision support including regional biodiversity planning?
1200-1300	**Lunch**
1300-1410	**Continue with overview of current and developing models**
1410-1430	**Examples of current modelling platform capability and future possibilities**
1430-1500	**Afternoon tea**
1500-1600	**What needs to happen to make models (re)usable and interconnected?** - Making models discoverable

	- Making models more accurate - Making them available to multiple Clouds
1630	**Close**

Day 2 - Friday 18 August - Model sharing and integration

Time	Session
0830-0900	**Coffee on arrival**

0900-0930	**Reflections on day 1**
	- Target user groups
	    - Modellers
	    - Researchers who (re)use models to answer research questions
	    - Decision makers - government, industry, NGOs
	- Collaboration between sectors (research - governments - industry)
	    - Governance required
	    - Existing collaboration vehicles

0930-1030	**Infrastructure required to support advanced ecological and biodiversity modelling - concepts**
1030-1100	**Morning tea**
1100-1230	**Developing activities to enable and enhance model use, sharing, discoverability, reuse and 'chaining'**
1230-1315	**Lunch**
1315-1400	**Summarising the workshop and next steps**
1400	**Close**