RESEARCH PLAN

UNDER REVIEW

THE WESTERN AUSTRALIAN BIODIVERSITY SCIENCE INSTITUTE

The Western Australian Biodiversity Science Institute

RESEARCH PLAN

This plan was developed in December 2014. A review is currently underway and is expected to conclude in early 2018, followed by regular bi-annual reviews.

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INTRODUCTION AND CONTEXT

PURPOSE OF THE WESTERN AUSTRALIAN BIODIVERSITY SCIENCE INSTITUTE

The purpose of the Western Australian Biodiversity Science Institute (WABSI) is to:

- Shape the strategic priorities for acquiring and managing terrestrial biodiversity knowledge.
- Deliver excellence in terrestrial biodiversity research by fostering active collaboration across sectors and between researchers.
- Ensure information is available in a form that is relevant and accessible to government policy makers, industry, land managers and other stakeholders.

PURPOSE OF THE RESEARCH PLAN

The purpose of this document is to identify key biodiversity research priorities within Western Australia and the process through which a comprehensive program of research will be developed through WABSI to address those priorities.

The Research Plan should be read in conjunction with:

- The **Governance Charter** of WABSI which sets out the principles, rules and processes through which the participating organisations will collaborate and undertake research.
- The **Business and Implementation Plan** that will guide WABSI's establishment and operations.

PARTICIPATING ORGANISATIONS

The Western Australian Biodiversity Science Institute (WABSI) is a formal collaboration between a number of scientific institutions operating in Western Australia and several Western Australian government agencies and authorities with research interests pertaining to the State's terrestrial biodiversity.

PARTICIPATING ORGANISATION	DESCRIPTION
Botanic Gardens and Parks Authority (BGPA)	BGPA is a Western Australian State Government authority formed to manage Kings Park and Bold Park. The Science Directorate undertakes research in native plant biology, underpinning conservation and ecological restoration of Western Australia's unique biodiversity, and biodiversity generally.
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	The CSIRO is Australia's national science agency. Research pertaining to Western Australia's terrestrial biodiversity is undertaken at the CSIRO primarily within its Land and Water Flagship, together with related activities in the Biosecurity and Agricultural Productivity Flagships, as well as within the National Biological Collections and Atlas of Living Australia which are managed by the CSIRO.
Curtin University of Technology (Curtin)	Curtin is Western Australia's largest university in terms of student numbers and is a member of the Australian Technology Network of Universities. Research pertaining to Western Australia's terrestrial biodiversity is undertaken primarily within the School of Science at the Faculty of Science and Engineering.
Department of Parks and Wildlife (DPAW)	Department of Parks and Wildlife is a Western Australian Government department charged with responsibility for conserving biodiversity and managing the State's national and marine parks. It also manages WA nature reserves, state forests and has some management responsibilities on unallocated Crown land. Researchers at Parks and Wildlife study, describe, monitor and map species and ecological communities in Western Australia, the outputs of which underpin strategies to protect, conserve and manage Western Australia's biodiversity. Parks and Wildlife also manages the State herbarium collection.
Department of Mines and Petroleum (DMP)	DMP is a Western Australian Government department charged with attracting private investment in resources exploration and development through the provision of geoscientific information on minerals and energy resources, as well as the management of an equitable and secure titles systems for the mining, petroleum and geothermal industries. It also has prime responsibility for regulating the extractive industries in Western Australia.
Environmental Protection Authority (EPA) **and** **Office of the Environmental Protection Authority (OEPA)**	The EPA is an independent authority that provides advice to the Government of Western Australia. Its advice is public. Its main functions are conducting environmental impact assessment, preparing statutory policies for environmental protection, preparing and publishing guidelines for managing environmental impacts and providing strategic advice to the Minister for Environment. It is the recipient of biodiversity information generated through the environmental impact assessment process. Office of the Environmental Protection Authority supports the EPA in conducting environmental impact assessments and developing policies to protect the environment. The OEPA also monitors compliance with Ministerial conditions related to approvals.

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PARTICIPATING ORGANISATION	DESCRIPTION
Murdoch University (Murdoch)	Murdoch is a Western Australian university and a member of the Innovation Research University group in Western Australia. It undertakes research pertaining to Western Australia's terrestrial biodiversity across its Centre for Fish and Fisheries Research, Centre for Phytophthora Science and Management, Centre of Excellence for Climate Change, Woodland and Forest Health, Land Management Group, Nature Based Tourism Group, the Parasitology Research Group and Conservation Medicine Group.
University of Western Australia (UWA)	UWA is a member of Australia's Group of Eight research intensive universities. Research pertaining to Western Australia's terrestrial biodiversity is undertaken primarily within the Faculty of Science. Regionally based research centres, including the Centre of Excellence in Natural Resource Management located in Albany, focuses research on the South West global biodiversity hotspot.
Western Australian Museum (WA Museum)	WA Museum is a Western Australian State Government authority formed to manage the State's museum and associated collections. Researchers at the WA Museum maintain and conduct research on the museum's arachnid and myriapod, entomology, mammaology, ornithology and subterranean biology collections. The WA Museum also performs an important vouchering service for biological surveys conducted in WA.

THE RATIONALE FOR A BIODIVERSITY INSTITUTE

By virtue of its geographical expanse, climatic diversity, areas of relative wilderness, regions with extremely nutrient-impoverished soils, and the fact that significant areas of the State have not been covered by sea or glaciated for a very long time, Western Australia has a globally unique and immense biodiversity that is characterised by significant endemism.

By way of example, there are more species of flowering plants in the Fitzgerald River National Park than in the United Kingdom, contributing to the South West of Western Australia being one of only 34 'Global Biodiversity Hotspots', defined as geographical regions that have at least 1,500 vascular plant species and have lost at least 70 percent of their original habitat.

In addition, Western Australia has many other important economic and social assets including:

- A rich endowment of minerals and petroleum resources that account for around 30 percent of Gross State Product and provide the State Government with around 20 percent of its annual revenues through taxation and royalties.
- A productive and diverse agricultural sector.
- A growing services sector.
- A growing population demanding increased urban development, particularly in the South West of the State.

By contrast with many other developed countries, Western Australia is relatively early in its development. Significant urban, industrial, resources and agricultural development has only taken place in Western Australia over the last 150 years. There remain significant and important opportunities for development and wealth generation within the State.

The challenge is to integrate the future social and economic development of the State with strategies for the effective conservation of biodiversity. Complex issues and some trade-offs are involved, the resolution of which requires a robust and rigorous scientific information base. However, the current status of information and knowledge about Western Australia's biodiversity is unclear because its collection and management is fragmented across multiple industry,

government and research organisations and there are no established mechanisms for aggregating and synthesising the data.

High value biodiversity within the State is at significant and increasing risk though a range of processes including:

- Land-use change for urbanisation, agricultural, minerals and industrial development.
- Introduction of exotic plants and animals, and disease.
- Changes in the environment including altered fire regimes, changed hydrological processes and climate change.

As a consequence, a growing number of ecosystems and individual species are under threat. This in turn has triggered an ever-increasing suite of regulatory controls that are creating delays in approval of projects and having sub-optimal impact as far as protecting the State's biodiversity.

A major task confronting policy makers, industry leaders and land managers is to find strategies for the optimal management of biodiversity that are compatible with the ongoing imperative for the State's development. In the broadest terms, the following set of decisions need to be made:

1. Whether an area of land should be protected for its biodiversity values.
2. When an area of land is to be developed, under what conditions development should occur, including ongoing monitoring arrangements.
3. How developed land can be most effectively managed to facilitate biodiversity conservation either on the land itself, or in a way that ensures development does not compromise biodiversity in adjacent and connected land areas.
4. Determining when, and to what standard, to rehabilitate land that has been disturbed.

In addition to decisions relating to land allocation and management, the growing number of species at threat of extinction also requires prioritisation of biodiversity management activities to achieve the greatest conservation return from a defined set of resources. A particular priority is how best to manage species and communities within land set aside for conservation, such as national parks and private conservation reserves.

At a fundamental level, the case for a biodiversity institute is to address these questions in a way that addresses the core objectives of responsible development and the conservation of the biodiversity of Western Australia.

Western Australia enjoys a rich endowment of natural resources. The continued development of land and resources will be the primary source of wealth within the State for many years to come. Development can be reconciled with the conservation of biodiversity, but only with robust scientific information that can be used by decision makers to avoid and minimise impacts and, where necessary, develop complementary management strategies, such as biodiversity offsets and restoration to address significant residual impacts.

A biodiversity institute has the potential to contribute to this need by providing more certainty around decision-making processes. Greater knowledge enables efficient decisions that take account of the needs of all stakeholders, substantially improving both productivity and environmental conservation.

PRINCIPLES FOR SETTING PRIORITIES FOR BIODIVERSITY RESEARCH

The purpose of the Research Framework is to identify key biodiversity research priorities within Western Australia and the process through which a comprehensive program of research will be developed to address those priorities.

The Research Plan is focused on supporting the needs of end users that include: business and industrial interests such as the mineral resources sector and urban developers, land managers; conservation managers, government agencies, regulator, consultants and science leaders.

Two outcomes are sought:

Biodiversity conservation — More effective and efficient strategies for setting priorities and conserving Western Australia's Biodiversity.

Facilitation of sustainable development — More effective, efficient and timely processes for environmental assessment, regulation and management.

To be effective WABSI will need to be successful in exploring and bridging the nexus between these end user needs and the research required to advance the scientific understanding of biodiversity. The nexus is illustrated in Figure 1.

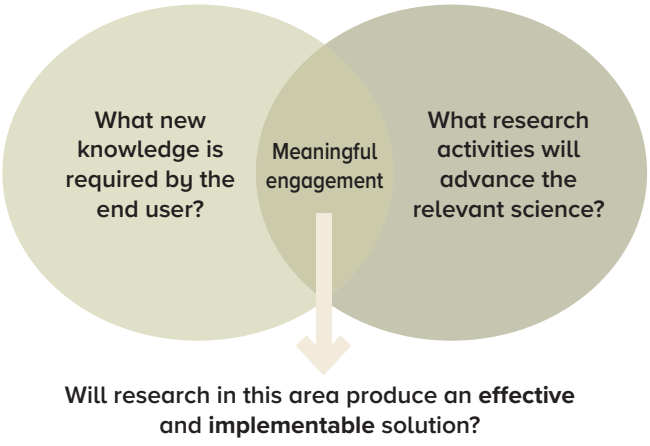


FIGURE 1 The nexus between science and end user needs

Building upon the two primary outcomes, the following Drivers of Value have been identified for assessing and ranking research priorities:

- **Improved access to knowledge** including species and communities, geographic distribution, management needs and values.
- **Excellence in science** including positioning Western Australian academic institutions at the forefront of biodiversity research.
- **Informed decision making** capacity to provide objective advice to decision makers when required.
- **Timeliness and reduced costs** including the capacity to streamline impact assessment, planning and management processes in order to provide timely advice.

PROCESS FOR DEVELOPING THE WABSI RESEARCH PLAN

Figure 2 describes the process followed to develop the Research Framework and the steps required to develop a draft Research Plan.

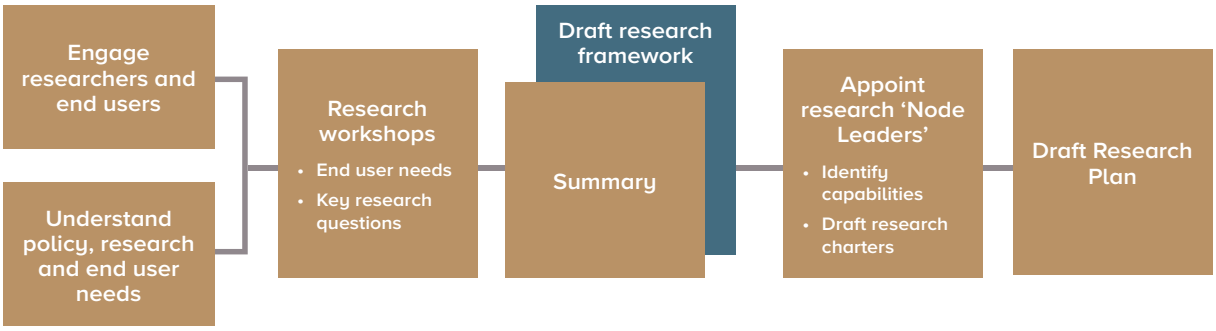


FIGURE 2 Key steps in developing the WABSI Research Plan

Importantly the process outlined above places emphasis on identifying end user requirements ahead of assessing the capacity and capabilities of the various participating organisations or key individuals to meet those needs.

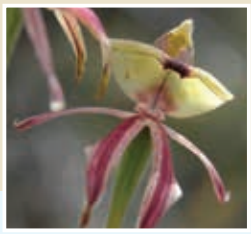
Following the formation of the WABSI Steering Committee the following steps were taken.

- Interviews with key end users within industry, government and participating organisations.
- Each of the participating organisations were engaged and invited to contribute research priorities.
- Four full day workshops were held to introduce the goals and purpose of WABSI, encourage collaboration amongst the participating organisations, discuss the over-arching Research Framework of WABSI, and identify key end user and research priorities.
- Node Leaders appointed and Research Plan developed.

A list of organisations and people that were involved and consulted in developing the Research Plan is contained in Appendix B.

Membership of each research node/theme is contained in Appendix C.

It is important to note that the Research Plan is a living document and will be subject to ongoing revision by WABSI.



RESEARCH FRAMEWORK

Figure 3 summarises the proposed structure of inaugural research nodes, cross cutting themes and priority landscapes for the initial phase of WABSI. It is important to note that further items may be added by the Board as WABSI matures.

CROSS CUTTING THEMES	RESEARCH NODES			APPLIED TO PRIORITY LANDSCAPES
Stakeholder Engagement	Biodiversity Survey	Processes and Threat Mitigation	Restoration and *ex-situ* Conservation	Developing North Kimberley
Transdisciplinary Research				Pilbara
Social and Economic Analysis				Western Deserts
Aboriginal Knowledge	Information Management Systems			Drying South West
Communication and Adoption				Island Arks

FIGURE 3 Proposed Research Framework

Each of the three elements described in the diagram has a distinct purpose and function in ensuring that biodiversity research is clearly directed to meeting the needs of end users including industry, conservation managers, land managers, researchers and regulatory authorities.

- **Cross cutting themes** require effective engagement with all stakeholders who may benefit from or may be impacted by a research project or program. A key principal embedded within WABSI is the need for end users to be actively engaged throughout all phases from conception to completion.
- **Research nodes** reflect the core organisational framework of WABSI and will be supported by leading researchers who oversee the development of a robust research program that builds capability, tools and methodologies in key aspects of biodiversity science.
- **The priority landscapes** reflect a requirement to have all science undertaken through WABSI linked to a program of activity that is targeted at a geographic area of the State. The focus on regions will assist in achieving the required integration between end users and each of the interrelated research nodes.

CROSS CUTTING THEMES

The cross cutting themes set the context within which all research commissioned by WABSI will be undertaken. All work commissioned should be directed to clear outcomes defined by end users.

It is expected that throughout the management cycle of a research project that the cross cutting themes are explicitly addressed with dedicated resources and appropriate expertise. Research teams should include members with the disciplinary background and experience required to undertake stakeholder driven research that considers the broader social and economic context within which the research is taking place and works with all stakeholders to communicate and define pathways for adoption. The following cross cutting themes have been identified:

- **Stakeholder engagement** — Research, using best science, should address the questions posed by end users, both conservation and regulatory, to ensure that the research outcomes are relevant to their needs and there are pathways to adoption.
- **Transdisciplinary research** — All research proposals must contain explicit reference to how the outcomes of individual research projects will be integrated with the other complementary research required across plant, animal, soil, climate and biological sciences and the related social and economic disciplines.
- **Social and economic analysis** — Research proposals must assist in building knowledge that will improve the effectiveness and/or reduce costs associated with managing biodiversity. Research should, wherever practicable, assess the relative costs and benefits of alternative approaches in delivering conservation outcomes in a regional and landscape context.
- **Indigenous knowledge** — Research proposals should, wherever possible, engage and develop strong collaborative relationships with Aboriginal land managers. Indigenous knowledge systems should be considered alongside Western-focused data systems to respect and recognise the value of Traditional ecological knowledge; empower two-way participation in biodiversity / land management information collection, management and access; support intergenerational transmission of traditional ecological knowledge; and encourage equitable sharing of benefits arising from access to traditional ecological knowledge.
- **Communication and adoption** — Ensure that the outcomes of WABSI research programs are effectively communicated with a particular focus on building the understanding of key decision makers and the general public on the value of biodiversity and ensuring clear plans are established to promote the adoption of findings that are relevant to biodiversity managers and other decision makers.

RESEARCH NODES

The draft Research Framework is organised across a core set of research nodes. Node Leaders will be responsible for driving collaboration and establishing the over-arching objectives of nodes and driving collaboration and disciplinary excellence within each. Proposed research nodes through which key research efforts will be coordinated and led by a Node Leader from one of the participating organisations are outlined below including a brief summary of the rationale for their inclusion:

- **Information Management Systems**
  A great deal of information on the State's biodiversity has been collected and interpreted by research agencies and industry. An improved knowledge management system will be developed to facilitate aggregation, interpretation and access to the existing data held by government, industry and research agencies. Information Management is a foundational program that supports the collection, analysis and reporting of information derived from the other Research nodes.
- **Biodiversity Survey**
  Western Australia is blessed with incredible diversity in the range of plant and animal species across varied landscapes/ecological communities. A comprehensive understanding of the State's biological resources, their distribution and processes that influence them can be delivered through a more coordinated and focused effort across agencies and industry.
- **Processes and Threat Mitigation**
  An understanding of the distribution of plant and animal species is not alone sufficient for effective management of biodiversity. Continued investment will build the capacity of land managers to understand and manage the processes that maintain or threaten ecosystems such as fire regimes, water availability and management, climate, exotic species, disease and fragmentation through land clearing.
- **Restoration and *ex-situ* Conservation**
  Collaboration between industry and researchers has developed leading restoration technologies for some regions of the State, notably within the alumina industry in the Darling Ranges. These capabilities will be extended across other land use systems and ecological communities, including developing technologies for *ex-situ* conservation and translocations of plants and animals.

PRIORITY LANDSCAPES

It is envisaged that the majority of research undertaken by WABSI will be targeted towards meeting defined objectives within a particular geographic region. Individual researchers and research projects will contribute to larger research programs that will facilitate the engagement of stakeholders, aggregation of research outcomes and communication of policy implications.

Priority landscapes have been selected based on:

- Uniqueness of the natural environment and biodiversity values.
- Importance to the economy and future development of the State.
- Capacity for engagement of a broad cross section of end users such as conservation managers, land developers and natural resource based industries (mining and agriculture).
- The ability to develop a research program that is focused on a defined set of issues and/or outcomes within the region.

In most cases the research commissioned will be sourced from several or all of the research nodes, with the geographic region providing a focus for integration. Geographic focus will also provide a more efficient and effective platform for stakeholder engagement. End user needs are rarely met through a single research initiative; rather it is the synthesis, aggregation and interpretation of multiple inputs that will assist in guiding approaches to biodiversity management.

In the initial phase of WABSI the following priority landscapes have been identified with particular emphasis on a number of key issues.

- **Pilbara** — with a focus on building strong collaboration between research organisations, government agencies, the minerals industry and pastoralists to effectively understand the biodiversity values of the region and ensure these values are protected and managed through timely regulatory processes and management actions.
- **Tropical and Developing North Kimberley** — with a focus on engaging Traditional Owners, understanding conservation needs and managing the future economic development of the tropical savannah's of the north.
- **Western Deserts** — with a focus on engaging Traditional Owners in participatory research aimed at understanding traditional ecological and cultural knowledge and re-establishing mosaic landscapes associated with traditional fire regimes.
- **Drying South West** — with a focus on managing high levels of endemic biodiversity within relatively small geographic areas associated with more intensive agriculture and human settlement in a drying climate.
- **Island Arks** — with a focus on understanding conservation values associated with Western Australian islands and their potential role as refugia and host sites for translocated plants and animals.

RESEARCH NODES – STRATEGIC RESEARCH PRIORITIES

INFORMATION MANAGEMENT SYSTEMS

Introduction and context

A great deal of information on the State's biodiversity has been collected and interpreted by research agencies and industry. However, the existing knowledge base is fragmented and difficult to access. All stakeholders agree that an enhanced information base, which can be readily accessed and easily interpreted by decision-makers, will improve decision-making.

An opportunity exists for WABSI to facilitate and enable improved information management. The potential benefits of improved information management are significant including:

- Improved access to knowledge to make better informed decisions and improve conservation management and research outcomes.
- Better informed planning processes, creating greater certainty and reduced compliance requirements for land managers.
- A capacity to support the streamlining of environment impact assessment and regulatory processes, thereby reducing duplication, costs and delays in decision making.

The concept of a single authoritative source of biodiversity information and data is attractive. However, it is a goal that has proven elusive to government, industry and other stakeholders due to the complexity and timeframes involved. Whilst considerable goodwill exists, significant barriers also remain. Competitive tension exists within industry as a result of the commercial advantage that a robust knowledge of biodiversity within a region can have in securing government approvals for projects. Similar tensions sometimes exist within government or academia, for either funding or the protection of intellectual property and data that may have a commercial or strategic advantage

Any successful approach to information management will require certain attributes to be fulfilled including:

- Providing **support** and services for stakeholders and the community to create, capture, manage and share terrestrial biodiversity knowledge.
- Enabling stakeholders to access data that is relevant to and addresses the **strategic** challenges and questions they face – for example access to data to support environmental impact assessment and approvals, setting conservation priorities, or modelling/predicting future trends in biodiversity condition.

- Being **sustainable** by facilitating collaboration, participation and contribution by stakeholders and end users, thereby ensuring their ongoing commitment and support.
- Avoiding duplication of effort in order to leverage, integrate and build upon existing analysis, core capabilities, tools, information and infrastructure ensuring efficiencies, rationalisation and creation of **synergies**.
- **Connecting** people (culture), connecting data (data) and connecting science (understanding) – i.e. bridging the disconnect between information and users, or producers and consumers of information; or private and public interests.
- Ensuring **open infrastructure and data** and avoid silos of data and data services so that there are common, consolidated, integrated and consistent solutions where information is available in a way that is relevant and accessible to stakeholders.
- Using world current **best practice** in creation and design, including the use of design principles.
- Rationalising **data policies** on restricted or sensitive information.

The issues associated with biodiversity information management will not be resolved quickly or easily. A concerted and disciplined approach over several years is required across government, industry and research agencies to ensure that information is made accessible by establishing clear policy frameworks and investing in the supporting infrastructure and information technology that is required.

A potential framework for coordinated information management through WABSI is outlined in Figure 4, page 18.

Objective

To create a collaborative environment, including a web-based data management platform, where biodiversity information is collected once, made openly accessible, and able to be used for multiple applications.

End user outcomes

1. Capacity to efficiently secure electronically (web-based) access to available biodiversity data of known quality and origin to support better planning and decision-making processes.
2. User friendly interface and tools to discover, interpret and analyse data using accredited methodologies.
3. Streamlined processes including data standards and quality guidelines that improve data quality, avoid duplication in collection of environmental data and therefore reduce costs and delays associated with both development and conservation planning.
4. Improved collaborations and knowledge sharing leading to enhanced conservation management and research outcomes.

Focus area 1: Policy commitment and foundations

Rationale

A number of foundational activities are required to underpin and facilitate a culture of data sharing across government agencies, industry and research organisations. Improved information management requires a high level commitment from the key organisations involved, a willingness to be guided by a coordinating agent and a capacity to contribute to a common infrastructure and standard.

Each stakeholder that collects biodiversity information must be recognised and have their right to store and manage data for their own purposes reaffirmed. However, an obligation to share information, including in a format that complies with common standards, is normative in many industries – including disciplines such as medical research, accounting and engineering.

Priority areas for commissioned work

WABSI will seek to develop an agreed framework and approach for the management of biodiversity information including:

- **Organisational commitment** — a commitment from all participating organisations to a common vision/objective, principles, road map and early initiatives for biodiversity information management and to establish a governance mechanism through WABSI to coordinate their efforts and invest in common standards and infrastructure over time. This is to include key business analysis and project management for organisational consultation, together with mapping and understanding user needs, priorities and barriers.
- **Policy incentives** — that facilitate open access to data and its reuse including storage and access associated with government environmental approvals and licensing and strengthened incentives for sharing of data collected for research and academic publication (for example supply of DOI[1] credit via citation).
- **Data standards** — that establish minimum requirements for data collected for different purposes such as vouchered collections, biological survey and so on.
- **Data collection workflows** — that map, standardise and streamline workflows for the collection and storage of data, including processes for lodgement of data associated with government approvals and licensing arrangements used for environmental impact assessment.
- **Knowledge networks** — that establish and recognise data custodians and providers, as well as the tools for annotation and validation of different data types.

Focus area 2: Data collection and access

Rationale

To achieve the objective of simplifying access to biodiversity information, a considerable investment needs be made in infrastructure that enables biodiversity data to be mobilised, organised and aggregated from a variety of sources in a web-based platform that supports end user access and use.

The benefits of a capacity to aggregate biodiversity information from multiple sources onto a shared platform are compelling. However, this in turn requires each agency and stakeholder to commit to investing in the common infrastructure and also ensuring that their own data management systems and standards are interoperable with the requirements of the shared platform.

Priority areas for commissioned work

Developing improved organisational practices, policies and knowledge management systems to facilitate integrated access, aggregation, sharing and interpretation of the biodiversity related data gathered and held by government, industry and research agencies (contributing to the State's commitment to establishing a State Environment Data Library through the Department of Mines and Petroleum). Key activities include:

- **Data storage and quality assurance** — develop a data storage, curation and quality assurance capability to ensure biological datasets are visible, accessible, managed according to best practice, as accurate as possible and able to be aggregated.
- **Data collection** — evaluate and provide data collection tools that enforce data and collection standard agreed in focus area 1.

[1] Document Object identifier (DOI) – to be used in published papers allowing access back to reference data sets.

- **Data service** — establish criteria and select a provider or system for data aggregation service development (IT platform) and support with agreed specifications for data repository, aggregation and interpretation and progressively building the capability of the information management system.
- **Data types** — identify different data types and understand the needs of different end users for different data types and their application.
- **Data mobilisation** — establish agreed priorities for the mobilisation of strategic data types into the data service or platform so as to progressively address knowledge gaps or development pressure points for Western Australia.

Focus area 3: Data interpretation and re-use

Rationale

Access to raw data is necessary but not sufficient to meet the needs of users of biodiversity information. A key requirement is to develop tools, methodologies and interfaces that stakeholders and the general community can use to build an understanding of the nature and value of Western Australia's biodiversity.

Priority areas for commissioned work

WABSI will invest in and support research and development of tools, methodologies and interfaces for improved access and interpretation of biodiversity information:

- **Tools for data access and interpretation** — ensure data users have access to tools to visualise and interpret data in ways that meet their needs.
- **Examples and tools supporting additional data re-use** — provide best practice examples, especially as they connect to data being generated and made available through WABSI.

FOCUS AREA	DESCRIPTION	WORK AREA
Focus areas are interconnected and strengthen each other	**Outputs of 2 project management areas and 3 core program areas**	**Work areas of activity, with those in red as priorities within first 12 months**
Engagement	• Steering Committee, Reference Group and engagement activities • Mutual agreed and understood conditions	**1. Governance** Review, approve, steer, monitor, benchmark goals, scope, expected outcomes
		2. Consultation Stakeholder collaboration, education, communication, information exchange
Analysis and planning	• Business analysis of landscape to determine needs, processes and outputs • Project management • Business development to attract funding	**3. Analysis and architecture** Policy, systems, workflows, data
		4. Planning Workplans, timelines, capability / resource requirements
Foundation	• Harmonisation of policy and practices across stakeholders • Ensure data is accessible, assessable, intelligible and usable (by contributors and users) • Streamlined and workable workflows intersect between stakeholders	**5. Policy incentives** Open data, access and licensing policies and frameworks
		6. Data standards Metadata, survey and habitat condition standards
		7. Data collection workflows Mapped, streamlined and standardised workflows for biodiversity and environmental assessment
		8. Knowledge network Key biodiversity data identities, networks and core capabilities
Collect and manage	• A repository for aggregation of biodiversity related data • Bringing together or mobilising in a digital repository a variety of data types including geo-referenced data	**9. Data service** Agreed specifications and a repository/platform to store and manage data
		10. Data types Mobilising and organising variety of biodiversity related data types and sources
		11. Data mobilisation Prioritised mobilisation of relevant data sets
Reuse	• Data discovery, visualisation and analysis tools that make data 'alive', accessible and reusable • Use cases by other nodes/themes	**12. Tools for reuse**
		13. Examples of reuse

FIGURE 4 Draft information management road map

WORKPLACE	STAKEHOLDERS	OUTCOMES
Workflow divided into quarters over a 3-year period (each box = 3months) Analysis-Architecture-Build/Integrate-Use		
	Senior management across WABSI partners	• Building confidence with stakeholders and community • Solutions developed via collaboration to maximise benefits
	Stakeholders, broader community / end users	
	Working level resources across WABSI partners	• Making theme outputs meaningful, effective and operational to stakeholders • Detailed timelines and resourcing
	Proponents, consultants, WABSI partners	**CULTURE** • Making data sharing the norm • Create data (rather than locked in PDF reports) • Ensure data understood and used across systems and users (standards) • Service and participatory culture
	WABSI partners	**DATA** • Visibility of data held within organisations • Improved discovery and ease of access to priority information
	Everyone interested in biodiversity, including a national and international audience	**UNDERSTANDING** • Data born digital: gathered once but used many times • Targeted analysis and data use for WA strategic issues

BIODIVERSITY SURVEY

Introduction and context

Government, community and industry require the capability to undertake biodiversity assessments that inform land use planning and natural resource management decisions. A core need in order to do this, whether for research, conservation planning or environmental impact assessment, is to characterise the biodiversity that occurs at a site, how this biodiversity is distributed across the landscape and assess its current and projected condition. Biodiversity that needs to be assessed runs the gamut from genes, to species (taxa), to ecological communities.

Comparison of the biodiversity of a site with other sites allows an evaluation of distinctiveness and significance including the degree to which elements of biodiversity at the site require protection or can be lost without a significant negative impact on overall biodiversity. This core need drives four subsidiary requirements:

1. **Capacity to identify biological elements** — Users need efficient, accurate and readily available identification tools in order to determine with confidence which elements of biodiversity occur at a site.
2. **What elements of biodiversity exist where** — Users need well-documented evaluation of what elements of biodiversity occur where and what factors influence this distribution.
3. **Capacity to determine significance** — For decision-making, users need to be able to determine the significance of all identified elements of biodiversity by establishing a context for an observation (of a species, ecological community or gene) at a given site.
4. **Standardisation** — In order to ensure rigour and maximum comparability, users need assurance that data quality and methodological standards are in place.

At the **species level**, a maintained census and identification methodologies for different taxonomic groups of all taxa that occur in Western Australia are required, backed by sufficient taxonomic activity to underpin the scientific validity of the census.

Foundational taxonomic work is particularly important in a state such as WA where biodiversity is still only partially known and new taxa are discovered regularly. Species-level censuses are currently maintained by the WA Herbarium (plants, algae and fungi) and WA Museum (animals). To determine significance, sufficient spatial records are required to estimate the area of occupancy, extent and abundance of species. For some groups such as birds, such datasets exist and they are relatively adequate. For other groups such as many invertebrates, the record set is relatively sparse and many collections in existing institutions (e.g. WA Museum) are yet to be data-based.

At the ecological community level, vegetation maps that are both structural and floristic are required at different hierarchical scales, to be able to assess the area of occupancy and distribution of each community and its current and projected condition through time. Vegetation maps may be developed through models based on rigorous methodologies derived from plot-based and remotely-sensed data. In contrast to other Australian States, protocols for vegetation mapping at all relevant scales are yet to be developed in Western Australia. New methodologies that could be deployed include classifications based on hyperspectral time-series satellite imagery, or community classifications based on genomic sampling.

At the **gene level**, a characterisation and catalogue of Operational Taxonomic Units (OTUs) or genetic units and assemblages are needed. Identification requires algorithms to search genetic databases for sequence matches. These are relatively straightforward and are already developed or are under development at global scales. However, sufficient spatial density of samples is required to understand the area of occupancy, extent and abundance of resolved genetic units. For taxonomic groups that are well characterised at the species level, gene diversity at least at coarse scales, can be estimated from taxon diversity. However, phylogeographic patterns and patterns of genetic structure for many species are unknown, limiting the validity of taxon surrogacy for gene diversity. In species groups that are poorly understood at a species level, such as many invertebrates, it may be more efficient to sample spatial gene patterns directly, without resolving species-level structure.

At all scales, appropriate industry standards for the collection of data need to be developed and, where available, they need to be more widely employed, including standard operating procedures, guidelines and manuals that promote consistency in sampling effort, and better collection and management of biodiversity data.

Objective

Develop a thorough and robust understanding of the full range of species and ecological communities in Western Australia, their geographic distribution and their current and projected condition through time.

End user outcomes

1. Capacity to accurately identify elements of biodiversity including robust data methodological, collection and quality assurance standards.
2. Understand the geographic distribution of species, ecological communities and genetic diversity.
3. Capacity to prioritise conservation effort against agreed criteria, such as comprehensiveness, adequacy and representativeness, biodiversity condition and trends for the purposes of environmental assessment and conservation planning.
4. Simple, efficient and effective guidelines for environmental impact assessments associated with regulatory processes

Focus area 1: Standards, identification tools and information systems

Rationale

A priority for end users is the capacity to reliably identify biodiversity and have confidence in the findings from fieldwork.

Irrespective of their needs, be it conservation research, conservation management or environmental impact assessment, a critical starting point is the capacity to identify the elements of biodiversity present at a site and to be able to place these findings in the context of the geographic distribution of different species.

A key concern is the development of robust methodologies and minimum standards for data collection in different contexts. All users are seeking greater confidence in the capacity of practitioners to reliably and efficiently identify species, ecological communities and interpret genetic data and information.

Priority areas for commissioned work

WABSI will support research aimed at developing tools, systems and standard processes to allow for consistent and efficient collection and interpretation of biodiversity data.

Two principal resources are required to support the identified user needs:

- **A Western Australian biodiversity identification portal** — This will assemble all existing identification tools and develop new tools as needed and cover, under a single portal, all taxonomic groups. It will support a range of identification methodologies, ranging from traditional morphological methods to genetic barcoding and genomic methods, to enable flexible and appropriate identifications for all biota.
- **A Western Australian vegetation information system** — This will help establish protocols and procedures, deploy innovative technologies and maintain data and analysis methods to deliver fit-for-purpose derived products such as vegetation maps suitable for biodiversity assessment, fuel load models appropriate for fire management, and site based plot data to inform on trends in habitat condition for species modelling or State of Environment reporting.

Focus area 2: Identify and trial new technologies

Rationale

Given the scale of the task in understanding the elements of biodiversity, their geographic distribution and condition, new technologies and approaches are required to drive faster and more cost effective biodiversity assessment.

A key priority is to develop, identify and trial innovative new technologies and systems for the

collection, collation and analysis of biological survey data that enables the taxonomic resolution of species, informs the circumscription of ecosystems and biological communities, and enables distribution of species across Western Australia to be predicted.

Key drivers for new technologies relate the scale of information required, and include lack of appropriate biodiversity data across large areas of the State, faster more efficient ways of quantifying biodiversity and its condition, testing assumptions of complementarity and surrogacy among biological groups, and maximising opportunities for sustainable utilisation of biodiversity.

Priority areas for commissioned work

WABSI will seek to invest in capabilities associated with the development of the following new technologies for biodiversity survey and assessment.

- **Molecular and genomic technologies** — Further develop the capability and understanding of the utility of employing molecular and genomic technologies in biodiversity survey and land-use planning.
  - Facilitate the experimental use of molecular and genomic tools in biological survey and monitoring programs.
  - Develop a conceptual framework to support the interpretation of the outcomes of genomic studies.
  - To guide policy prioritisation, develop “Phase 1” methodology for using genomics to derive knowledge on the relative species richness of specific groups of organisms and uniqueness of different Western Australian landscapes.
- **Remotely sensed technologies** — Assess the utility of, and develop protocols for, the use of remote sensing technologies in biological survey and monitoring of biodiversity condition. Examples include:
  - Satellite platforms for the capture of environmental information (multi-hyperspectral) to inform on biodiversity patterns and condition trends at a paddock to property, to landscape, to jurisdictional scales.
  - Airborne platforms (UAV/drones to aircraft) for the capture of environmental information (multi-hyperspectral) to inform on species presence, biodiversity patterns and condition trends at a site to bioregional scale.
  - Remotely operated camera traps and audio recording units (ARU) for the capture of ecosystem compositional information on species presence and trends in occupancy at a site to landscape scale.
  - Advances in RADAR and LIDAR sensors in measuring vegetation and habitat structure.

Focus area 3: Understanding pattern and significance

Rationale

Informed decision making by end users requires data on the presence of genes, species or ecosystems at a site to be placed in the context of the geographic distribution and the projected trajectory of biodiversity condition in the future.

Determining conservation significance and status (i.e. species based on IUCN red list criteria) is critical for both targeting conservation efforts and also informing environmental assessment, including prioritising conservation actions, identifying management and threat mitigation strategies, and targeting offsets.

Western Australia is covered by an extensive network of biological surveys sites from which, at a minimum, data has been collected on the presence and absence of plant and selected animal groups. While there are challenges for the collection, storage and management of this data, the data is still useful to help quantify what biodiversity is present and where it is located. This data can be utilised for the modelling and evaluation of biodiversity patterns across the landscape that is critical for informed strategic land management decisions, such as evaluation of cumulative impacts and significance.

Priority areas for commissionedwork

WABSI will seek to invest in capabilities associated with developing the capacity to collate and synthesise a comprehensive view of the status of biodiversity at varying scales within WA: local, bioregional, state. Outputs should support the informed evaluation of the potential impacts of future trends and developments on biodiversity including those required for regulatory processes. Key priorities are set out below:

Gap-filling baseline biological surveys

- Evaluate gaps in the spatial and environmental coverage of existing biological data across WA.
- Undertake biological surveys to fill priority gaps in data coverage, taking maximum advantage of advances in survey technologies (metagenomics, camera traps, audio recording units etc).

Collation and augmentation of baseline environmental data

- Collate, database and provide electronic access to best-available spatial layers for key environmental drivers of biological distributions across WA (terrain, soils, climate etc).
- Where necessary, develop refined spatial layers for key variables currently lacking adequate resolution or coverage – e.g. vegetation condition, microclimate, hydrology – taking maximum advantage of advances in remote sensing.

Collation of existing biological data

- Collate, clean, database and provide electronic access to species-location data from all available sources within WA.

Modelling of biological distributions

- Link best-available biological data and environmental layers to model, and thereby extrapolate, distributions of individual species of particular conservation concern and spatial patterns in overall community composition across WA.

Evaluation of current biodiversity status and significance

- Integrate biological data and modelled biological distributions with best-available spatial layers for vegetation condition and other relevant pressures (e.g. feral predators), to assess and report on the collective status of biodiversity at regional and whole-of-WA scales.
- Assess and map relative levels of biodiversity significance across WA as a function of the marginal contribution that each location is making to the collective status of biodiversity regionally and State-wide.

Evaluation of expected impact of proposed development and conservation actions

- Integrate knowledge on biodiversity patterns and significance, with information relating to threats and processes through model-based decision-support tools. These models will evaluate the expected cumulative impact of proposed development and/or conservation actions.

Ongoing monitoring and assessment of change in biodiversity status

- Design and implement field-based monitoring of changes in biodiversity, and remote sensing of changes in habitat condition and other pressures, to adaptively evaluate and calibrate model-based evaluations of cumulative impacts, and overall biodiversity status, over time.

PROCESSES AND THREAT MITIGATION

Introduction and context

Successful management of Western Australia's biodiversity demands more than an understanding of the full range of species and ecosystems, their geographic distribution and conservation significance.

Biodiversity management encapsulates the challenge of understanding complex living systems that are dynamic, adaptive and exhibit cyclical patterns associated with the impact of a wide range of processes. These include natural processes such as fire, climate, nutrient cycling, pollination, predation and water cycling as well as those impacts driven by human interaction, such as the introduction of new and exotic species, disease, altered water flows and land disturbance associated with human settlement, habitat fragmentation, agriculture and resource development.

Conservation managers face the practical issue of how to maximise biodiversity outcomes (including an evaluation of social and economic benefits) over time. This involves consideration of:

- Diverse, at times competing, views on the value of biodiversity relative to other societal outcomes.
- The interdependencies that exist, such as the role of biodiverse catchments in providing clean water and/or supporting agricultural productivity.
- Allocation and prioritisation of the limited resources devoted to biodiversity conservation to those areas and activities most likely to sustain ecological systems.

Optimising management is not a simple task and requires a systems based view.

Research may include both foundational knowledge and the development of creative/innovative solutions and tools for integrated management. Given the focus of the Research Node in meeting the needs of end users and the breadth of potential research topics, it is envisaged that the majority of WABSI research under this node will be embedded within priority geographic regions.

Objective

Continuously build the capacity of conservation managers to prioritise and develop cost-effective, integrated, on-ground strategies for biodiversity conservation.

End user outcomes

1. Evaluation of priorities for management of threats to species and communities of conservation concern.
2. Development of effective management strategies that integrate responses to the suite of processes and threats facing different geographic locations through time.

Focus area 1: Identifying and prioritising key threats and processes

Rationale

Capacity is required to identify the key threats to species and communities in order to prioritise research and management efforts. Methodologies are required to understand the potential impact of ecological processes on species and landscapes, and to build understanding of how the environment is likely to change through time. Examples of key processes include the capacity to determine thresholds for land disturbance and thresholds for local population extinction (minimum viable population size), predict and manage fire regimes, develop predator management strategies, predict the resilience of ecosystems to changing climate, and management of pests and disease.

Priority areas for commissioned work

WABSI will prioritise the development of tools that enable decision makers to understand trade-offs and prioritise efforts for the conservation of biodiversity (in the context of a region/landscape). WABSI will focus on:

- **Identification of key threats to species and communities** and understanding biological processes involved in species persistence.
- **Risk assessment and prioritisation** including tools for identifying dominant threats and ranking for management based on agreed criteria such as likelihood, impact and reversibility.

- **Ranking/prioritisation of conservation areas** including a capacity to identify refugia
- **Offset and policy responses** including options and methodologies for working with stakeholders to identify and respond to changes in land use.
- **Tools for regional and landscape assessment and planning** including interactive tools to support stakeholders to identify environmental assets in the landscape, assess the potential impacts of key threats and develop appropriate mitigation and management plans.

Focus area 2: Integrated management and process interactions

Rationale

Tools for the management of biodiversity are required based on a robust understanding of the key processes that drive/determine the persistence of species and communities, and ongoing condition, viability and resilience of Western Australia's ecosystems.

Managers are seeking capacity to define and understand the key ecological drivers and evolutionary processes, and the interactions between them, for priority regions and ecological communities. For example, an improved understanding of the interactions between the key processes of fragmentation, edge effects, changed soils, weeds, pests and climate in the South West will assist in targeting conservation and restoration efforts.

Equally important is the task of working with stakeholders to define short (2 year), medium (5 year) and long-term conservation strategies for priority regions and ecological communities. This will require interdisciplinary approaches to identify social and economic drivers and options for policy responses.

Priority areas for commissioned work

WABSI will invest in the development of tools to improve decision making and management. Examples of research that may be supported include:

- Guidelines for identifying and managing climate resilient ecological communities.
- Fire management guidelines.
- Managing species and communities in fragmented landscapes.
- Land use planning for existing and new uses such as irrigated agriculture.
- Thresholds for assessing grazing pressure in arid systems.

Focus area 3: Capacity to understand and manage specific processes and threats

Rationale

In addition to tools to assess and develop management priorities at a site or regional scale, there is a need to continue to understand and develop methods and technologies for managing specific processes and threats.

For example, whilst a landscape planning and prioritisation process may identify the management of predation as a critical issue, the effectiveness of existing techniques and tools for managing cat and fox predation are limited. Foundational research is required to understand the underlying mechanisms and processes taking place and how they may be more effectively controlled and managed.

Priorities for commissioned work

Tools and processes are needed to enable researchers and managers to identify the dominant processes that will influence the future evolution of the environment. Examples of key processes and threats include:

- **Priority pests and weeds** including containment of critical threats to endemic ecosystems, such as *Phytophthora cinnamomi* in the South West shrublands and heathlands
- **Fire management** including implications of climate change and asset protection in the South West, management of fuel loads and re-introduction of Aboriginal burning practices in northern and arid environments.
- **New techniques** for tracking and controlling ferals (foxes, cats, cane toads etc.) including cost effective culling, baiting and biological control.

- **Soil nutrients and nutrient cycling** including tools for managing soil chemistry and reintroducing critical soil biota.
- **Climate change and altered water flows** including capacity to model impacts and identify cost effective solutions for managing water regimes.
- **Small population processes and extinction in fragmented landscapes** including determining population viability and thresholds for loss.

RESTORATION AND *EX-SITU* CONSERVATION

Introduction and context

This node seeks to progressively build upon Western Australia's capacity to restore and rehabilitate key disturbed ecosystems, establish new populations of threatened species through translocations and protect species through *ex-situ* collections. Successful reconciliation of the ongoing development of the State, with the objective of biodiversity conservation, requires a proven capability to understand and restore species and ecological communities.

A key goal of the process of ecological restoration is recovering historic ecological continuity that was interrupted by ecosystem impairment. Historic continuity is not necessarily the recovery of what occurred in the past but rather the continuity or persistence of an intact ecosystem in response to an ever-changing environment, which can lead to new expressions of that ecosystem in the future.

This research node seeks to address the significant task of progressively building the capacity of land managers across the State to understand and develop successful strategies for the restoration of ecological communities and the reintroduction of species. Challenges include:

- Limits to our understanding of how to undertake restoration or reintroduce key animal and plant species across the vast majority of Western Australian ecosystems.
- The need to establish criteria for success in different environments to inform decision making.
- Building capacity to set standards for, and undertake restoration of, ecosystems when key environmental attributes such as climate, soil chemistry or groundwater levels have changed.
- Developing an understanding of the relative costs and benefits of restoration, including determining at what standard efforts of restoration should take place and in what timeframe.

When considered in conjunction with the needs of land users, these challenges manifest differently across the regions of the State. For example:

- Many ecological communities in the biodiverse South West of the State are localised and are often found in association with specific habitats and substrates. Urban development, agriculture and a drying climate have placed significant stress on key ecosystems, such as the jarrah forests and coastal heath lands that are suffering widespread Phytophthora dieback caused by disease, drought and changed fire regimes. Strategies such as selection of seed from drought resilient stock or maximising genetic diversity may be required to ensure these ecosystems persist into the future.
- The Western Australian Wheatbelt is facing a number of key threats including loss of arable land to salinity, and loss of species and ecological communities due to fragmentation and the relatively small areas of remnant vegetation that remains in good condition. Restoration strategies that are proven, scalable and low cost are required.
- Mining developments throughout the State require realistic and achievable mine closure standards, including consideration of the potential to maximise conservation outcomes across site and landscape scales.
- Conservation reserves facing threats and processes of degradation, such as Phytophthora or loss of critical weight range mammals through predation by foxes and cats, require restoration strategies.

Whilst researchers, industry and government agencies in Western Australia have delivered some notable advances in restoration science and practice, limited analysis and documentation of past restoration practices has made it difficult to define existing methodologies and continuously improve restoration practice. An opportunity exists for WABSI to harness

and leverage existing knowledge and expertise for wider application throughout the State.

Objective

Develop and facilitate the adoption of cost effective and scalable strategies and tools for the restoration and reconstruction of Western Australian ecosystems and the reintroduction of threatened plants and animals.

End user outcomes

1. An understanding of the science required to define appropriate criteria for restoration and translocation success.
2. Guidelines and policy frameworks through which standards for restoration, including closure standards, can be identified and set for different sites.
3. Proven low cost, scalable technologies for the restoration of ecological communities and translocation of plants and animals.
4. Capacity to measure and monitor restoration and translocation success, particularly in early formative stages.
5. Capacity to house, store, breed and release (translocate) a representative range of Western Australia's plant and animal species.

Focus area 1: Defining criteria for restoration success

Rationale

Restoration of sustainable native ecological communities requires an understanding of the composition of the community and the environmental conditions, such as soil health, under which the community can be successfully restored.

There are two approaches to achieving restoration targets representing ecological communities:

1. Evaluation of the conditions of a restoration site and selection of target species and communities that suit these conditions (note: these may or may not be endemic, based on changes to environment attributes).
2. Identify the range of environmental attributes required to support the desired target species or communities, and design and construct a restoration environment that provides those attributes.

Early and predictive indicators of restoration success are required, whereby the trajectory towards a sustainable and resilient ecological community, including both plants and animals, can be assessed. In particular there is a need to understand and integrate the requirements across plant, animal, soil, climate and biological processes.

Priority areas for commissioned research

WABSI will facilitate and commission work required to ensure future investments in restoration can be targeted, measured and assessed. Key areas in need of investment to establish the criteria for restoration success include:

- Techniques for determining species richness and community composition targets appropriate to each restoration site. Techniques should take into account the size of target areas and the scale-dependence of richness and composition, and allow for quantitative evaluation.
- Investigation and development of autonomous systems for restoration monitoring.
- Development of early indicators of restoration success encompassing biotic and abiotic properties of soils, plant ecophysiological measures, plant/invertebrate interactions, pollination services and plant reproductive output.
- Development of indicators for long term restoration success measures for key species, encompassing genetic diversity and the mating system.
- Risk analyses of restoration approaches — understanding climate variability/change, provenance (local vs non-local), use of surrogate species and ecosystems.
- *Ex-situ* management of source material (insurance populations), seed banks/orchards and use of islands for animals.

Focus area 2: Restoration technologies

Rationale

The future demands for restoration are significant, ranging from rehabilitation of mine sites, through the restoration of areas within conservation parks that have suffered degradation, the protection of remnant vegetation, to the restoration of fundamental ecological functions (such as ground water balances).

To address these challenges, contemporary restoration programs will aim to restore biodiverse plant and animal communities, often at a large scale. In practice, this means the return of tens to hundreds of species in many ecosystems, potentially across thousands of hectares.

Scale and cost are key drivers of research priorities for restoration – there is a clear need to develop proven, cost effective and scalable restoration. Industries involved in restoration, particularly the mining sector, strive to create procedures that ideally deliver the desired level of species return in one pass, produce the same outcome at any scale (small to large), and deliver a predictable and replicable outcome.

Priority areas for commissioned research

Achieving effective landscape scale restoration requires research and technology development in a number of key areas. Critically, it is the integration of these research areas that is necessary to improve outcomes:

- Landform stability and erosion management.
- Understanding physical, chemical, hydrological and biotic attributes of re-made soils and substrates to enable seedling establishment and plant growth.
- Understanding and capitalising on the role of soil biotic processes in restoration success.
- Development of seed technology for effective seed use and delivery to site.
- Creating native seed production farming enterprises to generate high quality seed and to reduce the impact of seed collection on wild sources.
- Development of surrogate species and ecosystems.
- Animal sourcing and captive breeding.

Focus area 3: Criteria for species re-introduction success

Rationale

Western Australia's biodiversity is noted for high levels of endemism, meaning that many plant and animal species are only found within a relatively small geographic area. This natural endowment, combined with changes in the environment and continuing demands associated with the State's development, mean that Western Australia has a disproportionate number of Australia's threatened plant and animal species, as listed under the State's *Wildlife Conservation Act 1950* and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*.

Many WA native animal and plant populations are still declining and captive breeding, translocation strategies and the management of threatening processes need to be improved to prevent extinction of certain WA animals.

As a consequence, many attempts have been made to undertake translocation of endangered species, and it is likely that many others will be targeted in the future in an attempt to improve their conservation status and reconstruct ecosystems. Translocation of both plant and animal species is both expensive and difficult. With translocations being used as part of species recovery programs, it is important that adequate meaningful and measurable criteria for success be developed. These will assist in prioritising species for translocation and in ensuring existing and future translocation efforts can be monitored to ensure a successful outcome that delivers viable and self sustaining populations of species targeted for translocation.

Long term success of translocations are dependent on multiple factors including the presence of genetically representative germplasm in *ex-situ* collections, survival of the first generation and achieving reproductive capability of genetically viable populations. However, measuring success can be problematic if there is a need to monitor over multiple generations of long lived plants or animals to assess sustainability and persistence. Measures based on Population Viability Analysis (PVA), mating system variation and genetic variation are useful, indirect measures and need to be adequately benchmarked against natural populations.

Priority areas for commissioned research

WABSI will seek to invest in capabilities associated with the development of criteria for species reintroduction success including:

- Developing appropriate *ex-situ*/captive breeding protocols.
- Adequate genetically representative germplasm in *ex-situ* collections including seed orchards and captive animal colonies.
- Developing methods for assessing long term reintroduction success including Population Viability Analysis, benchmarking genetic diversity, mating system parameters, and reproductive output against naturally occurring populations to determine reproductively capable population(s).
- Standards for translocation success based on life history attributes.

Focus area 4: Reintroduction technologies

Rationale

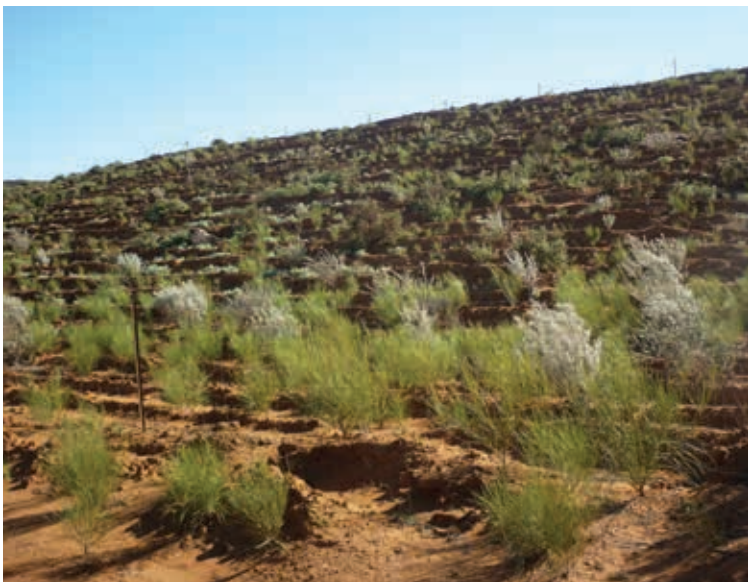
The technology required to successfully translocate animal and plant populations mirrors the requirements of restoration technologies including landform and soil attributes, seed/animal sourcing propagation and distribution. However, translocations of rare and threatened species require additional focus on the management of endangered source populations.

The ecosystem benefits of translocations also need to be explored. For example, many of the digging and burrowing mammals have declined or become locally extinct in WA and their return could facilitate the restoration of vegetation communities. The impact of 'ecosystem engineers' on soil aeration, water penetration, seed accumulation and germination, carbon and nitrogen recycling and landscape modification needs further examination. Further, integrated translocation of plants and animals needs to be examined as a possible tool for enhanced ecosystem restoration programs.

Priority areas for commissioned research

Achieving effective re-establishment of threatened species requires research and technology development in the following key areas:

- Innovative techniques for captive breeding such as cross fostering, artificial insemination and in-vitro fertilisation.
- Sourcing and storage of plant propagules development of technologies to better deliver plants for translocations and improve seedling establishment.
- Understanding biotic and abiotic attributes that both enable and optimise plant establishment, growth, survival and recruitment of subsequent generations.
- Developing appropriate, robust monitoring techniques to allow outcomes of translocations to be confidently determined.
- Assessing the value(s) of fauna translocations to broader ecosystem restoration practices.
- Creating *ex-situ* production enterprises (seed orchards and captive breeding) to generate high quality offspring to reduce pressure on wild populations.



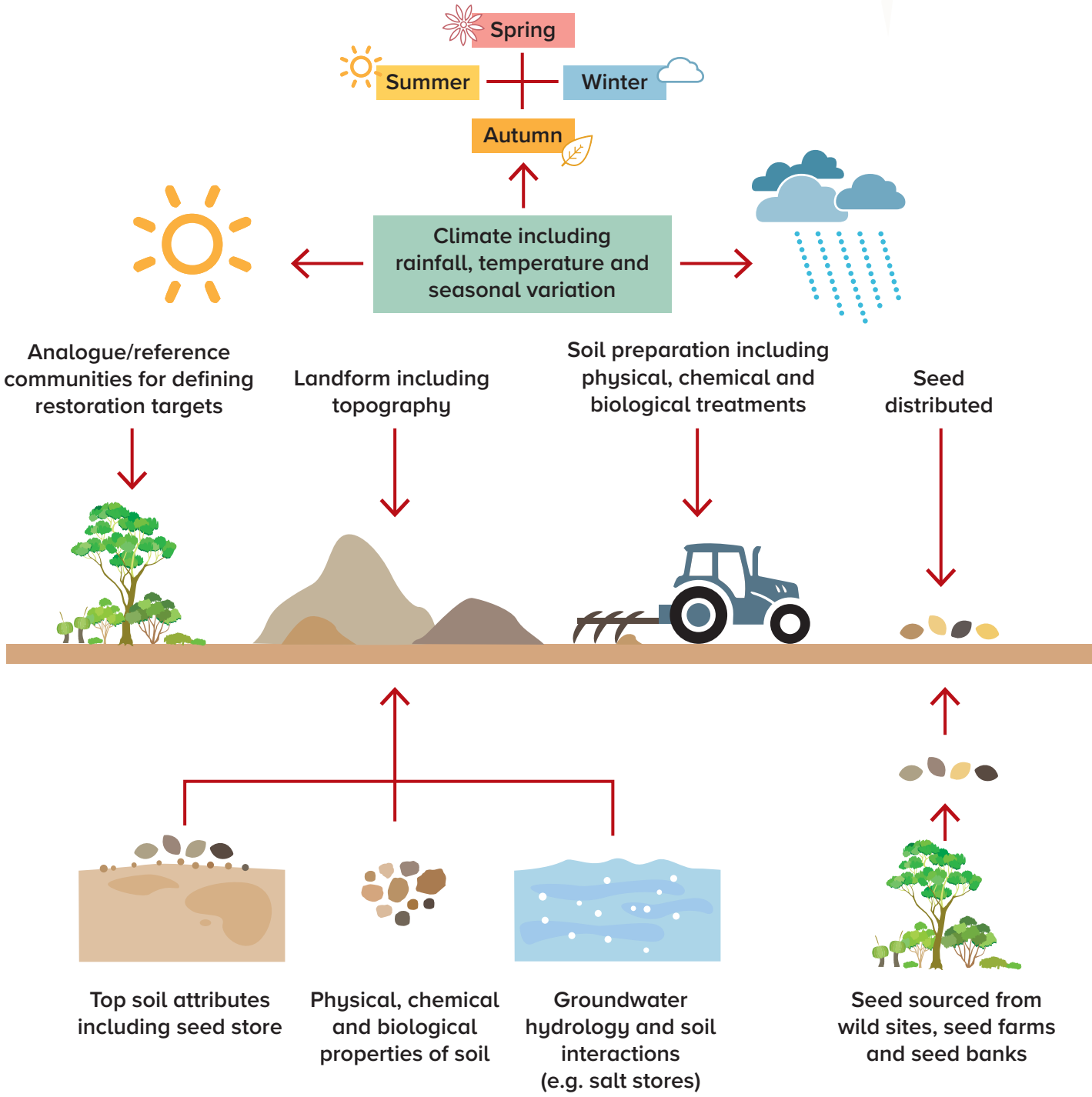
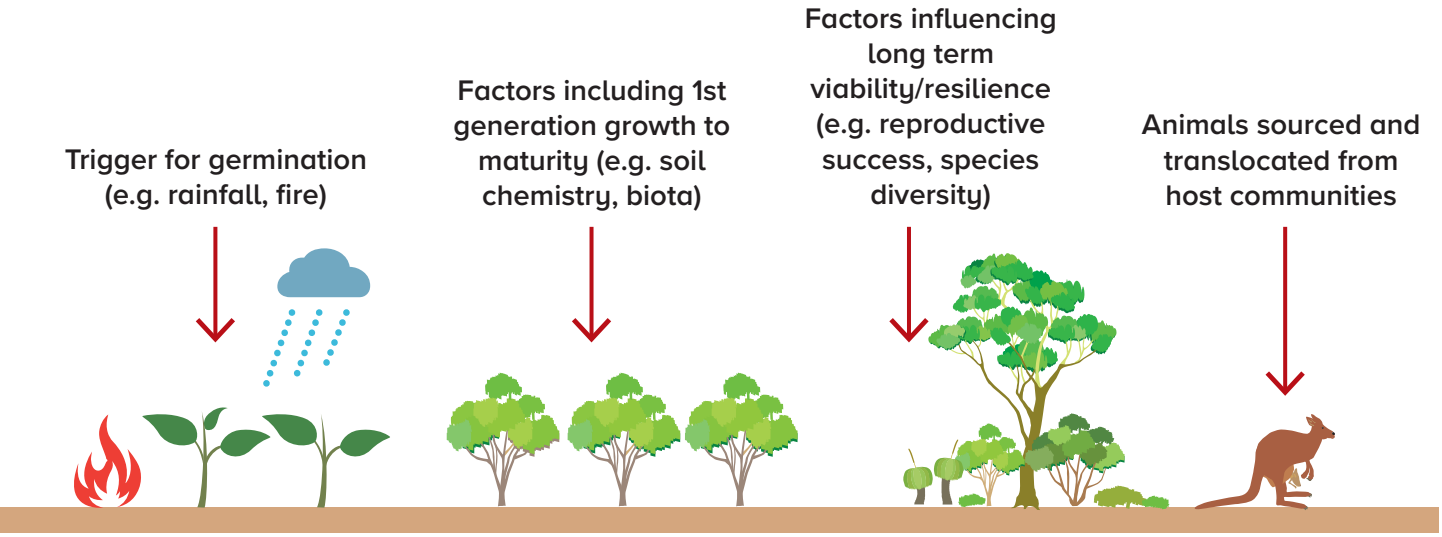


FIGURE 5 Key elements required for restoration of biodiverse ecosystems



Animals sourced and translocated from host communities

PRIORITY LANDSCAPES

SOUTHERN RANGELANDS – PILBARA

Partnerships for landscape scale understanding and collaborative management

Key drivers and end user needs

- The Pilbara region is an extensive and ancient landscape that is home to a vast array of native plants and animals, many of which are endemic to the region including numerous plant species, one of the world's richest reptile assemblages and one of the last habitats to support native animals such as the northern quoll, mulgara, greater bilby, leaf nosed bats and the olive python.
- The Pilbara is also home to one of the world's most productive and valuable mineral resource basins, focused on export of seaborne iron ore and support for off-shore oil and gas industries. Conservation lands and pastoral land-use are interlaced with minerals development and Aboriginal native title, resulting in a complex array of interests and stakeholders in the management of the region.
- Extensive data has been collected from the Pilbara and Southern Rangelands through environment impact assessment processes, and yet a coherent view of the region's biodiversity assets is yet to emerge. Further, analysis of key threatening processes and development of the collaborations required to effectively mitigate the cumulative impacts of the minerals and pastoral industries are in their infancy.
- Considerable goodwill is emerging to collaborate on identifying and resourcing appropriate studies to inform future management of conservation values in this important region. The establishment of a Pilbara Conservation Fund governed by government and industry stakeholders is being actively considered. Timely access to data to inform environmental approvals, environmental monitoring and agreed mitigation as well as offset strategies and rehabilitation technologies are all end user imperatives.

Key research issues

Key priorities for future research include:

- Improved information management and access across industry, stakeholders and government.
- Aboriginal engagement and transfer and recording of traditional ecological knowledge.
- Rapid biodiversity analysis including community level modelling methodologies for evaluating cumulative biodiversity impacts in the Pilbara.
- Guidelines for pastoral management and identification of high conservation land/refugia.
- Threatened species management and offset policy design.
- Management of ground and surface water for water sensitive ecosystems.
- Management guidelines for key processes and threats including fire, grazing pressure, predation by cats and foxes, and weed management.
- Guidelines for restoration of land disturbance including cost effective mine site rehabilitation

WABSI research priority – *Pilbara Futures*

A comprehensive research program to support government and industry investment in the management and conservation of biodiversity in the Pilbara including:

- Agreed protocols and information management systems for consolidating and accessing biodiversity survey data from the Pilbara (**Information Management Node**).
- Community-level modelling methodologies for assessing cumulative biodiversity impacts in the Pilbara (**Biodiversity Survey Node**).
- Identification and mapping of critical biodiversity assets (**Biodiversity Survey Node**).
- Threatened species and threat abatement planning (**Processes and Threat Mitigation Node**).
- Pilbara Restoration Initiative (**Restoration Node**).

Partners: Department of Parks and Wildlife, CSIRO, Botanic Gardens and Parks Authority, WA universities, WA Museum, BHP Billiton, Fortescue Metals Group, Rio Tinto, Environmental Protection Authorities, Department of Mines and Petroleum.

WESTERN DESERT LANDS

Engaging and working in partnership across land tenures in the western deserts of Western Australia.

Key drivers and end user needs

The Western Desert region of Western Australia encompasses a significant area of the State and supports a diverse range of terrestrial and aquatic ecosystems including many endemic plants and animals. Large areas of the desert landscapes are intact and in good ecological condition, and remain under the stewardship of Aboriginal people who continue to be culturally connected to country.

The Western Desert has important cultural, heritage and social value to Aboriginal communities, who continue to use their traditional knowledge and skills in their day to day life to live on country. The recognition of native title, establishment of Indigenous Protected Areas (IPAs) and joint management of national parks and nature reserves provides significant new opportunities for Aboriginal landowners to continue to practise and protect their culture, and for conserving biodiversity and improving the health of desert ecosystems. Collaborative engagement with other land managers who have rights in this region will also deliver improved land management and conservation outcomes.

There remain important opportunities for economic development within the region, including more intensive agricultural land use in some areas and mineral and gas exploration and development in others. There is limited biodiversity data available for the region hence increased survey would result in more efficient approvals and better biodiversity conservation outcomes. There is a need to understand how future development aspirations may be most effectively integrated with the cultural and nature conservation objectives of Aboriginal communities and the broader Western Australian community.

Key research issues

Although Western Desert ecosystems remain relatively intact, our knowledge of biodiversity is comparatively poor and there are important and ongoing threats to conservation values. Key priorities include:

- Intergenerational transfer and recording of Indigenous Ecological Knowledge.
- Surveying and modelling of the distribution of species and ecological communities.
- Understanding and improving fire management regimes to manage a transition from large hot season lightning caused fires to return to a small mosaic scale fire regime.
- Understanding and management of introduced predators, particularly cats and foxes, and their impact on critical weight mammals.
- Understanding and management of feral herbivores including goats, camels, horses and donkeys.
- Environmental weeds, particularly near water courses and water holes.
- Guidelines for compatible resource exploration and development.

New landscape conservation initiatives supported by coordinated research are needed. For example, changing the current unmanaged fire regime to a new regime akin to that of traditional Aboriginal fire is a substantial challenge that will require extension and expansion of traditional techniques and application of modern technologies to replicate aspects of traditional fire use across large parts of the landscape. The potential for self-funded fire and land management on Aboriginal lands through emissions abatement and carbon sequestration arising from good fire management are recognised.

WABSI research priority – *partnerships for land management*

A collaborative partnership working with traditional owners to understand:

1. Best practice methodologies for Aboriginal engagement, intergenerational knowledge transfer and recording of Indigenous ecological knowledge (**Aboriginal Knowledge Theme**)
2. Mapping of ecological communities of the Western Desert regions (**Survey Node**)
3. Fire management regimes and monitoring (**Processes and Threat Mitigation Node**)
4. Cat and predator control (**Processes and Threat Mitigation Node**)
5. Management and control of invasive weed species (**Processes and Threat Mitigation Node**)
6. Reintroduction of key species (**Restoration Node**)

DEVELOPING NORTHERN AUSTRALIA

Managing the development of northern Australia in a way that integrates the unique environmental, cultural and economic values of the region.

Key drivers and end user needs

The Kimberley is a hot spot for tropical plant and animal biodiversity. The region contains many endemic species and has not experienced the same level of biodiversity decline documented across tropical regions to the east.

The Kimberley has important cultural, heritage and social value to Aboriginal people, who continue to use their traditional knowledge and skills in their day to day life to live on country. The recognition of native title, establishment of a network of Indigenous Protected Areas (IPAs) and a strong focus on healthy country planning provides significant new opportunities for Aboriginal landowners to continue to practise and protect their culture, conserving biodiversity and generate economic benefits. The north Kimberley Fire Abatement project, for example, attracts significant corporate investment providing livelihood opportunities for Aboriginal people as well as biodiversity benefits.

With free flowing rivers, iconic interior ranges, and pristine coastlines, the region is a drawcard for tourists who come to experience its unspoiled landscapes. With its seemingly inexhaustible water supplies, the region's agricultural potential is also being re-examined amid calls for new dams so that northern Australia can become a food bowl for the region. The planned expansion of the Ord irrigation scheme has been bolstered by significant interest from foreign investors while the Water for Food Program is examining the region's of groundwater to support irrigated agriculture and more intensive cattle production. The possibility of coal and unconventional gas reserves also have the potential to transform the region's economy. These are development opportunities of an unprecedented scale but their progress will require clear strategies for the sustainable management and conservation of the region's biodiversity. Recent NRM and healthy country planning activities have highlighted a range of research needs across the Kimberley.

Key research issues

Key priorities for future research include:

- Improved information management and access across industry, stakeholders and government.
- Surveying and modelling of the distribution of species and ecological communities.
- Understanding the water requirements of groundwater and surface water ecosystems.
- Research to halt the decline of mammal biodiversity based on the management of fire, cats and feral herbivores.
- Research to support biodiversity management and monitoring by Indigenous rangers.
- Implementation of fire management to support biodiversity and the carbon economy.
- Modelling to determine the potential impacts of development.
- Environmental weeds, particularly near water courses and springs.

WABSI research priority

- Integrated catchment, coastal land and water planning for more intensive agricultural, gas and mineral development (**Processes and Threat Mitigation Node**)
- Aboriginal engagement in land and water planning (**Aboriginal Knowledge Theme**)
- Mapping patterns and threats to biodiversity (**Survey Node**)
- Managing mine de-watering (**Processes and Threat Mitigation Node**)

THE DRYING AND FRAGMENTED SOUTH WEST

Managing biodiversity hotspots in a changing environment

Key drivers and end user needs

South-western Australia is one of 35 regions on Earth classified as a global biodiversity hotspot. This recognises the extraordinarily diverse biota of the South West, at the same time as highlighting the significant threats to the persistence of the region's biodiversity. The South West supports Western Australia's largest urban centres; world-class tourism attracted by its coasts, wineries, wildflowers, forests and woodlands; the Western Australian Wheatbelt, which grows one third of Australia's export grains; and rapidly proliferating mining and other developments.

The biodiversity of the region is relatively well understood, with a complex array of conservation reserves and conservation and threat management plans in place. Moving forward, biodiversity managers will need to optimise conservation within the context of a measurably warming and drying climate and highly fragmented landscape whilst continuing to support the productivity of its cropping, grazing and horticultural lands, and expanding urban populations and resource extraction industries.

Key research issues

South-western Australia has already experienced a 20% decline in rainfall since the 1960s. Furthermore, the South West is the only region in Australia for which an ongoing decline in rainfall is consistently predicted across a wide range of climate models. A warming and drying environment combined with significant habitat loss is thus a real and over-arching challenge to the conservation of the diverse biota of the region.

Key priorities include:

- Understanding of the consequences of interacting threats such as habitat loss, fragmentation, salinisation, exotic invasions, nutrient enrichment and disease.
- Understanding the interaction of climate change and existing threats, particularly habitat fragmentation.

This includes identifying thresholds of climatic tolerance for ecological communities and iconic plant and animal species, the management of Phytophthora dieback in the Jarrah forests, and coastal shrublands and heathlands.

- Understanding of changes in fire regimes and the resilience of ecosystems to fire as the climate changes, and the impacts of a drying climate on fuel accumulation, flammability, resistance and resilience of ecosystems to fire will be needed to help adapt fire management including consideration of the need to protect built assets and infrastructure.
- Characterising climate thresholds for species and ecosystems, and understanding processes that contribute significantly to climate-resilience and adaptability in species, ecosystems and landscapes.
- Understanding interactions of fire, invasive species, pests and climate change.

WABSI research priority

A research collaboration aimed at understanding and setting priorities for biodiversity management in fragmented landscapes and a drying climate, focusing on:

- Tools for managing climate adaptation in key ecological communities (**Processes and Threat Mitigation Node**)
- Threatened species management and recovery planning (**Processes and Threat Mitigation Node**)
- Interactions between climate change, fragmentation, fire and weeds (**Processes and Threat Mitigation Node**)
- Managing species and communities in fragmented landscapes (**Processes and Threat Mitigation Node**)
- Guidelines for climate-resilient restoration. (**Restoration Node**)

ISLAND ARKS

Understanding and harnessing a unique and vast resource

Key drivers and end user needs

There are over 3,700 islands off the Western Australian coast, about 40% of Australia's total. Because of their relative isolation many are free of introduced plants and animals and are refuges for threatened, priority and endemic flora and fauna. Many islands also have significant cultural and heritage values for aboriginal people. For example, there are approximately 2,000 islands off the Kimberley coast and many are now covered by Native Title and are being managed for conservation and cultural reasons by traditional owners in collaboration with Parks and Wildlife.

With notable exceptions, such as Barrow Island where Liquid Natural Gas is to be processed, Western Australia's islands are a relatively poorly understood and potentially under utilised resource. From a

conservation management perspective, islands are an important resource as refugia, including translocation of threatened species such as critical weight mammals whose mainland habitat is no longer sustainable. From an industry and tourism perspective the potential of islands is also poorly understood.

Increasing use of islands by industry and the public for recreation, needs to be integrated with robust conservation strategies that address threats such as habitat loss and degradation, and introduction of weeds and pest animals and inappropriate fire regimes.

Key research issues

Management of islands by government, industry and Traditional Owners requires the development of adequate databases to capture the knowledge that exists and to underpin management decisions. Improved biosecurity protocols need to be developed, as well as effective techniques for controlling or eradicating invasive species on islands. Understanding the impact of traditional burning practices on island biota and how that might interact with invasive species impact and spread is required. Partnerships between all island users need to be developed to allow the sharing of ideas and to seek new and innovative ways of effectively managing islands.

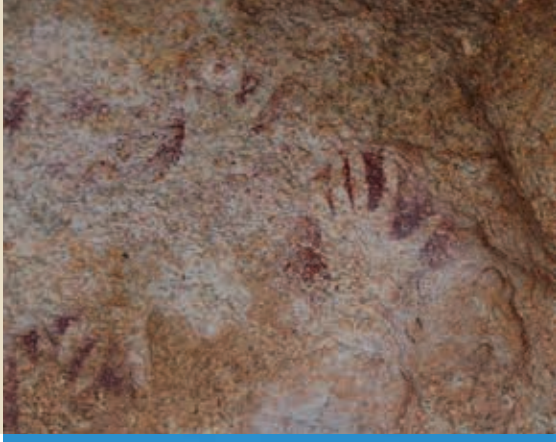
Key research needs include:

- Survey and capture of baseline biodiversity information from islands.
- Develop biosecurity protocols to prevent new incursions by weeds and pest animals.
- Management strategies to prevent spread of existing weeds and pest animals on islands.
- Management strategies for regulated and unregulated tourism / recreational visitation.
- Management of translocated populations on islands.
- Evaluation of the genetic viability of island populations of key species.

WABSI research priority – *understanding our island biodiversity*

Develop a comprehensive database on characteristics and values of islands to guide management intervention.

- Survey and capture of baseline biodiversity information from islands (**Information Management Node**).
- Prioritise islands for management action based on conservation values, threat likelihood and feasibility of undertaking action (**Biodiversity Survey Node**).
- Undertake population viability analysis of populations of species on islands most considered at risk (**Processes and Threat Mitigation Node**).
- Develop species enhancement tools (translocation etc) to ensure long-term persistence of island populations (**Restoration Node**).
- Understand impact of introductions on island ecosystems (**Restoration Node**).
- Improve knowledge of, control and eradication techniques for invasive species on islands (**Processes and Threat Mitigation Node**).
- Develop appropriate fire management tools including understanding interactions between fire and invasive species (**Processes and Threat Mitigation Node**).



NEAR TERM PRIORITIES AND SOURCING FUNDING

The research program outlined in this WABSI Research Plan is broad in scope and application. It would take many years (decades) and significant financial resources that are beyond the initial scope of WABSI.

In practice, the research plan will serve one of two purposes:

1. As a resource to attract block funding from government and industry.
2. As a guiding document for the development of end user and research collaborations that will then seek project level funding from investors.

In either case there is an inevitable need to identify a smaller number of more focused research initiatives, particularly in the formative stages of WABSI. When doing so it is important to be able to clearly articulate the criteria and rationale for selection. These are outlined below.

CRITERIA FOR SELECTION OF WABSI RESEARCH PRIORITIES

1. Managing the project through WABSI would enhance the economics of the project.
2. Managing the project through WABSI would allow the project to leverage the collective intellectual capital and research capability of WABSI partners.
3. Managing the project through WABSI would remove duplication in the project that might exist by merging similar projects or sharing knowledge across projects.
4. Potential to deliver a material gain in WABSI's primary outcomes of improved biodiversity conservation and industry/facilitation of sustainable development.
5. In the case of end user application, has the potential to deliver the materially improved products and outcomes within 5 years.
6. In the case of foundational research capacity, WABSI has the potential to place Western Australian research at the leading edge of global biodiversity research and deliver transformational insights within 10 years.
7. WABSI will have the capacity to draw upon or source the required research capability.

APPENDIX A

WABSI geographic areas — contextual information

	TROPICAL AND DEVELOPING NORTH KIMBERLEY	SOUTHERN RANGELANDS — PILBARA/MIDWEST	WESTERN DESERTS	DRYING SOUTH WEST
Climate	Tropical	Arid tropical – seasonally arid	Arid	Mediterranean
Weather patterns	Seasonal and predictable	Unseasonal and highly variable	Variable	Seasonal and predictable
Landform setting	Heterogeneous and complex	Heterogeneous and complex	Uniform	Heterogeneous
Fauna	Mostly intact	Significant decline	Significant decline	Significant decline
Flora/vegetation	Mostly intact but declining	Mostly intact but declining	Intact	Fragmented
Subterranean fauna	Unknown	Mostly intact but declining	Unknown	Unknown
Identification of species and ecological communities	Poor knowledge	Reasonable knowledge	Poor knowledge	Good knowledge
Geographic distribution of species and ecological communities	Poor understanding	Reasonable understanding	Poor understanding	Reasonable understanding
Threatening processes – appreciation	Moderate	Moderate	Moderate	High
Threatening processes – management intervention	Moderate	Low	Low	High
Tenure issues	Complex, poorly understood	Complex, poorly understood	Simple poorly understood	Complex but well understood
Key land management collaborator	Kimberley Land Council (KLC)	Rangelands NRM	Central Desert Native Title Services	Various NRM groups
Key resources industry	Pastoralism/minerals exploration/irrigated agriculture	Mining/pastoralism	Land management	Intensive agriculture/ mining
Key land use	Aboriginal/pastoral/ conservation	Pastoral/mining/ conservation	Aboriginal/ conservation	Agriculture/urban/ water/forestry/ conservation
Key stakeholders	The Nature Conservancy (TNC) PEW Environment Australian Wildlife Conservancy (AWC) Kimberley Land Council (KLC)	AWC Bush Heritage Carbon Neutral – *Yarra Yarra* Corridor Rangelands NRM Pilbara Corridors	Bush Heritage The Nature Conservancy Great Victoria Desert Trust	Bush Heritage Gondwana Link Carbon Neutral – *Yarra Yarra* Corridor

	TROPICAL AND DEVELOPING NORTH KIMBERLEY	SOUTHERN RANGELANDS — PILBARA/MIDWEST	WESTERN DESERTS	DRYING SOUTH WEST
Funding opportunities	Kimberley Science and Conservation Strategy NERP Northern Australia Hub Rangelands NRM	Rangelands NRM Gorgon Net Conservation Benefit Fund (Gorgon NCB)	BHP Billiton Great Victoria Desert Trust Rangelands NRM	South Coast NRM South West Catchments Council (SWCC) Northern Agricultural Catchments Council (NACC) South Coast NRM Wheatbelt NRM
Leveraging opportunities	NERP Northern Australia Hub TERN- AusPlots Rangelands	Pilbara Landscape Trust (proposed) Pilbara Corridors TERN- AusPlots Rangelands Gorgon Net Conservation Benefit Fund (Gorgon NCB)	Ten Desert Initiative Great Victoria Desert Trust TERN- AusPlots Rangelands	TERN- AusPlots Forests TERN - South West Australia Transitional Transect (SWATT)
Existing activity	CSIRO – Kimberley Metagenomics Parks and Wildlife – Kimberley Island Survey	Parks and Wildlife – Pilbara Biological Survey CSIRO Pilbara cumulative Impacts collaboration Karara Conservation Initiative AusPlots Rangelands – Murchison	Parks and Wildlife – Birriliburu Biological Survey AusPlots Rangelands – Katjarra	AusPlots Forest – Tall Eucalypt Forest SWATT – sandplain floristics AusPlots Rangelands – Coolgardie CSIRO/TERN – Credo Supersite
Traditional owner engagement	Extremely high and mandatory	Low	High and mandatory	High
Traditional owner capacity	High and increasing	Low and increasing	Low and increasing	Poor but increasing
Greenfield development potential	High but slow	High	High	Limited
Realised development potential	Low	High	Low	High

APPENDIX B

WABSI research planning consultation

NAME	COMPANY / ORGANISATION	POSITION
Matthew Daws	Alcoa	Senior Research Scientist
Professor Craig Moritz	Australian National University	Professor, Research School of Biology
Russell Barnett	Australian Venture Consultants	Founding Partner
Breanne Menezies	BHP Billiton	Principal Ecologist, Environmental Approvals
Gavin Price	BHP Billiton	Head of Environment
George Watson	BHP Billiton	Superintendent Ecology
Mark Donovan	BHP Billiton	Head of External Affairs
Mark Vile	BHP Billiton	Principal Ecologist
Roger Gregory	BHP Billiton	Superintendent GIS
Tara Read	BHP Billiton	Superintendent Rehabilitation
Stephen White	BHP Billiton Iron Ore	Manager, Rehabilitation and Biodiversity
Environment	Kimberley Land Council (KLC)	Rangelands NRM
Belinda Barnett	BHPBIO	Principal Ecologist
Dr Ben Miller	Botanic Gardens & Parks Authority	Ecologist
Dr David Merritt	Botanic Gardens & Parks Authority	Research Scientist
Dr Paul Nevill	Botanic Gardens & Parks Authority	Research Scientist, Genetics
Prof Kingsley Dixon	Botanic Gardens & Parks Authority	Director, Science
Piers Verstegen	Conservation Council of WA	Director
Alan Andersen	CSIRO	CSIRO Researchers
Andy Sheppard	CSIRO	Steering Committee CSIRO Rep
John La Salle	CSIRO	CSIRO Researchers
John Scott	CSIRO	CSIRO Researchers
Linda Broadhurst	CSIRO	CSIRO Researchers
Owain Edwards	CSIRO	Steering Committee CSIRO Rep
Simon Ferrier	CSIRO	OCE Science Leader and Senior Principal Research Scientist
Stephanie von Gavel	CSIRO	Steering Committee CSIRO Rep
Suzanne Prober	CSIRO	CSIRO Researchers
Dr Bill Bateman	Curtin University	Department of Environment and Agriculture Faculty of Science and Engineering

NAME	COMPANY / ORGANISATION	POSITION
Grant Wardell-Johnson	Curtin University	Associate Professor, Department of Environment and Agriculture
Dr Nihara Gunawardene	Curtin University	Research Fellow, Surveillance Entomologist Department of Environment and Agriculture Division of Science and Engineering
Todd Robinson	Curtin University	Research Fellow, Department of Spatial Sciences
Lesley Polomka	Department of Mines and Petroleum	Senior Environmental Officer, Operations, Environment
Michelle Andrews	Department of Mines and Petroleum	Deputy Director General – Strategic Policy
Phil Gorey	Department of Mines and Petroleum (DMP)	Executive Director, Environment
Sarah Comer	Department of Parks and Wildlife	Regional Ecologist
Kim Williams	Department Parks and Wildlife. South West Region, Bunbury WA	Regional Leader, Nature Conservation
Jason Hick	Emerge Associates	Director, Environmental Planner Environmental Science
John Gardner	John Gardner REALM Consulting	Principal
Bridget Hyder	Office of the Environmental Protection Authority	Manager, Terrestrial Ecosystems Branch
Ray Masini	Office of the Environmental Protection Authority	Manager, Marine Ecosystems Branch
Kelly Freeman	Office of the Environmental Protection Authority	Principal Environmental Officer, Terrestrial Ecosystems Branch
Shaun Grein	Fortescue Metals Group	Manager Environmental Studies
Piers Higgs	Gaia Resources	Director
Craig Anderson	Greening Australia (WA)	CEO — WA
Dr Treena Burgess	Murdoch University	Senior Lecturer in Plant Sciences
Dr Katinka Ruthrof	Murdoch University	Senior Research Fellow Academy, School of Veterinary and Life Sciences, Environmental and Conservation Sciences

NAME	COMPANY / ORGANISATION	POSITION
Matt Bellgard	Murdoch University	Director, Centre for Comparative Genomics
Professor Giles Hardy	Murdoch University	Professor in Forest Pathology, Academy, School of Veterinary and Life Sciences, Environmental and Conservation Sciences
Dr Peter Mawson	Perth Zoo	Director of Animal Health and Research
Dr Colin Yates	Science and Conservation Division, Department of Parks and Wildlife	Assistant Director, Science and Conservation Division
Dr David Coates	Science and Conservation Division, Department of Parks and Wildlife	Plant Science and Herbarium Program Leader
Dr Kevin Thiele	Science and Conservation Division, Department of Parks and Wildlife	Herbarium Curator, Plant Science and Herbarium Program
Dr Lachie McCaw	Science and Conservation Division, Department of Parks and Wildlife	Ecosystem Science Program Leader
Dr Margaret Byrne	Science and Conservation Division, Department of Parks and Wildlife	Director, Science and Conservation Division
Dr Neil Gibson	Science and Conservation Division, Department of Parks and Wildlife	Principal Research Scientist, Plant Science and Herbarium Program
Dr Stephen van Leeuwen	Science and Conservation Division, Department of Parks and Wildlife	Partnerships Manager
Mr Keith Morris	Science and Conservation Division, Department of Parks and Wildlife	Animal science Program Leader
Mr Paul Gioia	Science and Conservation Division, Department of Parks and Wildlife	Science Applications Unit Manager
Peter Davies	University of Western Australia	Pro Vice-Chancellor (Research)
Andy Whitely	University of Western Australia	Winthrop Research Professor and WAFP Fellow, School of Earth and Environment
Assoc/Prof Nicola Mitchell	University of Western Australia	Associate Professor, Animal Biology, School of Animal Biology
Barbara Cook	University of Western Australia	Associate Director, Centre of Excellence in Natural Resource Management
Laco Mucina	University of Western Australia	School of Plant Biology
Professor Raphael Didham	University of Western Australia	Future Fellow, Animal Biology, School of Animal Biology
Richard Hobbs	University of Western Australia	School of Plant Biology

NAME	COMPANY / ORGANISATION	POSITION
Sarah Dunlop	University of Western Australia	Head of School, Animal Biology Head, Experimental and Regenerative Neurosciences
Steve Hopper	University of Western Australia	Winthrop Professor of Biodiversity, Centre of Excellence in Natural Resource Management and School of Plant Biology
W/Prof Laco Mucina	University of Western Australia	Winthrop Professor of Vegetation Science and Biogeography School of Plant Biology M084
Tony O'Donnell	University of Western Australia	Dean/Winthrop Professor, Faculty of Science
Lisa Kirkendale	Western Australian Museum	Curator of Molluscs
Andrew Rowe	Western Australian Museum	Online Services Developer
Bill Humphreys	Western Australian Museum	Senior Curator
Evan Rogers	Western Australian Museum	Collections Database Manager
Mark Harvey	Western Australian Museum	Head, Department of Terrestrial Zoology
Morgan Strong	Western Australian Museum	Manager, Online Services

APPENDIX C

Interim Node Convenors

RESEARCH NODE LEADERSHIP	RATIONALE
Research Node: Information Management Systems **Lead Agency** – CSIRO **Supporting Agencies** — Office of The Environmental Protection Authority, Department of Minerals and Petroleum, Department of Parks and Wildlife	As the leader and custodian of the Atlas of Living Australia (ALA), CSIRO has significant experience and track record in developing the technical platform and data standards required. The ALA has also demonstrated effective facilitation skills in encouraging information sharing. ALA represents a logical and compelling platform for data aggregation and interpretation with all of Western Australia's vouchered collections already represented in the Atlas. In addition a new platform is required to house data from non-vouchered surveys and studies including those undertaken by industry for environmental impact assessment. WA government agencies will remain custodians of this data.
Research Node: Biodiversity Survey **Lead Agency** – Department of Parks and Wildlife **Supporting Agencies** — Universities, WA Museum	The Department of Parks and Wildlife is the agency with primary responsibility for coordinating advice to the government on the management of the State's biodiversity. The Department manages an active survey program including active collaborations across government and industry. It is uniquely placed to facilitate improved coordination and aggregation of biodiversity survey across the State.
Research Node: Processes and Threat Mitigation **Lead Agency** – University of WA **Supporting Agencies** — All WABSI organisations	UWA has demonstrated depth of experience and capacity in ecological research with active collaborations in place with all of the participating organisations of WABSI. The University is well placed to drive collaboration across organisations and has science leadership within the Research Node that is strongly respected across each of the participating organisations.
Research Node: Restoration and *ex-situ* Conservation **Lead Agency** – Botanic Gardens and Parks Authority **Supporting Agencies** — WA universities, Parks and Wildlife, Department of Mines and Petroleum, Perth Zoo, Alcoa	BGPA have played a leading role in the science of ecological restoration and forged strong linkages with industry. The Science directorate has significant capacity in plant ecology and restoration techniques and is well placed to drive the necessary collaborations across WABSI members.

It is noted that the primary responsibility of Node Leaders is to drive stronger linkages and collaborations across all of WABSI participating organisations. Individual projects and initiatives within each Node may be led by any of the participating organisations.

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CSIRO

Curtin University

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Department of Parks and Wildlife

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Western Australian museum