Tools to support decision makers in ecosystem management: Workshop report

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Contents

Workshop overview

Context:

- Dealing with complexity is common to many of the challenges we have – many things need to be considered (e.g., PESTLE); multiple values, some with competing or conflicting requirements (i.e., trade-offs), operating in a natural environment that is inherently complex and dynamic, where are lot of important factors are outside of our control or are unpredictable to some extent.
- We operate in an environment with incomplete information and uncertainty, and we struggle to get the most value from the information we do have to help inform our decisions. And we operate with limited resources (e.g. staff, time, skills).
- Billy Geary's work on developing a pipeline that helps to identify optimal fire and introduced predator management provides an example of a what decision support tool could do to help overcome some of the challenges and complexities we have in natural resource management to deliver biodiversity conservation, protecting life and property from bushfires and meeting other community expectations and legislative requirements.

Purpose:

- Consider some of the challenges we face in delivering on-ground management and explore how we might be able to do things better.

Workshop objectives:

- Introduce and use a decision support tool (Hemming et al. 2022)
- Recognise the good work already being done and the tools we currently use
- Identify some of the key challenges we have within fire management, invasive species management and biodiversity conservation that may benefit from having decision support tools, that help to deliver better on ground outcomes.
- Select some examples for development.
- Understand the challenge by defining the problem well.
- Outline the objectives of what we would like to achieve to address or overcome the challenge.
- Use this workshop as a catalyst to progress the development of decision support tools that help us to improve the way we do business.

Overview of decision support tools

Introduction to decision-support tools for conservation

Dr Billy Geary
School of Agriculture, Food & Ecosystem Sciences
University of Melbourne

Making decisions in conservation

There are lots of different flavours…

What…	Which…	When…	How much…
Species should we focus on?	Action(s) will deliver the greatest return?	Is best/worst to do an action?	Should we spend?
Locations should we act in?		Should we monitor?	Effort should we focus on this location?
Are we most uncertain about?			Data do we need?
Are the competing values?			Is enough?
Are the key indictors?			

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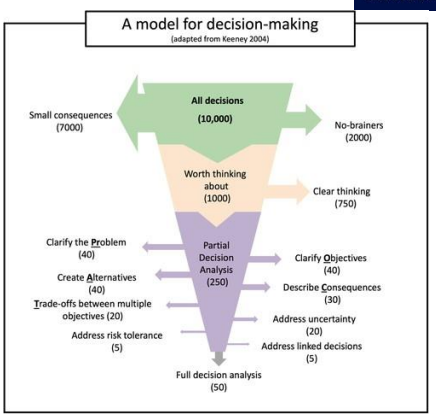
Making decisions in conservation

Has a range of challenges:

- Unclear decision problem(s)
- Diverse stakeholders
- Potential competing values
- Competing or intangible objectives
- Scare resources
- Uncertainty and risk
- Biases



Adapted from Hemming et al. 2022 *Conservation Biology*

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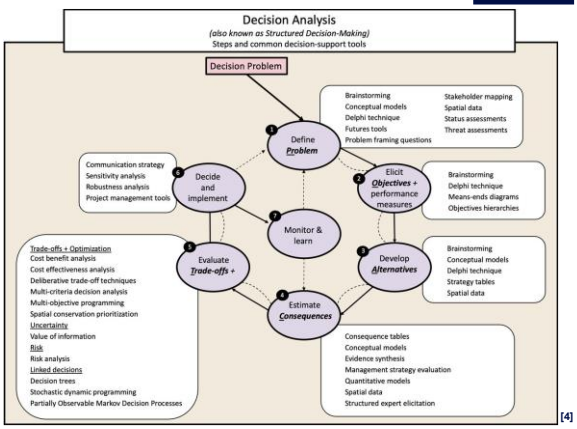
What is a decision-support tool?

Decision-support tools provide information and insight to a particular component of a decision, e.g.

- Comparing between options
- Identifying the optimal action
- Multi-value trade offs

Often embedded in broader frameworks

- Adaptive management
- Systematic conservation planning



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Adapted from Hemming et al. 2022 *Conservation Biology*

Building conservation decision-support tools

Problem Formulation	Modelling	Evaluation
Frame the Problem	Model of system dynamics	Monitor
Clear Objectives	Identify uncertainties	Update models
Management Actions	Decide and Act	Track progress

Adapted from Addison et al. 2013 *Diversity & Distributions*; Wintle et al. 2011 *Nature Climate Change*

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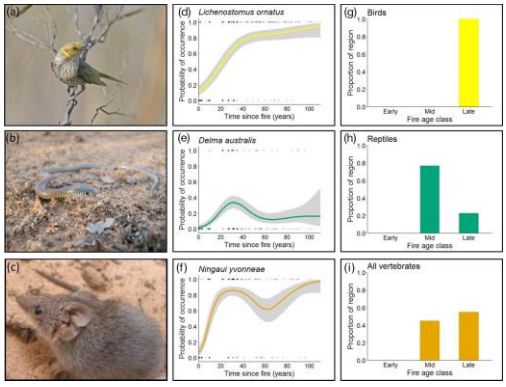
Example 1: Fire management for biodiversity conservation

Policy Goal	Manage fire in a way that balances the needs of many species
Objective	Maximise the geometric mean of abundance of species across landscape
Decision context	Species with competing needs Limited actions: burn/don't burn & suppress/don't suppress



Kelly et al. 2014 *Conservation Biology*

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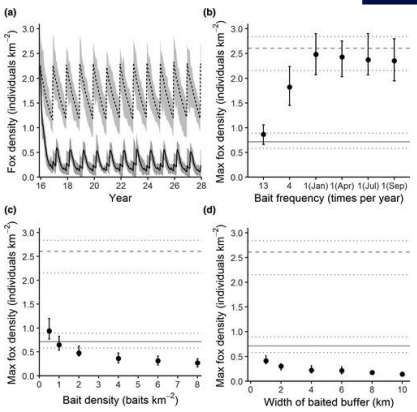
Example 2: Fox baiting scenario analysis

Policy Goal	Reduce the impact of red foxes on vulnerable species
Objective	Identify the fox baiting strategy that reduces red fox density the most
Decision context	Spatially and temporally explicit Customise the density and frequency of baiting events



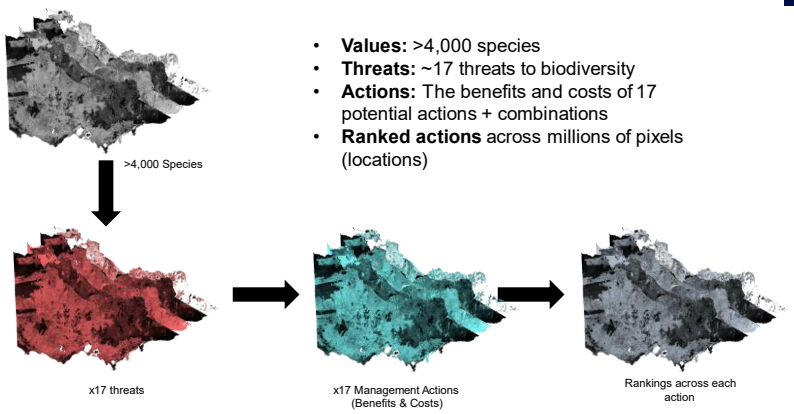
Hradsky et al. 2019 *Journal of Applied Ecology*

Example 3: Victoria's spatial conservation action planning tool

Policy Goal	Invest in a cost-effective set of actions that benefit the most species, accounting for the influence of climate change
Objective	Maximise the probability of persistence for all Victorian species over the next 50 years
Decision context	Thousands of species Many different ecosystems Diverse and changing threats Diverse stakeholder interests

Thomson et al. 2020 *Biological Conservation*

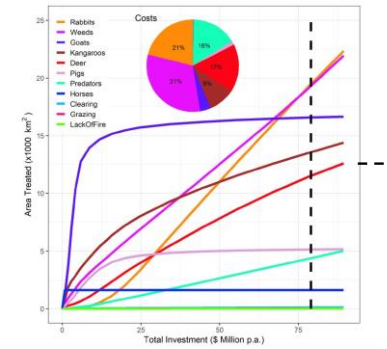
Example 3: Victoria's spatial conservation action planning tool

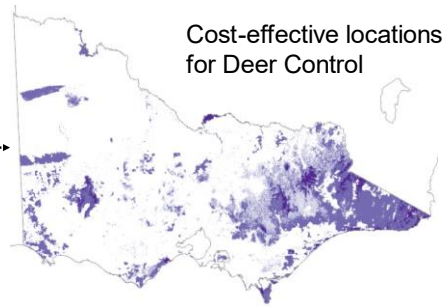


- **Values:** >4,000 species
- **Threats:** ~17 threats to biodiversity
- **Actions:** The benefits and costs of 17 potential actions + combinations
- **Ranked actions** across millions of pixels (locations)

Thomson et al. 2020 *Biological Conservation*

Example 3: Victoria's spatial conservation action planning tool





Cost-effective locations for Deer Control

Thomson et al. 2020 *Biological Conservation*

Key considerations

1. Have **clear links** between policy, tools, decisions and reporting
2. **Multiple entry points** to outputs for end users
3. Applicable to a **range of decision problems**of different scopes
4. Responsive to a **range of new information sources**
5. Appropriate **acknowledgement of uncertainty**
6. Responsive to **'events'** (e.g. large fires)
7. Built with **sustainability of effort** in mind
8. Engagement and support for users needs to be **genuine, two-way and ongoing**

Examples of existing tools

- Bushfire risk management framework (Tony Smith) – Appendix 1
- Fire regime optimization planning system (Brett Beecham) – Appendix 2
- Western Shield decision support tools (Ash Millar) – Appendix 3
- Regional Nature Conservation Planning (Kim Onton) – Appendix 4
- South Coast threatened species prioritization pilot project (Sarah Comer) – Appendix 5

Brainstorming of needs/opportunities for new/improved decision support tools

Ideas raised prior and during the workshop organized under the themes of fire management, invasive predators and concurrent / combined activities. Dot points listed in **bold** were developed further by breakout groups.

Fire Management

- Ecology-informed tools for optimal burning regimes
- What are the ecological opportunities for fire to support biodiversity conservation?
- How to integrate patch and landscape level planning and management to deliver multiple fire management objectives?
- Climate change: what are the longer-term considerations and what needs to be factored in fire management now?
- How to identify the best season(s) to burn given past fire regime and competing values/requirements?
- Weed and fire interactions – where is this important? How do we manage it?
- Fine grain fire mosaics – assessing the risks and benefits and optimizing the fire regime to achieve objectives
- Cultural burning – where, when, risks/benefits to ecosystems and biodiversity values and other community values.
- Species responses to fire - how best to manage fire regimes to promote/protect priority species (e.g. when and where to exclude fire)
- **Managing fire for both biodiversity and fire hazard reduction (fuel loads)**
- **Integration of wildfire dynamically into prescribed burning planning**
- **Managing fire in a changing climate**

Invasive predators

- Optimal baiting regimes given habitat and landscape context, and biodiversity values
- Baiting integration with disturbance (e.g., fire, dieback, recreation)
- Operational flexibility/responsiveness in the baiting program to optimize effectiveness of introduced predator control
- Beyond baiting – what/how to integrate other controls and approaches to optimize threat mitigation from introduced predators
- How to determine whether observed changes in predators or threatened species are a concern / need a response?
- How to respond to observed changes in introduced predators or threatened prey species/communities that require action
- **Predator - Disturbance interactions**

Concurrent / combined activities

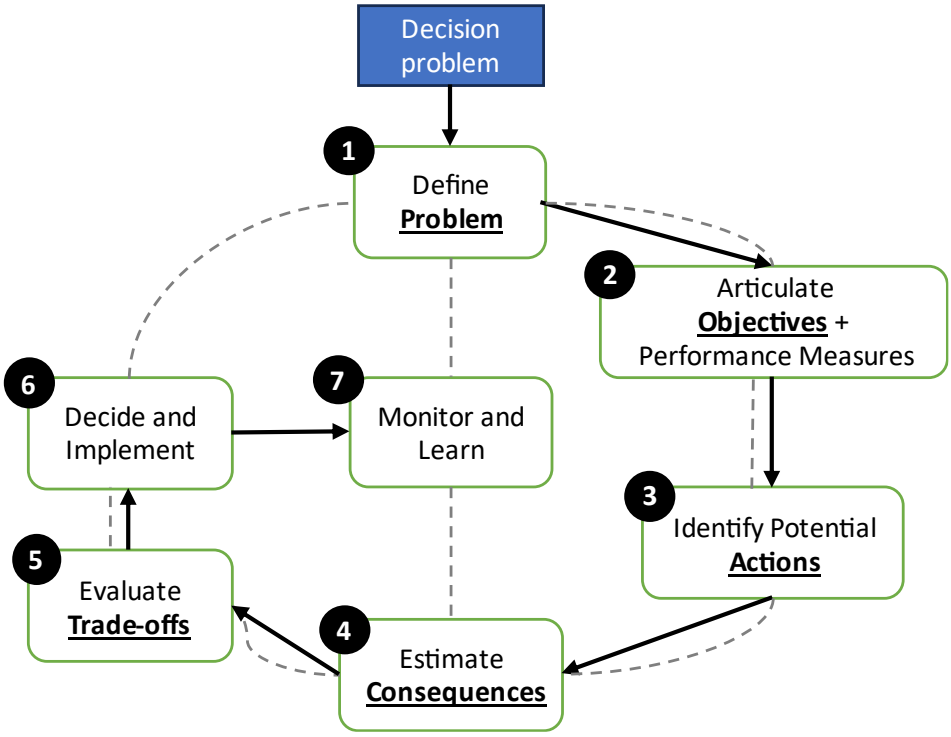
- Co-ordination / integration of different management activities to deliver improved biodiversity conservation outcomes.
- How to efficiently allocate resources across a portfolio of threatened species and threats - Prioritisation of species and actions
- Habitat loss and fragmentation - impacts / targets for restoration
- Carbon farming - identification of best sites
- Development offsets - identify the best options for biodiversity conservation outcomes
- Improved knowledge of the presence/absence of species
- **Landscape Fauna reconstruction - understanding/managing complexity from multiple species and threats, restoring ecosystem function, in the context of climate change**
- **Priority actions in the Nature Repair Market (Threatened species resource allocation)**

Other points raised that are not necessarily decision support tools but are still important to good decision making.

- Improved knowledge of the presence/absence of species
- Improved data organisation - accessibility, user friendly, opportunities for leveraging.
- Improved measurement of outcomes - important aspect of adaptive management

Development of selected themes by breakout groups

Small breakout groups focused on defining the problem and objectives for six selected themes, following the decision analysis approach of Hemming et al. (2022) and handout (Appendix 6).



Decision analysis (commonly referred to as structured decision-making) framework adapted from Garrard et al. (2017) and Hemming et al. (2022).

Predator-disturbance interactions

Problem:

How do we effectively manage the threat of foxes and feral cats in response to disturbance?

Does disturbance help or hinder?

[What is the] optimal time to target predators? – where? Intensity?

Management of Predators

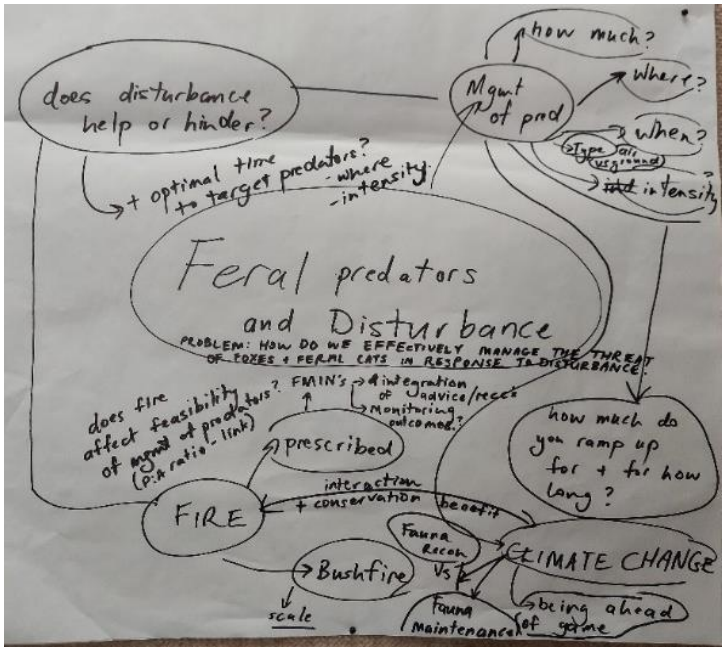
- how much?
- where?
- When?
- Type? – e.g. aerial versus ground deployment
- Intensity?
- How much do you ramp up and for how long?

Fire

- Does fire affect [the] feasibility of management of predators? (perimeter: area ratio – link)
- Prescribed fire
  -FMINs (Fire management information notes) – integration of advice / recommendations
  -monitoring outcomes
- Bushfire – scale

Climate Change

- Interactions with fire and conservation benefit
- Fauna reconstruction versus Fauna maintenance
- Climate change – being ahead of the game
- Climate change influence on management of predators



Managing fire for both biodiversity and fuel

Problem:

How to achieve both objectives (biodiversity conservation and fuel hazard reduction) in the landscape [at the landscape scale]

Look for synergies

How do we plan fire in the landscape to support meeting objectives for

- Conservation
- Silviculture
- Recreation
- Life/Property

How do we develop an integrated burn program to achieve reduced bushfire risk and conservation, silviculture and other values, at the landscape scale (district/region), over the long term, [and considering the] constraints

Integrate with external objectives

Why does it matter? – consistency, perception, efficiency, transparency, confidence, effectiveness

What is stopping us?

- Information / data
- Lack of system
- Lack of clear objectives for conservation

Constraints

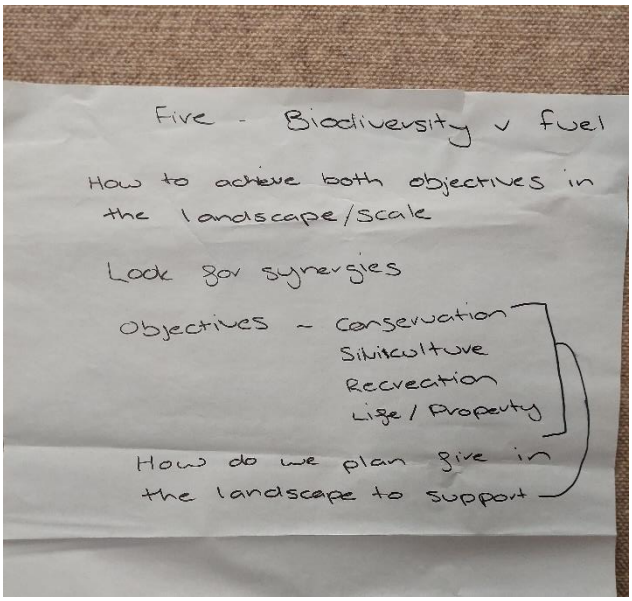
- Resourcing
- Skills / knowledge
- Vision
- Stakeholders / competing interests
- Change management

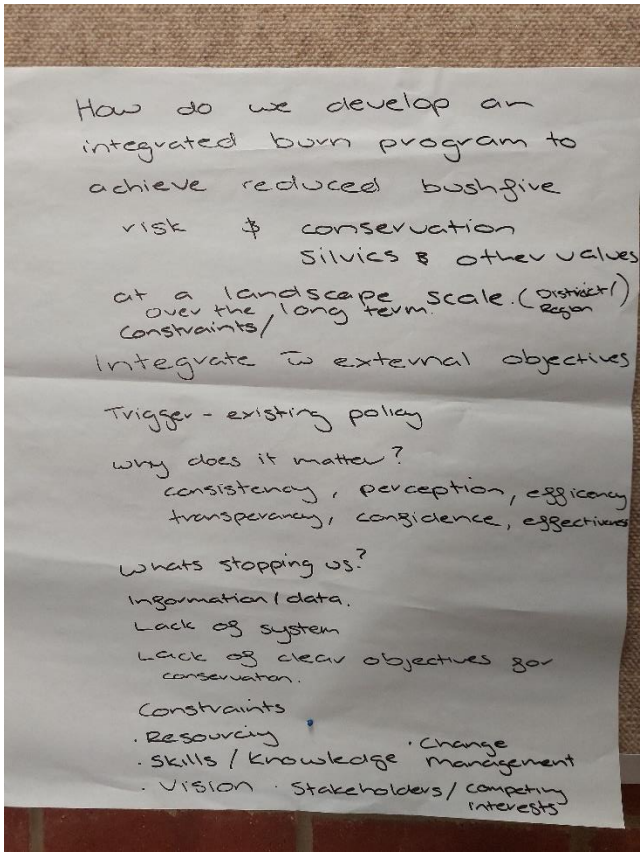
Who

- Conservation leaders
- Fire
- Science (specialist)
- Managers / Executive
- Practitioners

Linked decisions

Other programs – recovery, silviculture, Western Shield, Joint Management





Integration of wildfire dynamically into prescribed burning planning

Problem:

Large severe wildfire can create problems for species and ecosystem responses and [create] homogenous fuel age.

Need to tailor prescribed burn techniques where large severe wildfires occur. How to manage adjacent areas? How to manage within the wildfire scar?

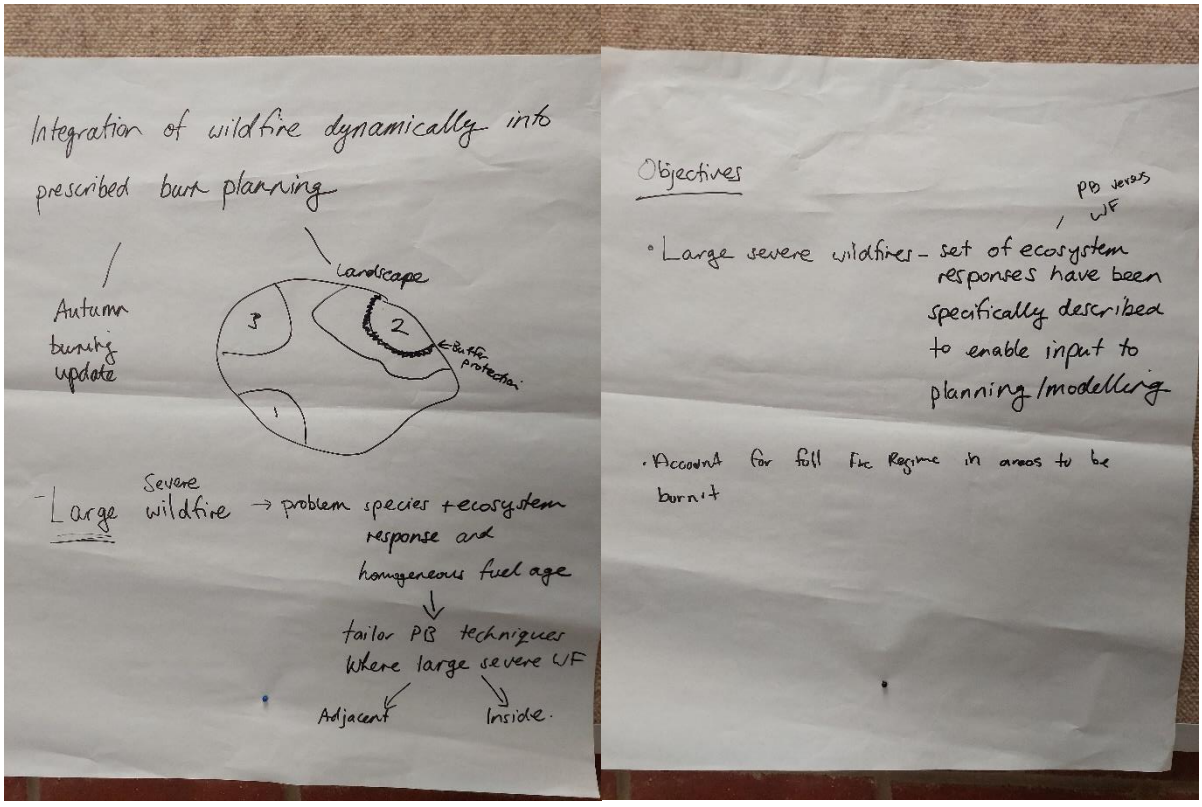
Autumn burning update – [need to integrate summer wildfires into a revision of the planned autumn burn options program in a timely way]

Landscape [context is important]

Objectives:

Large severe wildfires – [a] set of ecosystem responses have been specifically described (for prescribed burning versus wildfires) to enable input into planning / modelling.

Account for full fire regime in areas to be burnt



Managing fire in a changing climate

Problem:

Uncertainty

- Climate change [effects on]
  -fire
  -PC [Phytophthora cinnamomi]
  - species responses
- Moisture changing in [the] landscape
- Spatial scale at which different climate impacts [may be] occurring
- Return interval of fire changing
- Vegetation recovery intervals changing with changes in moisture (a combination od dryness and moisture changes)

Flow on effects across [the] community

Identifying Refuges – [importance, what, where, how to manage, etc]

Increased stochasticity – e.g. floods, insect plagues

How should we burn in a changing climate?

When is the most appropriate time to reintroduce fire into the landscape?

How are species recovering / returning post fire? [What are the] successional periods?

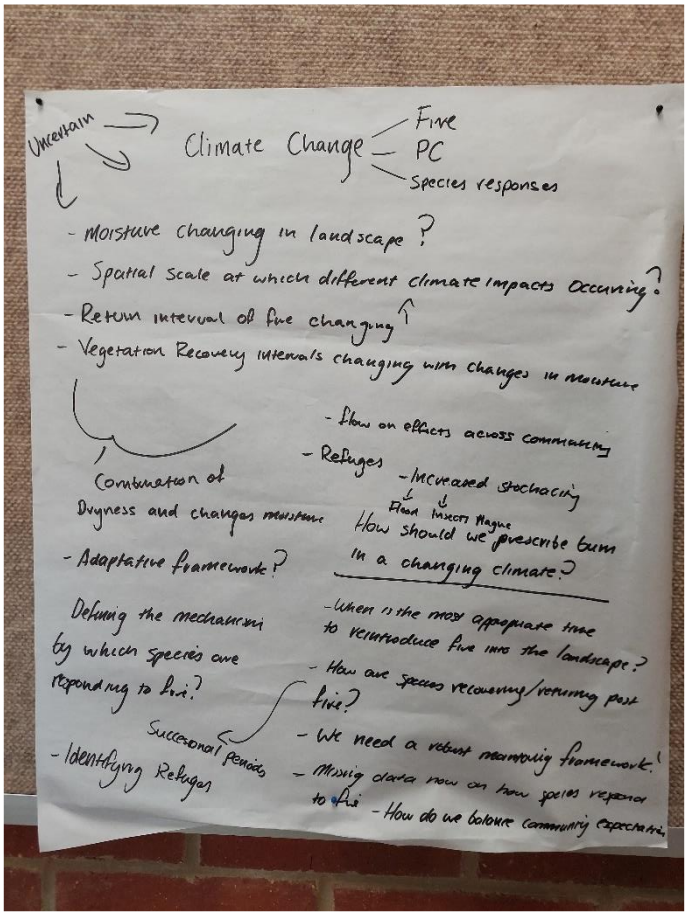
We need a robust monitoring framework

Missing data now on how species respond to fire

How do we balance community expectations?

[Is there a need for an] Adaptive framework?

Defining the mechanism by which species are responding to fire?



Priority actions in the Nature Repair Market (Threatened species resource allocation)

Problem:

How do we contribute priority actions for threatened species to the Nature Repair Market?

Statewide, ongoing

Listed species & communities

No clear threatened species targets/thresholds

Department's risk appetite e.g., translocations (assisted migration)

Ongoing legacy to the Department

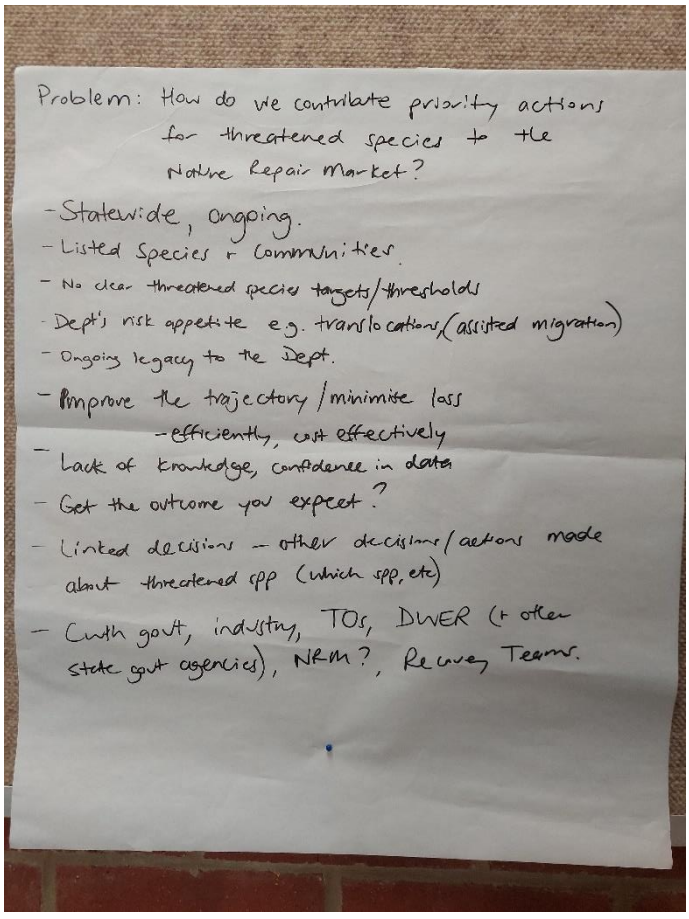
Improve the trajectory / minimise loss – efficiently, cost effectively.

Lack of knowledge, confidence in data

Get the outcome you expect?

Linked decisions – other decisions / actions made about threatened species (which species, etc)

Who needs to be involved – Commonwealth Government, industry, Traditional Owners, DWER (& other state Gov agencies), NRM?, Recovery teams



Landscape fauna reconstruction and climate change refuges

Problem:

Understanding

- Historical distribution of taxa
- Ecological role in ecosystem
- Which species, where

Objectives:

- Restoring ecosystem function
- Securing species in the face of climate change

How:

Dirk Hartog Model:

1. Interaction matrix (positive / negative interactions)
2. Population dynamics => timing (order & timing)
3. Ensemble modelling – quantify modelling

Selecting suitable sites (ID and threat abatement)

Many managed ecosystems have lost a significant proportion of species

Who needs to be involved – everyone!

<u>Scale</u>
- where

- consider values

- long term population success

Department's urgency of action

<u>Trigger</u>

- conservation status

- area management / investment

<u>Constraints</u>

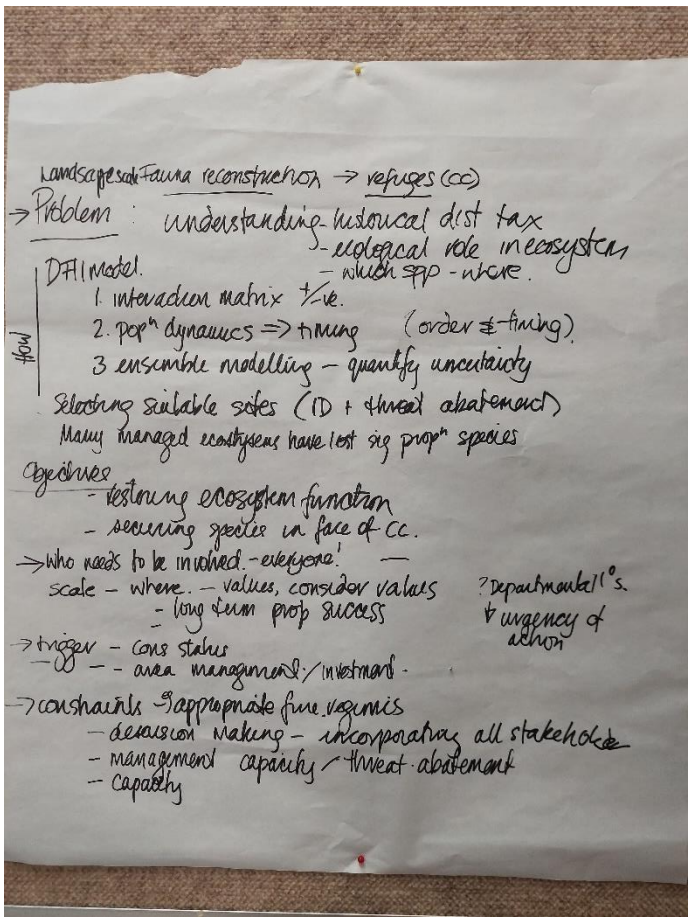
- inappropriate fire regimes

- decision making

- incorporating all stakeholders

-management capacity

- threat abatement capacity

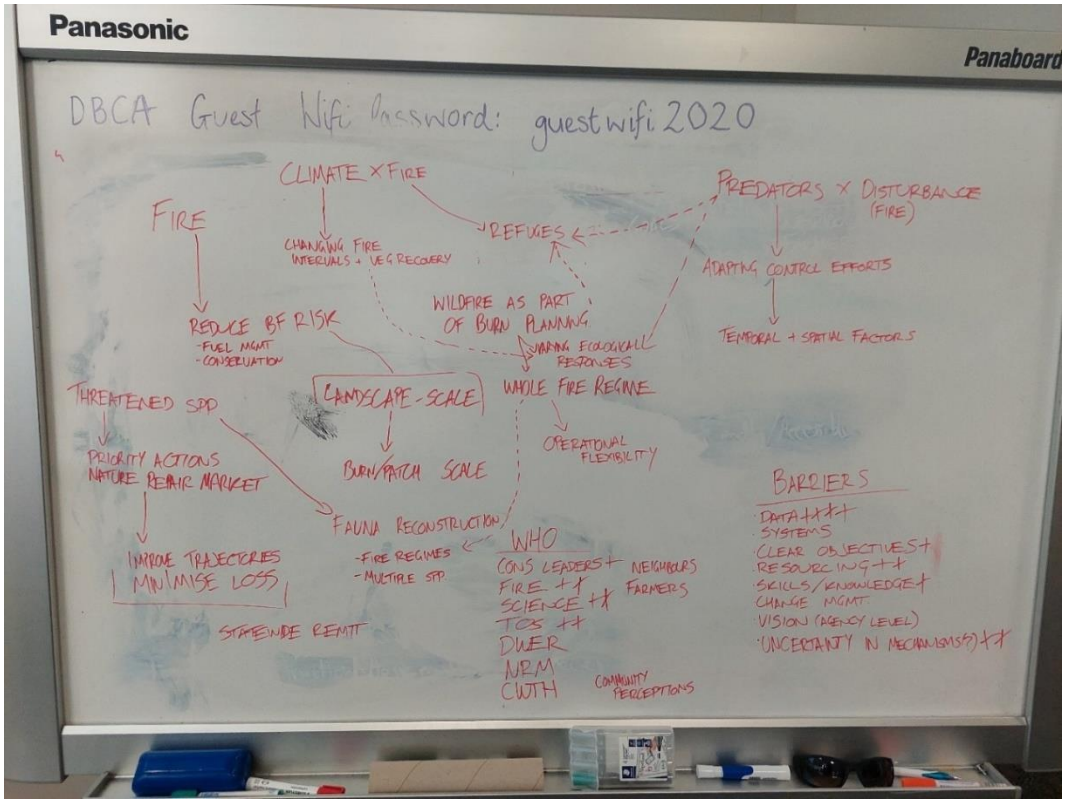


Synthesis of themes developed by breakout groups

- Some common themes that emerged across breakout groups included the balancing of multiple objectives, interactions between threats (e.g., climate–fire, predators–fire), the role of refuges in biodiversity conservation, operational flexibility in predator management and prescribed burning, and consideration of community perceptions/expectations.

- Key barriers identified included data availability, resourcing, having clear objectives, access to appropriate skills and knowledge, uncertainty regarding mechanisms, and lack of an agency level vision.

- Key stakeholders identified to be involved in the decision process included conservation leaders, fire, science, Traditional Owners, DWER, NRM groups, the Commonwealth Government, neighbours and farmers.



Future directions and wrap-up

Discussion points

- Revision of workshop purpose - explore needs & possibilities for tools to support decisions
- Overview of decision support tools
- Objectives
  – identify & understand key challenges (opportunities), outline objectives
  – catalyst to progress the development of decision support tools
- Output - collation & circulation of notes from the workshop
- Where next? [what, who, how, when]
- Opportunities for collaboration (internal and external)?

Appendices

Appendix 1: Bushfire risk management framework (Tony Smith)

Bushfire Risk Management Framework

Department of Biodiversity, Conservation and Attractions

PARKS AND WILDLIFE SERVICE

We are talking about this bit

Phases of burn planning

Strategic Planning	Program Planning	Operational Planning	Burning Implementation
Bushfire Risk Management Framework Regional Fuel Management Plan	3 Year Burn Program Annual Burn Program	Prescribed Fire Plan	Prescribed Burning Operations
Establish rationale for fuel management Define indicators of acceptable bushfire risk Apply indicators to determine regional fuel management targets	Develop a program of prescribed burning to achieve targets established in RFMP and other land management objectives	Define objectives for each prescribed burn Identify, assess and analyse risks associated with a burn and plan treatments for them Plan and document how the burn will be conducted	Implement risk treatments Apply prescribed fire to achieve burn objectives Maintain burn security
Decades 5 years	3 years 1 year	Months Weeks	Days Hours Minutes
State Region	Region District	Planned area	Treatment area

Context

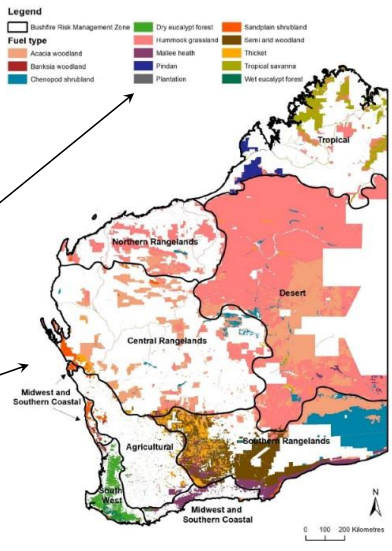
Category	Area (hectares)
DBCA-managed land (includes Legislated and Dept. Interest) 102 national parks, 11 regional parks; State forest, reserves and other land	**26,898,677**
MoU land (includes unallocated Crown land and unmanaged Crown reserves, but excludes Dept. Interest land)	**91,350,723**
Total	**118,249,400**

Large estate

Variety of fuel types (13 fire behaviour models)

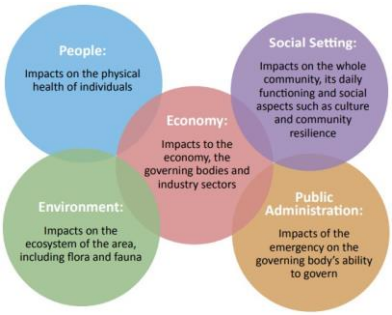
Diversity of climate, landscape and land use

8 Bushfire Risk Management Zones



Risk assessment

State Core Objectives for Emergency Management



Asset classification & prioritisation

Asset class	Priority
Settlements	1
Dispersed population	2
Critical Infrastructure	2
Susceptible habitat	2
Economic assets	3
Other assets	3

BRMF – Statewide Targets

Acceptable risk = *x* % of fuel less than *y* years.

y = unmanageable fire under 95th % FDI.

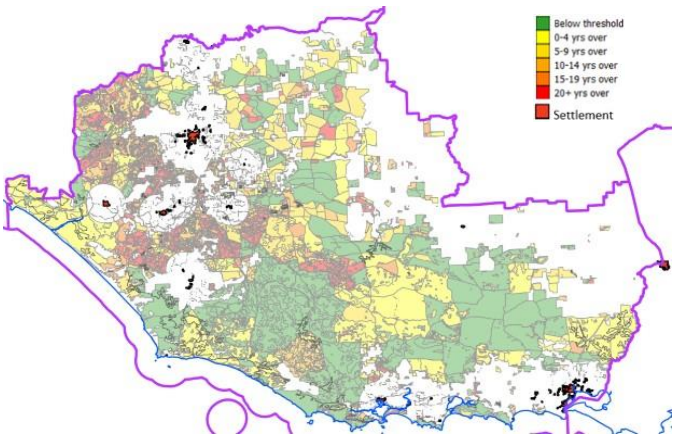
Fire Management Areas

Fire Management Area	Purpose	Location	Extent
Settlement-Hazard Separation (SHS)	To protect human life by reducing potential exposure to direct flame contact, radiant heat or ember attack.	Surrounding fire vulnerable towns, settlements, subdivisions and camping areas.	5 km: Dry eucalypt forest, Wet eucalypt forest 1 km: Pindan, sandplain shrubland, thicket, Banksia woodla 500 m: Tropical savanna, hummock grassland, mallee, P. pinaster plantation N/A: Acacia woodland, semi-arid woodland, chenopod shrubland
Critical Infrastructure Buffer (CIB)	To protect critical infrastructure by reducing potential exposure to direct flame contact, radiant heat or ember attack.	Surrounding fire vulnerable critical infrastructure.	100 m: Pindan, sandplain shrubland, thicket, heath, Banksia woodland, P. pinaster pine plantation 50 m: Tropical savanna, hummock grassland, grassland N/A: Dry eucalypt forest, wet eucalypt forest, Acacia woodland, semi-arid woodland, chenopod shrubland
Landscape Risk Reduction (LRR)	To prevent the occurrence of large, intense bushfires that may threaten neighbouring lands, infrastructure or the natural environment within the LRR.	Surrounding property, individual livelihood community sustainability, and environmental assets	Remainder of South West BRMZ: Wet eucalypt forest, dry eucalypt forest 5 km: Banksia woodland, P. pinaster plantation 1 km: Sandplain shrubland, thicket N/A: Tropical savanna, pindan, Acacia woodland, hummock grassland, mallee, heath, semi-arid woodland, chenopod shrubland
Remote Area Management (RAM)	To provide ecologically and culturally appropriate fuel management where required and practicable.	Where there is a low density of fire vulnerable assets.	All other Parks and Wildlife Service managed lands

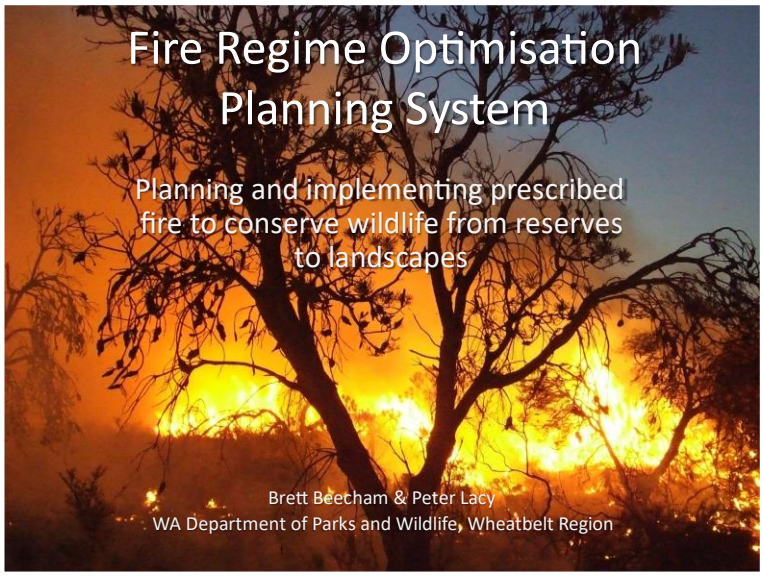
Targets

Fire Management Area	Fuel type	Location	Target
Settlement Hazard Separation	Dry eucalypt forest Wet eucalypt forest	5 km surrounding settlements	60% of fuel less than threshold intensity
	Pindan, Sandplain shrubland, Thicket, Banksia woodland	1 km surrounding settlements	
	Tropical savanna, Hummock grassland Mallee heath, P. Pinaster plantation	500 m surrounding settlements	
	Acacia woodland, Semi-arid woodland Chenopod shrubland	N/A	No targets apply
Landscape Risk Reduction	Dry eucalypt forest Wet eucalypt forest	Remainder of South West BRMZ	45% of fuel less than threshold intensity
	Banksia woodland, Sandplain shrubland, Thicket, Tropical savanna, Pindan, *Pinaster* plantation, *Acacia* woodland, Hummock grassland, Mallee heath	Outside of the South West BRMZ - as defined in the applicable Regional Fuel Management Plan	As defined in the applicable Regional Fuel Management Plan
	Semi-arid woodland, Chenopod shrubland	N/A	No targets apply. Managed as required to meet land management objectives

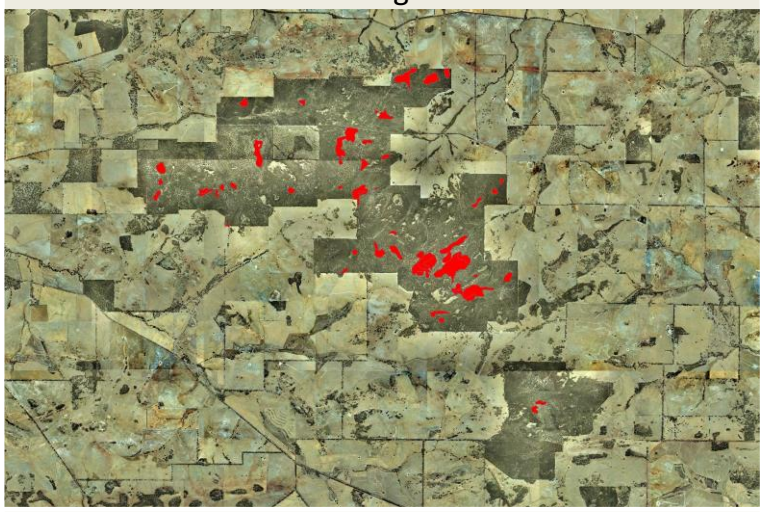
Warren Region fuel age in relation to Landscape Risk Reduction (LRR) target



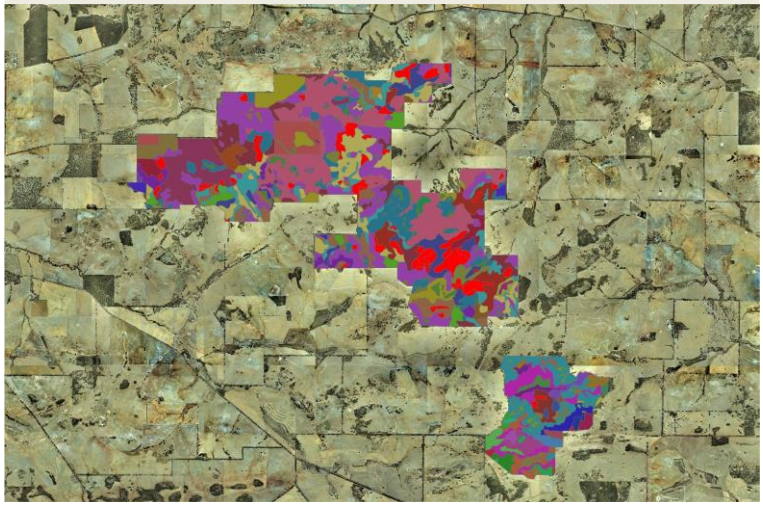
Appendix 2: Fire regime optimization planning system (Brett Beecham)



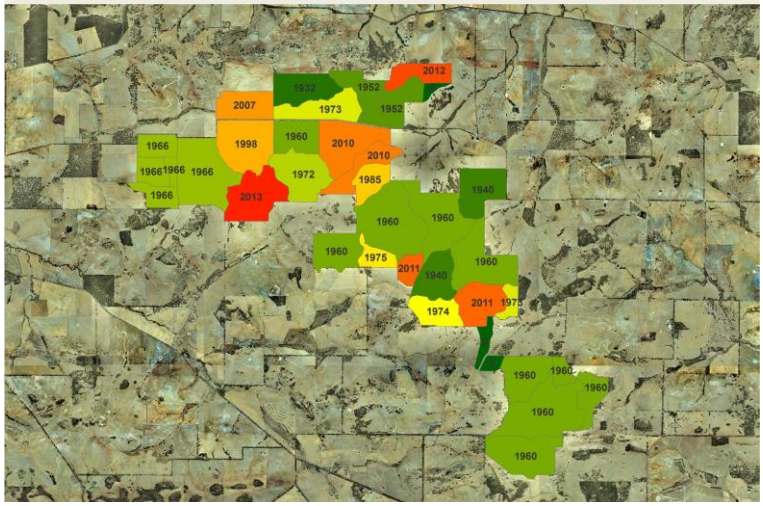
Kwongan



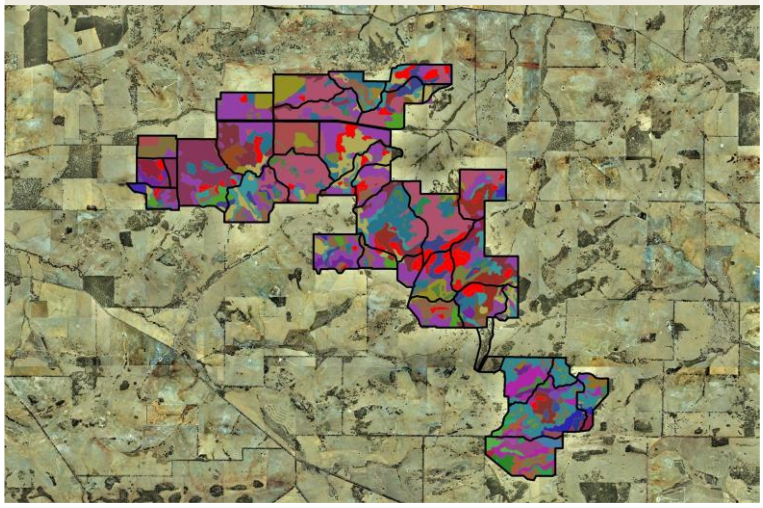
Vegetation communities



Fire History circa 2014



Complex mosaic



It's ecologically complex!

- Kwongan patches are embedded in a mosaic of other vegetation communities
- Each vegetation community contains flora and fauna species with different fire tolerances and needs:
  - Interval, frequency
  - Season
  - Intensity
  - Extent and spatial patterning

Multiple Management Objectives

- Use fire to maintain floristic diversity and structural integrity of kwongan
- Use fire, where appropriate, to maintain the diversity of other vegetation communities
- Use fire to maintain key habitat elements for fauna, particularly threatened species
- Use fire to reduce fuel loads and protect life, property and key infrastructure

Assumptions

To achieve our biodiversity conservation objectives we assumed:

- Maintaining each vegetation community in a range of time-since-fire age-classes maximises species richness of flora and fauna
- We defined this using an inverse or negative exponential time-since-fire (age class) distribution
- Other fire age or stage distribution models could be used/substituted as information improves or objectives change

Our objectives could also be defined by other components of the fire regime, such as fire interval or spatial configuration

The Solution

We needed a decision support system that simultaneously considered:

- The desired distribution of age-classes
- Biological requirements of flora and/or fauna
- Operational constraints
- Management objectives,

And informed us where and when to prescribe fire to best meet our objective(s)

The Decision Support System

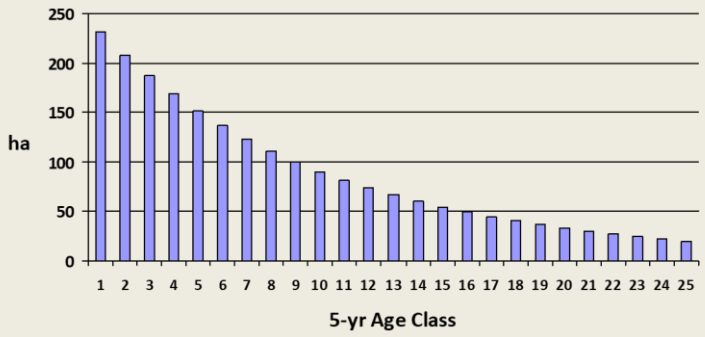
1. Generate the ideal time-since-fire age class distribution for each different vegetation community using the negative exponential model
2. Generate the actual time-since-fire ages class distribution for each different vegetation community
3. Compare the ideal and actual distributions for each community across the reserve or landscape
4. Solve to minimise the difference between the ideal and actual distributions for all communities through prescribed fire or fire exclusion over time

The Ideal Age-Class Distribution

For each vegetation community:

- Use a negative exponential (Weibull) model
- Specify input parameters:
  - Total area of each vegetation type (from imported GIS data)
  - Minimum and maximum tolerable fire intervals (years) based on ecological parameters eg. species vital attributes, structural elements
  - Time interval (planning period)
- DSS calculates:
  - Fire cycle – time taken to burn an area equivalent to the total area
    - Approximates the mean of the minimum and maximum fire intervals
  - Area of vegetation in first and final planning periods (time since fire)
  - Exponential regression curve to 'fit' these two data points
  - Area under the curve should equal the total area of the vegetation type

Ideal Time-Since-Fire Age Class Distribution

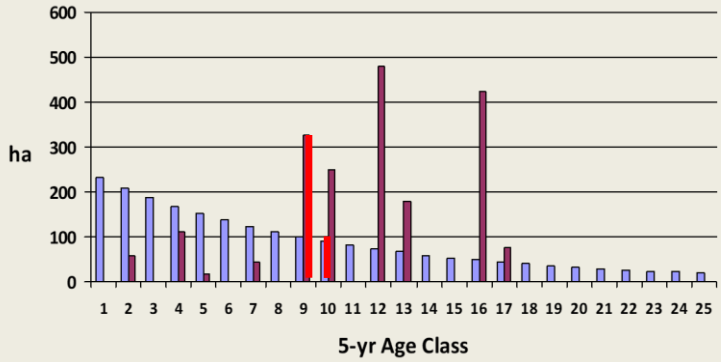


Comparing Ideal vs Actual

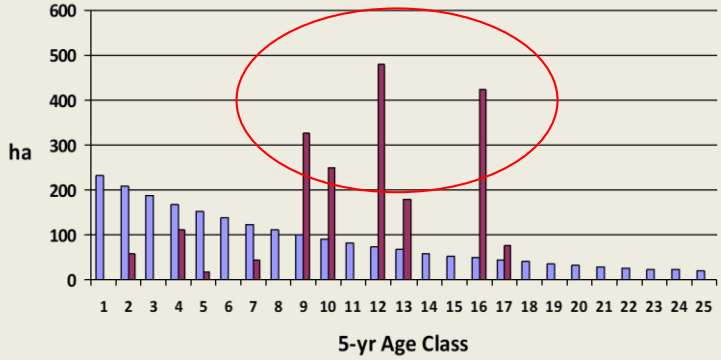
For each vegetation type:

- For each age class:
  - Finds the actual area (ha) for the planning period (p)
  - Finds the ideal area (ha) for the next planning period (p+1)
  - Compares the difference between the two areas (over or under represented)
  - Calculates a score based on the proportion over or under-represented relative to the total area of that vegetation community
- Adds these scores to produce a combined score of over and under represented areas

Comparing actual with ideal



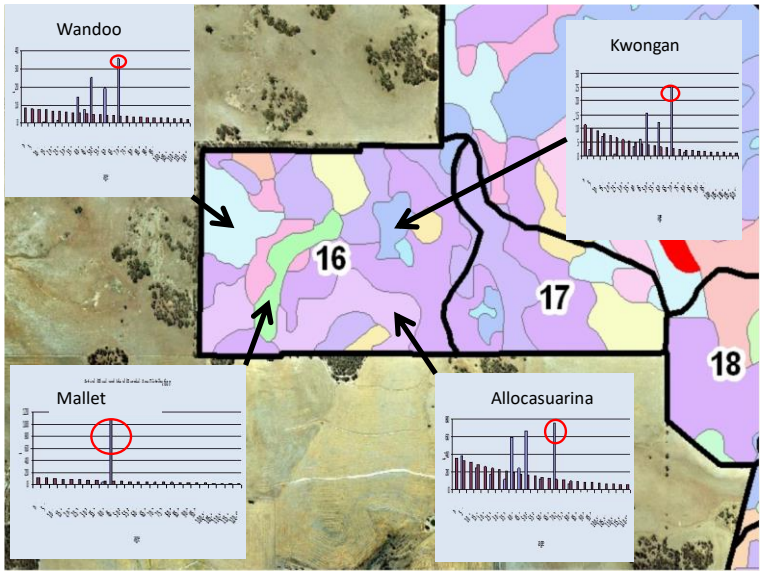
Over-Represented Age Classes



Under-Represented Age Classes

Scoring, ranking and solving

- Each management cell is 'virtually' burnt within the program
- A new 'actual' fire age class distribution is re-calculated for all the affected vegetation communities
- The ideal and new actual are compared, and a new score calculated
- This process is repeated for each management cell across the reserve
- Management cells are then ranked and selected according to which one(s) reduce the total area of over-represented age-classes across all communities by the greatest amount
- These are then 'locked' in and the program advances to the next planning period and repeats the process until the specified number of planning periods is reached.



DSS Inputs

- 'Lock' cells in or out (burn or don't burn)
  - Strategic protection , threatened species
- Set min and max burn intervals for:
  - Vegetation types based on biological attributes of sensitive species (default) plus a % tolerance over the max. interval
  - Individual management cells
- Set adjacency rule
  - At least one adjacent cell remains unburnt in the next planning period
- Set number of planning periods

Burn Schedule Output

Management Block	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18	19	20	21	22	29	30	31	32	33	34	35
Years																												
0								Burn								Burn			Burn							Burn		
5													Burn					Burn				Burn						
10														Burn	Burn									Burn				
15	Burn		Burn								Burn																	
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65			Burn										Burn				Burn									Burn		
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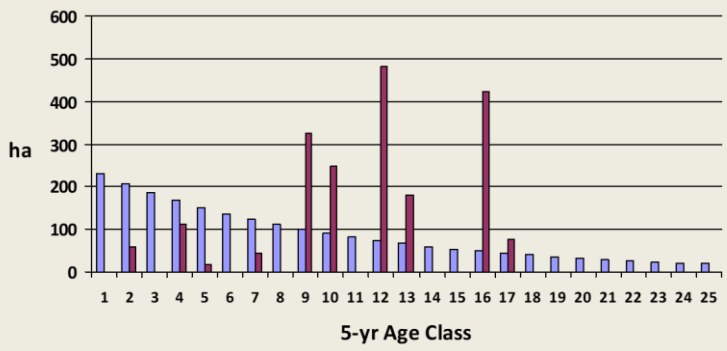
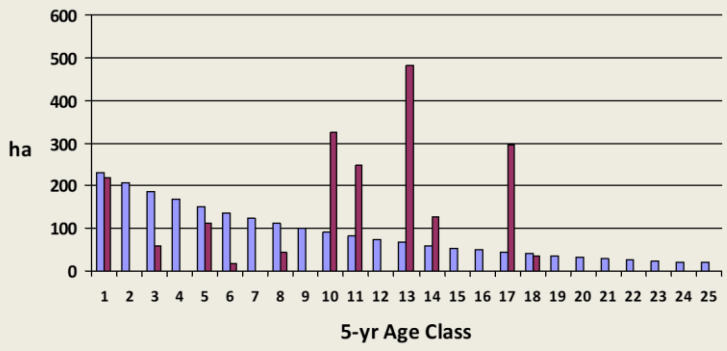
90									Burn							Burn					Burn					Burn		
95		Burn																			Burn		Burn		Burn			

Current

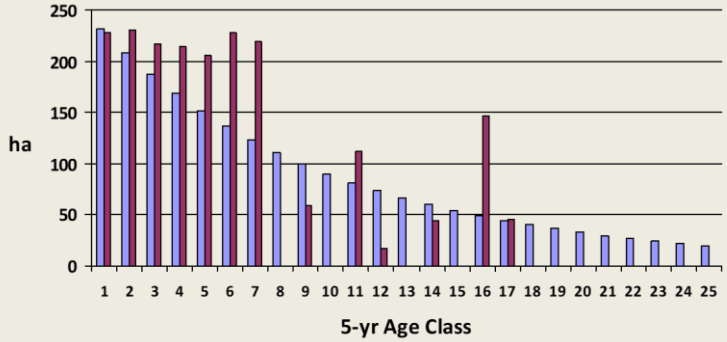


+ 5 Years

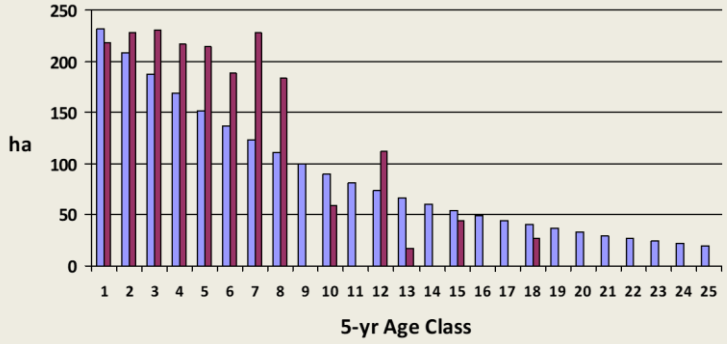


+ 10 Years

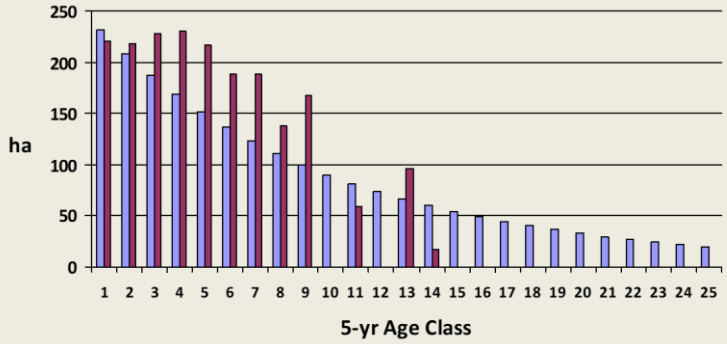
+ 35 Years



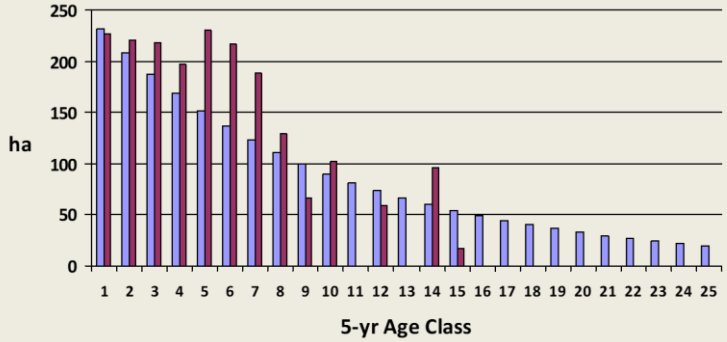
+ 40 Years



+ 45 Years



+50 Years



Appendix 3: Western Shield decision support tools (Ash Millar)

Adaptative management decision support tool

A comparison of toxic baits for feral cat and fox control in southwest Western Australia: An Adaptive Management experiment testing the effectiveness of cat management in complex management areas.

Daniel C. Gwinn [1], Michelle Drew [2]

[1] Biometrics Research, Fremantle, WA.
[2] Ecosystem Health Branch, Department Biodiversity, Conservation and Attractions, Kensington, WA.

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western shield

Western Shield prioritisation

- Prioritisation is critical.
- Bain 2013 Review – prioritisation tool / process. INFFER-based.
- Species selection criteria.
- Land area selection criteria.
- Priority drivers (in summary):
    1. The species at a site and their conservation status
    2. Importance of populations at a site
    3. Feasibility of being able to manage introduced predators at a site
- Led to removal of sites which received low benefit / feasibility ranking.

Department of Biodiversity, Conservation and Attractions western shield

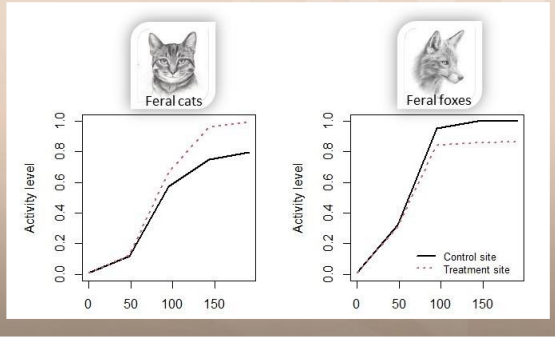
Background

- Feral cats and European red fox — damaging invasive species
- Extinction of 30 Australian mammals and threatened the existence of a further 125 mammal species
- WS — foxes since 1996 and, feral cats using Eradicat® since 2013
- Effectiveness of different baiting regimes in different environments has not been fully assessed.
- Challenge - determining the baiting frequency and intensity to maximise native species survival in different environments

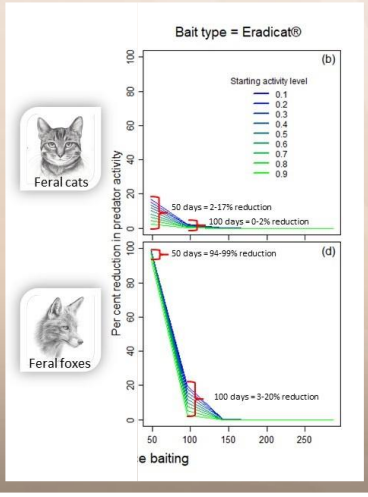
Department of Biodiversity, Conservation and Attractions western shield

Model

- Adaptive management experiment
- Developed novel spatio-temporal dynamic occupancy model
- Determine the potential influence of baiting on changes on predator activity AND
- Create an adaptive management decision support tool capable of predicting the outcomes of alternative baiting regimes.



Modelled bait impacts



- Cat activity reduced by < 20% (50 days after baiting)
- 100 days post baiting this impact was negligible
- Foxes 94 – 99% reduction, 50 days post baiting
- 100 days later this effect was reduced to 20%
- The impact was dependent upon the starting activity levels
- At sites with high starting activity (ca. 0.9) — the reduction in activity was predicted to be less
- Modelling clearly identified the need to have regular ongoing management in these environments

Appendix 4: Regional Nature Conservation Planning (Kim Onton)

Structured decision-support processes were applied to identify and prioritise conservation actions for DBCA's nine regions between 2021-2023. The plans are intended to guide regional conservation works programming to maximise conservation benefits within available resources. These processes identified and prioritised conservation actions for:

1) Landscape-scale threat abatement in priority reserves and landscapes ('Landscape actions'),
2) Addressing specific threats to threatened and Priority species and ecological communities ('Targeted actions'), and
3) Addressing information requirements to support the management of threatened and Priority species and ecological communities ('Learn actions').

Landscape actions

The regional conservation planning objective in relation to management of priority conservation reserves and landscapes was to minimise the impact of threatening processes on priority reserves and landscapes, or the conservation elements they support, at a landscape-scale to maximise biodiversity benefit and cost-effectiveness. Each region implemented the Landscape action process independently, using local expertise and existing conservation planning and other resources (where available) and tailored elements of the process as appropriate to reflect the region's landscapes and operational context.

Existing, improved and new actions to mitigate the impacts of key threatening processes were identified and developed. The scale of action implementation varied from an entire priority reserve or landscape to a portion addressing specific threats to one or more conservation elements.

To prioritise Landscape actions, a benefit-cost analysis was applied using threat impact as the metric. Regions applied the IUCN Threat Impact Scoring System (IUCN 2012) to determine the threat impact of threatening processes defined for each priority reserve or landscape or conservation element, based on the timing, scope and severity of the threat. The benefit of threat mitigation was estimated as the difference between the impact of the threat with and without mitigation action over 10 years. The benefit was also weighted by the feasibility of implementing the mitigation action. Costs of action implementation were estimated within broad cost categories, and each category was then given a score for the benefit-cost calculations.

The benefit-cost score (unweighted) was derived from the expected benefit score divided by the cost score. These scores were then adjusted using weightings to reflect the influence of other variables on the final benefit-cost score.

Reference:

- IUCN 2012. *IUCN Red List Categories and Criteria: Version 3.1*. *Second edition*. Gland, Switzerland and Cambridge, UK 32pp. Available at https://portals.iucn.org/library/sites/library/files/documents/RL-2001-001-2nd.pdf

Targeted actions

Targeted actions apply to populations or occurrences of threatened and Priority species and ecological communities where management intervention is required to address declines, maintain viable populations and occurrences, and mitigate threatening processes. The process for identifying and prioritising Targeted actions focused on developing management actions at the scale of populations and occurrences (rather than at the species or ecological community level) that are at risk of extinction or collapse from a known and identifiable threat, or where management programs

and conservation actions applied at the conservation reserve or landscape-scale do not adequately address a specific or localised threat.

The Targeted action process was undertaken at a state-wide level for threatened and Priority fauna species and flora species not endemic to a single region, and at a regional level for ecological communities and flora endemic to a single region. Estimations of benefit to inform the prioritisation of Targeted actions were made by regional staff and experts from BCS, CEM and external participants as was relevant. The outputs were three separate prioritisation processes for 1) fauna, 2) flora and 3) ecological communities, with independent rankings for each region.

Each threatened and Priority species and ecological community population or occurrence was 'screened' into an appropriate management category using specific criteria for flora, fauna and ecological communities. This included identifying threatened and Priority species and ecological communities that require targeted action to mitigate threats (Targeted action), or require further information about population or condition trends and threats to inform management actions (Learn action) or only require 'maintenance' actions i.e. they can be managed through landscape-scale threat mitigation action (Landscape action).

Regional staff, BCS and CEM representatives and invited external experts participated in a series of facilitated and structured workshops to consider the best possible action or suite of actions for threatened and Priority species and ecological communities screened to the Targeted action management category

A structured elicitation process following the IDEA protocol ('Investigate', 'Discuss', 'Estimate' and 'Aggregate') was undertaken to estimate the benefit and likelihood of success of Targeted actions (Hemming et al 2018).
Regional, district and specialist DBCA staff and subject matter experts from the Western Australian Museum, academia and consultancies participated in the elicitation process. Participants were asked to elicit the benefit and likelihood of success for the Targeted actions relevant to groupings of species and/or ecological communities that occurred within their region or for which they had subject matter expertise.

The group mean benefit for each Targeted action was weighted to reflect the relative extinction risk of a species or ecological community consistent with the IUCN Red List Guidelines (IUCN 2012). The final adjusted benefit was divided by the cost of the Targeted action to determine the cost effectiveness of the action. The cost to implement each action over 10 years was estimated by regions using budget data and staff estimates of the time required to implement actions, including the cost of travel, equipment, and materials.

References:

- Hemming V, Burgman MA, Hanea AM, McBride MF and Wintle BC 2018. A practical guide to structured expert elicitation using the IDEA protocol. *Methods in Ecology and Evolution*, 9(1), p169-180.
- IUCN 2012. *IUCN Red List Categories and Criteria: Version 3.1*. *Second edition*. Gland, Switzerland and Cambridge, UK 32pp. Available at https://portals.iucn.org/library/sites/library/files/documents/RL-2001-001-2nd.pdf

Learn actions

Through the processes for screening and developing Targeted actions for threatened and Priority species and ecological communities, information requirements were identified to inform

appropriate management actions. This includes information requirements about the abundance and distribution of species, condition of ecological communities, and threatening processes impacting species and ecological communities. Addressing these information requirements will then enable the development of either Targeted actions and/or Landscape actions.

The Learn action prioritisation process was based on a risk assessment and value of information analysis approach. Each region implemented the Learn action prioritisation process independently, making their own assessments about each component of the process and the regional expertise and capacity to undertake the Learn actions.

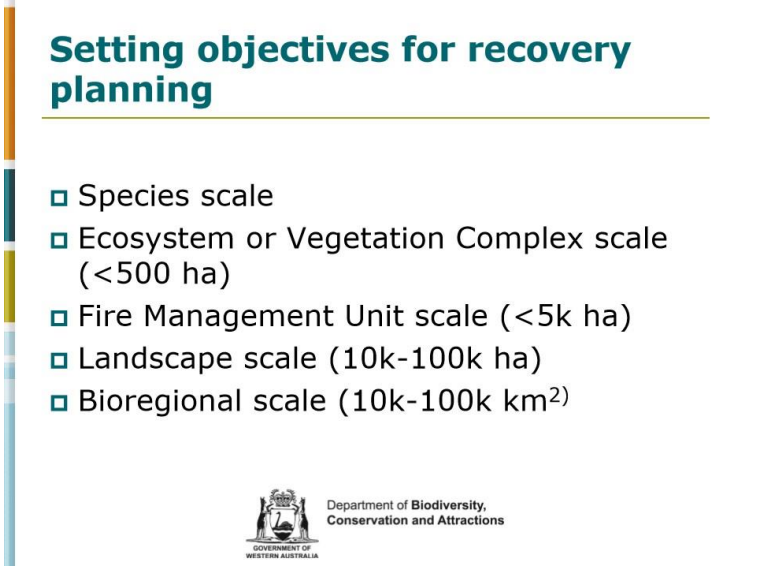
Regions identified threats to species and ecological communities allocated to the Learn management category using local knowledge and other resources where available. Where the specific threat impacting a population or ecological community was not known, regions considered the location of the population or occurrence to determine potential threats. The risk of each threatening process to each species and ecological community was analysed through a consequence-likelihood matrix . Risk was assessed at the species and ecological community level over a 10-year timeframe.

The feasibility of implementing Learn actions considered the ecological characteristics of the species and ecological communities, resource requirements (including costs) and availability, tenure and access considerations, and known/available survey, monitoring or research techniques. The Learn action prioritisation process considered to what extent addressing the information requirements would improve management decisions and outcomes for the threatened and Priority species and ecological communities. Regions estimated whether implementation of a Learn action would provide little to no improvement, some improvement, or would significantly improve or alter management decisions and outcomes. The degree of improvement was also recorded to provide further refinement of scoring.

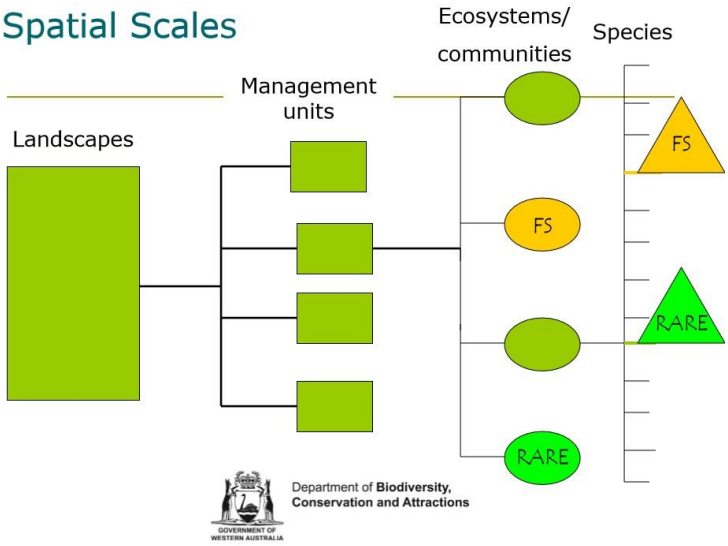
Each region made an assessment about whether they currently had the capacity and expertise to implement each Learn action. Those actions that were within the region's expertise and capacity progressed to prioritisation; these mostly related to monitoring, survey and threat assessment. Learn actions beyond the region's current capacity and expertise to address were allocated to an 'other' category. Regions will pursue opportunities to address these 'other' Learn actions as they arise with other sections of DBCA and/or external organisations as appropriate.

A Learn prioritisation score was calculated for all Learn actions to be implemented by regions based on the risk assessment, feasibility and the improvement to management.

Appendix 5: South Coast threatened species prioritization pilot project (Sarah Comer)



Spatial Scales



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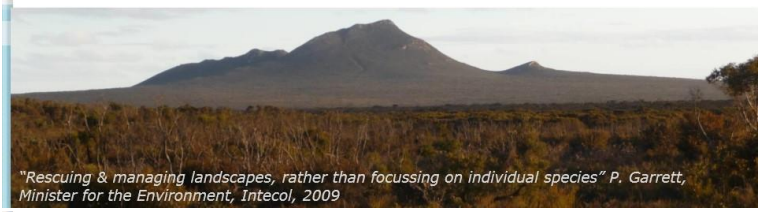
Why Regional Recovery Plans?

- Regional approach to prioritising and integrating the delivery of recovery actions and threat abatement.
- Efficient use of resources.
- Incorporate broader biodiversity conservation.



"Rescuing & managing landscapes, rather than focussing on individual species" P. Garrett, Minister for the Environment, Intecol, 2009

South Coast Threatened Species Pilot Project

- Pilot project to test the feasibility of an integrated regional approach to threatened species recovery and threat abatement.
- Overall Goal: To improve the conservation status of threatened species and threatened ecological communities occurring in the South Coast Region

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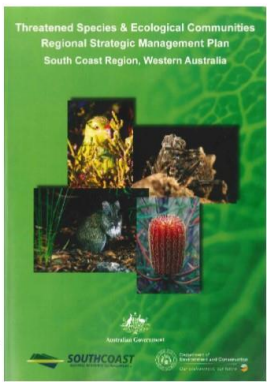
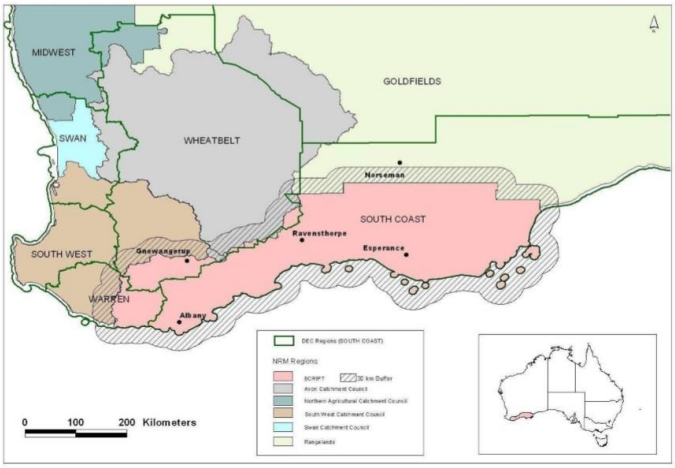


South Coast NRM Region



SOUTH COAST NRM REGION

- **8.6 million hectares**
- **770 km west to east**
- **800+ km of coastline, 120 islands**
- **Rainfall gradient from 1400 -300 mm**
- **2 IBRA subregions plus parts of 8 others**
- **2 major centres of plant endemism/ species richness**

120 vegetation associations
8000+ flora species
42 mammals, 300+ birds,
70 reptiles, 22 frogs

- **>50% of native vegetation cleared**

Threatened taxa ?

- 189 threatened species (2015 – 221)
  - 57 fauna (2015 =86)
  - 126 flora (2015=135)
  - 6 * ecological communities
- 4 specially protected species (2010)
- 837 priority species (2010)

- 75 Recovery Plans
- 23 Recovery Teams

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Questions we asked?

- What threatened species and communities occur in the Region?
- Where do they occur, which are endemic?
- Are there key areas for threatened species?
- What are the major threats?
- Does the current recovery process work?
- How can we prioritise?
- Can this be made more strategic?

Department of Parks and Wildlife

Prioritising species/communities

- Conservation status
- Level of endemism to region

Endemic to South Coast

- 26 Critically Endangered
- 30 Endangered
- 40 Vulnerable

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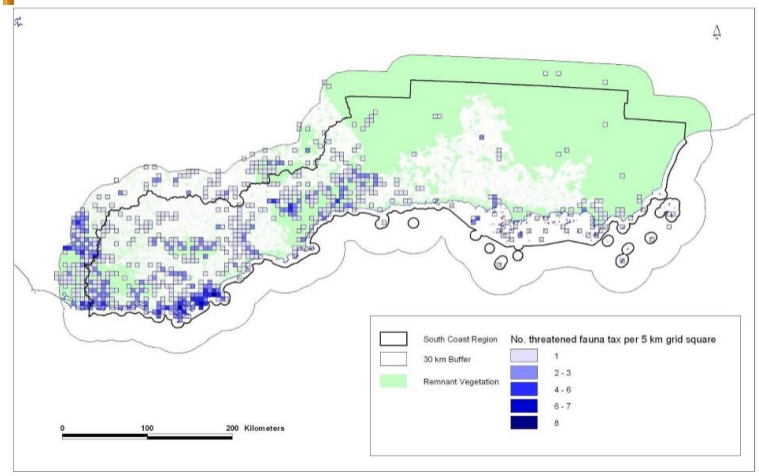
Prioritising areas

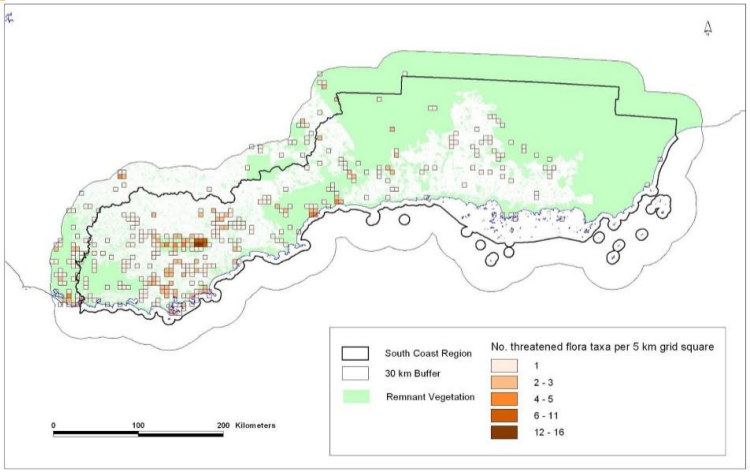
Threatened Species Density Grids

- Region divided into 5km grid squares
- Number of threatened taxa occurring within each grid

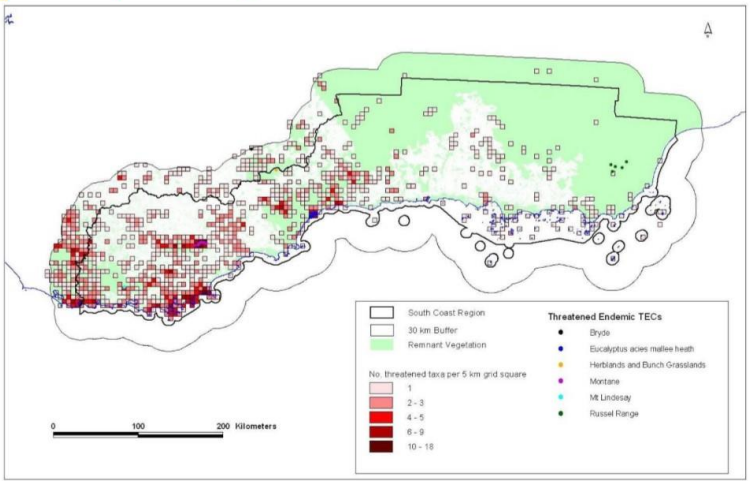
Threatened Fauna

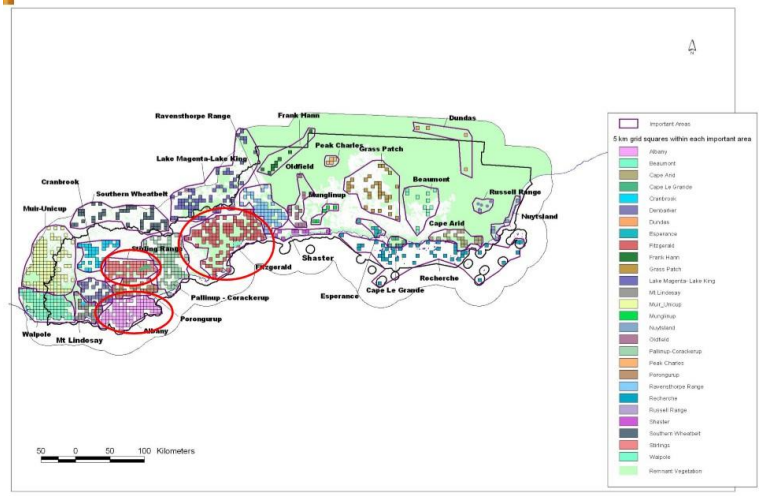


Threatened Flora



All Species/Communities





Major Threatening Processes

- *Phytophthora cinnamomi*
- Inappropriate fire regimes
- Introduced predators (cats & foxes)
- Salinity/altered hydrology
- Fragmentation of habitat
- Small population size
- Weeds
- Climate change

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Prioritise Threatening Processes

Threat Matrix

- Identify the vulnerability of threatened species/communities to threatening processes
- Species categorisation of threats were based on one or more of criteria:
  - Biological response to the threat
  - Distribution, size and number of sub-populations across the landscape
  - Degree of current impact of the threat
  - Risk of occurrence of the threat
- Categorized into Extreme, High, Low, No known Impact or Insufficient data.

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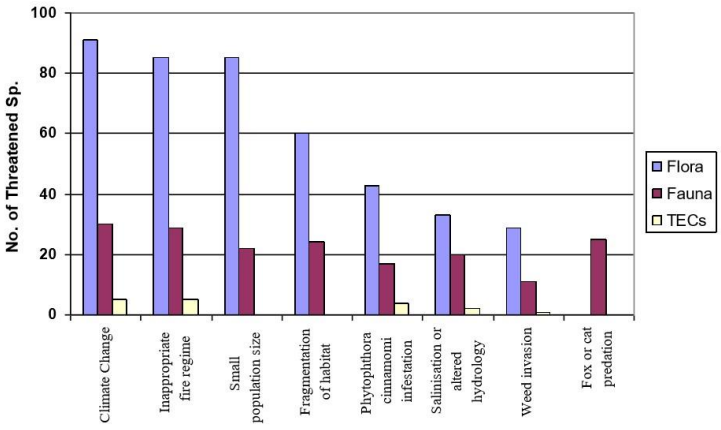

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Key Regional Recovery Actions

- Establish a Regional Recovery Team
- Increase involvement of NRM and community
- Increase understanding and awareness
- Increase knowledge of threatened species and their responses to threatening processes
- Prioritise threatened species recovery actions
- Threat abatement
- Develop recovery plans for key regional areas

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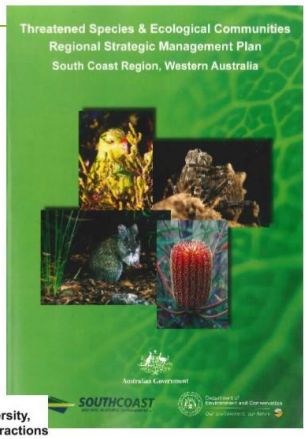
Regional Strategic Management Plan

Advantages

- Integrates threatened species recovery and threat abatement
- Provides strategic regional actions

Limitations

- Strategic rather than on-ground actions
- Not a formal Recovery Plan (ref Compliance Checklist)



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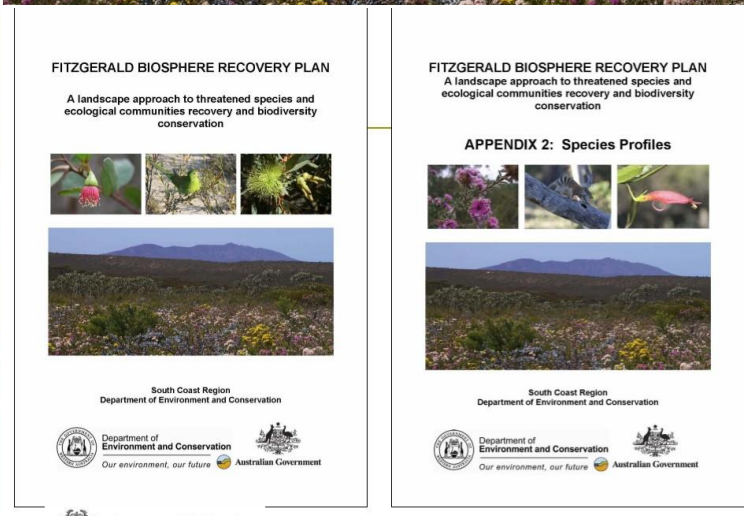
Fitzgerald Biosphere Recovery Plan (DEC, 2012)

- Landscape approach to threatened species and ecological community recovery and biodiversity conservation
- Formal national regional recovery plan under the EPBC Act



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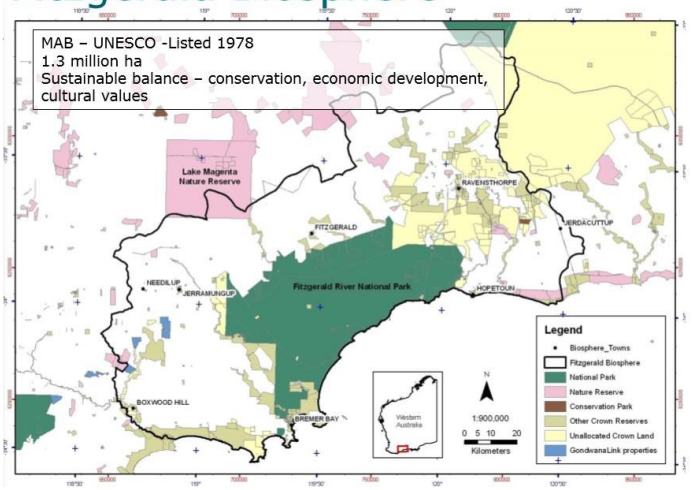
https://www.environment.gov.au/resource/fitzgerald-biosphere-recovery-plan-landscape-approach-threatened-species-and-ecological

Fitzgerald Biosphere



Threatened Species/ Communities of the Biosphere

- 38 threatened species
  - 9 fauna
  - 29 flora
  - 1 ecological communities
- 253 priority species
- 12 Recovery Plans
- 9 Recovery Teams

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Declared Rare Flora

Eremophila denticulata

Verticordia pityhrops

Coopernookia georgei

Verticordia helichrysantha

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Daviesia megacalyx

Threatened Fauna

Western Ground Parrot
Pezoporus flaviventris

Dibbler
Parantechinus apicalis

Western Bristle Bird
Dasyornis longirostris

Chuditch
Dasyurus geoffroii

Red-tailed Phascogale
Phascogale calura

Carnaby's Black-Cockatoo
Calyptorhynchus latirostris

Short-range Endemic Invertebrates

Anyphops francesae

Bothriembryom sp. Thumb Peak

Lychas austroccidentalis

Missulena granulosa

Podykipus East Mt Barren

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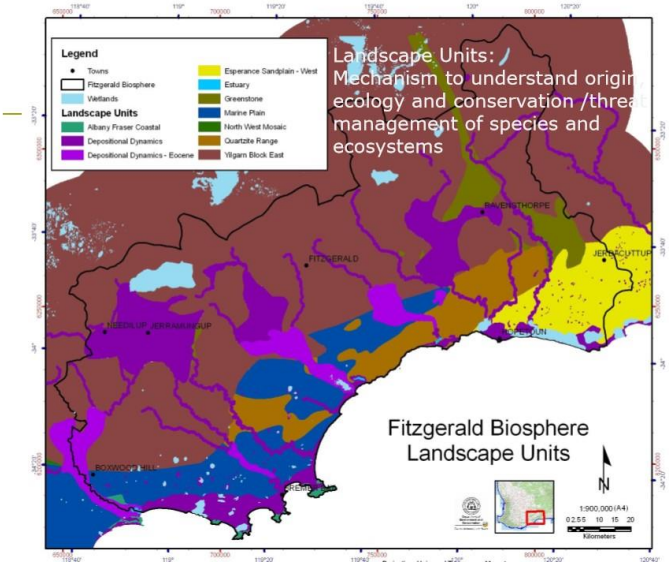
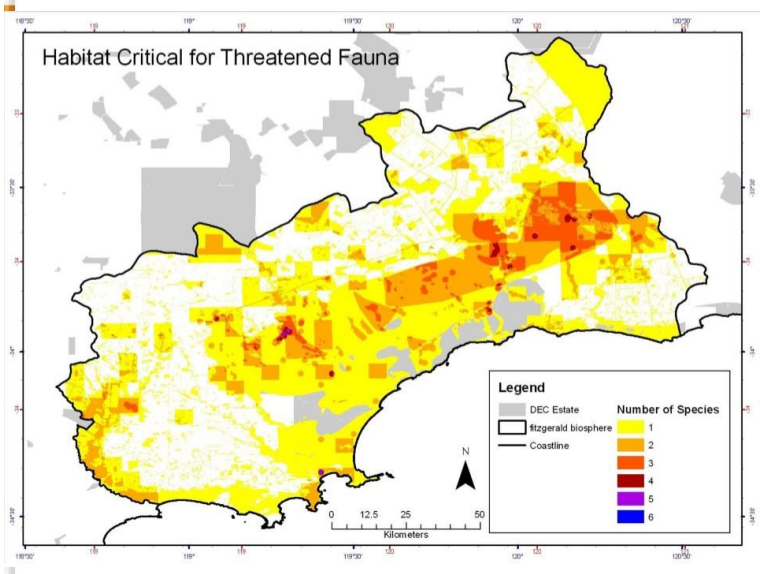
Polyxenid Ravensthorpe

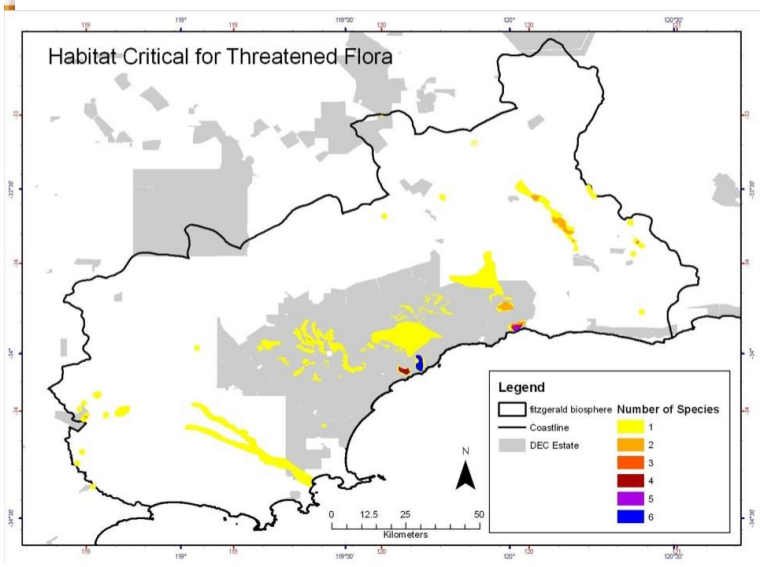
Landscape Patterns

- Interprets complex natural systems
- Represents distribution of species and ecosystems
- Landscape units based on geology, climate, drainage, soils, vegetation
- Different responses to threatening processes and management practices




Habitat Critical
Habitat that is critical to the survival of a species or ecological community


Habitat Critical for Threatened Fauna
Legend
DEC Estate
fitzgerald biosphere
Coastline
Number of Species
1
2
3
4
5
6
N
0 12.5 25 50
Kilometers


Habitat Critical for Threatened Flora
Legend
fitzgerald biosphere
Coastline
DEC Estate
Number of Species
1
2
3
4
5
6
N
0 12.5 25 50
Kilometers

Prioritising Threatening Processes

- Risk Ratings (Miradi software)
- Criteria used to assess risk over next 10 yrs:
  - Scope: proportion of population expected to be affected.
  - Severity: the degree to which the population is expected to be affected.
  - Irreversibility: degree to which the effects can be reversed.

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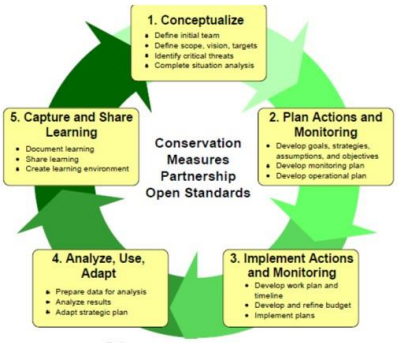
Open standards for the practice of conservation



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Risk Ratings (Miradi) – for fauna

Threats / Species	Invasive fauna	Inappropriate fire regimes	*Phytophthora cinnamomi*	Cats & foxes	Weeds	Salinisation/ altered hydrology	Climate change	Loss & fragmentation of habitat	Stochastic (chance) events	Summary Risk Rating
Carnaby's B-Cockatoo	High	Medium	Low		Low	Low	Low	High	Medium	High
Chuditch	Low	Medium	Low	High		Low	Low	Low	Low	Medium
Red Tailed Phascogale	Low	High		High	Low	Low	Medium	Low	Low	High
Dibbler		High	Medium	High		Low	Medium	Low	Low	High
Heath Mouse	Low	High	Low	High		Low	Medium	Low	Low	High
Malleefowl	Medium	Medium	Low	High	Low	Medium	High	High	Low	High
Numbat	Low	Medium		High		Low	Medium	Low	Medium	Medium
Western Bristlebird		High	Low	High	Low		High	Low	High	High
W. Ground Parrot	Low	Very High	Low	Very High	Low		High	Medium	High	Very High
Summary Risk Rating	Medium	Very High	Low	Very High	Low	Low	High	High	High	

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Overall Risk Ratings

- Fauna
  - Inappropriate fire regimes
  - Predation by feral cats and foxes
- Flora/Ecological Communities
  - Inappropriate fire regimes
  - Climate change
- *Phytophthora cinnamomi*

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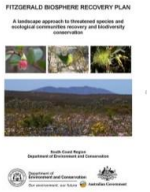
Recovery Actions

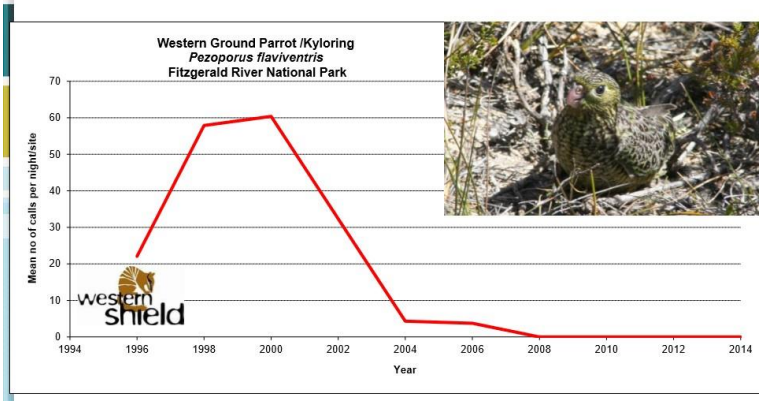


- Coordination and planning
- Community awareness and participation
- Abatement of threatening processes
- Monitoring and survey
- Translocations and ex-situ conservation
- Research

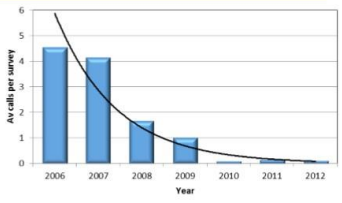
** Cultural engagement

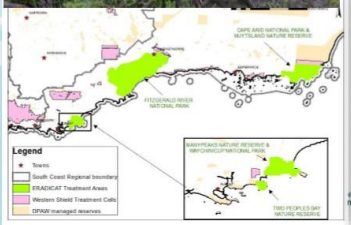
Recovery actions: adaptive management

- Monitoring informs management

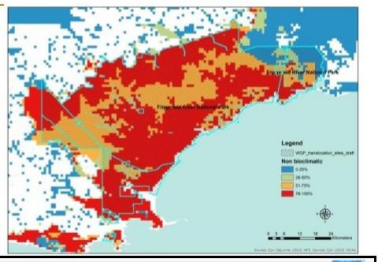


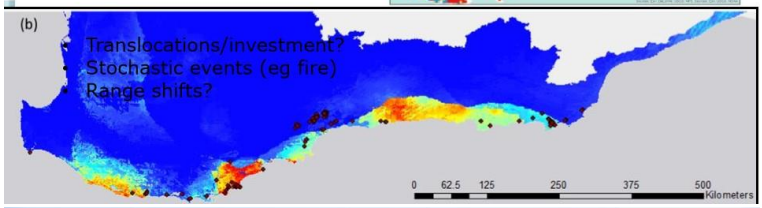
Integrated predator control 2010-2017





Climate Change?





Restoration?

Locally extinct mammal species

- Woylie (*Bettongia penicillata ogilbyi*)
- Numbat (*Myrmecobius fasciatus*)
- Bilby (*Macrotis lagotis*)
- Western Ringtail Possum (*Pseudocheirus occidentalis*)
- Western Barred Bandicoot (*Perameles bougainville*)

Single vs Multispecies

Difference between single species and multispecies recovery planning?

How do you improve conservation outcomes for numerous threatened species in particular landscape area, especially when resources are limited?

Prioritising taxa

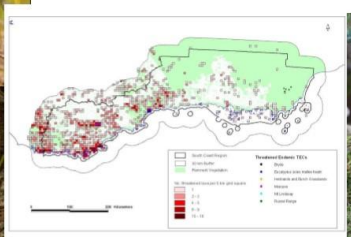
By conservation status?

By significance to region?

By role in ecosystem/community?

Or prioritising areas

for integration of recovery actions/threat amelioration?



Where to from here?

- Single Species recovery plans will still be used where appropriate
- Implementation of Fitz Biosphere RP
- Where possible, multiple species recovery plans will be used and form a basis for threatened species conservation with improved integration into protected areas




Questions?

Process of planning & response to threats is dynamic and related to knowledge



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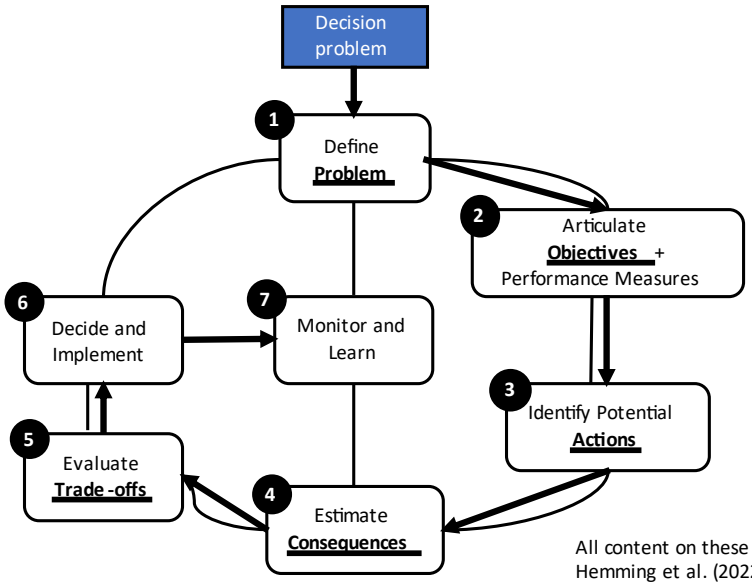
Appendix 6: Decision tools handout for breakout group brainstorming

Workshop– *Tools to support decision makers in ecosystem management*
DBCA Kensington 19th February 2024



All content on these pages is adapted from Hemming et al. (2022) *Cons Biol* e13868.

1 Define **Problem**

What is the problem?
Who needs to be involved?
How should the decision be made?

See overleaf for further questions related to each component.

2 Articulate **Objectives** + Performance Measures

Steps in identifying objectives and performance measures:

1. Identify what is important to achieve or avoid in a decision (i.e., objectives, values).
2. Rephrase values into succinct statements about what is to be achieved or avoided (e.g., maximise species persistence).
3. Separate fundamental objectives (the objectives of primary importance) from means objectives (the means of achieving fundamental objectives).
4. Clarify what is intended by each objective.
5. Define the performance measure for each objective (e.g., dollars for cost, number of distinct species for biodiversity).

See overleaf for further guidance on what makes good objectives and performance measures.

1 Define **Problem**

Decision component	Useful question
What is the problem?	What needs to be decided?
	What is the spatial scale and temporal scale of the decision?
	What is the trigger for the decision?
	Why does the decision matter?
	What is stopping the decision from being made?
	What constraints need to be considered? Are they real or perceived?
	What are the decision makers trying to achieve?
	What are the key uncertainties?
	What are the linked decisions?
Who needs to be involved?	Who are the decision makers and under what authority do they act?
	Who else needs to be involved or considered in the analysis and what are their values?
How should the decision be made?	When does a decision need to be made by?
	What is the legal and regulatory context that guides the decision?
	What resources are available to investigate and then implement the decision?
	What deliverable is required from the decision process?
	What analytical methods and tools might be needed?

2 Articulate **Objectives** + Performance Measures

A good set of *objectives* should be:
- Complete (cover all consequences of concern)
- Independent (no two objectives should contain overlapping concerns)
- Specific (sufficient detail that the consequences are clear, and performance measures can be easily selected)
- Understandable (any individual reviewing the process knows what is meant by the objective).
- Concise (they should be the minimum number appropriate for quality analysis).

A good set of *performance measures* should be:
- Measurable (can be recorded and analyzed in quantitative or qualitative terms)
- Understandable (defined the same way by all people)
- Sensitive (sensitive or responsive to distinguish the effect of alternatives in the time frame considered)

Appendix 7: Workshop agenda and attendees

Agenda

10:30 Introduction (10 min)

10:40 Overview of decision support tools (10 min)

10:50 Examples of existing tools (20 min)

11:10 Brainstorming in break-out groups (10+30 min)

11:50 Reporting back and synthesis (30 min)

12:20 Future directions and wrap-up (10 min)

Attendees

Conservation and Ecosystem Management
- Ashley Millar – Western Shield Coordinator

Regional and Fire Management Services
- Nicki Warnock – Research Officer FMSB
- Kimberly Onton – Divisional Leader Regional Services
- Michael Pasotti – Regional Fire Services Coordinator (online)
- Peter Gibson – Regional Fire Services Coordinator
- Tony Smith – Fire Planning Officer (online)
- Marissa Kruger – Conservation Officer, Wheatbelt Region

Nature Conservation Leaders
- Brett Beecham – Wheatbelt Region Program Leader Conservation
- Deon Utber – South Coast Regional Leader Conservation (online)
- Sarah Comer – South Coast Regional Ecologist
- Nicole Willers - Swan Region Ecologist

Biodiversity and Conservation Science
- Adrian Pinder – Ecosystem Science Program Leader
- Ben Miller – Fire Science Program Leader
- Lesley Gibson – Animal Science Program Leader
- Katherine Zdunic – Remote Sensing and Spatial Analysis Program Leader
- Carl Gosper – Plant Science Program Leader
- Ruth Harvey – Species and Communities Program Leader
- Jacqui Richards – Senior Conservation Zoologist
- Kathryn Schell – Species and Communities Recovery Team Leader
- Matt Chick – Research Scientist (Plant and Community Ecologist)
- Harry Moore – Research Scientist (Climate Adaptation Fauna Ecologist)
- Ryan Tangney – Research Scientist (FMP Plant Ecologist)
- Adrian Wayne – Senior Research Scientist (Forest Ecology) / Co-convener
- Tim Doherty – Research Scientist (FMP Fauna Ecologist) / Co-convener

External
- Billy Geary – Lecturer in Quantitative Ecology & Biodiversity Conservation, University of Melbourne