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A means-to-an-end:

a process guide for participatory spatial prioritisation in Australian natural resource management

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Foreword

Spatial prioritisation for natural resource management (NRM) investment is critical to ensuring investment is targeted as best as possible. In a changing climate with changing policy priorities and limited resources, how can we to prioritise efficiently and effectively in an uncertain future? This is one of many challenges facing NRM organisations and local communities across Australia.

To address this challenge, NRM organisations across the Southern Slopes Cluster have worked together with the researchers from universities and state agencies involved in the Southern Slopes Cluster Climate Change Adaptation Research Partnership (SCARP). In this collaborative report, co-authored by researchers and NRM planners, a process is defined to undertake spatial prioritisation to achieve multiple competing outcomes. The process embraces new tools and techniques and a solid engagement with both science and community values.

SCARP has shown us ways we can look at our challenge from different points of view in order to develop and implement strategies. These new strategies will need to be workable over normal planning horizons, yet not compromise our options for the future. This spatial prioritisation approach is just one new and well-tailored approach to planning for climate change adaptation that will help us use scarce resources wisely into an uncertain future.

Christine Forster AM

Chair, SCARP Steering Committee

1. Executive Summary

Spatial prioritisation for NRM in Australia aims to support decisions about where scarce resources should be invested to create the best possible outcomes. Many NRM objectives or goals require identification of regions and then localities for such investment. This guide was developed through action research with Tasmanian NRM organisations to help to address such 'where' questions. The report is intended as a working document for ongoing adaptation and refinement, as the process of spatial prioritisation is an evolving part of NRM planning and implementation. This report is not the final answer, but a waypoint that lays out progress thus far in a key task in adaptive management: knowing where to invest to achieve the best outcomes towards goals.

The project involved ongoing debate and discussion, sourcing information, engaging with experts and making decisions about how to address four specific 'where' questions:

Q1: Where in the landscape can/could and should carbon be stored?

Q2: Where are ecological systems at risk (e.g. saltmarsh, coastal, alpine)?

Q3: Where are the greatest risks of soil erosion as a result of extreme rainfall events (current and projected)?

Q4: Where are agricultural options likely to change substantially over time as a result of changes in climate?

One of these questions was deemed unanswerable with existing knowledge (Q4) and a subject for addressing through adaptive management. Others were found to be adequately addressed using existing modelling and mapping projects within the State Government (Q2 and Q3). The question about storing carbon in the landscape led to considerable discussion, consultation with experts, community engagement and ultimately both a spatial decision-support system and a process for identifying and addressing 'where' questions in the future.

This report uses examples and content from the discussions and approaches developed to address 'where' questions for NRM in Tasmania. The report is intended as a guide for practitioners, however the complete process devised in this guide was not tested in full and ongoing refinement of processes will be needed.

This process could be used as a practical guide to support decision-making for the implementation of regional strategies, rather than within regional strategies themselves.

1.1 An overview of the approach

The approach initially develops objectives drawing on the knowledge of the project team including NRM representatives, then includes broader expert, regional consultation and prioritisation with stakeholders (see Figure 1, and Box 1).

Early in the process, the team made a decision to use a spatial decision-support platform created the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), Multi-Criteria Assessment Shell for Spatial Decision Support (MCAS-S). MCAS-S is freeware that is intuitive and allows for participation in setting thresholds, as well as reclassifying and combining spatial layers (Lesslie 2012; MCAS-S development partnership 2014).

The participating NRM regions were not able to complete all stages of the process within the duration of this project, so the latter stages are outlined only as guidance for future implementation, without the benefit of learning by doing.

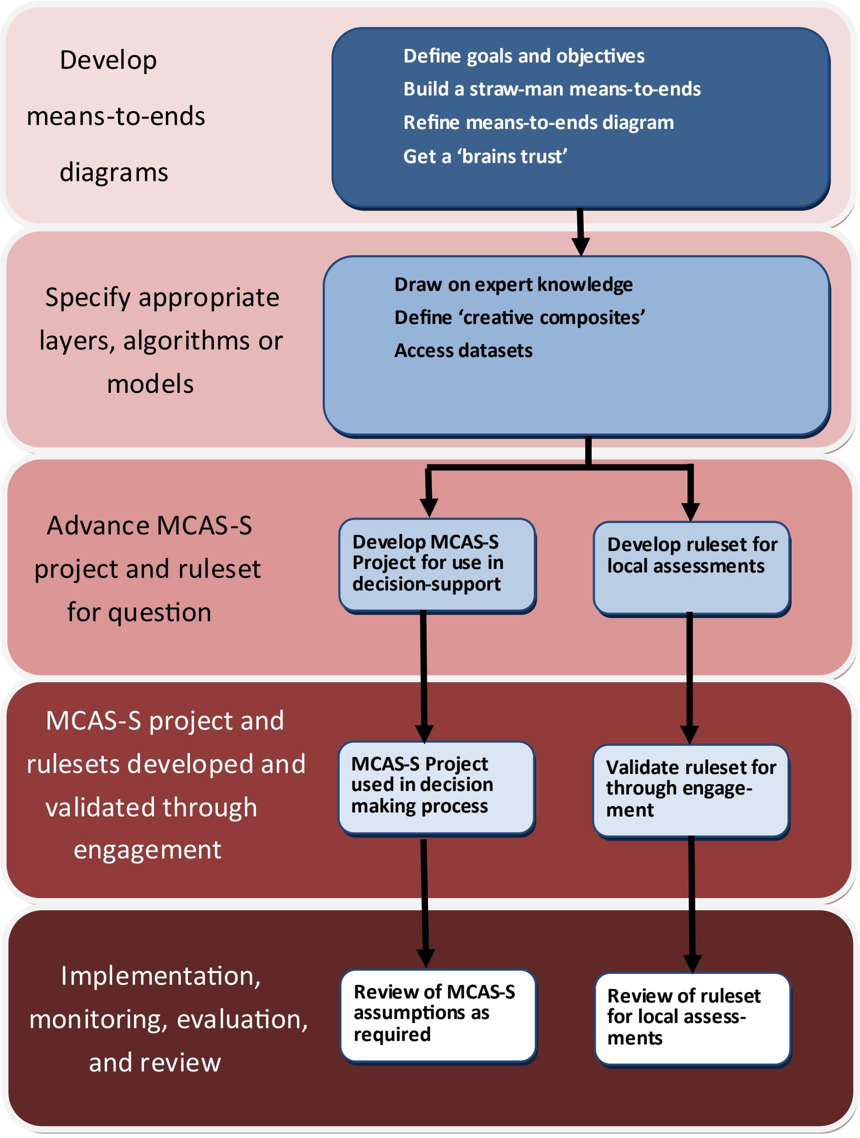

Figure 1: Overview of the spatial prioritisation process

Box 1: An overview of the process developed for spatial prioritisation

1. Means-to-an-end mapping

The process began with an attempt to define a 'means-to an-end' diagram. These diagrams are used to identify the goal and focus the approach by considering the type of data that will be required to answer the question. This first, crucial step benefits from several iterations and processes, to draw on community or stakeholder views, and to refine the question to incorporate the priorities and views of disciplinary experts, systems thinkers and people with a good understanding of farmer/landholder concerns. It aims to provide the basis for developing a where question that encapsulates the key concerns / values of the community, speaks directly to current or potential policy objectives, and can be informed by current and historical research.

2. Specify appropriate layers, algorithms and models

The second stage of the process is technical and oriented to defining the best spatial data as the means to the specified ends. Limitations of datasets need to be clearly articulated and understood so that a straightforward description of each layer can be used to present it to groups at later stages and clarify the uncertainty of the spatial model in total. Clarifying uncertainty in spatial representation at a regional or catchment scale enables a clearer understanding of which aspects of the 'means' is a reliable enough estimation within the maps and which will require ground-truthing through the process of localised implementation.

3. Advance MCAS-S projects and rulesets and for each question

At the third stage alongside the MCAS-S project a ruleset is developed to augment the spatial analysis with a place-based assessment. A ruleset may be as simple as a checklist for site characteristics to ground truth spatial assessments, or may require detailed fauna surveys, social research or other studies to ensure that local conditions are conducive to achieving goals. Local, regional and state requirements may also need to be considered at this stage including planning schemes, state policies and other institutional barriers and enablers. The ruleset will later be used in a revised form to identify priority areas for investment at a sub-regional scale, and inform the monitoring and evaluation of the outcomes of such activity. The two outputs from this stage -- a draft ruleset and an MCAS-S project -- should be designed to cover off on key issues across scales and so support cross scale prioritisation and implementation.

4. MCAS-Project and rulesets developed and validated through engagement

At the fourth phase, both the MCAS-S prioritisation and the ruleset are progressed through the engagement processes to include community perspectives, values, goals, knowledge and priorities. Participatory processes need to be well designed to empower participants to inform prioritisation and information and insight captured through these processes should also be drawn out to review and refine rulesets for local implementation. This phase is critical for implementation of NRM intervention that balances top-down priorities (programs or policies) with bottom-up process to address the priorities of diverse stakeholders and ensure authentic ownership and thus buy-in. Facilitation at this stage should be open enough to allow for creative and unforeseen considerations to emerge and structured enough to enable prioritisation of issues and values.

5. Implementation, monitoring, evaluation, reporting and review

The final phase requires policy, funding or other resources to create opportunities for implementation, and monitoring, evaluation and review of these. While this work is obviously crucial, it was not undertaken during the project and is therefore only dealt with briefly in this guide.

2. Introduction

The process presented in this guide aims to assist with spatial prioritisation for Natural Resource Management (NRM) in a changing climate. The report provides an adaptable approach that can be applied to different spatial prioritisation challenges and opportunities. It was developed through a process with the three Tasmanian NRM regions to answer what started as four deceptively simple questions:

> Q1: Where in the landscape should carbon be stored?
>
> Q2: Where are ecological systems at risk (e.g. saltmarsh, coastal, alpine)
>
> Q3: Where is the greatest risk of soil erosion as a result of extreme rainfall events (current and projected)?
>
> Q4: Where are agricultural options likely to change substantially over time as a result of changes in climate?

Lessons learnt while addressing these questions (particularly the first one) in Tasmania are included in boxes in the following process. This approach aimed to develop scientifically credible, regionally legitimate and relevant approaches (Cash et al. 2003) to spatial prioritisation that met the growing demand by funders for transparent, accountable and efficient prioritisation (Wintle 2008).

Spatial prioritisation is principally concerned with allocation or investment of scarce resources to achieve NRM outcomes in the most efficient and effective manner possible. It is complicated by the interconnected nature of the social, economic and environmental aspects of NRM, which can lead to a range of intended and unintended outcomes. These occur at different timescales and are sometimes very hard to predict.

Prioritisation can be as much about avoiding unintended negative consequences as it is about creating benefits. For example, large scale riparian revegetation may stabilise creek banks or sequester carbon (these may be the primary objectives) and provide ecosystem services for farmers (which might be co-benefits). On the downside it may reduce the productivity of adjacent pasture or cropping land (negative or unintended consequences). Connectivity corridors may allow native species to migrate across the landscape (primary objective) and improve amenity (co-benefit) values as well as providing habitat for pests and weeds (unintended consequences).

To account for multiple outcomes and manage them, spatial prioritisation for NRM needs to be honest about biases and reflective about assumptions; it also needs to be based on credible science and inclusive of the perspectives and issues of those who will be most affected. The process must critically assess conflicting outcomes, trade-offs, risks and co-benefits, as well as be simple and transparent enough that stakeholders and decision-makers can engage with the technologies, information, concepts and rationale (Jackson et al. 2013).

A process-oriented approach should be adaptable to future use in the context of new information and changing objectives and policies, for instance, as climate change affects landscapes or new climate related policies are introduced.

While there have been substantial advances in spatial modelling, process innovation for linking science and values has been largely lacking. It is increasingly recognised in natural resource management planning that the “quality of decision-making is a function of the process by which the decision is reached” (Sayer et al. 2013, pg. 8349). The cross-scale approach suggested here can link technical spatial assessment at a state wide or regional level with techniques, such as participatory GIS, that allow local landholders to map and discuss their own priorities, values and interests in relation to broader national or state objectives. Technologies, models and maps can be useful tools in this process but are always only means-to-an-end, rather than an end in themselves.

This report summarises the lessons from a spatial prioritisation process conducted as part of the NRM Climate Impacts and Adaptation Research Program in 2014. As part of the larger Southern Slopes Climate Change Adaptation Research Partnership (SCARP), a small, interdisciplinary research team from the University of Tasmania worked with the representatives of the three Tasmanian NRM organisations (NRM South, NRM North and Cradle Coast NRM), drawing on expertise from the University, Government, the private sector and NGOs to address our four priority ‘where’ questions.

3. Background and literature review

A focus on ‘where’ questions inevitably leads to asking about the ‘why’, ‘what’, ‘how’ and ‘with whom’. Iterative yet efficient processes are needed in order to ensure NRM interventions are linked to broad public values (e.g. policy documents and legislation) and community values (through engagement with those relevant communities) via cohesive goals and objectives (why we need to do what things). Goals and objectives, and the actions to achieve them need to be owned and enacted, often through well-coordinated linkages between different organisations and individual private landholders. As land management decisions are not made at regional or state-wide scale for most land-use (private land, particularly) much information that stems from spatial prioritisation will be advisory, for instance through extension. Alternatively it may inform the targeting delivery of a program to a specific locality, for instance through incentives such as grants. For instance, weed management funding through a Commonwealth program might require technical mapping of infestations or emerging threats, which in turn might result in prioritisation of where investments in weed management should occur, and engagement with land managers in those areas to establish how to get the best ‘bang for buck’. Technically optimum areas may be owned by private land managers who are not interested in this proposed investment. This is just one possible course of events in which an apparently technical ‘where’ question is complicated by people, places, values and processes. It demonstrates why the technical and social processes need to be well integrated in effective spatial prioritisation for NRM.

In the following sections we provide a brief overview of technical, spatial information of relevant biophysical parameters as well as key principles for processes by which these might be best applied by Australian NRM organisations in planning. As this literature is large, we mostly provide links to existing review and synthesis material while pointing to key findings or principles.

3.1 Towards principles for engaged and adaptive spatial prioritisation for NRM

While there are no silver bullets or panaceas for spatial prioritisation that reconcile complex biophysical and social considerations, and the interactions between these, there is widespread recognition that engaged processes and adaptive management need to be central to environmental management, and spatial prioritisation is no exception. Sayer et al. (2013, pg. 8351) provide 10 principles which “represent the consensus opinion of a significant number of major actors on how agricultural production and environmental conservation can best be integrated at a landscape scale”. These principles mesh with the goals of this project and have been adapted to guide the design of the process in this report:

1. Continual learning and adaptive management: evaluating and learning are key to adaptive management and need to be embedded in individual practice, organisational processes and among organisations.

2. Common concern entry point: ways of managing or solving problems need to be developed on the basis of trust among stakeholders. Such trust can be developed by addressing simpler, more easily agreed-on short term objectives.
3. Multiple scales: management is influenced at multiple scales of policy and governance and these different scales need to be considered together.
4. Multifunctionality: landscapes have multiple functions which need to be simultaneously considered. Trade-offs should be made explicit and reconciled carefully.
5. Multiple stakeholders: with differing objectives and ways of expressing them need to be effectively engaged with respect for their diverse perspectives and values.
6. Negotiated and transparent change logic: legitimate change requires that the logic is well communicated and accepted. Uncertainties should be clarified and consensus sought where possible.
7. Clarification of rights and responsibilities: entitlements, roles, rights and responsibilities need to be made clear and accepted by stakeholders. Facilitation and collaboration are new norms replacing consultation.
8. Participatory and user friendly monitoring: shared learning and ownership of problems or issues are the hallmarks of community based NRM. They rely on systems that enable linking of different kinds of knowledge both to frame problems and objectives, but also to monitor progress in addressing them. Such monitoring and evaluation is integrally linked to other principles, particularly 1 and 6 (above).
9. Resilience: refers to coping in the face of change, for instance through bouncing back after shocks. Resilience is often considered as an adaptation option that attempts to maintain the status quo and in many instances transitions to different systems configurations or transformation of systems, including governance, may be required to maintain livelihoods, lifestyles and landscapes in the longer term (Pelling 2011).
10. Strengthened stakeholder capacity: engaging stakeholders can be time-consuming and costly, both for organisations and stakeholders. There must be clear benefits for all parties through and from engagement. This will encourage stakeholders to come back next time with enthusiasm and knowledge, rather than be cynical or jaded.

Beyond these social principles for participatory practice attention to technical concerns can be guided by insights from recent research. A key objective in most NRM strategies is maintaining or enhancing biodiversity, and is enormously complex to understand across regional or landscape scales. Drielsma et al. (2014, pg. 81) highlight five issues that need to be considered together in grappling with this complexity: 1) it is not enough to focus on single species -- all biodiversity needs to be accounted for; 2) we need to work across tenure, not just within reserve systems to fully appreciate biodiversity across the landscape, in part because; 3) the landscape is variegated and all the components of it maintain some aspects of biodiversity (for example, degraded semi-native pasture may be the last strongholds of rare native herbs and grasses); 4) "Ecological processes, such as foraging, dispersal, predation, and seasonality;

fluctuations of vegetation structure and function; as well as threatening processes such as weeds and pests, over-grazing and firewood collection; are by definition dynamic and often involve complex non-additive interactions between multiple factors." and; 5) we need to consider future prospects and projections to move beyond a static view of current benefits or costs to consider how these might manifest in the future.

3.2 Biophysical elements of spatial prioritisation for natural resource management

There are many fundamental biophysical drivers, such as soil type, water availability and climate, which affect the spatial distribution of assets, species and ecosystems, as well as agriculture and other human activities. Biophysical drivers vary across space and time, so can have varying impacts on systems of interest. For example, underlying geology remains relatively constant over time while soils are more susceptible to disturbance and change. Climatic conditions vary seasonally and inter-annually, and we are now observing change over longer timeframes. Meanwhile, extreme weather events and bushfires can irrevocably alter ecological communities and economic activity in a matter of moments.

Identifying important drivers can improve our understanding of potential responses. Biophysical elements can also be used as surrogates for biodiversity or ecosystem resilience or function. For example, vegetation condition is often used to indicate the "health" of an ecosystem, based on the assumption that areas in good condition will support greater biodiversity and ecosystem stability. In the absence of perfect knowledge, the right biophysical element can help constrain the problem in geographic terms, and simplify many aspects of complex questions. Increasing technical capability and technology have made mapping many of the primary drivers of biophysical conditions and their variability (or probability of occurrence) possible. In some cases, and particularly in agriculture, modelling of these impacts and changes has been conducted at various scales to create maps of derivative landscape properties.

While biophysical elements may be less contested than social drivers, deciding which layers are the most important for a particular question may not always be straightforward. Biophysical elements are inconsistently understood or represented in existing datasets and tools, and it is important to understand the limitations of the layers used. For example, is a dataset used to represent "biodiversity" based on long-term monitoring, carried out in the appropriate season, and covering a range of target animals and plants? Or is it a survey of rare orchids, which may not be representative of an entire ecosystem and its health? These sorts of considerations help to ensure that the team developing spatial analyses recognises the potential limitations of all maps and models.

A variety of tools, approaches and technical methods for mapping and modelling understandings are reviewed elsewhere for conservation planning (Wintle 2008, Drielsma et al. 2014), connectivity mapping and landscape fragmentation (Rudnick et al. 2012), weed management (Scott et al. 2014), evaluating policy options (Bryan et al. 2011) and assessing opportunity costs of NRM activity against foregone productivity (Bryan et al. 2011). Below we give a brief overview of some of the more commonly used tools, and identify those which require specific expert input and those which may be more easily applied at the NRM level.

Satellite data are valuable sources of up-to-date, accessible information. For example, MODIS land products include downloadable data for vegetation cover, forest loss and gain, primary productivity and fire (https://lpdaac.usgs.gov/products/modis_products_table). These products can be downloaded for free, and updated in many cases every 16 days.

Species Distribution Models (SDMs) are used to identifying the potential distribution of an animal or plant under current and future conditions, and can incorporate many biophysical layers such as soil, habitat requirements and climate. Maxent (Phillips and Dudik, 2008) is one example of a simple, freely available model (https://www.cs.princeton.edu/~schapire/maxent/), but there are several other options available (e.g. BIOMOD [Thuiller et al. 2009], which includes ten different SDMs, and can be run in the R package). The Atlas of Living Australia website brings together biodiversity data from institutions around Australia and includes a spatial and analysis portal that can be used to produce a Maxent SDM for any species of interest (http://www.ala.org.au/).

GAP CLoSR was recently developed to assist decision makers "to plan connectivity of fragmented landscapes at the regional scale while taking into account the connectivity implications of fine-scale landscape features." It can also be used to compare the effects of different regional-scale plans and strategies on connectivity. Freely available, it includes a user-friendly interface to facilitate its use by NRM groups and local councils (https://github.com/GAP-CLoSR).

Government sites such as theLIST in Tasmania (http://dpipwe.tas.gov.au/land-tasmania/the-list), Vicmap data in Victoria (http://services.land.vic.gov.au/landchannel/content/productcatalogue) provide access to many layers, including soils and geology, climate, conservation value of estuaries and freshwater systems, vegetation types and condition, enterprise suitability, land tenure, and survey data for species of particular concern.

Models that require more technical input and/or licenced models include agricultural productivity models such as APSIM (Keating et al. 2003); invasive species models such as CLIMEX (Kriticos et al., 2014) and many hydrological models. These tools are often limited to subsets of species or land systems, but may be required to answer particular questions and are a good example of where developing relationships and collaborations between researchers and resource managers can be beneficial.

3.3 Tools for a process based approach: means-to-an-end, MCAS-S and rulesets

This project adopted a process based approach using means-to-an-end diagrams and the Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) as focal points or boundary objects. Rulesets for local assessment area crucial to effective local implementation; however these are covered in this report only briefly.

It is essential to recognise that spatial analyses are only the start of a much larger process to enable on-ground action in areas of NRM including land management decision making and environmental projects. As discussed a spatial analysis is the starting point from which to commence a much larger discussion around priorities, possibility for action and then the crucial step of engaging with relevant stakeholders to realise an opportunity for action (Jacobs et al. 2015).

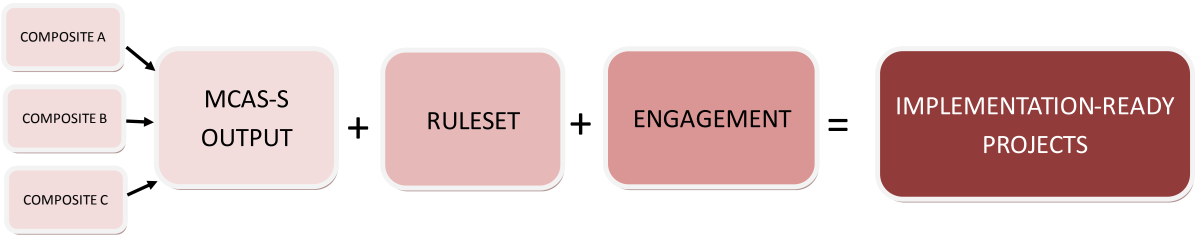

Figure 2: The linkages between key components in spatial assessment

3.3.1 The means-to-an-end diagram

Goals may be primarily driven by bottom-up or top-down processes, but they tend to require reconciliation of these approaches. NRM organisations work in a space between multiple groups (State and Commonwealth Governments, Local Councils, communities, research organisations and NGOs). They can potentially reconcile top-down and bottom-up approaches. For example, Commonwealth funding for riparian revegetation may have a blanket approach at a national scale that needs to be carefully adjusted to fit with application within a particular region or locality. Means-to-an-end diagrams serve an important role in reconciling these approaches. They depict what must be considered, discussed, developed and applied. Requirements might be defined by funders while other aspects may be negotiated. Spatial prioritisation can thus be considered as a process whereby regional and local intelligence can be combined with policy directives in a systematic manner. A generic means-to-an-end diagram for spatial prioritisation moves from primary inputs to an objective; but activity to develop the diagram must move in the opposite direction (Figure 1).

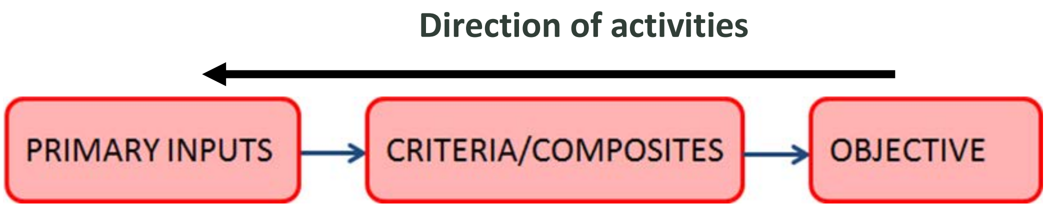

Figure 3: A generic means-to-an-end diagram

Creating a first draft of the means-to-an-end diagram provides an object that becomes the focus of structured discussion and debate. The competing goals, potential trade-offs and areas of greater certainty and uncertainty are brought to light. Sources of data, information, expertise, and knowledge gaps can be rapidly identified. Issues that are fundamentally unknowable (deep uncertainty) are identified and their influence or importance, at least to some degree assessed.

A small group of well-networked planners and researchers can thus rapidly assess issues that will need more or less work, people to consult about data sources and assessments of what has been done previously.

3.3.2 MCAS-S

Multi-Criteria Assessment Shell for Spatial Decision Support (MCAS-S) is a spatial prioritisation package and a particularly useful tool for combining, weighting and/or reclassifying layers in real-time with participants in order to incorporate values and priorities with stakeholders. Potentially, MCAS-S enables the inclusion of diverse voices, values and knowledge in spatial prioritisation. However, this inclusive approach needs to be pragmatically designed. To avoid frustrating participants a small project team need to develop an initial means-to-an-end rationale for spatial prioritisation and draw on expertise to select layers and develop composite or modelled datasets to use to address a ‘where’ question.

Such a process aims to finally arrive at scientifically informed and democratically-oriented spatial priorities that link regional scale planning priorities with local scales and ‘placed’ considerations of implementation.

While MCAS-S can assist, it is ultimately a tool to define areas for investment and its effectiveness depends on the people using it, the information within it and the process by which it is used. We detail these stages of the process below.

Our use of MCAS-S reflects a considered decision to avoid static and potentially controversial outputs such as hard copy maps, which are unable to change with shifting policies and regional priorities. The publication of final paper maps were widely regarded across the Southern Slopes (i.e. in Victorian Catchment Management Authorities [CMAs] and the South East Local Land Services as well as in Tasmania) as leading to suspicion amongst land managers. Single, static maps are unlikely to be useful in answering complex, changing resource management questions, as there is rarely going to be a single correct answer. Static maps are also hard to reconcile with best practice principles of integrated NRM planning outlined in Section 3.1 of this report. While static maps have value as tools to assist decision-making and paint a picture of landscape attributes and assets, MCAS-S can be used as participatory GIS. Here, participants can see and interact with the analysis, assumptions and uncertainties as well as the value judgements of decision-making.

Beyond creating hazard or risk oriented outputs, following Jackson et al. (2013), the MCAS-S outputs are adaptable to identifying areas of potential opportunity or high existing value, in relation to key policy drivers and regional priorities.

3.3.3 Rulesets

A broad state or region-wide spatial assessment does not enable implementation in localities or places. This implementation requires more fine-grained assessment as well as local engagement. Rulesets for local assessment need to augment broader spatial assessment. They help to address the specific implementation questions that spatial datasets simply cannot address. Rulesets may be as simple as a checklist that identifies criteria and can be filled in for an area that has been defined as potentially a good candidate for investment. Such a ruleset enables rapid and consistent assessment across candidate areas prior to or alongside engagement with landholders.

In this report rulesets are only discussed briefly as the ones developed through this process were not tested.

4. The approach in detail

Maintaining detailed records about the rationale for decisions throughout the process is particularly important in iterative participatory processes. Thinking and assumptions of a project team need to be clarified when outputs are used in workshop situations or decision-making contexts. The rationale for such choices needs to be transparent to participants across the stages of the process, whether through descriptions of why things have been done in a particular way, as answers to questions or through direction to formal documentation. Concise and clear rationales will allow and encourage participants to effectively understand and challenge assumptions and decisions.

Effective recording of rationale and assumptions can be done through maintaining files associated with each 'where' question on:

- decisions and rationales (including research relevant to these);
- assumptions / limitations, and; questions that rulesets might address.

4.1 Develop means-to-an-end diagram

4.1.1 Objective drafting

Spatial prioritisation starts with a goal or objective -- the end we hope to achieve -- and works back from those ends to define the means of achieving it.

The objective in the case of spatial prioritisation is a 'where' question. Initially getting this question roughly right will be sufficient as the question will undoubtedly be refined through the process.

The grammar of a 'where' question should reflect a well-defined purpose. This will often be driven by top-down policy, program or economic imperatives (e.g. where in the landscape should planting for carbon sequestration be conducted?). The auxiliary verbs (can, might, could, should, must) are important components of the question as they define whether the question is exploratory or imperative. Many 'where' questions examined at a regional level will be 'might' or 'could' questions that will identify localities for further investigation using a pre-defined ruleset.

4.1.2 Building a 'straw man'

Once a basic objective is in place, the first task is to delegate the development of a 'straw man' means-to-an-end diagram to an individual or small team (2-3 people) with subject matter expertise. The brief for this team should be to include as many elements as they think are relevant at the composite level and only then to fill in any primary layers/model that might help to inform those composites. It is important at the 'straw man' stage to try to include as much information as possible and let the larger group deliberate about what should then be left out, even where the experts developing the 'straw man' have strong views about the key drivers and the considerations that are peripheral.

The composite layers for NRM might represent:

- risk, threat or vulnerability;
- opportunity, opportunity cost, or some measure of value;
- current status, projected future status.

For example, to identify future refuges for a threatened species might be achieved by combining currently suitable with modelled future habitat. Consideration of boolean logic can be useful in thinking through where questions. For instance, identifying where there is low risk of bushfires AND high annual rainfall, but NOT close to settlements OR important infrastructure might be important in thinking where to site carbon plantations.

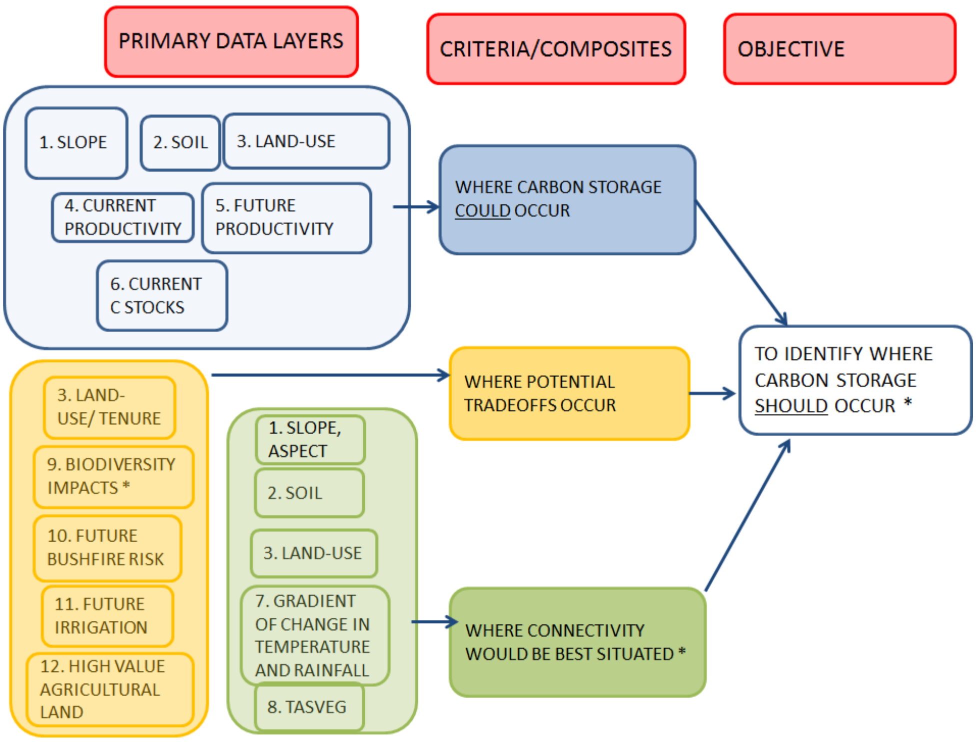

Figure 4: preliminary means-to-an-end diagram for the 'where to plant carbon in the landscape' question

4.1.3 Refining the means-to-an-end diagram

Refinement of a means-to-an-end diagram includes discussion within a broader project team which will move back and forth between the objective and means of achieving it. In our 'carbon in the landscape question' we quickly came to realise that that we were better off addressing a 'where could' rather than a 'where should' question, because the former question required too many assumptions about drivers of implementation and local concerns which were better off resolved at the level of project implementation (see Box 2).

Box 2: Reconciling different approaches and perspectives (theory and pragmatism)

In any process requiring collaboration between people with different backgrounds, interests and values, there will be differences in opinions and expectations. A well-defined objective and a means-to-an-end diagram can help focus dialogue, but a diverse project team will have to work through differences to develop an approach that is agreeable to all and meets pragmatic demands while still being credible.

For instance, while an ecologist may feel that it is important to define the theoretical underpinning of a decision and spend time understanding the perfect, ideal outcome for biodiversity, the NRM planner may feel there is more value in making pragmatic decisions in the early stages that implicitly exclude options not considered realistic.

In addressing the question “Where are ecological systems at risk?” a theoretically-oriented approach might move in a linear, step-wise way from identifying the suitability of future climate conditions for all ecosystems, through to identifying potential retreat pathways of systems of interest, and finally to consider the practical constraints of land availability, tenure and community concern.

This approach may be frustrating for the pragmatic NRM planner, functioning under tighter time constraints. They may want to skip straight to on-ground decisions by identifying what land is currently available for conservation.

The theoretical approach can contribute by identifying uncertainties and gaps that may or may not be addressed in the future; helping to understand the uncertainties involved in decision making; and developing software and spatial layers, among other things. This is critical to developing a credible rationale for investment in specific localities or areas.

The pragmatic approach drives the process toward outcomes by identifying the NRM goals and objectives; ensuring information can and will be incorporated into decision-making, and ultimately achieving the desired on-ground outcomes.

We found in Tasmania that the tension between theory and pragmatism was positive and helped achieve a balanced process. Combining both approaches is necessary to identify the appropriate ‘where’ questions; improve understanding of the risks, co-benefits and opportunity costs associated with achieving the goals, and work towards long-term planning.

Maintaining a respectful and constructive dialogue that enables different approaches to be reconciled and ensures a transparent process can be challenging and time-consuming, but is essential to achieving successful on-ground prioritisation.

To define the required composites and primary data layers that will be ultimately needed, it is useful to shift attention back and forth between these components. Doing this raised a variety of recurring questions in all four of our ‘where questions’. These are included here to help frame the development of means-to-an-end diagrams:

- Why do we want to know the answer to this question anyway?
  - Be specific and interrogate simple answers: what will change for whom, and how, as a result of the outputs?
- What precisely are the decisions that will be made using the outputs?
  - What is the component of the decision-making process that will rely on technical, and especially biophysical, spatial information?
- What sort of ‘where’ question are we trying to ask?
- What sort of question: Where can … ? Where could … ? Where should … ? etc.)
  - Do we really know enough to address this question in a spatially explicit way?
  - Does information availability or uncertainty constrain the form of the question ‘should’ to a ‘might’ or ‘could’ question, or abandon altogether (see Box 3)
- Who has already done work in this area and should be involved?
  - How can the team efficiently harness outside expertise and perspectives?
  - How can the team avoid ‘capture’ -- that is, individuals or groups claiming authority over the issue, when their claims are not necessarily legitimate or credible?
- What scale and scope does the question cover?
  - Is it a state/region wide first pass assessment?
- What resolution of outputs is really needed to address this question? Will it be a coarse, first pass assessment?

Box 3: Rejecting the question about future agricultural option

Tasmanian NRM organisations initially expressed an interest in understanding future changes in agriculture in response to climate change, particularly in order to attempt to foresee regional NRM changes if, for example, agriculture was likely to become more or less intensive. Early consultation with specialists made it clear that, while one could potentially model how climate would change potential agricultural options, the greatest driver of such change in real terms were going to be related to economic drivers such as the exchange rate, demand and access to markets. Climate change has already been acknowledged as a factor in the expansion of Tasmania's wine industry and been linked to irrigation investment in Tasmania. However, these trends and changes also depend on a variety of factors that cannot be predicted. The team felt that a meaningful NRM approach to these cannot be achieved efficiently or effectively by long term spatial projection of change and pre-emption. Rather it requires monitoring and proactive adaptive management of emerging and potential NRM concerns.

4.1.4 Get a brains trust

Recruiting key experts and decision-makers, either individually or as a group, should be done early. This brains trust act as a sounding board, and review the work of the project team. The group should be a combination of technical experts and people with extensive networks and knowledge of people who have a stake in the issue in question.

One way of considering who should be involved in a brains trust is to think through who are the best people to get together to reconcile top-down or bottom-up goals relevant to the question:

- Top-down goals: state or commonwealth policy, funding imperatives, market mechanisms, the need for credible science to inform decision-making
- Bottom-up goals: immediate or emerging concerns of land managers, emergency response, tension between upstream and downstream water users, social license to operate and other on-ground concerns

The brains trust act as an extended peer review network and provide critical oversight, especially with regard to the rationale for what is in and out of a means-to-an-end diagram and later the spatial analysis. They should have a wide understanding of technical and on-ground work that has already been done or is in process and how this can be applied in the current project. Finally, they should provide a sense of when the means-to-an-end diagram is good enough to take through to the next stage of attempting to develop an MCAS-S project to address the refined question.

4.2 Specify appropriate layers, algorithms and models

Once a means-to-an-end diagram has a sound rationale and addressing the question appears to be both credibly achievable and pragmatically useful, the team needs to identify and source data that can be combined to address the question. Much of this may have already occurred through earlier discussions. Already existing layers or datasets may be good enough, or new layers might need to be developed.

In this project, at this stage, we ran a daylong workshop with key spatial analysts and specialists with technical knowledge relevant to the issues we were addressing. Through a well facilitated process, such a workshop can rapidly clarify:

- Which datasets can represent which boxes in a means-to-an-end diagram?
- Where are new datasets needed (or in the pipeline) to improve on older 'place-holder' dataset?
- What are the disagreements about credibility of models or datasets?
- Who are the custodians of which datasets (and subsequently, what arrangements can be made to access data)?
- Where are there avenues for collaboration to address similar questions?

Our process used a combination of presentations, whole group discussions (group size less than 15), and break out groups to identify datasets that fulfilled the ambitions of each means-to-an-end diagram.

Further exercises in the workshop setting could include:

1. discussion on how to combine primary datasets to create desired composites (e.g. selection and weighting of primary datasets to develop composites – see Box 4)
2. negotiating appropriate thresholds of spatial data for different parameters and where these can be credibly defined (scientifically) or are open to decision-maker's discretion (value judgements).

Box 4: Creative composites and options

Deciding on appropriate layers for answering 'where' questions can be one of the most challenging steps. For instance, when addressing where ecosystems are most at risk, many highly correlated layers are likely to be available. They may all seem too important to leave out, but may only be indirectly related to the question under consideration. A good example of this is the numerous climate layers that are available in Tasmania. Some of these are climate variables from the regional climate model (e.g. mean monthly or annual temperature and rainfall, or maximum and minimum temperatures), and others are derived variables or indices (e.g. bioclimatic variables, cumulative growing degree days or forest fire danger index). Figure 5 shows examples of climate-related layers, of increasing complexity. While these variables can be very useful in guiding decisions, including too many, or inappropriate variables, can make the integration of variables within MCAS-S very difficult. Developing composite layers (Figure 5) is one way to ensure a lower number of more specifically appropriate layers are used.

Several issues need to be considered when choosing layers to answer questions about climate change, including:

1. What climate variable is most relevant (e.g. temperature, rainfall, water availability)? Is there a composite or derived variable available that is more applicable than the raw climate data?
2. Are changes in annual, seasonal, monthly or daily variables most important? Alternatively, are native vegetation communities more likely to respond to changes in extremes or variability in particular seasons?
3. Are the variables highly correlated? If so, perhaps one variable will suffice (e.g. Change in annual temperature and summer temperature may reflect the same trends)
4. Which time period is of interest (early, mid or end of century)?
5. Which emissions scenario do the data represent? Are absolute values or change values relative to past or current conditions important (e.g. Is it important to know the rainfall in mm, or just that it is projected to decline by 5-10%?);
6. What is the level of uncertainty associated with the values? (e.g. what is the model range; is it a variable that is not well represented by climate models (e.g. wind); how realistic is the ecological model?). If uncertainty is high, perhaps it is sufficient to know the general trends projected to occur in the future. Alternatively, would it help to consider best and worst case scenarios?
7. What is the resolution of the layers? Does the resolution reflect real added information (e.g. interpolation of climate data using a 30m Digital Elevation Model (DEM) gives a great picture, but is not adding real information about rainfall patterns at the fine scale)

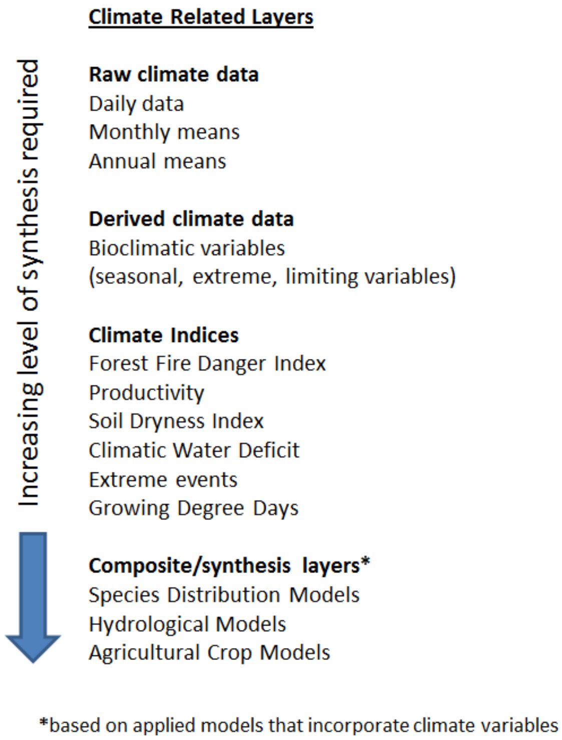

Figure 5: Examples of climate data, derived data and indices commonly available

4.3 Advance MCAS-S projects and rulesets for each question

The third stage makes a clear distinction between spatial analysis using datasets and more place-based analysis using rulesets as frameworks for implementation.

Spatial analysis using MCAS-S is advanced through transitioning from identifying layers to building a project or datapack within MCAS-S that is adequate to the task of broad-scale spatial prioritisation. Box 5 provides an account of these transitions for the ‘carbon in the landscape’ question in Tasmania. A key point here is allowing the dialogue between scientific concerns with credibility and the more pragmatic concerns of practitioners to proceed in order to develop an agreed approach that embraces compromise but also seeks avenues where win-wins are possible. In particular, the process outlined in Box 5 created a clear means of identifying areas of refugia where a greater level of on-ground care in assessment for implementation may be deemed necessary via the rulesets to guide implementation.

Box 5: Carbon and connectivity -- ecological and pragmatic considerations in Tasmania

In the process of identifying where to store carbon in the landscape using biodiverse carbon plantings the stages of discussion and deliberation provide an example of the overall process for spatial prioritisation. The initial 'straw man' means-to-an-end diagram attempted to capture all relevant parameters. Input from experts indicated that it could be simplified and the goals refined to maximise sequestration potential and biodiversity benefit and minimise risk. This revised means-to-an-end diagram was discussed with the NRM planners who took the diagram and developed a draft MCAS-S tool kit to address the question of where to store biodiverse carbon in the landscape. Further discussion between planners and scientists helped to uncover the underlying assumptions being made about the inclusion and exclusion of particular layers. When applying the draft means-to-an-end diagram, the NRM planner immediately masked out areas of high productivity agricultural land, believing that this land would be unavailable due to the high opportunity cost to private landholders. The scientist argued that this decision should be made later in the process in collaboration with the community because it may be that some high value land could be made available. Some high value land is being made available around the edges of pivot irrigators where circular cropping systems have been superimposed on traditionally rectangular paddocks. Opportunities may also arise in the future along the relatively fertile soils to be found along stream banks. This may hold true is if the proposed expansion of the dairy industry is undertaken in accordance with guidelines to maintain or develop riparian buffers to limit nutrient loss into waterways.
A revision of the process led to the development and general acceptance of the following goals when discussing where to store carbon in the landscape:

1. to minimise risk to biodiversity assets by protecting and enhancing existing assets and by revegetating degraded regions
2. to minimise risk to soils and water quality by protecting and enhancing ground cover and stream buffer zones
3. to mitigate potential impacts of climate change on natural resources
4. to identify where activities cannot take place.

Maximising connectivity can be achieved by assessing 1 and 2 but may not be desirable around areas of known refugia.

The NRM planners revised the MCAS-S datapack to include the following surrogate (composite) layers:

- mean annual increment layer (surrogate for potential sequestration rates for above-ground carbon)
- extent of native vegetation / trees (mask of areas already under trees)
- presence of biodiversity 'hotspots' (surrogate for all components of biodiversity – identifying areas where extra care needs to be taken in local assessment)
- AdaptNRM revegetation benefit layer (identifies areas where there is potentially high value in planting to create landscape connectivity at a regional scale)
- stream buffer and vegetation for all class of streams (identifies areas in which riparian revegetation is more or less an important consideration)
- soil erosion potential layer (identifies areas where soil erosion is greater risk)
- Climate Futures Tasmania layers – (A1 emission scenario layers were tentatively included: changes in rainfall intensity as indicator of areas where future erosion risk may worsen, changes in total annual rainfall and evapotranspiration across the century can be used to help decide species and provenance of trees to plant in local assessments)

Composites will always be surrogates for issues of concern and may be lacking specific details. For example, we may hope to assess where there areas suitable for riparian revegetation and fencing on the basis of multiple criteria (e.g. existing stock access to waterways, lack of existing native vegetation, rates of run-off or rill and sheet erosion in a catchment, etc.). Such fine scaled assessment may be technically achievable but not at a state-wide level. However, it may be quite adequate at a state-wide scale to develop maps indicating relative density of riparian zones with low native vegetation cover for different stream classes in order to establish areas (in our case of low 'riparian nativeness') where more detailed rulesets can be applied to guide implementation. A preliminary MCAS-S output was developed for this report following from the above considerations, which in this assessment identifies areas in the north of Tasmania (Figure 5) which meet general criteria of:

- largely cleared riparian areas
- moderate to high rain-driven erosion risk areas
- high potential to sequester carbon, and
- low levels of native vegetation at a sub-catchment scale.

In this analysis, high projected rainfall change over the course of the century (A2 scenario) and the presence of biodiversity hotspots provide risk layers to identify areas for more thorough analysis of risks in the rulesets.

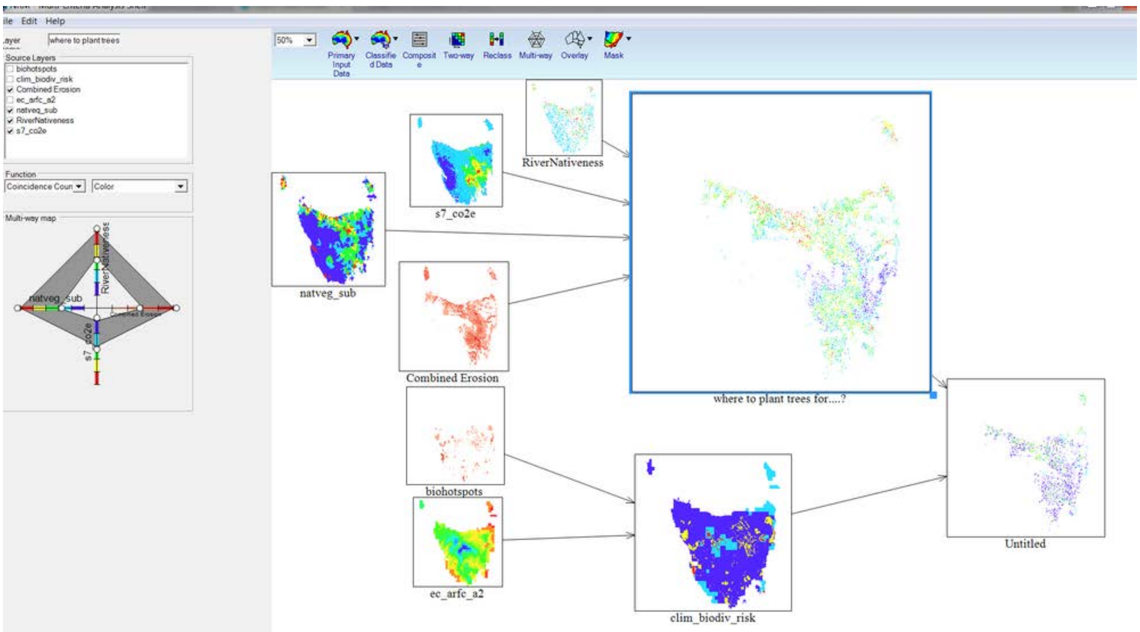

Figure 6: Preliminary MCAS analysis for the carbon in the landscape question

The development of such rulesets was not well advanced at the time of writing of this report, largely because of policy change which meant that implementation (for example, carbon plantings) was no longer a policy priority and therefore there was little impetus to do such analysis in the absence of specific imperative for implementation.

Nevertheless, general guidance for the development of rulesets for place-based analysis should spin-off from deliberation on the development and/or selection of layers and the MCAS-S process. Gaps in the data, assumptions about the validity of datasets, or compromises in the creation of composite layers can all usefully help identify what needs to be assessed on the ground. For example, as outlined in Box 6, useful datasets often need to be ground-truthed at a farm scale in order to ensure that they adequately represent the condition of native vegetation or other characteristics of interest.

Rulesets can also assess adoptability. Adoption of any intervention is usually a decision of specific land managers and engagement directly with farmers in a region with promising options for implementation is requisite for identifying the extent of willingness and capacity to adopt or engage in a given program.

Box 6: Cross-scale prioritisation

Even in a small state like Tasmania, it is obvious that a “one size fits all” approach will not achieve successful planning and prioritisation for future natural resource management. Different regions have different priorities and goals, resources and approaches, and therefore need flexibility in tools for spatial prioritisation.

A nested approach to planning and prioritisation is one way to provide flexibility, while building common resources and support networks. This helps overcome technical and resourcing challenges that exist at the regional scale, but allows for localised approaches to assessment, working with specific landholders.

Different goals can be achieved at the state wide, regional and sub-regional levels. At the state-wide scale, extensive mapping has been developed over many years by specialists. This sort of seamless spatial information provides landscape-specific information. For example, in Tasmania, TasVeg data layers are an invaluable resource that can unify state-wide understanding and communication, because everyone is using a common vegetation classification scheme. On the other hand, TasVeg may require some ground-truthing to provide accurate information at the farm-scale. At the sub-regional scale, very detailed information may be available, but not spatially represented across broader scales (e.g. data from agricultural models at the site scale). A nested approach enables this information to be used, whereas it may be discarded if a state wide answer is being sought.

Box 7: Developing Rulesets for siting biodiverse carbon plantings

At a finer scale (property/sub-catchment) more detailed consideration is required to identify sites for biodiverse carbon plantings. There are a range of positive and negative interactions between potential planting sites and existing land uses, in particular agricultural production which dominates at the landscape scale. Impacts on economic returns, management practices, and future land use options need to be considered in unison with biophysical site characteristics for any on-ground action to achieve multiple outcomes.

The adoption of biodiverse plantings will be reliant on the ability of potential sites to be able to fulfil outcomes that meet the program goals such as biodiversity benefits and carbon storage, while also encompassing goals of land managers / farmers including: financial, agricultural, environmental, non-agricultural income and personal/lifestyle/family goals.

Key considerations that will determine the likely adoption and configuration of proposed plantings will need to include;

- Landscape context (e.g. local biodiversity values and assets, surrounding landuse)
- Negative impacts on agricultural production (e.g. loss of production area, weeds, pest animals, crop competition)
- Positive impacts on agricultural production (e.g. shelter, erosion management, microclimate management, natural pest controls, salinity management, nutrient cycling)
- Climatic and climate related risks (e.g. drought, flood, fire)
- Financial costs, returns and risk to investors and landholders
- Impact on farm operations (reduce/increase management requirements, stock and machinery movement, utility and farm infrastructure)
- Capacity to undertake works (labour resources, equipment, knowledge, maintenance)
- Impact on future management options
- Alignment with expectation and preferences of land managers (personal and family goals, conservation interest, etc.)
- Alignment with regulatory planning and approval requirements

Adoption is likely when an acceptable compromise between trade-offs is achieved as potential options rarely address all goals equally. Thus outcomes will be influenced by landholder perceptions and experience of many things including: the impact that proposed planting will have on the property; their capacity to adopt relevant actions or practices, and; the availability of adequate support services to address concerns and provide information and other resources. The availability of programs to support biodiverse plantings for carbon storage are likely to increase adoption by offsetting potential negative outcomes to the landholder's goals while building capacity to make assessments that enable adoption.

While broadscale spatial assessment identifies biophysical potential, rulesets need to be designed to assess and enable socio-economic processes that assist adoption.

4.4 MCAS-S Project and rulesets validated and developed through engagement

At the fourth phase, both the MCAS-S prioritisation and the ruleset are progressed through the engagement processes to include community perspectives, values, goals, knowledge and priorities. This stage was not completed during the life of this project. So we provide only preliminary and brief advice on design in this section.

This stage involves participatory processes and stakeholders, and therefore the legitimacy of the whole assessment can be affected by the design of this stage. A useful resource for guiding the recruitment for such processes is Reed et al. (2009). In brief, it is crucial to include participants who have something to lose and/or gain through implementation and be aware of the stakes of these participants. It will also be useful to include key opinion leaders or decision-makers.

It may also be critical to involve independent experts or area specialists in the workshop. Participants may be tempted to use the flexibility of the technology to arrive at a 'preferred answer' rather than one that is credible, and specialists may need to provide a rationale for particular classifications or thresholds. These rationales should have been developed prior to the workshop anyway and can usually be included in preliminary presentation of the means-to-an end rationale.

This clear and concise rationale for MCAS-S projects and/or rulesets should be presented to frame discussion. This should not be presented as a *fait accompli*, but as a version that has been developed through analysis and refinement but is open to review through this process. The objective should be clearly stated and it may be useful to say what is not being attempted (e.g. optimisation, economic modelling etc.) as well as highlighting research and empirical evidence or theoretical justification of decisions that have been made.

Depending on the size and type of groups, a competent and non-aligned facilitator may be a useful contributor both to run and help design the process. Independent facilitation allows the project team to focus on presenting and answering questions rather than managing a group.

It is likely that validation of rulesets will require a different group of participants and process than testing of regional MCAS-S prioritisation.

Some guiding questions to help design of a presentation of MCAS-S means-to-an-end rationale

Goal:

- What is the objective or goal?
- Why do we want to know the answer to this 'where' question?
- What does the current workshop aims to achieve, and where does it sit in the overall process of prioritisation and implementation?

Process to date:

- How have the team gone about addressing the question to date?
- Who has done what?
- What were the linkages with other projects and activities?

Rationale:

- What is the overall rationale?
- What were the key decisions made to date and how are they justified?
- What assumptions were made and how significant are these?
- What are the known limitations of the approach?
- How fit-for-purpose is it?

Data:

- What are the weightings, classifications and combinations of data that have gone into creating the output map?
- How is the final output sensitive to changes in classification or combination?
- What is relatively certain and how does it affect our ability to alter input layers of combination?
- What is scientifically uncertain and how has uncertainty been managed (see Box 8)?
- Which inputs are socially contested? How have social considerations been managed?

Workshop process:

- What does the workshop aim to achieve?
- What are the stages of the process and how do they lead to the goal?
- What will participants gain from their contributions?
- How will the results of the workshop affect the next stages?

Box 8: Planning within uncertainty

It is impossible to accurately estimate the future of natural systems under climate change for a range of reasons (Harris et al. 2014). Firstly, there is uncertainty around the human dimension, which will determine future emissions scenarios and response to climate change. Then there is the uncertainty represented by the range in climate models, and inherent in the natural variability of the climate system. Lastly, there is the uncertainty about how, or when, particular species and natural systems will respond to the changing climate.

The human dimension of uncertainty creates a need to respond proactively to manage and create opportunities. Rather than trying to predict then act, it can be more effective to use incomplete knowledge to assess the benefits, costs, risks and opportunities of different policy options and select the 'least worst' of these (Weaver et al. 2013).

Although people often focus on the uncertainty associated with climate models, it is important to note that there is a degree of uncertainty associated with many ecological models as well. For example, the results of species distribution models (SDMs) under both current and future climate conditions can be affected by the choice of statistical model, the environmental variables used, and bias in locality data. In some cases, this uncertainty has been found to be greater than that associated with the climate model or emissions scenario used.

All models are attempting to describe species or community responses to potentially novel future climate conditions, so there is no way to validate the results. However, NRM planners can still use such models effectively to inform decisions about ongoing conservation.

Uncertainty should not incapacitate action. Effective planning and conservation management within such uncertainty require action and adaptive management underpinned by ongoing monitoring to track successes, failures and other changes as they occur. Importantly, it requires an understanding of the pros and cons of available models and tools, so that decisions are well informed. Communication of what is known, such as general trends and impacts, as well as what is less certain, is essential to explain why doing nothing is not an option. Uncertainty can be reduced by only thinking about short time frames, however, this approach may reduce the availability of options for adaptation in the future. A risk-assessment approach which considers both 'worst case' and 'best case' scenarios at a range of time-scales is a more effective way of dealing with uncertainty.

4.5 Implementation, monitoring, evaluation, reporting and review

The final phase requires policy, funding or other resources to create opportunities for implementation, and monitoring, evaluation and review of these. While this work is obviously crucial, it was not undertaken during the project and is therefore not discussed in this guide.

While implementation will often be outsourced to private landowners or contractors for on-ground works such as riparian revegetation or developing landscape connectivity, it is increasingly important to demonstrate outcomes of program investment through monitoring, evaluation and reporting (MER). In its *Portal Report* (Wallis et al. 2015) SCARP provide resources to inform the development of MER systems that support both the ability to deliver and account for outcomes, and to learn from the successes and mistakes of intervention. The latter learning is central to adaptive management, and an imperative for making the best use of scarce resources as well as managing change and dealing with unprecedented transitions and transformations.

5. Conclusion

This report outlines a process for spatial prioritisation for NRM. The authors have attempted to develop a means of efficiently and effectively utilising the growing number of spatial datasets, models and research to inform implementation for NRM outcomes. The process relied of both researchers and NRM planners being resourced to work together, and committing to learning from one another in grappling with ways to address deceptively complex ‘where’ questions. The resulting 5-phase process is not presented here as ‘the answer’. Rather, we hope that by documenting this process and our lessons from it we can provide a platform for future work to develop credible and legitimate approaches to spatial prioritisation that are also efficient and effective.

References

Bryan, B.A., King, D., Ward, J.R., 2011. Modelling and mapping agricultural opportunity costs to guide landscape planning for natural resource management. Ecological Indicators, Spatial information and indicators for sustainable management of natural resources 11, 199–208. doi:10.1016/j.ecolind.2009.02.005

Cash, D.W., Clark, W.C., Alcock, F., Dickson, N.M., Eckley, N., Guston, D.H., Jager, J., Mitchell, R.B., 2003. Knowledge systems for sustainable development. Proceedings of the National Academy of Sciences of the United States of America 100, 8086–8091.

Drielsma, M., Ferrier, S., Howling, G., Manion, G., Taylor, S., Love, J., 2014. The Biodiversity Forecasting Toolkit: Answering the “how much”, “what”, and “where” of planning for biodiversity persistence. Ecological Modelling 274, 80–91. doi:10.1016/j.ecolmodel.2013.11.028

Harris, R.M.B., Grose, M.R., Lee, G., Bindoff, N.L., Porfirio, L.L., Fox-Hughes, P., 2014. Climate projections for ecologists. WIREs Clim Change 5, 621–637. doi:10.1002/wcc.291

Jackson, B., Pagella, T., Sinclair, F., Orellana, B., Henshaw, A., Reynolds, B., Mcintyre, N., Wheater, H., Eycott, A., 2013. Polyscape: A GIS mapping framework providing efficient and spatially explicit landscape-scale valuation of multiple ecosystem services. Landscape and Urban Planning 112, 74–88. doi:10.1016/j.landurbplan.2012.12.014

Jacobs, B., Nelson, R., Kuruppu, N. and Leith, P., 2015. An Adaptive Capacity Guide Book: assessing, building and evaluating the capacity of communities to adapt in a changing climate. Southern Slopes Climate Change Adaptation Research Partnership (SCARP): UTS, University of Tasmania.

Keating, B.A., Carberry, P.S., Hammer, G.L., Probert, M.E., Robertson, M.J., Holzworth, D., Huth, N.I., Hargreaves, J.N.G., Meinke, H., Hochman, Z., McLean, G., Verburg, K., Snow, V., Dimes, J.P., Silburn, M., Wang, E., Brown, S., Bristow, K.L., Asseng, S., Chapman, S., McCown, R.L., Freebairn, D.M., Smith, C.J., 2003. An overview of APSIM, a model designed for farming systems simulation. European Journal of Agronomy, Modelling Cropping Systems: Science, Software and Applications 18, 267–288. doi:10.1016/S1161-0301(02)00108-9

Kriticos, D. J., G. F. Maywald, T. Yonow, E. J. Zurcher, N. I. Herrmann, and R. W. Sutherst. 2014. CLIMEX Version 4: Exploring the effects of climate on plants, animals and diseases. CSIRO, Canberra.

Lechner, A.M., Doerr, V., Harris, R.M.B., Doerr, E., Lefroy, T. (In press, Accepted, 15th April) 2015. thA framework for incorporating fine-scale dispersal behaviour into biodiversity conservation planning. Landscape and Urban Planning

Lesslie, R., 2012. Mapping our priorities–innovation in spatial decision support, in: Figgis, P., Fitzsimons, J.A., Irving, J. (Eds.), Innovation for 21st Century Conservation. Australian Committee for IUCN Inc., Sydney, Australia, pp. 156–163.

MCAS-S development partnership 2014. Multi-Criteria Analysis Shell for Spatial Decision Support version 3.1 User Guide, (No. CC BY 3.0.). Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), Canberra, Australia.

Pelling, M., 2011. Adaptation to Climate Change. Routledge, New York.

Phillips, S.J., Dudík, M., 2008. Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. Ecography 31, 161–175. doi:10.1111/j.0906-7590.2008.5203.x

Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management 90, 1933–1949.

Rudnick, D., Ryan, S., Beier, P., Cushman, S., Dieffenbach, F., Epps, C., Gerber, L., Hartter, J., Jenness, J., Kintsch, J., Merenlender, A., Perkl, R., Perziosi, D., Trombulack, S., 2012. The Role of Landscape Connectivity in Planning and Implementing Conservation and Restoration Priorities. Issues in Ecology. Issues in Ecology.

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.L., Sheil, D., Meijaard, E., Venter, M., Boedhihartono, A.K., Day, M., Garcia, C., Oosten, C. van, Buck, L.E., 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. PNAS 110, 8349–8356. doi:10.1073/pnas.1210595110

Scott, J.K., Webber, B.L., Murphy, H., Ota, N., Kriticos, D.J. and Loechel, B. 2014. AdaptNRM Weeds and climate change: supporting weed management adaptation

Thuiller, W., Lafourcade, B., Engler, R., Araújo, M.B., 2009. BIOMOD – a platform for ensemble forecasting of species distributions. Ecography 32, 369–373. doi:10.1111/j.1600-0587.2008.05742.x

Wallis, P.J., Harwood, A., Leith, P., Hamilton, L., Bosomworth, K., Turner, S.L., Harris, R.M.B. and Bridle, K. 2015 Southern Slopes Information Portal Report: Climate change adaptation information for natural resource planning and implementation. Southern Slopes Climate Change Adaptation Research Partnership (SCARP), Monash University, University of Tasmania, RMIT University.

Weaver, C.P., Lempert, R.J., Brown, C., Hall, J.A., Revell, D., Sarewitz, D., 2013. Improving the contribution of climate model information to decision making: the value and demands of robust decision frameworks. WIREs Clim Change 4, 39–60. doi:10.1002/wcc.202

Wintle, B.A., 2008. A review of biodiversity investment prioritization tools. ., A report to the Biodiversity Expert Working Group toward the development of the Investment Framework for Environmental Resources.

For more information about SCARP please go to:

http://www.climatechangeinaustralia.gov.au/en/impacts-and-adaptation/southern-slopes/

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