



Aquatic refuge MCAS-S Datapack for the Tasmanian Midlands

*A worked example of using the MCAS-S tool for addressing aquatic
questions in the Tasmanian Midlands*

REPORT – PRE-PRINT VERSION

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Aquatic MCAS-S Datapacks from the Landscapes and Policy Hub.

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The aim of this users' guide is to describe the datapack and provide detailed instructions on how the spatial data can be integrated with MCAS-S software for decision support. The instructions take the form of a worked example. You will need to download and install MCAS-S software to your desktop. The worked examples then step you through using MCAS-S and how to open an MCAS-S package to combine layers. This guide is not intended to be a comprehensive guide to using MCAS-S, nor to replace the program-specific user-guide. For more detailed information on how to use MCAS-S, including how to prepare spatial data for MCAS-S, please see the ABARES website - <http://daff.gov.au/ABARES/Pages/data/mcass.aspx> and User Guide (ABARES 2014). The report is an output of the Landscapes and Policy Research Hub.

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Glossary	
ABARES	Australian Bureau of Agriculture and Resource Economics and Sciences
Information Panel	Left-hand panel in MCAS-S used to edit maps.
Input layer	Data layer contained within the Primary folder of an MCAS-S project.
Integrated data layer in MCAS-S	Any layer that combines data from >1 layer.
Mask	A type of data layer used in MCAS-S to restrict analyses (integration of maps) to a defined area.
MCAS-S	The Multi-Criteria Analysis Shell for Spatial Decision Support is a decision support tool designed specifically for non-GIS users to integrate spatial data
MCAS-S Datapack	A series of folders and data layers organised and formatted ready for use in an MCAS-S project.
Overlay	A type of data layer used in MCAS-S as a visual reference. Overlays do not influence any calculations occurring in integrated maps.
River-section	Internodal reach of a drainage network. See Figure 1.
River-section catchment	Local-scale catchment of a river-section i.e. the drainage basin supplying surface flows direct to that river-section but excluding the drainage basin for all upstream river-sections. See Figure 1.
Tip file	A small metadata record used to describe data layers exported from MCAS-S.
Upstream catchment	Total catchment area upstream of an arbitrary point e.g. the location of a field site
Viewer window	A pop-up window within in MCAS-S that shows the value of a pixel in a map plus values of all input layers to that map upon mouse hover over the pixel of interest. The viewer opens by default but if closed can be opened via the Edit tab.

Illustration of river and catchment components

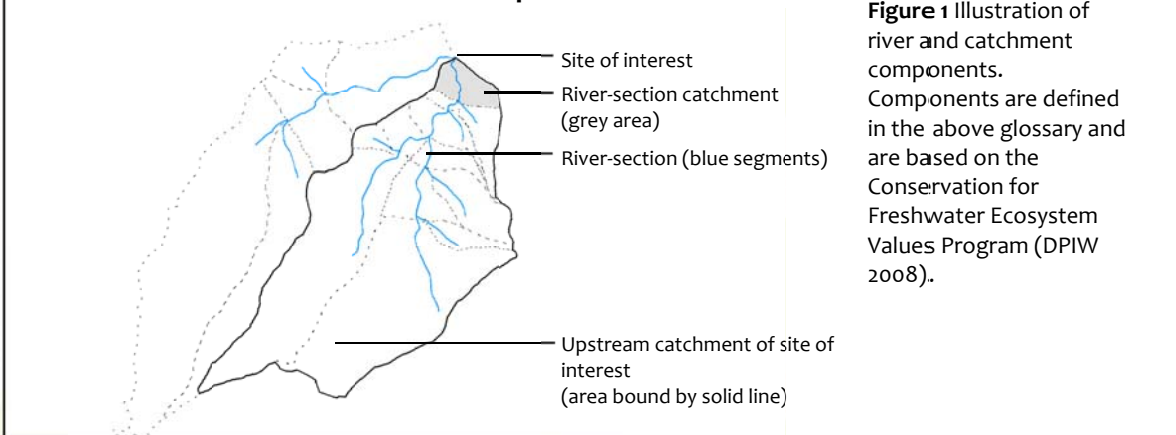


Figure 1 Illustration of river and catchment components. Components are defined in the above glossary and are based on the Conservation for Freshwater Ecosystem Values Program (DPIW 2008).

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1.0 The Freshwater Environment

The health or condition (ecological state) of aquatic ecosystems (rivers, lakes and wetlands) is a combined result of processes within the ecosystem and in the surrounding catchment (terrestrial environment). Land-use, catchment integrity, riparian vegetation condition, surface and groundwater, geology and the intensity and frequency of disturbances all play a significant role in determining the structure of the physical environment of aquatic ecosystems and therefore, have a significant effect on aquatic biodiversity and the functioning of ecosystems such as rivers.

Making decisions about how to manage aquatic ecosystems in a changing climate is thus challenging because variation in climate can influence aquatic ecosystem condition via multiple pathways, many of which are poorly understood and indirect. Long-term changes in rainfall directly influence aquatic ecosystems through variation in surface run-off, sedimentation and erosion, but also indirectly impact aquatic ecosystems through, for example, changes in land and water management, tree growth and/or groundwater recharge.

1.1 The MCAS-S Tool

The Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S), developed by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) is a decision support tool designed specifically for non-GIS users to integrate spatial data.

The tool is free and users require little training to combine spatial data and assess results. It therefore has the potential to be a very useful decision support tool for aquatic ecosystem management because a range of spatial data can be easily integrated to explore potential futures or the effects of management decisions, even in workshop situations when data may be incomplete and decision-making is by consensus. Here we show how we used the tool to explore spatial variability in the projected effects of climate change on rivers of the Tasmanian Midlands.

1.2 The Aquatic refuge MCAS-S Datapack for the Tasmanian Midlands

This users' guide and data package includes a MCAS-S datapack containing spatial data that can be used to identify river sites least likely to experience high summer water temperatures and therefore may act as refuge from future changes in climate. The datapack consists of spatial data in a form that can be readily opened using MCAS-S software, and a worked sample of an MCAS-S query (known as an MCAS-S 'project') that shows how the spatial data can be combined to support decision-making. The aim of this users' guide is to describe the datapack and provide detailed instructions on how the spatial data can be integrated with MCAS-S software for decision support. The instructions take the form of a worked example. You will

need to download and install MCAS-S software to your desktop. The worked examples then step you through using MCAS-S and how to open an MCAS-S package to combine layers.

This guide is not intended to be a comprehensive guide to using MCAS-S, nor to replace the program-specific user-guide. For more detailed information on how to use MCAS-S, including how to prepare spatial data for MCAS-S, please see the ABARES website - <http://daff.gov.au/ABARES/Pages/data/mcass.aspx> and User Guide (ABARES 2014).

Installing MCAS-S Software

To use the datapack, you need to download and install the free MCAS-S software onto your computer.

1. Go to MCAS-S home page: www.abares.gov.au/mcass
2. Go to the right-hand side menu and click on **MCAS-S Tool**
3. A new page opens with two download options –
 - a. MCAS-S Version 3.1 installer (150MB)
 - b. MCAS-S Version 3.1 user guide (10MB)
4. Download the (a) installer (arrives zipped) then unzip. If you are new to MCAS-S, also download the MCAS-S user guide.
5. Once downloaded, follow prompts to install (requires 'Quicktime' to also be installed)
6. Register as a user

Unzip the MCAS-S Datapack

Before you start playing with our worked example, the next step is to extract the datapack from its zipped folder (right-click and unzip). If the datapack isn't unzipped correctly, MCAS-S will not be able to upload the spatial data and a red cross will appear in each map box instead of a map.

Now you are right to go!

Worked Example: Mapping potential refuges from high summer river temperatures in the Tasmanian Midlands

2.0 About the Worked Example

This worked example steps you through how you might use MCAS-S to consider a query for mapping potential refuges from high summer river temperatures in the Tasmanian Midlands. We provide background information about the issue, sketch out the essential ‘means-to-end’ diagram, and then take you through a data combining exercise.

3.0 The Northern Tasmanian Midlands Bioregion

The Northern Midlands Bioregion as defined by the Interim Biogeographic Regionalisation for Australia (IBRA; Department of Environment 2012) is bounded to the west by Tasmania’s Western Tiers and to the east by the Eastern Tiers and the Ben Lomond Plateau. The region comprises lowland plains. Most of the area falls within the catchments of the Macquarie and South Esk rivers, but the area also overlaps with the Meander, Tamar estuary, Brumbys-Lake and North Esk catchments (Figure 2).

The region is largely comprised of privately owned land with a history of grazing for wool dating back to the 1820s. Wool continues to be the largest enterprise in the region (Mooney et al. 2010), however production has diversified to include cropping. The region is currently undergoing a period of irrigation development that will result in a greatly expanded region of irrigated cropping, including improved pasture for dairy farming and poppies. The historic land-use has resulted in a number of conservation issues, including fragmentation of remnant and riparian vegetation and rural tree decline (Mooney et al. 2010).

In the upper parts of each of the midlands’ catchments, but outside of the bioregion, land-use is dominated by forestry (production and plantation) and land identified as ‘minimal use’ (forests, remnant vegetation and native grasslands; Figure 2. Data source: Brown 2009, Tilyard 2010, NRM Cradle Coast et al. 2012). These areas are likely to have a significant influence on the health of the rivers located within the bioregion because they make up a large proportion of total catchment area. For this reason, the spatial data supplied with this data package, and the maps and analyses presented, use the catchment boundaries rather than the bioregion boundary (Figure 2).

Map of the Tasmanian Northern Midlands bioregion

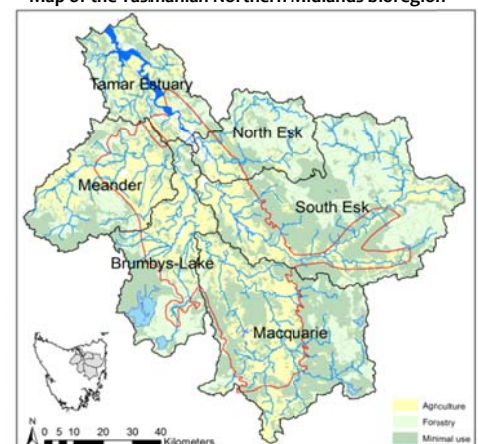


Figure 2 Map of the Tasmanian Northern Midlands bioregion (v.7; red) and catchments overlapping the region (black). Map includes Land-use (NRM Cradle Coast et al. 2012) and major waterways. Bioregion data from the Australian Government Department of the Environment all other base layers are from the CFEV database (2005) and theLIST Hydrography Dataset © State of Tasmania.

4.0 Aim

Climate projections from the Climate Futures for Tasmania project suggest that Tasmanian rivers are likely to experience increases in summer temperature that will severely impact aquatic biodiversity, including fish and macroinvertebrates (Barmuta et al. 2013). While the rise in ambient temperatures is likely to be state-wide, local and catchment-scale features can protect rivers from experiencing similar rises in water temperature and thus have the potential to create locations that act as refuge for aquatic organisms during summer periods.

This MCAS-S Datapack can be used to identify river locations that could act as climate refuges by integrating spatial data on the location of landscape features that may influence river temperatures.

The types of spatial data considered for the analysis included topographical features, groundwater inflows, tree cover, solar radiation and enhanced flows associated with climate change or shandyng for irrigation (transport of irrigation water along natural waterways). Data on land tenure/protection and biological condition are also included for the purpose of prioritising refuges.

5.0 Input data layers

A complete list of input data layers available for analysis are shown in Table 1. The input layers are grouped into four refuge types:

- Thermal buffers – Potential refuge locations from high summer temperatures due to landscape position or the presence of biophysical features (including groundwater inflows) that prevent or reduce increases in river temperature.
- Hydrological stability– Potential refuge locations from high summer temperatures due to enhanced river flows associated with climate change or irrigation development. Enhanced flows will reduce oxygen stress associated with high water temperatures.
- Protection/tenure – Potential refuge locations from intensification of land-use including land clearing that may impact existing refuges.
- Biological condition – Indicator of existing refugia. This data can also be used to prioritise potential refuges identified from above data sources for example to indicate whether a potential refuge is currently in good condition or whether some form of restoration would be required for the refuge to be functional.

The data in each of these input layers is binary; '1' for grid cells that meet the refuge criteria outlined in Table 1 and '0' for grid cells that do not meet the criteria. Justification for each criterion are provided in Table 1.

Table 1 Base data layers available for the Tasmanian Midlands refuge analysis.




Data layer	Refuge type	File name/s	Source	Refuge description	Refuge criteria	Justification
Solar radiation (SRAD)	Thermal buffer	SRAD	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Areas where average net radiation (1981-2006) for 4 warmest months of the year (Dec-Mar) is low.	Net radiation \leq 14.5 MJ.m ⁻² .d ⁻¹ .	A cut-off of 14.5 captured known shady gullies. However, this was an arbitrary decision since no data exist to support this criterion or any other.
Groundwater dependency	Thermal buffer	Grndwater	Bureau of Meteorology and National Atlas of Groundwater Dependent Ecosystems	Areas where vegetation greenness during dry years suggests groundwater inflows are likely.	Categories \geq 6.	Categories \geq 6 indicate some level of groundwater inflow. However, this is an arbitrary decision since no data exist to support this criterion or any other.
Groundwater dependent ecosystems	Thermal buffer	GDEs	Conservation of Freshwater Ecosystem Values project, DPIPWE CFEV database v1.0 2005. 	Known groundwater dependent ecosystems	River-section catchments containing known groundwater dependent ecosystems.	Groundwater inflows are likely to occur where groundwater ecosystems are present.
Local-scale riparian vegetation condition	Thermal buffer	RipVegLocal	Conservation of Freshwater Ecosystem Values project, DPIPWE CFEV database v1.0 2005. 	River-section catchments with a high proportion of native vegetation in the riparian zone (50m wide).	Proportion of native vegetation $>$ 0.80.	Based on ecosystem metabolism data collected in Tasmania: Magierowski et al. 2010, Davies et al. 2012.
Catchment-scale riparian vegetation condition	Thermal buffer	RipVegCatch	Conservation of Freshwater Ecosystem Values project, DPIPWE CFEV database v1.0 2005. 	River-section catchments with a high proportion of native vegetation in the riparian zone (50m wide) of the entire upstream catchment.	Proportion of native vegetation $>$ 0.80.	Based on ecosystem metabolism data collected in Tasmania: Magierowski et al. 2010, Davies et al. 2012.

Table 1 Base data layers available for the Tasmanian Midlands refuge analysis.


Data layer	Refuge type	File name/s	Source	Refuge description	Refuge criteria	Justification
River slope	Thermal buffer	Slope	Conservation of Freshwater Ecosystem Values project, DPIPWE CFEV database v1.0 2005. 	River-section catchments containing river channels with high degree of slope (vertical drop/river-section length).	River slope ≥ 0.04 .	Personal observation P.E.Davies, see also Magierowski et al. 2010
Projected hydrological conditions for macroinvertebrates	Hydrological stability	bugs_h_cs39 bugs_h_cs69 bugs_h_uk39 bugs_h_uk69	LaP Freshwater ecosystems and National Climate Change Adaptation Research Facility (NCCARF)	Location of river sections that will experience an increase in flows beneficial to biota under climate change & current water management rules including Tasmania Irrigation (2 climate models, 2 time periods)	Mean projected hydrological change for macroinvertebrate < 0	As defined by Barmuta et al. 2013
Projected hydrological conditions for native fish	Hydrological stability	fish_h_cs39 fish_h_cs69 fish_h_uk39 fish_h_uk69	Freshwater ecosystems project, Landscapes and Policy Hub	Location of river sections that will experience an increase in flows beneficial to biota under climate change & current water management rules including Tasmania Irrigation (2 climate models, 2 time periods)	Mean projected hydrological change for fish < 0	As defined by Barmuta et al. 2013
Projected hydrological conditions for riparian vegetation	Hydrological stability	ripveg_h_cs39 ripveg_h_cs69 ripveg_h_uk39 ripveg_h_uk69	Freshwater ecosystems project, Landscapes and Policy Hub	Location of river sections that will experience an increase in flows beneficial to biota under climate change & current water management rules including Tasmania Irrigation (2 climate models, 2 time periods)	Mean projected hydrological change for riparian vegetation < 0	As defined by Barmuta et al. 2013
Projected river temperatures	Thermal buffers	MaxT_cs39 MaxT_cs69 MaxT_uk39 MaxT_uk69	National Climate Change Adaptation Research Facility (NCCARF)	Areas projected to experience increased summer temperatures that are less likely to impact macroinvertebrates and fish. (2 climate models, 2 time periods).	Summer maximum temperatures $< 25^{\circ}\text{C}$	As defined by Barmuta et al. 2013

Table 1 Base data layers available for the Tasmanian Midlands refuge analysis.




Data layer	Refuge type	File name/s	Source	Refuge description	Refuge criteria	Justification
Riparian reserves	Protection/tenure	RipReserves	Department of Primary Industries, Parks, Water and Environment (DPIPWE)	Vegetated areas where riparian zone is protected under the Forest Practices Act.	Reserved land only	All riparian areas protected under the Forest Practices Act are included.
Reserves	Protection/tenure	Reserves	Department of Primary Industries, Parks, Water and Environment (DPIPWE)	Land area identified as reserved in the Tasmanian Reserve Estate Layer 2008.	Reserved land only	All reserves included.
Naturalness score	Biological condition	Naturalness	Conservation of Freshwater Ecosystem Values Program, DPIPWE CFEV database v1.0 2005. 	Areas with a high overall naturalness score in the Conservation of Freshwater Ecosystem Values database.	"NSCORE" >0.85	Highest condition category within the CFEV database for this variable. (DPIW 2008)
Aquatic invertebrate community condition	Biological condition	BugCond	Conservation of Freshwater Ecosystem Values Program, DPIPWE CFEV database v1.0 2005. 	Areas with a high macroinvertebrate condition score in the Conservation of Freshwater Ecosystem Values database.	"BUGCO"=1	Highest condition category within the CFEV database for this variable. (DPIW 2008)
Native fish community condition	Biological condition	FishCond	Conservation of Freshwater Ecosystem Values Program, DPIPWE CFEV database v1.0 2005. 	Areas with a high fish condition score and a low probability of exotic fish occurrence in the Conservation of Freshwater Ecosystem Values database.	"FISHCON"=1 and "EXOTICF">/= 0.65	Highest condition category within the CFEV database for this variable. (DPIW 2008)

Table 1 Base data layers available for the Tasmanian Midlands refuge analysis.

Data layer	Refuge type	File name/s	Source	Refuge description	Refuge criteria	Justification
River-section catchments containing <i>Galaxias fontanus</i> (swan galaxias)	Biological condition	fontanus	Tasmanian Inland Fisheries Service (IFS)	Location of existing populations of <i>Galaxias fontanus</i> . This species is unlikely to disperse from these locations thus refuge for this species cannot exist outside these locations without translocation.	Upper and lower boundaries of all known <i>G. fontanus</i> populations (natural and translocated)	All populations included therefore no arbitrary decision made.
Projected eucalypt cover	Thermal buffer	euccover_cs69 euccover_uk69	Vegetation and Fire project, Landscapes and Policy Hub	Projected change in eucalypt tree cover (%), (2 climate models, 1 time period).	River-section catchments expected to experience an increase in percent eucalypt cover under climate change.	Arbitrary decision made to include only areas projected to show an increase in eucalypt cover. No data exist to support this criterion or any other.

6.0 Means-to-End Diagram

A means-to-end diagram is the important first step in scoping out the problem you are trying to consider. The means-to-end diagram shows how the input layers relate to one another and how they will be combined.

Our means-to-end diagram in Figure 3 shows how the different input layers can be combined in an MCAS-S analysis for identifying aquatic refuges in the Tasmanian Midlands. This is the design described in this worked example described below and is available for download (see sections 8.0).

We recommend that a means-to-end diagram be completed for any MCAS-S analysis to ensure model structure is appropriate to the project aims. Within MCAS-S, each of the boxes in Figure 3 is a stand-alone map that can be exported to GIS or Google Earth™ or saved as an image.

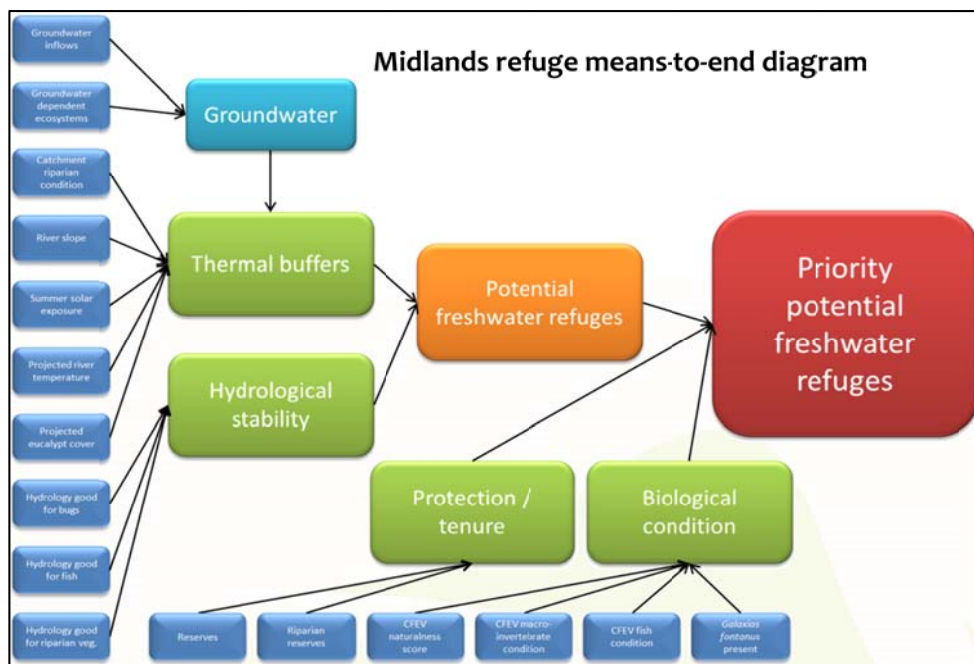


Figure 3 Means-to-end diagram for the Tasmanian Midlands refuge model, analysis and datapack. Dark blue boxes represent the input nodes and all other boxes represent different levels of spatial data integration. The red box represents the final integrated product, a map illustrating the location of highest priority potential refuges.

7.0 The MCAS-S package structure

The Aquatic Refuge MCAS-S Datapack for the Tasmanian Midlands consists of two MCAS-S project files and a set of three MCAS-S data folders. The project files are Midlands.mcas and Midlands_blank.mcas. Midlands.mcas contains the completed worked example described in this document. Midlands_blank.mcas contains links to the data used in the worked example but the workspace is blank so that users can select and combine the layers from scratch.

The three data folders are Data, History and KML (see Table 2). The 'Data' folder contains all of the input data layers necessary for the Tasmanian Midlands climate refuge analysis. The 'Data' folder includes four sub-folders: Primary, Classified, Overlay and Mask. Most of the input data layers for this analysis are located in the 'Primary' sub-folder. We have also added some useful overlays and masks to their respective sub-folders. Some folders are initially empty but these should not be deleted as MCAS-S will write to these folders for various operations.

Table 2 MCAS-S folder structure and descriptions (adapted from MCAS-S User-Guide; ABARES 2014)

Level 1	Level 2	Description
Data	Primary	Gridded input layers for each refuge type: Thermal buffers, hydrological stability, protection/tenure and biological condition.
	Classified	Gridded data exported from MCAS-S by user (initially empty).
	Overlay	Line or point data used for visual reference only: Catchments and major rivers.
	Mask	Gridded data used to restrict the area of analysis: combined area of 6 midlands catchments.
History		Cached project files (initially empty).
KML		GoogleEarth™ (*.kml) files exported from MCAS-S ¹ (initially empty).

8.0 Details of the worked example

To gain the most from the worked example, open the MCAS-S file in your unzipped folder, and follow what we do in the text by having a play on the MCAS-S screen.

Open the file: Midlands.mcas

¹ Note at time of publication there was a maximum resolution (1000*1000 cells) for viewing MCAS-S layers in Google Earth™. To view files at a finer resolution in Google Earth™ the user must export the layer from MCAS-S and convert to *.kml in an alternative application. Google Earth™ will render a lower resolution version but this might not adequately represent some maps.

8.1 Input data layers

The file Midlands.mcas contains a worked example using most of the input layers provided in the Aquatic Refuge MCAS-S Datapack (Figure 4). This worked example is based on the model structure shown in the means-to-end diagram in Figure 3.

The input layers are arranged around the outer edges of the screen and are the smallest maps shown. Each input layer has two categories: 'o' (light grey) for areas that do not meet the threshold criteria for refuge (see Table 1) and '1' (dark grey) for areas that do meet the threshold criteria for refuge.

The datapack contains multiple versions of any input layer based on projected changes in climate (projected river temperatures, projected eucalypt cover, and projected hydrology for macroinvertebrates, fish and riparian vegetation). This is because the projections were obtained from the Climate Futures for Tasmania project which generated projections using a number of global climate models and times (see Corney et al. 2010). The default projections used for each of these layers in the worked example are from the CSIRO-Mk3.5 global climate model for the time period 2040-2069. Other projections available in this datapack are CSIRO-MK3.5 (2010-2039), UKMO-HadCM3 (2010-2039) and UKMO-HadCM3 (2040-2069). Users can replace these layers with other versions and instructions are detailed below.

The Climate Futures for Tasmania project showed that the CSIRO-Mk3.5 global climate model tends to forecast dryer conditions for Tasmania than the other global climate models and the time period 2040-2069 was projected to experience the effects of climate change more dramatically than the period 2010-2039. Therefore, the default version of the Tasmanian Midlands MCAS-S model shows the most extreme of the projected changes in climate for the region.

For more information about global climate models and the projections of the Climate Futures for Tasmania project see Corney et al. (2010).

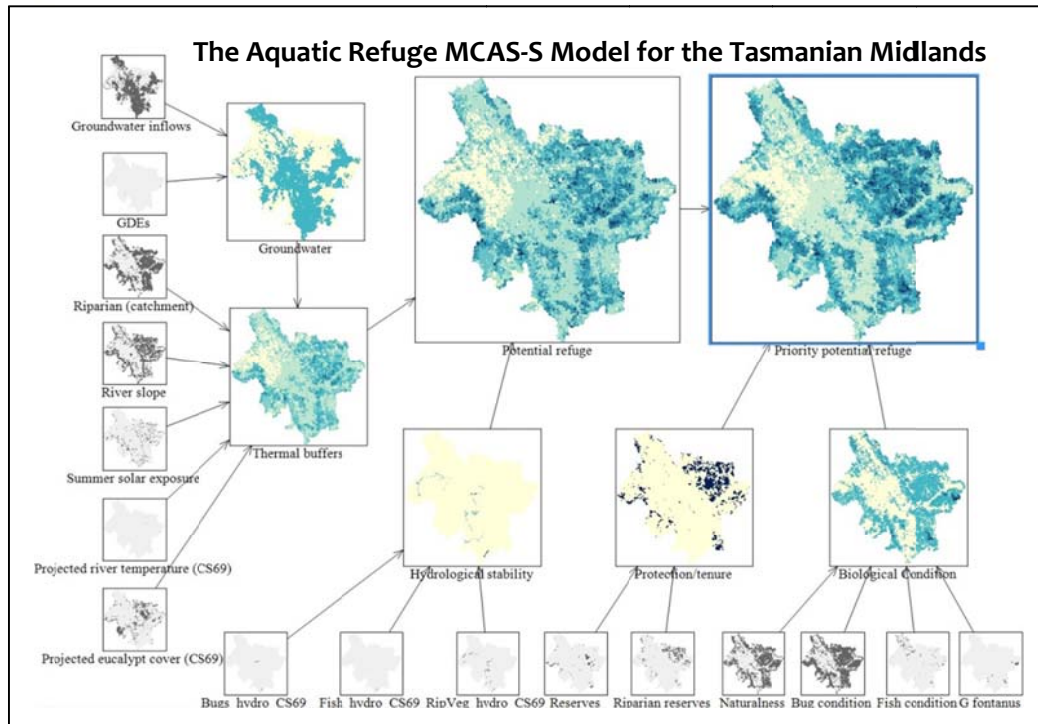


Figure 4 Image of the Aquatic Refuge MCAS-S Datapack model for the Tasmanian Midlands. Input layers are monochrome; dark grey indicates areas that meet the refuge criteria values outlined in Table 1. The integrated layers use different shades of blue to illustrate the degree of overlap of the dark-grey areas in the input layers and thus indicate the relative potential that an area may function as an aquatic refuge (darker blue=higher relative potential, yellow = no overlap as none of the layers meet their refuge criteria values).

Familiarise yourself with the different input layers by clicking on each individually and then viewing information about the number, colours and titles of different states within the map layer in the left-hand information panel (Figure 5). At this point it will also be useful to view the information about the different input layers in Table 1.

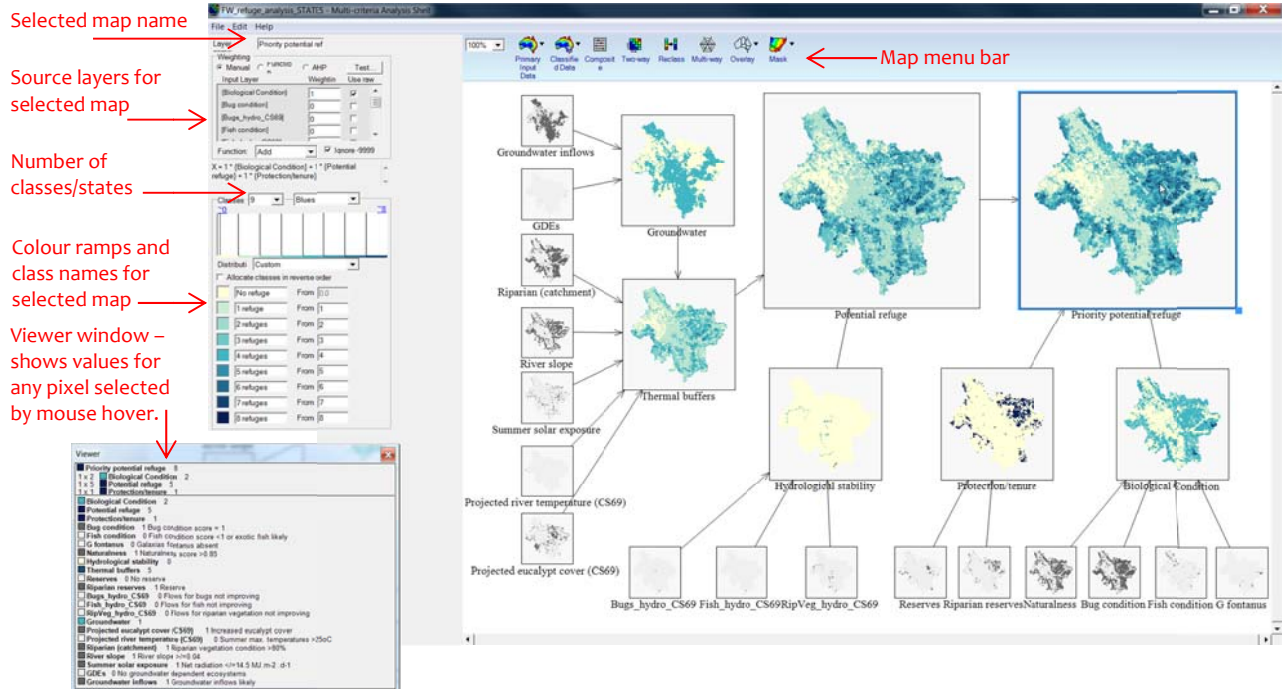


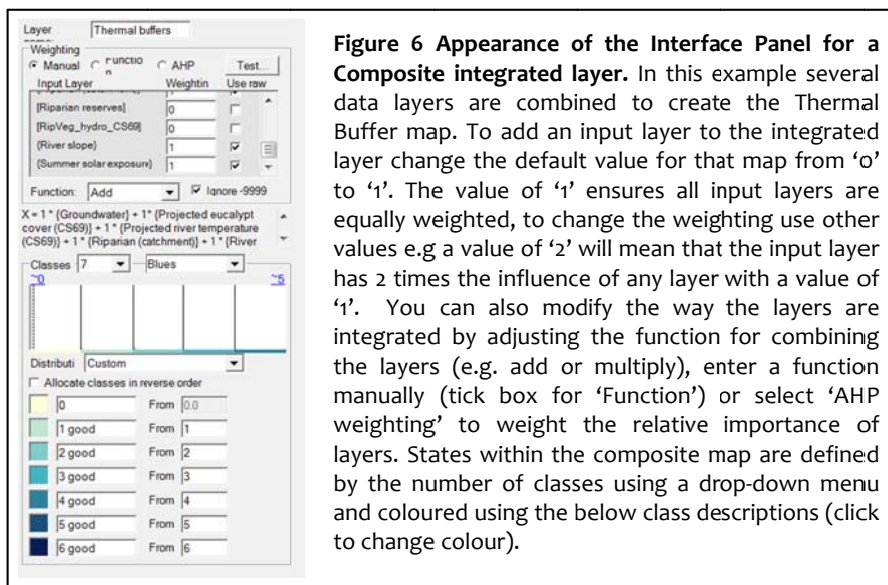
Figure 5 Layout of the graphical user interface of MCAS-S. Layers are shown in the right-hand side workspace and can be modified using options available in the left-hand side interface panel. Select the layer of interest (here ‘Priority potential refuge’) and available options will appear in the interface panel. A mouse hover over a pixel of interest will result in the Viewer Window displaying the names and values of the pixel in the selected layer and in any layer used in the calculation of the selected layer.

8.2 Integrated data layers

Any layer that combines data from more than one layer is considered an integrated data layer. In this worked example all of the integrated data layers use a blue colour scheme: darker regions indicate locations that meet a higher number of the refuge criteria (Table 1). The integrated layers were all created using the ‘Composite’ tool on the map menu bar. We used a very simple rule set to integrate data layers. All input layers were weighted equally in each integrated layer such that the value for a given pixel in each integrated layer is equal to the number of input layers that meet the refuge criteria for that pixel (Figure 6). Within MCAS-S, a mouse hover over a pixel of interest on an integrated layer will result in the Viewer Window displaying the names of the layers that meet the refuge criteria for that pixel.

There are five intermediate integrated layers in our worked example (Groundwater, Thermal buffers, Hydrological stability, Protection/tenure, Biological condition; Figures 3 & 4). These may be of interest to users wanting to know more about particular types of refuge, for example features that buffer river temperatures versus locations projected as hydrologically stable.

The two larger integrated data layers, the ‘Potential refuge’ and ‘Priority potential refuge’ data layers, are the main outputs from this MCAS-S worked exercise and are described in detail below.



8.3 Potential refuges

The 'Potential refuge' layer combines the 'Thermal buffers' and 'Hydrological stability' layers and thus combines the data from the 10 input layers that can be described as refuge locations from high summer temperatures due to the presence of physical features and/or good river flows. This layer does not include data on land tenure or biological condition, thus locations may require restoration or protection to be functional as refuge for aquatic organisms.

8.4 Priority potential refuges

The 'Priority potential refuge' layer integrates the 'Potential refuge' layer with data layers on land tenure and biological condition to identify locations that have high refuge potential but are also in good biological condition and are currently protected, that is the refuge is unlikely to be impacted by changes in land-use.

A likely modification to our worked example would be to change how the reserve layers are weighted in the prioritisation. Land managers may be more interested in prioritising unreserved land over reserved land (rather than the reverse). This would be useful for example for prioritising locations for private land conservancy. To make this change to the worked example:

- 1) click on the 'Protection/tenure' (intermediate) layer and on the left-hand side of the MCAS-S interface switch the 'Weighting' from 'Manual' to 'Function',
- 2) select 'Edit'. In the Function Editor enter the following formula – "iif ((1 * {Reserves} + 1 * {Riparian reserves}) < 1, 1, 0)" excluding quotation marks and select 'Raw' rather than 'Classified' variables (see Figure 7).



- 3) then press OK. The formula will give all pixels outside of reserves and riparian reserves a value of '1' and all other pixels a value of '0'.
- 4) You can compare the original weighting and the formula you just entered by toggling between 'Manual' and 'Function'. MCAS-S will remember the formula you entered under 'Function'.

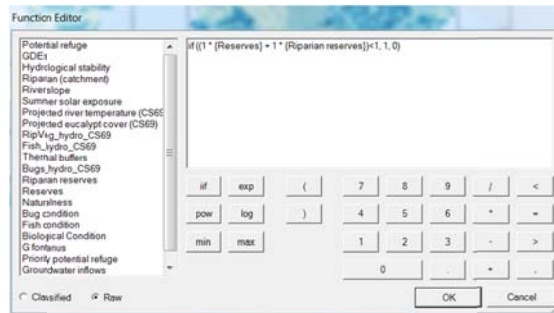


Figure 7 Using the Function Editor to combine data layers.

8.5 Overlays and Masks

The Aquatic MCAS-S Datapack contains a number of overlay and mask files.

The overlay layers included are catchments and rivers, these can be added to the maps displayed on screen and are a useful visual reference. The catchments and rivers are defined by and were sourced from the Conservation and Freshwater Ecosystem Values Program (DPIW 2008 and theLIST Hydrography Dataset, © State of Tasmania). Overlays do not influence any of the calculations occurring in the model. Any line or point data can be added to the overlay folder and viewed in MCAS-S, however it is important that the projection of this data matches the projection of the raster layers in our datapack (GDA1994; see also Appendix 1).

A single mask layer has been included in the datapack, 'mid_mask'. This mask restricts any analyses to the six catchments overlapping with the Tasmanian Midlands Bioregion (See Figures 2 & 4). The midlands mask is active in the default version of our datapack. We did this because the extent of all of the data layers included in the datapack covers the entire state of Tasmania. The mask restricts the map windows to just this area we are interested in (that is, it makes MCAS-S zoom (or mask) to the area of interest). The layers in this datapack cover the entire state so that they are fully compatible with other MCAS-S layers produced for Tasmania (by the Landscapes and Policy Hub, and also by state government departments and natural resource managers). To remove this mask and show the full extent of the data layers – select the “Mask” tab on the Map menu bar and then uncheck the box for “mid_mask\Region 0”.

8.6 Modifying state thresholds, number of states, or layer colour scheme

Clicking on any layer within the worked example will open a box on the left-hand Information Panel to show details about that layer (Figure 5 & 6). Many of the options within the information panel can be altered including the layer name, colour scheme, the number, limits and colour of classes and the names of the categories or classes within each layer.

8.7 Modifying Integrated layers

There are several options within MCAS-S for integrating layers. Details for how to alter these options can be found in the MCAS-S User Guide (See Section 6: Explore and combine data; ABARES 2014).

In the aquatic refuge worked example, the input layers all have two categories ('0' or '1'). The easiest way to increase the influence of a layer on the final integrated layers ('Potential refuge' and 'Priority potential refuge') is to replace the number 1 with a higher number. The higher the number the greater the influence on the final integrated layers. Other ways of modifying the final result are to:

- Delete layers - right click, then delete. Note you cannot undo a delete! You'll need to drag the map back in from the Primary Input Data tab if you make an error.
- Change the input layers for an existing integrated data layer – Modify connections by changing the input layers on the Information Panel or by modifying how the layers are integrated (by selecting and completing either 'Manual', 'Function' or 'AHP weighting' (Figure 6)).
- Add layers from the primary folder – Click and drag layers from the 'Primary Input Data' tab.
- Create new integrated layers- Click and drag from either the 'Composite', 'Two-way', 'Reclass' or 'Multi-way' tabs to create a new blank map. Create connections by selecting input layers on the Information Panel. Note in the worked example all integrated layers were created using the Composite tool.

8.8 Exploring the results from other climate models or time periods

The default version of the worked example Midlands.mcas uses climate projections based on the CSIRO-Mk3.5 global climate model for the time period 2040-2069. The layers incorporating these projections are 'Projected river temperature (CS69)', 'Projected eucalypt cover (CS69)', 'Bugs_hydro_CS69', 'Fish_hydro_CS69' and 'RipVeg_hydro_CS69'. In each 'CS69' refers to the model (CS=CSIRO-Mk3.5) and time period ('69' = 2040-2069).

To change the climate model or time period:

1. Use 'Save as' to save your project under a new name. This will allow you to look back at the original project to ensure that you integrate layers correctly and compare results.



2. Delete the five layers carrying the code CS69 (right click, then delete).
3. Click the Primary data tab and then the folder for the climate model and time period of interest.
4. Drag and drop all layers within the folder (note there are no data for eucalypt cover for the time period 2010-2039, so this layer cannot be incorporated into the analysis for refuges for this time period). As you drop each layer into the workspace you will need to enter some information about the layer. This information is exactly the same for all layers in the Tasmanian Midlands datapack and is:
 - a. In the pop-up window for 'Layer Data Format' select 'Categorical'.
 - b. In the Information Panel change 'Type' to 'Numerical'.
 - c. In the Information Panel enter '0' in the box next to "category 0"
 - d. In the Information Panel enter '1' in the box next to "category 1". Note some layers will not have this category, indicating that there are no refuges as defined by the criteria in Table 1 for this climate projection.
 - e. At this point, you can also change the 'Layer' name and the names used for 'category 0' and 'category 1' by replacing the default options.
5. You can resize the new windows manually by clicking on the bottom right-hand corner and dragging or by using a shift-click to select all new layers plus one of the target size and in the Information Panel choose 'Shrink to smallest' or 'Expand to largest'.
6. You now need to connect all of the replacement layers with the appropriate integrated layers.
 - a. Click on the 'Thermal buffers' integrated layer then in the Information Panel scroll down the list of 'Input Layers' (they are in alpha order) and find your new layers; for each enter a 'Weighting' of '1' and check the 'Use raw' option.
 - b. Similarly, for the 'Hydrological stability' integrated layer change the weighting and 'Use raw' check-box for your new layers.

8.9 Modifying or creating new input layers for MCAS-S

We highly recommend that you attend an MCAS-S training workshop or consult with a GIS expert before attempting to modify or create new input layers.

All of the input layers have been created from existing resources, and converted as outlined in Table 1, and according to the best available ecological information. Modifying or creating new input layers will require some GIS expertise. The original layers must be obtained from the source outlined in Table 1, converted to raster format and modified so that they have the same projection and extent as the data layers within this datapack. The easiest way to do this is to create the raster and set the environment settings to those of the raster contained within the

'Mask' folder for this datapack (mid_mask). The settings for the layers in the datapack are also outlined in Appendix 1. Areas of no data must be set to a value of '-9999'.

8.10 Viewing results

Larger versions of your input and integrated data layers can be viewed simply by double-clicking on the layer of interest or by adjusting the zoom function in MCAS-S. You can also export layers for use in other applications. The available options for exporting are accessed via a right-click on the layer of interest and include:

1. Show in Google Earth: Note at time of publication there was a maximum resolution (1000*1000 cells) for viewing MCAS-S layers in Google Earth™. To view files at a finer resolution in Google Earth™ the user must export the layer from MCAS-S (see 3 below) and convert to *.kml in an alternative application. Google Earth™ will render a lower resolution version but this might not adequately represent some maps.
2. Save image: Allows you to save the map, legend and/or histogram of the layer of interest.
3. Export: Creates a GEOTIFF or ASCII file of the layer and saves it to the Data\Classified folder. This procedure requires the creation of a small metadata file known in MCAS-S as a tip file. See Appendix 2 for details on completing a tip file metadata record.

9.0 Biological conclusions from the worked example

9.1 What we did

We developed the Aquatic Refuge MCAS-S Datapack for the Tasmanian Midlands to identify potential refuge locations for aquatic biota from short-term summer temperature maximums.

We included information on groundwater inflows, riparian condition, river slope, solar exposure and river flow projections based on climate modelling and current water management rules including Tasmanian Irrigation allocations.

Our approach to analysis was to classify each input layer into locations that potentially provided refuge and those that were unlikely to according to the best available ecological knowledge.

We then integrated the layers using very simple rules; each refuge location was equally weighted in the final map of potential refuges. We inferred that a location was more likely to offer refuge to aquatic fauna if it had more features likely to provide refuge.

9.2 What it told us

The majority of the high refuge potential locations occurred in the upper parts of the five catchments and in areas often described as shady gullies with groundwater flows. These

locations tended to be publically owned for forestry or reservation. On flatter land dominated by private land ownership for agriculture, a few locations of good catchment-scale riparian condition were identified. However, for much of the area the only buffer to increased summer maximums under climate change was groundwater inflows. Groundwater inflows themselves are influenced by future rainfall and are likely to decline under changing climate. We note also that the groundwater data used in our datapack is inferred from remote sensing (satellite) data. Actual groundwater inflows have not been measured in sufficient detail across the region to be used in this analysis. Further research is required to validate whether these inferred flows reflect actual inflows into rivers that benefit biota.

The most striking result from the potential refuge map produced was that a large proportion of the land area within the Meander River catchment did not have a single feature that might act to buffer river temperature increases. For the rest of the Tasmanian Midlands, much of the land area either had some potential for groundwater inflows and/or good riparian tree cover on smaller watercourses.

9.3 Hydrological stability

Another finding was the lack of locations meeting the criteria for hydrological stability (improved flows for biota under climate change and current water management rules). This integrated map layer identified very few locations and thus had little impact on the final map of potential refuges. Through careful observation of the data used to create the input layers (unpublished data), we observed that these projected flow improvements were largely a result of shandying of water for irrigation rather than changes in climate. These model projections are based on water allocations and do not guarantee that the water will actually be shandied. The timing and duration of these releases will also influence their ability to benefit aquatic biota.

Water trading is likely to influence the flows actually observed in the Tasmanian Midlands and will likely influence aquatic biota. Water trading may also allow for the purchase of water for environmental benefits, for example water releases during peak summer temperatures to help buffer rises in river temperature. Such analyses are beyond the scope of this worked example and datapack but have been the focus of research conducted by the Landscapes and Policy Hub Social and Economic Futures project (Contact Prof John Tisdell for more information).

Information on biological condition of aquatic communities and land-tenure were used to prioritise potential refuge locations. The relative importance of many locations changed but looking at the two maps for the entire region there are very few obvious differences. This is largely a result of the relationships between several of the input data layers. For example, locations with good riparian vegetation condition were likely to occur in reserves and these

locations were likely to have healthier aquatic communities. Thus, the similarities between the Potential Refuge and Priority Potential Refuge layers reflect that the locations identified as 'likely to provide refuge' are already performing this function and are protected to some degree.



Appendices

Appendix 1.0 MCAS-S data layer specifications for the Northern Tasmanian Midlands.

We recommend that you use any input layer from your region of interest to set your GIS environment settings to ensure that layers match exactly.

<i>Data layer/file specifications</i>	<i>Northern Tasmanian Midlands</i>
Coordinate reference system / projection	Map Grid of Australia Zone 55 (GDA 94) Projection: Transverse_Mercator
Northern extent	6274792.617223
Southern extent	5788200.498673
Eastern extent	998166.455230
Western extent	210374.568925
Recommended cell size	250
No data or null values	-9999

Appendix 2.0 MCAS-S tip files (adapted from ABARES 2014)

Field	Description	Example
Filename	Shortened version to display when mouse hovers over map	Aquatic_refuges
Description	More information on the data, including units if applicable	Aquatic refuges in the Tasmanian Midlands.
Custodian	Organisation that owns the data	University of Tasmania
Currency	Year	2014
Lineage	Processing completed on the data (for example, source, calculations, software/commands used)	Incorporates data on groundwater inflows, riparian vegetation, slope, climate change, irrigation development, land tenure and biological condition.
Source	Source of the data	NERP- Landscapes and Policy Hub
Resolution (cell size)	Grid size of the raster data	251
Exclude masked regions?	Check box Yes/No	Yes
Mask value	Value for grid cells with no data	-9999

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