Bushfire Attack Level Toolbox Documentation
Release 2.1

Geoscience Australia

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CONTENTS

OBJECTIVES

This training workshop provides an introduction to the Bushfire Attack Level Toolbox, outlines what the Bushfire Attack Level Toolbox does (and does not do) and how it can be used to support emergency management activities. By the end of the workshop, participants should be able to demonstrate the following skills and knowledge:

- Understand the purpose of the Bushfire Attack Level

- Understand the limitations of the Bushfire Attack Level Toolbox

- Be able to install and test the Bushfire Attack Level Toolbox

- Run example calculations of the Bushfire Attack Level Toolbox

1.1 Target audience

- Officers supporting bushfire planning and management activities

- Officers responsible for managing vulnerable infrastructure assets

1.2 Prerequisites

- An understanding of Geographic Information Systems;

- An understanding of bushfire hazards and the impacts on assets;

- A computer with:

    - Windows (XP, 7, 8, 10)

    - ArcGIS 10.2 or later, including the Python extensions

    - Internet access (to download the toolbox)

TWO

WORKSHOP AGENDA

The Bushfire Attack Level Toolbox training workshop is facilitated by Geoscience Australia, supported by Department of Fire and Emergency Services (WA).

- Welcome

- Background

- Introduction to Bushfire Attack Level Toolbox

- Installing the Toolbox

- Executing an analysis

- Extracting BAL values

- Recap

INTRODUCTION

3.1 About Geoscience Australia

Geoscience Australia is the geoscience advisor to the Australian Government on matters of national importance, and custodian of the geographical and geological data and knowledge of the nation.

By understanding the geological history and geospatial aspects of our continent, we build our knowledge and capability to prepare us for the future.

We deliver a wide range of products that address important and significant national issues to assist government and the community to make informed decisions about the use of natural resources, the management of the environment, and community safety.

Through six key strategic priority areas, Geoscience Australia provides applied research and information for the Australian community to obtain sustainable economic, social and environmental benefits.

- Building Australia's Resource Wealth

- Ensuring Australia's Community Safety

- Securing Australia's Water Resources

- Managing Australia's Marine Jurisdictions

- Providing Fundamental Geographic Information

- Maintaining Geoscience Knowledge and Capability

We apply our geoscience knowledge and capability to acquire, store and manage Australia's national fundamental geological and geographic information.

This enables Australia to make critical decisions regarding our natural resource potential and marine environment, and helps to build our resilience to natural hazards.

It also ensures sustainable Australian communities by managing our precious water resources.

Geoscience Australia continues to actively promote Australia's mineral and energy resources to international trade partners, increasing awareness of the opportunities Australia's vast resource sector provides.

Working with our government partner organisations, we have broadened our scope of work in support of Australia's efforts to reduce the impact of natural disasters in our region.

3.1.1 Community Safety Branch

In Australia we are exposed to many hazards - fires, floods, earthquakes, tsunamis, and extreme weather. These natural events transform into natural disasters when lives are lost, and property is destroyed. Geoscience Australia understands these hazards and the risks they pose to communities.

As our population grows, people and infrastructure become exposed to hazards. It is not enough to simply respond, we must prepare.

To protect the vulnerable we must understand the risks they face and manage the impact of natural hazards to avoid disaster.

How do we ensure Australia's community safety?

We must recognise the worst case, plan for the best outcome and consider how we develop our unique landscape. Combining short-term response and long term planning, making decisions based on evidence specific to Australia's circumstances.

Geoscience Australia models and measures the hazards that put us in danger. We identify what parts of Australia are most at risk, and assesses the potential financial and social costs facing our environment, our industries and the people they support.

We must understand how hazards impact our society, to allow communities to prepare for emergencies, to provide advice to prevent emerging disasters and to build a safer and more resilient future, for us all.

The vision for the Community Safety Branch is to develop and deliver authoritative nationally consistent data and information to enable decision makers, governments, businesses and the community to better understand the consequences of hazard events and to contribute to more resilient communities.

WHAT IS THE BUSHFIRE ATTACK LEVEL

The Bushfire Attack Level measures the **severity of a building's potential exposure** to ember attack, radiant heat and direct flame contact. It is intended to improve the resistance of buildings to bushfire attack from burning embers, radiant heat, flame contact or a combination of these. It applies to buildings sited in designated bushfire-prone areas, as defined in the National Construction Code, Volume 2 *[NCCV2]*.

By improving the ability of buildings in bushfire-prone areas to withstand attack from bushfire, there is an increase in the protection afforded to building occupants (until the fire front passes) as well as to the building itself.

However, improving the design and construction of buildings is only one way that property owners can address the damage caused by bushfire. Other measures fall within the areas of planning, subdivision, siting, landscaping and maintenance.

Note: It should be borne in mind that the measures contained in this Standard cannot guarantee that a building will survive a bushfire event on every occasion. This is substantially due to the degree of vegetation management, the unpredictable nature and behaviour of fire, and extreme weather conditions (AS 3959–2009).

The bushfire attack level is a measure of the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kilowatts per metre squared. When calculated, the Bushfire Attack Level Toolbox toolbox provides classified levels:

- BAL–LOW
- BAL–12.5
- BAL–19
- BAL–29
- BAL–40
- BAL–FZ

Appendix G in AS 3959–2009 describes the threats associated with each BAL.

FIVE

HOW DO WE DETERMINE BAL

The Bushfire Attack Level Toolbox toolbox applies Method 1 from AS 3959–2009 to determine the BAL. Method 1 is a simplified procedure to determine the BAL, which involves five steps. This method is subject to limitations on the circumstances in which it can be used.

> **Warning:** This method is not valid where the effective slope under the classified vegetation is more than 20 degrees downslope. Within the BAL toolbox, where the slope is greater than 20 degrees, a constant value of 200 is assigned to the BAL.

There are five steps in determining the BAL based on method 1 in AS 3959–2009.

Step 1: Determine the relevant FDI

Step 2: Determine the classified vegetation type(s)

Step 3: Determine the distance of the site from the classified vegetation type(s)

Step 4: Determine the effective slope(s) under the classified vegetation type(s)

Step 5: Determine the BAL from the appropriate table

Note: AS 3959-2009 includes a sixth step, which refers to construction requirements. This is not of interest in the BAL toolbox, so is omitted here.

The following sections provide details on determining the BAL, using Bushfire Attack Level Toolbox.

5.1 Determine relevant FDI

The relevant Fire Danger Index (FDI) is based on Table 2.1 from AS 3959–2009, for each jurisdiction or region within a jurisdiction. The FDI is an indication of the chance of a fire starting, its rate of spread, intensity and the difficulty of suppresion based on the combination of air temperature, relative humidity, wind speed and both long- and short-term drought effects. The FDI used in AS 3959–2009 refers to the Forest Fire Danger Index calculated by the McArthur Mk 5 Forest Fire Danger Meter using the equations published by Noble *et al.* (1980)[1].

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[1] Noble, I. R., G. A. V. Bary and A. M. Gill (1980): McArthur's fire-danger meters expressed as equations. *Australian Journal of Ecology*, **5**, pp 201–203, DOI:10.1111/j.1442-9993.1980.tb01243.x

Table 5.1: Jurisdictional and regional values for FDI (adapted from Table 2.1, AS 3959, 2009).

State/region	FDI
Australian Capital Territory	100
New South Wales	•
1. Greater Hunter, Greater Sydney, Illawarra/Shoalhaven, Far South Coast, and Southern Ranges fire weather districts	100
2. NSW alpine areas	50
3. NSW general (excluding alpine areas, Greater Hunter, Greater Sydney, Illawarra/Shoalhaven,Far South Coast and Southern Ranges fire weather districts)	80
Northern Territory	40
Queensland	40
South Australia	80
Tasmania	50
Victoria	•
1. Victoria alpine areas	50
2. Victoria general (excluding alpine areas)	100
Western Australia	80

Note: The FDI values may be able to be refined within a jurisdiction or region where sufficient climatological data is available and in consultation with the relevant regulatory authority.

Note: The FDI values were provided by the Australasian Fire and Emergency Service Authorities Council (AFAC).

Note: Alpine and sub-alpine areas are defined as per the National Construction Code, Volume 2 *[NCCV2]*.

5.2 Vegetation classification

The vegetation of the site is classified in accordance with the guidance provided in Table 2.3 and the corresponding figures in AS 3959–2009. Where there is more than one vegetation type, each vegetation type is classified separately with the worst case scenario applied. For example, if there is a mix of grassland and shrubland, then the vegetation would be classified as shrubland, as this results in a higher BAL.

Note: The predominant vegetation type of a site may not necessarily be the worst case scenario.

In general, the land cover datasets often only present the predominant vegetation type. Therefore, we cannot always determine the "worst case" value of BAL. This could also be determined by validation on the ground.

AS 3959–2009 provides a list of exclusions for low threat vegetation and non-vegetated areas, where the BAL is classified as LOW. This includes vegetation greater than 100 metres from the site, small (< 1 ha) areas of vegetation that are also more than 100 metres from other vegetation and low threat vegetation that includes grassland managed in minimal fuel conditions. This includes lawns, golf courses, orchards and cultivated gardens, amongst others. Non-vegetated areas include waterways, roads, buildings, footpaths and rocky outcrops.

Table 2.3 in AS 3959–2009 sets out seven major vegetation classifications:

```
* Forest
* Woodland
* Shrubland
* Scrub
* Mallee/mulga
* Rainforest
* Grassland
```

Each of these major vegetation classifications has between one and eleven types, each of which has an indicative figure in the Standard. See Figures 2.3 and 2.4(A) to 2.4(G) in the Standard for these figures. There is also a brief text description of the vegetation types (height, foliage cover, habit, etc.).

Note: Overstoreys of open woodland, low open woodland, tall open shrubland and low open shrubland should be classified to the vegetation type on the basis of their understoreys; others to be classified on the basis of their overstoreys.

5.3 Distance to vegetation

The distance to from the site to the classified vegetation is measured in the *horizontal plane*.
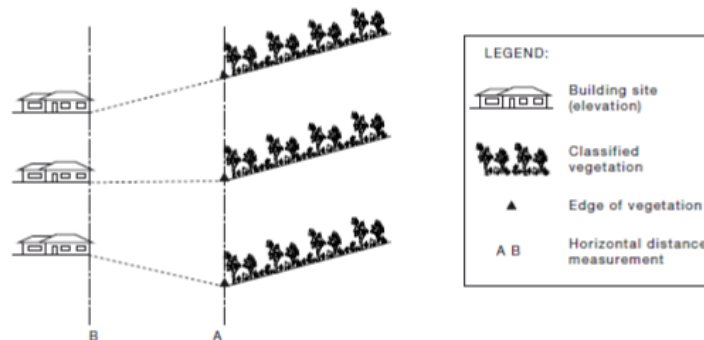

Fig. 5.1: Determination of distance from site from classified vegetation. The measurement is the horizontal distance, from Point A to Point B. From AS 3959–2009.

In the above figure, the distance from the classified vegetation to the site is the same in all three cases, irrespective of the slope over the intervening distance. In Bushfire Attack Level Toolbox, the effective distance is measured betwen the centre of grid cells of the input raster elevation data.

5.4 Effective slope under the classified vegetation

In determining BAL, 'slope' refers to the slope under the vegetation in relation to the building. It is not the slope between the vegetation and the site. The slope of the land under the classified vegetation has a direct influence on the rate of fire spread, the severity of the fire and the ultimate level of radiant heat flux.

The definition of upslope and downslope is the definition of the slope, relative to the site being evaluated. If the slope of the land under the classified vegetation is **downhill** from the edge of the classified vegetation nearest the site, then the slope is considered **downslope**. If the slope of the land under the classified vegetation is **uphill** from the edge of the classified vegetation nearest the site, then the slope is considered **upslope**.
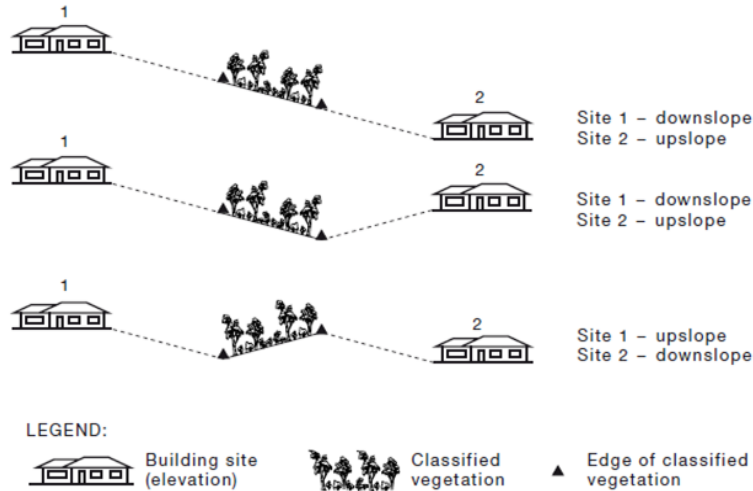

Fig. 5.2: Determination of effective upslope and downslope. From AS 3959–2009.

5.5 Determine BAL from appropriate table

AS 3959-2009 provides a set of lookup tables, from which we can determine the BL based on a combination of the FDI, distance from classified vegetation and effective slope.

DATA REQUIREMENTS

The Bushfire Attack Level Toolbox requires only two datasets to determine BAL – a classified vegetation dataset and a digital elevation model. With these two datasets, it is possible to determine the slope and aspect of a site, and the classified vegetation types described in AS 3959–2009, to enable determination of BAL.

6.1 Digital elvation model

A digital elevation model (DEM) is a digital model that represents a geographic location's height above mean sea level. DEM's are developed by a wide range of techniques, and have widely varying horizontal grid resolutions.

At the national scale, Geoscience Australia has published the 1-arcsecond Shuttle Radar Topography Mission (SRTM) Digital Elevation Models Version 1.0 (see http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_72759), which is freely accessible. This DEM has a grid resolution of approximately 30 m by 30 m (at the equator). There are also other DEM's available through the Geoscience Australia Data and Publications Search portal. Other organisations may have higher-resolution and more up-to-date DEMs available for use in the Bushfire Attack Level Toolbox.

For the Bushfire Attack Level Toolbox, it is recommended to use a DEM with a horizontal grid resolution comparable to the SRTM DEM (~ 30m), or higher for best results.

6.1.1 Format

Any raster format supported by ESRI ArcGIS 10.2 can be used in Bushfire Attack Level Toolbox. 32-bit floating point data in either GeoTIFF or the native ESRI Grid format is recommended.

6.1.2 Projection

The input DEM must be presented in a projected coordinate system, with a linear unit of metres. Projected coordinate systems such as Universal Transverse Mercator (UTM), or the Map Grid of Australia (MGA) are suitable for projecting elevation data for use in the Bushfire Attack Level Toolbox.

> **Warning:** The Bushfire Attack Level Toolbox will fail to execute if the input DEM is in a geographic coordinate system.

For the western portion of Western Australia, the GDA94/MGA Zone 50 projection would be an appropriate choice of projected coordinate system.

6.2 Vegetation data

A classified vegetation dataset is required for determination of BAL. The availability of classified vegetation datasets is varied, and the classifications used are similarly diverse, depending on the application for which they were intended and the methods used to derive them.

For the examples used in this training workshop, we have used the National Vegetation Information System (NVIS), which provides information on the extent and distribution of vegetation types in Australian landscapes. This data has a horizontal resolution of 100 m by 100 m. Other organisations may have higher-resolution and more up-to-date classified vegetation datasets available for use in the Bushfire Attack Level Toolbox.

For optimal results, it is recommended to use a classified vegetation dataset that is of a comparable resolution to the DEM used.

6.2.1 Format

Any raster format supported by ESRI ArcGIS 10.2 can be used in Bushfire Attack Level Toolbox. Generally, an unsigned integer data type will be sufficient to describe the classified vegetation type. Either GeoTIFF or the native ESRI Grid format is recommended.

6.2.2 Classification

The vegetation data needs to represent different classification types. Ideally, the data will match the vegetation classes set out in AS 3959–2009. These are numbered 1–7 and are defined as follows:

Value	Classification	Description
1	Forest	Tall, open forest, tall woodland, open forest, low open forest, pine plantation
2	Woodland	Woodland, open woodland, low woodland, low open woodland, open shrubland
3	Shrubland	Closed heath, open heath, low shrubland
4	Scrub	Closed scrub, open scrub
5	Mallee/Mulga	Tall shrubland
6	Rainforest	Tall closed forest, closed forest, low closed forest
7	Grassland	Low open shrubland, hummock grassland, closed tussock grassland, tussock grassland, open tussock, sparse open tussock, dense sown pasture, sown pasture, open herbfield, sparse open herbfield

> **Warning:** The input data must be in this numerical format for the Bushfire Attack Level Toolbox to execute correctly. Values other than those listed here will be ignored and may produce incorrect BAL values.

The Bushfire Attack Level Toolbox provides users with the option to map their classified vegetation to the required classes. By default, the mapping matches the numerical values from NVIS to the required AS 3959–2009 values.

6.2.3 Projection

The input classified vegetation dataset must be presented in a projected coordinate system, with a linear unit of metres. Projected coordinate systems such as Universal Transverse Mercator (UTM), or the Map Grid of Australia (MGA) are suitable for projecting elevation data for use in the Bushfire Attack Level Toolbox.

Note: The vegetation dataset can be in either a geographical or a projected coordinate system. It will be reprojected to the same projection and same resolution as DEM by the BAL tool.

For the western portion of Western Australia, the GDA94/MGA Zone 50 projection would be an appropriate choice of projected coordinate system.
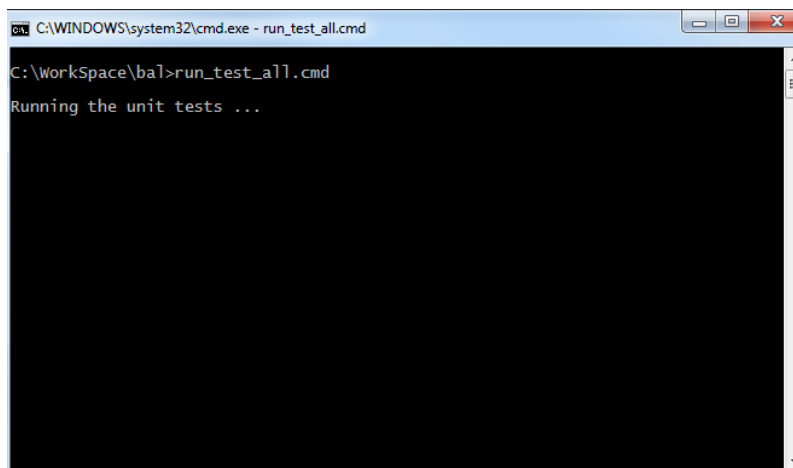
INSTALLING THE BUSHFIRE ATTACK LEVEL TOOLBOX

Instructions for installing the Bushfire Attack Level Toolbox are given in the User Guide and Set up sections.

7.1 Testing the installation

Important: Testing the installation before using it will allow you to identify any issues with the installation of the Bushfire Attack Level Toolbox before using it. Without testing the toolbox first, you may obtain results that are inconsistent with the intended application of the toolbox.

The code includes a suite of unit tests that ensure elements of the code base work as expected. The code should be tested before running the toolbox. Users will need to install the Nose package to run these tests.

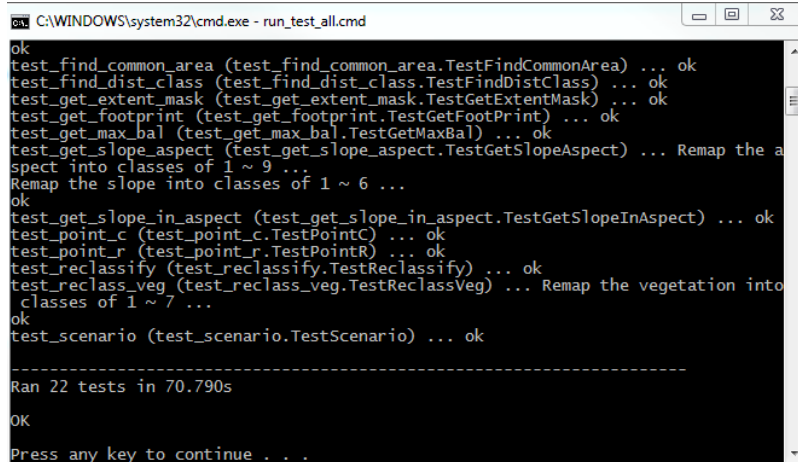The test suite can be run from the main directory. On Windows, run the **run_test_all.cmd** script from the main BAL directory.

Fig. 7.1: Running the BAL test suite in a Windows command prompt.

If the test suite fails, then there will be a message indicating which test failed and a description of the failure. If you get this, copy the description and create a ticket on the Bushfire Attack Level Toolbox Issue Tracker.

Fig. 7.2: Windows command prompt showing successful completion of the test suite. Notice the last few messages indicating the number of tests and "OK".

7.2 Adding the toolbox into ArcGIS 10.2

Follow the steps below to add the Bushfire Attack Level Toolbox into ArcGIS 10.2:

- Open the ArcToolbox window. See Fig. 7.3.

- Right click **ArcToolbox** at the top of the window, see Fig. 7.4.

- Select **Add Toolbox…**, a dialog box is open. See Fig. 7.5.

- In the dialog box, navigate to the location of the package, for example `C:\bal`, you will find the **BAL.tbx**. See Fig. 7.5.

- Select **BAL.tbx** and click **Open**, a new toolbox called **BAL** is added to the ArcToolbox. See Fig. 7.6.
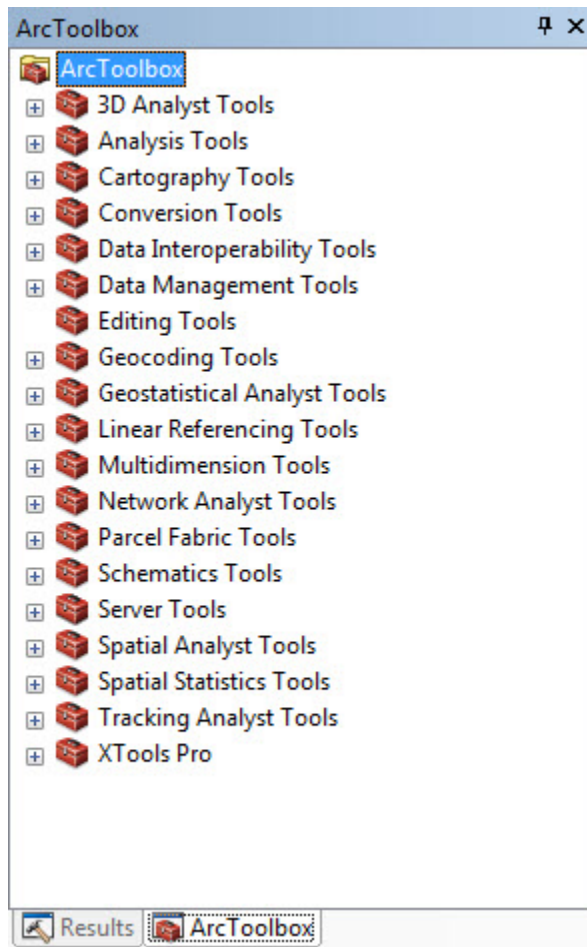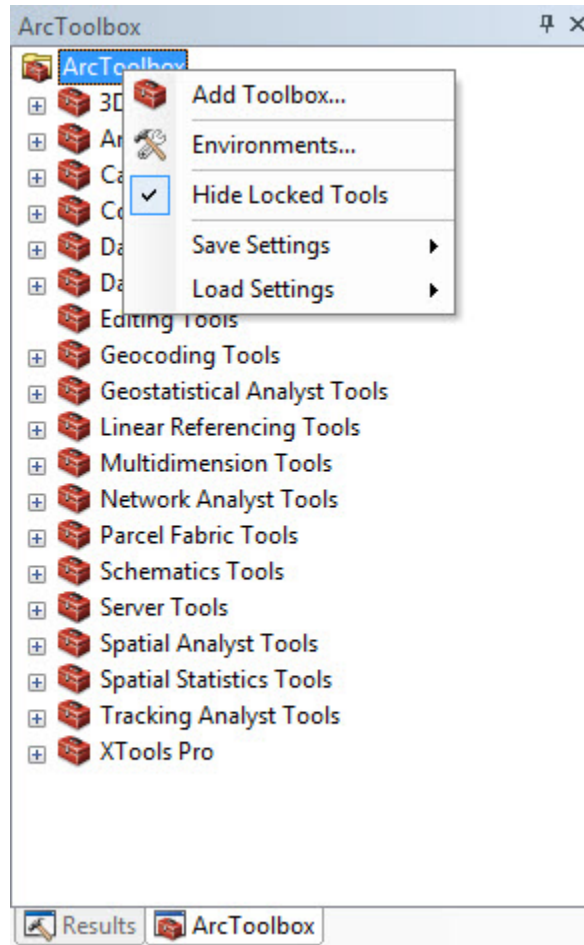
Fig. 7.3: The ArcToolbox window.

Fig. 7.4: Right click **ArcToolbox** in the ArcToolbox window.
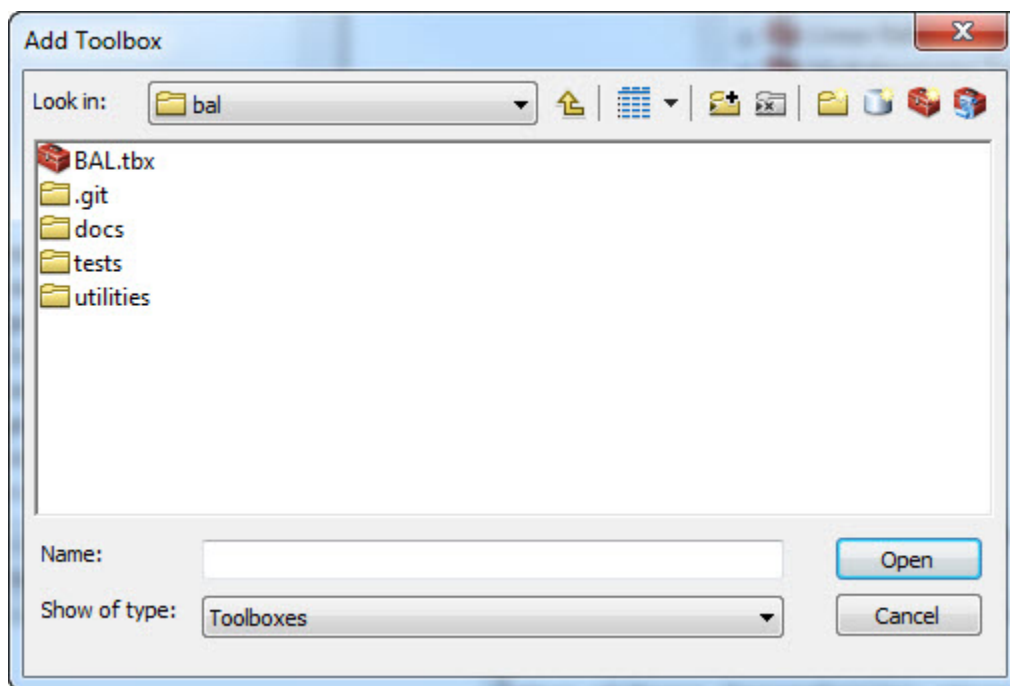
Fig. 7.5: The **Add Toolbox** dialog window.
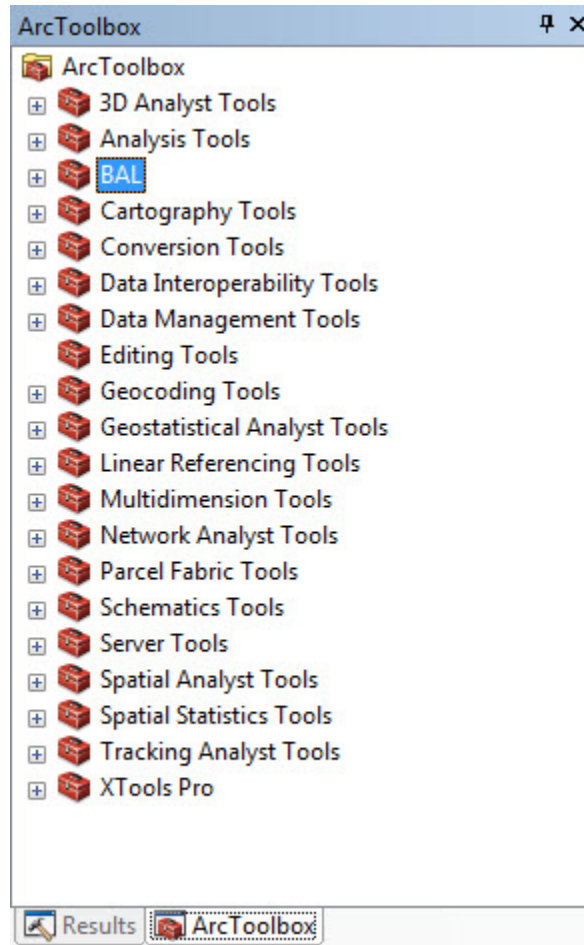
Fig. 7.6: The **BAL** toolbox is added.

EIGHT

RUNNNING THE TOOL

To calculate the BAL, we use the **BAL calculation** tool within the **BAL** toolbox installed in ArcGIS 10.2.

Select the *BAL → BAL calculation* tool, see Fig. 8.1.
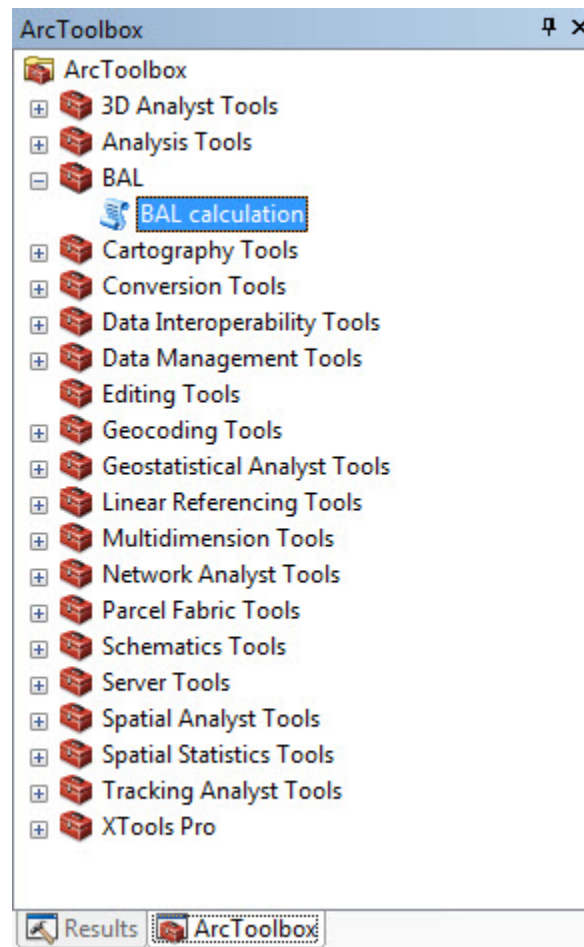
Fig. 8.1: Select the tool **BAL calculation**.

Then the **BAL calculation** window is open, see Fig. 8.2.
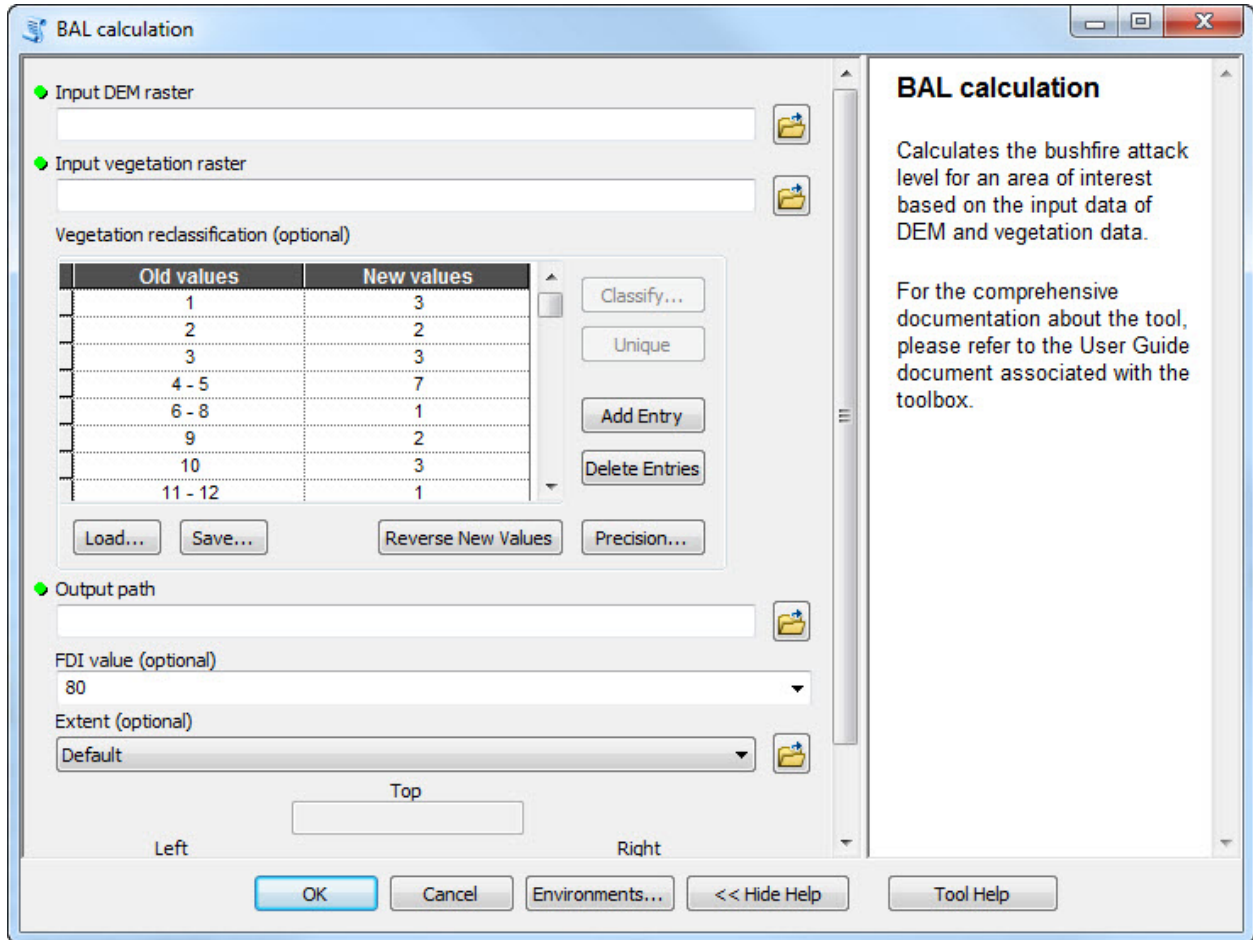
Fig. 8.2: The **BAL calculation** window.

8.1 Getting help from within the toolbox

On the left of the dialog window is the input fields, options and the output fields. We will work through these in turn. On the right, help content for each of the dialog's entry fields are displayed. As you move to different entry fields the content in this panel will update.

You can toggle the tool help on and off, by clicking the *Tool Help* button on the lower right corner of the dialog window.

Another way to access the help is via the menus. Right click on the *BAL calculation* script and select "Help". This will display the full help menu for the Bushfire Attack Level Toolbox.

Fig. 8.3: Accessing the BAL Toolbox help menu.

8.2 Input fields

8.2.1 Input digital elevation model

The first input field is the digital elevation model. Click the folder icon button to browse to the location of the required DEM raster file. The DEM **must** be in a projected coordinate system, with a linear unit of metres. Additional information can be found in the *Projection* section.
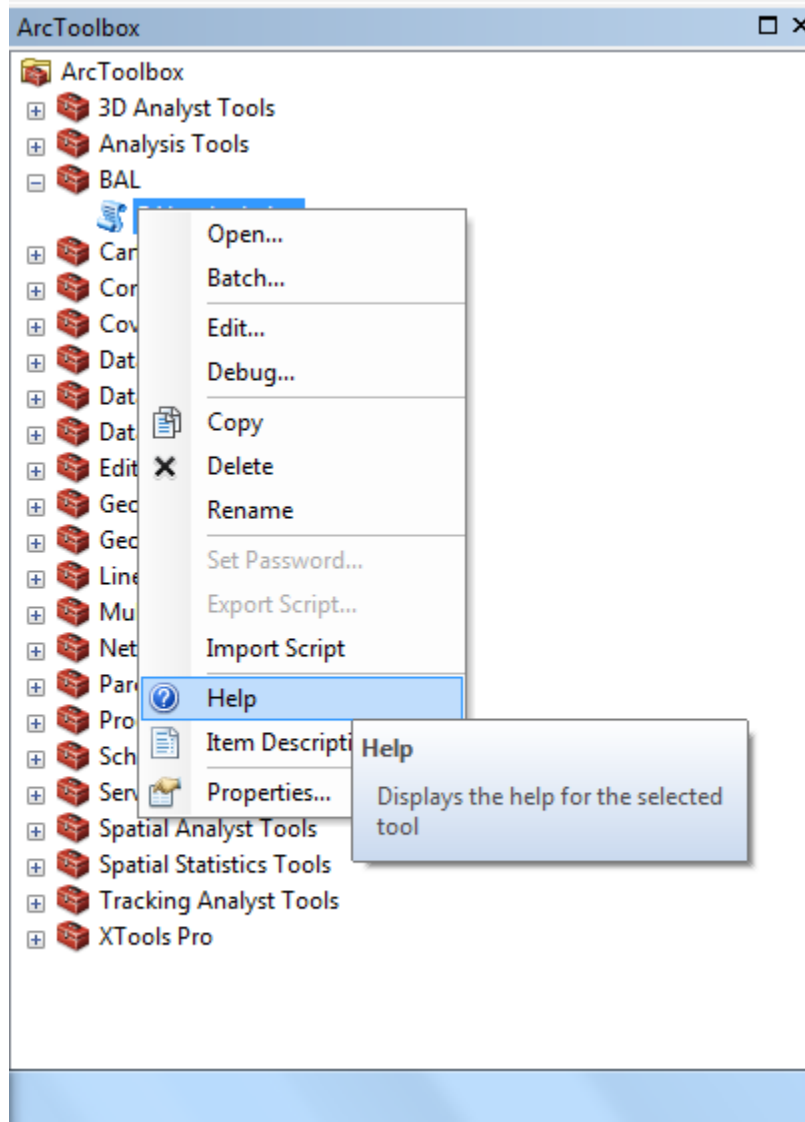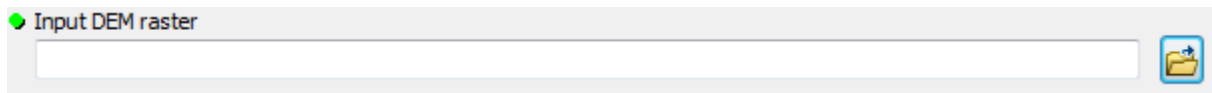

Fig. 8.4: Digital Elevation Model input field.

8.2.2 Input classified vegetation raster

The second input field is for the classified vegetation layer. Again, click the folder icon button to browse to the location of the required classified vegetation raster file. As with the DEM, the classified vegetation raster should be in a projected coordinate system, matching the DEM, though this is not essential.
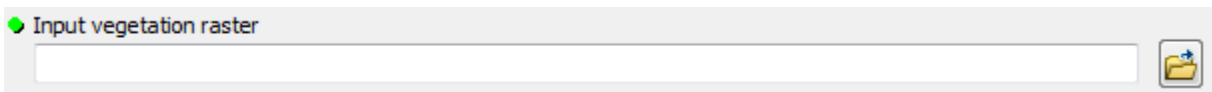
Fig. 8.5: Classified vegetation raster input field.

The next input field is the vegetation reclassification table. It is presumed that the input classified vegetation dataset will not exactly match the classification required in AS 3959-2009 (see *Vegetation classification*). For this reason, the Bushfire Attack Level Toolbox allows users to reclassify the input dataset to the values required for calculation of the BAL.
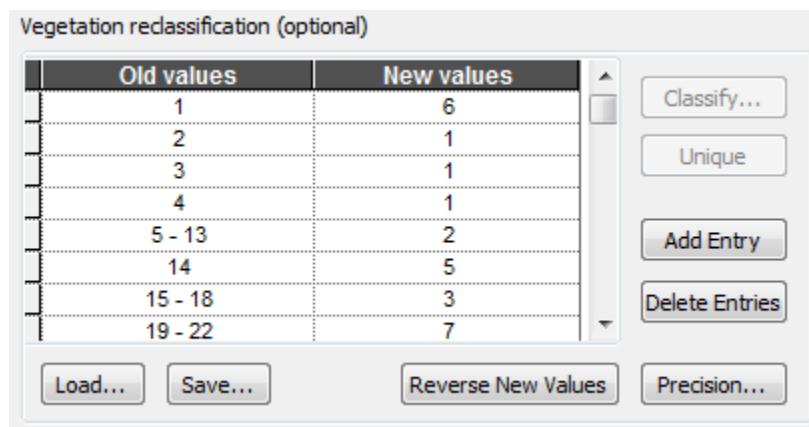
Fig. 8.6: Vegetation reclassification table, pre-populated with values to reclassify National Vegetation Information System data to AS 3959–2009 values.

The reclassification table is pre-populated with values matching the National Vegetation Information System (NVIS) data. Under the "Old values" column, the integer values representing different vegetation classes in the NVIS classes. Under the "New Values" column are the integer values to which the NVIS classes will be mapped. These new values represent the seven classes set out in AS 3959–2009.

A different clasified vegetation dataset will necessitate a change to the reclassification table. You can add and delete entries using the *Add Entry* and *Delete Entries* buttons. You can save the existing table using the *Save. . .* button, or load a pre-existing table using the *Load. . .* button.

Classifying another vegetation dataset should be done in consultation with someone with expertise in vegetation classification. AS 3959–2009 does provide some descriptive information on the vegetation types in each of the primary 7 classes and the sub-classes (Table 2.3).

8.2.3 Output path

The output path is specified in the next field. Click the folder button to browse to a folder that you want to store the results of the BAL analysis.
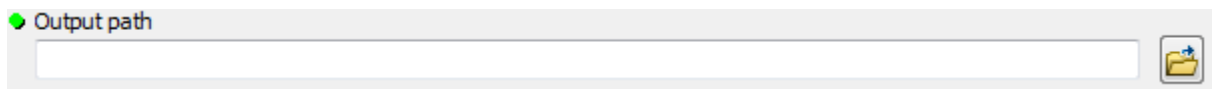
Fig. 8.7: Output path field entry.

Note: There are some limitations to the name length and file path length in ESRI applications. The maximum number of characters in the full path name (including file name) is 128 characters. In testing, each folder name's length should be restricted to a maximum of 8 characters.

8.2.4 FDI value

The Fire Danger Index (FDI) value used to evaluate BAL is defined in AS 3959–2009, and is based on the jurisdiction (i.e. State or Territory), or a sub-region within jurisdictions, as defined in the National Construction Code, Volume 2 *[NCCV2]*. The default value is an FDI of 80, but values of 100, 80, 50 and 40 can be selected. The *Help* sidebar provides the FDI values for different regions, as per AS 3959–2009.
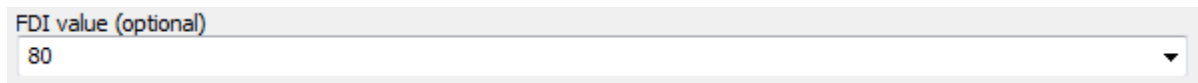
Fig. 8.8: Fire Danger Index (FDI) options menu.

8.2.5 Extent

The *Extent* option provides a way to select the area for analysis. There are four options in the dropdown menu: *Default*, *Union of Inputs*, *Intersection of Inputs* and *As Specified Below*.

The *Default* option is the common area between the DEM and the classified vegetation data layers. It is not possible to calculate BAL in areas where there is only one input data (i.e. DEM or classified vegetation). The *As Specified Below* option allows users to manually select an area of interest. This may be a subset of the complete coverage of the
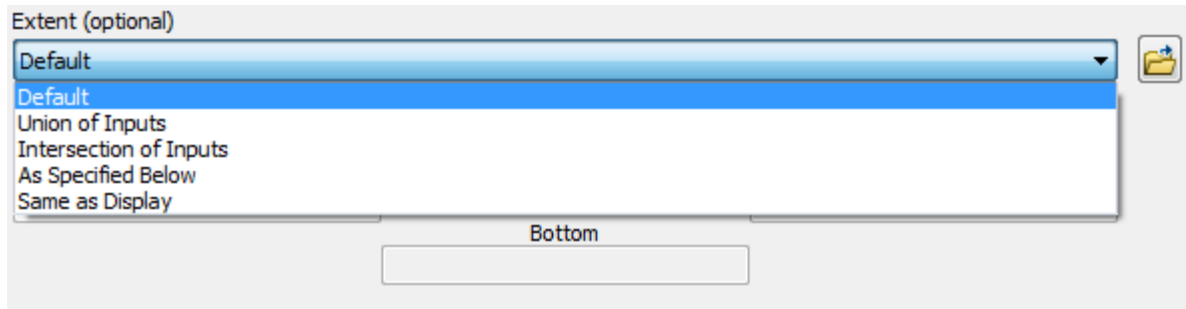
Fig. 8.9: Extents options menu.

DEM and classified vegetation. If the specified region is larger than the intersection of the inputs, then the extent of the intersection of the inputs will be used.

Note: If specifying the extents manually, these should be in projected coordinates, i.e. in the coordinate system the DEM uses.

8.3 Run the toolbox

Once the input datasets have been specified and the other options set, you can now click the *OK* button to execute the analysis. When the analysis runs, a dialogue window will appear and start displaying a series of messages.
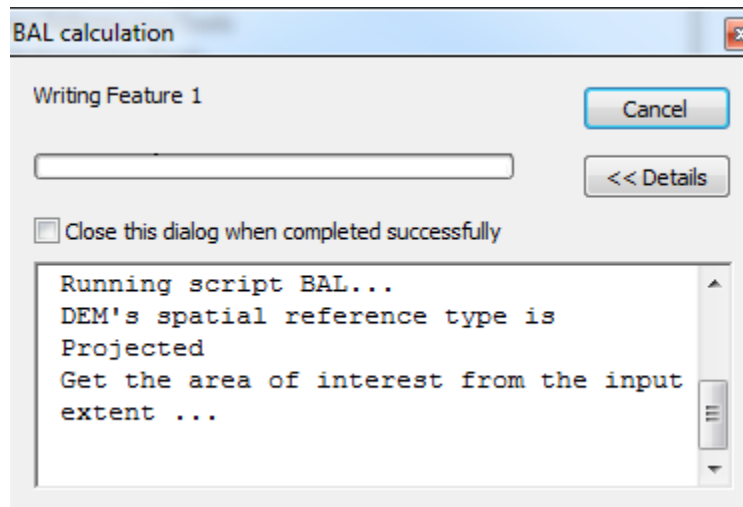
Fig. 8.10: Progress dialogue for the BAL calculation.

Depending on the extent of the region, and the horizontal resolution of the DEM and classified vegetation data, the analysis will take anywhere from less than a minute to several hours to execute. When the analysis is complete, the BAL calculation dialogue will indicate successful completion:

Click the *Close* button in the top right corner to close the BAL calculation dialogue. You can review the log messages by opening the *Results* panel in ArcCatalog: *Geoprocessing → Results → Current Session → BAL calculation → Messages*.

```
BAL calculation                                                                          ⊠

Completed                                                                      [  Close  ]

                                                                               [ << Details ]

☐ Close this dialog when completed successfully

 ┌─────────────────────────────────────────────────────────────────────────────────┐ ▲
 │ Executing: BAL C:\WorkSpace\bal\examples\input\jerram_dem C:\WorkSpace\bal\examples│ █
 │ \input\jerram_veg "1 6;2 1;3 1;4 1;5 13 2;14 5;15 18 3;19 22 7;23 4;24 25 NODATA;26│
 │ 4;27 28 NODATA;29 4;30 1;31 2;32 5;99 NODATA" C:\WorkSpace\bal\examples\output 80 #│
 │ Start Time: Wed May 24 11:34:24 2017                                               │
 │ Running script BAL...                                                              │
 │ DEM's spatial reference type is Projected                                          │
 │ Get the area of interest from the input extent ...                                 │
 │ Reclassify the vegetation map ...                                                  │
 │ Remap the vegetation into classes of 1 ~ 7 ...                                     │ ▤
 │ Reclassify slope and aspect ...                                                    │
 │ Remap the aspect into classes of 1 ~ 9 ...                                         │
 │ Remap the slope into classes of 1 ~ 6 ...                                          │
 │ Get common area of input data ...                                                  │
 │ Calculate the BAL ...                                                              │
 │ Successfully completed BAL calculation!                                            │
 │ Completed script BAL...                                                            │
 │ Succeeded at Wed May 24 11:35:02 2017 (Elapsed Time: 37.88 seconds)                │
 └─────────────────────────────────────────────────────────────────────────────────┘ ▼
```
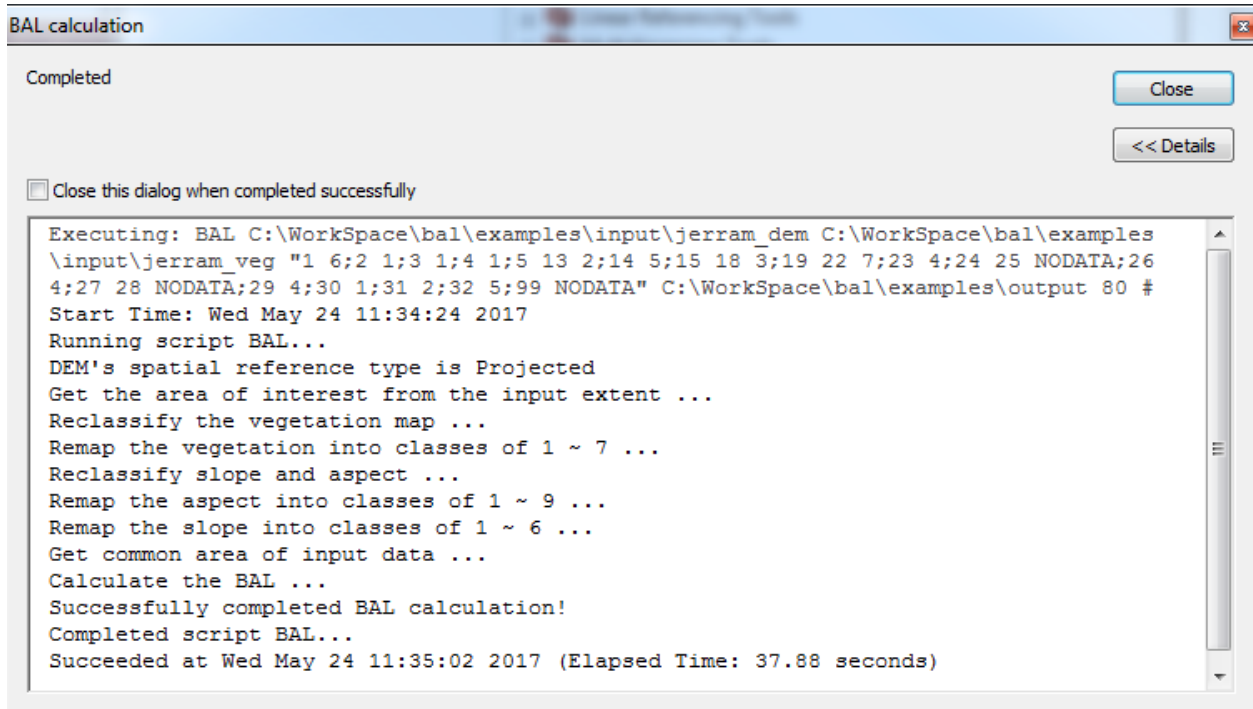
Fig. 8.11: Completed dialogue for the BAL calculation. Note the final line says "Succeeded at. . . ".

8.3.1 Check the output

On successful execution of the BAL calculation tool, there should be 9 raster datasets in the output folder. There are eight, for each of the cardinal directions (north, northeast, east, etc.). A ninth raster dataset represents the maximum BAL of all eight directions for each grid cell.

The output rasters are ERDAS Imagine raster files (with a `.img` extension), 32-bit floating point data, using the same projected coordinate system as the input DEM.

The data can now be added to an ArcMap session for inspection.

BIBLIOGRAPHY

[NCCV2] National Construction Code, Volume 2. http://www.abcb.gov.au/Resources/Publications/NCC/ NCC-2016-Volume-Two

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