MatrixGreen: Landscape Ecological Network Analysis Tool – User manual

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Version 0.4, 2012-06-27 (added support for ArcInfo/ArcMap 10.x)

This manual is applicable for MatrixGreen version 1.6.4, which only is supported for ArcInfo/ArcMap version 9.3.x, and version 1.7.0, which is only supported for ArcInfo/ArcMap version 10.x. No additional ArcGIS-extensions are required for any of these two versions.

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Installation

Download the setup file

To get access to your own copy of MatrixGreen (MG), send an email to orjan.bodin@stockholmresilience.su.se or aze@kth.se with the following information:

- Your name
- Your email
- The name and address of your organization
- Phone
- Your position/role (e.g. researcher, consultant, etc)

You will then receive information on how to download the setup files from an ftp server (i.e. you will get an IP address and a username/password combination). To install MG, download the zip-file "MGSetup_1_6_4.zip" or "MGSetup_1_7_0.zip", unpack "MGSetup.msi" and "setup.exe" to any arbitrary folder on your PC and double click on "setup.exe".

OBSERVE – choose version 1.6.4 if you are running ArcInfo/ArcMap 9.3.x, and version 1.7.0 if you are running ArcInfo/ArcMap 10.x.

IMPORTANT! If you already have a previous version of MatrixGreen installed, start by uninstalling that version (using "Add or Remove Programs" in the Windows Control Panel). Also note that the Microsoft .NET Framework 3.x must have been installed. There are typically several versions of the .NET Framework installed on your computer.

Install the files

When launching the setup program, you will see a warning message since this software was downloaded from the Internet (Fig. 1). Press "Run" to continue.

Fig. 1. Warning message. Press "Run" to continue.

After having pressed “Run”, a welcome screen is shown (Fig. 2). Press “Next” to continue.

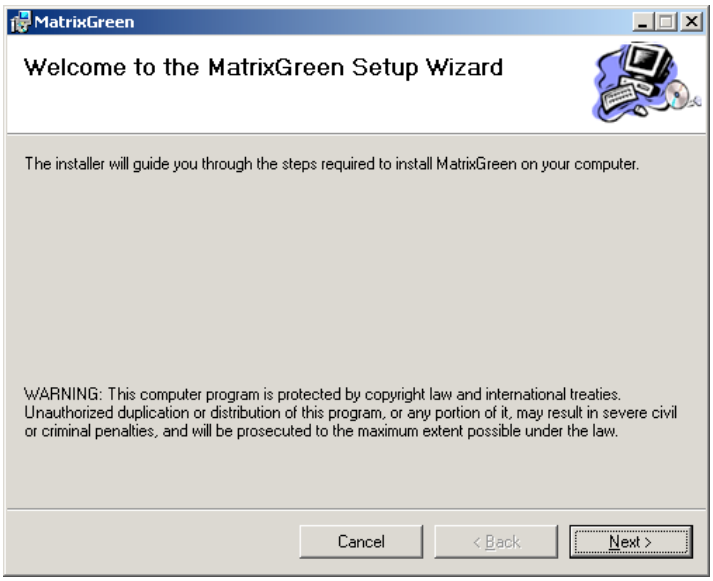

Figure 2. Welcome screen.

In the next step you’re asked to choose a folder where the MG files will be installed (Fig. 3). It is advisable to accept the default option (typically “C:\Program Files\MatrixGreen”).

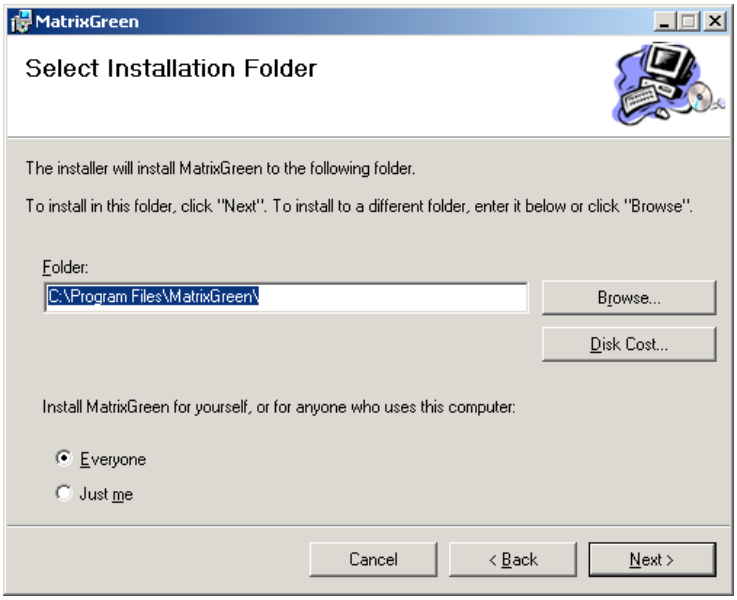

Figure 3. Choose installation folder.

Now, the actual installation process will begin (Fig. 4). Press “Next” and wait until the installation process has finished.

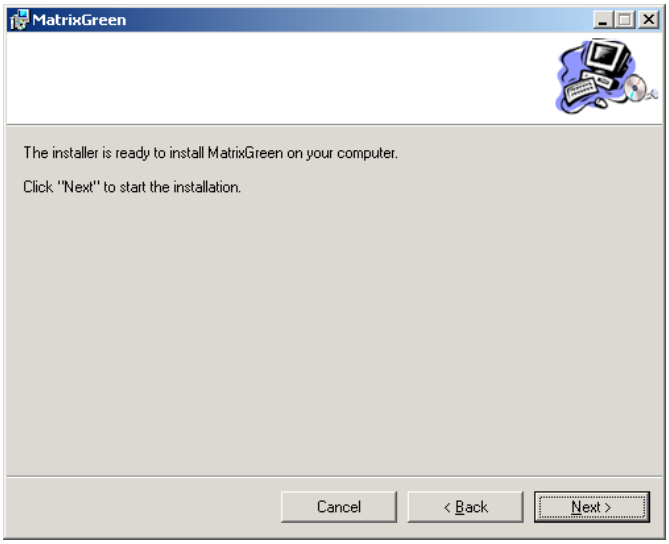

Figure 4. Installation starts.

During the installation, the setup program will check that you have the right version of ArcGIS installed, and that you also have installed the .NET framework. If you do not have .NET installed, you will be asked to install it; otherwise MG will not work properly.

Make MatrixGreen visible from within ArcGIS

MG is an implemented as a Toolbox extension to ArcGIS. Hence, to make MG visible from within ArcGIS, the MG Toolbox extension has to be enabled. In the Menu "Tools/Extensions", click "MatrixGreen" (Fig. 5).

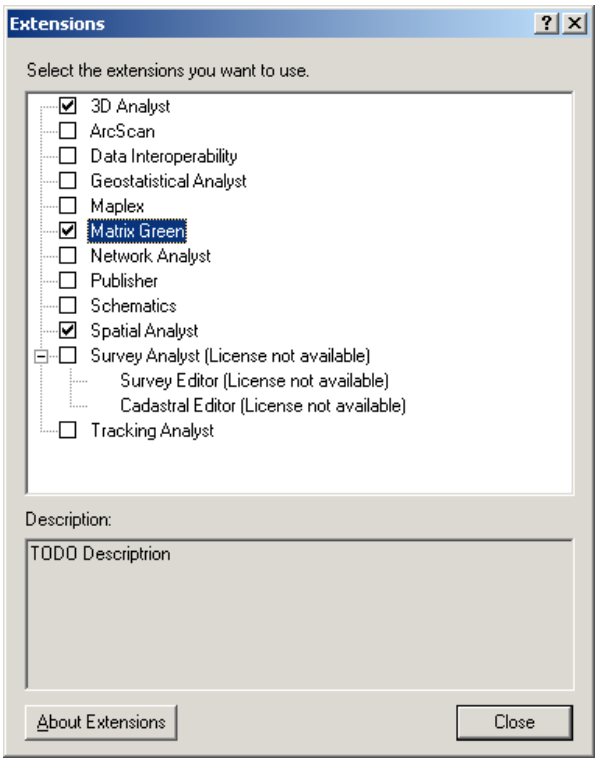

Figure 5. MG as shown in "Tools-Extensions"[1]

[1] All screenshots are based on ArcInfo/ArcMap 9.3, thus things might look a bit different on ArcInfo/ArcMap 10.3

You also need to make sure that the MG Toolbar is set to visible. This is done in the Menu “View/Toolbars” (Fig. 6).

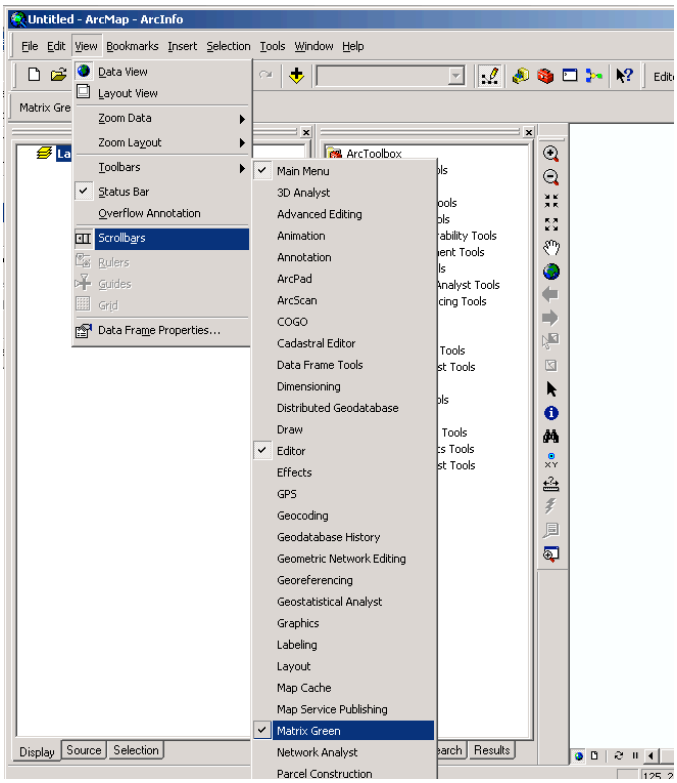

Figure 6. View/Toolbar menu.

MatrixGreen should now be visible in your list of installed toolboxes (Fig. 7) and the MG toolbar should also be visible. If the MG toolbox is not visible, try to press the green button on the MG toolbar. When both these items are visible, the installation is completed.

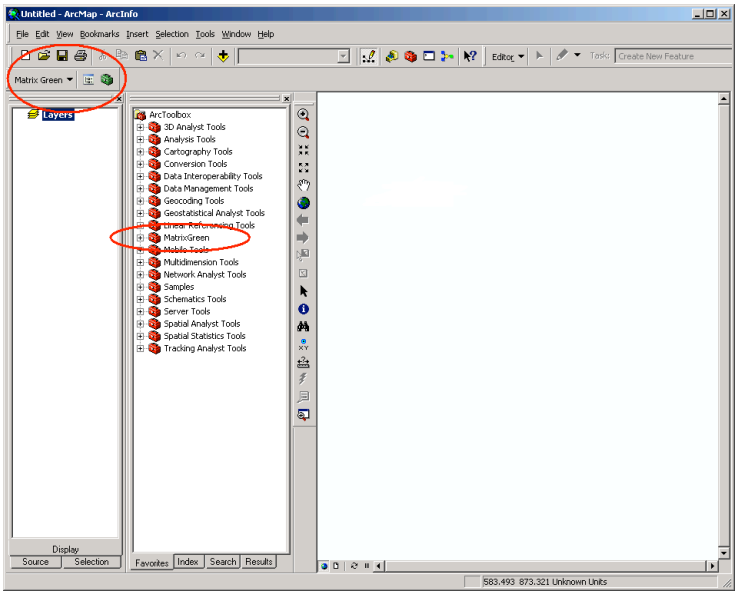

Figure 7. ArcGIS list of toolboxes (lower right red circle) and the MG toolbar (upper left red circle).

Overview of how to use MatrixGreen

Before the details about MG are presented, the simple flow chart below (Fig. 8) shows how MG is supposed to be used.

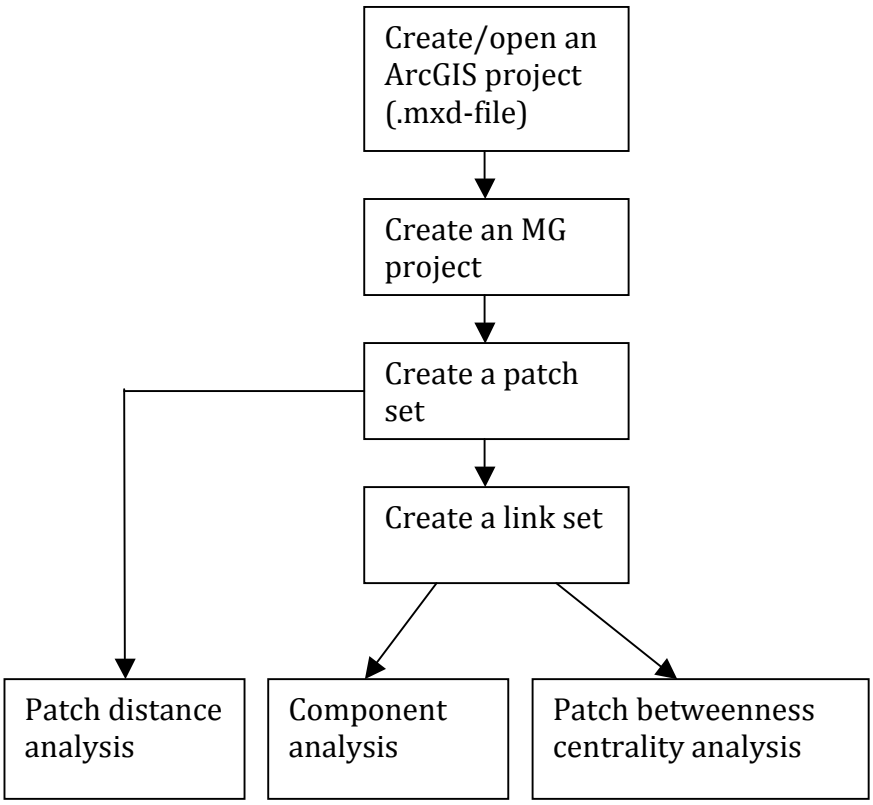

Fig. 8. Simple flow chart of MatrixGreen

Creating an MG project

All analyses using MG require that you have created an MG project. An MG project file (i.e. a file with the extension .mg along with an accompanying folder structure) will store and keep track of all the data and analyses for a specific project. You can create and store as many MG projects as you wish, and they provide a way for you to organize your data and connectivity analyses. Please note that an MG project file (.mg) is not the same thing as an ordinary ArcGIS project file (.mxd). If you create the MG project file in a new empty folder, that folder can be moved and placed in any other location on your (or someone else's) computer.

To create your first MG project, it is advisable to first set up ArcGIS to show the MG project browser. The browser will let you browse through all data and analyses of a specific MG project. To show the browser, click on the project browser button on the MG toolbar (Fig. 9). Note that the MG project browser is a dockable window, thus I can be placed wherever possible according to your preferences.

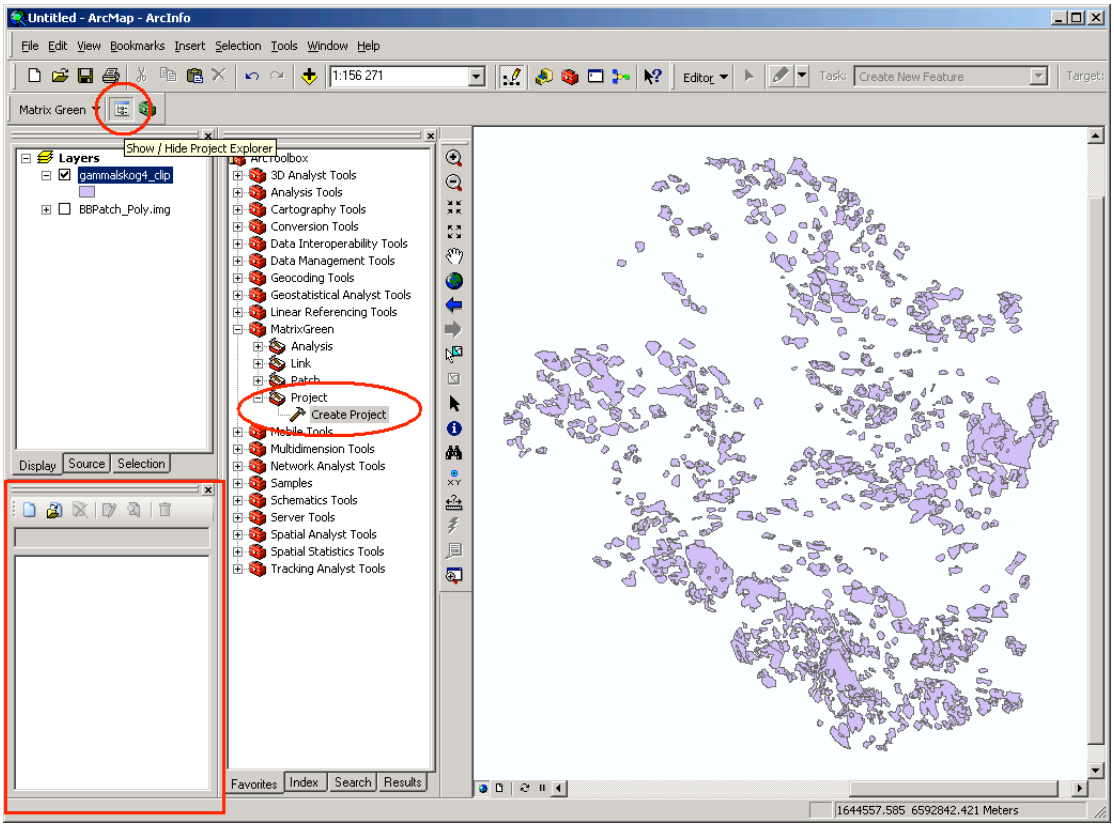

Figure 9. MG project browser (lower red rectangle to the left) and the MG toolbar button used to show/hide the MG project browser (upper left red circle). The red circle to the right shows the MG tool "Create project".

Next, you can create the project. This can be done by either pressing the top left icon in the MG project browser, or you could use the "Create project" tool in the MG toolbox (Fig. 9). A dialog box will then appear (Fig. 10 shows the dialogue window if you used the MG toolbox to create the MG project).

In the dialogue box, enter a name of the project file and its location (preferably in a new, empty folder to be able to move the entire project to another location or computer). Also define a name for your project, and optionally add a description of the project. Press ok and the project name should appear in the MG project browser (if "Open project" was checked in the dialogue window).

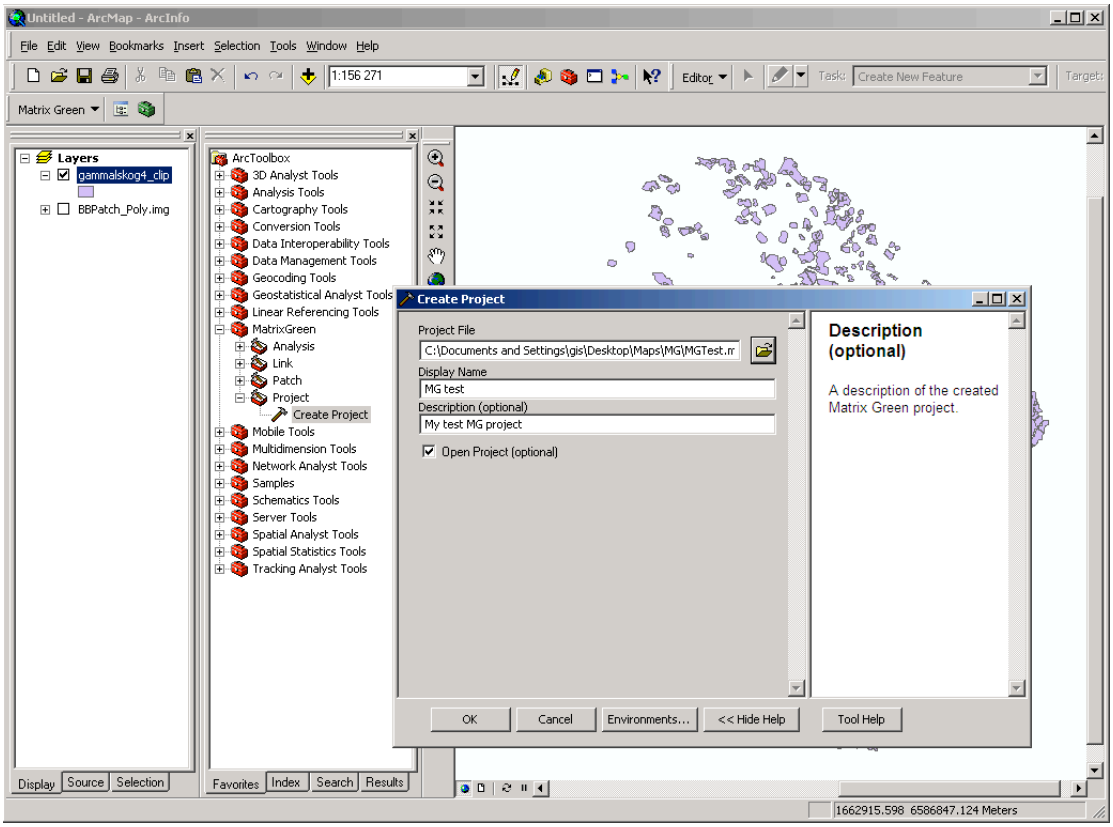

Figure 10. The "Create project" dialogue window (using the MG toolbox).

Creating a patch set

When you have created your first MG project, you're almost ready to create your first *patch set*. Creating a set of habitat patches (patches) is the starting point for all network analyses. In the network model, a patch corresponds with a node, often symbolized using a dot. A patch can be defined based on different types of geographic data (rasters or feature classes such as polygons), and is identified as a single coherent area of suitable land. *Note: There may be a bug when creating a patch from a raster, why it is recommended to use feature classes as the source.*

A patch set can be created in three different ways:

- From raster data
- From Feature data
- From another patch set

Using raster data, a patch is identified as a single coherent region of pixels where their values are not null. Using Feature data, a patch is defined as a polygone. It can also be created by importing an already existing MG-patch set.
Common for all these methods is that a minimum and/or maximum area can be given so that only patches within those limits will be created. The unit for the area is the same as the units defined in the ArcGIS-project or the projection of the feature class.
Before you are able to create a patch set, you accordingly need some input data (raster, feature class, or an exiting patch set). It is advisable that you open (or create) an ordinary ArcGIS project to store all your non-MG data files if that has not already been

done. In fig. 10, two different layers of data (one raster and one Feature class) have been opened in an ArcGIS project.

Note that overlapping polygon features can sometimes create problems and it is therefore highly recommended to first use the ArcGIS "Dissolve" tool when preparing your input data.

When you have prepared your input data, you're ready to create a patch set. In the MG toolbox there is a group of tools named "Patches", where you can choose the appropriate method to create your patch set. Fig. 11 shows the dialogue window that appears when you choose to create a patch set from Feature data. You will have to specify which MG project the patch set will be assigned to, the feature class that will be used to create the patches, the name and a description of the patch set, and optionally a minimum and maximum area. If you check "Overwrite existing" any pre-existing patch set with the same name in the same project will be deleted, and if you check "Add to map", the patch set will be added as an new layer to the existing ArcGIS project, and also made visible.

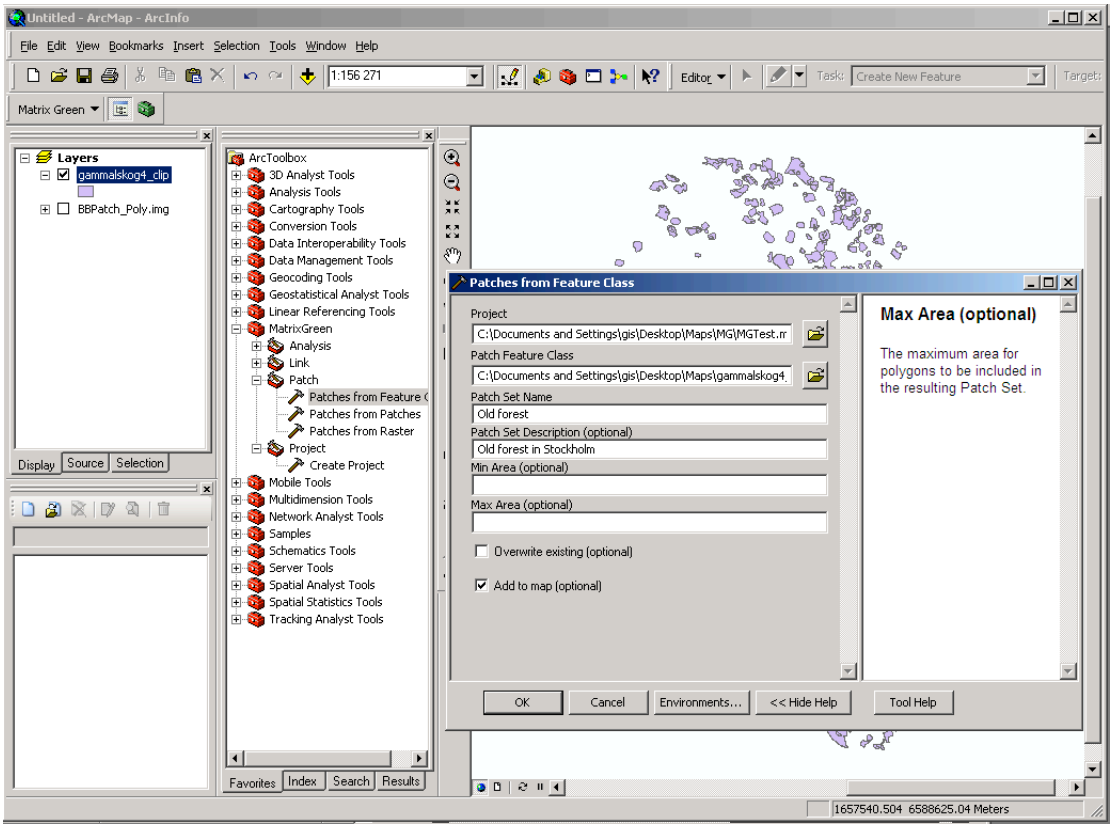

Figure 11. Dialogue window for the MG tool "Patches from Feature class"

When a new patch set has been created it typically looks like in fig. 12. The patch set has been added to the ArcGIS project as a layer on its own (orange color), and is also visible in the window to the right. Additionally, the patch set is added to the MG project, and shown in the MG project browser as a leaf at the base level (here named "Old forest").

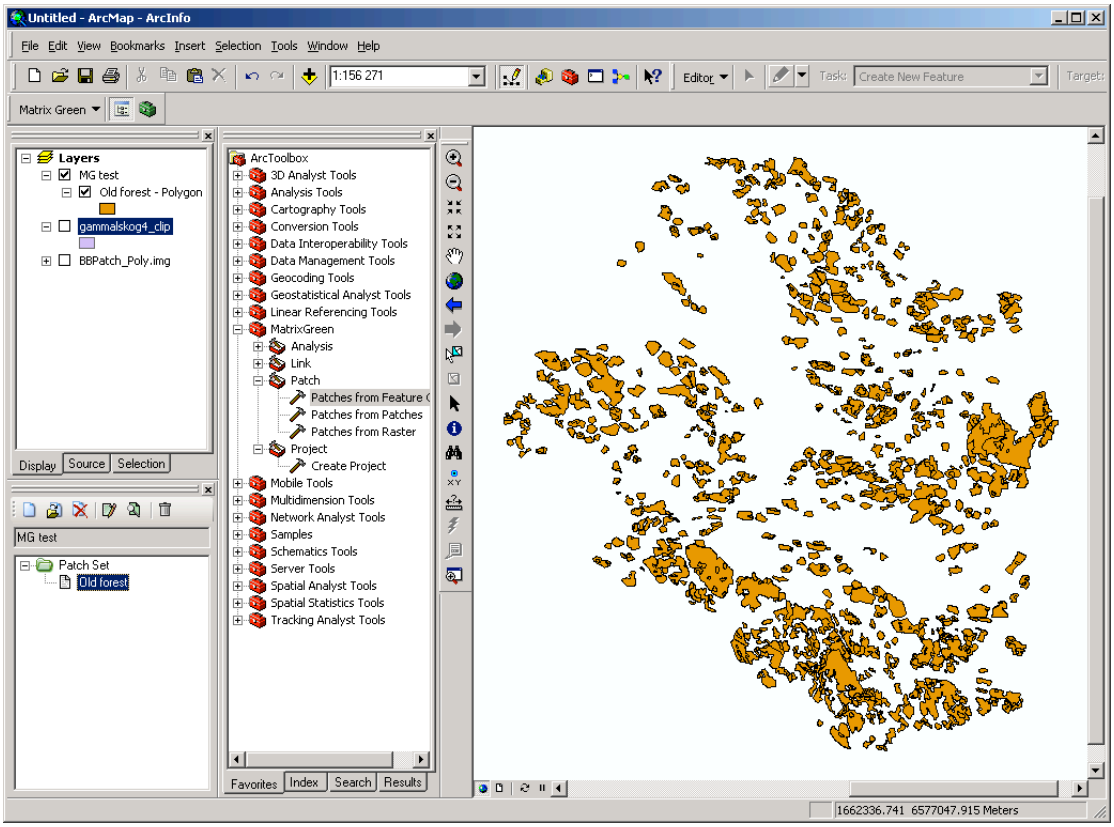

Figure 12. New patch set (named "Old forest") has been added both as a MG patch set, and as a new layer in the ArcGIS project.

Creating a link set

A network consists of nodes and links. In MG, a node is represented by a patch. Thus, to construct a complete landscape network, we need to create a set of links for each set of patches.

A link set is a set of links between patches in a patch set. The links are defined based on the maximum dispersal distance for a certain species. If a patch is perceived as being within reach for a dispersing species (i.e. the distance is shorter than a user defined maximum dispersal distance), the pair of patches will be connected through a link.

The perceived distance can be calculated based on either the Euclidean distance (straight line) between the centre points of each pair of patches (MG tool "Find links CC"), or between the closest edges of each pair of patches(MG tool "Find links EE"). It can also be calculated using the least-cost path distance (LCP) across a friction surface (MG tool "Find links LCP"), which requires you to define a raster where the raster cell values correspond to the cost of moving across the cell (as perceived by the species).

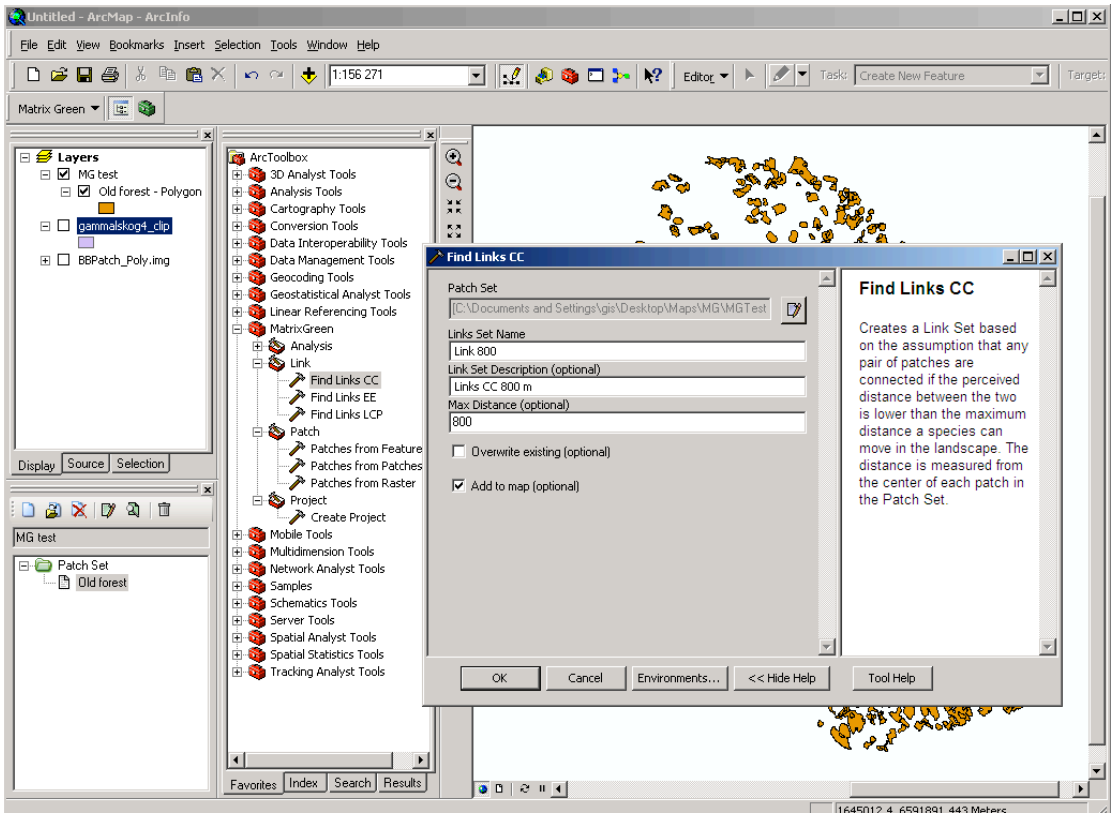

Figure 13. Dialogue window used when creating link sets

The following inputs are common for all three approaches in creating link sets: Input Patch set (from your existing MG project), name and description of the link set, the assumed maximum dispersal distance of the target species (Fig. 13). Like when creating patch sets, you can choose if any pre-existing link set should be over-written, and if the links should be shown as a layer in ArcGIS. A newly created link set named “Link 800” is shown in Fig. 14, both as a leaf under the patch set item “Old forest” in the MG project browser, but also as an ArcGIS layer of lines.

If links are to be created using the LCP method, you will also need to specify a raster file containing the friction data (as stated earlier). Also, it will take a very long time to calculate all LCPs for a large network/landscape, thus only use this method with care and/or patience!

Note! If you have raster cells with “No Data”, you will need to change these into some high value representing a barrier. MG currently interprets friction value “No Data” as “0” which is probably not what you intended. A typical example is if you have extracted a study region and do not want the LCP to be created outside of that study region. Also note that most network analysis methods assume that you only have direct LCPs from one patch to the next. In order to conform with this criterion, the friction value within all patches needs to be set to a very high value corresponding to a barrier.

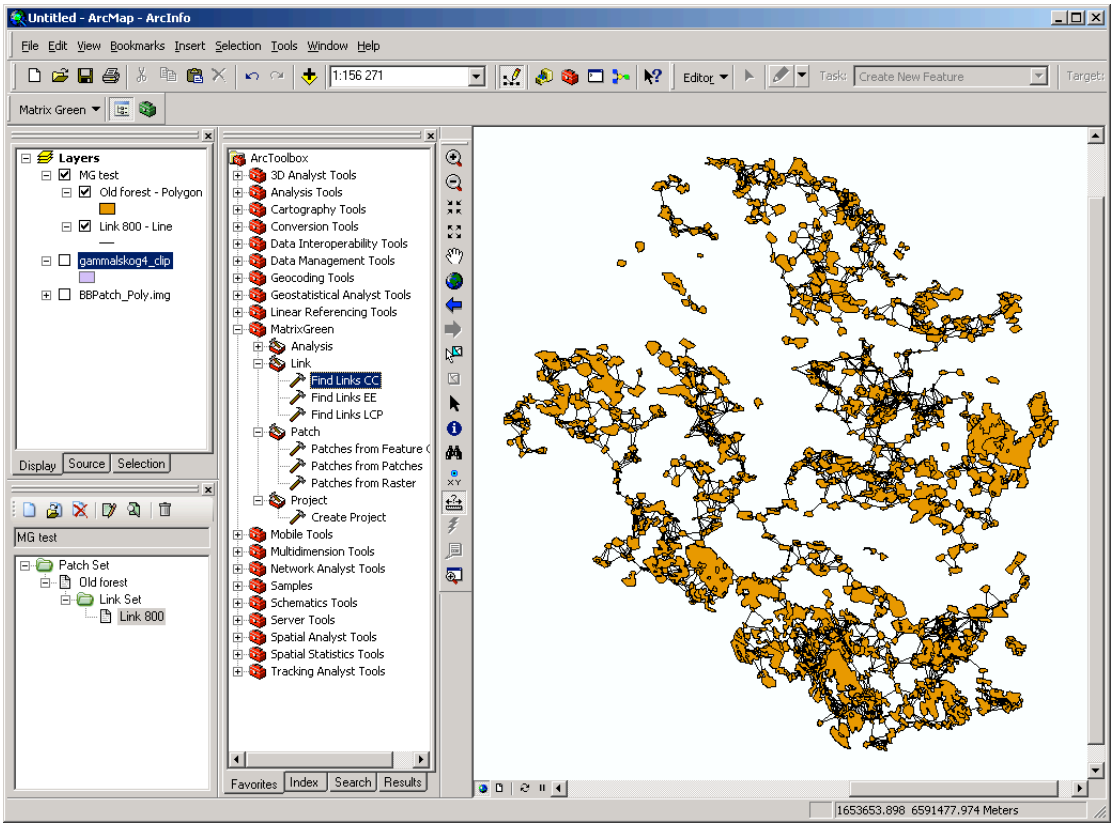

Figure 14. A patch and a link set are displayed ("Old forest" and "Link 800" respectively).

When both a patch set and an accompanying link set have been created, a complete landscape network is created. This network is then the basis for further analyses of the landscape's connectivity.

Analyzing the connectivity of the landscape network

MG supports two kinds of analyses. The first is focused on the whole landscape/network level ("Component based analysis" and "Patch distance analysis"), and the second is focused on individual patches' contributions to landscape connectivity ("Betweenness centrality"). There are many other network-based metrics that can be used to assess both whole-network characteristics as well as the importance of individual patches. Some of these metrics are planned to be supported in coming versions of MG.

Component based analysis

A component is a set of patches that are connected for a certain dispersal distance. Any patch within a component can be reached from any other patch within the component but not from patches outside the component. Hence, a component can be seen as an isolated segment of the landscape in terms of connectivity. The size of the component is the total size of all the patches that are connected. The smaller the total area of the component, the less likely it will be able to support a viable population.
Component analysis is therefore particularly useful when assessing the level of large-scale connectivity, i.e. the connectivity from a landscape perspective.
Component based analysis is supported by the MG tool "Component Analysis" (part of the MG tool group "Analysis"). The inputs are the patch set and the link set. You can add a description to the result (see Fig. 15). The results are presented as a leaf under the link set, and optionally also as a layer in ArcGIS (Fig. 16).

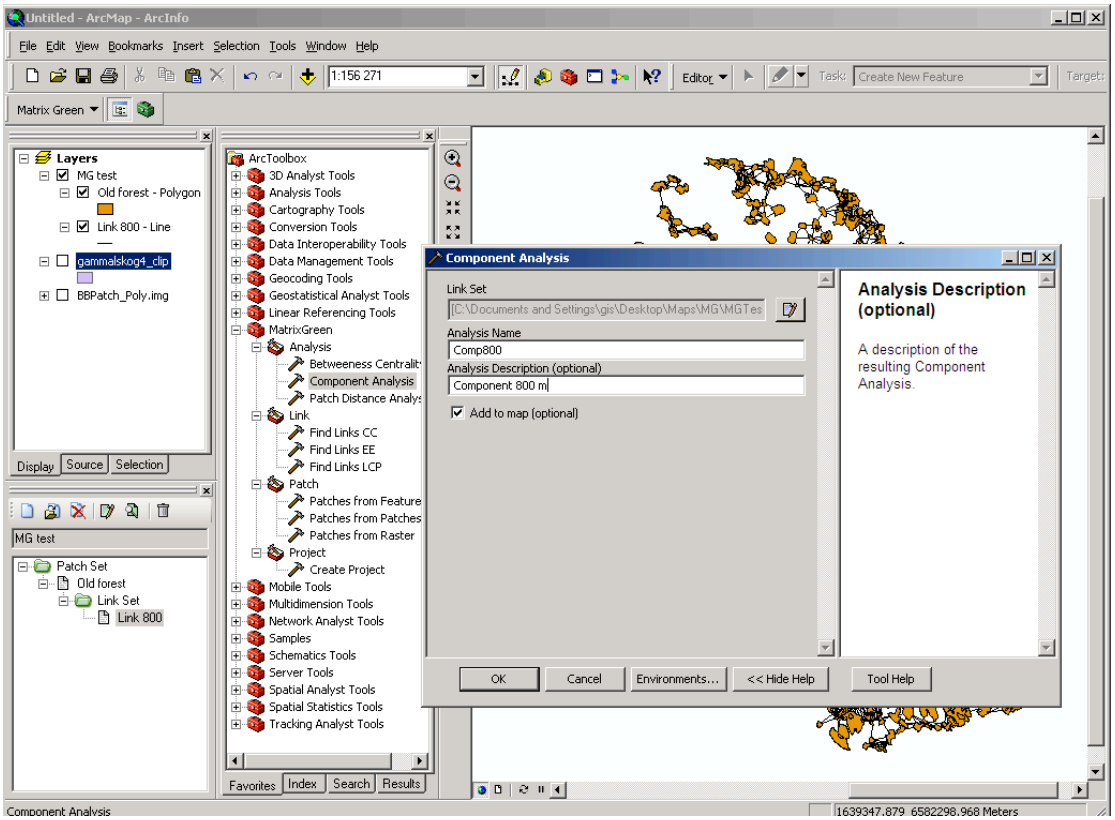

Figure 15. Dialogue window for the MG tool "Component analysis"

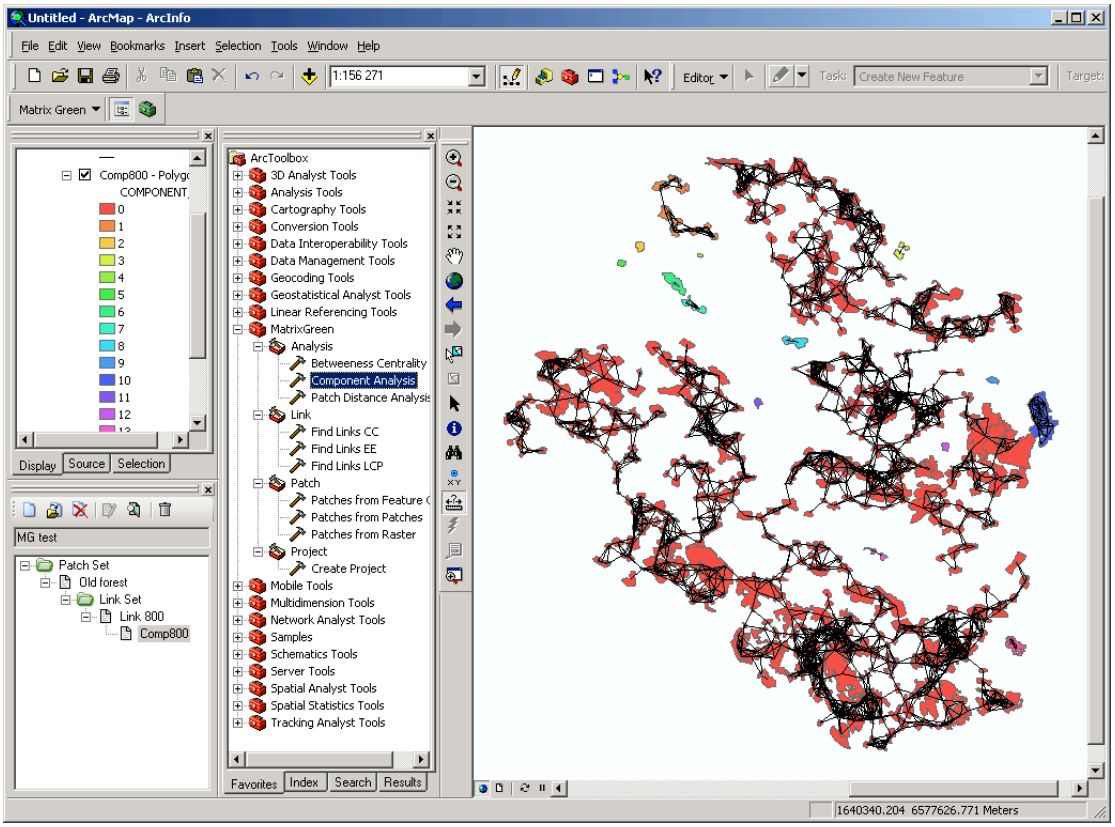

Figure 16. The result from a component analysis. All patches in each component are presented using the same color, and all components have their own unique color.

Patch distance analysis

This tool creates a diagram illustrating the size of the largest component for a range of maximum dispersal distances. Hence, it can be used to study whether there are any critical thresholds in terms of maximum dispersal distances in the landscape. It can also be used to get an overview of how well connected the landscape is for different species with different dispersal distances.

Hence, this analysis can be defined as a macro analysis since it will (1) create a range of link set, and then (2) do a component based analysis for each of these link sets. The link sets will not be stored, nor will the component data. Instead the results are presented in a diagram (Fig. 17). The diagram will also be visible as a leaf in the MG project browser. The curve in the diagram shows the size (in % area) of the largest component for that specific maximum dispersal distance.

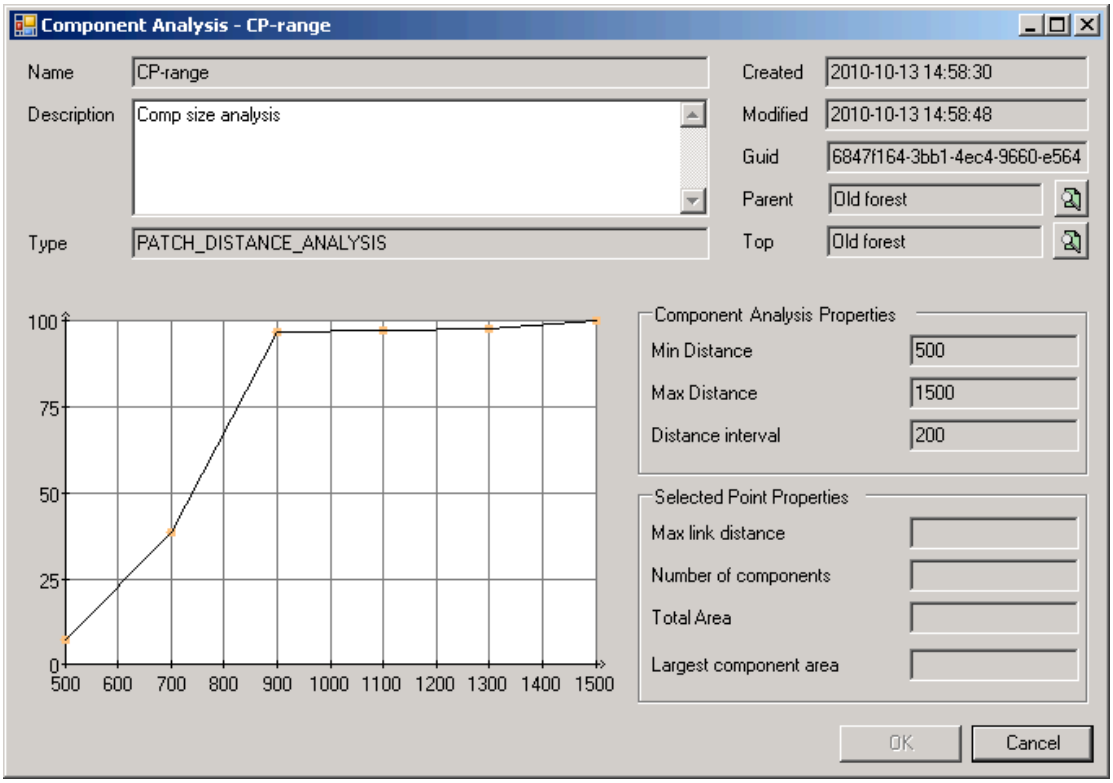

Figure 17. A diagram from a Patch range analysis.

The Patch distance analysis tool needs a patch set and a maximal dispersal range (and size of interval) as inputs (Fig. 18).

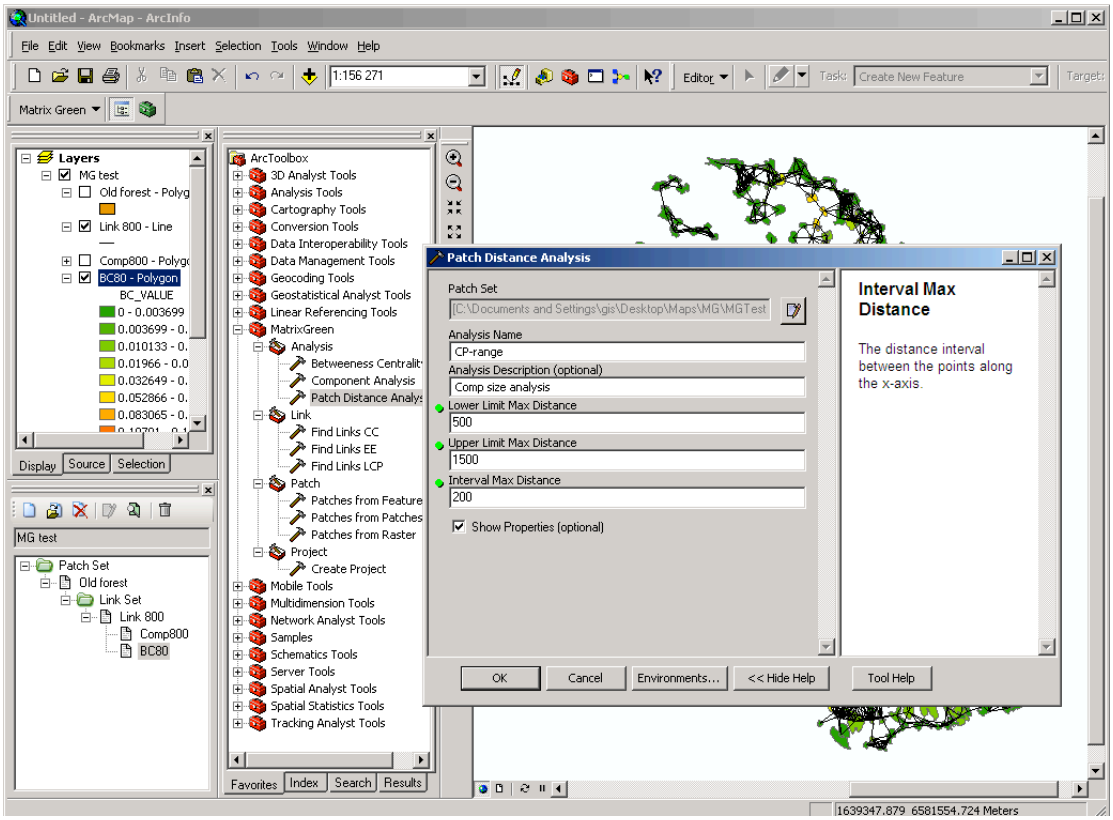

Figure 18. The dialogue windows for the MG tool "Patch range analysis"

Betweenness centrality analysis

Using network analysis, different aspects (i.e. level of importance) of the *individual* patches and/or links can be analyzed. Betweenness centrality is a way to identify patches that are centrally situated within the network from a connectivity perspective, and this metric has been proposed as a suitable measure of the stepping-stone importance of individual patches. The patches with the highest betweenness centrality scores are situated in such a way that most of the shortest routes between any two patches in the landscape pass through these high-betweenness-centrality patches. They can therefore be argued to be important stepping stones in the landscape. The betweenness centrality score ranges from 0 to 1, and a patch with a high score could thus be an important stepping stone in the landscape.

The MG tool "Betweenness centrality" calculates the betweenness centrality for all patches in the landscape. It takes a link set (and therefore indirectly a patch set), a name and a description as input (Fig. 19). As for the other tools, you can choose to add the results to the ArcGIS map directly.
The result is linked to the corresponding link set, and is presented in the MG project browser as a leaf on its own (Fig. 20). Fig. 20 also shows how the result can be used to visualize each patches level of betweenness centrality (and therefore it presumed level of importance as stepping stone).

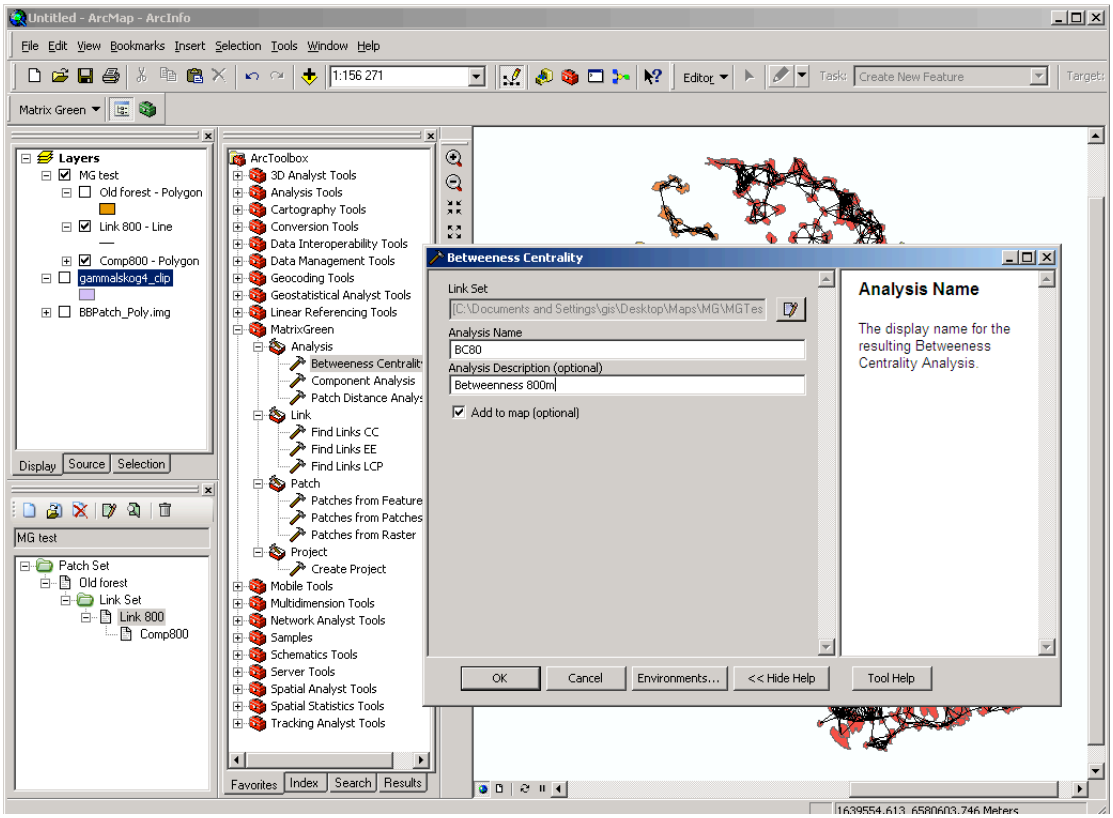

Figure 19. Dialogue window of Betweenness centrality tool.

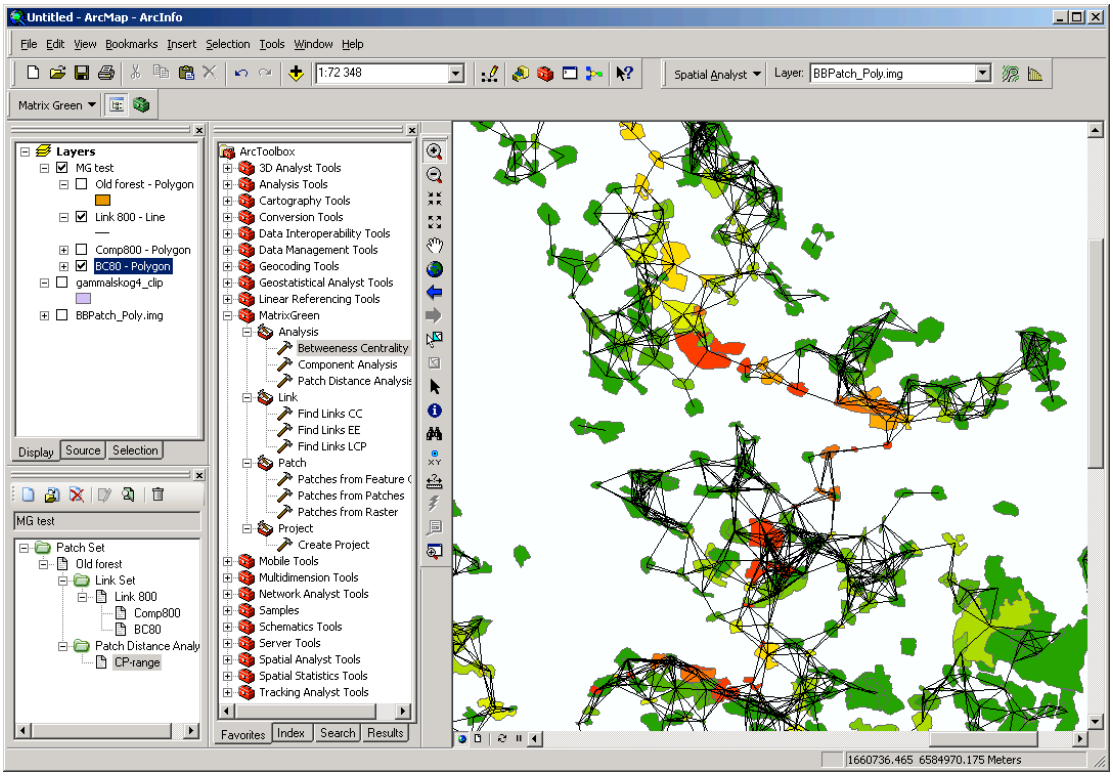

Figure 20. The results of the Betweenness centrality analysis (see the leaf "BC80" under the link set "Link 800" in MG project browser). The color of the patches is set according to their level of Betweenness centrality (high = red and low = green). It is apparent that the patches that act as bridges (i.e. stepping stones) between larger clusters of patches get higher scores (as expected).

Other features

Here we describe some other features of MG which are not linked to any specific type of analysis.

Make results visible in ArcGIS

All datasets and results (except the result from the Patch range analysis) are stored in Feature classes. Thus, the results can be showed, analyzed and manipulated in ArcGIS as would any other Feature class. However, to make that possible, the data has to be added as a layer in the ArcGIS layer browser. This can be done automatically when the analyses are carried out (check the option "Add to map"), or it can be done afterwards. To do this afterward, point to the specific dataset/result (e.g. a patch set) in the MG project browser, and right click on the item. Then a menu pops up, and one of the option it whether to make the data visible or not (Fig. 21). If checked, the layer will be added to the ArcGIS layer browser. Also, the menu item "Layer display" gives you an option to use any of the pre-programmed rendering styles in presenting the data. Please note that you can also use the many more different options available in ArcGIS to define how the results should be presented.

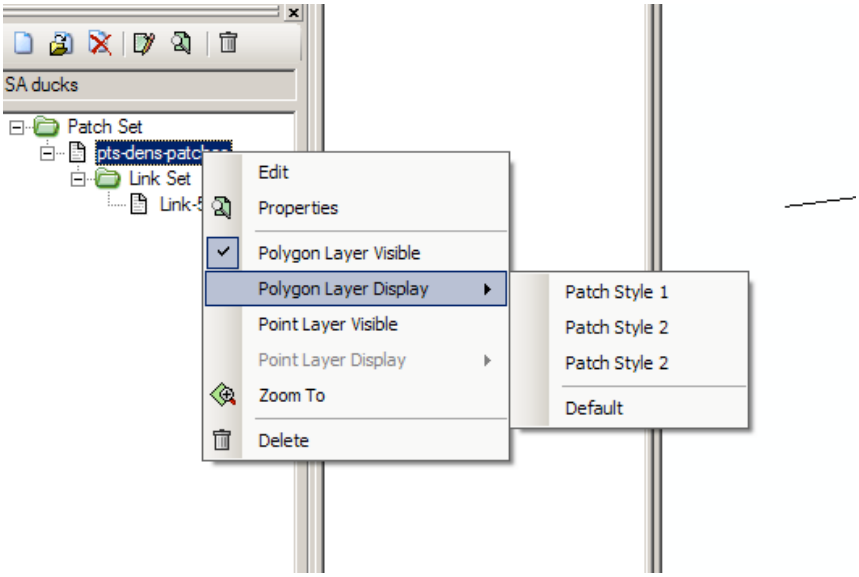

Figure 21. Patch set menu (shown by right click the patch set in the MG project browser).

Also note that some of the results are stored as multiple types. For example, a patch set is stored both as a set of polygons, but also as a set of points (each point correspond to the centre point of the patch). One or both of these layers can be made visible in ArcGIS by selecting appropriate items in the menu shown in Fig. 21.

Results as attribute tables

Since most of the results are stored as Feature classes they can be analyzed as any other Feature data. The attribute tables for a Patch set, a Link set and the results from a Component analysis are presented in Fig.22. Note that each new MG specific item (e.g. a patch, a link, etc) are given a unique ID along with some other data (stored in separate columns). These data can, for example, be used to filter the results (e.g. only show the patches with an area larger than a certain threshold etc).

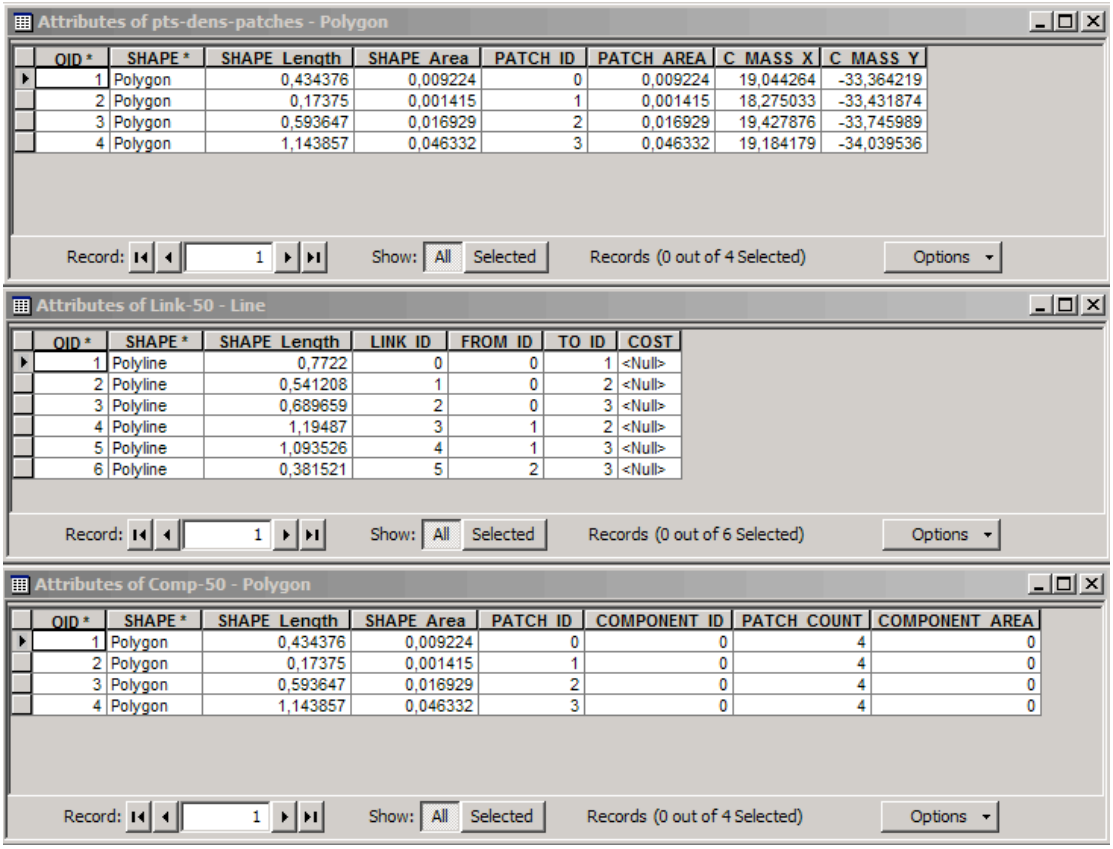

Figure 22. Attribute tables of (from top to bottom): Patch-set, Link set, and the result from a Component analysis.

Program settings for least-cost path links

When using a high value for the maximum distance in the MG tool "Find links LCP", the least-cost path algorithm can consume lots of internal memory, eventually making the program crash, or links between certain patches to be ignored. There are two ways of handling this. When MG is installed, a configuration file called matrixgreen.conf is created in the folder "C:\Program Files\EcoConn\MatrixGreen\conf\". This can be edited using a regular text editor and contains two rows called "mg.settings.lcp-boost-max-rows=" and "mg.settings.lcp-boost-max-cols=". When an lcp becomes too long to calculate, that patch is ignored which is reported as "skipped patches" in the dialogue window when the calculation of LCPs has completed. The max-cols and max-rows can be increased to avoid the skipping of patches with the drawback of the entire calculation to crash instead.

In the same file, there is a setting called "mg.settings.lcp-patch-line-option=" that controls how the LCP polyline features should be created. You can choose between three different values here: *center*, *edge* or *original*. The value *center* creates a straight line within the patch from the center point to the edge and then continues with the LCP between the edges of the patches. The value *edge* creates polyline features of the LCPs only between the edges. The value *original* is like the *center* option but it creates an LCP-like line within the patch instead of a straight line.