**USER GUIDE**

**for**

**LandAdvisor,**

**A customizable ArcGIS toolbox for conservation assessment and planning**

*Documentation Version: Little Karoo 3.0 alpha release*

May, 2012

***Contact information:***

John Gallo

Center for Landscape Analysis

The Wilderness Society

San Francisco, CA

415-398-1111 X 100

Email: john\_gallo@tws.org

Table of Contents

[Table of Figures and Tables 3](#_Toc326321406)

[Introduction 4](#_Toc326321407)

[Toolbox Background 4](#_Toc326321408)

[Where to go for Help, Support and to Log Suggestions and Ideas? 4](#_Toc326321409)

[Modelbuilder 4](#_Toc326321410)

[Document overview 5](#_Toc326321411)

[Start-up guide 5](#_Toc326321412)

[Quick Start-up using the Little Karoo data 5](#_Toc326321413)

[More details (optional) 8](#_Toc326321414)

[Notes about using different parameter values 9](#_Toc326321415)

[Methods 12](#_Toc326321416)

[Look-up Tables and Diagrams 12](#_Toc326321417)

[Spatial Units and Conservation Actions 13](#_Toc326321418)

[Combination of Criteria (Normalization) 14](#_Toc326321419)

[Biodiversity Value of a Place 14](#_Toc326321420)

[Multi-scale and Multi-Extent Habitat Representation 15](#_Toc326321421)

[Species Representation Value 24](#_Toc326321422)

[Composite Representation Value 24](#_Toc326321423)

[Composition Value 24](#_Toc326321424)

[Connectivity Analysis 24](#_Toc326321425)

[Contiguity Value 27](#_Toc326321426)

[Spatial Context 27](#_Toc326321427)

[Net Benefit versus Gross Benefit 27](#_Toc326321428)

[Cost of Management Action 1 (Acquisition) 29](#_Toc326321429)

[Cost of Management Action 2 (Private Stewardship) 30](#_Toc326321430)

[Benefit / Cost 31](#_Toc326321431)

[Summarizing all criteria per site 32](#_Toc326321432)

[The Maximize-short-term-gains Heuristic 33](#_Toc326321433)

[Customizing LandAdvisor for your Region 34](#_Toc326321434)

[Set the Environment of your .mxd 34](#_Toc326321435)

[Pre-processing your own Data for the analysis 37](#_Toc326321436)

[Start-up using your data 39](#_Toc326321437)

[Developers Guide 42](#_Toc326321438)

[Function of Diminishing Returns 42](#_Toc326321439)

[Integrating the Connectivity Algorithm From The Islands Trust Effort 45](#_Toc326321440)

[The Maximize-short-term-gains accounting system 45](#_Toc326321441)

[Copying select Models and submodels from one toolbox to another 46](#_Toc326321442)

[LandAdvisor Factory Toolbox 46](#_Toc326321443)

[Tips, Tricks, and Suggestions for Using and Customizing LandAdvisor 47](#_Toc326321444)

[Working with Modelbuilder 47](#_Toc326321445)

[License 53](#_Toc326321446)

[GNU GENERAL PUBLIC LICENSE 54](#_Toc326321447)

[TERMS AND CONDITIONS 55](#_Toc326321448)

[References for all sections 55](#_Toc326321449)

Table of Figures and Tables

[Figure 2: Biodiversity Value of a Place (numbers in the ovals are sample weights). 15](#_Toc326321399)

[Figure 3: A simple function of diminishing return (FDR) 17](#_Toc326321400)

[Figure 4: A more complex FDR designed to address ecological and conservation planning principles 18](#_Toc326321401)

[Table 1: Summary of all Parameters 19](#_Toc326321402)

[Figure 5: Cost of Acquisition 30](#_Toc326321403)

[Figure 6: Estimating a near-optimal set of properties to conserve 34](#_Toc326321404)

[Table 2: Input Data; The Sonoma 1.0 Column indicates which data are not necessary for this version (3.0). See text. 40](#_Toc326321405)

Introduction

Toolbox Background

This toolbox implements a utility-maximization framework [(Davis et al. 2006).](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandAdvisor_LittleKaroo_v3_0_alpha\support\references\Davis_Costello_Stoms_2006.pdf)  (Note: the hotlinks work if this document is in the support folder of the LandAdvisor directory.) This framework is based on the marginal value approach and return on investment principles that are increasingly prevalent in conservation science. These are discussed at length in the white paper in the support folder (Gallo & Lombard In Revision). The framework was first applied in a real-world case study in 2005 to create the [Regional Conservation Guide](http://www.conceptioncoast.org/projects_rcg.html) for the Conception Coast Project. The geoprocessing of this first application was performed manually. The second application was programmed using modelbuilder in order to make the effort more transparent and transferable. This second application occurred in the Little Karoo of South Africa in 2008, and provided decision support to a land trust and a government agency partnering to purchase and manage land for conservation ([Gallo and Lombard unpublished)](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandAdvisor_LittleKaroo_v3_0_alpha\support\references\Gallo_Lombard_Spatial%20Decision%20Support%20System.pdf) (A complete revision of that paper is in process). The third and fourth applications are underway, one by the Islands Trust Fund of Canada, and the other by the Sonoma County Agricultural and Open Space Preservation District. The modelbuilder toolbox that resulted from the second application has been improved further, bringing us to the present toolbox. Previous names of LandAdvisor that may be present in some documentation include Lorax, BioVision, and LandAdvisor.

This version is released under the General Public License 3.0, with some additional stipulations. This means that the models and scripts are open access, and then improvements by anyone on the models, scripts, and framework are open access too. The details of this open source license are provided at the end of this document.

This version of the toolbox is compatible with ArcGIS 10.0 (ArcView or greater)and requires a Spatial Analyst license. Please see the [minimum specs](http://resources.arcgis.com/content/arcgisdesktop/10.0/arcgis-desktop-system-requirements) for a computer running ArcGIS 10.0

Where to go for Help, Support and to Log Suggestions and Ideas?

For help, the first step is to become familiar with the outline of this document.

Additionally, we have developed an online “collaboratory” (collaborative laboratory) designed to help with the application and further development of this model. It is there that you can download the model, data, the user guide, and then log support questions, interact with other people applying the model, use the project management tool called JIRA, and utilize many other collaborative tools.

The site is called [The Landscape Collaborative](http://landscapecollaborative.org) and embodies a broad mission “to inspire, empower, and assist people in sustaining our natural landscape. We are currently a budding community of scientists and practitioners sharing tools, knowledge and skills in implementing a [Landscape Decision Support Architecture](http://landscapecollaborative.org/display/WEB/Vision).” (Current November 2011)

Modelbuilder

Modelbuilder allows you to “program” models without knowing a command line programming language. You drag and drop commands/tools onto a blank “page”, and connect them with arrows. You can program iterations, loops, and feedbacks too. You can nest models within models, and link them together. There is also a good interface for documenting your work and providing a help file for your model. Please see the [Working with Modelbuilder](#workingwithmodelbuilder) section of this document for more information.

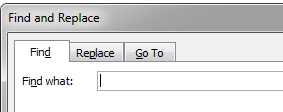
Document overview

The Quick start Guide is for end-users wanting to run LandAdvisor on their machine using the Little Karoo data.

The rest of the document is for GIS Analysts and Developers wanting to apply the model to their landscape and/or to use or modify sections of the model.

The table of contents is hotlinked to every section, and there is a link at the bottom of every page to return to the table of contents.

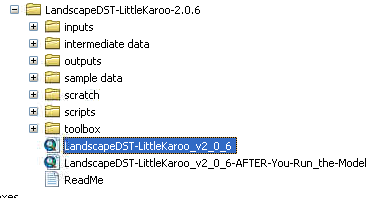
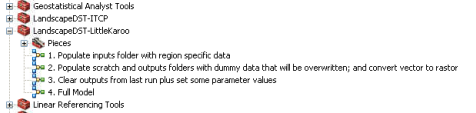
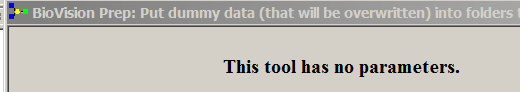
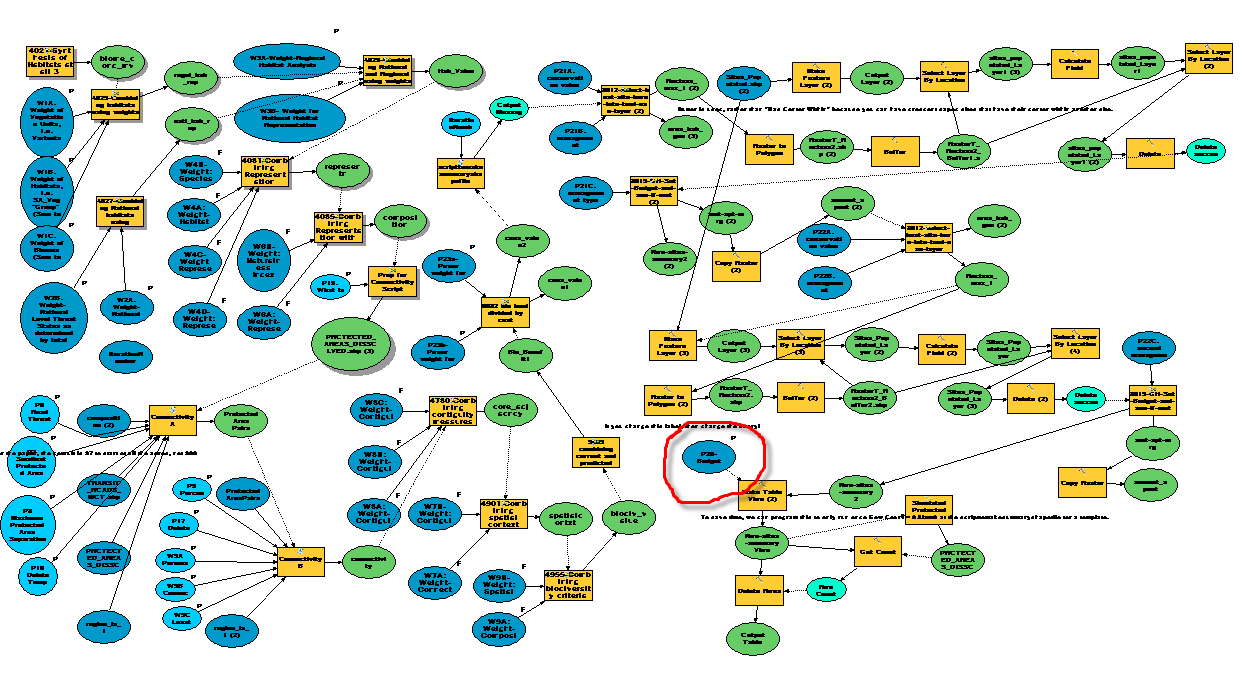
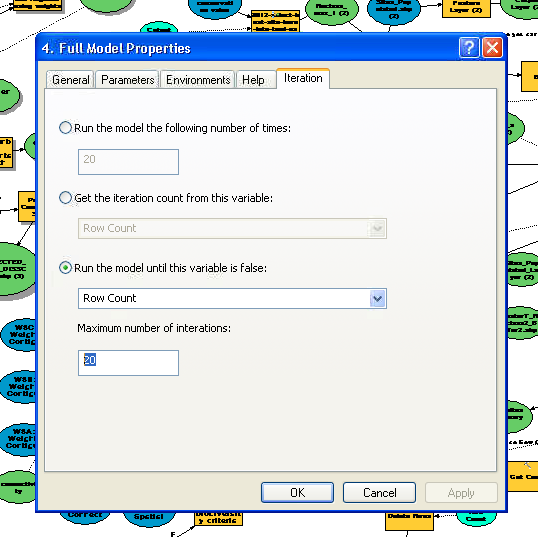
There are also hotlinks throughout the document, like this one to [Pre-processing your own data for the analysis.](#preprocessingyourowndata) You can use the back button in your pdf reader to return to where you were, and if viewing the word version, you can but the back button on your toolbar: .

One of the best ways to use this document is with the find function in your .pdf or .doc reader, i.e.: 

This is a living document, so please feel free to make edits/additions using tracked changes and comments to the MS Word version of this document (in your support folder). Send all comments/edits to John Gallo.

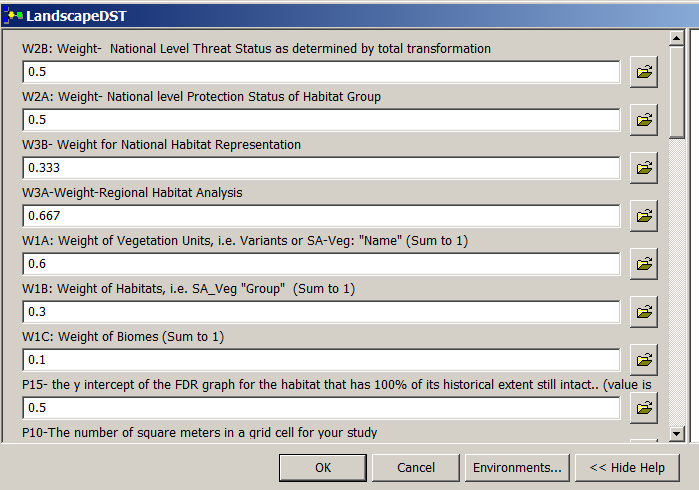
Start-up guide

Quick Start-up using the Little Karoo data

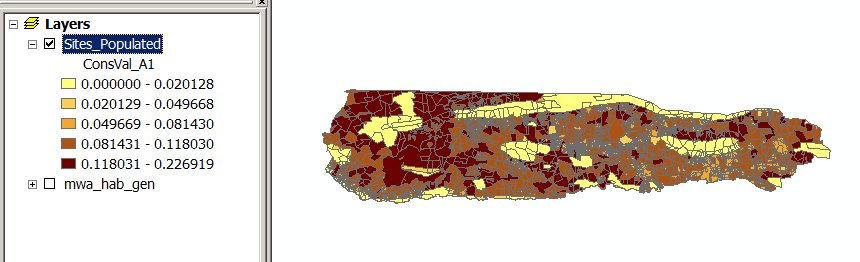
* Unzip the LandAdvisor zip folder into a location on your GIS harddrive
  + Note: It is best to put it in a location that is fairly close to the root folder. Some people have run into problems if they place it too deep in the directory structure. It is best but not mandatory to put this in a drive other than your C: drive.
* Open the LandAdvisor-LittleKaroo\_vX .mxd in the unzipped hierarchy under …/LandAdvisor root folder. If there are several, use the one with the highest version number.
  + 
  + Note, if a screengrab shows LandscapeDST, that is the same as LandAdvisor
* Once opened, you should see a Toolbox called LandAdvisor-Little Karoo.
  + It should now be included on the long list of Favorite GIS Toolboxes that you are familiar with, such as “Cartography Tools”. Double click LandAdvisor to expand it. Example:
  + 
  + Run models 1-3 in order.
    - Run a model by double clicking it.
    - When a model says “This tool has no parameters” it is not an error. Just press OK. Example:
    - 
    - If it does have parameters, you can just use the default parameters.
  + Now run model “4. Full Model”
    - The Default settings for Version 2.1.0 are to keep running until enough properties are selected such that 25 Million Rand are spent towards acquisition, stewardship, and management actions over the next 30 years.
    - To change the default value of the model budget to be higher or lower, double click on the oval within the red circle below.
    - 
    - To make the model run a certain number of times rather than until the budget is met, right click on the above model, and select model properties/Iteration and click the top radio button and fill in the desired number of iterations.
    - 
  + After model 4 runs, you can add all or some of the layers in the outputs folder and examine the results.
    - * Click the add layers button, , and navigate to the outputs folder. (See [tables](#LandscapeDSTTables) for list of layers).
      * Tip: You can click the top one, hold down shift, and click the bottom one. This will highlight them all. Press add.
      * Tip: you can highlight them all in your mxd. Right click on one of them and press “Add to Group”. You can rename the group Outputs.
        + **Sites\_Populated.shp** is the shapefile that summarizes all the important layers by site (in this case, a site is defined as contiguous property under the same ownership.)
        + The grids **cons\_value1**, and **cons\_value2** are the estimated value of conserving each hectare according to the acquisition strategy (1) or private stewardship strategy (2).
      * You can repeat the above for the inputs.

More details (optional)

* The nutshell of each model:
  + “**1. Populate inputs folder with region specific data”** This model asks you which type of Sample Data from the Little Karoo you want to use. [As of June 2010, there are only high resolution (100 m) data for the entire region, but subregional datasets may be clipped soon.] The model then copies these data into the input data folder while changing the file names to the correct names.
  + **“2. Populate scratch and outputs folders with dummy data that will be overwritten; and convert vector to rastor.”** This model puts “dummy” grids into the scratchworkspace so that the overall LandAdvisor model can run. The LandAdvisor model is composed of many sub-models, each one with required inputs. These required inputs need to be pre-existing for the model to start. The dummy grids you make now will be overwritten with the true data before they are used.
  + “**3. Clear outputs from last run plus set some parameter values**” After you run the model once there will be some data in the scratch and outputs folder for that run. These need to be cleared out before the model can run correctly again. This model also sets some of the parameter values.
  + **4. Full Model** This is the juice. See the methods section below for details.
    - It may take a minute to open, because it has to check to be sure everything is in place first.
    - For Model 4 a long list of parameters will be provided. You can simply use the default parameters and press “OK”. For example:



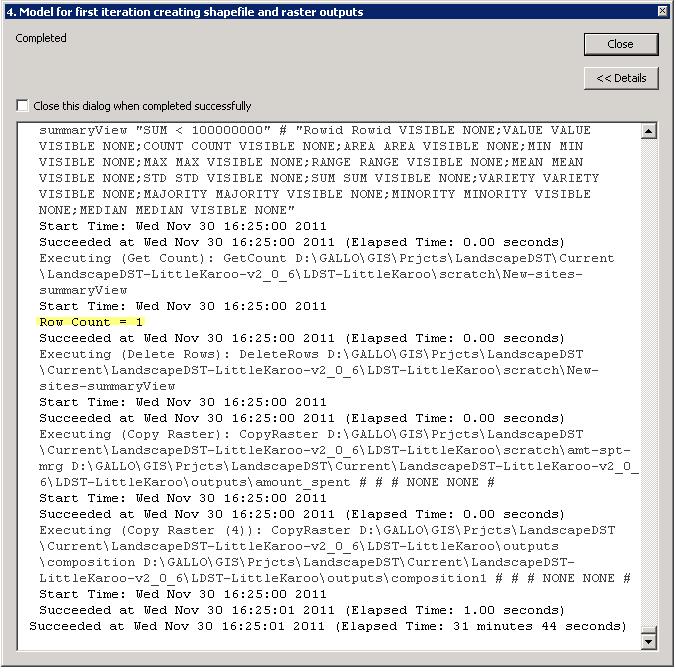
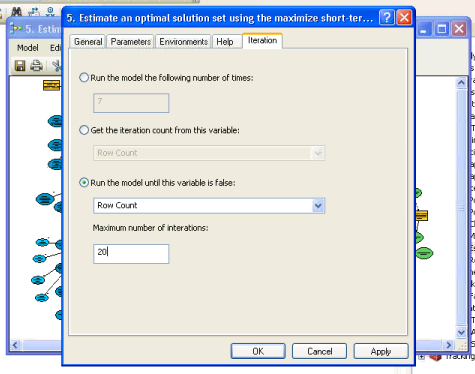
* + - It takes some time to load the parameter list and to change values.
    - **For definitions of the parameters, see the** [**Method**](#methods)**s Section**
    - Eventually, the graphical user interface (GUI) where you change the weights and parameters will likely be a lot more user-friendly.
    - The screen grab below shows the final result for the default parameters from 14 June 2010 (they have since been modified slightly). In this case, The Relative Conservation Priority of implementing Action 1 (Acquisition and then Management in this case) is mapped, with no stretch of the color ramp.



Notes about the model run

* Similarly, when the model is populating the shapefile, it gives a green error message in the details window. This is fine. It occurs when it gets to a null value.

Notes about using different parameter values

* If you would like to experiment with different parameter values, you can change them either by opening one of the above models and double clicking on the parameter and changing it; or, you can simply double click the model in the toolbox and change the parameter in the dialogue that loads. See the below chapter, especially the parameters look up table, for details about each parameter.
* To dramatically speed up the processing of the models 4 and 5, you can change some of the default parameters. For instance, changing P7 to 400 million will change the minimum size (in ha) of a core area considered for the connectivity analysis reducing the number of connectivity analyses significantly to about three. Secondly, you can reduce the budget from 25 Million to 10 million to decrease the number of iterations needed to meet the budget. See the[methods](#methods)for a table and descriptions of all the parameters.
* Do not be alarmed if it takes a lot of processing time to change any particular parameter value. That is one of the biggest drawbacks with the current modelbuilder interface. One of the top usability improvements in future iterations is to fix this annoyance, probably via calling a parameter table.
* If you are trying different parameter values, make sure you don’t overwrite your previous outputs by accident.
  + Note: This means that if you want to run the model once, and then again with different parameter values, *and you want to keep all the results from your first run*, then you need to copy the output folder from the first run and paste it somewhere else before running the model again.
* If you change the Budget parameter, then when model 4 completes you will need to assess it to see if it completed because the budget was met or the maximum number of iterations. In the Run Details Window, one of the lines near the end of the run window will read Row Count = 1 or Row Count = 0. If 0, then the budget was met, if 1, then the max number of iterations was met.
  + 
    - * If Row Count = 1. Run model 4 again. Repeat your assessment of how it finished. (You’ll need to have the setting such that the run window stays open after the model completes). If you r computer can handle it, increase the max number of iterations in the model properties/Iterations dialogue. [May, 2012: these last two bullets may need to be updated.]
  + If you set the Parameter for the budget very high, such that the computer needs to run for days to meet it, then it may run out of memory and crash. In this case, look in the outputs folder at a file like new\_reserves to find out how many times it iterated before it crashed, and then set the max iterations a few iterations below that, as per the below:
    - * 
      * In this case. Close arc map, reopen, and run model 4 again. Repeat your assessment of how it finished. (You’ll need to have the setting such that the run window stays open after the model completes).
* Sometimes (in 9.3), after changing the parameters and re-running, the model puts a lock on some of the files, and will give an error message sequence such as the below :

Executing (4849-Make-individual-Reserves (2)): 4849-Make-individual-Reserves2 %scratchworkspace%\Connectivity %scratchworkspace%\Connectivity\rsv0

Start Time: Thu Jun 30 16:11:40 2011

Running script 4849-Make-individual-Reserves2...

ERROR 999998: Unexpected Error.

Failed to execute (4849-Make-individual-Reserves (2)).

* The way to solve this particular error (often), is to close ArcMap (and Arc Catalogue to be on the safe side) and then re-open. It should work fine after that process.

Methods

Look-up Tables and Diagrams

There are three living documents in the support folder that are essential to reviewing these methods. These documents are helpful in implementing LandAdvisor in a new region.

[LandAdvisor vX\_X Tables.xls](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandAdvisor_LittleKaroo_v3_0_alpha\support\Document%20Source%20Files\LandscapeDST%20v2_x%20Tables.xlsx)

There should be an excel file with this name (X.X. is the version number) in your support folder. It has several tables within it. They are accessible by clicking the tabs at the bottom of any particular worksheet. Some of them are pasted into this document later. They are summarized as follows:

Conservation Actions worksheet:

Defines the conservation actions 1-4 used in parameterizing the model. (Version 2.X only has two actions.)

Inputs

Gives a quick indication of what each input file is for this version. It also indicates which of these may be obsolete and not necessary. Future versions should be cleaner.

Outputs

Gives a quick indication of what each input file is for this version. It also indicates which of these may be obsolete and not necessary. Future versions should be cleaner.

Parameters

A list of the parameters used in LandAdvisor, their default values, and brief description. (The Weight Parameters are not listed here, rather, they are displayed on the multi-criteria hieararchy diagram, described later.)

Advanced Parameters

These are advanced parameters that need to be turned on from within an edit window before they will show up as tool parameters when you press “open.”

[Multi-Criteria Hierarchy](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandAdvisor_LittleKaroo_v3_0_alpha\support\Document%20Source%20Files\Multi-Criteria%20Hierarchy.vsd).vsd ([or .pdf)](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandAdvisor_LittleKaroo_v3_0_alpha\support\Document%20Source%20Files\Multi-Criteria%20Hierarchy.pdf)

The diagrams of how all the criteria relate with the default weights. Some of them are pasted into this document later.

[Calibrating the Continuous Benefit Functions-Habitats.xlsx](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandAdvisor_LittleKaroo_v3_0_alpha\support\Calibrating%20the%20Continuous%20Benefit%20Functions-Habitats.xlsx)

This file is a tool that helps advanced users define the shapes of the continuous benefit functions (functions of diminishing returns). It corresponds to several of the advanced parameters of the LandAdvisor. I

Spatial Units and Conservation Actions

Spatial Units

A “cell’ is the unit of analysis, and is the cell size of all the raster grids. In the case of the Little Karoo, a cell was 100 m X 100 M (1 ha). A “site” is the geographic unit for reporting results. In the case of the Little Karoo, a Site was defined as a property, which was mapped as all the cadastres (parcels) that were contiguous and owned by the same person/entity. The value of a site is defined here as the mean value of all the cells in a site. This can be done for any type of value such as conservation value, habitat representation value, etc. This can be customized for any unique application. The term “place” is used in later diagrams as a generic term for area, and could be a cell, a site, or any other polygon.

Types of Conservation Action

This is a multi-objective model. It considers multiple types of conservation action (i.e. management alternatives.) The Little Karoo version considers two:

* Action 1: Acquisition. In this case the land is acquired (purchased) by a land trust and then donated to a government agency, who is then responsible for the proper stewardship of the land.
* Action 2: Private Stewardship. In this case the private landowner maintains ownership of the land and enters into an agreement to perform the proper stewardship of the land. Such agreements are often called easements or covenants, and often provide a tax incentive or other benefits to the landowner.

The Little Karoo Version (2011) is already partially set up to include two more types of conservation action.

Scenarios

It is possible to parameterize the model differently according to different projected scenarios and assumptions. One benefit of doing this is to see which sites are conservation priorities in multiple scenarios. The LandAdvisor Little Karoo 2.0.0 has a very basic scenario, as no threat data or models were readily available. The scenario assumption is that all lands that are not conserved in any way in the present cannot be counted on to conserve biodiversity in the future without intervention.

Combination of Criteria (Normalization)

Multiple spatial criteria are combined using a weighted sum. Before the weighted sum, each criterion is transformed to have values that lie between 0 and 1. The minimum and maximum value of a criterion are determined, and every value is transformed according to the following equation: (x-min)/(max-min). This way there will be a 0, a 1 and values in between. The multi-criteria framework is hierarchical, so the output layer of a multicriteria analysis was often used in another analysis. Because the maximum value of such an output may be less than 1, all outputs are transformed using the above equation.

Biodiversity Value of a Place

This is defined in LandAdvisor Little Karoo 2.X for each cell as the weighted sum between the Composition Value of the cell and the Spatial Context Value of the cell. These in turn are comprised of subcriteria, and so on (Figure 1).

Figure : Biodiversity Value of a Place (numbers in the ovals are sample weights).



Multi-scale and Multi-Extent Habitat Representation

The key to understanding this criterion is understanding the lower level criterion called Habitat Representation Value (Figure 1), which is described first.

Habitat Representation Value:

Model current name:

“4016-Book-Habitat-Conditional-Marginal-Value (2)”

(This is a model within model “4. Model for the first iteration and the Table Outputs” and within Model “5.Multiple Iterations”)

Key input layers:

Map of Habitats:

In the Little Karoo, there is a multi-resolution shapefile (vector based GIS layer) of the vegetation created by local expert Jan Vlok based on aerial photo interpretation and ground truthing (Vlok et al. 2005). Each place on the landscape is classified by biome, habitat type, and vegetation unit. The spatial distribution of the vegetation units are nested perfectly within habitat types, which are nested into biomes. For the Habitat Representation Criterion, just the habitats were mapped (N ~20) and converted to a grid file as per the protocol for setting extent and resolution in the section titled [Pre-processing your own data for the analysis.](#preprocessingyourowndata) Additional information about these data is provided in the [Metadata](file:///C:\Users\jgallo\AppData\Roaming\Microsoft\Word\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) document (in the Support Folder).

* File name: habitats\_g

The conservation target (% goal) for each habitat:

In the Little Karoo, a rigorous study had been performed previously determining the conservation targets (% of the habitat that should be protected in reserved to achieve adequate representation) for each habitat. The method was based on the plant species richness of each habitat type. Additional information about these data is provided in the [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) document.

* File name: targets\_g

Stewardship level:

This layer is the relative effectiveness of the current land management in protecting biodiversity. It is based on the duration/commitment of the management designation in place, as well as the quality of the management in preserving biodiversity. The end-user determines this value for every place. A standard practice is to assign each place to a particular management class, and then, during an expert workshop, to assign the stewardship value to each management class. In the Little Karoo, lands owned by the government and operated as parks received a quality of 1, multiple use lands owned by the government received a lower score, and conservation areas under private ownership received an even lower score. Each expert proposed a score for each land class and the final score was the mean value among all experts.

This is a prime layer for improvement in the Little Karoo, as it could have hundreds of different values, not just 4. Note: the layer was pre-processed, and is hence an input layer, but in future versions the populating of this layer should be part of the DST. It is also copied to the outputs folder to help with cartography and context. Additional information about these data is provided in the [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) document.

* File name: mngmt\_quality (mwa\_hab\_gen is an exact copy. We are mid process or switching over to using just the mngmt\_quality input layer.)

Naturalness index:

This layer is the ecological condition (i.e. transformation and degradation) of an area . The amount of downweight is determined by the end-user using a Condition Benefit Scale. For instance, the Little karoo had two different layers, based on remote sensing data, that indicated how degraded any particular cell on the landscape. Hence, cells classed as Natural received a value of 1, near-natural = 0.7, moderately degraded 0.656, and all else a value of 0. (The value of 0.656 was the average value among all the participants of the expert workshop.) Note: this layer was preprocessed for this version of the DSS, hence it is an input and an output. Eventually it will be parameterized as part of the model, with the input data being the remote sensing layers, and this would be an output only. Additional information about these data is provided in the [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) document.

* File name: condition (cwa\_hab\_gen is an exact copy. All the models that call for it still need to be changed to call for condition instead)

Analysis Summary

The principle of habitat representation is that in order to preserve biodiversity, it is wise to preserve the different habitat types of a study area. Hence, the more a particular habitat type that is conserved, the better for biodiversity. Because conservation is all about trade-offs, it is important to conserve a minimum amount of all the habitat types of a region, rather then all of any one particular habitat. LandAdvisor uses a new approach called functions of diminishing returns (FDR) to implement this logic: simply put, as more of a particular habitat type is conserved the relative benefit to biodiversity of conserving the next hectare of the habitat type diminishes. The percentage of the habitat conserved at any given moment corresponds to a point on the FDR curve, thereby giving a quantitative measure of benefit ().

Figure : A simple function of diminishing return (FDR)

In this example, conserving a habitat that has 20% of its extent protected in reserves has a relative benefit of 0.80, while conserving a habitat that has 30% of its extent protected has a value of 0.7. The power of this approach comes from the ability to make the FDR curve nonlinear in order to reflect ecological and conservation principles. Figure 2 is an example of such a curve. The LandAdvisor end-user sets the values of several key parameters which will then apply to every habitat’s FDR. Each habitat could have its own uniquely shaped FDR, or it may have the same shape as some or all of the other habitats. The relative benefit of protecting the next hectare of the habitat not only depends on the shape of the curve, but also on how much of the habitat has already been protected.

Usage of FDR allows accounting of different stewardship and naturalness categories (defined earlier) in determining habitat representation by using quality-weighted area (QWA). [[Insert: The publication will want to define these here? Draft text: A user-defined management quality value, ranging from 0 (worst) to 1 (best), needed to be assigned to every cell on the landscape. This was done by assigning each ownership-management category a default value (determined at the end-user workshop).]] In the future, these standard values could then be adjusted for individual properties as information became available. A user-defined habitat integrity value from 0 (worst) to 1 (best) needed to be assigned to every cell. This was simply the inverse of habitat conversion, so pristine habitat was a 1, and moderately degraded habitat was a user-defined fraction. To determine the total QWA for a particular cell, the stewardship value of the cell is multiplied by the naturalness value and the area of the cell. The QWA of every cell of habitat is summed to get the habitat’s total QWA conserved. This is then used as the x-axis value of the FDR to determine the relative value of conserving the next cell of that habitat (y-axis value).

Figure : A more complex FDR designed to address ecological and conservation planning principles

Parameters

To determine the best parameter values for a particular region and scenario, it is recommended that the end-user uses the [Calibrating the Continuous Benefit Functions-Habitats.xlsx](file:///C:\Users\jgallo\AppData\Roaming\Microsoft\Word\Calibrating%20the%20Continuous%20Benefit%20Functions-Habitats.xlsx) worksheet (the Calibrator worksheet tab) to change the values. Alternatively, the end-user can learn the formulae used, which are described in Appendix A.

Parameter 12: “initial flatline”

It is arguable that the first several percentage points of habitat representation are all equally important. Hence, the end-user has the ability to set an initial flatline for the FDR curves of all habitats. This is a value from 0-1, with 0.1 corresponding to 10% of the habitat’s QWA being conserved before any downward slope occurs. This parameter is set in Model 3.

Parameter11: “FDR initial downward slope”

The end-user then determines how steep the slope of the FDR curve should be between the initial flatline and reaching the habitat target, described earlier (if there is a habitat target). For the steepest slope possible, a value of 0 is used, for nearly no slope at all, a value of 0.99999 is used. (There is either an error in the calibrator or the formula itself not allowing the use of a value of 1.0; see JIRA ticket X) . This parameter is set in Model 3.

Parameter 13: “FDR Impact of Target”

LandAdvisor gives the end-users the option to use conservation targets in shaping the FDR (Moilanen 2007). Targets provide a good benchmark for measuring progress, are simple to convey, and have several other socio-cultural merits (Carwardine et al. 2009). Some regions have much more scientifically and socially robust habitat targets than other regions. For these “target confident” regions, it makes sense for there to be a large vertical drop in the FDR once the target is reached. (Note, many regions set their targets using different assumptions about QWA, so may need to be recalibrated accordingly.) For other regions, the targets are somewhat arbitrarily set. A value of 1 will cause the curve to drop to the x-axis, and a value of 0 will result in no drop at all, just an inflection point. This parameter is set in Model 3.

Parameter 15: “FDR y-intercept”

End-users have the option of accounting for historical habitat degradation in defining the shape of the FDR curve. [[Material to consider inserting for the paper: For example, 45.8 % of the world’s historical temperate grasslands and shrublands have been converted to human uses, compared to only 2.4% of the boreal forests (Hoekstra et al. 2005). If, hypothetically, each had 9% of their original extent conserved, then it would arguably be much more important to conserve the next 1% of grassland than forest (Hoekstra et al. 2005). ]] To override this option, the user simply uses the default value of 1 for this parameter. The assumption is that if much of a habitat’s current extent is degraded, then, all else being equal, it is more important to conserve the next cell of this habitat than one that has had very little degradation in its extent. [[Alternate text to consider for the paper: A counter-argument can be made that humans have altered the earth so much that using a historical baseline to guide conservation priorities has limited value. BioVision is programmed such that the scientific advisors of an effort can debate this issue and set a parameter value which determines how much this consideration should be applied. ]] LandAdvisor implements this assumption by calculating the average naturalness value of each habitat type. The FDR of the habitat with the lowest average naturalness value has a y-intercept of 1.0. The FDR of the habitat with the highest average naturalness value has a y-intercept of the value entered for this parameter. All other habitats have a FDR y-intercept between these values, depending on their average naturalness value. This parameter is set in Model 3.

Parameter 14: “FDR x intercept”

Keep this at the default value of 1. It is not working correctly in the calibrator. It will either be turned off or fixed in the next version.

A summary of these and all the other parameters is provided in Table 1.

Table : Summary of all Parameters

(Note: the strawman parameters were used as the baseline values for the academic paper, the simple version uses the parameter values that are distributed with the model.)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter #** | **Short name** | **Default Values (For the Strawman Version)** | **Targeted Sensitivity Values** | **Default Values (For the Simple Version)** | **Description/Notes** |
| **1** | **Statutory Conservation Area Quality** | **1** |  | **1** | **The estimated "management quality" of statutory conservation areas (Genrl\_type = 1). From 0-1.** |
| **2** | **Mountain Catchment Area Quality** | **0.74** |  | **0.74** | **The estimated "management quality" of mountain catchment areas (Genrl\_type = 2). From 0-1. (Based on local expert workshop for Little Karoo)** |
| **3** | **Private Conservation Area Quality** | **0.15** |  | **0.15** | **P3: The estimated "management quality" of private conservation areas (Genrl\_type = 3). From 0-1. (Based on local expert workshop for Little Karoo)** |
|  |  |  |  |  |  |
| **5** | **Stream Benefit Factor** | **0** |  | **0** | **If animals tend to travel along stream corridors, even if the habitat type is not their standard preference, then give this a value.** |
| **6** | **Road threat multiplier** | **20** |  | **20** | **The road layer (which has a max value of 1) is multiplied by this constant before it is overlaid on the composition output to create the cost layer for the least cost path connectivity analysis.** |
| **7** | **Smallest protected area** | **37,000,000** |  | **400,000,000** | **The size (minimum number of contiguous core cells) required to make a core zone eligible for the connectivity analysis. In map units, which is often meters. Core cells are defined by P19.** |
| **8** | **Max protected area separation** | **50,000** |  | **80,000** | **For the connectivity analysis, what is the maximum distance (in map units) between core zones that should be considered?** |
| **9** | **Percentage of corridor values to keep** | **4** |  | **4** | **Least cost corridor provides values for every cell on the landscape. Only the best offer viable corridors. Which threshold should be used?** |
| **10** | **cell size** | **10,000** |  | **10,000** | **The number of mappig units per cell. 1 cell is 1 ha in the Little Karoo. The mapping unit for the project is 1 m.** |
| **11** | **FDR initial downward slope** | **0.5** |  | **0.5** | **This is variable o; it is used as: i+(a-i)o where i is the intersection point of the line thatgoes from q to the point on the x axis of 1 + (1-r)** |
| **12** | **FDR initial flatline** | **5** |  | **5** | **this is variable flat, whihchi is multiplied by 0.01 before it is used in the equations. It becomes q.** |
| **13** | **FDR impact of target** | **0.3** | **0,1** | **0.3** | **This is variable u. The y value is u\*v** |
| **14** | **FDR x intercept** | **1** |  | **1** | **the variable is f.** |
| **15** | **FDR y intercept** | **0.75** | **0.5,1** | **0.75** | **y = (1-s)\*(1-r)+s where s is this parameter and r = % remaining.** |
| **16** | **Delete temp datasets A** | **yes** |  | **no** | **If checked, this will delete the temporary datasets for the conenctivity analysis A before moving on…** |
| **17** | **Delete temp datasets B** | **yes** |  | **no** | **If checked, this will delete the temporary datasets for the conenctivity analysis B before moving on…** |
| **19** | **core management quality** | **0.7** | **0.14,1** | **0.7** | **What is the minimum level of management quality that can qualify as a core area that needs connecting? In the little Karoo, municipal Conservation Areas, i.e. Watershed Conservation Areas, count. (they have a value of 0.74).** |
| **20** | **budget** | **100,000,000** |  | **25,000,000** | **The number of Rand ($1 ~= 7 Rand) budgeted for conservation action (acquisition plus private stewardship)** |
| **23a; 23b** | **"power weight" of benefit/cost1; & benefit/cost2** | **2 ; 2** | **1,3 ; 1,3** | **2 ; 2** | **Values greater than 1 will put more emphasis on the benefits functionin determining conservation value; values less than 1 will put more emphasis on the cost function. Needs major justification for 23a not equal to 23b.** |

Vegetation Unit and Biome Representation Value:

As described earlier, the habitat layer is nested. Within each habitat type there are several sub-habitats, known in the Little Karoo as vegetation units. A case could be made that it is important for biodiversity if we represent each of these in conservation areas. In the case of the little Karoo, targets have not been assigned to each vegetation unit. We decided that a valid assumption was to have each unit have the same target as its parent habitat. The model is currently programmed to apply all the same parameter values already assigned to the habitats.

Conversely, if geologic timeframes are considered, then it makes sense to consider representation at the biome level. Each habitat type is a member of only one biome type, so the biomes are be mapped using the habitat data. These are analyzed in a similar way.

Regional Representation Value

The three resolutions of representation analysis (habitat, vegetation unit, and biome) are combined in a weighted sum. These are weights 1A, 1B, 1C, found in both Model 4 and Model 5, and need to sum to 1.

Supra-regional Representation

The principle of habitat representation applies for different geographic extents, and will have different results depending upon the extent. It is important to consider the larger context when pursuing habitat representation for a region. One way to do this it to do a habitat representation analysis for a much larger region, to clip out the results that overlap the region of study, and then combine the two in a weighted sum. These are weights 3A and 3B, found in both Model 4 and Model 5, and need to sum to 1.

Species Representation Value

The same principle of functions of diminishing returns is applied to species representation (Figure 1) as well.

Unfortunately, LandAdvisor Little Karoo 2.0 does not have the model or raw data used to create the species representation value criteria. The model (without the data) is available upon request, and may be in the LandAdvisor factory by the time you are reading this.

Determining the species representation value is more challenging than determining habitat representation value. It is recommended that for the first iteration of creating LandAdvisor for your region. More details are provided in the [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) document.

* File Name: species\_mv

Composite Representation Value

This is the weighted sum between the multi-scale multi-extent habitat representation and the species representation (Figure 1). Its parameters are Weights 4A and 4B in both Models 4 and 5. (Note there is a placeholder weight, 4C, for another type of representation, such as physical geography.) [[Improvement idea for user guide: Consider adding a subsection to all criteria titled: key outputs and have a filename, and maybe even a screen grab.]]

Composition Value

The composite representation value is combined in a weighted sum with the naturalness value ([described earlier](#naturalness)) to indicate the composition value of every cell (e.g. hectare) on the landscape (Figure 1). The reason that naturalness is used here as well as an input to the representation analyses is as follows. The representation analyses show how important it is to conserve the next hectare of a habitat type, assuming that the hectare is in good condition. If the particular hectare is in poor or moderate condition, then it follows that the conservation importance should not be as high. This logic is implemented via the weighted sum. The degree to which this logic should be implemented is determined by the end user via the alteration of the weights.

Connectivity Analysis

Model current name:

Combinatin of 4 models: “ prep for connectivity script”, “Connectivity A” , “Connectivity B”, and “4880 Connectivity Standardize”

Key inputs:

* Road layer
  + TRANSIT\_ROADS\_MOT
* Layer to identify core zones (stewardship level), which is an input to an earlier analysis, and is updated as the maximize-short-term-costs heuristic iterates.
  + mngmt\_quality (mwa\_hab\_gen is an exact copy. We are mid process of switching over to using just the mngmt\_quality input layer.)
* Raw “cost surface”
  + composition (which is an output from an earlier stage)

Background

Least cost corridor methodology helps indicate the important habitat linkages between pairs of core reserve areas (Beier et al. 2009; Gallo 2007; Hartley & Aplet 2001; Lombard & Church 1993; Singleton et al. 2001). An enhancement of the least cost corridor methodology tentatively called “Least Cost Connectivity” is applied in LandAdvisor, and is described here. The major difference is that this new algorithm calculates many pairwise connections and also prioritizes the connectivity values among different linkages, not just within a particular linkage.

A least cost path (LCP) analysis is the starting point for the methodology (i.e. Ferreras 2001; Rouget et al. 2006). The central assumption to this method is that movement by an animal or plant, either by an individual or between generations, is easier or harder on different cells of the landscape. Cells that are harder are assumed to have a high “cost” or friction. For instance, moving across pristine habitat has low cost, and moving across a road or other paved surface has a very high cost. Least cost path analysis identifies the narrow path between any two core areas that has the least total cost for the species in question. [[Alternate text to consider for the paper: The cost surface can be defined for a particular focal species, (or set of species). Or it can be based on the conservation value as determined by the rest of the model (Rouget et al. 2006a), which is what I did here (i.e. locations that scored well in the habitats representation and/or species representation analyses received a low cost). Additionally, I added a roads layer, and gave higher traffic roads a higher cost than lower traffic roads. Hence, crossing over a busy highway is a high “cost” to movement.]]

Least cost corridor is an enhancement of LCP that results in corridors of varying width and value, among other improvements. The algorithm assigns a value to each cell on the landscape that is the total cost of the best path that passes through that cell and connects two particular core areas (reserves). Cells that are along the best path between two core areas will have the lowest relative value. In this way, every cell in the landscape is assigned a least cost corridor value. The best practice is to then select the high quality cells. The user defines what percentage of the best cells to keep (Parameter 9). A standard approach is to choose a threshold such that the narrowest corridor on the landscape is wide enough for the species and/or ecological processes being targeted (Beier et al. 2008). This is known as a Least Cost Corridor output if done for a species. One rule of thumb is that a “corridor” corresponds to the needs of one species, while a “linkage” corresponds to the needs of many (Beier et al. 2008).

Method

The first step of Least Cost Connectivity is to identify core reserves by mapping all the polygons that are completely comprised of cells over a minimum level (Parameter 19) of stewardship quality (i.e. protection quality), and then selecting those resulting polygons that are over a certain size threshold (Parameter 7). Core aresignation can eventually incorporate other factors such as naturalness and habitat quality (Beier et al. In Press) by utilizing the “composition” output of the model in helping define core areas.

In this analysis, the composition layer is the primary basis for the cost surface; cells that have a high composition value are assigned a low cost. This identifies linkages that connect a lot of high biodiversity value land together (Rouget et al. 2006). The secondary component of the cost surface is the roads layer. Roads that are estimated to have lots of traffic at high speeds are assigned a very high cost (less than or equal to 1). Animals either cross these roads at risk of death or avoid crossing them altogether, both of which are costly to a species. Roads with less and slower traffic are assigned a lower cost (See [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) document for the values used in the Little Karoo analysis). Because crossing a 25 m road is often more risky for an animal than crossing over 25 m of poor quality habitat, the roads layer is multiplied by a constant (Parameter 6) before it is combined with the composition layer to make the cost surface. (The value of the cell of the cost surface is the maximum value of that cell from either the new roads layer or the composition layer.) Eventually, other cost factors such as geographic barriers canbe added.

For any given pair of core areas, the following three criteria are combined in a weighted sum:

* “Connectivity Envelopes”: The Least Cost Corridor output described earlier is divided by the total cost value of the corresponding Least Cost Path. This way, all cells on the least cost path get a value of 1, and those at the edge of the corridor get a value such as 1.1 or so (depending on the value of Parameter 9, mentioned earlier). These values are then inverted and normalized, such that the cells along the least cost path get a value of 1, and the cells at the outer edge of the corridor get a value just above 0.
  + (max – x ) / (max –min)
* Permeability Index: One of the problems with Connectivity Envelopes is that it does not attempt to distinguish the relative value of linkages between different pairs of core areas. Some corridors may be forced to traverse much moderate and low quality habitat, while others traverse much more high quality habitat. Linkage Permeability addresses this.
  + The first step is to divide Least Cost Corridor by the length of the Least Cost Path, not the total value. Hence, linkages that traverse a high percentage of high quality habitat will have a low relative value for this processing output known as the impermeability layer (not the permeability layer).
  + All of the impermeability cells that fall outside of the envelope created by the Standard Connectivity are turned to a null value (which is essentially a 0 value).
  + To normalize, the pair of reserves that produces the lowest impermeability value is selected, and that lowest value becomes the benchmark value (“overall min”). The highest impermeability value of any of the corridors is defined as “overall max.”
    - Here is the equation: (“overall max” – x) / (“overall max” – “overall min”)
  + The output is the Permeability layer. “Overall min” becomes a 1 in this layer (as it is the most permeable point of the most permeable linkage), and all the values for all the other linkages are less than 1 and greater than or equal to 0.
* Least Cost Path Length: A final assumption is that if two different linkages have the same maximum permeability value, but one corridor is much shorter than the other, then the cells in the shorter corridor should get a higher relative connectivity value.
  + To implement this assumption, all the cells in a given least cost corridor envelope are assigned the value of the corresponding least cost path length (measured in number of cells).
  + To normalize, the pair of reserves that have the shortest least cost path are selected, and the number of cells on that path is tallied. That value becomes the benchmark value (“overall min”). The highest least cost path length of any of the corridors is defined as “overall max.”
    - Here is the equation: (“overall max” – x) / (“overall max” – “overall min”)
  + “Overall min” becomes a 1 in the Least Cost Path Length layer, and all the values for all the other linkages are less than 1 and greater than or equal to 0.
  + This layer is then combined with the other two analyses in a weighted sum.

In order to speed up the processing time, the end-user is allowed to specify the maximum allowable distance between two core areas to be analyzed (Parameter 8). The suggested approach is to visually assess the map of all the cores of the landscape, and to identify the largest distance between two cores that does not have another core within the direct or near direct path. Setting this parameter can dramatically reduce processing time by avoiding processing between core areas that are on opposite sides of the region and that have several core areas between them.

The weighted sum is performed for each pair of reserves. The outputs of all these analyses are overlaid on top of each other, and the maximum value of a cell among all the layers is selected. This way, when corridors overlap on top of each other, the best value is displayed on the final connectivity map. The final connectivity map is then normalized using the standard equation, such that the best value on the map is 1, and the lowest valued cell that is a part of the lowest valued corridor is 0.

Contiguity Value

Another assumption of the model is that, all else being equal, land that is adjacent to a protected area has higher conservation value then land that is isolated. The ecological justification for this is that conserving such land increases the size of the pre-existing reserve, thereby reducing edge effects and also theoretically increasing the number of species that can feasibly survive within the protected area.

How far can a particular cell (e.g. hectare) be from the protected area boundary to be considered adjacent? Does it need to be touching? Or does it need to be part of the parcel that is touching? Or part of the overall property (which could include several parcels with the same owner)? Or part of the watershed? The model is designed to let the end-user determine which of these three types of adjacency count, and if they all count, what the relative weights are. This is done via a weighted sum. The model can be easily modified to allow a fourth category that is the adjacent cells only.

Spatial Context

This is the weighted sum between Connectivity and Contiguity (Figure 1), with the potential of adding several other spatial context variables later.

Net Benefit versus Gross Benefit

Contextual Diagram:



Model current name:

“5085 combining current and predicted stewardship level with biodiversity (2)”

Key inputs:

* “mngmt\_quality ” = current [stewardship value](#stewardship) at place Y



* “mgmt1efftvnss” = stewardship value of proposed conservation action 1 at place Y (e.g. acquisition for creation of a reserve). In most cases, this will be the corresponding management class value used in creating the stewardship value layer.
* “mgmt2efftvnss”= stewardship quality of proposed conservation action 2 at place Y (e.g. private conservation areas). Determined the same as mgmt1efftvnss, but for a different management action.
  + Note, it is also possible to combine biome or habitat info with ownership and management to create more nuanced maps of current and potential stewardship quality. For instance, it may be that private conservation areas perform relatively poorly at conserving habitats that have species of high economic returns (e.g. rare hardwoods or game species) compared to regular habitats. These layers are created during pre-processing exercises. The Little Karoo example illustrates how the potential stewardship quality of action 2 varies across the landscape (see figure below).



*This is one of the more experimental aspects of the current version, and can be learned last. It should be revised/restructured in regions that have threat data, and are incorporating these data into the model at some stage.*

The net conservation benefit of conservation action X at place Y is the difference between the gross benefit of conservation action X at place Y minus the benefit of no action at all. This is a fine tuning detail that was programmed into the model because in the Little Karoo, and elsewhere, there are multi-generational landowners that are excellent stewards of the land and their children have the same philosophy. Acquiring that land might be as costly as acquiring a similar property that is owned by a developer and poorly managed. However, acquiring this well stewarded land will NOT have nearly as much of a NET improvement for biodiversity as acquiring the land from the developer.

Gross benefit is currently defined as the multiplication of the biodiversity value of a place (defined earlier) and the stewardship value ([described earlier](#stewardship)) of the proposed conservation action for that place. There are merits to making this a weighted product, which should be explored. The benefit of no action at all is the multiplication of the biodiversity value and the current stewardship quality. As per the above figure, Net Benefit is the Gross Benefit minus the Benefit of No Action.

Cost of Management Action 1 (Acquisition)

Summary and Contextual Diagram

The cost of Action 1 (Acquisition) was estimated for every property for the region, and was comprised of two primary factors: cost of purchase and ongoing management costs (Figure 5). This layer was created during a preprocessing step.

Figure : Cost of Acquisition



File name:

cost\_mngmt1

Model name:

This model was performed as “pre-processing” and is not part of the toolbox. It is available upon request.

Key metadata:

Cost of Purchase

For the Little Karoo, a pre-existing datalayer existed that estimated the purchase price of every property in the region for the year 2000. It was created by correlated known sale prices with the geographic characteristics of the properties, and extrapolating the relationships to all the other properties. The layer had an extreme variance, and was cleaned up in several ways, such as by removing all of the very small properties, and adjusting for inflation (see [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) Document for details).

Calculation of Management Costs

The estimated cost (per year) of managing each property was estimated based on local expert input. Management of a property by the government agency that would take over (CapeNature) is much less expensive if the property adjoins a current reserve. Also, the larger a property, the cheaper it is to manage per hectare (see [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) Document for details). The model multiplies this annual expense, by the number of years in the timeframe of analysis (a user-defined parameter).

Cost of Management Action 2 (Private Stewardship)

Summary and Contextual Diagram

The cost of Action 2 (Private Stewardship) was estimated for every property for the region. In this action, the private landowner maintains ownership of the land, and enters into an agreement or contract that they will be good stewards of the land for a specified period of time. Cost was comprised of two primary factors: cost of advertising and then securing the contractual agreement, and then any ongoing management/partnership costs of the agreement (Figure 5). This layer was created during a preprocessing step.



File name:

cost\_mngmt2

Model name:

This model was performed as “pre-processing” and is not part of the toolbox. It is available upon request.

Key metadata:

Cost of securing the agreement

For the Little Karoo, this comprised of the time required for creation of the contract (accounting for time lost to unsuccessful efforts), plus legal support provided to the landowner for the requisite transactions, plus overhead expenses (see [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) Document for details).

Ongoing management and maintenance costs

For the Little Karoo, this required periodic monitoring to verify that the terms of agreement were being met, providing advice and support about management practices, and contracting with Public Works for some restoration actions, with larger properties being cheaper per hectare, and annual costs decreasing over the course of the time frame (The Little Karoo effort used 30 years, see [Metadata](file:///C:\GIS\Prjcts\LandscapeDST_vX\LandscapeDSS_LittleKaroo_v2_0_7\support\LandscapeDST%20v2.x%20Metadata%20and%20Other%20Information.docx) Document for details).

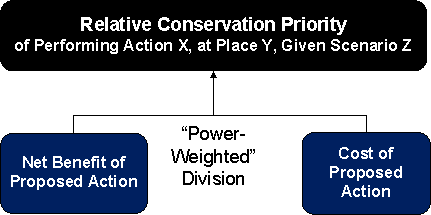
Benefit / Cost

Model Used:

6082 bio beni divided by cost

Overview

The model divides the estimated benefit of conserving an area by the estimated cost in order to estimate the relative conservation priority. Because the cost layer is often highly speculative, and often has a high degree of uncertainty compared to the benefit layer, there is a real need for giving the user the ability to decrease the relative impact that the cost layer would have on the final results. Because they are combined via division, giving them weights only changes the final values; it does not change the relative influence of the cost layer in determining the spatial distribution of priority sites. Hence, we implement what we call “power weighted” division:



Equation:

*If* Net Benefit of Proposed Action *< 0 then* relative conservation priority *= 0, otherwise:*

*If* cost of proposed action = 0 *then* relative conservation priority = 0, *otherwise*:

Where *n* is Parameter 23.

If n is set to be greater than 1, then the benefit layer will have a stronger influence in setting the spatial priorities. Put another way, sites that have a high conservation benefit will have a higher likelihood of having a high conservation priority. If n is set to be less than 1, then the opposite is true. Mathematically speaking, the parameter could have been put in the denominator. However, the maximum-gains heuristic is based on the number of dollars (or other currency) spent, so it is best not to manipulate that value. Another reason to use the numerator is that benefit uses a relative measure, not any set unit.

Note: Parameter 23a is the n value for the equation regarding action 1 (acquisition in the case of Little Karoo) and 23b is the n value for the equation regarding action 2 (private stewardship in the case of the Little Karoo). There must be a very solid and well documented justification and peer review for using different values for these two sister parameters, as this will affect the relative return on investment of the two approaches.

Summarizing all criteria per site

Model Name:

7008-Generic-Summarize-outputs-by-Site-Shapefile (2); within Model 4.

Overview

A shapefile (a map and associated table) is created that summarizes all the criteria for every site in the region. For each site, the average value of all the cells of a particular criterion is calculated and stored in the table. This is repeated for every criterion of interest. The “sites” used in the Little Karoo were properties. Slight modifications are possible such that the model could be repeated to populate all the parcels in the region, or all the subwatersheds, etc. It is also possible to summarize by total value within a site, variance, etc.

The Maximize-short-term-gains Heuristic

Model Name

This is embedded into the tail end of “4. Full Model”

Summary and Contextual Figure

The site on the landscape that had the best estimated benefit to cost ratio for acquisition is selected. [[Fodder for paper: To provide the draft conservation area network design that could then be refined by a stakeholder process into a conservation plan, the prototype implemented an iterative “maximize short term gains” heuristic (Davis et al. 2006; Wilson et al. 2007). This is usually not as accurate as simulated annealing for estimating optimality, but is much faster (McDonnell et al. 2002). ALSO: We originally had the heuristic select the best property/action combo on the landscape, but it only selected stewardship properties. (Stewardship costs did not take into account any tax benefits to the landowner, which would be a cost to society, that could arise in the future.)]] Then the site with the best best estimated benefit to cost ration for stewardship is selected. The model then assumes that these actions occur on these two properties, and then recalculates everything accordingly. Because of functions of diminishing returns, a site that was second best is not necessarily the site that is chosen on the second iteration. The model repeats this process until either the conservation budget is met (a user defined parameter) or the targeted number of properties have been selected (see Figure 6).

Figure : Estimating a near-optimal set of properties to conserve



The site that was selected on the first iteration for acquisition will be designated with a “1” in the SequenceA1 column of the sites\_populated.shp shapefile. The acquisition site selected in the second iteration will be designated with a “2,” and so on. The sites selected for Action 2, Private Stewardship, will be designated in the SequenceA2 column.

To set the maximum number of iterations, see the section in the Quick start guide.

In future iterations of the model, the end-user should get options for decreasing processing time by selecting several sites during each iteration (while also decreasing optimality).

Customizing LandAdvisor for your Region

Note: please use the files (tables etc) mentioned at the [beginning of the methods.](#Lookuptables) Know also that there is a “[tips and tricks for working with modelbuilder](#tipsandtricks)” section that also has some tutorials.

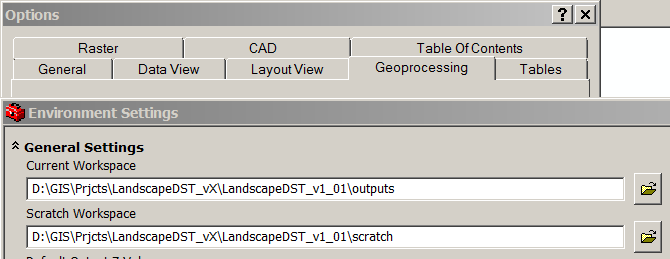
Set the Environment of your .mxd

If you want to make a new .mxd, make sure you implement the following steps.

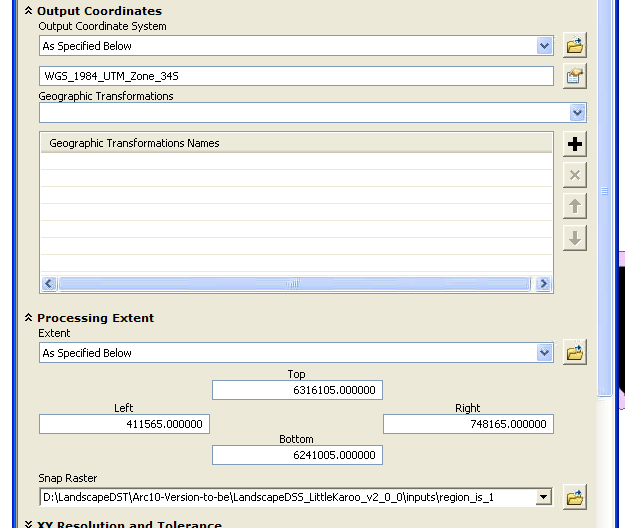
* Make a new .mxd, then add any pre-existing toolboxes, or make a new one.
  + Right-click in the toolbox area and clicking “add toolbox” and then navigate to your toolbox, which should be in your LandAdvisor version X.X directory.
* click the box for “Overwrite the outputs of geoprocessing operations” such that there is a checkmark when you are done. (In 9.3. it was at In Tools/Options/Geoprocessing, in 10.0 it is in Geoprocessing/Geoprocessing Options)



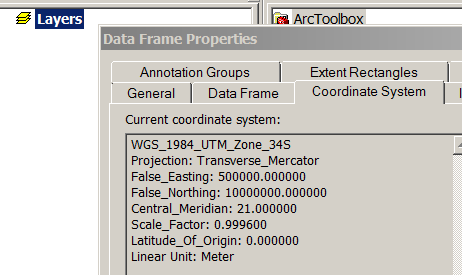
* Set your workspace and scratchworkspace
  + ArcGIS 9.3 (If the model still works in 9.3?): In your .mxd go to Tools/Options/Geoprocessing/Environment/General and set them
  + 10.0: go to Geoprocessing/Environments/Workspace
  + Suggestions are that …/LandAdvisor/scratch is your scratchworkspace and that …/LandAdvisor/outputs is your workspace.

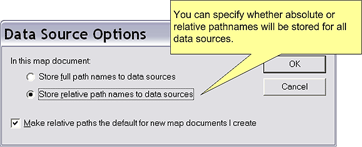


* Set your extents:
  + To be safe, set your output coordinates, based on a standard input layer.
  + Very important for making sure rasters align: set your processing extent and snap raster, based on a standard input layer. (region\_is\_0 is what is used in the sample analysis).

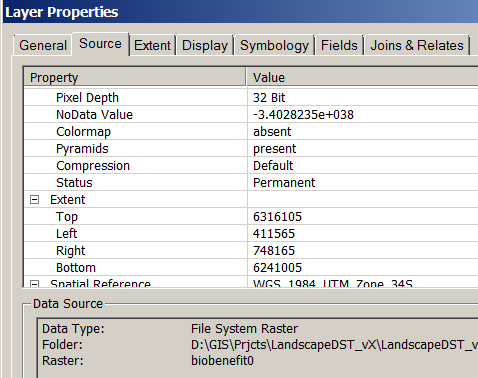


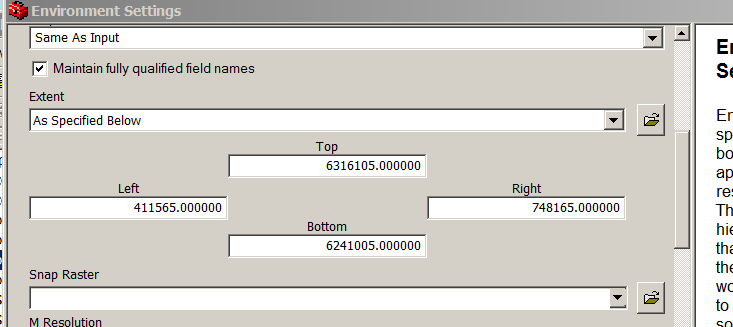
* + Set Raster Analysis to Maximum of inputs.
* The unit of analysis for the .mxd should already be set to a meter.
  + If you want to double check this: One way to do this is to use a coordinate system that has the meter as the default unit. For example, any of the UTM projections. You can check the system that your mxd is using by right clicking the word “Layers” and selecting properties, and going to the coordinate system tab.



* Best Practice: It is important that we be able to leverage our collective resources. Hence, it would be great if any innovations you make can be shared with others. Often, land trusts and other partners have limited GIS budgets and only have the ArcView License of ArcGIS. Tools only available in ArcEditor or higher shuld be designated as such in their help overview. See also the compatibility [matrix](http://www.esri.com/library/brochures/pdfs/arcgis10-functionality-matrix.pdf) (using find).
* (Optional and suggested) Set your .mxd to “relative path” if it is not already.
  + This allows you to share your work with others if you make any changes to the model. It also makes it easy for you to move the LandAdvisor folder around on your harddrive.
  + To set this option, look under the File menu, click Document Properties, then click the Data Source Options button found on the lower right. This will open the Data Source Options dialog box, and you can specify whether to store absolute or relative paths.  
      
    
  + The functionality of relative path only occurs within the same root drive, it does not span data from the D: drive to the C: drive.

Pre-processing your own Data for the analysis

* Open a new .mxd and set its environment
* Set the projection
  + Import at least one of your input data layers. If this file has projection data set, this will set the projection of the .mxd
  + Any other time you import a layer that is not in that projection, press cancel. Do not let ArcMap adjust for the different projection. Every datalayer in your project should be the same projections. Over in Arc Catalogue copy it into the correct projection and then import the corrected file.
  + Double check that the projection is set correctly: Right click Layers/Properties/annotation Groups
    - The projection for LandAdvisor Little Karoo is WGS\_1984\_UTM\_Zone\_34S.
  + Set project extent.
    - This is especially important when you are creating raster files. If the extent is set, then they will all overlap perfectly, if not, then they will probably not all overlap.
      * To add: a screen grab of non-overlapping grids
    - To define your extent, first find out which one of your raw data input files has the largest geographic extent. It can be a shapefile or a raster. If a shapefile, convert it to raster with the finest resolution responsible for your data, and that your system can handle. (The sample data has about 2 million cells for the region of study). Right click the resulting raster and go to properties/source and scroll down to extent:
      * 
    - Write down the extent figures, and then set it into your environment: extent is partway down on Tools/options/geoprocessing/environments



* Optional: Add your custom toolboxes
  + Open the toolboxes window while you are in ArcGIS ArcMap 9.X
    - i.e. click on the red toolbox icon 
  + Now, right-click in the toolbox window in some blank space, and select “Add Toolbox” from the menu that pops up.
  + Navigate to …/LandAdvisor/Toolboxes
    - Click on the “LandAdvisor” toolbox version that you want
    - Click Add
    - Also add the Toolbox named “Favorites\_1”
  + (optional) Add a new toolbox, and call it LandAdvisor Pre-processing <your region name>
    - Add a model under that toolbox, and use this model to do your first pre-processing task. Examples include converting Core wildland areas shapefile into a grid of core areas, where all cores have a value of 1 and all else is no data.
* Decide where you are going to store you pre-processed input data that is ready for the model
  + See below section titled “Start up using Your Data”
* Populate that folder with all the data that you will need to run the sub-model or model of your choice.

Start-up using your data

* Put all the required data into the inputs folder. See Table 2 or for the most up to date see LandAdvisor v2.x Tables.xls for an indication of which data layers are needed as inputs (tab: Inputs). Most of the data layers that are not needed are indicated as such in the third column. “Pre-processed” or “need to finish” data are needed.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table : Input Data; The Sonoma 1.0 Column indicates which data are not necessary for this version (3.0). See text.   |  |  |  | | --- | --- | --- | | **GIS\_Layer (raster unless .shp)** | **Description** | **LandAdvisor Sonoma 1.0** | | biomes\_g | A grid depicting the distribution of the major biomes in the region. This will be unneccesay for many regions in the world, as they only have one biome (also termed ecoregion). | not needed, value is 1, weight is 0 | | Cadastres.shp | Also knows as parcels. These polygons were used in the contiguity analysis to identify areas adjacent to already protected reserves. | pre-processed | | condition | The ecological condition (i.e. transformation and degradation) of an area. The amount of downweight is determined by the end-user using a Condition Benefit Scale. (Usually a pristine hectare gets a score of 1, and urban concrete a score of 0). Note: this was preprocessed for this version of the DSS, hence it is an input and an output. Eventually it will be parameterized as part of the model, and will be an output only. | pre-processed | | cost\_mngmt1 | cost of buying the land, and managing it for X years (I think x = 30), cost is in 1000s of Rand per ha. (Original dataset was buy\_n\_mng\_ha) | need to finish | | cost\_mngmt2 | cost of inspiring and overseeing stewardship of the land, and managing it for X years (I think x = 30), cost is in 1000s of Rand per ha. | need to finish | | cost\_mngmt3 | Not considered for sample data of version 1.01; therefore a filler dataset of 999999 or something like that was made. ( | not necessary | | cost\_mngmt4 | Not considered for sample data of version 1.01; therefore a filler dataset of 999999 or something like that was made. | not necessary | | habitats\_g | A grid depicting the distribution of all the habitats in the region. | pre-processed | | mgmt1efftvnss | The relative effectiveness of the management type 1 in protecting biodiversity. Can vary across the landscape. For instance, stewardship may be more effective in fynbos than succulent karoo. | value is 1 | | mgmt2efftvnss | The relative effectiveness of the management type 2 (also known as Conservation Action 2, see worksheet tab) in protecting biodiversity. Can vary across the landscape. For instance, stewardship may be more effective in fynbos than succulent karoo. | Need to create: mngmt\_quality value for mngmnt2 (single value) | | mgmt3efftvnss | The relative effectiveness of the management type 3 (also known as Conservation Action 3, see worksheet tab) in protecting biodiversity. Can vary across the landscape. For instance, stewardship may be more effective in fynbos than succulent karoo. | not necessary | | mgmt4efftvnss | The relative effectiveness of the management type 4 (also known as Conservation Action 4, see worksheet tab) in protecting biodiversity. Can vary across the landscape. For instance, stewardship may be more effective in fynbos than succulent karoo. | not necessary | | ~~mngmt\_quality~~ | ~~The relative effectiveness of the~~ **~~current~~** ~~management in protecting biodiversity. It is It is based on the duration/commitment of the management designation in place, as well as the quality of the management in preserving biodiversity. This is a prime layer for improvement in the Little Karoo, as it could have hundreds of differnt values, not just 4. Note: the layer was pre-processed, and is hence an input layer, but in future versions the populating of this layer should be part of the DST. It is included as an output field to help with cartography and context.~~ | ~~pre-processed~~ Not necessary anymore with version 3.0. It is derived in the first step of model 4. | | protweight | The degree to which one of the supra-regional habitat types is unprotected on a supra-regional scope. V1.01 note: This was done this way because South Africa had already done a national level GAP analysis, and had this value as one of its outputs (Rouget et al. 200X). See also transfweight. Other regions may have a very different set of inputs and weights for this supra-regional analysis. | pre-processed | | region\_is\_0 | Every cell in the region is = 0 (The pixel value for this raster must be signed integer. Floating point values can be converted using Spatial Analyst Tools -> Math -> Int) | pre-processed | | region\_is\_1 | Everycell in the region = 1 (The pixel value for this raster must be signed integer. Floating point values can be converted using Spatial Analyst Tools -> Math -> Int) | pre-processed | | Sites.shp | The shapefile that has the boundaries of all of the sites. A site was defined as all the cadastres (properties) that were adjacent and owned by the same person. | pre-processed | | species\_mv | The combined marginal benefit of all the important species at a place. This depends on the status of each species, how much of its known extent is conserved, the CWA for that extent, and the precision of the observations. This was pre-processed for this Version. Normally it is an output only, not an input as well. | not needed, value is 1, weight is 0 | | targets\_g | The conservation target (or threshold) for protection for each habitat type in the region (e.g. oak woodland +30%). The aspatial list was made spatial by joining to the habitats layer. | pre-processed | | TRANSIT\_ROADS\_MOT | The roads layer that gets burned into the cost surface that goes into the connectivity analysis. Needs a field called ROADS\_THT that ranges has a max value of 1, and min value is >= 0. The highest traffic/speed roads in the region are a 1. | pre-processed | | transweight | The degree to which one of the supra-regional habitat types is transformed on a supra-regional context. V1.01 note: This was done this way because South Africa had already done a national level GAP analysis, and had this value as one of its outputs (Rouget et al. 200X). | not needed, value is 1, weight is 0 | | variants\_g | A grid depicting the distribution of the specific habitat type variations in the region (N ≈ 250 or so). (In other words, there are several habitat variant polygons mapped within one larger habitat type polygon). These data are not always available. | not needed, value is 1, weight is 0 | | watersheds.shp | A shapefile of the watershed boundaries in the region. This is used in the contiguity analysis to identify areas adjacent to currently protected areas. | pre-processed | | streams.shp | a shapefile of the streams in your region. (Or any shapefile, and set the streams weight parameter to 1) | NEW | |  |  |

* + There are three options for populating the inputs folder.
  + Option one (easiest) is to put all of your input data into a single folder or geodatabase on your harddrive, then to open the tool called **Data Prep: putting region-specific-data into the inputs folder** and to click on the folders icon of the parameter and browse to your data location.
  + Option two is to give each input data file the exact same name as the sample data names, and to paste them into the inputs folder.
  + Option three may be best in the long term, especially if you have a well established and stable datadirectory and workflow. This option is to copy, paste, and then edit the data prep tool: to open each input file location and point it to the appropriate location on your harddrive. This way, you can keep all the appropriate input files in separate folders in your data directory.
    - Note: you can also prepare for workshop settings by giving yourself the option of running the analysis with low resolution data. This gives you faster speed. To do this, first make the low res data files. Then can copy and paste this Data Prep model, rename it, and then change the filenames to match the low res data locations.

Developers Guide

Function of Diminishing Returns

A unique function of diminishing return curve is created for each habitat (two curves can be identical however).

Given that:

p = the percent of historical distribution of the habitat that is currently “conserved”. This is represented as a decimal. Area protected is equal to a function of the quality of the area protected and quality of the protection. (i.e. the weighted sum of the management weighted area and the condition weighted area, with the default weights = 0.5). This is the X axis.

r = the percent of historical distribution of the habitat that is remaining on the landscape. This is represented as a decimal. If this cannot be estimated for all the habitats in the region (which should have a mean of 100%) then this nuance can be ignored, and the value of 1 can be used for every habitat.

t = the conservation target (i.e. goal) for the species in question (e.g. if we want to protect 30% of the oak woodlands of a region in reserves, then t = 0.3)

Then it is possible to find the relative benefit of conserving the next gridcell of any habitat. The key to all of this is that arctangent is the

From Wikipedia:

Inverse trigonometric functions are useful when trying to determine the remaining two angles of a [right triangle](http://en.wikipedia.org/wiki/Right_triangle) when the lengths of the sides of the triangle are known. Recalling the right-triangle definitions of sine, for example, it follows that

\theta = \arcsin \left( \frac{\text{opposite}}{\text{hypotenuse}} \right).

Often, the hypotenuse is unknown and would need to be calculated before using arcsine or arccosine using the [Pythagorean Theorem](http://en.wikipedia.org/wiki/Pythagorean_Theorem): *a*2 + *b*2 = *h*2 where *h* is the length of the hypotenuse. Arctangent comes in handy in this situation, as the length of the hypotenuse is not needed.

\theta = \arctan \left( \frac{\text{opposite}}{\text{adjacent}} \right).

For example, suppose a roof drops 8 feet as it runs out 20 feet. The roof makes an angle *θ* with the horizontal, where *θ* may be computed as follows:

\theta = \arctan \left(\frac{\text{opposite}}{\text{adjacent}} \right) = \arctan \left( \frac{\text{rise}}{\text{run}} \right) = \arctan \left( \frac{8}{20} \right) = 21.8^{\circ}.

To do that, the following user-defined parameter values are set:

s = "minimum y-intercept"- the y intercept of the CBF graph for the habitat that has the highest percentage of its historical extent still intact.

q = "initial flatline" The x value to which the curve is flat, (expressed as a value between 0-1)

o = "Initial downward Slope factor" - the slope factor for the curve between x = q and x = t;

u = "impact of target"- this factor affects the amount that the curve drops vertically once the target is met. (expressed in values 0-1)

f = "Right side slope" - The scaler affecting the x-intercept of the CBF curve, acceptable values from 0-1, default is 1.

m = the number of map units in a gridcell (for UTM projections, the map unit is a meter)

Then the following variables are derived to make the final equation more manageable:

a = the y-intercept of the FDR curve for the habitat in question = (1-s)(1-r) + s

i = a – t\*tan((π/2)-atan((1-q+f-1)/a)

v = i + (a-1)\*o

Given all of the above, the y value of any habitat on the landscape is determined as follows:

If target < q , then the following statement is followed:

If x < q then:

y = a

otherwise:

y = m\*v-(p-q)\*tan((π/2)-atan((1+f-r-q)/(v\*u))

Otherwise, the following statement is followed:

If x < q then:

y = o

otherwise:

If x<t then:

y = a – (x-q)\*tan((π/2)-atan((t-q)/(a-u))

otherwise:

y = v\*(1-u)-(x-t)\*tan((π/2)-atan((1+f-r-t)/(v\*(1-u)))

Integrating the Connectivity Algorithm From The Islands Trust Effort

The vision of interoperability is coming to light! The Connectivity Algorithm was specified by John Gallo, honed by Randal Greene and John, and was coded by Randal for the Islands Trust Conservation Planning Effort. The steps involved for pasting it into LandAdvisor will likely be the same for future iterations, and are as follows:

1. Paste Connectivity A and Connectivity B scripts into the Scripts folder
2. Add the LandAdvisor ITCP toolbox to the project. Copy the Connectivity A and Connectivity B Script Tools to the LandAdvisor Little Karoo Toolbox.
   1. (Alternatively, just make the Script Tools from scratch)
3. Right click the Script tool/ Properties/ and set the appropriate locations for the inputs to the model.
   1. First, program the Prep for Connectivity Scripts Model and the LandAdvisor Prep to put these inputs into the workspace and scratchworkspace.
      1. Note: it is TRANSIT\_ROADS\_MOT.shp not TRANSIT\_ROADS\_MOT
   2. Create any other requisite items in the LandAdvisor Prep: Put dummies… such as a scratch.gdb Geodatabase, if I remember correctly.
4. Optional: In the Parameter name field of the Sript Tool Properties, # script arguments to start with P22, P23, etc.

The Maximize-short-term-gains accounting system

The sites\_populated shapefile has a column called sequenceA1 that gives the iteration number that a particular property was selected into the solution set. If it is a really small reserve, it is possible that it is not accounted for using this system (there will be a gap in the number sequence). Go into the scratch folder and look for a file named new\_rsrv1\_X where X +1 = the iteration number that is missing. Convert that raster to vector, zoom to polygon, and then overlay it with sites\_populated to see which site it is, and manually enter the iteration number to sequenceA1. The same holds true for ‘sequenceA2’ for the second conservation objective modeled.

Copying select Models and submodels from one toolbox to another

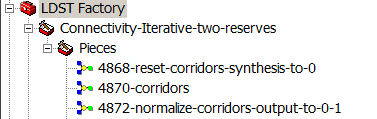
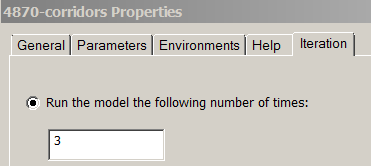
It seems that the key to this task is to do it within Arc Catalogue rather than opening Arcmap, opening the toolboxes, and copying and pasting.

LandAdvisor Factory Toolbox

There is one more toolbox called LDST Factory. This is where you can put partially constructed tools, or tools that worked for you on your data directory structure, but you have not had time to integrate into LandsapeDST. For instance, I pasted the model for running the greedy heuristic that I had going on an earlier prototype of LandAdvisor called Lorax, but did not have time to add into version 1.01. The purpose of including such incomplete pieces is to at least show people the commands that were used, even if the input data and directories are nonexistent.

Iterative Connectivity analysis for two reserves

An example such tool is the one that runs an old version of the connectivity analysis between two cores, and does it for a large number of different cost surfaces. This can be useful when doing sensitivity analyses of cost surfaces, or for doing Monte Carlo analyses in which some of the cost surface data are unknown (example is McClure et. al in production). Some instructions for it are as follows:

* Add the LDST Factory toolbox to your .mxd if it is not there already
  + For instruction on that, see “Pre-processing your own Data”
* As of now (Aug 30) find the three corridors model pieces, as per below:
  + 
  + You are going to run all three of them in sequence.
* As of now, it is modeled to run with three cost layer inputs, a layer in which all cells are 0, and two cores. Their names have to be as follows: core1, core2, region\_is\_0 and cost0, cost1, cost2
  + core1 and core2 need to have the same extent as the cost layers. If the core layers just are the minimum bounding rectangle (the default if you do not set your extent) then the analysis won’t work. See above for setting extent.
* All these need to be in the inputs folder.
* To run it for 100 cost layers, use inputs: cost0, cost1, …. cost99
  + Right click on the model 4870 and click edit model.
    - Right click anywhere in the white space of the model and go down to model properties.
    - Click on the iteration tab, and tell it to run the iteration for 100 times.
  + 

Tips, Tricks, and Suggestions for Using and Customizing LandAdvisor

After a relatively easy learning curve, you will be able to customize and improve the model. For instance, you may want to add additional criteria, or you may want to build link sub-models to the current model.

IMPORTANT: Do not add any of the ESRI tools to the 1\_Favorites folder. John did that once and it was a mistake. An eventual task is to go back into all the models that used such tools and have them instead use the tool from the default ESRI location. That way people willnot have to load the 1\_Favorites toolbox to run the model.

Working with Modelbuilder

Modelbuilder is not an extension, rather, it is included as part of the ArcGIS products. It is available in the ArcView version of ArcGIS (along with the more powerful versions too). You can start using it by right clicking on the toolbox, and “add toolbox” then right click on the toolbox and “add model.”

A great way to quickly learn the modelbuilder graphic user interface (GUI) is through the ESRI Geoprocessing tutorial. In ArcGIS this is in the Help/Getting started/Tutorials section, and it can be viewed online by everyone at : <http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=Geoprocessing_Tutorial> The fifty page document of raw notes has some troubleshooting notes and solutions, and is available upon request.

Tutorials

This document is written for someone who has some familiarity with ArcView 9.3 and Modelbuilder. If these are new to you, then a good place to start is the tutorial in the help contents of ArcGIS 9.3. Go to Getting started/Tutorials. (Or online at <http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=Geoprocessing_Tutorial> ) This will link to a video and .pdf that has a tutorial on Geoprocessing, with many tricks for modelbuilder. You will then understand Modelbuilder pretty well. At the least, please browse the help under “Geoprocessing/UsingGeoprocessing Tools/Automating your work with Models”. Unless otherwise noted, all quoted sections below are from ArcGIS help. There is also a 1 hour free tutorial (video?): <http://training.esri.com/acb2000/showdetl.cfm?DID=6&Product_ID=844> There is one for scripting too: <http://training.esri.com/acb2000/showdetl.cfm?DID=6&Product_ID=815> The full web tutorial is $116 and can be acquired for free with a successful [ESRI Conservation Program](http://www.conservationgis.org/index.html) grant proposal. See also this 20 minute tutorial/intro <http://letters-sal.blogspot.com/2009/10/getting-started-with-arcgis-model.html>

Optimizing RAM usage:

Increasing your Virtual Memory: <http://windows.microsoft.com/en-US/windows-vista/Change-the-size-of-virtual-memory> <http://searchsystemschannel.techtarget.com/feature/Windows-7-virtual-memory-performance-optimization>

Managing tools and Toolboxes

Models are stored in toolboxes. Best to review the Help sections on toolboxes, especially [“Basic Toolbox Management.”](http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Basic_toolbox_management)

ArcToolbox and Modelbuilder act differently within ArcMap and ArcCatalogue:

“The ArcToolbox window can be opened in the four ESRI desktop applications: ArcCatalog, ArcMap, ArcGlobe, and ArcScene. Geoprocessing settings can vary between these applications. If you have two or more of these applications open at once, changes to the geoprocessing settings in one application are not reflected in other currently running applications.” **I found that it was best to do all Modelbuilding interactions from within ArcMap.**

“If you create a new toolbox in ArcToolbox while in ArcMap, ArcGlobe, or ArcScene, the toolbox will not appear in ArcCatalog's ArcToolbox window. You must add it to ArcToolbox the next time you're in ArcCatalog.”

Model Naming Convention

Each Toolset is named with 2 numbers preceding it, and the models within each toolset start with those two numbers, followed by 2 more digits. In general, lower numbers need to be run before higher numbers, or they were when I developed the model. Often, one model needs to be run at least once on your computer before a following model can be run. Once all the sub-models have run once on your computer, the super-models containing many sub-models should run. After this, the parameters of the super-models can be changed as per your particular fancy. Remember, you can add variables and parameters as you see fit. (see ESRI tutorial).

Some background on how to share tools: <http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=An_overview_of_sharing_tools_and_toolboxes>

Relative Pathnames

All tools and .mxds in LandAdvisor should be stored as *relative pathnames*. That means that if you move the .mxd or tool into a different folder, or rename the folder that the data is stored in, it will not work. Important: Relative paths cannot span disk drives. Relative pathnames explained: <http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Pathnames_explained:_absolute,_relative,_UNC,_and_URLhttp://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Pathnames_explained:_absolute,_relative,_UNC,_and_URL>

Arc 9.3 toolboxes can be saved in version 9.2 for distribution to 9.2 users.

Intermediate data

What is it?

* To determine if any data variable contains intermediate data, right-click the data variable—if there is a check mark next to Intermediate, then the data is considered intermediate. If there is no check mark, the data is not intermediate and will not be deleted.

How does it act?

* Intermediate data will only be deleted when:
* You execute the model using its dialog.
* You execute the model from the command line or a script.
* Intermediate data will *not* be deleted if you run the model from the ModelBuilder window. This allows the has-been-run state of the model to be saved between sessions, so each time you open a previously run model in its ModelBuilder window, you will not need to rerun the entire model.
* In ModelBuilder, all derived data elements are automatically flagged as intermediate.
* If you want to delete intermediate data after running a model in the ModelBuilder window, click the Model menu and click Delete Intermediate Data.
* Note: When you run a model from its dialog box, unlike when running the model within the ModelBuilder window, the intermediate data—data referenced by derived data elements that are flagged as intermediate—will be deleted after the model has executed.

Managing Intermediate Data: Where to put it?

The LandAdvisor standard, write all data to a %scratchworkspace% and make sure to mark the data as NOT MANAGED otherwise it will be automatically deleted. I believe that any file that you may want to access again in a later analysis should be marked as NOT INTERMEDIATE as well. That way you can pick up any point in the model.

See Managing intermediate data in shared models in the web help for more information.

If you add a model to a model, the output of the submodel will be marked as intermediate by default. Best to change this.

Checklist for periodic maintenance:

Periodically delete all files in a scratch folder (Any models will have to be run from the start after such a housecleaning)

Checklist for building a model

* Set to relative path
* Make name AND label (for now, make them the same)
* All done in model properties.
* Does it have an output parameter set if you want to link it to another model?

Checklist for commands within a model

* Make sure it is checked as intermediate or not, as appropriate

Making and Renaming new version of the Toolbox

ArcMap is finicky about how you do this, even if all is in relative path. A symptom that you did it wrong is if you open the new version's toolbox and there are some red X's through some of the models. This paragraph will need refinement over time, but for starters, this worked today:

* Copy the entire Folder into a new Folder in your directory
* Open up the .mxd with the Toolbox open
* Rename the toolbox and the Toolbox label from within ArcMap
* Close the .mxd
* Rename the entire Folder the new version of the Toolbox (e.g. from LandAdvisor\_v1\_012 to LandAdvisor\_v2\_0\_0)
* Open it to make sure it works.
* I'm assuming that you can then copyu and paste the entire folder back to the original Folder, so it is alongside the other versions...

Troubleshooting Tips for when you are making new models:

“Data does not exist”or “model has already run”:

If you execute a model with data variables that have been changed, but not been refreshed, you'll get an error message, such as "Input data does not exist". Need to “Validate entire model” first. See [Validation](http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Validation) .

Re-running models with new parameters

Won’t run because input files “do not exist”

The files need to be loaded into the .mxd, or refer to a hard-drive path. That is why it is recommended to use the pre-made .mxds indicated in the methods. Also make sure you ran the Prep model that populates the scratch folder with dummies the first time before the model is run. Finally, make sure that the scratch and workspace are still set correctly. They sometimes reset after an ArcMap crash.

Won’t run because output file already exists

Sometimes models won’t re-run if the output file already exists (even if file overwrite is checked). In this case, manually move the pre-existing file to a temp folder, delete it from ArcMap, and re-run the model. Sometimes even this does not work, because the file is still in memory. I just rebooted both ArcCatalog and ArcMap, and that did the trick. It may be that closing the ArcMap .mxd and opening it might also work.

Creating new joins and calculate does not work

Sometimes this is because the box is checked in geoprocessor settings (general) “maintain fully qualified field names.” Try unclicking. Also, sometimes you can get away with copying the file after the join is made, rather than calculate and then remove join.

Model acts as if it is using the wrong scratch folder

It probably is. Sometimes when a mxd crashes, and you reload it, it puts in a different scracthworkspace and workspace in the options/geoprocessing settings. Even worse, sometimes when you put the computer into hibernate, then pull out the software key, then wake up the computer, then put in the hardware key after it cannot find it, then it also resets the workspace and scratchworkspace. Reset and run..

Problem copying Toolboxes

Note: This problem occurred after I loaded Windows 7 64 bit OS onto my laptop. Problem: when I copy and paste a whole LandAdvisor Folder Structure, then when I open the toolbox up (the one in that new structure) then many of the models are crossed out with red X’s. I dig down to find the problem and find that ArcGIS does not know where to find one of its own commands, like Copy Raster. I point it to the right direction for that particular command, and then have to do it for dozens of others. Note, If I paste the structure next to the other structure, so it has the same path to the ArcToolbox, **then it works.** Goes against my memory of the problem. Maybe it is working now because I am running ArcCatalogue in Compatibility mode (Windows XP SP3) As a test, I pasted

Problem Closing ArcMap:

Sometimes ArcCatalogue will not implement a copy correctly, and it is probably because a file is considered still in use by ArcMap. Close ArcMap, open Windows Task Manager, make sure that it completely closes out. If not, consider using “End Process.”

Some moderately advance tips for building new models

[In-line Variable substitution (click here):](http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=In-line_variable_substitution)

This is a great trick. It is especially useful for when a model needs preliminary outputs in the early part of the model to run. Also, for scratch and working spaces.

[Displaying model data symbology (with color ramps) (click here):](http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Displaying_model_data)

This allows you to have your modelbiulder outputs be in something other than black and white color ramps.

[Feedback an output into a previous input (click here)](http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Iteration_using_feedback)

Working with NoData and Null Values

Merging layers where one has some NoData

Sometimes you will want to merge layers in which one has some NoData and you want the merge to just take the data from the one that has it. This was dealt with in model 2210 and the key is the conditional command: con (IsNull (biodiv2), 0, biodiv2)

Join: Select all except NULL values:

I think I used this when processing the Cadastre layer.

In the SQL statement the OID of the base table must be specifically included: [BaseTable].[OBJECTID] IS NOT NULL AND [JoinedTable].[FieldName] IS NOT NULL

Speeding up the computer processing:

1. Defragment your hard drive;
2. if using Vista, then use any other appearance theme than the default, which is “Aero.” It is a memory hog. Under Personalize/Window Color and Appearance (using the classic windows control panel). A similar rule applies for Windows 7
3. If Vista: Add RAM to your computer by installing more RAM or by designating one of your flash drives as “Ready Boost.” Latest word on the street is that 32 bit vista only can use up to about 3 GB of RAM. Not sure about Windows 7. Performance increase of Ready Boost is under debate.
4. Beware: Installing a 64 bit OS to be able to use more RAM probably won’t work. As of now, ArcGIS only has a 32 bit version, so it is not clear whether a 64 bit system with more RAM would be faster. Also, there are some complaints about running ArcGIS on 64 bit systems.

Documentation of models

If you type in the description of the model, it displays, unless you have put something in the abstract of the model documentation. Then it uses that. The ideal documentaiotn approach is to populate the Model Documentation with the description of the model. When adding stuff to the help file, also put “ Help File Populated” at the end of the description. Then, also open model properties and under description type “see documentation”.

When working quickly, put draft info and notes in the model documentation, and then when documenting it for real, copy and paste this info into the abstract, summary, etc.

Help Documentation File

To Test, then Do: All Help was compiled using the edit documentation function. (It appears that it is stored in the Toolbox itself, so should export with the Root folder. Optional for future: export as .html files, and compile as a compiled help file, and save in the LandAdvisor/LK/Support Folder. Then, each model edited would to refer to that location. Updating of the help file would need to be done on that file, and not in the normal way. For more info see: <http://webhelp.esri.com/arcgisdesktop/9.1/index.cfm?TopicName=Toolbox%20Help%3A%20Referencing%20a%20compiled%20Help%20file>

Dealing with schema lock

Often times you get a schema lock error. This is often because you had to make a feature class layer for some operation such as a join. Even after removing the join the layer will still exist. The next time you go to make a feature class layer of the feature class, it will say there is a schema lock. Thus, after removing the join, you must also delete the feature class layer. Example in the model near the end which selects only the sites that are greater than the mean + standard deviation.

Clues on how to implement eventual advanced options:

Skipping the Connectivity analysis for X number of iterations, or skipping recalculation for X number of interations:

You can set this up by using a branching script See Branching: Implementing If-Then\_Else logic. You can use the Get Count (Data Management) help as a hint.

Naming Multiple iterative outputs:

Iteration Variables: ModelBuilder provides two variables that contain the current iteration number and the current list index.

**%i%**— the current position, or index, in a list variable. The first position is zero.

**%n%**— the current model iteration. The first iteration is zero.

You can use these variables in calculations and pathnames. For example, the pathname of an output dataset might be:

E:/Data/Result%i%\_%n%

Note: It the first file in an iterative sequence is usually 0 not one. i.e. cost0, cost1, cost2 etc.

Programming multiple outputs rather than writing over previous outputs:

From “how to do a sensitivity analysis”  Since one output will be created for each expression in the list all subsequent outputs to the list will be overwritten. To create unique outputs for each output resulting from the changes in the buffer (from the list) each output name should be followed by %i%. Instead of one buffer being created (Roads\_Buffer) and being overwritten with each implementation of the list, three outputs will be created (Roads\_Buffer0, Roads\_Buffer1, and Roads\_Buffer2). Multiple outputs will be created from each process if %i% is added to each of the subsequent processes from the list.

How to create a new workspace folder every time the model is run? How to make automatic?

You can use the tool: create folder (under geoprocessing/workspace). Bu the tool to create workspace [needs an ArcInfo license.](http://resources.esri.com/help/9.3/arcgisdesktop/com/gp_toolref/data_management_toolbox/an_overview_of_the_workspace_toolset.htm)  ☹

You can set a variable called workspace, and make it a parameter. How to link the two together with just one name? Can’t link a variable to a variable.

Possible workaround: Script tool?:

“Scripting languages typically provide a mechanism for accessing arguments passed to the script from the caller. VBScript, for example, provides a comma delimited string of all input arguments, while Python uses its system module. A script must use these mechanisms if it is not the source of a script tool, as shown in the example below:

# Import native arcgisscripting module

import arcgisscripting, sys

# Create the geoprocessor object

gp = arcgisscripting.create()

# Set the input workspace

gp.Workspace(sys.argv[1])

The argument list in Python is zero based, with the actual script call being the first argument. The second argument is the first user-specified value following the script name. Following is an example of how to call the script in the example above, specifying an input workspace:

Clipdata.py "d:\soils\Newfoundland"

License

Terms and Conditions as of this version:

Following the lead of our friends in the field, the terms and conditions for using the Landscape Decision Support Toolbox are currently that:

1) **The rules of the** [**General Public License**](http://www.gnu.org/licenses/gpl.html) **version 3.0 apply to the software (i.e. the Toolbox). (Preamble is below)** If there are any portions of the GPL that we overlooked that are in conflict with the below conditions, then the below take precedence.

 2) You agree to acknowledge the intellectual property of the prior authors in all applications and dealings with this software.  Currently, you can cite the User Guide that is in the support folder.

3) If you publish some of the intellectual property located in the support folder, such as the Gallo and Lombard paper in revision, you either cite the paper or at the very least list John Gallo and Amanda Lombard in your acknowledgments section.  The draft is provided because time is short, we are losing species at an increasing rate, and we need to share our knowledge.

4) You agree to not share the password and/or zip file with with anyone, as it is important that every user sees the terms and conditions and registers.

5) You agree to inform the LDST coordinator (currently  john\_gallo(at)tws(dot)org) of any publications or projects associated with this software. (We want to at least build a database of efforts using the framework.)

GNU GENERAL PUBLIC LICENSE

Version 3, 29 June 2007

Copyright © 2007 Free Software Foundation, Inc. <<http://fsf.org/>>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble

The GNU General Public License is a free, copyleft license for software and other kinds of works.

The licenses for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change all versions of a program--to make sure it remains free software for all its users. We, the Free Software Foundation, use the GNU General Public License for most of our software; it applies also to any other work released this way by its authors. You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for them if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs, and that you know you can do these things.

To protect your rights, we need to prevent others from denying you these rights or asking you to surrender the rights. Therefore, you have certain responsibilities if you distribute copies of the software, or if you modify it: responsibilities to respect the freedom of others.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must pass on to the recipients the same freedoms that you received. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

Developers that use the GNU GPL protect your rights with two steps: (1) assert copyright on the software, and (2) offer you this License giving you legal permission to copy, distribute and/or modify it.

For the developers' and authors' protection, the GPL clearly explains that there is no warranty for this free software. For both users' and authors' sake, the GPL requires that modified versions be marked as changed, so that their problems will not be attributed erroneously to authors of previous versions.

Some devices are designed to deny users access to install or run modified versions of the software inside them, although the manufacturer can do so. This is fundamentally incompatible with the aim of protecting users' freedom to change the software. The systematic pattern of such abuse occurs in the area of products for individuals to use, which is precisely where it is most unacceptable. Therefore, we have designed this version of the GPL to prohibit the practice for those products. If such problems arise substantially in other domains, we stand ready to extend this provision to those domains in future versions of the GPL, as needed to protect the freedom of users.

Finally, every program is threatened constantly by software patents. States should not allow patents to restrict development and use of software on general-purpose computers, but in those that do, we wish to avoid the special danger that patents applied to a free program could make it effectively proprietary. To prevent this, the GPL assures that patents cannot be used to render the program non-free.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS

See accompanying license document in the support folder, or go to <http://fsf.org/>.

References for all sections

Beier, P., D. Majka, and S. Newell. 2009. Uncertainty analysis of least-cost modeling for designing wildlife linkages. Ecological Applications **19**:2067-2077.

Beier, P., D. R. Majka, and W. D. Spencer. 2008. Forks in the Road: Choices in Procedures for Designing Wildland Linkages. Conservation Biology **22**:836-851.

Beier, P., W. Spencer, R. F. Baldwin, and B. H. McRae. In Press. Toward Best Practices for Developing Regional Connectivity Maps. Conservation Biology **25**:879-892.

Carwardine, J., C. Klein, K. Wilson, R. Pressey, and H. Possingham. 2009. Hitting the target and missing the point: target-based conservation planning in context. Conservation Letters **2**:4-11.

Davis, F., C. Costello, and D. Stoms. 2006. Efficient conservation in a utility-maximization framework. Ecology and Society **11**:33.

Ferreras, P. 2001. Landscape structure and asymmetrical inter-patch connectivity in a metapopulation of the endangered Iberian lynx. Biological Conservation **100**:125-136.

Gallo, J. 2007. Engaged Conservation Planning and uncertainty mapping as means towards effective implementation and monitoring. Department of Geography, University of California, Santa Barbara.

Gallo, J. A., and A. T. Lombard. In Revision. Increasing the impact of systematic conservation planning: recommendations, a decision support system framework, and a precursory model. .

Hartley, D., and G. Aplet. 2001. Modeling wildlife habitat corridors in the greater Grand Staircase-Escalante ecosystem. Pages 173-183 in C. van Riper, K. A. Thomas, and M. A. Stuart, editors. Proceedings of the Fifth Biennial Conference of Research on the Colorado Pleateau. USGSFRESC/COPL/2001/24.

Hoekstra, J. M., T. M. Boucher, T. H. Ricketts, and C. Roberts. 2005. Confronting a biome crisis: global disparities of habitat loss and protection. Ecology Letters **8**:23-29.

Lombard, K., and R. Church. 1993. The gateway shortest path problem: generating alternative routes for a corridor location problem. Geographic Systems **1**:25-45.

McDonnell, M., H. Possingham, I. Ball, and E. Cousins. 2002. Mathematical methods for spatially cohesive reserve design. Environmental Modeling and Assessment 107-114.

Moilanen, A. 2007. Landscape Zonation, benefit functions and target-based planning: Unifying reserve selection strategies. Biological Conservation **134**:571-579.

Rouget, M., R. M. Cowling, A. T. Lombard, A. T. Knight, and G. I. H. Kerley. 2006. Designing Large-Scale Conservation Corridors for Pattern and Process. Conservation Biology **20**:549-561.

Singleton, P., J. Lehmkuhl, and W. Gaines. 2001. Using weighted distance and least-cost corridor analysis to evaluate regional-scale large carnivore habitat connectivity in Washington. International Conference on Ecology and Transportation (ICOET).

Vlok, J. H., R. M. Cowling, and T. Wolf. 2005. A vegetation map for the Little Karoo. Unpublished maps and report for a SKEP project supported by CEPF grant no 1064410304.

Wilson, K. A., E. C. Underwood, S. A. Morrison, K. R. Klausmeyer, W. W. Murdoch, B. Reyers, G. Wardell-Johnson, P. A. Marquet, P. W. Rundel, M. F. McBride, R. L. Pressey, M. Bode, J. M. Hoekstra, S. Andelman, M. Looker, C. Rondinini, P. Kareiva, M. R. Shaw, and H. P. Possingham. 2007. Conserving Biodiversity Efficiently: What to Do, Where, and When. PLoS Biology **5**:e223.