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| Lab Assignment 4  **Intervention Modeling for Natural Capital Improvement Programming** |

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| **Section** | **Assigned** | **Due** |
| **AB** | **5/8** | **5/15** |
| **AA** | **5/9** | **5/16** |

Lab policy: <http://courses.washington.edu/geog464/guidelines_win2017.html>

Lab schedule: <http://courses.washington.edu/geog464/labschedule_17.html>

Canvas: <https://canvas.uw.edu/courses/1152834>

1. **Background**

In Lab 3 conditions of a WRIA were assessed for functional water flow (WF) and water quality (WQ) by analysis unit, while computing the potential for revenue that could be used to undertake dryland and wetland green infrastructure projects. The combinations of WF or WQ with dryland or wetland are called functional intervention types (FITs). The green infrastructure FIT project are expected to increase the value of water flow and water quality. To gain an understanding of current value of those functions ecosystem service valuation was examined. Locations of water flow and water quality were identified by mapping the rivers and wetlands using King County GIS Center data. Once conditions are assessed then it is reasonable to perform invention modeling. Knowing where conditions are vulnerable (at-risk) and knowing the location and value of ecosystem services on the landscape helps us understand where we might want to invest effort for improvements using intervention modeling. In geodesign, an intervention model is composed of three sub-models: design-change model, impact model and decision model. We can iterate among the sub-models using information to improve our approach to a natural capital improvement program problem.

1.1 Introduction to Lab Assignment Instructions

In this lab assignment we work with analysis units (AUs) when forming program packages to improve ecosystem services value. As mentioned earlier, AUs are sub-sub-watershed drainage areas as the basis of our design alternatives. Maximizing improvement in ecosystem services value for AUs is our objective. However, what is the top level of our attempt at maximization? That number could be a goal, but we do not know how all variables (WF, WQ, dryland, and wetland) are to be considered. As the foundation of the deliverable for this assignment, **at least three packages (each can be considered a scenario) must be developed as potential recommendations**. Each package developed for improvement programming is often called a ‘priority list’ and a ‘priority array’, depending on the capital improvement context, i.e., water, transportation etc.

In regards a design-change model, not all AUs must participate within a package of improvements. In this assignment, each package as a scenario for investment will focus on different characteristics of water flow (WF) and water quality (WQ) addressed using green infrastructure dryland (dry) and/or wetland (wet) improvement strategy. These four variables, manipulated in various amounts by acres, provide the foundation to create different packages of AU acres to be improved as an approach to design-change modeling. In anticipation of limits for expenses, the total potential revenue approach from lab assignment 3 will be used herein; that is, you should not spend more than you raise in revenue. Whatever package is formulated, you must balance the budget for the package where total potential revenue equals (or is greater than) the total costs (expenses for the projects) within a ‘reasonable amount’ of difference, or where expenses are less that revenue That is, you should not spend more than expenses.

An impact model strategy would use the acres within all AU’s to compute ecosystem value improvement. Function level of increase in ecosystem value for AU acres improved is considered the impact for that package; it is called net-benefit improvement. That is, a package can be associated with a high ecosystem value in areas where the values are already high. The increase might not be very much. So, we are interested in the change in benefit; that is, benefit above what is currently available as an ecosystem service value. Packages with balanced budgets, and having high net-benefit ecosystem service value would be preferred.

A decision model considers the tradeoffs among the impacts. Some of the impacts might be more in the uplands and more in lowlands. As a general rule since we are considering overall water function (water flow and water quality), the more lowland an impact, the better a package for people in a WRIA-wide improvement. However, if we are considering salmon habitat improvement, the more upland a package, then better a package. What stakeholder values do your packages want to prioritize? Trade-offs are of various types and everywhere. The decision model makes use of the three package scenarios and compares them for a preferred choice. You are to rank the scenario packages.

1.2 Learning objectives

1. Refine understanding of design-change modeling for water flow and water quality in light of dryland and wetland green stormwater strategiesfor improving functional performance of water flow and quality of ecosystem services.
2. Refine understanding of impact modeling using net-benefit measurements for increasing the ecosystem value of rivers/lakes and wetlands within AUs across WRIAs.
3. Refine understanding of decision modeling using trade-offs of ecosystem service value impacts across a WRIA within analysis untis as a basis for making recommendation of a particular package.

1.3 Data resources

Use the data resources you have downloaded and developed in lab assignments 1 – 3 to inform your choices to develop GSI improvement scenario packages. The data resource for this lab includes the following elements:

1. Lab4\_WRIA?.gdb with an AU subwatershed feature class with attribute fields created in prior lab assignments and new fields required by the GSI\_cost tool.
2. A folder named ‘arctools’ that contains the GSI toolbox and Python script.
3. ‘compromise\_demo.txt’, a batch text file input for the GSI\_cost tool
4. ‘layers’ folder with two graduated color layer files for two of the attribute fields generated by the GSI\_cost tool
   1. AU\_cost\_balance.lyr
   2. AU\_esv\_net\_roi.lyr

These are distributed in zip archive files you can download from this Canvas folder:

<https://canvas.uw.edu/courses/1152834/files/folder/lab/data/Lab4_restart>

Be sure to download the file associated with the WRIA you have been working in for the previous lab assignments.

Extract the contents of the zip archive to a conveniently named folder for this lab assignment adjacent to the workspace folders for the previous lab assignments.

1.4 Tools

The GSI\_cost tool assembles many of the steps and work flows you have performed thus far into a single tool. The GSI toolbox is inside the ‘arctools’ folder in the downloaded zip archive and the instructions to load toolboxes into the ArcToolbox pane is [here](http://desktop.arcgis.com/en/arcmap/10.4/analyze/managing-tools-and-toolboxes/using-the-arctoolbox-window.htm). The help file for the GSI\_tool is ‘..\arctools\GSI\_cost\_tool\_help.pdf’.

**2.0 Forming an Improvement Intervention Model**

Intervention modeling in capital improvement programming involves three sub-models: change model,

impact model, and decision model. Using these three sub-models we can consider WF and WQ improvement across the landscape.

As described in lecture 11, different stakeholder viewpoints encourage different improvement packages. We can weigh WF and WQ components within different packages to increase benefit derived from the investment. The highest investment might be considered the best package. However, spatial equity is a concern as well, i.e., do the projects address widespread needs across the WRIA?

In this assignment you are to create three packages of projects, each package is considered a scenario for investment. You will evaluate trade-offs among your packages as part of a decision model. Using the three packages establish a 1, 2, 3 priority order for them; why is one better than the next? You will consider this issue as part of decision modeling that makes use of the information from the impact model, which of course makes use of the design change model information.

Some stakeholders (technical specialists, elected officials, and public groups) might see WF or WQ as being more important within each of the packages. The [stakeholder perspectives introduced in lecture 11](http://courses.washington.edu/geog464/LOO/LOO-11.pdf) (see the [LOO11](http://courses.washington.edu/geog464/LOO/LOO-11.pdf)) are relevant to a WRIA Consortium approach to decision modeling. Such perspectives can form the basis of the difference in the packages. If you get together with students in class to discuss you could easily consider different packages within a role-lay deliberation played out by a WRIA Consortium. This will enhance your understanding of participatory decision modeling.

**2.1 Design-Change Modeling**

As per lab assignment 3, we want to develop packages of project acres that: 1) have an overall total cost, 2) we can pay for using revenue from income tax, 3) both 1 and 2 form a balanced budget (within a reasonable range of $, and 4) have a high level of ecosystem service value for that balanced budget.

Projects are AU-centric, that is, formed of acres within AUs considering WF and WQ functional services improved though a dryland and/or wetland strategy. Not all AUs must participate within each package of improvements; but whatever package is formulated you must balance the budget for the package within a reasonable number of dollars.

Each package as a scenario for investment will focus on different characteristics of water flow (WF) and water quality (WQ) addressed using green infrastructure dryland (dry) and/or wetland (wet) improvement strategy. These four variables, manipulated in various amounts in terms of acres, provide the foundation to create different packages as an approach to design-change modeling.

2.1.1 Using Revenue Generated from Within a WRIA

We will use the revenue amounts generated in lab assignment 3 sub-section 2.1.2. You computed total potential revenue for the jurisdiction, but used the portion of revenue within the clipped part of the jurisdictions within the WRIA.

2.1.2 Total Cost

We use the same cost schedules and a similar approach to total costs in Lab assignment 3 sub-section 2.1.3. The cost amount per acre for GSI improvement depends on the order (functional level) of water function (WF\_order, WQ\_order) being improved and the improvement type (dryland, wetland). The cost schedule for each AU comes from multiplying these cost amounts per acre value by the number of allocated improvement acres (i.e., water flow acres or water quality acres).

2.1.3 Balanced Budget

In lab assignment 3, sub-section 2.3.1 we compared revenue and costs to achieve a balanced budget. Use this same approach for each of a minimum of three scenarios. Make sure you have a balanced budget for each of the scenarios. We will start out with a ‘compromise scenario’, that is, one in which there is a reasonably similar amount of flow acres and quality acres being improved using a similar amount of acres for dry and wet strategy.

Note that it is possible to develop one scenario, then move on to impact modeling to compute the ecosystem service valuation, then return to design-change model and create a second scenario. This kind of workflow would iterate between Section 2.1 and Section 2.2, until you have three scenarios with an ecosystem service valuation (impact model) for each.

2.1.4 Try to calculate a balanced budget

Open the GSI\_cost tool from the GSI toolbox and read the tool help file so you understand the input dialog settings. Use these parameters for your first use of GSI\_cost:

1. Workspace gdb: use a new file geodatabase called ‘compromise1.gdb’ you create in your Lab 4 working folder.
2. Subwatershed layer: Load the ‘WRIA?\_base’ feature class from the distribution geodatabase into the ArcMap table of contents and then drag it into the dialog as the ‘subwatershed layer’
3. Batch text file: ‘compromise\_demo.txt’
4. Results layer file: ...\layers\AU\_cost\_balance.lyr

As the tool runs it will display summary statistics from the output feature classes and load the results into ArcMap’s table of contents using symbology from the layer file you selected.

This ‘compromise’ scenario includes the complete set of function intervention type (FIT) combinations (FD, FW, QD and QW) with different areas allocated for projects in the AUs. Look for the table ‘…\compromise1.gdb\GSI\_cost\_summary’ that contains all the summary statistics shown while the tool was running. The fields to take note of at this time are ‘SUM\_wf\_acres’, ‘SUM\_wq\_acres’, ‘SUM\_AU\_TPR’, ‘SUM\_GSI\_cost’, ‘SUM\_AU\_cost\_balance’.

How well did these compromise scenarios achieve a balanced budget and what changes could you make to the variables to attain a balanced budget?

Balancing the budget and keeping all FITs in this compromise scenario means you are only able to work with the number of acres available for intervention. Make a copy of ‘compromise\_batch.txt’ and name it ‘compromise\_batch\_2.txt’. Open it and change the scenario filename settings in ways that will come closer to a balanced budget. You can add as many scenario filename settings as you like. Use a new empty file geodatabase to receive the outputs of the GSI\_cost tool when you run your new batch input file.

Were you able to achieve a balanced budget? Were you surprised by any of the outcomes to the changes you made to the area allocated for dryland or wetland GSI intervention measures?

Write a short account of your experience trying to balance the budget for a compromise scenario and include some screenshots of the outcomes and steps taken to approach a balance of revenue and cost schedules.

**2.2 Impact Modeling**

Compute net-benefit of ecosystem service value for each of the scenarios. Use the evaluation model information from lab assignment 3.

What are the net benefits from project packages? Those with higher net benefits are preferred, holding all else constant.

These benefits accrue by how much change in WF and WQ are being proposed. Each acre of WF and WQ is in some current condition. We want to enhance these conditions. Thus, we want to enhance the condition of the WF and WQ function acres in terms of the unit increments as computed in Lab assignment 3.

Begin your impact model work by displaying these fields from the balanced compromise feature class outcome: 'FD\_esv\_net', 'FW\_esv\_net', 'QD\_esv\_net' and 'QW\_esv\_net'. These fields that show the net environmental services value gain for each FIT and shows where the compromise scenario would have an effect on the landscape. The field ‘AU\_esv\_net\_roi’ is the sum of the FIT’s esv net divided by the GSI\_cost and shows the relative expense to achieve the expected improvement in environmental services. Extend your account of the balanced compromise scenario with your observations of the scenario impacts on the landscape using these five measures.

Changing the area available for dryland and wetland intervention to balance the compromise scenario is reflected in the landscape impact. At this point do you have a better appreciation for the problem if water quality or water flow is more expensive? Similarly, dryland and wetland intervention types are valued differently. Now that you have seen the compromise scenario impacts you are in a better position to craft two additional scenarios informed by desired changes in the landscape.

Previously you evaluated the amount of river and wetland acres present in each AU. You might take the importance of these resources as a starting point and adjust the compromise scenario to benefit the AUs that account for a greater portion of the river and wetland acres. ‘Sum\_riv\_ac’ and ‘Sum\_wet\_ac’ are the fields in the WRIA?\_base feature class that report the acres of rivers and wetlands in each AU. Once you know which AUs you want to favor and how to favor them you can change the parameters of your compromise scenario to achieve this impact. You can choose which of the four FITs to include in your scenarios and how much area to allocate for dryland or wetland intervention. Program your batch input text files with the scenarios you want to evaluate and run them with the GSI\_cost tool. You will find it useful to use ‘AU\_esv\_net\_gain.lyr’ as the ‘results layer file’ to use when results are loaded to the ArcMap table of contents so you can quickly evaluate the outcomes. Also make use of the GSI\_cost\_summary table to prioritize your results in terms of balanced budget, gain in environmental services and the impact on the landscape.

Keep track of your progress as you did with the compromise scenario. Explain why the impacts of the compromise scenario could be improved upon. What impacts were more desired and your plan to achieve this outcome? Keep track of the choices, decisions and outcomes you experience as you refine your scenarios as this information will be useful for describing your decision model recommendations .

At least three packages are desired for comparison within a decision model. Iterate on the cost computation to achieve a balanced budget for each and high net-benefit for each where possible.

**2.3 Decision Modeling**

Depending on the stakeholder viewpoints, we can weight WF and WQ components within different packages to increase benefit derived from the investment. The highest investment might be considered the best package. However, equity is a concern as well. Do the projects address widespread needs across the WRIA?

Evaluate the trade-offs among your packages. Recommend a priority to these packages.

Another way to consider trade-offs is to weigh the benefits of the components WF and WQ; you could even consider habitat ecosystem functions if you like; just document your approach. That is, some stakeholders (technical specialists, elected officials, and public groups) might see WF, WQ or Habitat as being more important within each of the packages. This can even form the basis of difference of the packages. Consider technical knowledge about which might be more important for overall ecosystem health, perhaps even introducing other function performance. The [stakeholder perspectives introduced in lecture 11](http://courses.washington.edu/geog464/LOO/LOO-11.pdf) are relevant to a consortium approach to decision modeling. If you get together with students in class to discuss you could easily consider different packages within a role-lay deliberation played out by a WRIA Consortium. This will enhance your understanding of participatory decision modeling. Jurisdictions have their own perspective depending on where the jurisdiction is situated within the WRIA, that is, either upstream or downstream.

**3.0 Deliverables**

Provide as least three different scenarios for natural capital improvement. Depict these in maps.

Provide tables of your AU scenario package (priority lists) as appropriate.

Provide an essay that describes each of the scenario packages and offer a priority recommendation among. Provide the justification for this recommendation.