SWAMPS Modeling Workshop

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I. Overview

This workshop shows use of the Systems model in Wetlands to Allocate water and Manage Plant Spread (SWAMPS) and its Graphical User Interface (GUI). SWAMPS identifies ways to allocate water and recommend invasive vegetation control to improve bird habitat for select species at the Bear River Migratory Bird Refuge, Utah. Workshop activities also use a website that provides spatial and hydrologic information at the Refuge and may help improve monitoring capabilities. This document is written as a tutorial of step-by-step actions to take to achieve the main workshop objectives.

II. Workshop Objectives

You will use the SWAMPS model to identify how wetland performance at the Refuge is affected by changes in input data describing Refuge hydrology, ecology, and management. Specific workshop objectives are:

1. Enter data into the model
2. Run the model and interpret results
3. Identify how wetland performance at the Refuge is affected by changes in initial invasive vegetation cover, and
4. Use results to recommend invasive vegetation control and water allocation in wetland units at the Refuge.

III. Software Requirements

To run SWAMPS, you will need the following software installed on your computer:

a. General Algebraic Modeling System (GAMS) version 24.1.3 and a license for the Conopt solver. Download from www.gams.com.
b. Matlab,
c. Microsoft Excel, and
d. SWAMPS data and modeling files available on GitHub.

See Appendix 1 (p. 6) for instructions for how to download, install and configure GAMS, MATLAB, and the data and modelling files so all the programs correctly interact with each other and the model data. A comprehensive description of the model is provided in the

paper and in the GitHub repository at https://github.com/alminagorta/Systems-model-in-Wetlands-to-Allocate-water-and-Manage-Plant-Spread.

IV. Workshop Activities

Here, we provide step-by-step instructions for four workshop exercises that:

A. Run the base case scenario and explore results,
B. Increase the initial invasive vegetation cover,
C. Decrease the water available on the Bear River, and
D. Use hydrology and vegetation cover monitoring tools at http://brmbr.weebly.com/

Appendix II provides a fifth exercise to examine how budget changes affect wetland performance at the Refuge

Exercise A. Run base case scenario and explore results

In this exercise, you will use existing base case input data for the Refuge to run the model and explore how the model recommends water allocation and invasive vegetation control in the Refuge's 25 wetlands units.

1. Type GUI_GAMS_v1 at the Matlab prompt.

2. In the **GUI_GAMS_v1** window, select the **Input Type** option in the menu bar and check the option '**To use Excel data**' (Figure 1). This option allows input data using the pre-populated input data of the Refuge.

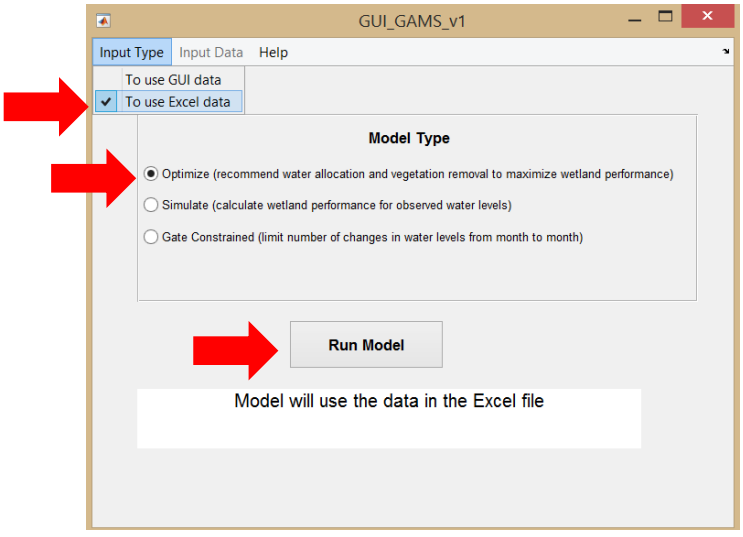

Figure 1. Selecting GUI options

3. Then select the model type as **Optimize** and click the **Run Model** button. Over the course of a minute, intermediary optimization results will appear in the Matlab command line window.

4. When the model run finishes, five figures will appear:

    - Water depth for each wetland unit and per month (Figure 2),
    - Invasive vegetation cover for each wetland unit (Figure 3),
    - Habitat suitability for invasive vegetation cover (Figure 4),
    - Weighted usable area for each wetland unit and per month (Figure 5),
    - Spatial and temporal wetland performance (Figure 6).

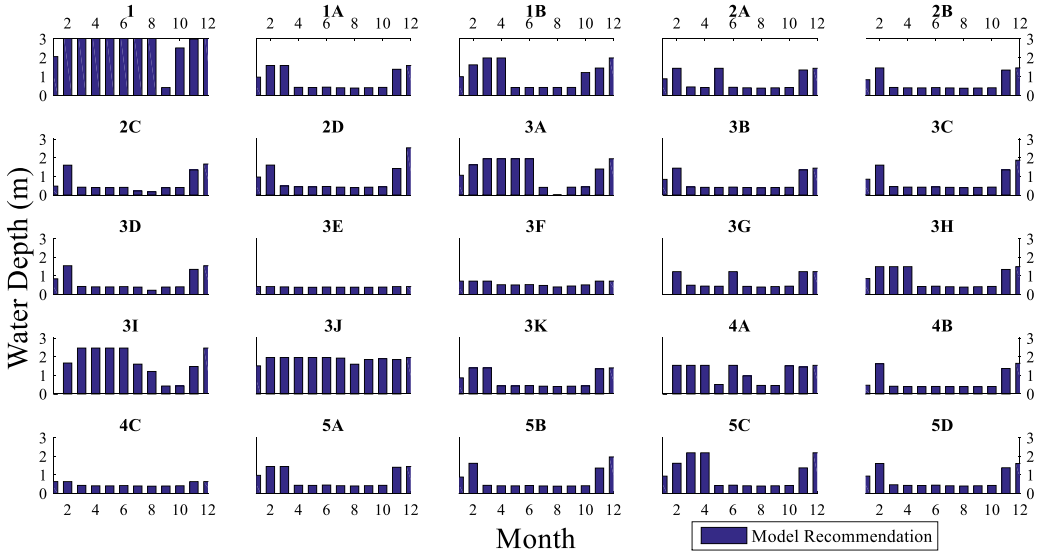

Figure 2. Model recommended (optimized) water allocations by month and wetland unit during 2008

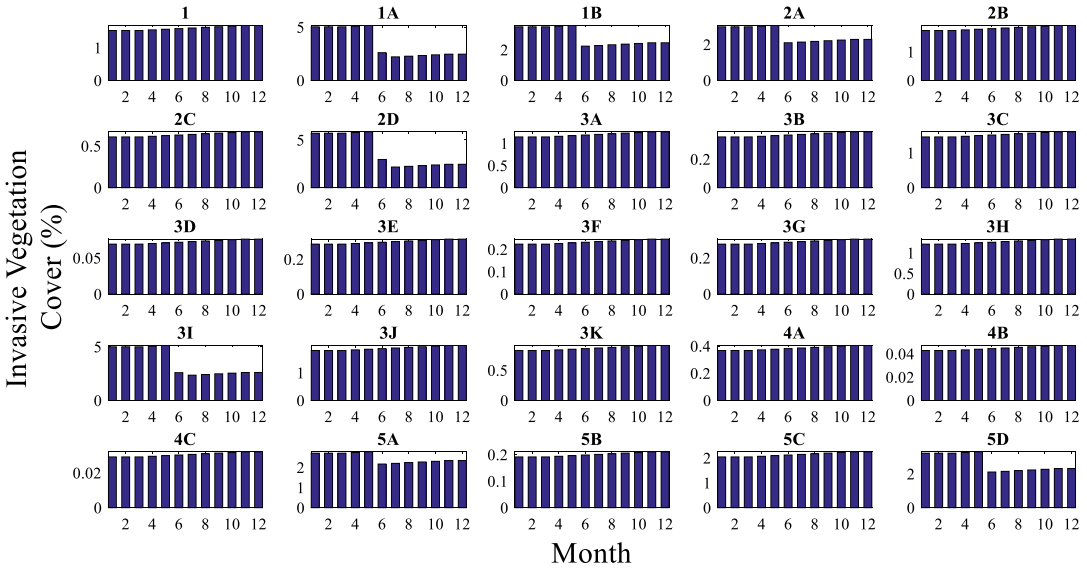

Figure 3. Invasive vegetation cover (Phragmites) over time in the Refuge wetland units

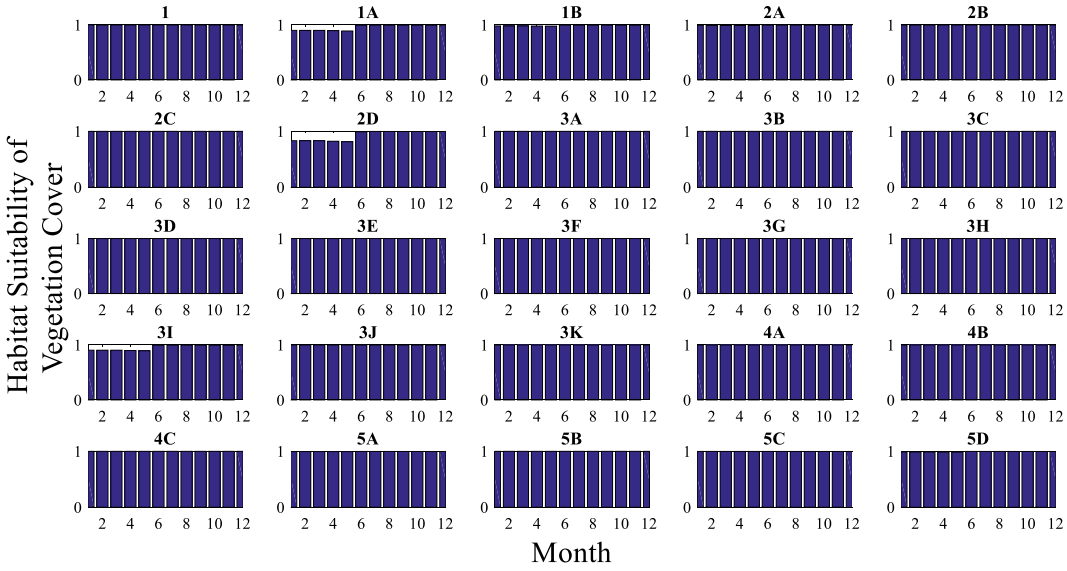

Figure 4. Habitat suitability of vegetation cover over time in the Refuge wetland units. 1=Excellent habitat quality; 0=Poor habitat quality.

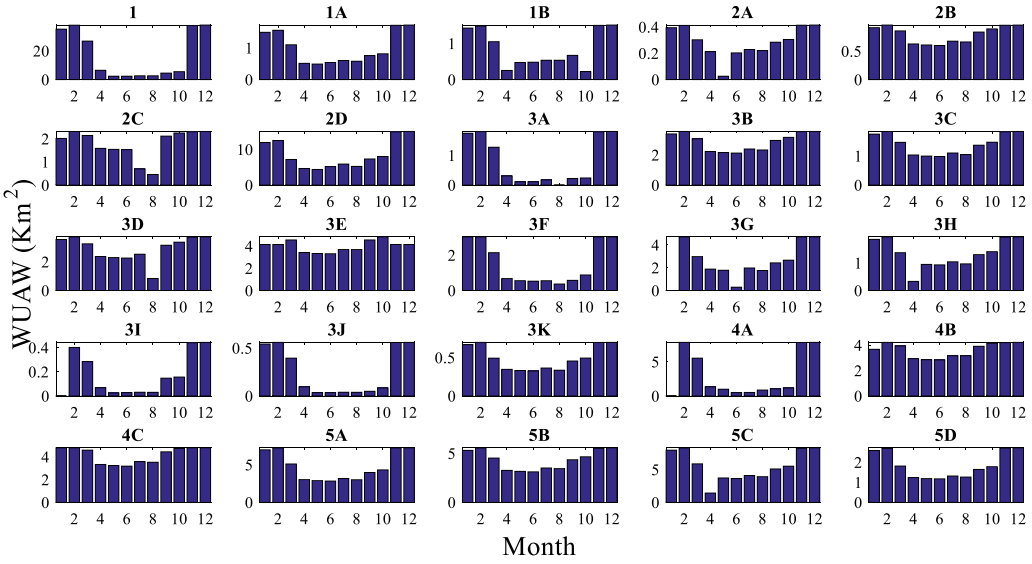

Figure 5. Weighted usable area for wetlands (WUAW) at the Refuge

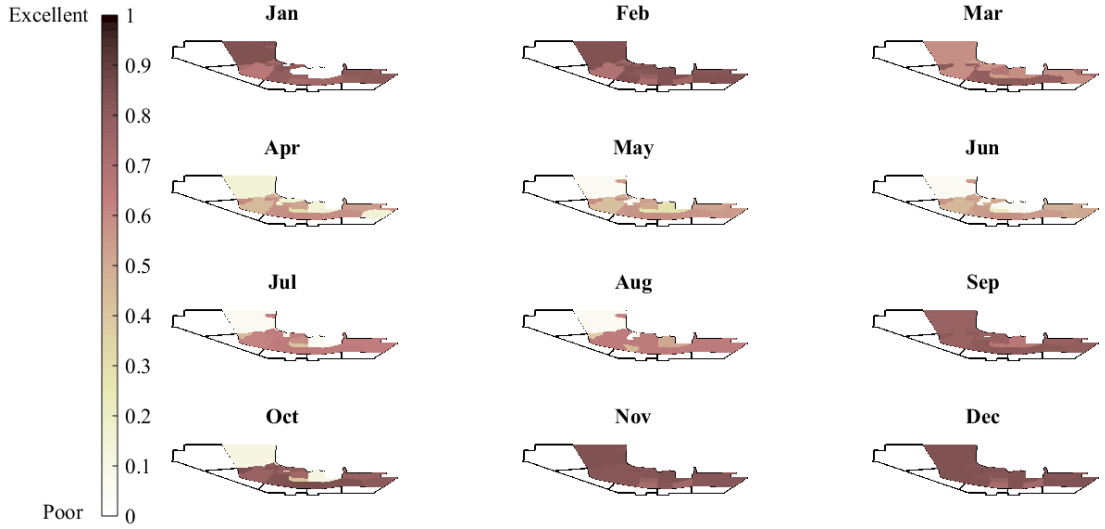

Figure 6. Spatial and temporal distribution of composite habitat suitability index (HC) for optimized case. Dark shading denotes areas with water depths and vegetation cover more suitable for the three priority bird species.

5. Interpret the results by answering the following questions:

    a. What water depths does the model recommend for wetland unit 3I between July and October?

b. During what months does the model have difficulty maintaining excellent habitat suitability for priority bird species?

Exercise B. Increase the initial invasive vegetation cover

In this exercise, you will use Excel to increase the initial invasive vegetation cover by three times the value in the base case and interpret the model results.

1. In the **GUI_GAMS_v1** window, select the **Input Type** menu and check the option **To use Excel data**. This option will allow entering input data in the Excel file 'BRMBR_Input.xls'. This Excel file is located in the folder titled 'SWAMPS_v1.0' that you downloaded.

2. Open the Excel file *BRMBR_Input.xls* and search for the sheet named *Init_CV* that has the input data for initial invasive vegetation cover (the sheet is almost at the end – see Figure 7). In this sheet, Column A labeled wu represents the wetlands units and Column B (labeled InitCViv; blue cells) indicates the initial invasive vegetation cover [expressed as percentage of total area of the wetland unit].

3. Multiply all the values of initial vegetation cover (blue cells) by three. **Save** and then close the Excel file.

4. In the GUI, select the model type as **Optimize** and **Run** the model.

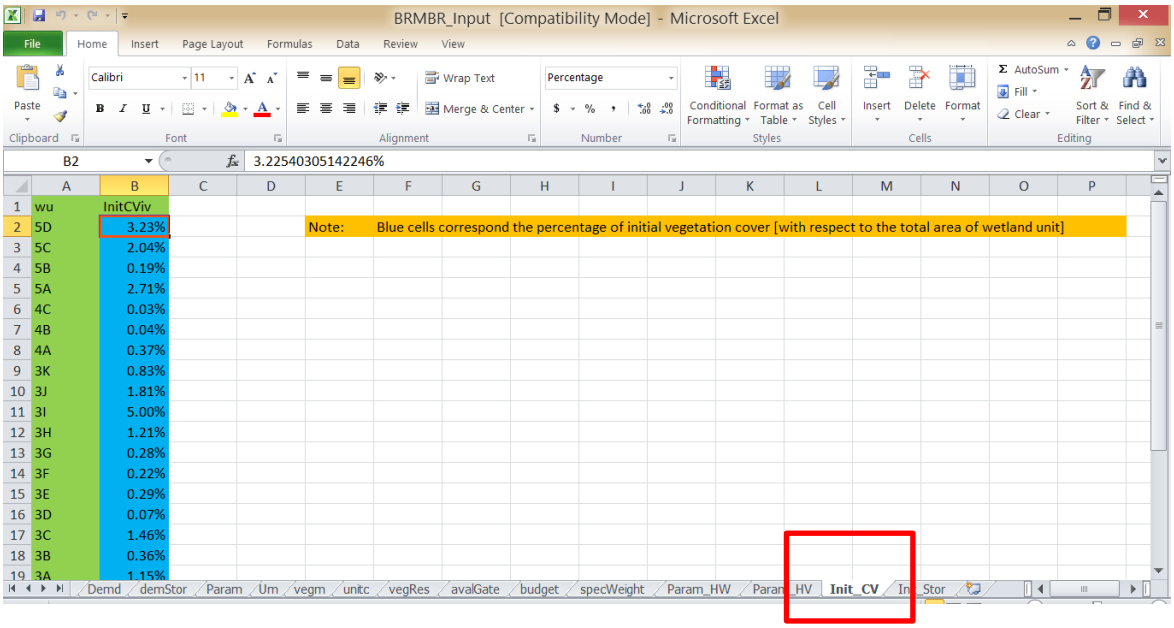

Figure 7. Alternative input data using Excel in SWAMPS

5. The model will again generate the 5 results figures as for Exercise A. Two of these figures for invasive vegetation cover and habitat suitability of invasive vegetation cover are shown below as Figures 8 and 9.

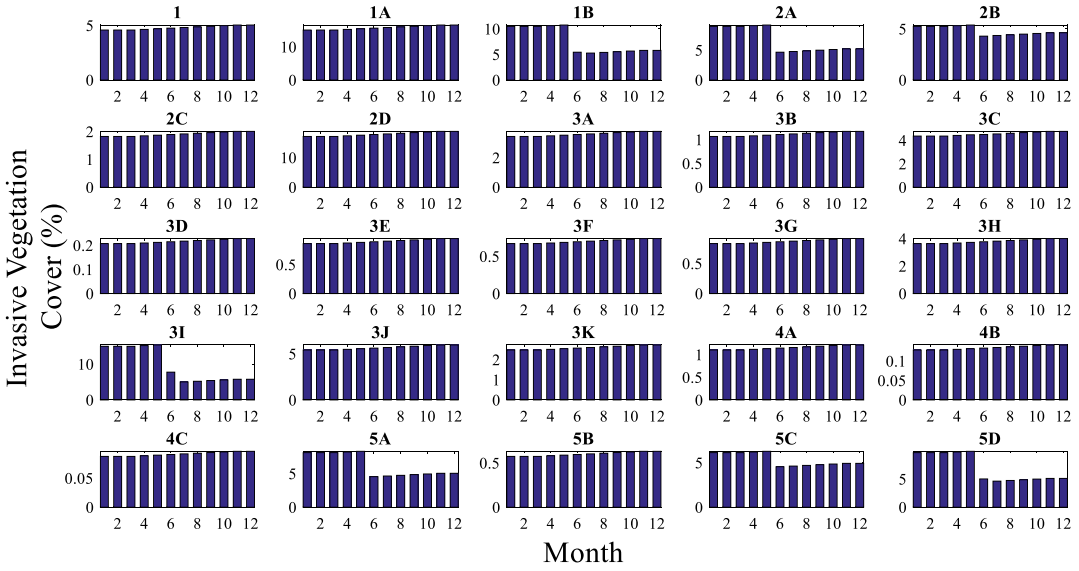

Figure 8. Invasive vegetation cover after increasing three times the current invasive vegetation at the Refuge

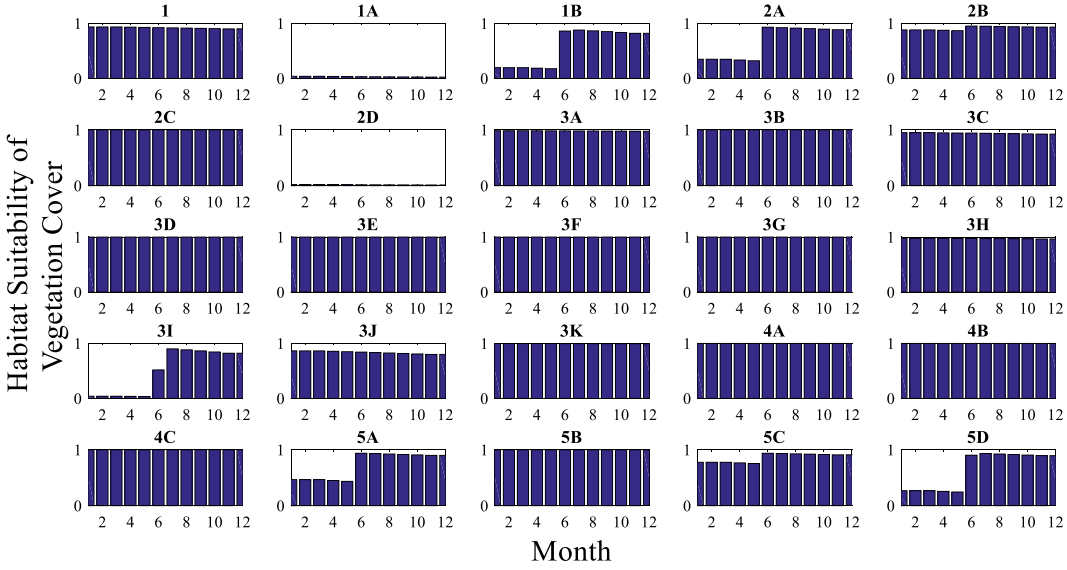

Figure 9. Habitat suitability after increasing three times the current invasive vegetation

6. Interpret the results in Figures 8 and 9 by answering the following questions:

    a. How does invasive vegetation cover change over time in units 1 & 1B?
    b. When does the model remove invasive vegetation in unit 1B?
    c. Does the vegetation removal improve habitat suitability of invasive vegetation cover? How? Why?

Exercise C. Decrease the water available on the Bear River

In this exercise, you will use Excel to decrease the water available on the Bear River at the Corinne station.

1. As In Exercise B, open the **GUI_GAMS_v1** window, select the **Input Type** menu, and check the option **To use Excel data**.

2. Open the Excel file *BRMBR_Input.xls* and search for the sheet named *Inflow* that has the input data for initial invasive vegetation cover (the sheet is 13th from the left). Inflow data are organized by Year (column A) and Month (column B) for the Corinne station (Column D), Malad river (Column E), and Box Elder Creek (Column F) and specified in units of ha-m (1 ha-m = 10,000 m^3 = 8.1 ac-ft).

3. Enter the value for 500 ha-m in July, August, and September to represent a summer drought.

4. **Save** and then close the Excel file.

5. Back in the GUI and as in Exercise B, sect the model type as **Optimize** and **Run** the model.

6. Use the results to identify how wetland performance changes and how the model recommends to reallocate water among wetland units during the now drier summer months.

Exercise D. Use hydrologic and vegetation cover monitoring tools at http://brmbr.weebly.com/

In this exercise, you will use the hydrologic and vegetation cover monitoring tools at http://brmbr.weebly.com/ further interpret model results.

1. Open the website http://brmbr.weebly.com/ and navigate through the interactive maps of the Refuge that show wetland units, landsat imagery, and classified imagery of vegetation cover.

2. What wetland units look to have the most invasive vegetation cover in 2008?

3. At the top of the webpage, click the tab Hydrologic Information, and view realtime analyses of flow data from the Corinne station gage for the last week and last 5 years.

4. How do flows for 2015 compare to flows for 2011 and 2012?

Appendix 1: Set-up the SWAMPS model on your computer

A. Set GAMS path in Windows

For Windows interact with GAMS in Matlab, it is necessary to add the GAMS directory to the path environment in Windows. To do that:

1. Identify the directory where GAMS was installed. For example: 'C:\GAMS\win64\24.1';
2. Open your **System Properties** (Figure 10) and then open **Advanced system settings** and **Environment Variables** (Figure 11)
3. Select path in the **system variables** list and **Edit**. Then add a semicolon (;) and paste the GAMS installation directory (e.g., C:\GAMS\win64\24.1) recorded in step B1, without any backslash (\) [See Figure 12]
4. OK all windows
5. To check the correct settings, Open the **command prompt** and type **gams** (A message similar to Figure 13 should appear)

This GAMS-Windows set up will allow you use all the optimization capabilities of GAMS in Matlab and allow visualization of GAMS models directly within MATLAB.

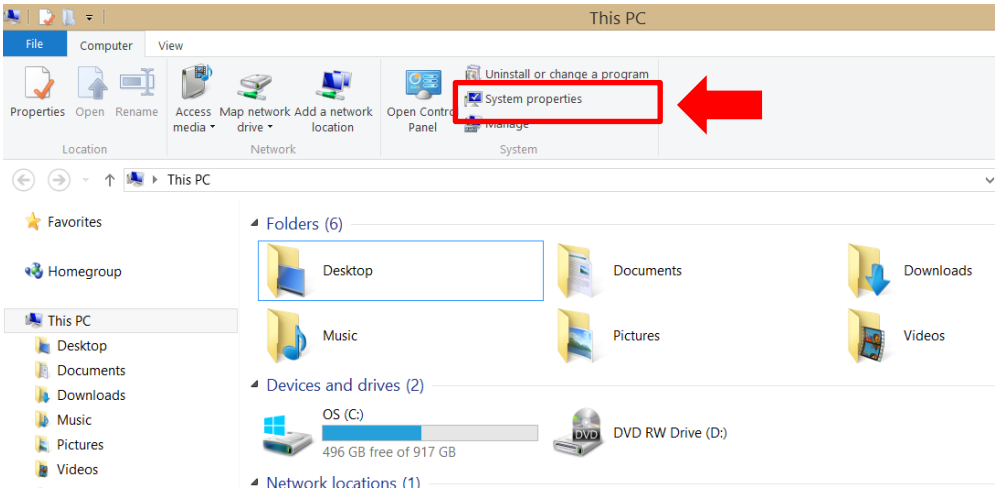

Figure 10. Screenshot to access System properties in Windows 8

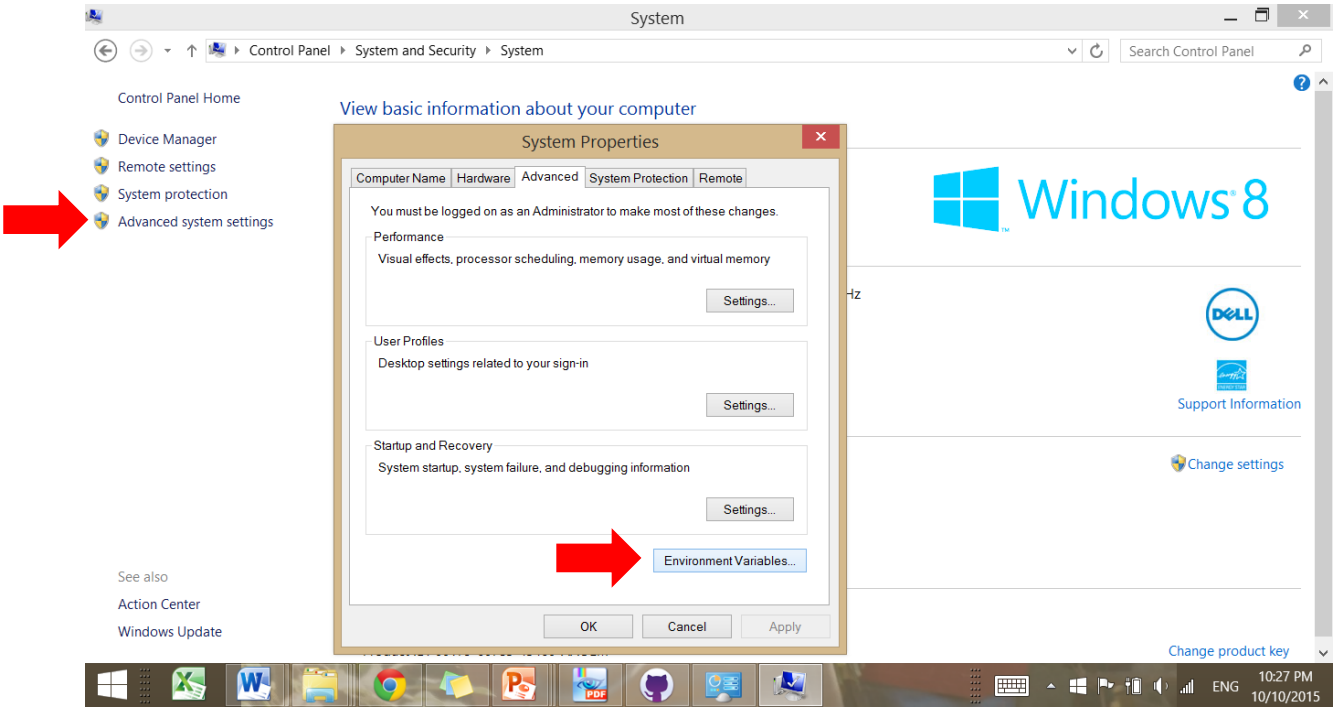

Figure 11. Screenshot of the Environment Variables

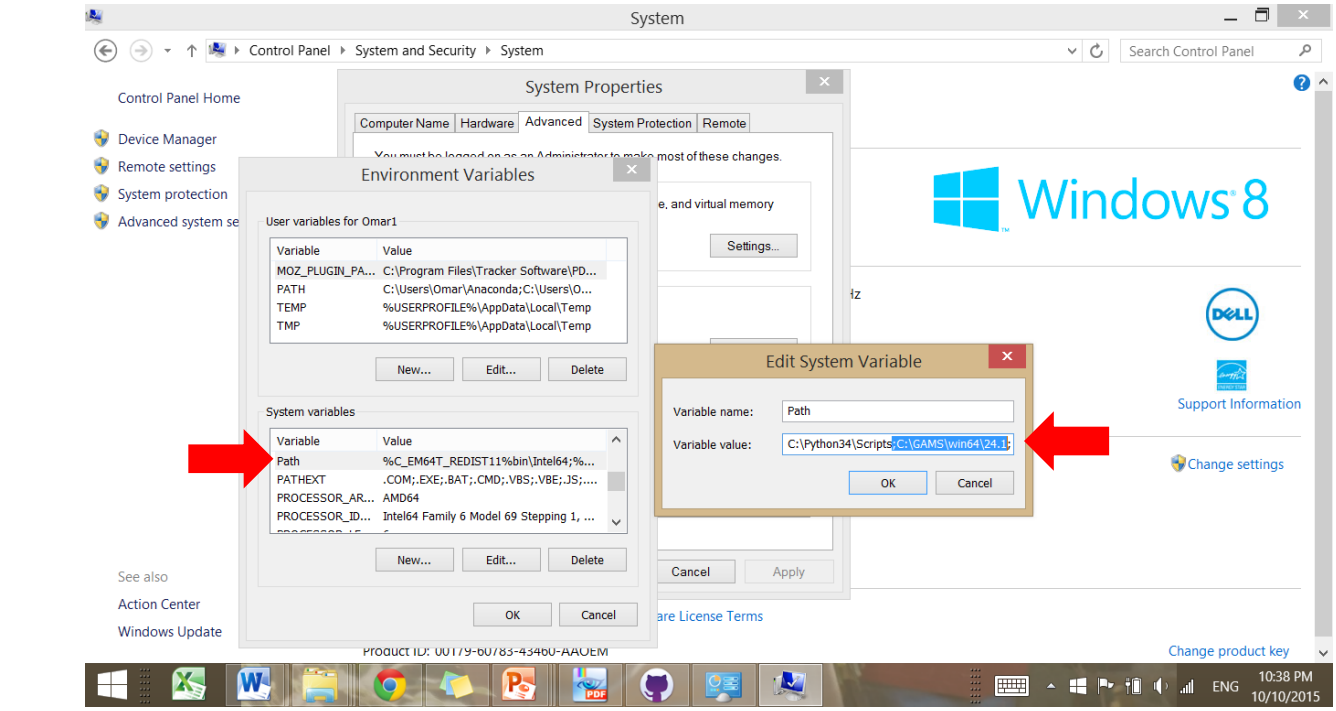

Figure 12. Screenshot to add GAMS path

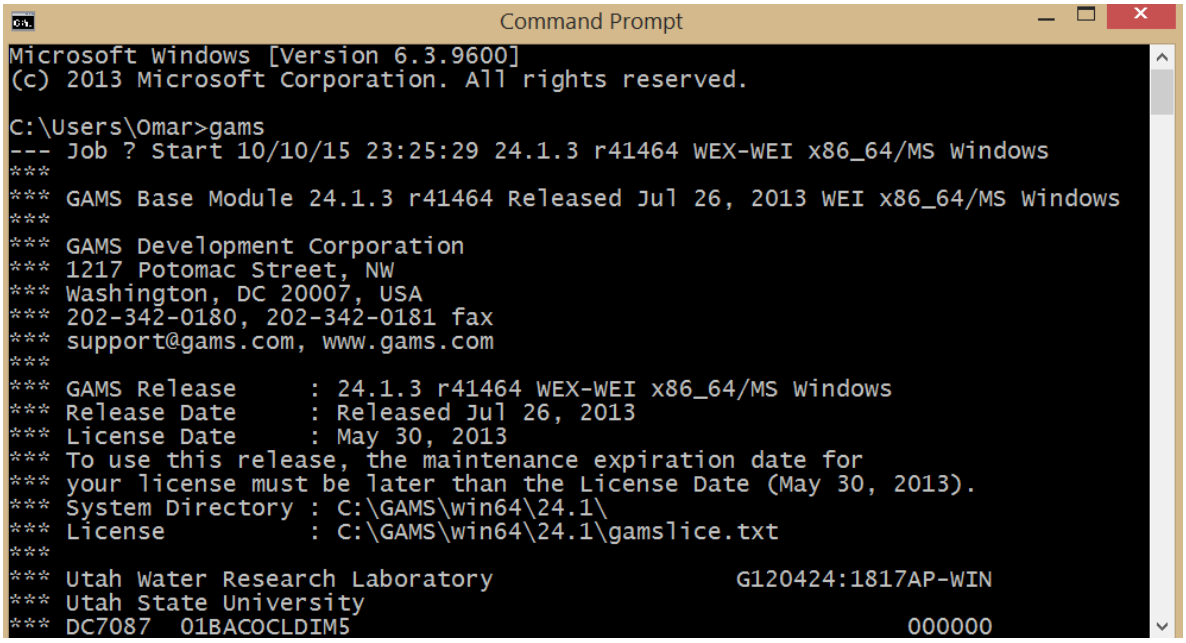

Figure 13. Expected message in the command prompt after setting up the GAMS path

B. The Graphical User Interface

1. On the GitHub repository for the SWAMPS model, click the **Download ZIP** icon and save the zip file to a location that has a short name (like the Desktop).

2. Use WINZIP to unzip the file.

3. The GUI is located in the folder “SupplementaryDocumentation\Graphical User Interface”
4. Open Matlab and select the folder created in step B2 as the current directory (Figure 14). Then, in the MATLAB command window, type (Figure 15)

   >> **GUI_GAMS_v1**

5. If you experience any error, test that the GAMS path is listed correctly in Matlab. In the Matlab command Window type `which gams`. The command should return

   `C:\GAMS\win64\24.1\gams.mexw64`

6. If the model runs but does not show the figures of results, check the GAMS version installed on your computer. You should have only version 24.1. Avoid having additional GAMS versions on your computer; it can create problems on the GUI.

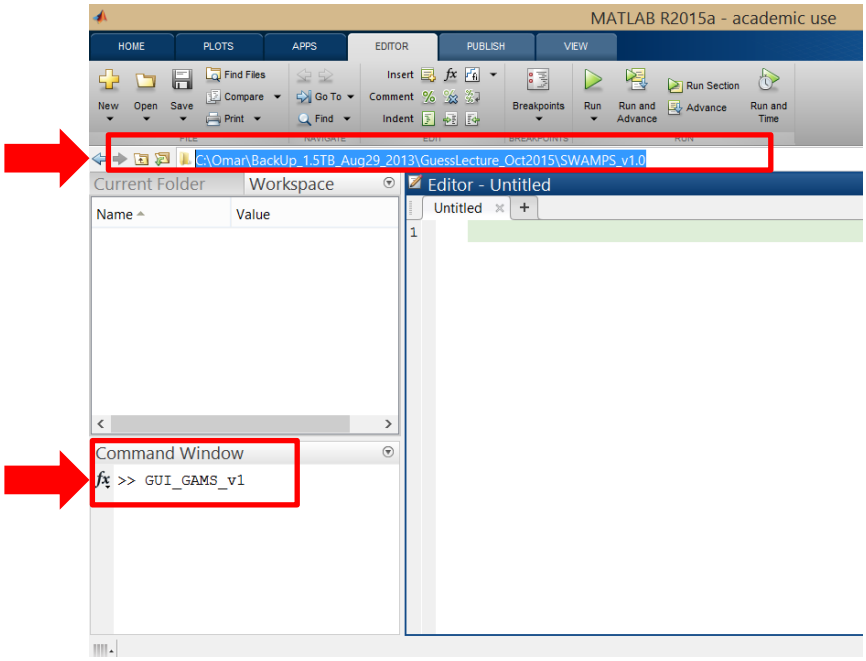

Figure 14. Screenshot to select the appropriate folder and execute the GUI

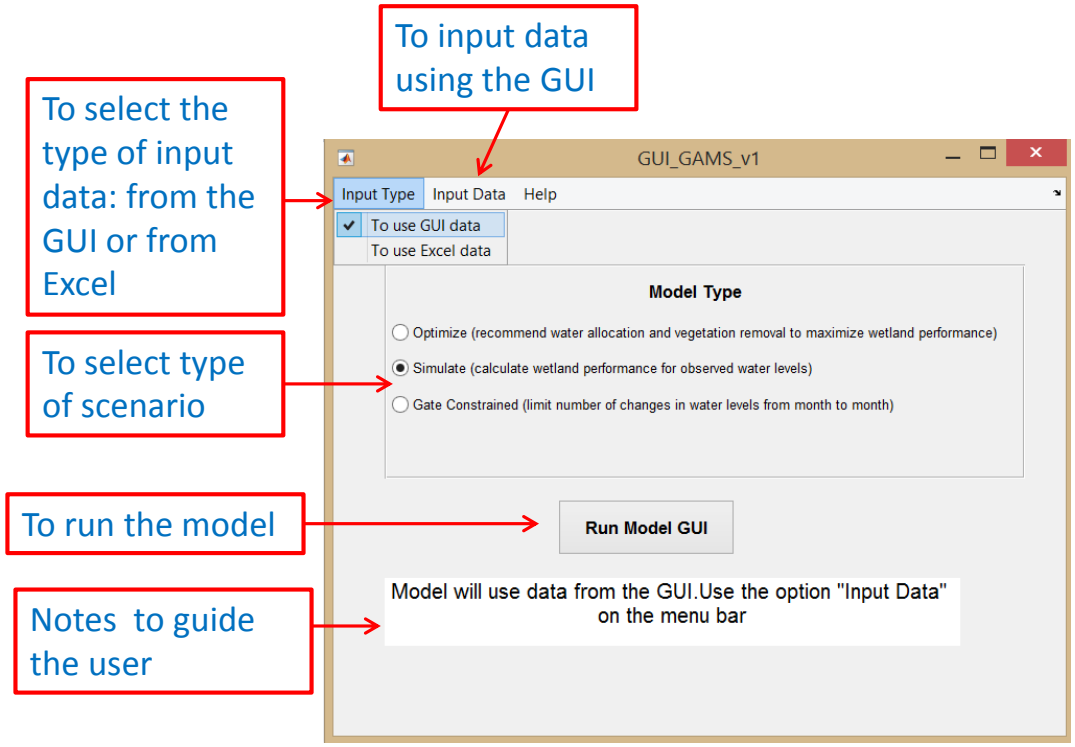

Figure 15. Main features of the SWAMPS GUI

Appendix 2: Additional Exercise

Exercise E. Evaluate effects of budget

In this exercise, you will use the model GUI to identify how changes in the budget to control invasive vegetation effects wetland performance.

1. In the GUI, select the **Input Type** menu and check the option **To use GUI data** (Figure 16). This option allows to input data using the GUI.

2. Then, select the model type as **Optimize** to determine the model recommendation.

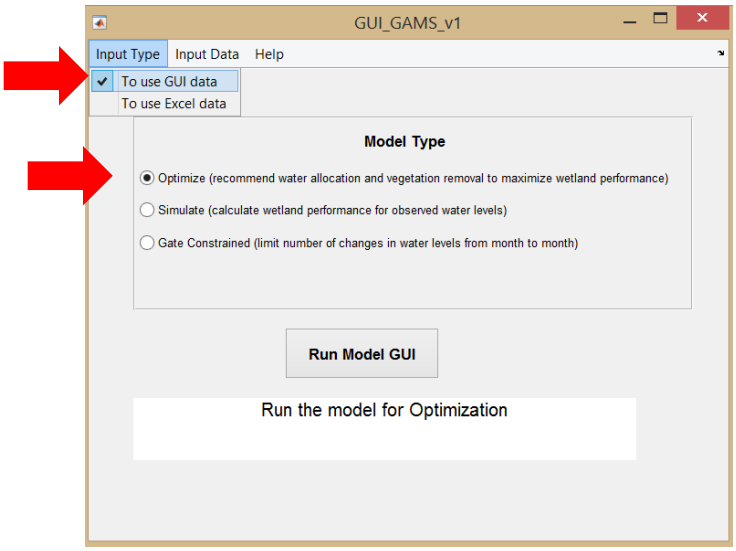

Figure 16. Selecting GUI options

3. From the **Input data** menu, select **Modify Budget** and input $10000 in the window that opens (Figure 17).

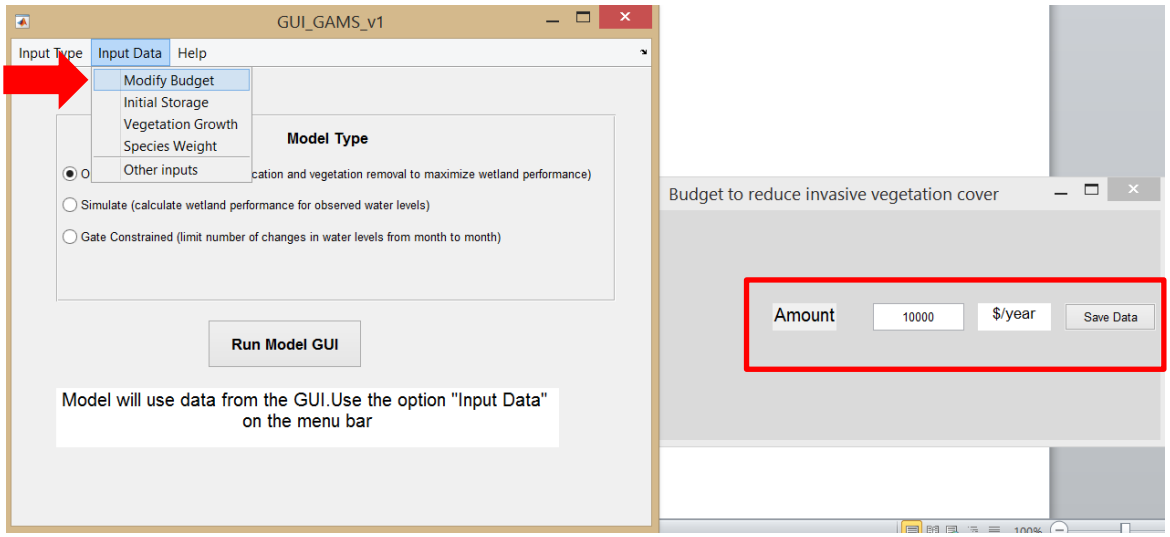

Figure 17. Modifying total budget to reduce invasive vegetation

4. **Save** the data and **run** the model.

5. Once the figures of results open, identify how the water depth, invasive vegetation cover, and habitat suitability change compared to the results for Exercises A and B.