

OWC-SWAT+ Tool

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Introduction

Welcome to the OWC-SWAT+ tool. This project is a collaboration between people at the Ohio State University, the Old Woman Creek National Estuarine Research Reserve, and the Erie Soil and Water Conservation District. This tool was designed to remove barriers resource managers may face is accessing watershed modeling scenarios. The OWC-SWAT+ tool is built in R shiny and is freely available to users anywhere.

Many other stakeholders within and around Old Woman Creek engaged in feedback on the model. We are greatly appreciative of their support in making this tool locally relevant.

Commented [KH1]: Add disclaimer about watershed model uncertainty

Commented [KH2]: Maybe add more to this?

Using OWC-SWAT+

Download the 'TestApp' folder. Navigate inside the folder and click the 'run.bat' file.

GoogleChromePortable	5/1/2023 5:00 PM	File folder	
R-Portable	5/1/2023 5:01 PM	File folder	
SWATPlusGUI	5/3/2023 2:01 PM	File folder	
.Rhistory	5/1/2023 5:44 PM	RHISTORY File	0 KB
run	5/1/2023 5:50 PM	Windows Batch File	1 KB
runShinyApp	5/1/2023 5:53 PM	R File	1 KB
ShinyApp	5/1/2023 8:01 PM	Text Document	346 KB

Figure 1. OWC-SWAT+ GUI folder

A command window will open as well as the app within Google Chrome. **Do not close the command window, it will crash the app.**

When you first open the app, it may take a few seconds to populate all calculated values.

Management and conservation practices

To create a land management scenario, navigate to the following tab: **Change inputs and run OWC-SWAT+ > Management and conservation practices.**

Altering management scenarios

Altering management scenarios can change fertilizer applied, tillage rates, as well as crops in rotation. Management in Old Woman Creek includes four crops: Corn, soybean (bean), winter wheat (wheat), and a cereal rye cover crop. The seven scenarios available to the user are:

1. Corn-Bean – Full tillage
2. Corn-Bean – No Till
3. Corn-Bean – Rotational No-Till
4. Corn-Bean – Reduced Till
5. Corn-Bean – No Till with a rye cover crop
6. Corn-Bean-Wheat – double crop bean
7. Corn-Bean-Wheat – rye cover crop

The initialization of the tool will automatically populate the model with the baseline rates of each rotation (Figure 1). These percentages represent the total percent of *row cropland only* (). This excludes watershed area that is in pasture, forested, or urban. To change the coverage of any management practice, alter the value within the text box. The amount of percentage points you changed this practice from the baseline will populate (Figure 2). However, **you must ensure the total of all seven scenarios totals 100%. Hence, if you decrease a management scenario you need to increase the amount of another management scenario, and vice versa.** An error will populate below 'Rates of management on row crop lands:' if all seven scenarios do not total 100%, stating 'Input management rates do not add up to 100% -- Adjust before running SWAT+'.

While the code will attempt to get as close to the input percentages as possible, they may end up being slightly above or below the user input due to the small size of the watershed. The exact area that went into the scenario and the difference from the baseline will be printed at the top of 'Visualize outputs'.

OWC-SWAT+

[About OWC-SWAT+](#)
[Change inputs and run OWC-SWAT+](#)
[Visualize outputs](#)
[Documentation](#)

Management and conservation practices

Climate change scenario

Total rate of all seven management scenarios needs to add up to 100%
Rate of buffers + grassed waterways on each management scenario cannot total greater than 100%
e.g. buffers 50% & grassed waterways 50% = OK, buffers = 100% & grassed waterways = 100% = model will crash
To calculate an even rate on a subset of scenarios for grassed waterways (grw) or vegetated buffers, use the following equation:
Input rate = desired total rate of buffers or grw on cropland (percent) x (1 / fraction of total cropland to have buffer or grw on (decimal percent))

Corn Bean - Full Tillage <input type="text" value="21"/> Change from 21% to 21% (change 0%)	Vegetated buffer rate <input type="text" value="0"/>	Grassed waterway rate <input type="text" value="0"/>
Corn Bean - No Till <input type="text" value="40"/> Change from 40% to 40% (change 0%)	Vegetated buffer rate <input type="text" value="44"/>	Grassed waterway rate <input type="text" value="26"/>
Corn Bean - Rotational No Till <input type="text" value="15"/> Change from 15% to 15% (change 0%)	Vegetated buffer rate <input type="text" value="44"/>	Grassed waterway rate <input type="text" value="26"/>
Corn Bean - Reduced Till <input type="text" value="4"/> Change from 4% to 4% (change 0%)	Vegetated buffer rate <input type="text" value="44"/>	Grassed waterway rate <input type="text" value="26"/>
Corn Bean - No Till with rye cover crop <input type="text" value="10"/> Change from 10% to 10% (change 0%)	Vegetated buffer rate <input type="text" value="44"/>	Grassed waterway rate <input type="text" value="26"/>
Corn Bean Wheat /Double crop bean <input type="text"/> Change from 9% to 9% (change 0%)	Vegetated buffer rate <input type="text"/>	Grassed waterway rate <input type="text"/>

Climate data to run:
☒ Recent observed climate (2013-2020)
☒ Climate change scenario

Clicking "Run OWC-SWAT+" can take up to 30 minutes.
Recent observed climate = ~ 6 min
Climate change scenario = ~ 12 min
Check inputs before running!

Climate change scenario
Climate change inputs are ready to run! The overall temperature change is 0 C and the overall precipitation change is 0.1%

Rates of management on row crop lands:
Management rate input is 100%, ready to run!

Physical conservation practices:
Total input rate of vegetated buffers is 35% and total input rate of grassed waterways is 21%.
This is an change of 0 cropland acres with vegetated buffers and 0 cropland acres with grassed waterways

Conservation ditch rate = 0%

Winter cover rate:
Rye cover crops = 11%
Winter cover (rye + winter wheat) = 20%

Tillage rates:
Full till management = 21%
No till management = 60%
Reduced till management = 4%
Rotational till management = 15%

Fertilizer application:
Incorporated N (%) = 94.65
Incorporated P (%) = 50.64
[Download scenario N and P \(Download\) - 507](#)

Figure 2. OWC-SWAT+ management tab

Corn Bean - Full Tillage

Change from 21% to 21% (change 0%)

Corn Bean - Full Tillage

Change from 21% to 15% (change -6%)

Figure 3. Example of changing corn bean -- full tillage from 21% to 15%

Changing rates of physical BMPs

Grassed waterways and vegetative buffers

1. Altering the rate of grassed waterways and vegetated buffers on each management scenario
2. Calculating an even rate to apply to a subset of scenarios to achieve a desired percentage on all cropland

Method #1 would be best if you have a particular interest in looking at the management scenarios individually and nutrient and sediment loss at the field level. Method #2 is best for investigating response at the watershed level, and better for imposing a 'random' application on the watershed (i.e., ensuring there's no bias towards any management scenario). While method #1 is more straightforward, method #2 requires the following calculations be done:

1. Sum the total % of cropland acres for all scenarios you want to implement the grassed waterway or vegetated buffers.
2. Use the following equation to get an even rate to put on each of these subset of management scenarios:

$$\text{Input rate} = \text{BMP rate} \times (1 / \text{cropland with BMP})$$

Where

BMP rate = desired rate of buffers or grassed waterways (percent, whole)

cropland with BMP = the total percent of cropland the BMP will be applied to (percent, decimal)

The final rates of grassed waterways and vegetated buffers on cropland acres will appear on the right-hand side under 'Physical conservation practices'. Additionally, this will show you the overall change from the baseline to the generated scenario. **Note that you can only have 100% implementation of BOTH vegetative buffers and grassed waterways.** E.g., if vegetated buffers are at 50% implementation, the maximum implementation of grassed waterways is then 50%. if vegetated buffers are at 100% implementation, the maximum implementation of grassed waterways is then 0%.

Rates of management on row crop lands:

Management rate input is 100%, ready to run!

Physical conservation practices:

Total input rate of vegetated buffers is 35% and total input rate of grassed waterways is 6%.

This is an change of 0 cropland acres with vegetated buffers and -1212 cropland acres with grassed waterways

Figure 4. Display of final vegetative buffer and grassed waterway rates on cropland acres

Conservation ditches

To alter the rate of conservation ditches in the OWC-SWAT+ model, you can use the slider bar provided to change the total rate of implantation between 0-100%. Note that altering the rate to 100% only changes 38 km (24 miles) of stream because the implementation is only done on streams of SWAT order 2, which have an average width of 1 m (3.28 ft) and 0.1 m depth (0.33 ft). **Note: because of limitations**

in SWAT+, conservation ditches can only affect sediment. Remember to consider this when examining results of conservation ditches.

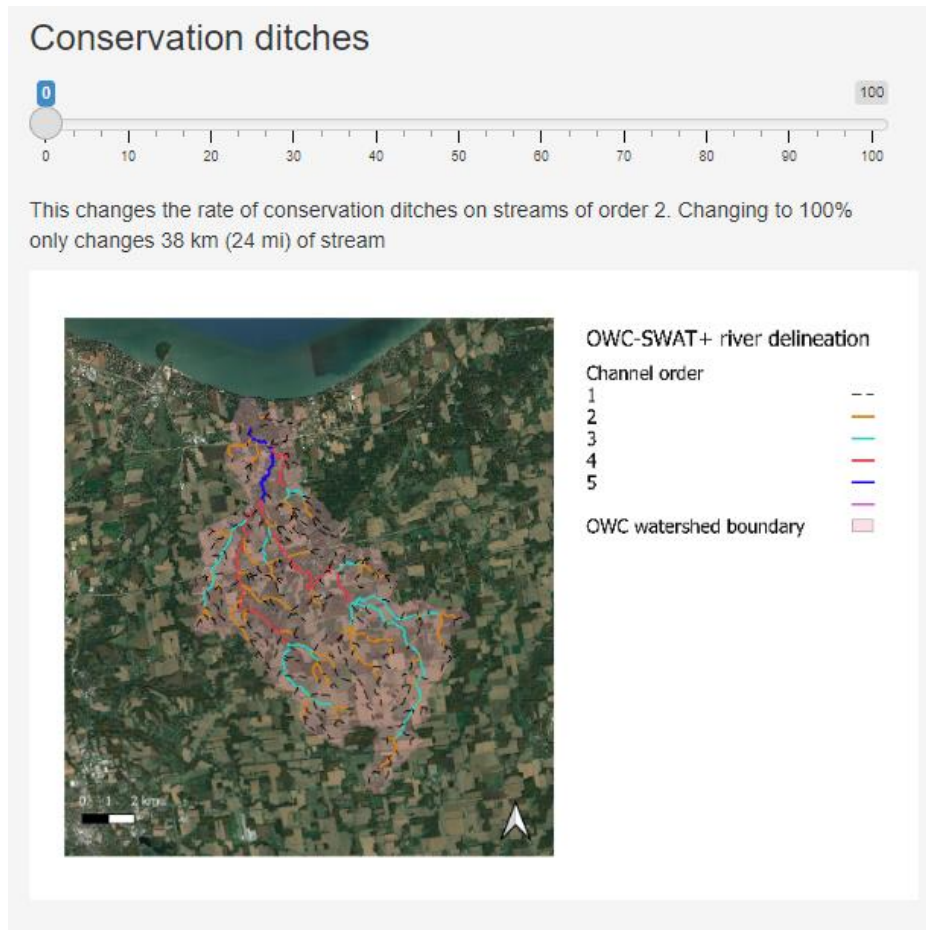


Figure 5. Change rate of conservation ditches.

Climate change scenario

To generate a climate sensitivity scenario, navigate to **Change Inputs and run OWC-SWAT+ > Climate change scenario**

The climate scenario compares historical climate (1990-2019) at the Norwalk WWTP with a generated 'future' climate based off the historical record. This method was devised by the group in order to translate results to the farming/land-management community more easily. For instance, while land

managers have little if no connection to General Circulation Models (GCMs), they relate to the historical, experienced climatic record, and may have an easier time relating to 'a drought year like 2012 were to 5x more often'. Hence, the two functions of generating a climate sensitivity are as follows:

1. You can alter the historical record to contain more 'extreme' climatic years.
 - a. Low precipitation, high temperature (drought)
 - b. High precipitation, average temperature (wet)
 - c. Average precipitation, high temperature (warm)
2. You can add a linear increase to the overall precipitation and temperature change

Historical climatic years that are used to fulfill option #1 are listed next to the inputs. These were calculated using water years (October-September). The number of years added to the historical climate will display next to the inputs. Historical years marked as 'average' climatic years (i.e., those not listed on the page between years 1991-2019) will be replaced with the 'extreme' years. **The maximum number of extreme years input must be equal to or less than the period of record (30 years).** Note: While you can take years away in each of these categories, it is only recommended to do so if you want to add additional extreme years of another type. To change the number of years, *input the total number of years* you want in the 'future' climatic dataset, including those that already exist in the historical dataset.

Option #2 adds a linear increase in precipitation or temperature to the dataset. For instance, if you add 1 C to the climatic 'future' dataset, the first year will increase by +0.03 C ($1\text{ C} * 1/30$) and the final year (year 30) will increase by +1 C ($1\text{ C} * 30/30$). This works the same for precipitation as well. Note: this means that the user- input will not be reflect of the mean. I.e., if you add +1 C, the mean temperature change will be greater than +1 C.

Average temperature and precipitation for the historical (1990-2019) and 'future' climatic datasets and the difference between them will display below inputs as they are changed. Please allow a few seconds for the table to update after desired changes are made.

Data	Temperature (C)	Precipitation (mm)
Change (C, %)	0.00	0.10
Future climate (user generated)	10.29	1021.61
Historical (1990-2019)	10.29	1020.61

Commented [KH3]: Add table with summary of years pcp and tmp here

Data	Temperature (C)	Precipitation (mm)
Change (C, %)	0.11	0.58
Future climate (user generated)	10.40	1026.48
Historical (1990-2019)	10.29	1020.61

Figure 6. User-generated changes in precipitation and temperature. Top: User-inputs accounted for in table. Bottom: Values being calculated from user inputs, wait for update to populate.

The management that is input into the climate scenario is what is implemented in the 'Management and conservation tab'. To investigate the effects of climate alone, make no changes to the 'Management and conservation tab'.

Run OWC-SWAT+ and visualize outputs

Run OWC-SWAT+

When you have decided finally on the inputs you want to run in OWC-SWAT+, check which climate data you want to run (Recent observed climate (2013-2020) and/or Climate change scenario). If you set up a climate scenario, but do not check the 'Climate change scenario' option, this scenario will not run. You will have to wait for the model run to complete, then click the 'Climate change scenario' and use 'Run OWC-SWAT+' again. The model runs can take up to 20 minutes to complete. If you hit 'Run OWC-SWAT+' before you are ready—you will either need to wait until the run is complete or close out of the app and open it again. However, if you close out of the app, all changes to management and climate you made will be reset to the default inputs. *Make sure to double-check inputs before running the model!*

Climate data to run:

- ☒ Recent observed climate (2013-2020)
☐ Climate change scenario

Run OWC-SWAT+

Clicking 'Run OWC-SWAT+' can take up to 20 minutes.

Recent observed climate = ~ 6 min

Climate change scenario = ~ 12 min

Check inputs before running!

Figure 7. Select climate data to run and run the model.

Once you hit run, the following pop-up will appear:

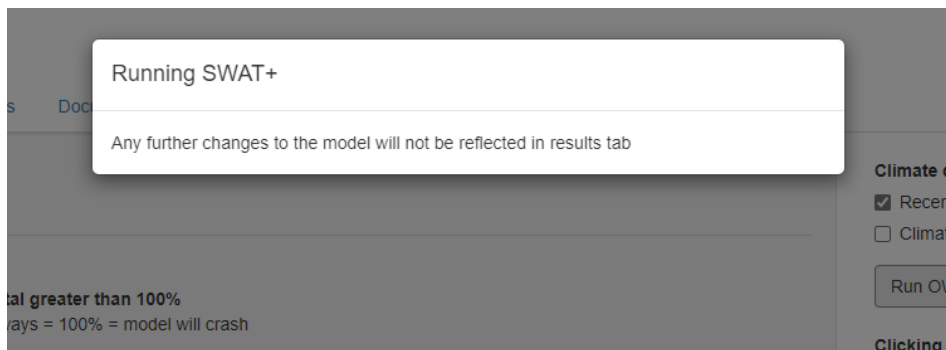


Figure 8. Running SWAT+ pop-up

You can click anywhere on the app to close this pop-up while the model runs. **Be sure not to change any inputs after you hit 'Run OWC-SWAT+' if you want to reference them for the visualize outputs page. Any further changes to management or climate data will not be reflected in the visualize results tab unless you run the model again.** If you ran SWAT+ with user-inputs that are not within the defined parameters, an error will pop-up at the bottom of the right-hand side of the page. However, if the model run was successful, 'OWC-SWAT+ run complete' will populate in its place.

Fertilizer application:

Incorporated N (%) = 173.65

Incorporated P (%) = 129.64

Average annual N applied (lb/acre) = 195

Average annual P2O5 applied (lb/acre) = 105

Error: Error: Management rates do not total 100%

Fertilizer application:

Incorporated N (%) = 94.65

Incorporated P (%) = 50.64

Average annual N applied (lb/acre) = 107

Average annual P2O5 applied (lb/acre) = 59

OWC-SWAT+ run complete

Figure 9. Example of failed (left) and successful (right) model runs.

Visualize outputs

Once the 'Change inputs and run OWC-SWAT+' tab populates 'OWC-SWAT+ run complete' at the bottom right-hand corner (Figure 8) you're results will populate within a few seconds in the 'Visualize outputs' tab. The first table shows the amount of acres of each management scenario and associated acreage in vegetated buffers and grassed waterways for each management scenario, as well as the change between the baseline and user-generated scenario.

Management scenario	Scenario area acres	Scenario + vegetated buffer area acres	Scenario + grassed waterway area acres	Change in scenario acres	Change in scenario + vegetated buffer area acres	Change in scenario + grassed waterway area acres
Corn Bean - Full Tillage	1698.00	0.00	0.00	0.00	0.00	0.00
Corn Bean - No Till	3247.00	1434.00	854.00	0.00	0.00	0.00
Corn Bean - Rotational No Till	1224.00	541.00	317.00	0.00	0.00	0.00
Corn Bean - Reduced Till	327.00	145.00	95.00	0.00	0.00	0.00
Corn Bean - No Till with rye cover crop	765.00	367.00	213.00	0.00	0.00	0.00
Corn Bean Wheat/Double crop bean	728.00	327.00	198.00	0.00	0.00	0.00
Corn Bean Wheat/rye cover crop	83.00	37.00	22.00	0.00	0.00	0.00

Figure 10. Total area and change in area from baseline of each management scenario, vegetated buffers, and grassed waterways

There are then two headings for each climate forcing. One titled 'Results for a recent climate (2013-2020)' and one titled 'Results for climate and land use change'. Results for a recent climate reflects changes in land-use/agricultural management only. Results for climate and land-use change reflect changes in climate and land-use/agricultural management, if the user input changes for either of these. If no changes are input and the model is ran, the output will reflect that the baseline is the same as the scenario. Figure 10 demonstrates the different inputs being compared in both scenarios. **It is important to note the scenarios have different baselines.** While both use recent land management, one is driven by 8-years of recent climate (2013-2020) and one by 30-years of historical climate (1990-2019).

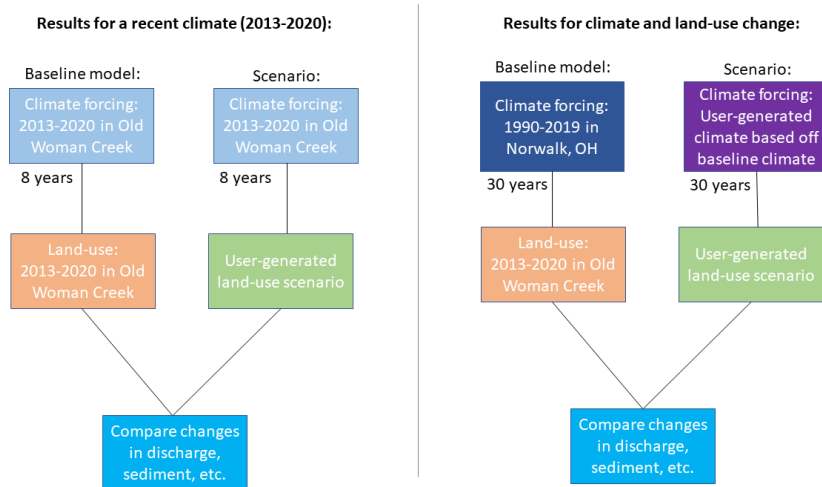


Figure 11. Flow chart of inputs used to generate a 'baseline' model and the user-generated scenario

There are three graphics for each scenario that will populate:

1. Change at Berlin Rd. between the baseline and scenario (percent)
2. Loss from agricultural scenarios at the field-level
3. Crop yields

Graph #1 shows only as a percent change from the baseline. Graphs #2 and #3 show as the model outputs for the baseline and the scenario. For #2, this is because the outputs from field loss (kg/ha) can be very small, and sometimes produce misleading results when translated to a percent change.