

SWAT TOOLS- AN INNOVATIVE INFRASTRUCTURE FOR WATERSHED MODELERS

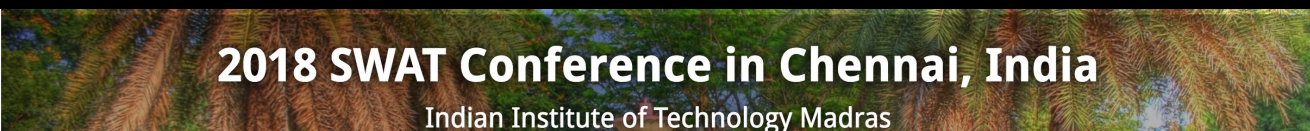
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2018 SWAT Conference in Chennai, India

Indian Institute of Technology Madras

January 12, 2018

Ownership to SWAT ???
USDA_ARS

Texas A & M University

SARA (COMPLETE) SWAT

2018 SWAT Conference in Chennai, India
Indian Institute of Technology Madras

January 12, 2018

TAR Principle- A Guide

Team Work:

GRA: Dr. (s) Naresh Pai and Gurdeep Singh, Mr. Eeshan Kumar
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Reaching Out: Live User Statistics Availability

<https://saraswat-swat.rcac.purdue.edu/infographic>

OUTLINE

How to Access

Background

- Land Use Checker module
- Land Use Update module with a case study

Smart Interface

Conclusion

ACCESS

url: <https://saraswat-swat.rcac.purdue.edu>
Search term: swat tools purdue

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SWAT Tools

Log In Register

Welcome to SWAT Tools

SWAT Tools features four applications designed to assist with your analysis of SWAT model data. A screenshot of each tool can be found below as well as a description and link to each tool's related paper or presentation.

You will need to register to get started. This can be done by clicking the registration link located in the above navigation bar or clicking "Get started" below. Once signed up, you will gain access to detailed manuals for each tool and a contact form if further assistance is required.

Get started

Click here to view latest user statistics

LUU Checker

LUU Checker compares multiple land use cover datasets against a base layer on a subbasin level. Emerging land use covers are detected and a user defined percentage area of the new land use covers is applied to the base raster in the relevant subbasins.

Presentation

SWAT LUU

SWAT LUU is a geospatial tool that ingests multiple land use/land cover geospatial datasets and other associated information interactively and prepares the input files necessary for activating the land use update (LUU) module in SWAT.

Paper

LUU Uncertainty

Small LULC errors can have a substantial effect on watershed model output. LUU Uncertainty enables the user to integrate LULC realizations in the SWAT model and evaluate the sensitivity of SWAT output to LULC errors.

Paper

Field SWAT

Field SWAT is designed to map SWAT simulations from a HRU layer to a user-defined field boundaries layer. The tool ingests spatial and nonspatial SWAT outputs and helps in visualizing them at the field scale using four different aggregation methods.

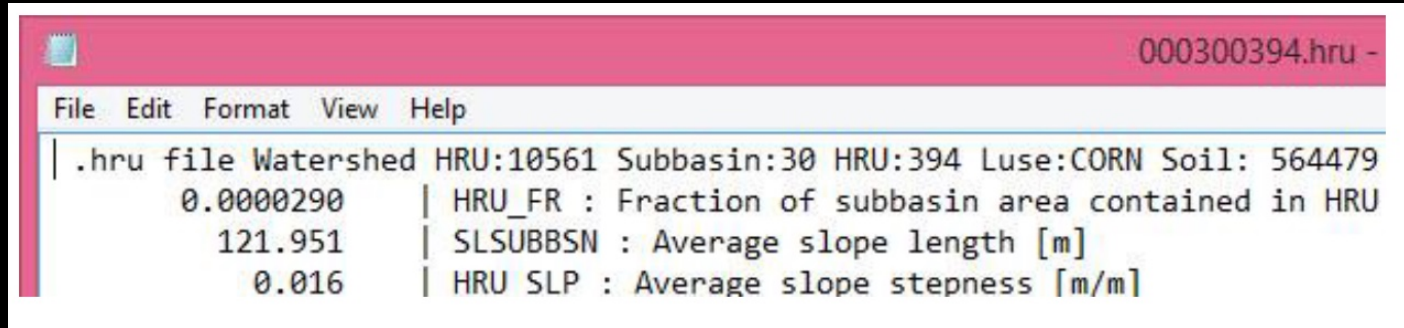
Paper

BACKGROUND

- SWAT 2009: released January 2010
- New module inclusion: land use change (LUU)* 
- Input files required: lup.dat, file1.dat, file2.dat,....

*Arnold et al. (2010)

LUU USE CONDITIONS

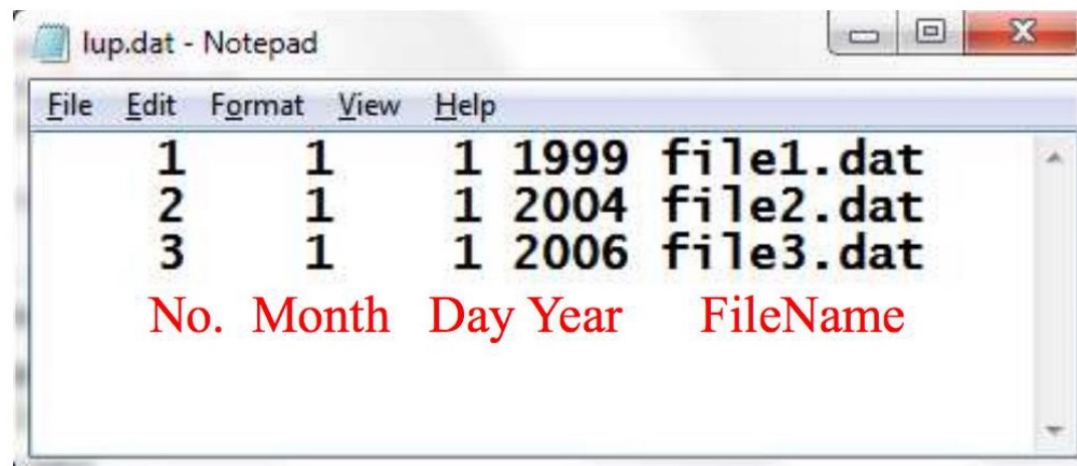


```
000300394.hru -
File Edit Format View Help
|.hru file Watershed HRU:10561 Subbasin:30 HRU:394 Luse:CORN Soil: 564479
0.0000290 | HRU_FR : Fraction of subbasin area contained in HRU
121.951 | SLSUBBSN : Average slope length [m]
0.016 | HRU SLP : Average slope stepness [m/m]
```

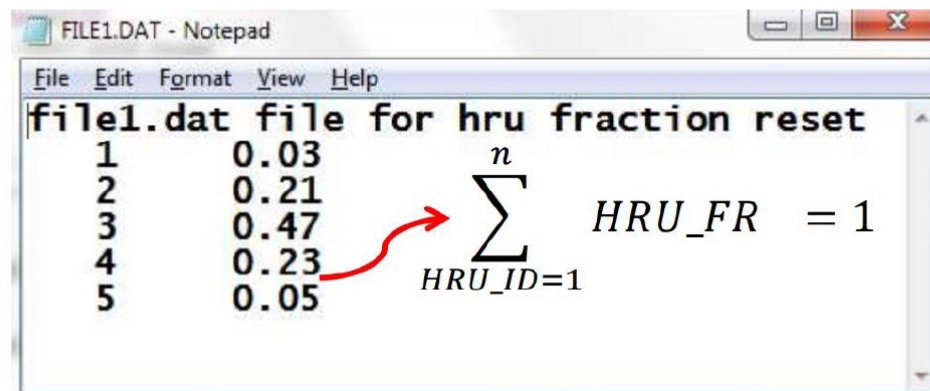
- HRU_FR is updated
- HRUs can't be added or deleted
- Sum of HRU_FR – 1
- Base LULC data is needed for initiation

FILE STRUCTURE

.dat files



```
lup.dat - Notepad
File Edit Format View Help
1 1 1 1999 file1.dat
2 1 1 2004 file2.dat
3 1 1 2006 file3.dat
No. Month Day Year FileName
```



```
FILE1.DAT - Notepad
File Edit Format View Help
file1.dat file for hru fraction reset
1 0.03
2 0.21
3 0.47
4 0.23
5 0.05
```

$\sum_{HRU_ID=1}^n HRU_FR = 1$

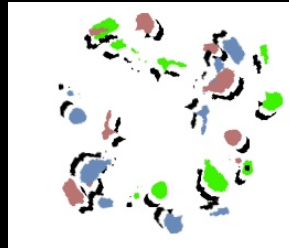
SWAT Model's ability to simulate water quality impacts of LULC changes are limited if only one LULC image is used as base layer for long-term modeling*

*Chiang et al. (2010)

HRU Modeling Challenges 1

- LUC module needs updated area of HRUs each time new LULC data is input but there are challenges...
1. Numerous HRUs: few 100's to 1000's
 2. Fragmented HRUs:

Mapping challenge



Fragmented
HRU



Regular
LULC raster
grid

HRU Modeling Challenges 2

Land-use layer1 (6 land uses and 3 soils)		Land-use layer2 (6 land uses and 3 soils)	
Subbasin 1 HRUs	Subbasin 2 HRUs	Subbasin 1 HRUs	Subbasin 2 HRUs
1 lu 1 – soil 1	1 lu 4 – soil 1	1 lu 1 – soil 1	1 lu 4 – soil 1
2 lu 2 – soil 2	2 lu 5 – soil 2	2 lu 2 – soil 2	2 lu 5 – soil 2
3 lu 3 – soil 3	3 lu 6 – soil 3	3 lu 3 – soil 3	3 lu 6 – soil 3
4 lu 4 – soil 1	4 lu 1 – soil 3	4 lu 4 – soil 1	
		5 lu 5 – soil 2	
		6 lu 6 – soil 3	
Subbasin 3 HRUs	Subbasin 4 HRUs	Subbasin 3 HRUs	Subbasin 4 HRUs
1 lu 1 – soil 3	1 lu 4 – soil 3	1 lu 1 – soil 3	1 lu 4 – soil 3
2 lu 2 – soil 2	2 lu 5 – soil 2	2 lu 2 – soil 2	2 lu 5 – soil 2
3 lu 3 – soil 1	3 lu 6 – soil 1	3 lu 3 – soil 1	

- ☐ Land-use layer 1 - base layer for HRU delineation
- ☐ Land-use layer 2 - updating HRU fractions
- ☐ New land-uses 5 and 6 in subbasin 1 will not get simulated

- ☐ Land-use 2 - base layer for HRU delineation
- ☐ Land-use 1 - updating HRU fractions
- ☐ Land-use 1 in subbasin 2 and landuse 6 in subbasin 4 will not get simulated.

- Map hrus to a regular raster layer

Pai, N. and D. Saraswat. 2011. SWAT2009-LUC: A tool to activate the land use change module in SWAT 2009. Trans. ASABE, 54(5):1649-1658

- Develop a new raster dataset for accommodating emerging LULC for long term simulation (LUU_Checker)

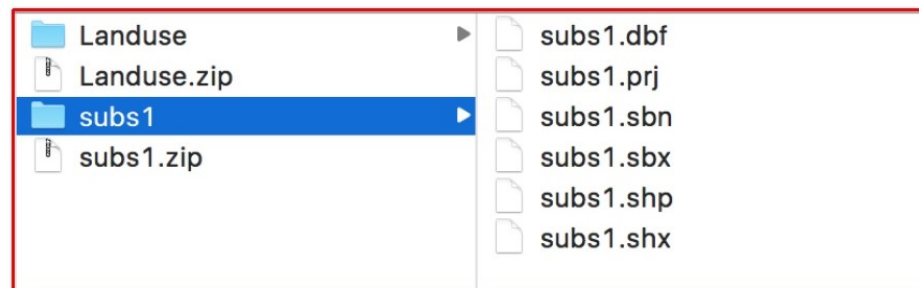
Step 1

Step-1:

Subbasins Shapes Folder:

- Compress the folder containing a subbasin shapefile into a zip format.
- The name of the zip file and shapefile should be same.

Subbasin Shapefile:
 No file chosen ? 



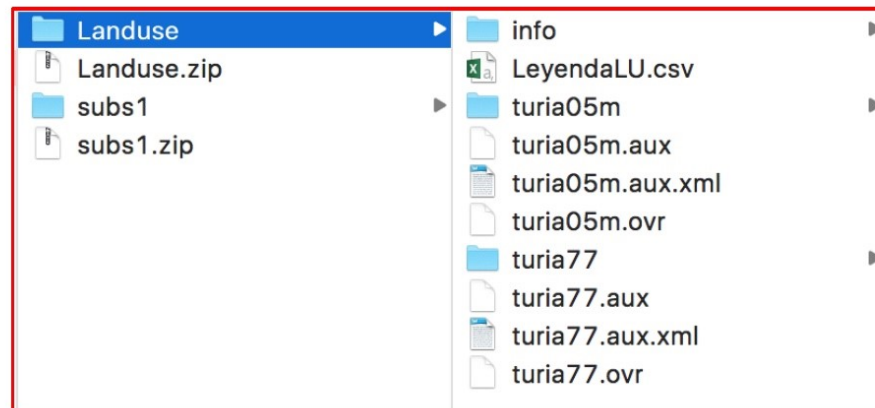
Step 2

Landuse Folder:

- Compress the landuse folder that contains all the land use files into a zip format and upload.

Landuse Folder:

No file chosen ☒



Step 3

Base Landuse Raster File:

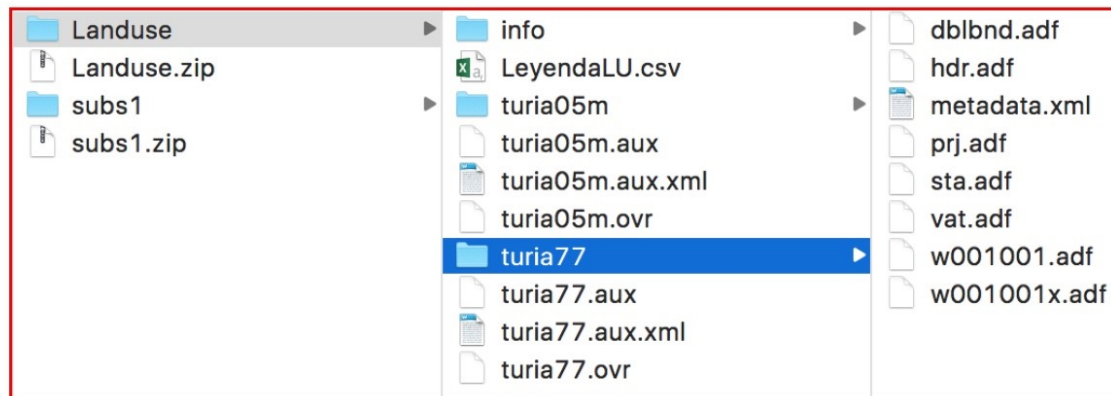
- User can select either the first year (1977) or the latest layer (2005) as the base.

Base Landuse Raster File:

Choose File No file chosen

Upload

?



Step 4

Number of New Landuse Layers:

- Select the number of landuse layers other than the base layer.
- If 2 landuse layers are available and one layer is selected as base layer, then the user should input 1.

Number of New Landuse Layers:



Step 5

New Landuse layers:

- On selecting the number of new landuse layers, a hidden select option will appear depending on the number of new landuse layers provided in the previous step.
- Select the remaining landuse layers.

Landuse layer1:

Choose File

No file chosen

Select

?

Step 6

LULC New Percentage

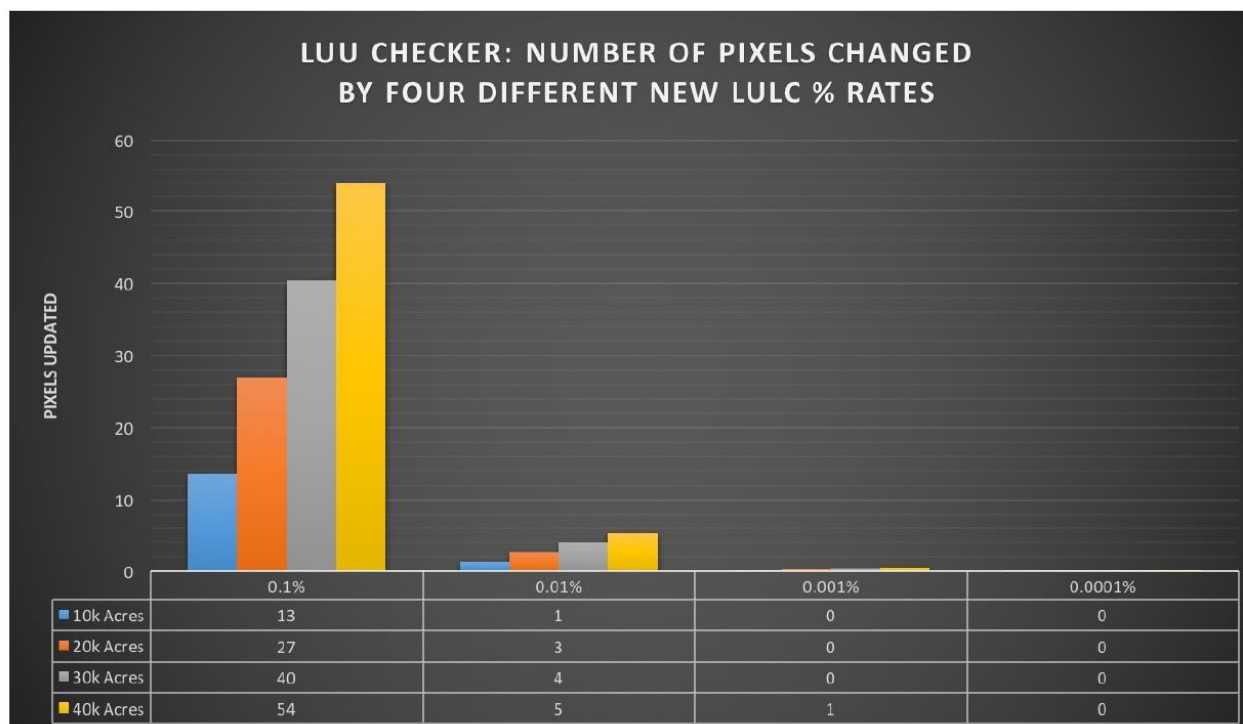
- Provide the percentage value for new landuses that needs to be updated.

LULC New Percentage:

Warning: Be careful while selecting a percentage threshold value lower than 0.01. In smaller subbasins (<10,000 acres), a threshold value percentage of less than 0.01 may result in 0 pixels being designated to account for emerging landuse/landcover in the composite landuse raster.

Step 6- continue

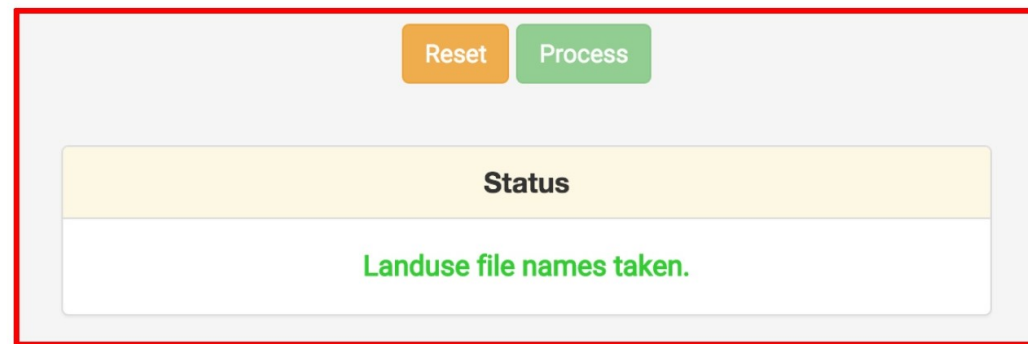
LULC New Percentage- a Scenario



Step 7

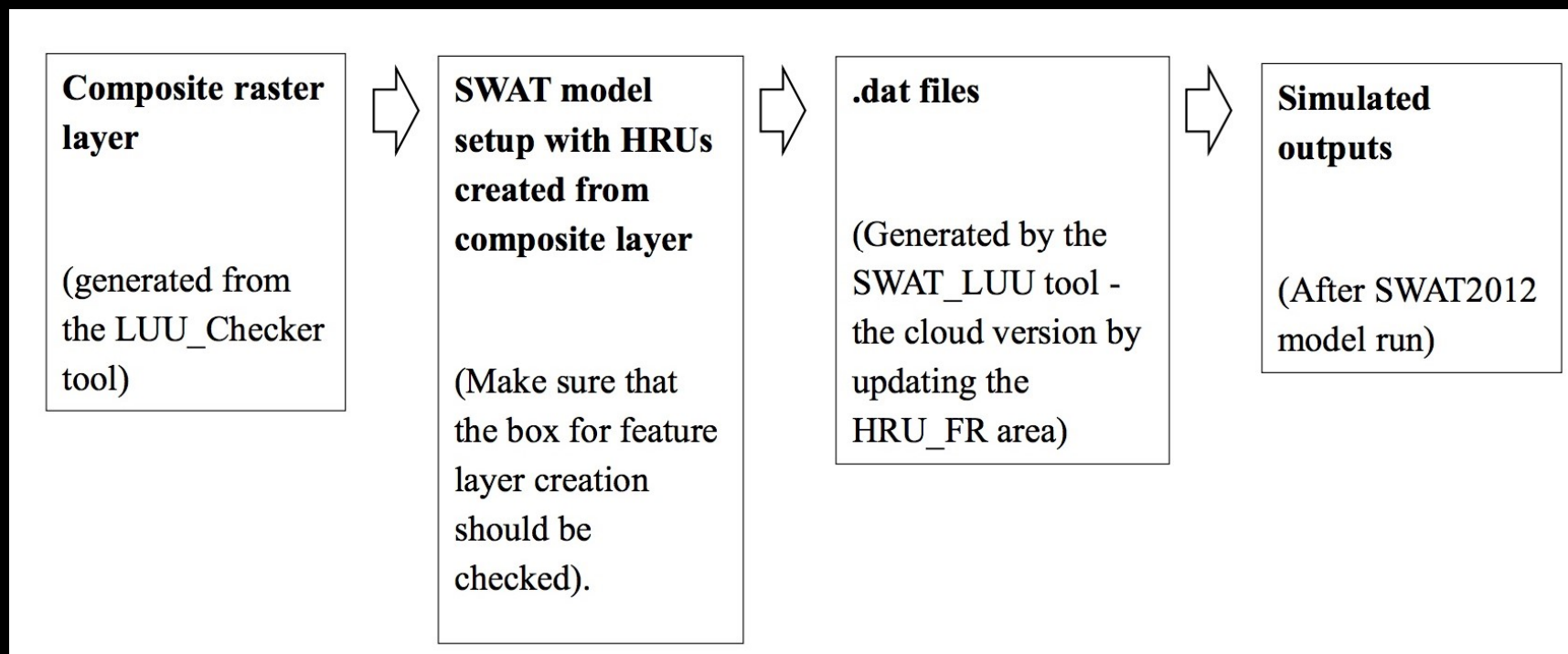
Process:

- After uploading all the required files, the tool is ready to process the files.
- The program runs on the server and creates a new composite raster in GeoTiff format.



The screenshot shows a web interface for the LUU Checker. At the top, there are two buttons: 'Reset' (orange) and 'Process' (green). Below these buttons is a status box with a yellow header labeled 'Status' and a white body containing the text 'Landuse file names taken.' in green. The entire interface is enclosed in a red rectangular border.

Land Use Update Modeling Workflow



Composite raster layer contains HRU level LULC data in different temporal land use data layers that is subsequently used for SWAT_LUU tool

CASE STUDY: CACHE RIVER WATERSHED

Drainage area: 5,066 km²

Subbasins: 27

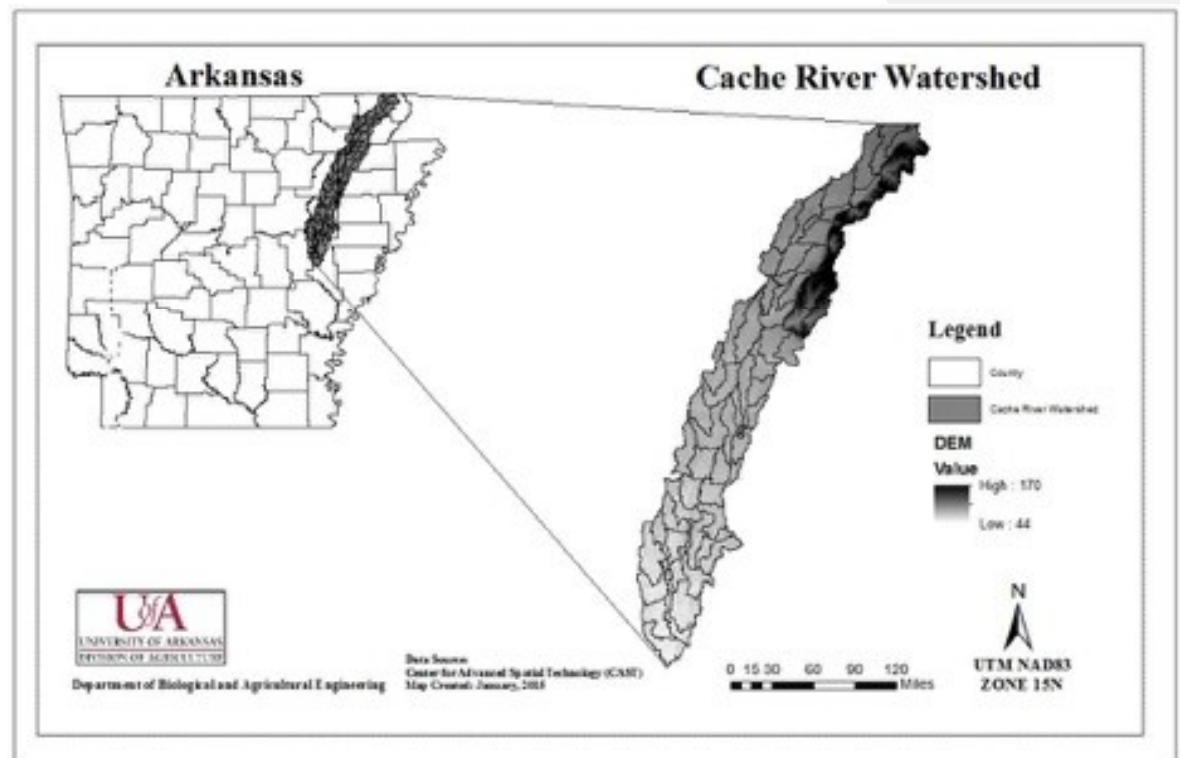
LULC: 2006

Soil: SSURGO

Slope: 4 classes

HRUs: 12,321 (14,053)
(Thresholds: 0%, 0%, 0%)

Study period: 1999 - 2006



Marginal crop land (soil health and land capability - 3.3 to 11.3%)

RESULTS – COMPARATIVE PERFORMANCE

- SWAT model with dynamic and targeted LULC*- i.e. one with realistic land use land cover was found to result in:
 - Sediment ($< 1.8\%$ for Switchgrass; $< 1.6\%$ for Miscanthus),
 - total phosphorus ($< 2.3\%$ for Switchgrass; $< 2\%$ for Miscanthus) and
 - total nitrogen (< 2.1 percent for Switchgrass; $< 2.5\%$ for Miscanthus)

Compared to single land use layer model

*Singh, G. and D. Saraswat. 2016. Development and evaluation of targeted marginal land mapping approach in SWAT model for simulating water quality impacts of selected second generation biofeedstock. Environmental Modeling and Software, 81(c): 26-39

SMART USER INTERACTION

ISSUE #1- FILE EXTENSION

Problem

- User had issue with SWAT LUU NOT recognizing their landuse layers

Cause

- Landuse data was missing the **.aux** files
- Instead only the **.aux.xml** ones were present
- SWAT LUU uses these files to get the landuse layer names, due to the double extension, it incorrectly thought the layer names ended with **.aux**

Solution

- Fixed by copying the **.aux.xml** files and removing the **.xml** from the copy
- Alt fix would be using the actual **.aux** files
- Content of the files is not important which is why the first fix works

ISSUE #2- HRU ID MISMATCH

Problem

- Execution of SWAT LUU was halting after the TxtInOut folder was processed

Cause

- Caused by the number of HRU ids discovered in the TxtInOut directory not matching the number of HRU ids found in hrus1.shp

Solution

- Added method to compare the number of HRU ids found in the TxtInOut against the number of HRU ids found in hrus1.shp
- If they match, continue the process.
- If they don't match, halt the process and alert the user

ISSUE #3- FRACTIONAL AREA CALCULATION

Problem

- User's SWAT LUU process was failing
- Pinpoint error to occurring in the **calculate_new_fractional_areas** method

```

• self.inside_watershed_indexes is an array generated from the hru1 raster
  # get indexes for the parts of the current landuse layer inside the watershed
• landuse_layer_values_inside_watershed = landuse_layer_raster[self.inside_watershed_indexes]

```

- The goal is to extract landuse values at the hru locations

Cause

- Analysis of the hrus1 and landuse raster revealed mismatching resolutions
 - Hrus1: 16 bit signed integer with 25m² resolution (4416 x 6455)
 - landuse: 8 bit unsigned integer with 30m² resolution (4315 x 5840)
- Problem #1 – grids do not match. Problem #2 – individual cells in grids do not represent the same area

ISSUE #4- COMPRESSED FILE TYPE

Problem

- Error occurring when user attempted to upload compressed SWAT model

Cause

- SWAT Model folder compressed, but not as a Zip file
- User's SWAT Model was a RAR file

Solution

- Improved error and help messages to provide even more details making it explicit that the compressed folder needs to be **.zip**

uid_1_luuchecker_20170628T191851: Uploaded shapefile does not have .zip extension.

Report

uid_1_luuchecker_20170628T191851: Uploaded shapefile does not have .zip extension.

SWAT Model Input:

Choose File No file chosen

Validate ?

The input should be a zip folder (**single file with .zip extension**) with name same as the Swat folder that is compressed. The input folder should contain all required data.

If you are experiencing a server error due to the size and/or duration of your upload, please try going to **Home > Set Upload Speed** and lowering your upload speed.

ISSUE #5: INTERNET SPEED AND FILE SIZE

Problem

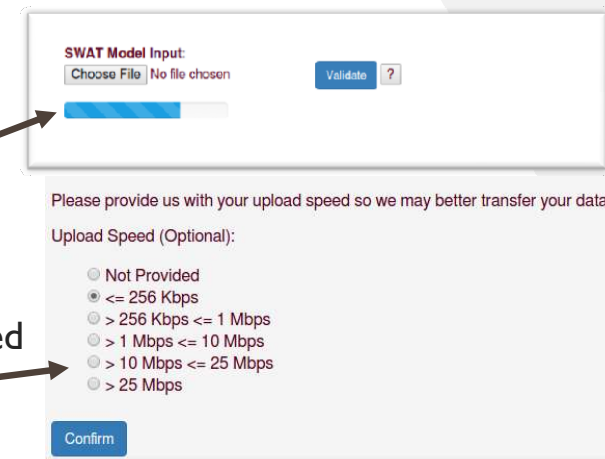
- Upload timing out

Cause

- User attempting to upload file larger than supported by nginx's settings
- ITAP unable to increase nginx max file size

Solution

- Detect large file uploads and upload directly to a S3 bucket
- Bypasses the nginx server
- Decision to use S3 based on file size and user's internet speed
 - Internet speed collected from a new form



SWAT Model Input:

No file chosen ?

Please provide us with your upload speed so we may better transfer your data.

Upload Speed (Optional):

☐ Not Provided
☒ <= 256 Kbps
☐ > 256 Kbps <= 1 Mbps
☐ > 1 Mbps <= 10 Mbps
☐ > 10 Mbps <= 25 Mbps
☐ > 25 Mbps

CONCLUSION

- LUU_Checker, a cloud based tool, dynamically account for temporal evolution of complex landscape.
- The composite raster data layer, generated by the LUU_Checker tool, creates HRUs with all the possible land uses present in different temporal land use layers.
- Eventually, the SWAT model and temporal land uses are input in the SWAT_LUU tool to update the HRU area corresponding to temporal land use layers.

CONCLUSION- continue

- Potential for class room teaching
- Several measures are taken to guide users

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THANK YOU

QUESTIONS