

Summary

The objective of this study is to establish growth parameters of hybrid poplar in SWAT model. Energy security and sustainable require a suite of biomass crops, including woody species. Selected hybrid poplar is expected as bioenergy feedstock for the capability of rapid growth. The quality of water and soils will be a concern when hybrid poplars are planted at wide geographic and latitudinal rang as a biomass feedstock. In this study, Soil and Water Assessment Tool (SWAT) modeling was employed to simulate the water and soil impacts of the hybrid poplar. In SWAT, fast growing tree growth parameters for hybrid poplar (*P. tristis* Fisch. x *P. balsamifera* L. cv. Tristis #1 (NC 5260)) in the Midwest were established and improved based on growth and climate data. Sensitivity analysis was used to see what effects of hybrid poplar parameters on biomass production, hydrological output (water yield) and tree growth outputs (plant uptake of Nitrogen and Phosphorus). The most sensitive parameters are: optimal and base temperature(T_OPT,T_BASE), radiation-use efficiency (BIO_E), light extinction coefficient (EXT_COEF), leaf area development (ALAI_MIN) and fraction of tree biomass accumulated each year converted to residue during dormancy (BIO_LEAF).

Motivation

Sensitivity analysis results in potential variables ranges and suggested values. Establishment of growth parameters of hybrid poplar in SWAT 2012 and reflection of growth, maturity and nutrient uptake of fast growing trees can better simulate hydrologic and water quality impacts of hybrid poplar.

Method

Relative sensitivity for tree growth parameters was calculated using the One-at-a-time (OAT) to see what effect of tree parameters on biomass production, hydrological output (water yield) and tree growth outputs (plant uptake of Nitrogen and Phosphorus).

Latin hypercube sampling (LHS) method was used for generating a sample of plausible collections of parameter values from a multidimensional distribution. In this project, LHS sampled 35 variables, the range of each variable ($\pm 50\%$) is divided into 10 equally probable intervals and 10 sample points were then placed to satisfy the Latin hypercube requirements.

The relative sensitivity equation $Sr = (x(y_2 - y_1)) / (y(x_2 - x_1))$ is often used to mathematically compare each parameters influence on a predicted output, x_1, x_2 and y_1, y_2 corresponding to $\pm 10\%$ of the initial parameter and output values, respectively (James and Burges, 1982)

Implementation

Study area

the U.S. Forest Service Harshaw Experimental Farm near Rhinelander, Wisconsin ,USA (45.6°N, 89.5°W)

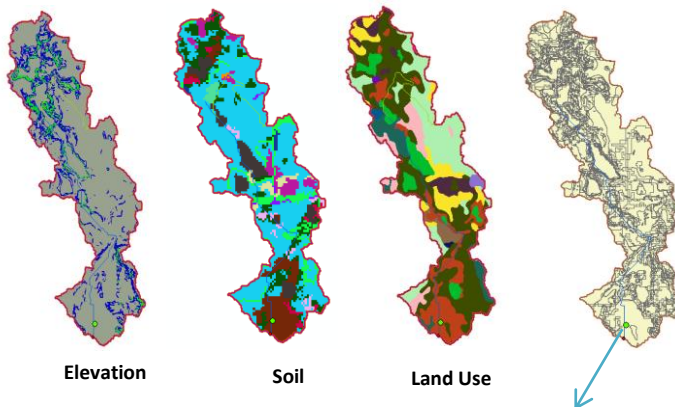
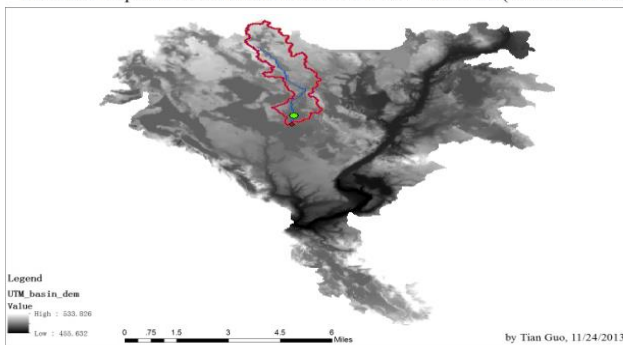
Objective

hybrid poplar clone (*P. tristis*Fisch. x *P. balsamifera* L. cv. Tristis #1 (NC 5260))

SWAT Model Setup

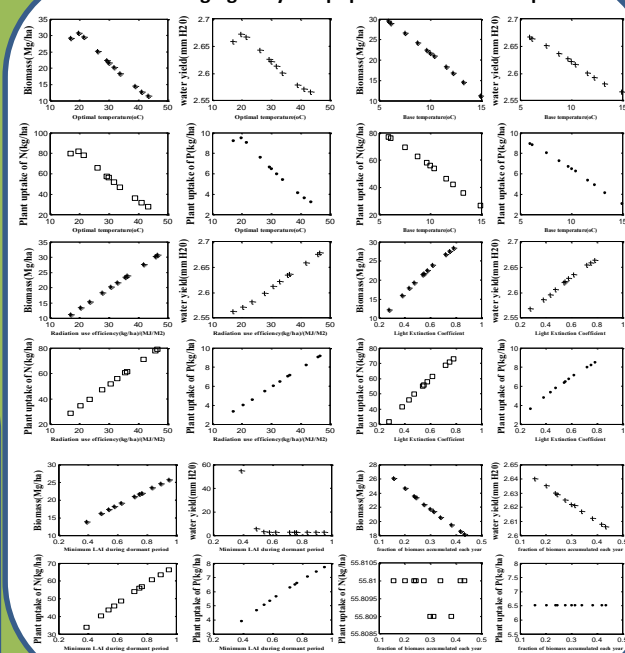
A SWAT model was developed with experiment stations-specific soil and weather characteristics to validate derived parameters and growth algorithm improvements. The model consisted of a single hydrologic response unit (HRU) representing soil, landuse, elevation and climate characteristics of U.S. Forest Service Harshaw Experimental Farm.

Elevation map of Crescent Creek-Wisconsin River watershed (070700011305)



199 HRUs were generated by ArcSWAT.
NO.182 HRU with slope 0-10%, land use Wetlands-Forested and Soil 421089 (soil name: Loxley), was chosen to represent study area.

Effects of changing of hybrid poplar variables on outputs



Relative sensitivity analysis of tree growth parameters

Parameter	Parameter definition	Biomass (t/ha)	Water yield (mm H ₂ O)	Plant uptake of Nitrogen (kg/ha)	Plant uptake of Phosphorus(kg/ha)
T_OPT	Optimal Temperature(°C)	-1.25005	-0.06813	-1.34541	-1.34892
T_BASE	Base Temperature(°C)	-1.11045	-0.05526	-1.2067	-1.21183
BIO_E	Radiation Use Efficiency in ambient CO ₂ (g/g)/(MJ/m ²)	1.003824	0.055301	0.999928	0.999386
EXT_COEF	Light Extinction Coefficient	0.778904	0.031215	0.778949	0.778891
ALAI_MIN	Minimum leaf area index for plant during dormant period	0.73763	-0.06979	0.746482	0.746831
BIO_LEAF	Fraction of tree biomass accumulated each year converted to residue during dormancy	-0.402462	-0.013592	0	0
GS	Maximum stomatal conductance	-0.09344	-0.14948	0	0
CHTMX	Maximum canopy height	0.00314	0.022753	0	0
PLTNRI	Plant N fraction at emergence(whole plant)	0	0	1.000107	0
PLTPRI	Plant P fraction at emergence(whole plant)	0	0	0	1.427393

Conclusion and Discussion

The most sensitive parameters are: T_OPT,T_BASE, BIO_E, EXT_COEF,ALAI_MIN and BIO_LEAF. The sensitivity analysis results in a potential ranges and values of growth parameters of hybrid poplar. To qualify the resultant output, biomass yields were examined with respect to a numbers of published yields of the plantation. Sediment and nutrient losses were compared to measured values from experimental plots.

Reference

Raj, Gbin. "Optimal land use planning on selection and placement of energy crops for sustainable biofuel production." (2013).
James, L. D., and S. J. Burges. "Selection, calibration, and testing of hydrologic models." *Hydrologic modeling of small watersheds* (1982): 437-472.