Functional Approach to Simulating Short Rotation Woody Crops in Process Based Models

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Background Information

Fig.1 Bioenergy crop

http://www.greenpacks.org/2013/11/15/corn-ethanol-may-not-be-a-green-solution-for-biofuel/ http://www.biofueldaily.com/reports/ADM_To_Construct_Biodiesel_Facility_In_Brazil_999.html

http://www.qdma.com/forums/showthread.php?t=25608&page=17 https://cfs.nrcan.gc.ca/projects/134/2

Background Information

- *ArcSWAT*
- *create and edit SWAT input files*
- *Soil and Water Assessment Tool*
- *A publicly available eco-hydrologic watershed model*
- Simulate long term effects of various watershed management decisions on hydrology and water quality response

SWAT

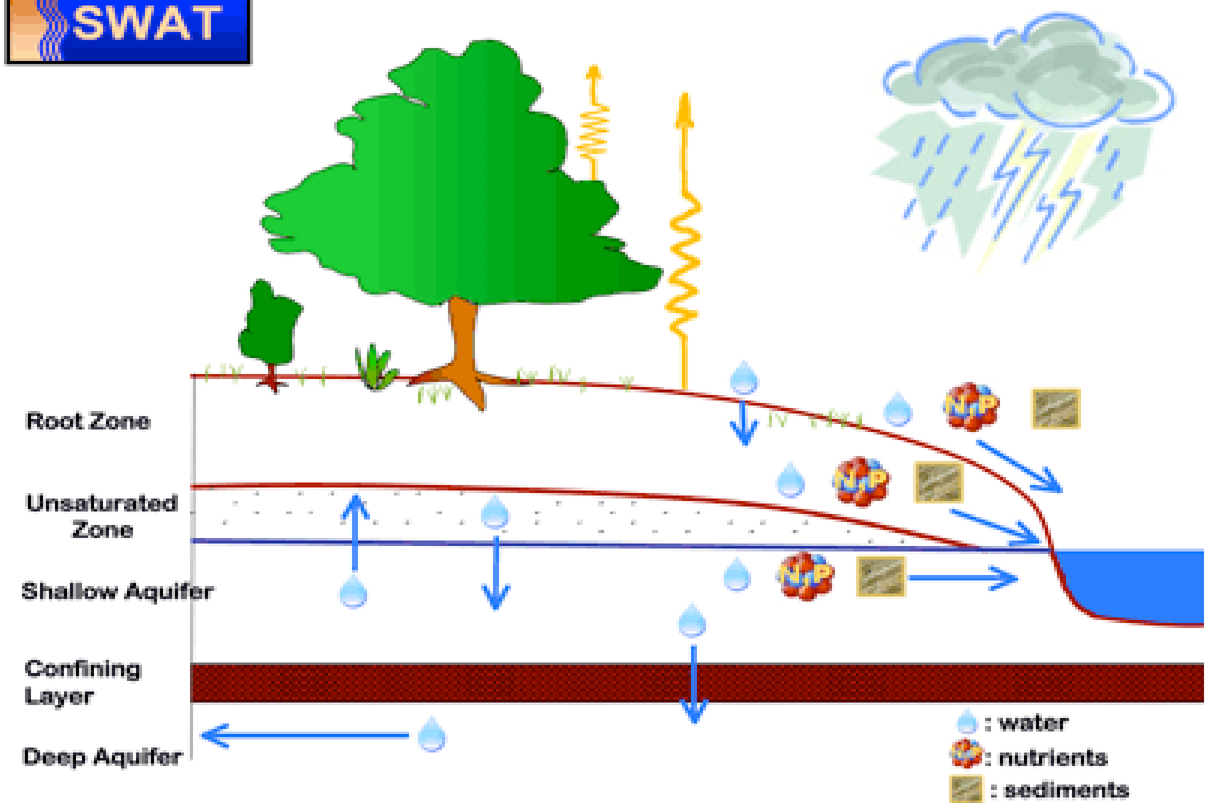

Fig .2 The scenario simulated by SWAT

http://ches.communitymodeling.org/CCMP-Newsletter-February-2009.html#item1

Study area

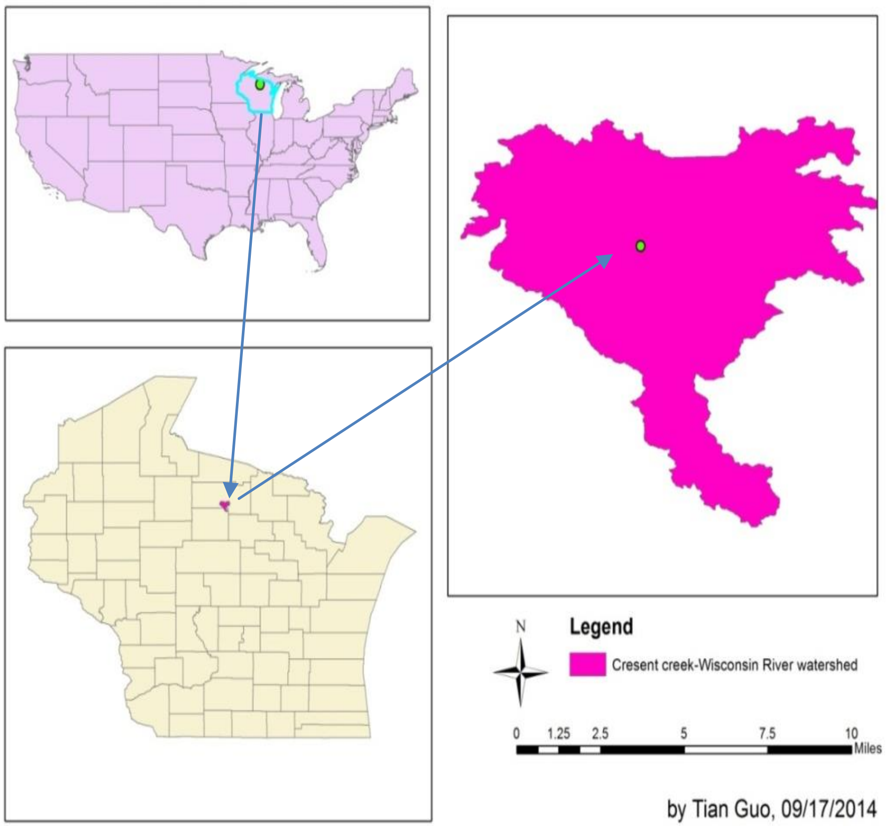

Fig.3 Location of hybrid poplar site in Crescent Creek-Wisconsin River Watershed in Wisconsin

Table 1 Suggested values and potential parameter range for hybrid poplar 'Tristis #1' (Populus balsamifera L. × P.tristis Fisch) compared to current parameters for populus in ALMANAC and SWAT2012 crop database

Parameter Acronym in ALMANAC	Parameter Acronym in SWAT	Parameter definition	Populus balsamifera L. × P.tristis Fisch (HYPO)		Populus (POPL)
			Suggested value	Range	Database value
TG	T_BASE[1] [PHU][1]	Base Temperature(℃) Heat Units to Maturity	4 [1750]	0-6 [2150-1500]	10 -
TB	T_OPT[2]	Optimal Temperature(℃)	25	25-30	30
WA	BIO_E[3,4]	Radiation Use Efficiency in ambient CO_2 (kg/ha)/(MJ/m^2)	20	20-35	30
EXTINC	EXT_COEF[3,4]	Light Extinction Coefficient	0.20 (SWAT) 0.30 (ALMANAC)	0.20-0.60	0.45
DMLA	BLAI[3,5,6]	Maximum leaf area index(LAI)	9.50	5.00-9.50	5.00
DLAP(1,2)	LAIMX2[3,5,6]	Fraction of BLAI corresponding to 2nd point on optimal leaf development curve	0.95	0.95-0.98	0.95
DLAI	DLAI[3,5,6]	Point in growing season when LAI declines	0.99	0.99	0.99
	BIO_LEAF	Fraction of tree biomass accumulated each year converted to residue during dormancy	-	-	0.300
TREED	TREED[3,5,7]	Tree leaf area decline factor	0.500-4.500	0.500-4.500	
DLAP(1,2)	FRGRW2[3,5,6]	Fraction of growing season coinciding with LAIMX2	0.40	0.40-0.45	0.40
	ALAI_MIN[3,5,6]	Minimum leaf area index for plant during dormant period	0.000	0.000-0.750	0.750
DLAP(1,2)	FRGRW1[3,5,6]	Fraction of growing season coinciding with LAIMX1	0.05	0.05-0.07	0.05
DLAP(1,2)	LAIMX1[3,5,6]	Fraction of BLAI corresponding to 1st point on optimal leaf development curve	0.05	0.05-0.30	0.05
BP_1	PLTPFR1[2]	Plant P fraction at emergence(whole plant)	Existing value	Existing value	0.0007
GSI	GSI[2]	Maximum stomatal conductance	0.0070	0.0040-0.0070	0.0040
CNY	CNYLD[3]	Plant N fraction in harvested biomass	0.0005	0.0005-0.0015	0.0015
CPY	CPYLD[3]	Plant P fraction in harvested biomass	0.0002	0.0002-0.0003	0.0003
	WSYF[3]	Lower limit of harvest index ((kg/ha)/(kg/ha))	0.000	0.000	0.010
CHTYR	MAT_YRS[5]	Number of years required for tree species to reach full development (years)	6-9	6-9	10
	BMX_TREES[2]	Maximum biomass for a forest (metric tons/ha)	Existing value	Existing value	200
	BM_DIEOFF[2]	Biomass dieoff fraction	Existing value	Existing value	0.100
HI	HVSTI	Harvest index for optimal growing conditions	0.50	0.40-0.60	0.76

[1] Maximum and minimum daily temperature from NOAA; [2] Assumed; [3] Modified parameter from hybrid poplar growth simulation; [4] Landsberg and Wright, 1989;

[5] Hansen, 1983.[6] Zavitkovski,1981;7 Estimation based on literature data; Michael *et al.*,1988.

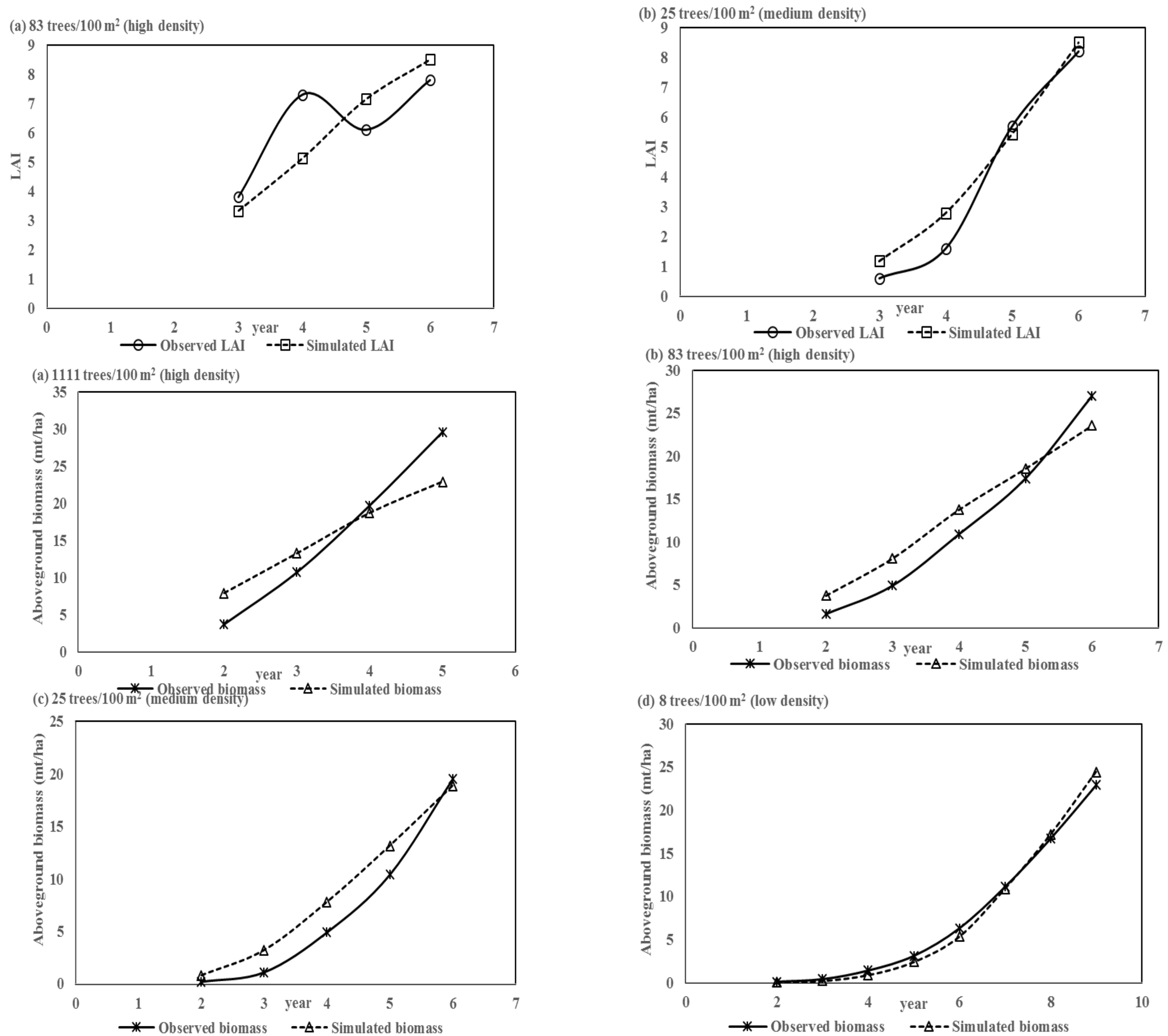

Fig.4 Yearly observed and simulated LAI and aboveground biomass of hybrid poplar Tristis #1 with various spacing by the modified ALMANAC model

Table 1 Model outputs with various populations by the modified ALMANAC

Model	Populus	Tree population (trees/100 m^2)	Density level	Output (Annual aboveground biomass (AAB), LAI and root biomass (RB))	Percent error (P_{BIAS} %)	Nash-Sutcliffe coefficient (NSE)	Coefficient of determination R^2
ALMANAC	Populus balsamifera L. × P.tristis Fisch	1111	high	AAB (mt/ha)	1.6	0.82	0.98
		83	high	LAI	3.6	0.96	0.76
				AAB (mt/ha)	19.0	0.91	0.91
		25	medium	LAI	-11.2	0.98	0.98
				AAB (mt/ha)	-21.5	0.96	0.96

In conclusion, modeled aboveground biomass and LAI results from the modified ALMANAC for the hybrid poplar site with various spacing in Wisconsin were satisfactory. Thus, suggested values and potential parameter range for hybrid poplar 'Tristis #1' (*Populus balsamifera* L. × *P.tristis* Fisch) are reasonable. The modified ALMANAC model is able to simulate biofeedstock production modeling for *Populus* with various population at large landscape scales. The improved algorithms of LAI and biomass simulation for tree growth could also be used in other process based models, such as SWAT, EPIC and APEX.