THE VARIABILITY OF RUNOFF AND SOIL EROSION IN THE BRAZILIAN CERRADO BIOME DUE TO THE POTENTIAL LAND USE AND CLIMATE CHANGES

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Motivation

Changes in land use and climate can influence runoff and soil loss, threatening soil and water conservation in the Cerrado biome in Brazil. Due to the lack of long term observed data for runoff and soil erosion in Brazil, the adoption of a process-based model was necessary, representing the variability of both variables in a continuous simulation approach.

Purpose

- ❏ Calibrate WEPP (Water Erosion Prediction Project) model for different land uses **(undisturbed Cerrado, fallow or bare soil, pasture, and sugarcane)** under tropical conditions inside the Cerrado biome;
- ❏ Predict runoff and soil erosion for these different land uses;
- ❏ Simulate runoff and soil erosion considering climate change scenarios.

The WEPP Model

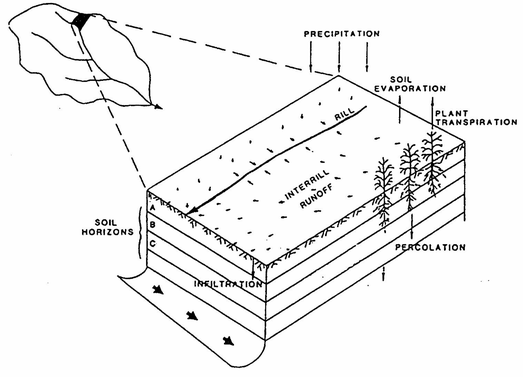

Figure 1. WEPP hillslope profile (Source: USDA).

Methods

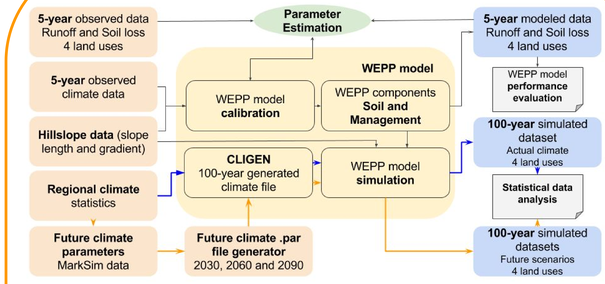

Figure 2. Flowchart of the WEPP model calibration and simulation phases.

Study area

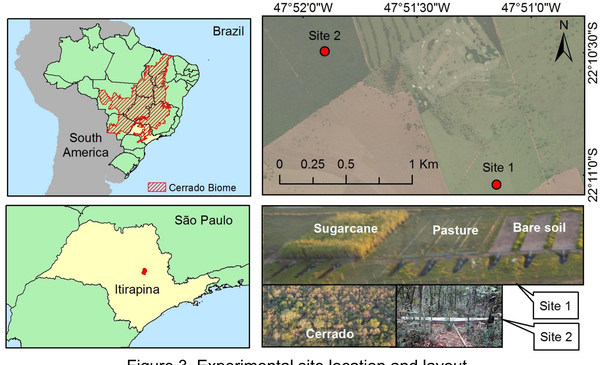

Figure 3. Experimental site location and layout.

Runoff, soil loss and meteorological observations were conducted from 2012 until 2016.

Experimental plots: 5 m width, 20 m length, 9% slope gradient, 3 replicates per treatment.

Parameters optimized: critical shear; initial saturation level; effective hydraulic conductivity; interrill erodibility; rill erodibility; biomass energy ratio; maximum canopy height; maximum root depth; canopy cover coefficient.

Results

WEPP calibration

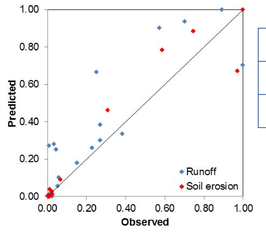

Table 1. Model performance evaluation.

Variable	R^2	NSE	RSR	PBIAS
Runoff	0.71	0.76	0.49	-8.48%
Soil erosion	0.92	0.91	0.30	-10.49%

R^2 - Coefficient of determination;
NSE - Nash–Sutcliffe model efficiency coefficient;
RSR – RMSE observations standard deviation ratio;
RMSE – Root mean square error;
PBIAS – Percent bias.

Figure 4. Comparison between observed and WEPP calculated variables.

Runoff and soil erosion simulations

Simulations in different land uses

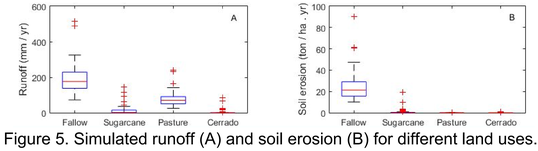

Figure 5. Simulated runoff (A) and soil erosion (B) for different land uses.

Table 2. Observed and simulated averages for runoff and soil erosion.

Land use	Rainfall (mm yr⁻¹)		Runoff (mm yr⁻¹)		Soil loss (ton ha⁻¹ yr⁻¹)	
	Observed[1]	Simulated[2]	Observed[1]	Simulated[2]	Observed[1]	Simulated[2]
Cerrado	1388.11	1323.20	2.35*	2.99*	0.14*	0.04*
Fallow			137.70	189.51	16.13	23.37
Pasture			45.20*	74.26	0.11*	0.08*
Sugarcane			15.92*	11.33*	0.63*	0.64

(1) – 5-year observed means; (2) – 100-year simulated means using WEPP model; (*) indicates no difference between means in the same column (P value > 0.05).

Simulations using present and future climate

Table 3. Present and future WEPP simulated averages for precipitation, runoff, and soil erosion; using present and future climate inputs.

Land use	Climate	Rainfall (mm yr⁻¹)		Runoff[2] (mm yr⁻¹)		Soil loss[2] (ton ha⁻¹ yr⁻¹)	
		Mean	Change[1]	Mean	Change[1]	Mean	Change[1]
Cerrado	Present	1325.28	-	10.39	-	0.11	-
	2030	1339.42	14.14	12.23	1.83	0.14	0.03
	2060	1358.91	33.64	8.41	-1.98	0.13	0.02
	2090	1375.34	50.06	9.60	-0.80	0.12	0.02
Fallow	Present	1325.28	-	240.71	-	29.59	-
	2030	1339.42	14.14	240.38	-0.33	29.82	0.24
	2060	1358.91	33.64	232.35	-8.36	28.68	-0.91
	2090	1375.34	50.06	237.10	-3.61	29.68	0.09
Pasture	Present	1325.28	-	96.57	-	0.11	-
	2030	1339.42	14.14	97.86	1.29	0.12	0.00
	2060	1358.91	33.64	94.98	-1.58	0.11	0.00
	2090	1375.34	50.06	97.18	0.61	0.12	0.00
Sugarcane	Present	1325.28	-	20.97	-	0.90	-
	2030	1339.42	14.14	22.15	1.18	0.90	0.00
	2060	1358.91	33.64	18.55	-2.43	0.90	-0.01
	2090	1375.34	50.06	19.49	-1.49	0.88	-0.02

(1) – Changes in rainfall, runoff or soil loss in relation to the present climate scenario. (2) Runoff and soil loss have no difference between means considering different climates.

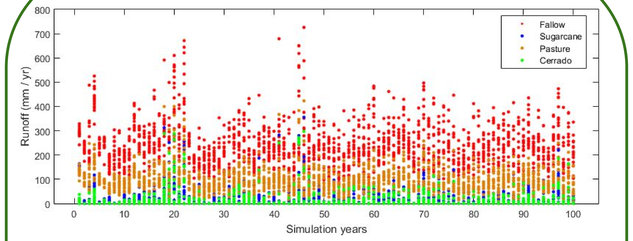

Figure 6. Runoff variability considering different climate changes scenarios on four different land uses.

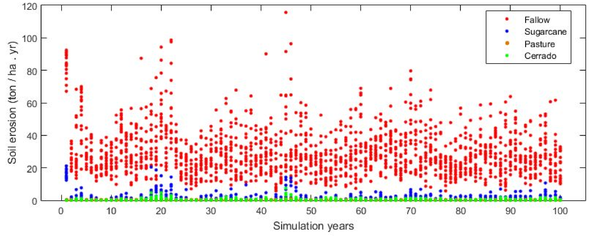

Figure 7. Soil erosion variability considering different climate changes scenarios on four different land uses.

Conclusions

- ❏ The WEPP model can be used under tropical conditions since it is calibrated;
- ❏ Transitions in land use can change patterns of runoff and soil loss rates;
- ❏ Possible future climate scenarios may increase the variability for runoff and soil erosion. However, no increase in the rates are observed.
- ❏ The runoff behavior is distinct for all land uses, but for soil loss there are similarities between pasture and undisturbed Cerrado, suggesting that soil sustainability could be reached when the management follows conservation principles.

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