Direct and Indirect Controls of Soil Water Storage in a Hummocky Landscape

Asim Biswas* [1], Eric Lamb [2] and Bing Cheng Si [1]

[1] Department of Soil Science, [2] Department of Plant Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

1. Introduction

- Soil water is the main limiting factor in semi-arid agriculture and a key element in environmental health.
- Topographic indices, soil texture, vegetation, and water table depth control soil water storage (SWS) at a location.
- Some factors control SWS directly, while others indirectly (they are present but cannot be measured directly).
- Complex relationship needs to be understood in identifying direct and indirect controls of SWS.

2. Objective

- To examine the complex relationship between SWS and direct and indirect controls of SWS in a hummocky landscape.

3. Theory

- Structural equation modelling (SEM) is a confirmatory multivariate technique that helps to measure what we cannot see (latent) based on what we can see (observations).
- Different terrain indices represented latent topography, particle sizes represented latent soil texture, while organic carbon (OC) represented both during recharge and discharge period.
- Path coefficients are the partial correlation coefficients between dependent and independent variables.

4. Materials and Methods

- Study Site: St. Denis National Wildlife Area (52º12′N, 106º50′W), Saskatchewan, Canada.
- Study Area: Hummocky landscape (Fig. 1), 10 to15% slope, loamy unsorted glacial till parent material, Borolls to Aquolls soil type, Grass cover.

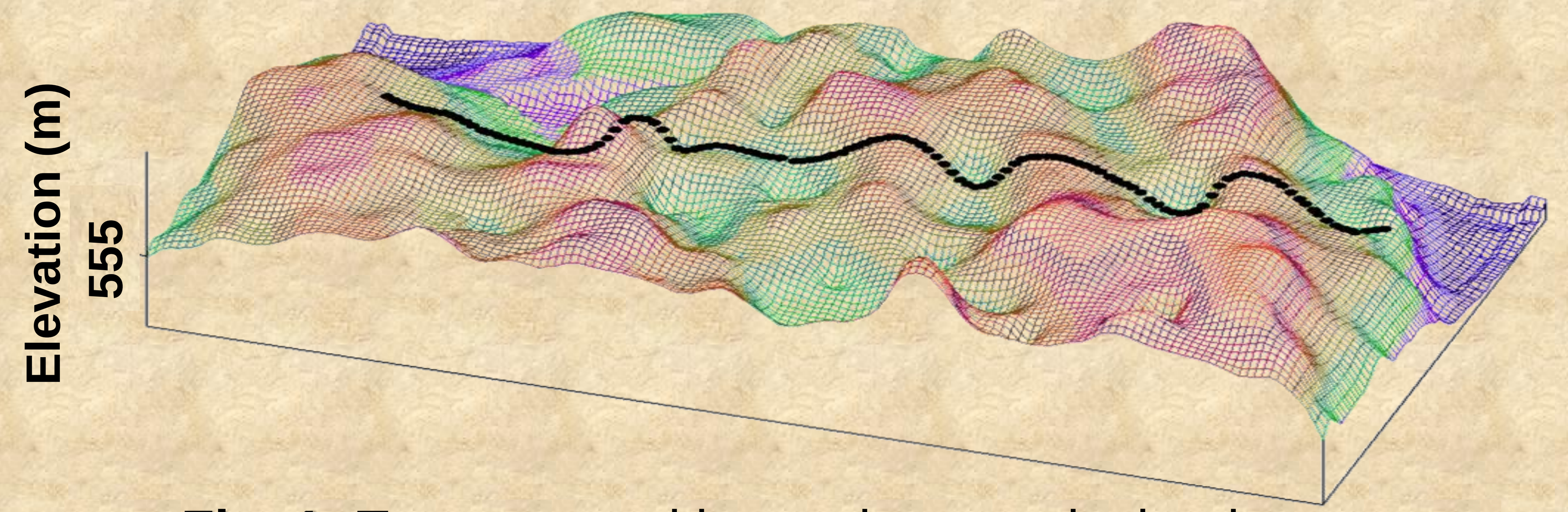


Fig. 1: Transect position on hummocky landscape

- 128 sampling points with 4.5-m interval.
- SWS (up to 140 cm using a Neutron Probe and Time Domain Reflectometry), elevation, sand, silt, clay, OC were measured and different terrain indices were calculated using System for Automated Geo-scientific Analysis (SAGA) software (Fig. 2).

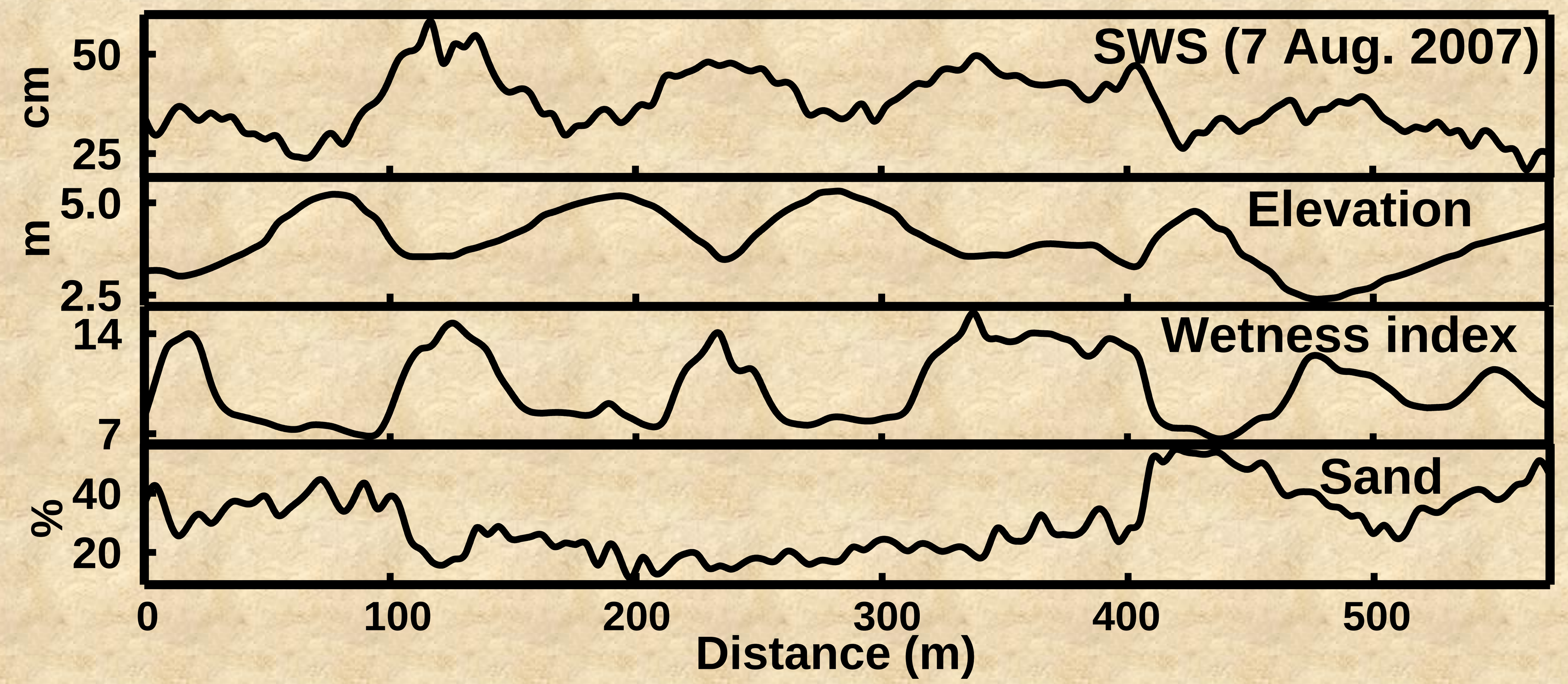


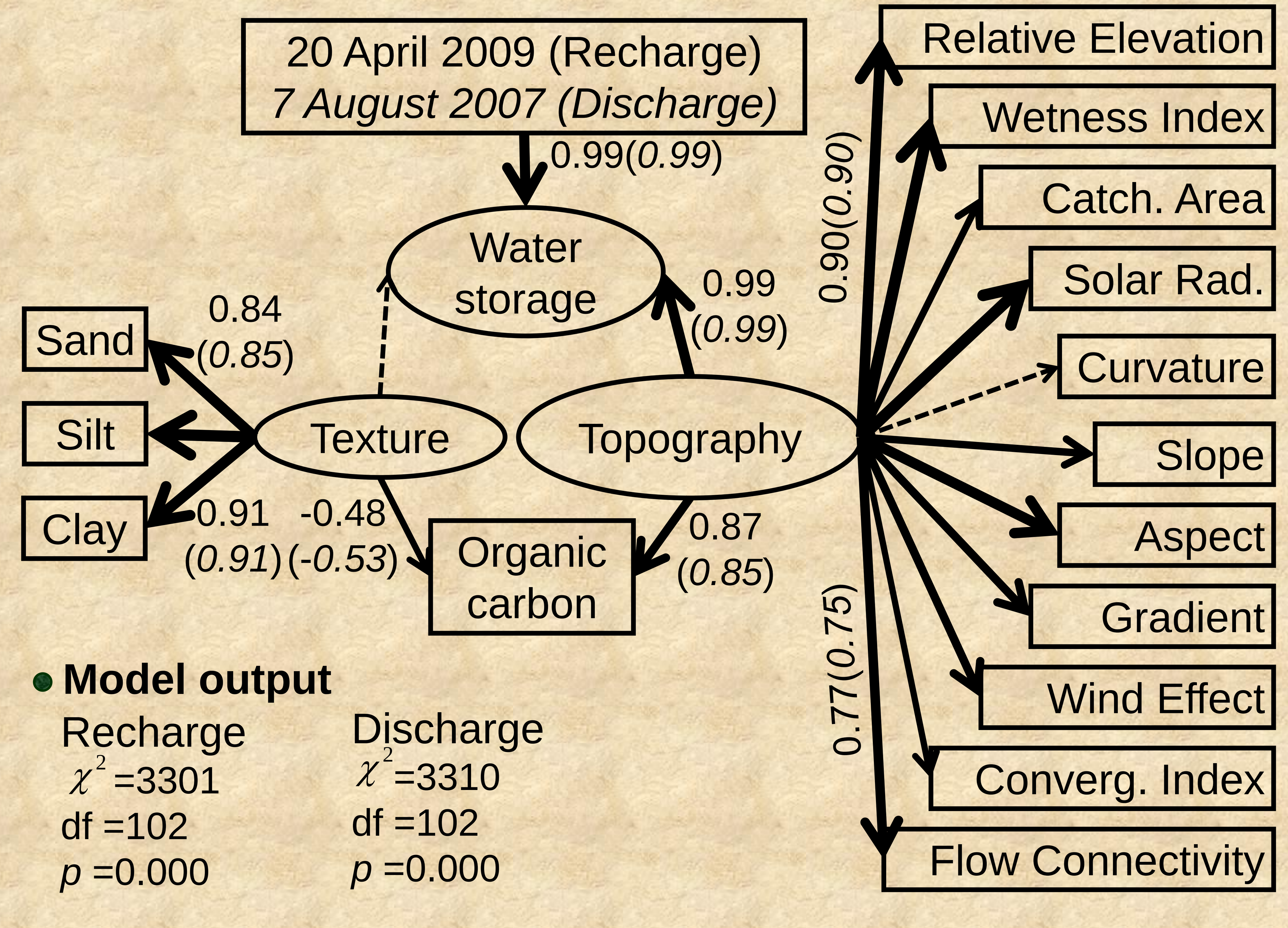
Fig. 2: Spatial distribution of SWS, elevation, wet. index & sand.

5. Results and Discussion

Table 1: Standardized path coefficients for different factors during recharge (wet) and discharge (dry) periods

Factor	Re.	Dis.	Factor	Re.	Dis.
Wet. Index	0.97	*0.97*	Aspect	0.86	*0.87*
Catch. Area	0.33	*0.34*	Gradient	0.67	*0.66*
Solar rad.	0.96	*0.96*	Wind effect	0.61	*0.61*
Curvature	Insig.	*Insig.*	Converg. Index	-0.36	*-0.34*
slope	0.42	*0.43*	silt	0.94	*0.94*

*Re.- recharge; Dis.- discharge, Insig.- insignificant



- **Model output**

Recharge	Discharge
χ^2 =3301	χ^2 =3310
df =102	df =102
p =0.000	p =0.000

Fig. 3: Final structural equation model with standardized path coefficients for SWS and controlling factors of recharge and discharge period in *italics.*

5. Results and Discussion (Cont.)

- Large standardized path coefficients indicated topography to be a major control of SWS during recharge and discharge period (Fig. 3).
- Topography controls the runoff process during snowmelt or rainfall and redistributes water in the landscape.
- Depressions receive water from surrounding and store more water than knolls at all seasons (Fig. 2).
- Insignificant path coefficient for soil texture indicated weak control during recharge or discharge period (Fig. 3).
- Relative elevation, wetness index, solar radiation, aspect best represented topography.
- Organic carbon represented latent topography better than that of latent soil texture.
- Terrain indices and particle sizes respectively control latent topography and texture directly, which control SWS indirectly.

6. Conclusions

- Topography was a major control of SWS irrespective of the seasons.

7. Acknowledgement

- U of S Deans' Scholarship, NSERC, Dr. Yates, Jason, Caden, Danny, Amanda, and Henry