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SHEAR STRESS PARTITIONING OF OVERLAND FLOW ON DISTURBED AND UNDISTURBED RANGELANDS

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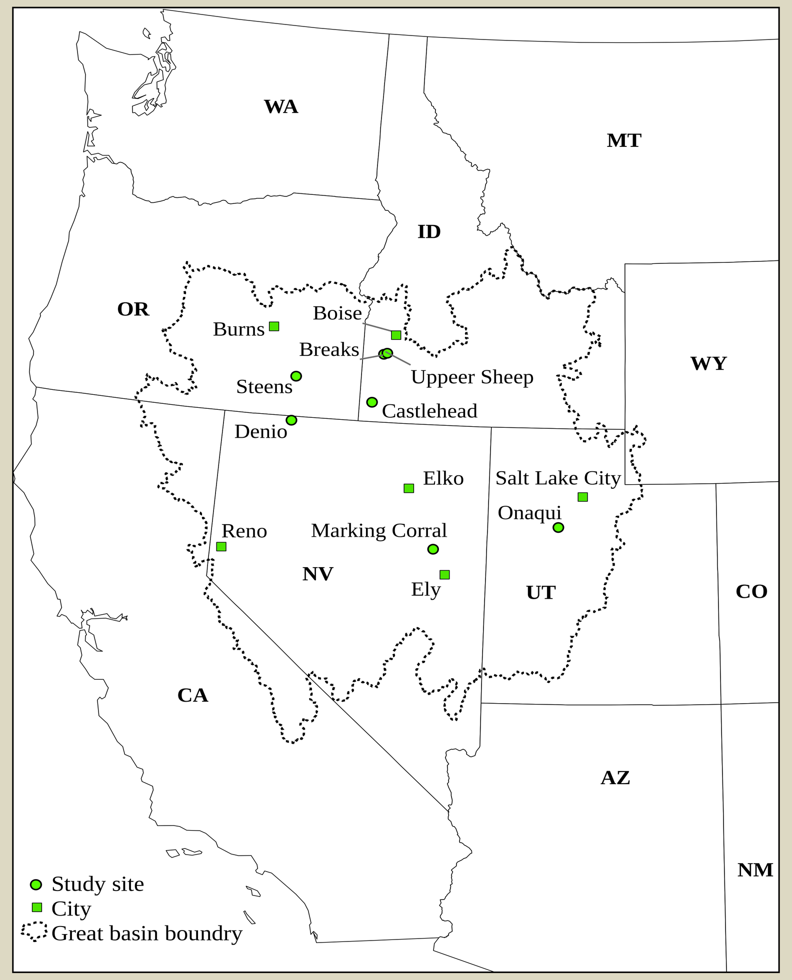
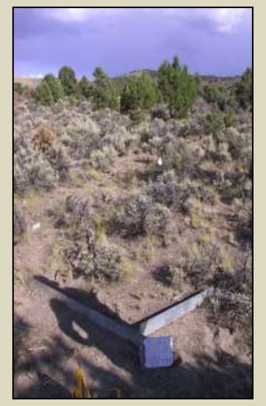
Objectives

1) **To estimate the components of overland flow shear stress on disturbed and undisturbed rangelands by applying the Darcy-Weisbach friction partitioning method to field collected experimental data.**
2) **To investigate the vegetation cover limit at which the soil shear stress component is substantially reduced, limiting the erosion rate.**

Study Areas





Control Site (untreated)

Uncut Site

Cut Site

Burn Site

Tree Mastication Site

Site	State	Treatment	Landscape	Soil type
Denio	NV	Burned, Untreated	Sagebrush Steppe	sandy loam
Breaks	ID	Burned, Untreated	Sagebrush Steppe	course sandy loam
Steens	OR	Cut, Uncut	Western Juniper	silt loam
Onaqui	UT	Burned, Tree mastication, Cut, Untreated	Sagebrush Steppe Utah Juniper	gravely loam
Marking Corral	NV	Burned, Cut Untreated	Pinyon-Juniper Sagebrush Steppe	gravelly loam
Castlehead	ID	Burned, Cut, Untreated	Western Juniper Sagebrush Steppe	stony loam
Upper Sheep	ID	Burned, Untreated	Sagebrush Steppe	silt or silt loam

Theory

$\tau_s / \tau_t = f_s / f_t$

$\tau_t = \gamma R_h \sin(\tan^{-1}(S))$

$f_t = 8 g R_h \sin(S)/V^2$

τ_s is the shear stress exerted on soil grains (N m^{-2})
τ_t is the total shear stress (N m^{-2})
f_s is the Darcy-Weisbach hydraulic friction factor of soil
f_t is the hydraulic friction factor of the composite surface

γ is the specific weight of water (N m^{-3})
R_h, is the hydraulic radius (m)
S is the average slope of the plot
g is the acceleration due to gravity (m s^{-2})
V is the measured velocity (m s^{-1})

Methods

1. Average slope, ground cover, vegetation cover, and micro topography were measured for each plot (All plots are 2x4 m).

2. All plots were pre-wet prior to experiments.

3. Water was released at different inflow rates approximately 4 m upslope of runoff collection point.

4. For each inflow rate, flow velocity was measured by salt tracer method while the width and depth of each flow path were measured by ruler at several transects.

5. Total outflow discharge rate was determined from timed runoff samples collected during simulations.

$$Q = \frac{1}{n} A R_h^{2/3} S^{1/2}$$

$$K = A R_h^{2/3}$$

6. Total flow discharge was proportionally distributed to the flow paths according to their conveyance factor (K).

Concentrated versus Sheet Flow

$$R_h = \frac{wd}{w + 2d}$$

In shallow flow (sheet) :
$d \ll w \rightarrow (w+2d) \approx w \rightarrow R_h \approx d$

R_h is the hydraulic radius of flow
d is the depth of flow
w is width of flow

$(d - R_h)/R_h > 0.05 \rightarrow$

Concentrated flow

$(d - R_h)/R_h <= 0.05 \rightarrow$

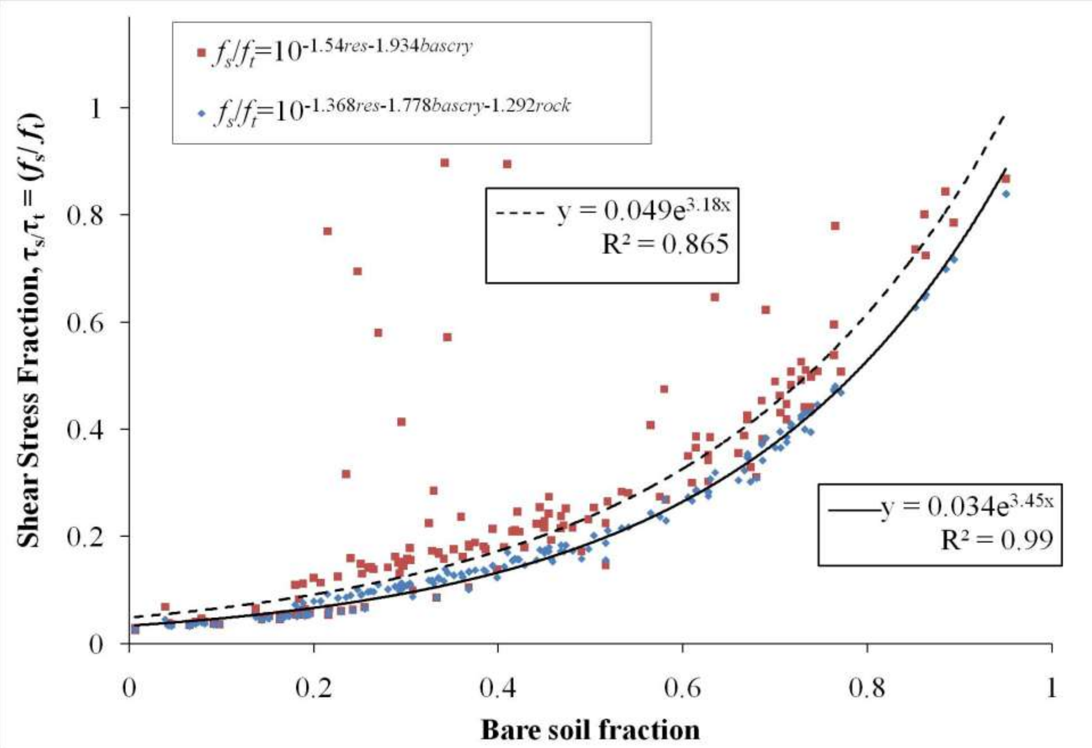
Sheet flow

Empirical Hydraulic Friction Equations

Flow	f_t	R^2	n	f_s	f_s / f_t
Concentrated	$10^{0.524+1.54res+1.934bascry}$	0.44	171	$10^{0.524}$	$10^{-1.54res-1.934bascry}$
	$10^{0.832+1.439res+1.776bascry-1440Q}$	0.46	391	$10^{0.832-1440Q}$	$10^{-1.439res-1.776bascry}$
	$10^{0.235+1.368res+1.778bascry+1.292rock-1499Q+1.722S}$	0.52	391	$10^{0.235-1499Q+1.722S}$	$10^{-1.368res-1.778bascry-1.292rock}$
Sheet	$10^{-0.251+2.094res+3.258bascry+0.972rock}$	0.52	101	$10^{-0.251}$	$10^{-2.094res-3.258bascry-0.972rock}$
	$10^{0.004+2.237res+3.141bascry+1.157rock-1182Q}$	0.52	178	$10^{0.004-1182Q}$	$10^{-2.237res-3.141bascry-1.157rock}$
	$10^{-0.18+2.119res+2.126bascry+1.103rock-1201Q+1.861S}$	0.54	178	$10^{-0.18-1201Q+1.861S}$	$10^{-2.119res-2.126bascry-1.103rock}$

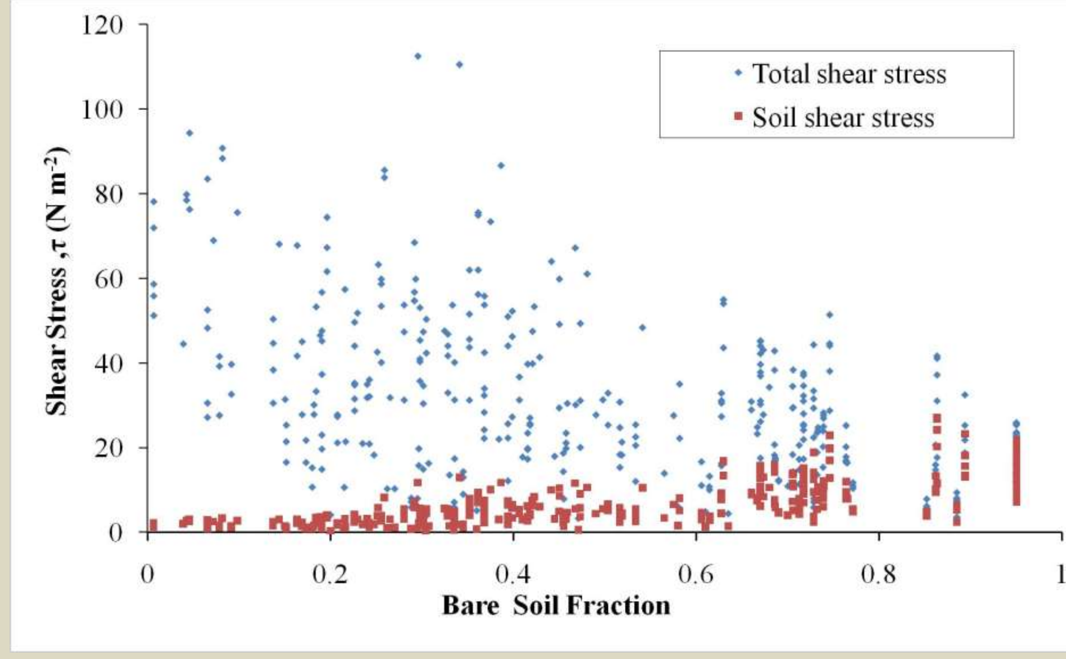
res*, *bascry* and *rock: are the fractions of litter cover, basal plant and cryptogam cover, and rock cover to the total ground area respectively.
Q: is the flow discharge (m^3 s^{-1})
S : is the average slope

Shear Stress Partitioning Equations

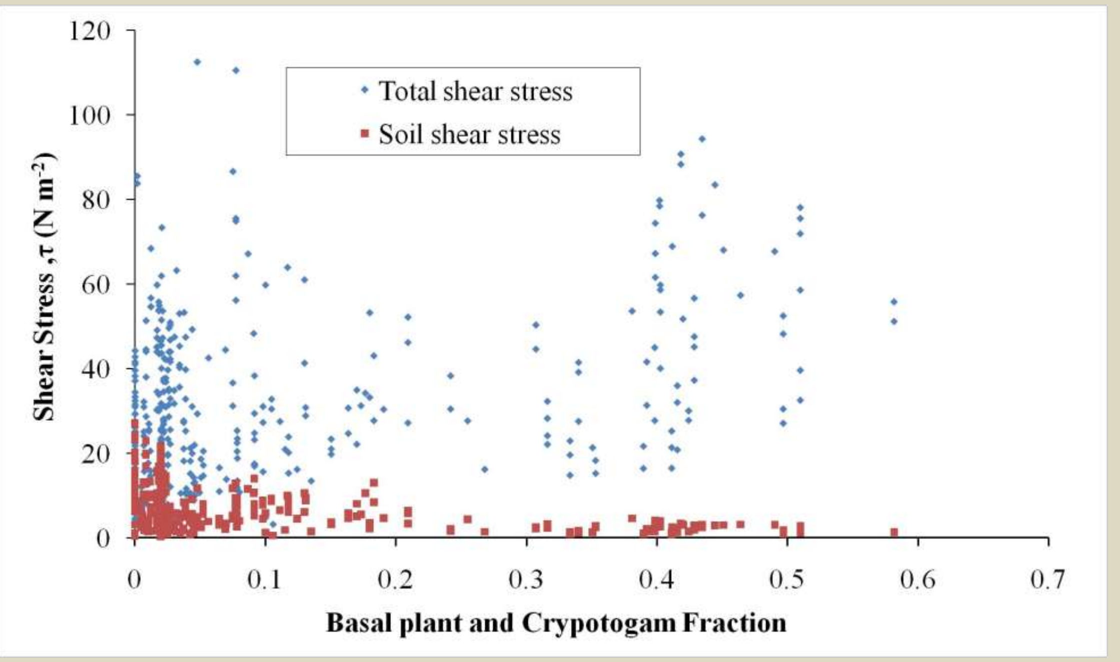


Empirical equations that predict the ratio of soil shear stress to the total shear stress of concentrated flow as a function of bare soil fraction of total area

Soil Shear Stress reduction by vegetation cover



Shear stress (τ_t) and soil shear stress ($\tau_s = (f_s/f_t)\,\tau_t$), where $f_s/f_t = 10^{-1.368res-1.778bascry-1.292rock}$, versus bare soil percent



Shear stress (τ_t) and soil shear stress ($\tau_s = (f_s/f_t)\,\tau_t$), where $f_s/f_t = 10^{-1.368res-1.778bascry-1.292rock}$, versus basal plant fraction

Acknowledgements

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