Considerations and Development of the Hydrologic Function Section in Rangeland ESD's

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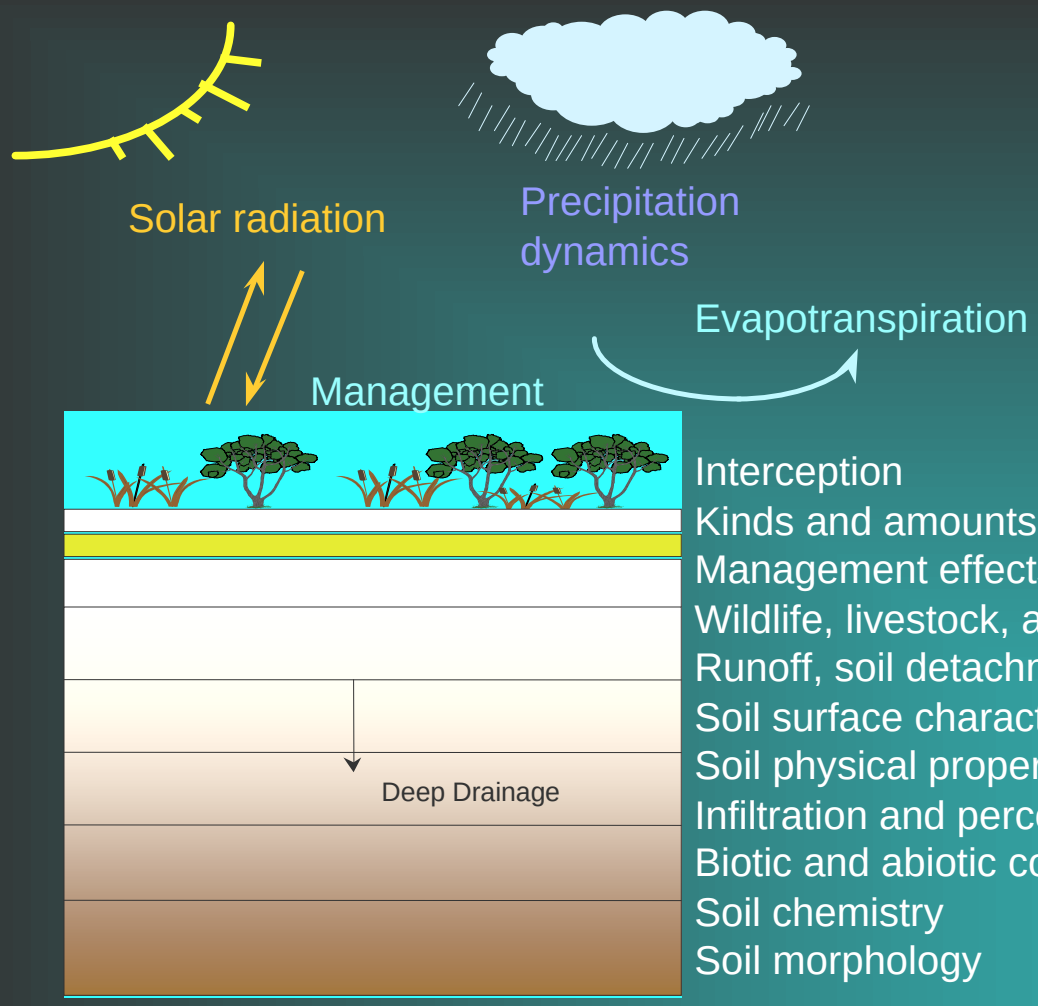
Hydrologic Cycle



Interception
Kinds and amounts of vegetation
Management effects
Wildlife, livestock, and other biotic components
Runoff, soil detachment, sedimentation, nutrients
Soil surface characteristics (crusts, cryptogams)
Soil physical properties
Infiltration and percolation
Biotic and abiotic components in the soil
Soil chemistry
Soil morphology

Chapter 7 Rangeland and Pastureland Hydrology and Erosion

Section 1 Hydrologic Cycle and Effects of Vegetation, Grazing, and Management on Hydrology and Erosion

Contents:

Rangeland Hydrology: Key Issues to Consider (See Handout)

- Climatic flux is an inevitable factor which affects ecological and hydrologic cycles in rangeland plant communities.
- We need to look beyond average climate values to understand the affect of drought and unexpected storm events.
- Examine interacting factors (veg—soil—env—mgt.)
- Relate unexpected events to thresholds in "State and Transition Models".

Handout

NRCS Ecological Site Descriptions: Hydrology and Erosion Considerations

Hydrologic Functions:

ESIS allows a narrative description about the hydrology of the site. The purpose of this document is to provide a guide to types of information which may included in this section. Future ESIS templates will allow Figures and Tables.

ESIS: Hydrologic Function Data Entry

Hydrology (infiltration and runoff), water quality, and erosion information about the respective site should be included in the Hydrologic Functions Section of the ESD.

Suggestions:

•Use state and transition model and describe corresponding hydrologic changes
•Can use RHEM model outputs for various states—compare and contrast.
•Evaluate trends in runoff and sediment yield for S&T's
•Describe how changes in vegetation affect hydrology
•Describe how changes in hydrology affect vegetation
•Discuss plant community composition and distribution relative to infiltration and runoff
•How do conservation practices (prescribed burning, and brush management affect hydrology and erosion?
•What are the impacts of wildfire or intense burns on hydrology and erosion?
•Discuss grazing intensity and changes in plant community composition (in context with S&T model). As plant community composition shifts i.e., species, growth forms, life forms, what are the effects on hydrology and erosion?
•What are the impacts of hoof action and compaction with given soil surface physical properties (texture) on hydrology and erosion?
•What is the role of rainfall interception on this site. How many canopy layers for vegetation (reference vegetation in S&T)
•What are the rainfall dynamics associated with this ESD. Refer to climate section and explain peak rainfall months and possible accelerated runoff

Rare Climatic Events: High Intensity Convective Storms, Design Storm Frequency, Time of Year, Drought, Rain on frozen soils etc.

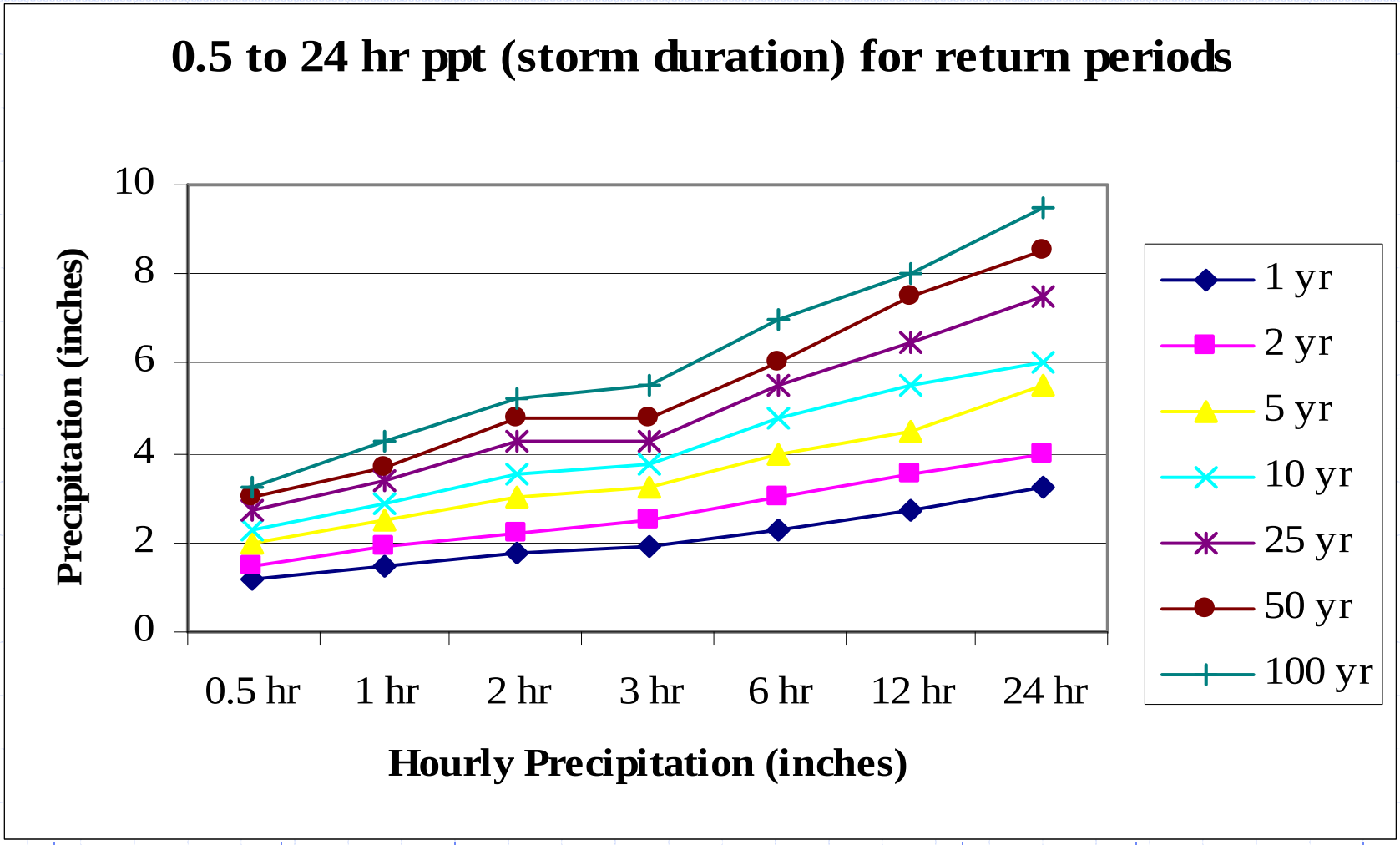
Water Erosion 3/12/03

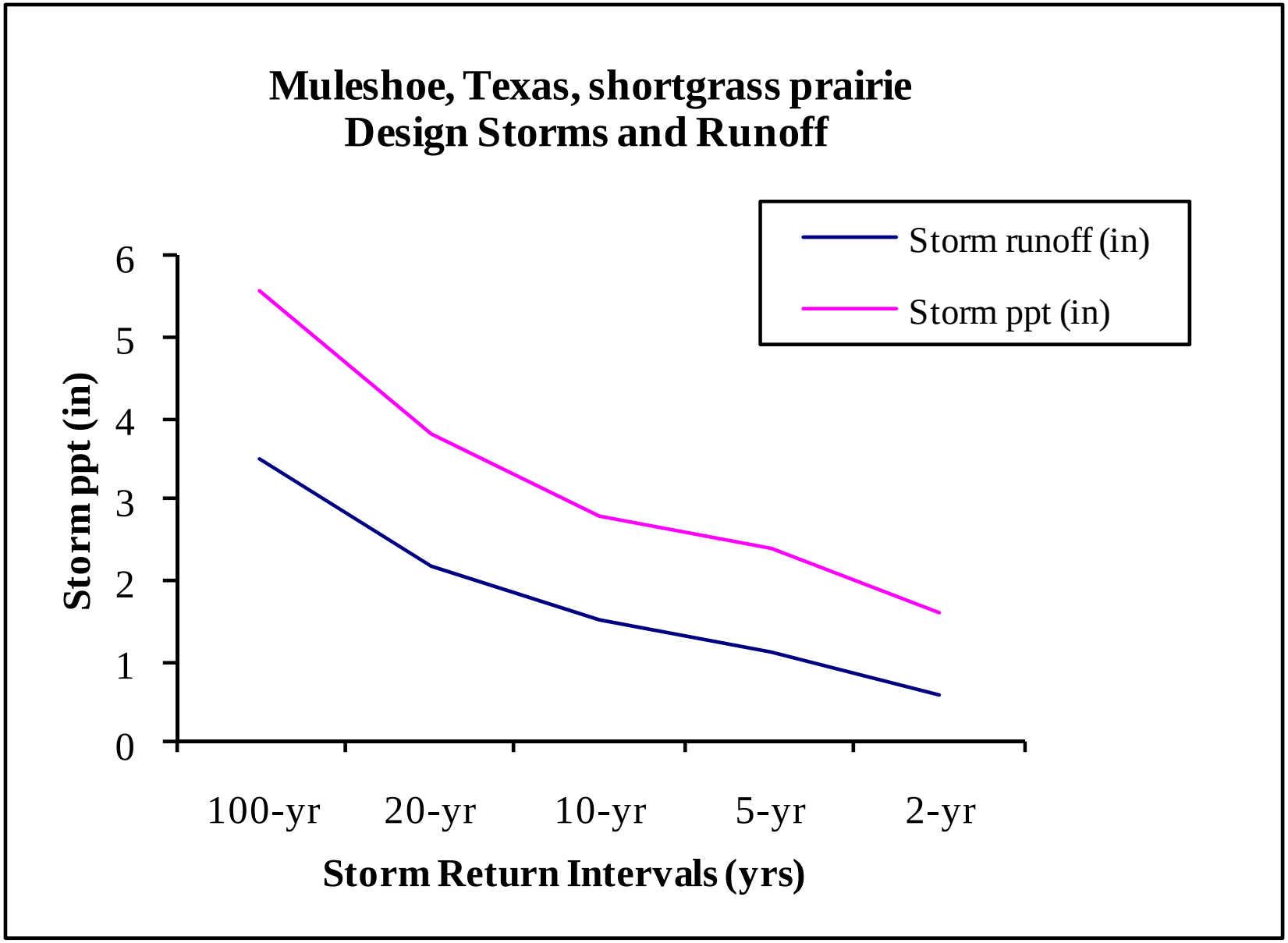
Water Erosion 3/12/03: Leavitt Creek Wyo.

Spring Runoff from a severely damaged watershed
3/12/03

Climatic Features

Precipitation amounts and yearly storm return periods (Tarrant Co.)




Muleshoe, Texas, shortgrass prairie
Design Storms and Runoff
Storm runoff (in)
Storm ppt (in)
Storm ppt (in)
0
1
2
3
4
5
6
100-yr
20-yr
10-yr
5-yr
2-yr
Storm Return Intervals (yrs)

When does Runoff and Soil Loss Occur?
(Denio, Nevada, Mountain Big Sage Site)

year		ppt		inf		ro		sed		months
		in.		in.		in.		t/ac		soil loss
2003		16.50		10.30		2.70		0.56		M/MJJA/O
4		17.20		8.60		3.90		0.30		MAMJJA/O
5		17.40		11.30		5.00		0.28		AMJ/ASON
6		19.70		13.00		5.30		0.44		MAMJJASO
7		21.70		9.80		8.20		0.54		MAMJJASON
8		13.90		10.00		4.30		0.27		MAMJ/AS
9		19.90		8.90		4.50		0.35		MAMJ/ASO
10		25.10		14.20		9.50		1.19		AMJJASO
11		13.80		9.60		3.30		0.48		MAMJJASON
12		12.60		6.10		1.20		0.13		MAM/JA/ON

Months in red = 2 highest soil loss

Bare Ground, Canopy, and Basal Gaps

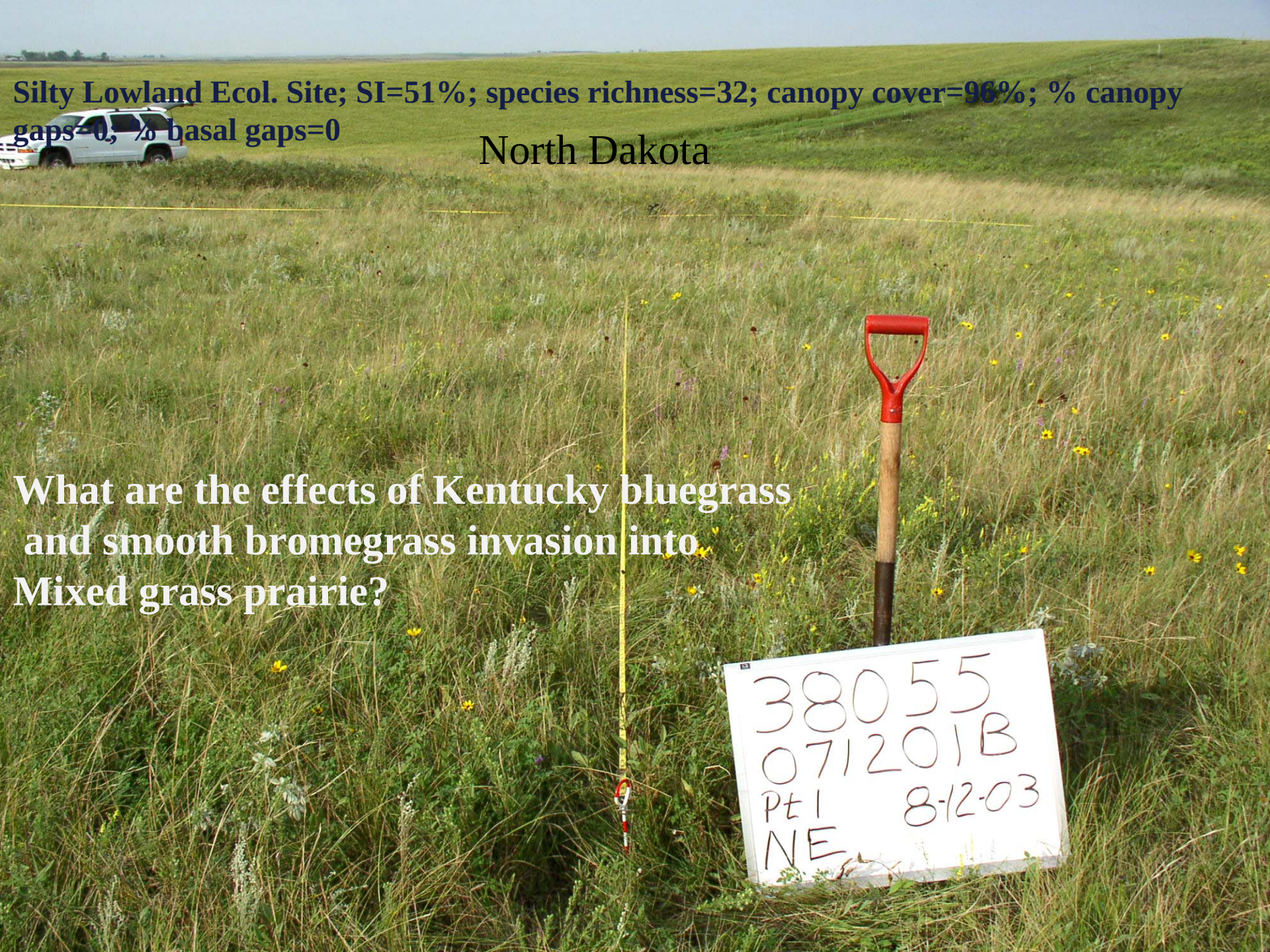
Black Grama (*Bouteloua eriopoda*) grassland, New Mexico, USA

Mesquite (*Prosopis glandulosa*) shrubland, New Mexico, USA

- Bare areas erode
- Nutrients are depleted
- Invasives can become established

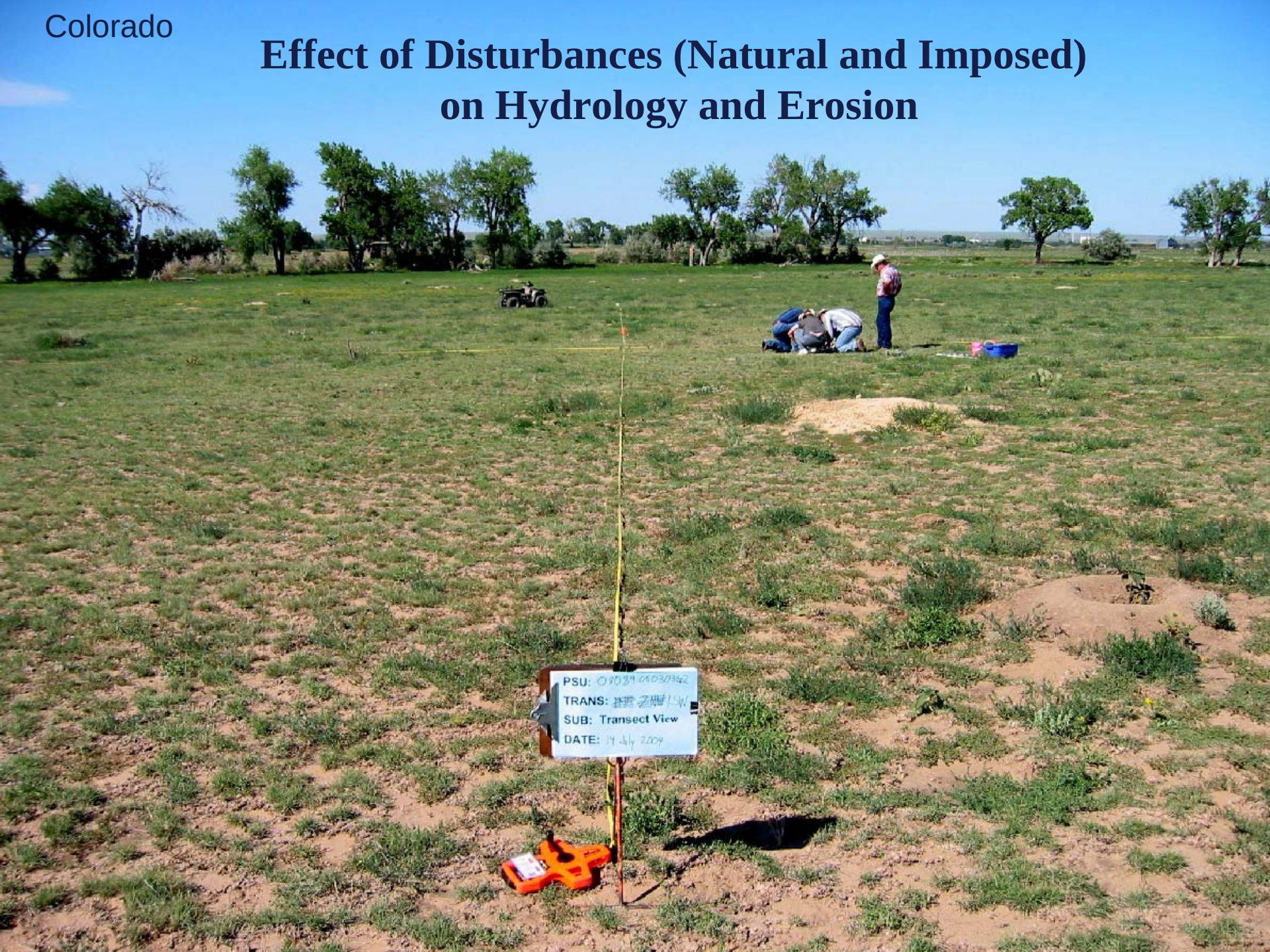
Prescribed Burning and Wildfire Effects on Hydrology and Erosion

Effects of Grazing Management


Silty Lowland Ecol. Site; SI=51%; species richness=32; canopy cover=96%; % canopy gaps=0; % basal gaps=0
North Dakota
What are the effects of Kentucky bluegrass and smooth bromegrass invasion into Mixed grass prairie?
38055
071201B
Pt 1
8-12-03
NE

Colorado

Effect of Disturbances (Natural and Imposed) on Hydrology and Erosion



Using Tools to Study and Evaluate Hydrologic Response in a State and Transition Context.

RHEM Web Tool — Rangeland Hydrology and Erosion Model Web Tool

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Now: Thu, Feb 04 2010

About the RHEM Web Tool

The RHEM Web Tool is a simple web-based interface for the Rangeland Hydrology and Erosion Model. The interface will allow the user to input commonly known rangeland characteristics and use parameter estimation equations to construct model input files, run the model, view the results, and compare different scenarios.

About RHEM

The Rangeland Hydrology and Erosion Model (RHEM) is designed to provide sound, science-based technology to model and predict runoff and erosion rates on rangelands and to assist in assessing rangeland conservation practices effects. RHEM is a newly conceptualized, process-based erosion prediction tool specific for rangeland application, based on fundamentals of infiltration, hydrology, plant science, hydraulics and erosion mechanics.

RUN RHEM MODEL

This tool was built using the following technologies:

1. RHEM Model
2. Cligen Weather Generator
3. CodeIgniter
4. MySQL
5. Google Maps

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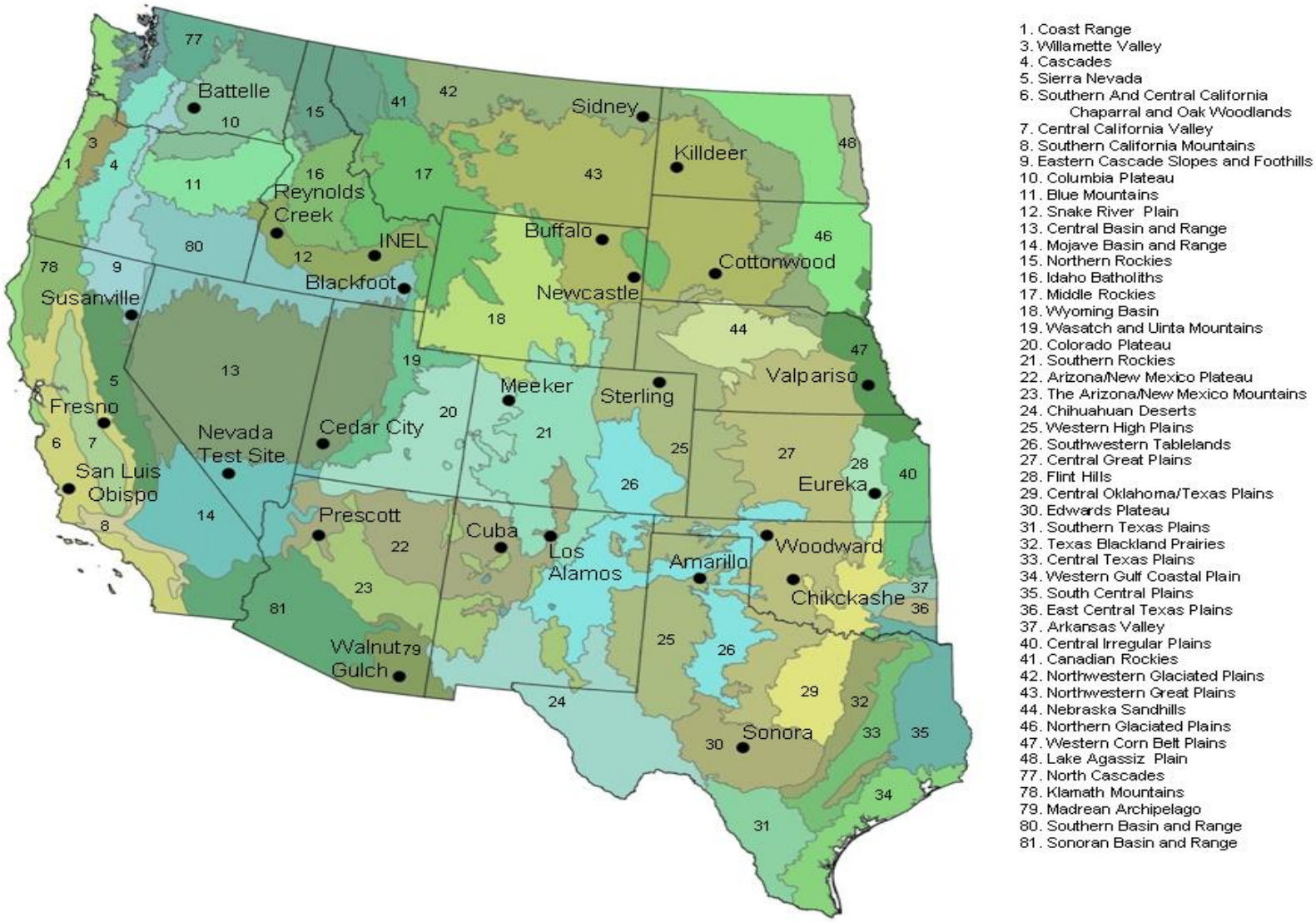
RHEM developed from actual field data



Rangeland soil erosion study sites used to develop and validate the Rangeland Hydrology and Erosion Models and displayed over Omernik level III ecoregions.

RHEM Web Tool

Rangeland Hydrology and Erosion Model Web Tool

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INPUT PARAMETERS

OUTPUT

1. Define Scenario

Clear Scenario

Name:

Description:

Select units: Metric: English:

Show User Scenarios

2. Climate Station

3. Soil Texture Class

4. Slope

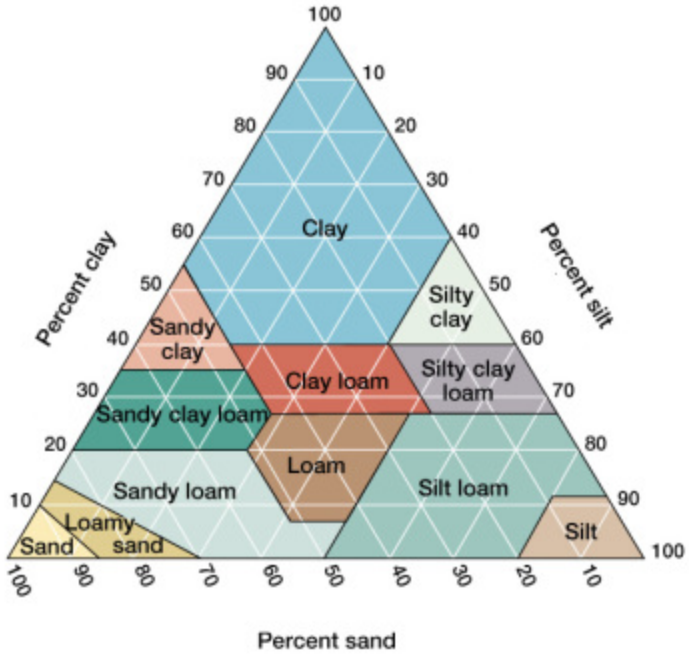
5. Cover Characteristics

6. Run Scenario

7. Compare Scenarios

Welcome

To begin using this tool please start building a scenario using steps 1 to 6.
You can also compare scenarios by clicking on the "7. Compare Scenarios" panel at the bottom left.



Dominant Plant Growth Form:

Bunch Grass

Foliar Plant Canopy Cover %:

Basal Plant Cover %:

Biological Soil Crusts %:

Rock Cover %:

Litter Cover %:

6. Run Scenario

7. Compare Scenarios

4. Slope

Length (meters): 45

Slope Shape: Convex

Steepness: 10%

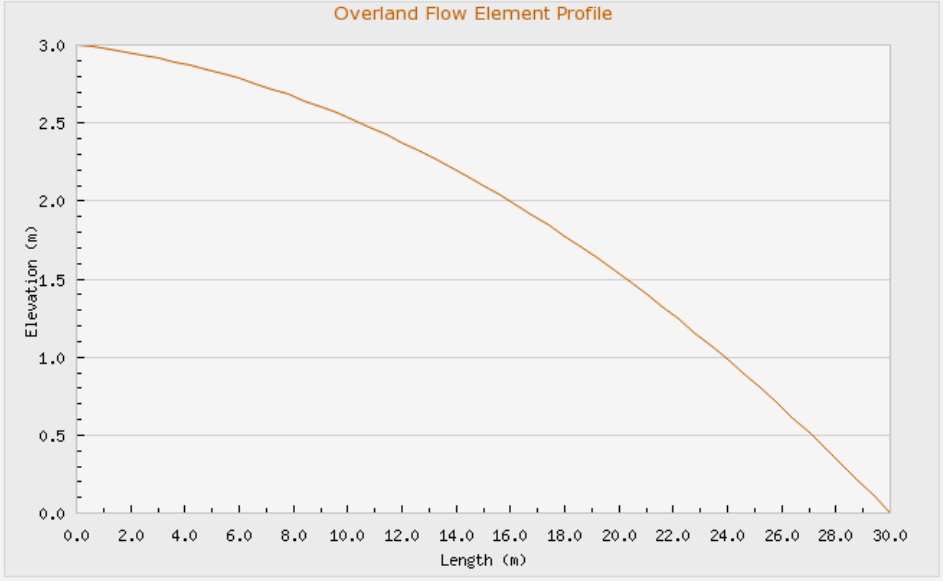
Show Graph

5. Cover Characteristics

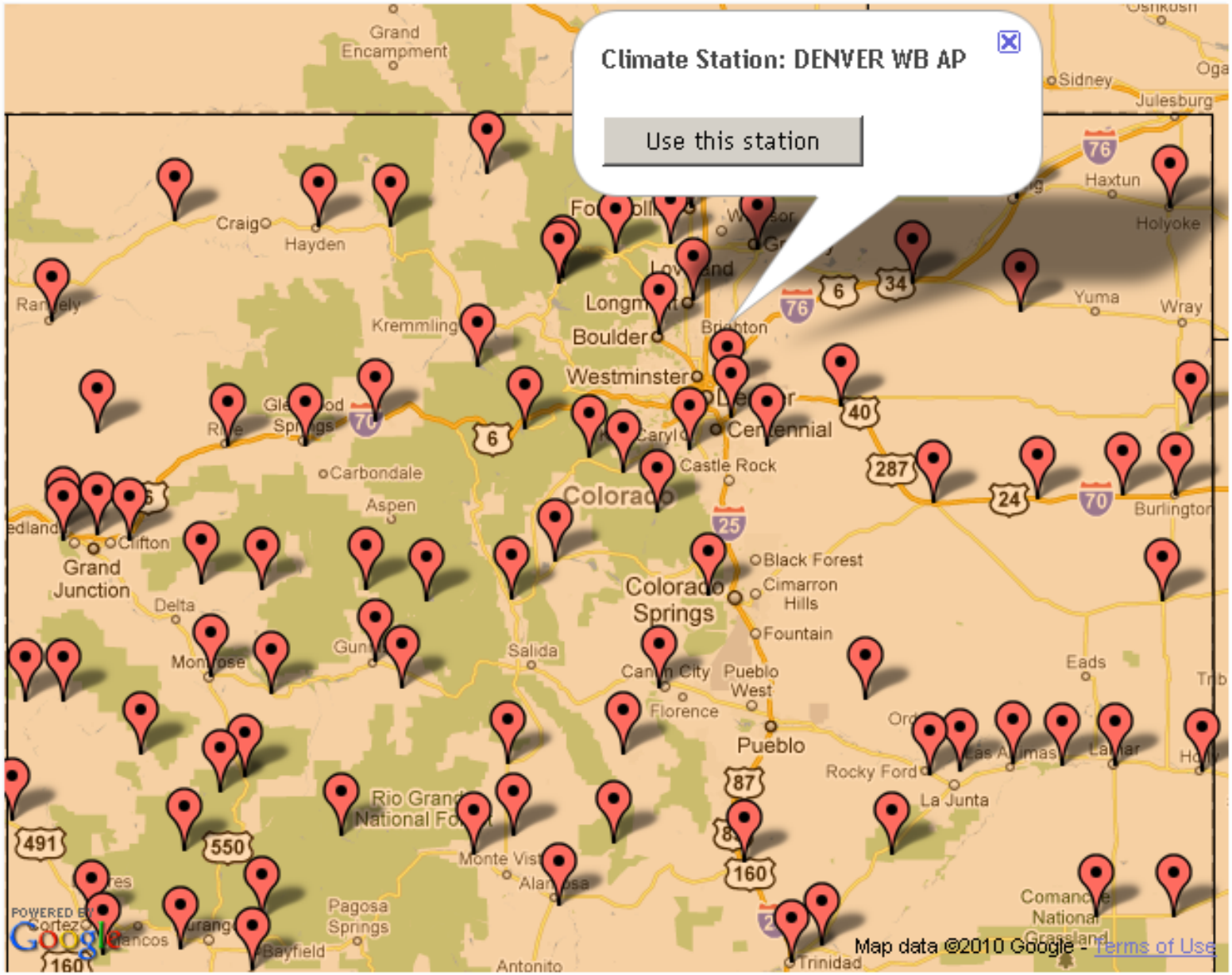
6. Run Scenario

7. Compare Scenarios

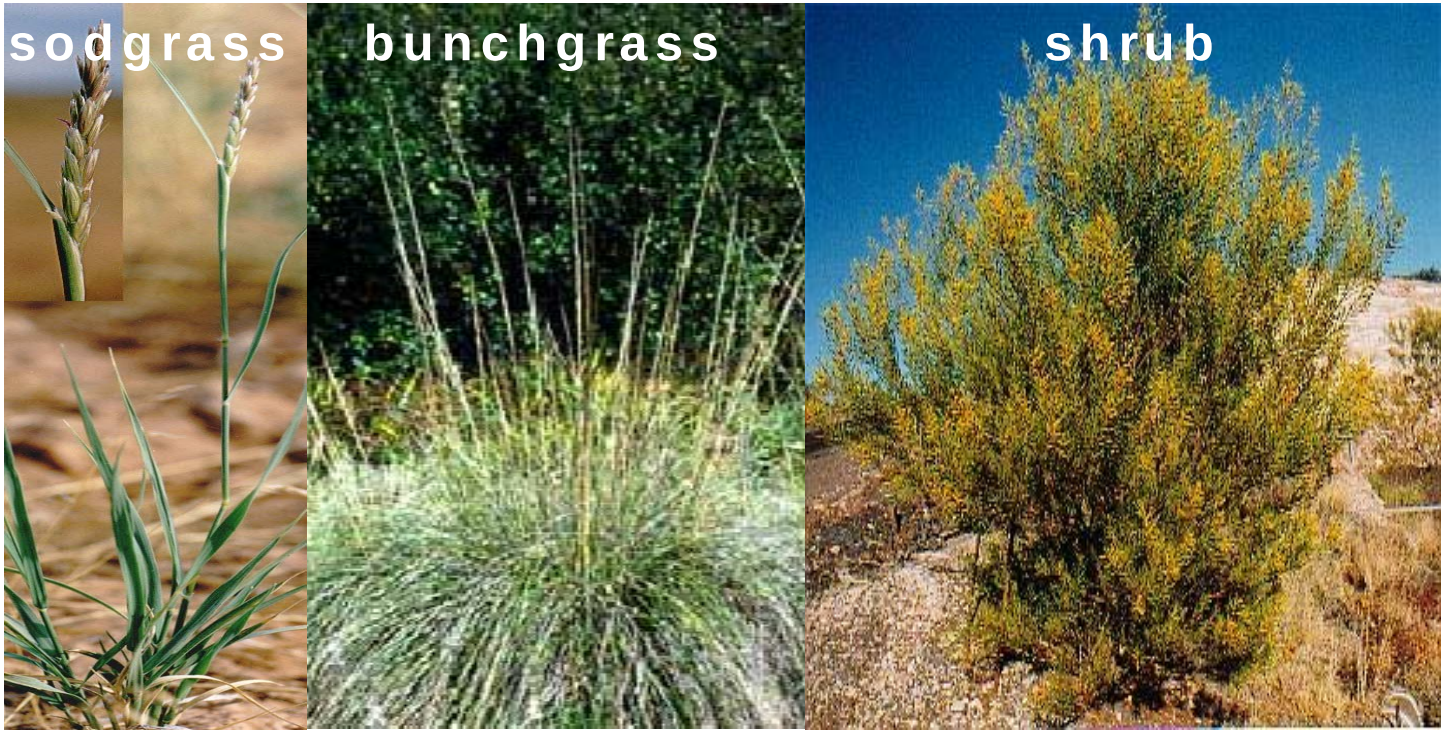
SLOPE GRAPH



CLIMATE STATIONS MAP



Parameterization
for infiltration/runoff/erosion



RHEM Outputs

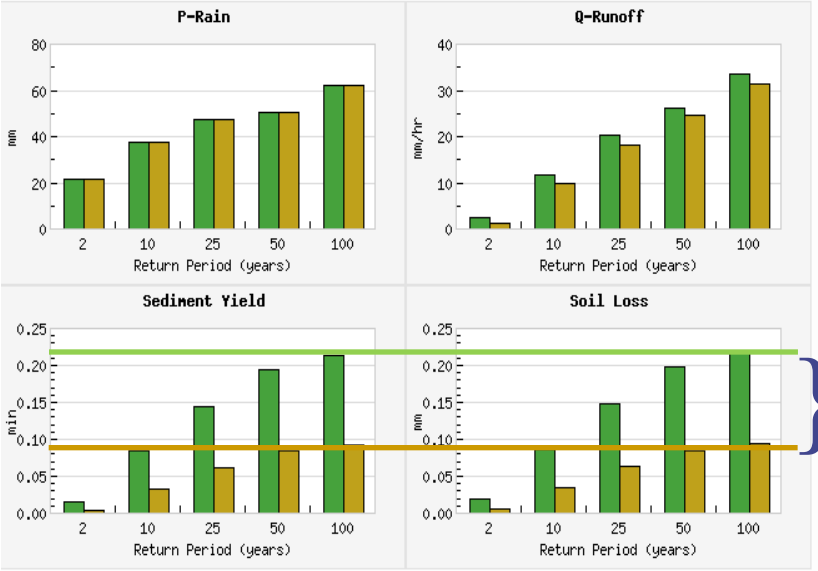
SCENARIO INPUTS

Download report as CSV

	No Practice	With Practice
State ID	NM	NM
Climate Station	ALBUQUERQUE WB AP	ALBUQUERQUE WB AP
Soil Texture	Sandy Clay Loam	Sandy Clay Loam
Moisture Content	0.25	0.25
Slope Length (meters)	30	30
Slope Shape	S-Shaped	S-Shaped
Slope Steepness	10	10
Vegetation Community	Bunch Grass	Bunch Grass
Canopy Cover %	50	80
Basal Cover %	5	8
Cryptogams Cover %	5	8
Rock Cover %	0	0
Litter Cover %	50	80
Total Ground Cover %	60	96

Total Ground Cover % 60 % 96%

RETURN PERIOD GRAPHS



Benefit

2 YEAR RETURN PERIOD RESULTS

	No Practice	With Practice
Rain (mm)	21.80	21.80
Runoff (mm)	2.31	1.10
Sediment Yield (ton/ha)	0.02	0.00
Soil Loss (ton/ha)	0.02	0.00

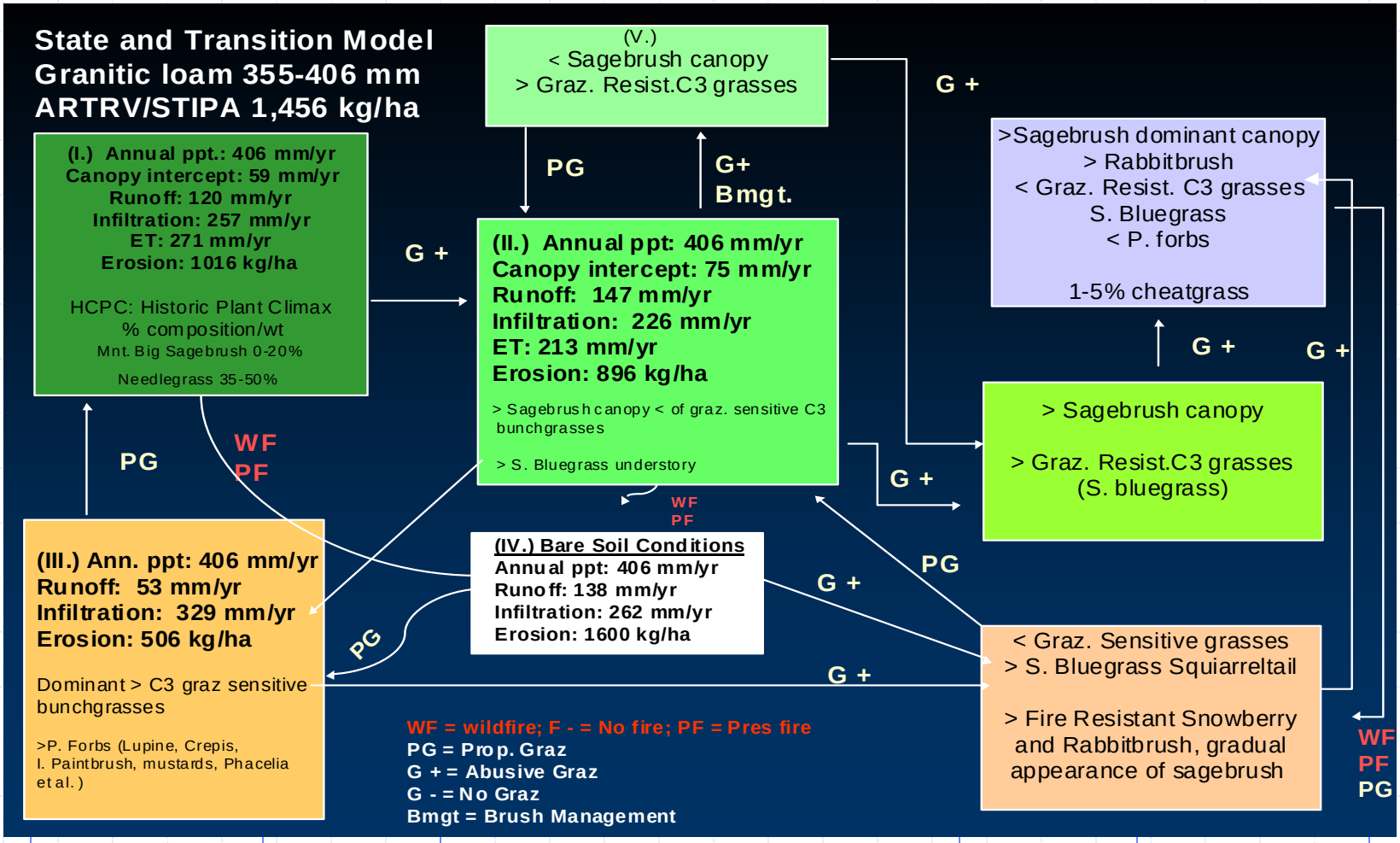
10 YEAR RETURN PERIOD RESULTS

RHEM Inputs

RHEM Outputs

Using RHEM to Evaluate Hydrologic Response to Management: Before and After Conditions

State and Transition Model: Granitic loam 14-18 in ARTRV/STIPA Hydrology and Erosion Patterns



United States Department of Agriculture
NRCS Natural Resources Conservation Service
Ecological Site Description

Plants | ESIS | ESD | EST Forestland | EST Rangeland

Data Access

- Data Edit/Entry, Download, Reports
- ESD Options
- Return to Reports Selection Screen

Report Selections

- General
- Physiographic Features
- Climate Features
- Water Features
- Soil Features
- Plant Communities
- Site Interpretations
- Supporting Information
- Rangeland Health Reference Sheet
- Complete Report
- HTML Printable Format

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

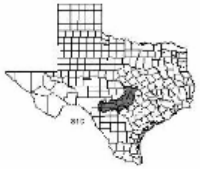
ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Adobe 29-35" PZ

Site ID: R081CY355TX

Major Land Resource Area: 081C - Edwards Plateau, Eastern Part



Physiographic Features

This site is classified as upland. Slope gradient range from 1 to 20 percent. It is presumed that this site was formed in residuum from weathered limestone. Elevation for this site ranges from 1000 to 1700 feet above sea level.

Land Form: (1) Hill

	Minimum	Maximum
Elevation (feet):	1000	1700
Slope (percent):	1	20
Water Table Depth (inches):		
Flooding:		
Frequency:		
Duration:	None	None
Ponding:		
Depth (inches):		
Frequency:		
Duration:	None	None
Runoff Class:	Low	Medium
Aspect:	No Influence on this site	

Climatic Features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

little bluestem	*Schizachyrium scoparium*	Leaves	N	N	U	U	U	U	U	U	U	N	N
awnless bushsunflower	*Simsia calva*	Fruits/Seeds	N	N	N	N	U	U	U	U	U	N	N
awnless bushsunflower	*Simsia calva*	Leaves	N	N	U	U	U	U	U	U	U	N	N
Indiangrass	*Sorghastrum nutans*	Fruits/Seeds	N	N	N	N	N	N	N	N	D	D	D	D
Indiangrass	*Sorghastrum nutans*	Leaves	N	N	U	U	U	U	U	U	U	N	N
composite dropseed	*Sporobolus compositus var. compositus*	Leaves	N	N	U	U	U	U	U	U	U	N	N
vetch	*Vicia*	Fruits/Seeds	N	N	N	P	P	N	N	N	N	N	N
vetch	*Vicia*	Leaves	D	D	D	D	D	N	N	N	N	D	D

Legend: P = Preferred D = Desirable U = Undesirable N = Not consumed E = Emergency T = Toxic X = Used, but degree of utilization unknown

Hydrology Functions:

The soils on this site are well drained with very low water holding capacity. Surface runoff can be rapid due to the slope and physiography of the site. Soils correlated with this site are in Hydrologic Groups C and D. The reference HCPC site is dominated by tall bunchgrass species that are correlated with high hydrologic function. When conditions degrade, into states 2 and 3, composition of desirable tall grasses decreases and mid and short grasses become more dominant. If soil conditions also degrade and management is consistent with overuse, hydrologic function decreases significantly. Hydrology and erosion dynamics are discussed below for states 1, 2, and 3.

The Open Grassland/Oak Hillside State, representative of HCPC, is the most productive of the plant community phases. With reference to the state and transition model, state 1 is the most hydrologically stable with lowest runoff and soil loss. This is due to the prominence of tall grass cover. Greater foliar and basal plant cover of big and little bluestem creates many raindrop interception layers. In addition, many lower statured forbs are located in the understory. Litter cover accumulating during the winter months can provides protection from raindrop impact. The morphology of big bluestem roots is characterized with thick coarse vertical and lateral roots. Rhizomes form a rigid, coarse, open network in the upper 2 inches of soil with branching roots arising from them. Where fractures occur in the underlying rock, roots can penetrate into deeper strata. Infiltration studies have shown the bluestem, indian grass, and switch grass are associated with higher infiltration capacity compared to other short statured grasses which tend to have more thick fibrous surface roots (e.g., gramas, buffalograss, dropseeds, three awn grasses).

Where the geologic substrate is fractured (commonly associated with oat mottes), infiltration is rapid and immediate. This water percolates deep into the substrate and largely escapes the evapotranspiration (ET) process. In the non oak mott portions of this site, runoff often occurs during high intensity, short duration storms. This is a common occurrence, even when range condition is high. In this state, runoff, on the average, displaces and erodes little soil. Water quality is high with little or no sediment. Intermittent channels and water flow paths carry runoff water without appreciable degradation in the channels. Seeps and spring flow are common on this site after high rainfall periods and may last several weeks. If adequate rainfall is received throughout the growing season, spring flow may last throughout the year. Stream channels and intermittent adjacent channels serve as recharge areas--water can percolate via fractures in the geologic substrate. As this water moves downward, it contributes to the recharge of aquifers and provides a constant source of subsurface water for sustained base flow to creeks and streams.

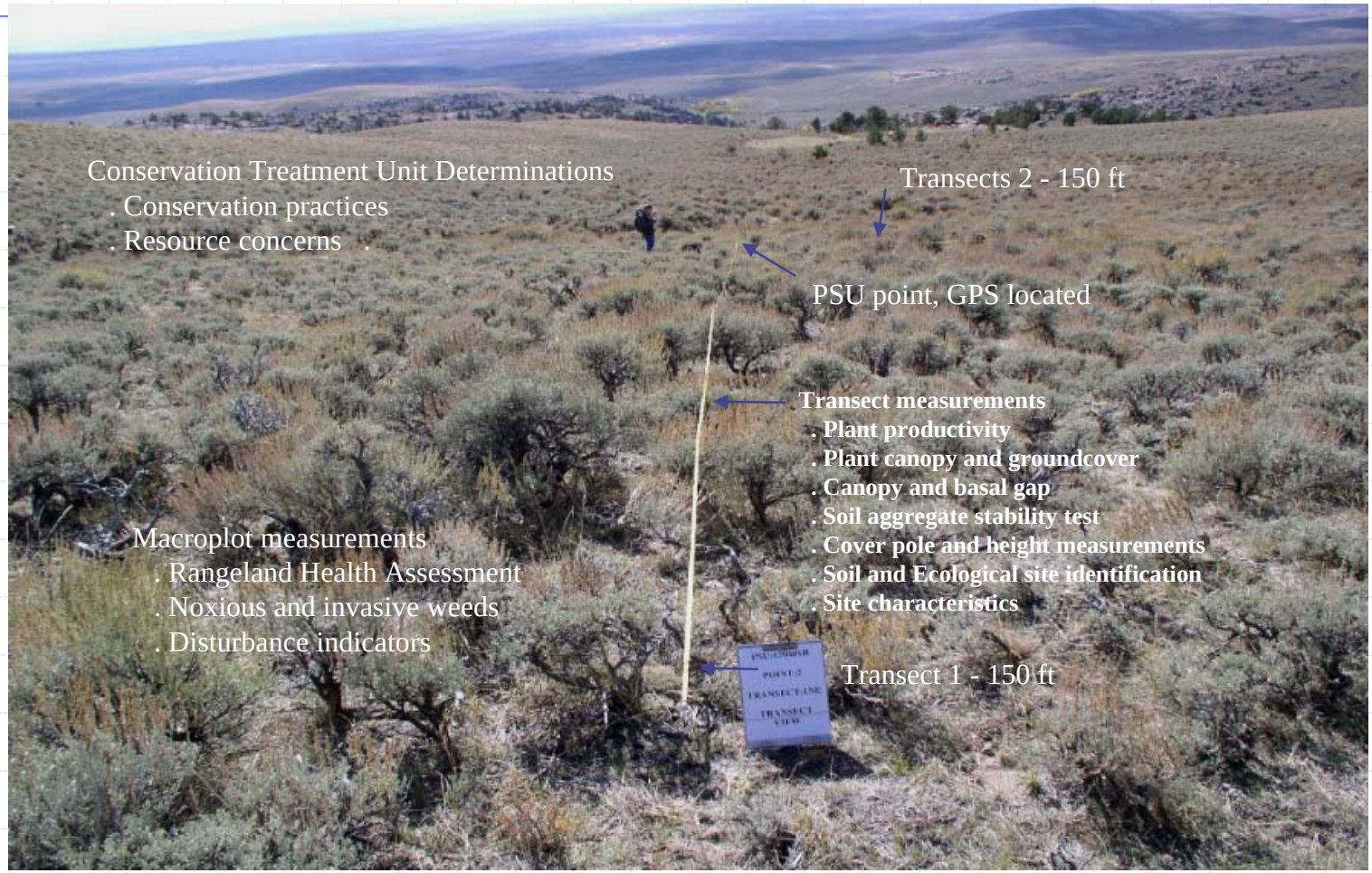
State 1: Open Grassland/Oak Hillside Community (HCPC)

Model Predictions return periods based on 50 years climate data.

(Return)(Period)	(Precip)(in)	(Runoff) (in)	(Erosion) (t/ac)
(50 yr)	(52.7)	(9.6)	(2.3)
(25 yr)	(49.5)	(3.8)	(2.0)
(10 yr)	(44.5)	(2.9)	(1.4)
(5 yr)	(40.1)	(1.5)	(0.7)
(2.5 yr)	(35.6)	(0.4)	(0.2)
(50 yr) (avg.)	(32.9)	(0.8)	(0.4)

Based on 50 years of climate data, there is a 85 percent chance there will be runoff and delivered sediment for these conditions. [Rangeland Hydrology and Erosion Model (RHEM) predictions—model calibrated from field data]. The average sediment to runoff ratio is (0.4/0.8 = 0.5). For every 1.0 inch

Rangeland NRI Data to assist in development of ESD's



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