



Effect of Grazing Treatment on Soil Moisture in Semi-arid Rangelands

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Project Focus

- *This four-year study uses GIS and remote sensing to:*
 - *Examine specific drought effects relative to livestock grazing/rest treatments and bare earth exposure*
 - *Model and monitor rangeland condition*
 - *Forecast rangeland health/condition using cellular-automata and Markov chain analysis*

Interesting Findings...



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- To address our primary study questions, we...
 - Fenced
 - Pre-sampled
 - Instrumented
- This paper is a product of our instrumentation



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Focus of this Paper

- Compare soil moisture levels at the O'Neal study area across three treatment pastures:
 - Simulated Holistic Planned Grazing (SHPG)
 - Rest-rotation (RESTROT)
 - Total Rest (TREST)



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Why Soil Moisture?

- Water is the limiting factor
- Soil moisture typically has a direct relationship with ground cover
- But, is there also a treatment effect? Or interaction?
 - Can grazing animals effect soil moisture?
 - Does the type of grazing have any effect?



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The Study Area

- The O'Neal Ecological Reserve was donated to ISU's Department of Biological Sciences by Robin O'Neal. This 100 ha site is located about 30 miles south of Pocatello, Idaho.
- Surrounding BLM land adds another 1467 ha.





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Soils in the Study Area

- The entire study area is McCarey series-McCarey variant.
 - Shallow, well-drained soils over basalt flows
 - Originally formed from weathered basalt, loess, and silty alluvium



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Pre-treatment Sampling



- Vegetation cover
- Hi-res aerial photography (2" resolution)

Grazing



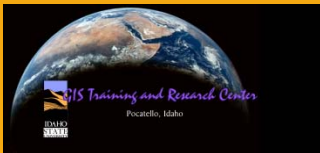
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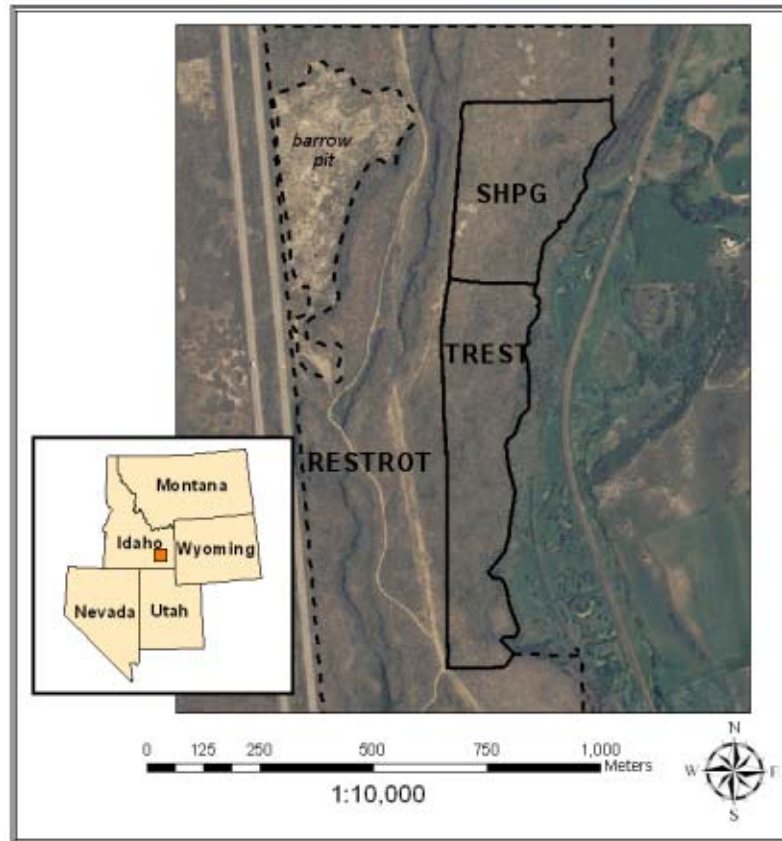
- Prior to this experiment (i.e., up to and including 2005)
 - No fences existed
 - Grazed as a single rest-rotation allotment (1467ha +)
 - 300 head of cattle for one month (May)



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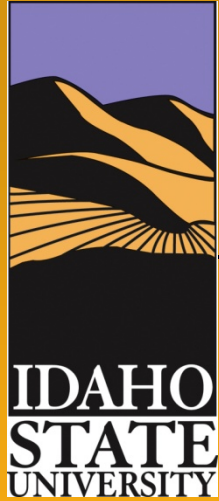
Treatment Pastures





Grazing (cont'd)

- This experiment:
 - Rest-rotation (RESTROT): 300 head of cattle graze for one month (May of each year)(1467ha)
 - Simulated Holistic Planned Grazing (SHPG): 125 head of cattle graze for six days (first week in May)(11ha)
 - Total Rest (TREST): Zero livestock (13ha)



Grazing Summary

■ Stocking information

Treatment	Animal Days/ha
Simulated Holistic Planned Grazing (SHPG)	36
Rest Rotation (RESTROT)	6
Total Rest (TREST)	0



Instrumentation (cont'd)

- Soil moisture can be estimated using:
 - Electrical resistance blocks
 - Tensiometers
 - Gravimetric calculations
 - Neutron probes
 - Time domain reflectrometry
 - **Capacitance sensors**
 - Decagon ECH₂O-10
 - 10cm depth





Instrumentation

- 36 Decagon soil moisture probes
- 12 in each pasture (three replicates of four probes)
- Accuracy= $\pm 2\%$ Volumetric Water Content (VWC) (*after calibration*)
 - %VWC estimates the amount of stored water on a volumetric (not gravimetric) basis



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Instrumentation (cont'd)

- Weather station on site (inside TREST pasture)



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Annual Sampling

- Vegetation cover (point-intercept transects)
 - 50 randomly located plots per treatment
 - Two 10 meter transects per plot
 - Transects placed perpendicular to each other (forms a “+”)
 - 100 observations per transect
 - Designed to sample SPOT5 satellite pixels



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Annual Sampling (cont'd)

- Forage estimates (hoop sampling)
- Photo points
- SPOT5 Satellite imagery



Soil Moisture is a Function of...

- Soil type/structure (no difference can be attributed in this case, as the entire study area is one homogeneous soil type)
- Plant cover (more plants tend to mean lower water content in the soils...its all in the plants)
- **Animal impact?**



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Hypothesis to test

- Does animal impact (trampling and breaking of soil crust) have a measurable effect on soil moisture?
 - If so, is the effect positive or negative?



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The Data

- Soil moisture (%VWC) was collected every six hours beginning in **June** 2006
- All probes were calibrated ($R^2 = 0.997$)
- Mean soil moisture was calculated for each day and each week

The Analysis



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- Data from the growing season (April 1-August 30)
- Compared statistically, for example
 - SHPG 2006 vs. RESTROT 2006
 - SHPG 2006 (50%) vs. SHPG 2006 (50%)
 - Week * Year * Pasture

Between pastures

Within pastures

All effects



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Statistical Tests

- Daily means tested with single-factor ANOVA
- Weekly means tested with Mixed-Procedures Models
 - Fixed effects calculated with Prasad-Rao-Jeske-Kackar-Harville method.
 - Degrees of freedom follows Kenward-Roger method.



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RESULTS

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Pre-treatment Conditions

- No difference in vegetation cover (shrubs, grasses, litter, and bare ground exposure)...
 - Save for a difference in shrub cover between the SHPG and TREST pastures (TREST > SHPG)





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Vegetation Conditions

- During the study (2006-2008)
 - The difference in shrub cover between SHPG and TREST persisted
 - No other changes were found...
 - Except litter, which was significantly higher in SHPG beginning in 2007 ($P < 0.001$)





Tests Between Pastures

- SHPG %VWC higher in 2006-2008 ($P < 0.001$)

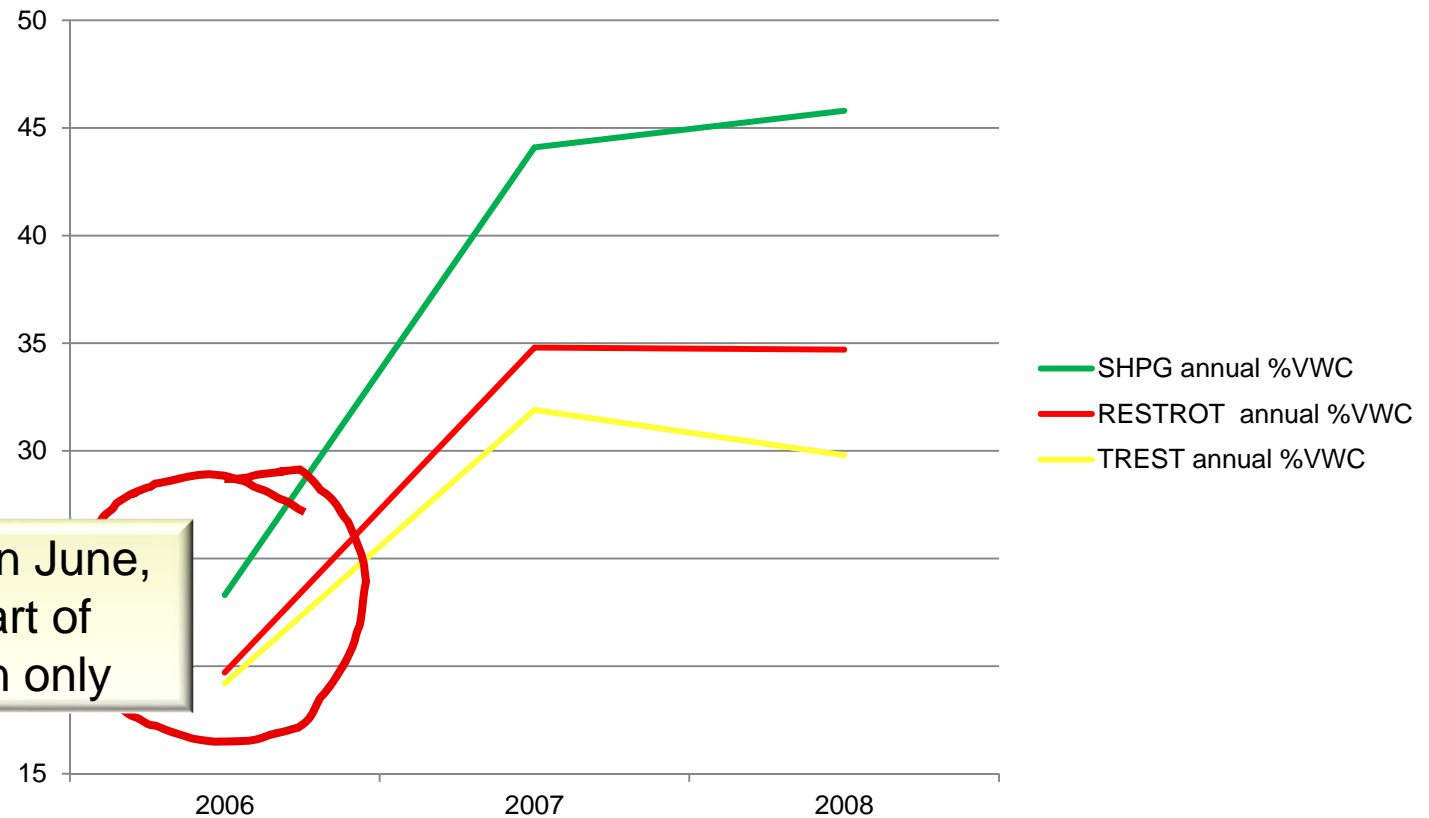
Treatment	\bar{x} %VWC		
	2006	2007	2008
SHPG	23.3	44.1	45.8
RESTROT	19.7	34.8	34.7
TREST	19.2	31.9	29.8



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Between Pastures (cont'd)



Started in June,
dry part of
season only

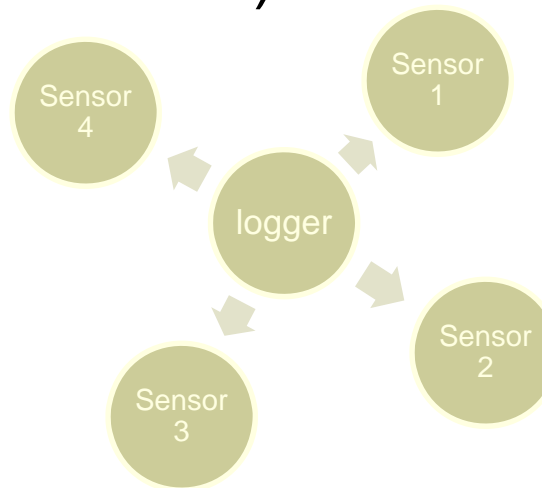


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Tests Within Pastures

- Compared daily mean %VWC of 6 sensors vs. 6 sensors
- One pair from each set of loggers
 - SHPG ($P = 0.03$) different
 - RESTROT ($P = 0.15$) no difference
 - TREST ($P = 0.12$) no difference





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Comparisons in Context

- Within pasture differences were less than between pasture differences



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Mixed Procedures Model and Type Three Test of Fixed Effects

- Significant effects ($P \leq 0.05$)
 - WEEK ($F_{stat} = 92$)
 - YEAR x PASTURE ($F_{stat} = 20$)
 - WEEK x YEAR ($F_{stat} = 6$)
 - PASTURE ($F_{stat} = 5$)



The Big Picture

- The differences in soil moisture can be attributed to:
 - Environmental effects (for example...)
 - Soils in week 2 were wetter than week 18
 - Soils in the SHPG pasture were wetter in 2007 than in 2008
 - Soils in week 10 of 2007 were wetter than soils in week 10 of 2008
 - Treatment effects (for example)
 - Soils in the SHPG pasture were wetter than the other pastures

Animal Impact (revisited)



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- Does trampling and breaking of soil crust have a measurable effect?
 - Focus on the production pastures which
 - Have statistically different %VWC
 - Diverging soil moisture trends
 - Are both grazed by cattle in May
 - **But...**



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Not all Grazing is the Same

■ Time... Animal Days per hectare

Treatment	Animal Days/ha
Simulated Holistic Planned Grazing (SHPG)	36
Rest Rotation (RESTROT)	6
Total Rest (TREST)	0

■ Effect on litter (aka mulch)

A likely “mechanism”





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Too Much of a “*Good thing*”

- Six days of grazing at high AD/ha appears to benefit rangelands
- However, 10 days or 14 days or 21 days may damage rangelands
- **It's all about TIME**



Thank You

■ Questions?

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This study was made possible by a grant from the National Aeronautics and Space Administration Goddard Space Flight Center. ISU would also like to acknowledge the Idaho Delegation for their assistance in obtaining this grant.

