SageSTEP Pinyon-Juniper Hydrology: Implications for Rangeland CEAP

Fred Pierson – PI & Research Rangeland Hydrologist
Jason Williams – Hydrologist & Support Scientist
Osama Al-Hamdan – Post-Doc Research Scientist

ARS - Northwest Watershed Research Center, Boise ID
1. What are the hydrologic impacts of woodland encroachment?
2. What effects do tree reduction treatments have on short- and long-term hydrologic response?
Conceptual Framework for Assessing Hydrologic Impacts

Rainfall Intensity
- High
- Low

Hydro Process Transition Zone

Concentrated Flow
- Fire

Phase III PJ

Rainsplash-Sheetflow

Sagebrush Steppe - Good Condition

Site Susceptibility
- Bare Ground +
+ Ground Cover -
+ Surface Roughness -
- Soil Water Repellency +
+ Aggregate Stability -

Runoff and Erosion Overland Flow Velocity

Hydrologic Vulnerability

Phase I - II PJ
Woodland Encroachment

Heterogeneous Cover/Soils

Hydrologically Stable

Coarsened Structure

Hydrologically Unstable
Woodland Encroachment

Hydrologically Stable – Rainsplash Processes

Published REM Nov - 2010

Transition Zone

Concentrated Flow

Cumulative Runoff (mm)

Bare Soil and Rock Cover (%)

Sediment Yield (g·m⁻²)

Cumulative Runoff (mm)

Sediment Yield (g·m⁻²)
Assessing Treatment Impacts

Rainfall Intensity
- High
- Low

Hydro Process Transition Zone
- Fire

Concentrated Flow
- Phase III PJ

Rainsplash-Sheetflow
- Phase I - II PJ

Sagebrush Steppe - Good Condition

Hydrologic Vulnerability
- Runoff and Erosion
- Overall Flow Velocity

Site Susceptibility
- Bare Ground +
- Ground Cover -
- Surface Roughness -
- Soil Water Repellency +
- Aggregate Stability -
Onaqui, UT Treatment Effects

### Interspace

- **Cumulative Runoff (L)**
  - Bullhog: 60 L
  - Fire: 50 L
  - Cut: 40 L

- **Total Sediment (g)**
  - Bullhog: 150 g
  - Fire: 200 g
  - Cut: 160 g

### Juniper Coppice

- **Cumulative Runoff (L)**
  - Fire: 70 L
  - Bullhog: 5 L

- **Total Sediment (g)**
  - Fire: 3000 g
  - Bullhog: 500 g
Marking Corral, NV Treatment Effects

**Interspace**
- Cumulative Runoff (L)
- Control vs. year 1

<table>
<thead>
<tr>
<th>Fire</th>
<th>Cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>

**Juniper/Pinyon Coppice**
- Cumulative Runoff (L)
- Control vs. year 1

<table>
<thead>
<tr>
<th>Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
</tr>
</tbody>
</table>

**Interspace**
- Total Sediment (g)
- Control vs. year 1

<table>
<thead>
<tr>
<th>Fire</th>
<th>Cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>140</td>
<td>30</td>
</tr>
</tbody>
</table>

**Juniper/Pinyon Coppice**
- Total Sediment (g)
- Control vs. year 1

<table>
<thead>
<tr>
<th>Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
</tr>
</tbody>
</table>
Summary

Short-term Impacts
(concentrated flow)

1. Fire has largest impact on tree coppice

2. Fire impact on tree interspaces – depends on GC

3. Cut trees have minimal positive impact on erosion

4. Bullhog has little impact on overland flow – cover on tree coppice
Long-term Impacts of Juniper Control

- Hydrologic Vulnerability
  - Rainfall Intensity
    - High
    - Low
  - Rainsplash-Sheetflow
  - Sagebrush Steppe - Good Condition
  - Juniper Woodland (Steens Mtn., OR)
  - Site Susceptibility

- Concentrated Flow
  - Fire
  - Phase III PJ

- Erosion
  - 85% bare
  - 145 g erosion
  - 40% bare
  - 20 g erosion
  - 60% bare
  - 45 g erosion

20-Year Juniper Control
10-Year Juniper Control
### SageSTEP: Regional Conservation Effects

#### Replication by Experiment Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Replication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Rainfall Plots</td>
<td>324</td>
</tr>
<tr>
<td>Small Rainfall Plots</td>
<td>974</td>
</tr>
<tr>
<td>Concentrated Flow Plots</td>
<td>930</td>
</tr>
</tbody>
</table>

#### Replication by Plant Community

<table>
<thead>
<tr>
<th>Community</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrubland Sites</td>
<td>6</td>
</tr>
<tr>
<td>Woodland Sites</td>
<td>5</td>
</tr>
</tbody>
</table>

**Soil Types:** loam, silt loam, sandy loam
USDA – CEAP: Rangeland Conservation Environmental Assessment Project

**User’s Input**
- Storm
- Slope
- Soil

**K_e, F_e, F_r, K_{ss}, K_c, \tau_c**

**Hydrology & erosion parameters**

**Model Core**
- Hydrology (Infiltration) (Overland flow generation)
- Erosion processes (Splash and sheet erosion) (Concentrated flow erosion)

**Model Output**
- Hydrograph
- Sediment yield
- Soil loss uncertainty

**USDA Agricultural Research Service**

**NRCS Natural Resources Conservation Service**

**RHEM Web Tool**
- Rangeland Hydrology and Erosion Model Web Tool
### SageSTEP contributions to model development:

#### Friction factor ($f$): (R$^2$=0.54)
\[
\log f = 0.298 + 1.156 \text{litter} + 1.956 \text{basal} + 1.383 \text{rock} - 1490 Q + 1.565 S
\]

#### Velocity ($V$): (R$^2$=0.51)
\[
\log V = -0.953 - 0.471 \text{litter} - 0.685 \text{basal} - 0.562 \text{rock} + 957 Q + 0.273 S
\]

- **litter**, **basal**, and **rock**: are the fractions of litter cover, basal plant and cryptogam cover, and rock cover to the total ground area respectively.
- **bare**: is the bare soil fraction of the total ground area.
- **$Q$**: is the rill discharge
- **$S$**: is the average slope

---

**Submitted for Publication**

**Water Resources Research**

---

**Model uses data commonly obtained in rangeland assessments.**
Rangeland - CEAP
Conservation Effects Assessment Project

Conservation Practices
- Fire management
- Brush management
- Prescribed grazing
- Range Seeding
- Pest management
- Riparian management
- Habitat Management

Initial focus of CEAP for Rangelands

AGWA – Rangeland
SWAT and KINEROS
Watershed assessment

National Assessments
- Natural Resource Inventory
- RHEM hillslope-scale
- Future Watershed-scale
Publications


