Improving Water Quality of Grazing Lands

Kevin Wagner
1. Evaluate effects of providing alternative water on:
   - Percent time cattle spend near stream
   - Bacteria (E. coli) loading

2. Evaluate effects of grazing management on bacteria runoff from:
   - Rangeland
   - Improved pasture
   - Irrigated pasture
Objective 1 - Alternative Water
(2S Ranch, Lockhart)
Alternative Water Evaluation

Samples collected bi-monthly at ranch inlet (PC1) & outlet (PC2)
Objective 1 – Methods

- **Flow Measurement**
  - Calculated from flow depth using Manning’s Equation

- **E. coli Analyses**
  - EPA Method 1603

- **Treatments**
  - **Year 1:**
    - No alternative water provided
  - **Year 2:**
    - Alternative water provided along with stream access
Alternative Water Evaluation
Cattle Tracking – quarterly using GPS collars
Alternative Water Evaluation
GPS Collar Results
Alternative Water Evaluation
GPS Collar Results

- Statistically significant difference between treatments at 15, 35 & 50 ft

<table>
<thead>
<tr>
<th>% Time Near Stream</th>
<th>15 ft</th>
<th>35 ft</th>
<th>50 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Alternative Water</td>
<td>1.8%</td>
<td>4.5%</td>
<td>6.8%</td>
</tr>
<tr>
<td>With Alternative Water</td>
<td>0.9%</td>
<td>2.2%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Percent Reduction</td>
<td>-48%</td>
<td>-52%</td>
<td>-53%</td>
</tr>
</tbody>
</table>
## Alternative water supply effectiveness

<table>
<thead>
<tr>
<th>Reduction in Time Spent in Stream</th>
<th>Reduction in Time Spent near Stream</th>
<th>Percent time cattle drank from trough</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48-53%</td>
<td></td>
<td>This Study</td>
</tr>
<tr>
<td>90%</td>
<td></td>
<td></td>
<td>Miner et al. (1992)</td>
</tr>
<tr>
<td>85%</td>
<td>53%</td>
<td>73.5%</td>
<td>Clawson (1993)</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td></td>
<td>Godwin and Miner (1996)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>92%</td>
<td>Sheffield et al. (1997)</td>
</tr>
</tbody>
</table>
Alt. Water Effect on *E. coli* Conc.

- **Median *E. coli* conc. (without alt. water)**
  - PC1 = 89 cfu/100 ml
  - PC2 = 161 cfu/100 ml

- **Median *E. coli* conc. (with alt. water)**
  - PC1 = 147 cfu/100 ml
  - PC2 = 470 cfu/100 ml
Alt. Water Effect on *E. coli* Conc.

- No statistically significant difference between PC1 & PC2 conc. before treatment (p=0.1835)
- Statistically significant difference between PC1 & PC2 conc. after treatment (p=0.0209)
Alt. Water Effect on *E. coli* Load

- **Median *E. coli* load (without alt. water)**
  - PC1 = 1.3 G-org/day
  - PC2 = 1.9 G-org/day

- **Median *E. coli* load (without alt. water)**
  - PC1 = 0.3 G-org/day
  - PC2 = 0.9 G-org/day
Alt. Water Effect on *E. coli* Load

- Median daily load (billion org./day)
  - Pre-BMP = 0.82
  - Post-BMP = 0.45

- Pre-BMP & post-BMP load not significantly different (p=0.7566)
Conclusions - Alternative Water

- Statistically significant reduction (of 48-53%) observed in the % time cattle spent within 15, 35, and 50 ft of the stream as a result of providing alternative water.

- However, no concurrent statistically significant change in *E. coli* levels observed.
  - Possibly due to degraded range conditions resulting from prolonged drought.
Objective 2 - Grazing Management Evaluation
Objective 2 – Grazing Mgt. Eval.

- **Objective**
  
  Evaluate effects of grazing management on bacteria runoff from (1) rangeland, (2) improved pasture and (3) irrigated pasture

- **3 Treatments Tested (8 total treatments)**
  
  1: No grazing
  
  2: Moderate (prescribed) grazing
  
  3: Heavy grazing (2 x moderate stocking rate)
    
    - No heavy grazing @ Riesel
USDA-ARS Research Center, Riesel
Improved Pasture Site
Texas A&M Beef Cattle Systems Center
Irrigated Pasture Site
Objective 2 – Methods

- **Rainfall Measurement**
  - Tipping bucket rain gage

- **Flow Measurement**
  - V-notch weir with bubble flow meter

- **Sample Collection**
  - Automated samplers

- **E. coli Analyses**
  - EPA Method 1603
Objective 2 - Results
Welder Wildlife Foundation

- No runoff since work began in Nov. 2007
- 21.6 inches of rain between Nov. 07 & Sep. 09
Grazing Mgt. Effect on *E. coli* Conc

**Median *E. coli* conc. (cfu/100 ml)**
- BB1 (ungrazed) = 7,600
- BB2 (mod grazed) = 3,670
- BB3 (hvy grazed) = 4,328

**Median *E. coli* conc. (cfu/100 ml)**
- SW12 (ungrazed) = 1,285
- SW17 (mod grazed) = 19,150
Grazing Mgt. Effect on *E. coli* Conc

- SW17 significantly different than SW12 & BB3 (p=0.000)

- BB1, BB2, BB3 & SW12 not significantly different
Comparison of *E. coli* level to Stocking Rate (This study)

Relation of *E. coli* GeoMean to # Stocking Rate

![Graph showing the relation between E. coli GeoMean and grazing days per acre-year.](image-url)
Comparison of *E. coli* level to Stocking Rate (Other studies)

![Graph showing the relation of E. coli GeoMean to # Stocking Rate](image-url)
### Comparison of E. coli level to Stocking Rate (Other studies)

<table>
<thead>
<tr>
<th>Site</th>
<th>Reference</th>
<th>SR</th>
<th># Grazing days/ac/yr</th>
<th>GeoMean EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW12</td>
<td>This study</td>
<td>0.0</td>
<td>0.0</td>
<td>1.09E+03</td>
</tr>
<tr>
<td>SW17</td>
<td>This study</td>
<td>5.7</td>
<td>64.0</td>
<td>2.61E+04</td>
</tr>
<tr>
<td>BB2</td>
<td>This study</td>
<td>6.1</td>
<td>59.8</td>
<td>4.30E+03</td>
</tr>
<tr>
<td>BB3</td>
<td>This study</td>
<td>2.9</td>
<td>125.9</td>
<td>3.08E+03</td>
</tr>
<tr>
<td>BB1</td>
<td>This study</td>
<td>0.0</td>
<td>0.0</td>
<td>8.80E+03</td>
</tr>
<tr>
<td>Grazed pasture</td>
<td>Doran et al. 1981</td>
<td>2.9</td>
<td>124.5</td>
<td>3.59E+04</td>
</tr>
<tr>
<td>Ungrazed pasture</td>
<td>Doran et al. 1981</td>
<td>0.0</td>
<td>0.0</td>
<td>4.16E+03</td>
</tr>
<tr>
<td>Ungrazed pasture</td>
<td>Robbins et al. 1971</td>
<td>0.0</td>
<td>0</td>
<td>1.89E+04</td>
</tr>
<tr>
<td>Grazed pasture</td>
<td>Robbins et al. 1972</td>
<td>1.2</td>
<td>312.8</td>
<td>6.30E+03</td>
</tr>
<tr>
<td>RA</td>
<td>Edwards et al. 1997</td>
<td>2.3</td>
<td>156.3</td>
<td>2.33E+03</td>
</tr>
<tr>
<td>RB</td>
<td>Edwards et al. 1998</td>
<td>2.3</td>
<td>156.3</td>
<td>1.70E+04</td>
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<tr>
<td>WA</td>
<td>Edwards et al. 1999</td>
<td>7.7</td>
<td>47.5</td>
<td>5.48E+03</td>
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<tr>
<td>WB</td>
<td>Edwards et al. 2000</td>
<td>3.0</td>
<td>121.4</td>
<td>3.47E+04</td>
</tr>
</tbody>
</table>
Grazing Mgt. Effect on *E. coli* Load

- **Median *E. coli* load (10^9 cfu/storm event)**
  - BB1 (ungrazed) = 2.2
  - BB2 (mod grazed) = 6.6
  - BB3 (hvy grazed) = 3.5

- **Median *E. coli* load (10^9 cfu/storm event)**
  - SW12 (ungrazed) = 3.5
  - SW17 (mod grazed) = 18.4

- Differences significant at p=0.057
Comparison of *E. coli* load to Stocking Rate (This study)

Relation of *E. coli* Load to # Stocking Rate

![Graph showing the relation between E. coli load and stocking rate.](image-url)
Comparison of *E. coli* load to Stocking Rate (Other studies)

Relation of *E. coli* Load to # Stocking Rate

\[ y = 3 \times 10^8 x + 4 \times 10^{10} \]

\[ R^2 = 0.6257 \]
### Comparison of *E. coli* load to Stocking Rate (Other studies)

<table>
<thead>
<tr>
<th>Site</th>
<th>SR</th>
<th># Grazing days/ac/yr</th>
<th>E. coli load/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW12</td>
<td>0.0</td>
<td>0.0</td>
<td>1.33E+10</td>
</tr>
<tr>
<td>SW17</td>
<td>5.7</td>
<td>64.0</td>
<td>6.50E+10</td>
</tr>
<tr>
<td>BB2</td>
<td>6.1</td>
<td>59.8</td>
<td>6.17E+10</td>
</tr>
<tr>
<td>BB3</td>
<td>2.9</td>
<td>125.9</td>
<td>4.56E+10</td>
</tr>
<tr>
<td>BB1</td>
<td>0.0</td>
<td>0.0</td>
<td>4.59E+10</td>
</tr>
<tr>
<td>Doran et al. 1981</td>
<td>2.9</td>
<td>124.5</td>
<td>6.89E+10</td>
</tr>
<tr>
<td>Doran et al. 1981</td>
<td>0.0</td>
<td>0.0</td>
<td>1.49E+10</td>
</tr>
<tr>
<td>Robbins et al. 1971</td>
<td>0.0</td>
<td>0.0</td>
<td>7.65E+10</td>
</tr>
<tr>
<td>Robbins et al. 1972</td>
<td>1.2</td>
<td>312.8</td>
<td>1.28E+11</td>
</tr>
</tbody>
</table>
Conclusions - Grazing Management

- At Riesel, statistically significant (order of magnitude) increase in concentrations and loadings at moderately grazed site over ungrazed site
- At A&M Beef Cattle Systems Center, no statistically significant difference between treatments
- E. coli levels in runoff from ungrazed continue to be significantly greater (i.e. 2 orders of magnitude) than Texas Water Quality Standards
Continued Research

- **Grazing mgt** evaluation to continue through ~June 2011 (possibly expand to analysis of fecal coliform & *enterococcus*)
- **Alternative water** to be evaluated at another site (with more riparian veg.) using GPS collars only
- **Use of rip-rap to exclude cattle** to be evaluated at Beef Cattle Systems Center then potentially at cooperator’s ranch
Continued Research

- **Stream crossing** to be evaluated using GPS collars
- **Shade** to be evaluated at another site using GPS collars
- **Other BMP** Evaluation Needs?
Questions?

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http://grazinglands-wq.tamu.edu/index.php