A PRELIMINARY EXAMINATION OF THE EFFECTS OF FERAL PIGS ON WATER QUALITY AND SOIL LOSS WITHIN A HAWAIIAN WATERSHED

NREM Dept.
Chad Browning
Dr. Greg Bruland
Dr. Carl Evensen
Problems & Speculations

- **Spread disease** (Freed et al. 2005, USGS 2006)

- **Destroy/consume native vegetation** (Drake 2001, Sweetapple 2004); **Spread invasive plants** (Stone et al. 1992)

- **Reduce soil cover** (Mitchell 1997)

- Increase soil loss and runoff

- Sedimentation into streams, estuaries, and coral reefs

- Intensify flooding?
Objectives

- How much runoff is generated in the forested areas of Mānoa watershed?

- How do characteristics (slope, soil type, ground cover, canopy cover, and feral pig disturbance) influence runoff and soil loss within Mānoa watershed?

- What is the water quality of runoff from these higher forested reaches? Are there differences between runoff amount and sediment loads in the plots where feral pig activity is excluded and those that are unrestricted?
Manoa Watershed

Legend

<table>
<thead>
<tr>
<th>Slope (%)</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 15</td>
<td>Light yellow</td>
</tr>
<tr>
<td>15 - 30</td>
<td>Orange</td>
</tr>
<tr>
<td>30 - 60</td>
<td>Red</td>
</tr>
<tr>
<td>60 - 90</td>
<td>Dark red</td>
</tr>
<tr>
<td>90 - 306</td>
<td>Maroon</td>
</tr>
</tbody>
</table>

Pig Plot Sites

Streams

Trails

Streets

Pauoa Flats (PF)

Manoa Cliffs (MC)

Manoa Falls (MF)

Round Top (RT)

Puu Pia (PP)

Palolo (PLO)

Waahila Ridge (WR)
Site Layout
How do these interact to influence runoff?

Runoff collection

- Soil Type
- Veg Cover
- Soil Moisture
- Through-fall
- Total Amount
- TSS
- Slope

What is the content and amount of runoff?
Data Collection – Runoff

- **Antecedent conditions**
  - Soil Series
  - Slope readings (clinometer)
  - Soil water content
  - Vegetation monitoring

- **After rain event**
  - Throughfall gauge
  - Runoff collection
    - Total volume
    - TSS
Data Analyses

- One-way ANOVA
  - Fenced vs. Unfenced
  - Among Sites
  - Post-hoc comparison of means w/ LSD test

- Correlation/Multiple Regression Analysis
  - Spearman (non-linear)
Vegetation Monitoring

Manoa Cliffs (fenced)

- Rocks
- Roots
- Green Veg
- Litter
- Bare Soil

Manoa Cliffs (unfenced)
Avg. Runoff Amount

Runoff Amount (L)

Fenced
Unfenced
Avg TSS in Runoff by Month

TSS (g/L)

<table>
<thead>
<tr>
<th>Month</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov</td>
<td>0.013</td>
</tr>
<tr>
<td>Dec</td>
<td>0.015</td>
</tr>
<tr>
<td>Jan</td>
<td>0.006</td>
</tr>
<tr>
<td>Feb</td>
<td>0.081</td>
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</table>
### Correlations with Runoff

<table>
<thead>
<tr>
<th></th>
<th>RO Amt</th>
<th>TSS</th>
<th>TDS</th>
<th>Thru-fall</th>
<th>Slope</th>
<th>SMoist</th>
<th>Canopy Cov</th>
<th>Mid Cov</th>
<th>Bare Cov</th>
</tr>
</thead>
<tbody>
<tr>
<td>RO Amt</td>
<td>0.66</td>
<td>-0.55</td>
<td>0.64</td>
<td>NS</td>
<td>0.76</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>TSS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.70</td>
<td>0.72</td>
<td>NS</td>
<td>0.50</td>
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<tr>
<td>TDS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>-0.61</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Thru-fall</td>
<td>NS</td>
<td>0.61</td>
<td>NS</td>
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<td>NS</td>
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<td>NS</td>
<td></td>
</tr>
<tr>
<td>Bare Cov</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

**TSS = -0.03 + 0.10(SoilMoisture) + 0.03(BareSoilCover)**
Conclusions

- Heterogeneity between sites and over time
- Changes in vegetation cover over time
- Large amounts of runoff produced
- TSS trend over time
- Soil water content – highly correlated
Management Implications

- Identification of areas in the watershed most susceptible to runoff and soil loss
- Provide baseline data that can be used for CBA
- Additional research needed
Acknowledgments

- Thesis committee: Dr. Greg Bruland, Dr. Carl Evensen, Dr. Ali Fares

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MAHALO

Questions?
Avg TSS in Runoff by Month

<table>
<thead>
<tr>
<th>Month</th>
<th>TSS (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOV</td>
<td>0.013</td>
</tr>
<tr>
<td>DEC</td>
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</tr>
<tr>
<td>JAN</td>
<td>0.006</td>
</tr>
<tr>
<td>FEB</td>
<td>0.081</td>
</tr>
</tbody>
</table>
Hypotheses

- Runoff and erosion in forested areas of the Mānoa watershed will be correlated with throughfall and slope.

- Forested areas open to pig activity will produce more runoff and erosion than areas in which pig activity has been excluded.

- Areas open to pig activity will negatively affect water quality through increased sediment transport and nutrient input.
Outline

- Introduction
- Objectives
- Materials and Methods
- Results
- Conclusions
- Questions
Conclusions – Hypotheses

- Hypothesis 1 – Correlation between throughfall amount and slope
- Hypothesis 2 – More runoff and erosion in unfenced areas
- Hypothesis 3 – Reduced water quality content in runoff from unfenced plots
Runoff Collection

- Activated prior to target week
- Collected after target rainfall (then deactivated)
- Collect only portion of total runoff after thoroughly mixed
Runoff Results (TSS)

- Lyon
- Manoa Cliffs
- Manoa Falls
- Palolo
- Pauoa Flats
- Puu Pia
- Round Top
- Waahila Ridge
Vegetation Monitoring
Canopy Cover

***Canopy cover remained the same for all 4 months***
Mid-canopy cover remained the same for all 4 months.
# Slope and Background Data

<table>
<thead>
<tr>
<th>Site</th>
<th>Elevation</th>
<th>Slope (handheld clinometer)</th>
<th>Soil Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyon</td>
<td>215m</td>
<td>15-16%</td>
<td>Lolekaa Silty Clay</td>
</tr>
<tr>
<td>Manoa Cliffs</td>
<td>450m</td>
<td>8%</td>
<td>Rough Mountainous</td>
</tr>
<tr>
<td>Manoa Falls</td>
<td>171m</td>
<td>16-18%</td>
<td>Lolekaa Silty Clay</td>
</tr>
<tr>
<td>Palolo</td>
<td>225m</td>
<td>25-27%</td>
<td>Rough Mountainous</td>
</tr>
<tr>
<td>Pauoa Flats</td>
<td>538m</td>
<td>6%</td>
<td>Rough Mountainous</td>
</tr>
<tr>
<td>Puuu Pia</td>
<td>209m</td>
<td>26%</td>
<td>Lolekaa Silty Clay</td>
</tr>
<tr>
<td>Round Top</td>
<td>340m</td>
<td>25-26%</td>
<td>Tantalus Silt Loam</td>
</tr>
<tr>
<td>Waahila Ridge</td>
<td>340m</td>
<td>14%</td>
<td>Manana Silty Clay</td>
</tr>
</tbody>
</table>