Managing Water Yield from Pine Forests

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What is Water Yield?

**Water Yield = Precipitation (P) – Evapotranspiration (ET)**

- Fraction of rainfall that becomes surface and groundwater

Adopted from Ellison et al (2012)
Core Concept: Lower ET slightly $\rightarrow$ Increase WY a lot

**ET $\approx 2.9$ mm/day** *(Gholz and Clark, 2002)*

**ET $\approx 2.2$ mm/day** *(Bracho et al., 2008)*

Yield and ET relative to rain.

[Diagram showing percentage of yield and ET relative to rain]
Previous Work: Water Yield Model

Pine Plantation (PP-High/Low)

Low Basal Area (LBA 8-14)

Stand Age $\rightarrow$ LAI

Basal Area $\rightarrow$ LAI

Leaf Area Index (LAI) $\rightarrow$ ET/PPT

Water Yield $= \left(1 - \frac{ET}{PPT}\right) \times MAP$

Cumulative over a 25-yr rotation

McLaughlin et al (2014)
Previous Results: Cumulative Water Yield (CWY)

Pine plantations (PP) vs. systems managed for lower basal area (LBA)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>All PP in SJRWMD</th>
<th>ΔCWY (MGD) Public PP in SJRWMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBA-8</td>
<td>202 to 268</td>
<td>40 to 53</td>
</tr>
<tr>
<td>LBA-10</td>
<td>104 to 170</td>
<td>21 to 34</td>
</tr>
<tr>
<td>LBA-12</td>
<td>27 to 92</td>
<td>5 to 18</td>
</tr>
<tr>
<td>LBA-14</td>
<td>-37 to 29</td>
<td>-7 to 6</td>
</tr>
<tr>
<td>LBA-14+Fire</td>
<td>96 to 162</td>
<td>19 to 32</td>
</tr>
</tbody>
</table>
Model Estimates: Lingering Uncertainty

Sources of uncertainty:
- Climatic variation and site/soil differences
- Species effects
- Water use in young stands
- Fire effects

Solution: A more rigorous, field based approach to estimate vegetation water use and water yield

McLaughlin et al., 2014
Study Design: Forest Water Use

Management Actions:
Typical silviculture, thinning, fire, herbicide, species

Guides Treatment Selection

Environmental Setting:
Soils, climate, water table depth

Guides Site Selection

6 sites, 6 plots/site, 3 banks/plot
Wires in the Woods: Measuring Soil Water

6 sites

6 plots/site: LAI, BA, fire treatments

Three sensor banks/plot

15 minute soil moisture + water table

Diagram showing soil moisture measurement setup with PVC well, data logger, and water table.
**Analysis Methods: High Resolution Water Balance**

- Use diurnal signal in total soil moisture (TSM) from sensor observations
- Significantly lower cost than other approaches (e.g., eddy covariance)

\[ ET = TSM_j - TSM_{j+1} + 24 \times Q \]
Across Site ET: Water Use (ET/PET)

\[ y = 0.076x + 0.49 \]
\[ R^2 = 0.52 \]

\[ y = 0.0037x - 0.11 \]
\[ R^2 = 0.41 \]

\[ y = 0.70x + 0.18 \]
\[ R^2 = 0.74 \]
Year 2 (of 4) Results: Water Use (ET/PET)

Plots at Green Swamp Site
1. Clear cut
2. Mature pine, sparse understory
3. Mature pine, dense understory
4. Moderately thinned pine
5. Extremely thinned pine
6. Longleaf pine—with sparse understory

Daily ET (cm)
Conclusions and Ongoing Work

• Significant effect of forest attributes on water use
• Differences due to understory management can be substantial
• Soil water balance method works

Further work:
• Continued measurements across sites and climate variation
• Contend with interception losses to actually measure WY
• Fire, species effects
• Scaling using satellite based LAI measurements
Thank You!

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