An Irrigation Scheduling Web Application for Managing Limited Water Supply
Next Generation Irrigation Scheduling

Going beyond field level ET demand/replacement

-- to --

Multi-Field Irrigation Optimization
(Deficit Irrigation)
Key Challenges

- Efficiency is linked to irrigation intensity
  → Efficiency must be simulated explicitly

- Farm level optimization depends on all fields
  → Fields must be scheduled conjunctively

- Conjunctive scheduling must consider farm level irrigation capacity
  → Optimization must be sensitive to water supply & delivery constraints

- Optimization implies some level of deficit irrigation
  → Yield reductions must be simulated
Irrigation Management with limited water supply

- **Irrigation Efficiency Model**: designed specifically for simulating consequences of less than full irrigation (deficit irrigation)

- **Irrigation Management Online**: user interface components for managing limited water supply
  - Short term constraints
  - Long term constraints
  → User is integral part of optimization process
Scheduling for Four Crops on Seven Fields

Water demand and supply

- Peas
- Alfalfa
- Wheat
- Potatoes

Limit
Example Seasonal Water Demand Output

Water Use

- Total
- App: Potatoes
- App: Winter Grain
- App: Rapeseed (Canola)
- App: Peas
- App: Alfalfa

Water Supply Capacity (2,383)
Proposed Changes

- A small field of alfalfa in last year of production could be fallowed
- A second field of alfalfa could be deficit irrigated
- A circle of winter wheat could be deficit irrigated
- Alfalfa cutting dates could be shifted slightly
Original & Revised Water Demand
Initial view, after running an analysis. Events are displayed in the form of a modified Gantt chart with each event as a block in the chart.

Clicking these arrows moves the calendar start date one day forward or backward.

Red on Yellow indicates that Supply capacity has been exceeded. Notice that it is exceeded for 14 days.
Clicking on an event also causes **Event Summary** to be updated with info about the event.

Clicking on an event ‘selects’ the event. White on blue indicates selected event.
Value displayed in the event blocks can be Hours of operation (shown in previous screens), Gross application depth, Net application depth, or system flow rate.
Events can be dragged left or right to change their start date. Here, an event is being dragged as indicated by the green rectangle. The rectangle’s color changes to red if the user drags the event to a date when it cannot occur.

Buttons in the event blocks are used to edit the event.

X → delete the event
Arrows → shift the event 1 day forward or backward

Events can be dragged left or right to change their start date. Here, an event is being dragged as indicated by the green rectangle. The rectangle’s color changes to red if the user drags the event to a date when it cannot occur.
After an event is dragged, deleted, or added the Flow Rate row is updated automatically…

A double click in the gray area will create a new event.
Final view, after editing.

After deleting, shifting, and adding several new events the supply capacity is not exceed during the 14 day interval.
Full Season Output
(single field)

- Soil moisture status
- Precipitation
- Application History
- Soil Moisture Measurements
- Recommendations for timing and duration of upcoming irrigations
Tabular Output

- List application dates and amounts
- Field level performance summary
Links to Economic Analysis

- Excel spreadsheet based analysis
- Spreadsheet contains macros to download farm data and recent analyses
- Macros also upload revised yield parameters

→ Facilitates maximum flexibility when enumerating operational costs
### GROSS INCOME Description

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>Yield (tn/ha)</th>
<th>Price ($/Tn)</th>
<th>Gross Income ($/ac)</th>
<th>Total Cost ($/ac)</th>
<th>Gross Margin ($/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marcos Alfalfa Field</td>
<td>1.5</td>
<td>5.0</td>
<td>$7.50</td>
<td>$8.33</td>
<td>-$0.83</td>
</tr>
</tbody>
</table>

### VARIABLE COST Description

<table>
<thead>
<tr>
<th>Operations</th>
<th>Materials Details</th>
<th>Labor $/acre</th>
<th>Machinery $/acre</th>
<th>Materials $/acre</th>
<th>Total Cost $/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate Fertilizers</td>
<td>50.0</td>
<td>15</td>
<td></td>
<td></td>
<td>50.0</td>
</tr>
<tr>
<td>Nitrate Fertilizers</td>
<td>0.0</td>
<td>1</td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Other Fertilizers</td>
<td>0.0</td>
<td>0</td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Herbicide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre emergence</td>
<td>1.0</td>
<td>12.0</td>
<td></td>
<td></td>
<td>12.0</td>
</tr>
<tr>
<td>Post emergence</td>
<td>1.0</td>
<td>20.0</td>
<td></td>
<td></td>
<td>20.0</td>
</tr>
<tr>
<td>Seed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insecticide &amp; fungicide</td>
<td>1.0</td>
<td>25.0</td>
<td></td>
<td></td>
<td>25.0</td>
</tr>
<tr>
<td>Others (crop monitoring, soil moisture measurement, soil sample, etc)</td>
<td>1.0</td>
<td>10.0</td>
<td>20.0</td>
<td>10.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Total Operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>294.0</td>
</tr>
</tbody>
</table>

### Irrigation

- Electricity & motor mante: see ir page
- Repair and maintenance: see ir page
- Labor: see ir page
- Total Irrigation: 99.2

### Harvest and Other Yield Varying Costs

- Harvest: % 10.0
- Other variable costs: 0.7
- Total Harvest and Other Yield Varying Costs: 0.7
Wizard driven setup

Water Management Unit
- Command area
- Delivery rate & volume

Weather Data Source
- USBR AGRIMET
- WyEast IFPNet
The above OISO analysis is a summary for July 8\textsuperscript{th}. The last irrigation date entered was June 28\textsuperscript{th}. The last cutting of alfalfa was June 10\textsuperscript{th} and the next assumed alfalfa cutting date is July 15\textsuperscript{th}. If there have been more recent irrigations, or soil moisture measurements please let us know by reply email or call 541-602 6845. For more complete details you can go directly to the web site:
http://bre-rose.bioe.orst.edu/Realtimeirrigationschedule/index.htm
Irrigation Efficiency Model

- Analysis of application efficiency
- Spatial variability
- Full season forecast
- Multiple levels of ET demand
- Conjunctive scheduling
- Alternative or unconventional scheduling strategies
Yield Reduction Model

- Initially: FAO 33 (1979)
  - widely used
  - unsatisfactory under ordinary field conditions

- During the last few years, a team of scientists from various countries have been developing a new crop-water production model to replace FAO 33.
The new FAO yield model “AQUACROP” will be available and ready for distribution in 2007-2008.

The model describes the effect of water stress occurring at particular moments in the growing period and it requires only a minimum of input data which are readily available or can easily be collected.
Reconciling Soil Moisture Estimates

- Accurate estimation of crop available water is critical for economic optimization.

- Two estimators are commonly used:
  - calculated cumulative ET
  - direct measurements

Both of these estimators have some error...
Plant Available Water in Field: Quarter circle (Alfalfa)
Current/Future Work

- Completed 3rd year of field trials
- Continued trials next year in: OR, WA, ID, CA
- Adding Salinity Component
  - collaboration with Rick Snyder (UC Davis)
- Integration with SSURGO web service
- Negotiating hosting on NRCS web farm
Full Season Output
(multi field output)
IEM Overview

- Simultaneous scheduling of multiple fields
- Simulates multiple levels of ET demand
- Full season forecasting of irrigation requirements (historical averages)
- Analysis of application efficiency
- Allows for alternative or unconventional scheduling strategies