The Importance of Scale in Managing Agricultural Risk through Climate Information

An example with apple disease in the Southeast

Mark A. Boudreau
Elizabeth Kramer
Fall Outlook – Warmer and drier conditions are likely to set in as drought worsens. Typically, La Niña leads to fall, winter, and spring seasons that are warmer and drier than normal. This trend usually begins in mid-September over the entire Southeast, then intensifies and sets in most strongly over Florida and the coastal areas of the Gulf of Mexico and Atlantic Ocean in the heart of the winter. Because this La Niña has developed so strongly and quickly, there is an even greater likelihood that the warm and dry patterns will be stronger than the usual La Niña patterns this fall. The figures below show typical rainfall and temperature departures from normal during La Niña events.
Uncommon Cold Strikes in Georgia

An icy fountain in Atlanta, where temperatures have been 20 degrees below normal.

By KIM BEVERSON and ROBBIE BROWN
Published: December 8, 2010

ATLANTA — What people in the South don’t know about cold is a lot.

When it gets chilly like this — and mind you, 20 degrees is really cold here — morning news anchors remind viewers to wear warm coats, hats and gloves.

Related
Miamians Bundle Up; Tourists
Insist It’s Fine (December 9, 2010)
Cold Leaves Detroit Unfazed
(December 9, 2010)
Onion seedlings planted, then freeze

Winter wheat planting delayed, then opportunity lost

Oats planted instead of hardier rye, seedlings damaged or growth stunted
Apples and Disease

in the Southern Appalachians

- Outreach: Connecting scale of information with scale of decision
- Research: Much needed work beyond field scale
- **Micro**
  *The weather in the orchard*

- **Meso**
  *Seasonal climate variability in the landscape*

- **Macro**
  *Climate change regionally and beyond*
• **Micro**

*The information:*

*Daily weather data (temperature, moisture)*
• **Micro**

*The decision:*

*Should I spray today?*
Numerous models exist for disease response to weather in an orchard

- Fireblight
- Scab
- Sooty blotch & flyspeck
- Powdery mildew
- Nectria canker
- Fruit rots
Apple scab, caused by the fungus *Venturia inaequalis*

### Table 1. Minimum Hours of Leaf Wetness Required for Infection by Scab

<table>
<thead>
<tr>
<th>Temperature (F)</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>41</td>
</tr>
<tr>
<td>36</td>
<td>35</td>
</tr>
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<td>61-75</td>
<td>6</td>
</tr>
<tr>
<td>77</td>
<td>8</td>
</tr>
<tr>
<td>79</td>
<td>11</td>
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From Mills (1944), Jones (1980), and MacHardy & Gadoury (1989), as amended by Stensvand et al. (1997).
# WatchDog Plant Disease Stations

## WatchDog 2000 Series Plant Disease Station
- **Item #**: 3684WDPD
- **Description**: WatchDog 2000 Series Plant Disease Station
- **Price**: $813.0

## WatchDog Plant Disease Micro Station
- **Item #**: 3684PD1
- **Description**: WatchDog Plant Disease Micro Station
- **Price**: $667.0

### Apple Scab

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (°C)</th>
<th>% Wet Time</th>
<th>Days</th>
<th>Degree</th>
<th>Infection</th>
<th>Degree</th>
<th>Wash</th>
<th>Fungicide</th>
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<tbody>
<tr>
<td>04/22</td>
<td>51.0</td>
<td>37.7</td>
<td>9</td>
<td>43.0</td>
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<td>256</td>
<td>13</td>
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<tr>
<td>04/23</td>
<td>60.8</td>
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<td>6</td>
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<td>20</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>04/24</td>
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<td>27.2</td>
<td>6</td>
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<td>None</td>
<td>23</td>
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<td>25</td>
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<tr>
<td>04/27</td>
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<td>41.5</td>
<td>22</td>
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<tr>
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<td>28.1</td>
<td>3</td>
<td>37.2</td>
<td>None</td>
<td>36</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Overall**: 152.0

**Base Temperature**: 33
**Upper Temperature**: 79
**Wetness Threshold**: 6
• **Micro**

*Will farmers use the information?*

Yes, many already do for apples.
Meso

The information:

Forecasts from CPC models
Pacific conditions and ENSO outlook
The decision:

Should I develop a less/more aggressive spray program?
Should I sanitize (pruning; litter & alternate host removal)?
Meso

The decision:

Should I develop a less/more aggressive spray program? Should I sanitize (pruning; litter & alternate host removal)?

But can we predict likely disease levels based on seasonal climate patterns?

- Little studied
- Requires long-term, consistent data sets
Response of Apple Diseases to Climate Variability

Henderson County, NC  cv ‘Rome’  1974-2010
Deviation from Mean Disease Incidence

ENSO phase (ONI prior SON-FMA)

ln(% fruit infected + 1)

Neutral  El Nino  La Nina

Apple scab, *Venturia inaequalis*

Prior winter ENSO phase
Powdery mildew, *Podosphaera leucotricha*

Precipitation March-September

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**Percent Diseased Leaves**

-60.00
-40.00
-20.00
0.00
20.00
40.00
60.00
80.00

**Precipitation terciles**

<table>
<thead>
<tr>
<th>Difference fr mean</th>
<th>Dry years</th>
<th>Mesic years</th>
<th>Wet years</th>
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<tbody>
<tr>
<td>29.0</td>
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<td></td>
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<td>46.3</td>
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<tr>
<td>45.0</td>
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</tbody>
</table>

*P > 0.10*
Sooty blotch/Fly Speck
Fungal disease complex
Total Precipitation Mar-Sep

Percent Diseased Fruit

Dry years
Mesic years
Wet years

Difference fr mean

P<0.01

Precipitation terciles

39.5
66.7
73.9
Meso

Will farmers use the information?

Perhaps, if it is credible and demonstrably saves money
Macro

The information:

Long-term historical trends & GCM predictions
Macro

The decision:
Orchard siting, cultivar selection

Public policy
Impact of climate change on apples

- **Earlier flowering in Europe, N. America**  

- **Earlier migration of aphids into Britain**  
  Fleming and Tetchell 1995

- **Earlier ascospore release, more infection periods for apple scab in Quebec modeling**  
  Bourgeois et al 2004
Techniques from landscape ecology to confront the scale demon

- Habitat patches as sources/sinks for invasive species, endangered species, etc.

  - Spatially explicit population models
  - Graph theory
Disease development in individual orchards
Connectivity among orchards in production area
Connectivity among production areas

Many measures of connectivity
- Structural
- Potential
- Actual

Climate and land use will greatly affect connectivity!
Spatial Statistics for Apple Orchards

Percent of Landscape = .61
Patch Density = 2.5/100 ha
Mean Nearest Neighbor = 167 meters

Data Source: USDA NASS 2010
Macro

Will farmers use the information?

Unlikely without improved models, extensive outreach, and policy changes
(and some extreme weather)
Apples and Disease

in the Southern Appalachians

- Outreach: Connecting scale of information with scale of decision
- Research: Much needed work beyond field scale
Farmers may not plan on this scale,
But for a sustainable and resilient food supply . . .

Society must!