



Introduction to Disease Modeling

addVANTAGE Professional

» The purposes of agro-meteorology



Agro-Meteorology has many objectives

- Identify micro-climates
- Determine the suitability of a plot for a specific crop
- Assist to identify seeding/harvesting time, germination, maturity
- Compute growth models
- Compute yield models
- Compute disease models
- Compute irrigation models
- Provide research with data for assessing the efficiency of new varieties (of seeds, fertilizers, agro-chemicals)

» The purposes of agro-meteorology



Agro-Meteorology has many objectives

- Provide Traceability (which spray/irrigation was applied when + why)
- Prevent application of agro-chemicals when wind speed is too high and wind comes from the wrong direction
- Provide database to protect against punitive/damage claims (water, health,...)
- Prevent overhead irrigation if wind speed is too high
- Provide insurance companies with real-time ag-met data for micro-insurance products

» The purposes of agro-meteorology



What are the tools of Agro-Meteorology ?

- Micro- and Macro-climatic monitoring equipment (weather stations)
 - Air temperature and relative humidity
 - Precipitation
 - Wind speed and direction
 - Solar Radiation: global radiation, PAR, UV
 - Leaf wetness
 - Soil temperature, moisture, conductivity, salinity
- A wide variety of computer models: growth, yield, pest, disease, ETo, ETc
- Field observations (scouting)

» What are Disease Models?



- **Disease models estimate a) growing conditions and/or b) the growth stages for a pest/pathogen**

- Identify key periods when inputs (labor, pesticide, etc) can positively control the pest/disease
- Models vary depending upon the researcher who designed them
- Weather can significantly effect the initiation and growth of disease/pests
- Most models use a some combination of temperature, relative humidity, leaf wetness, and/or precipitation



» Site Specific Weather

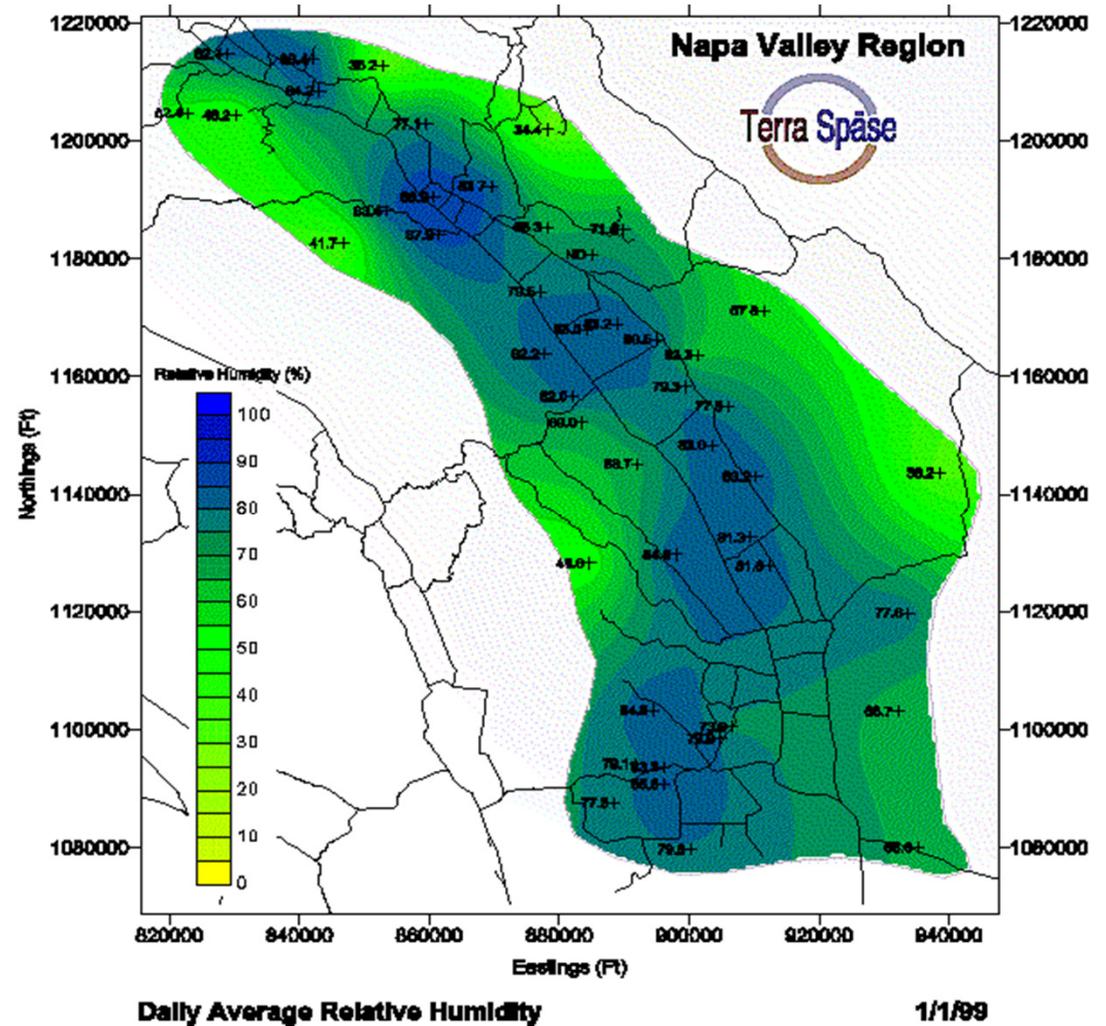


- **In the past weather data for agriculture was collected regionally**
 - Airports
 - Local extensions offices
 - Regional weather mesonets
- **Site specific data has been shown to be significant in the past 15 years relative to disease modeling**
 - Basic weather parameters change over short distances
 - Timing of inputs can be crucial (especially given resistance issues)

» Weather Variability



- Daily Average RH
- Napa Valley, CA
- 7 days

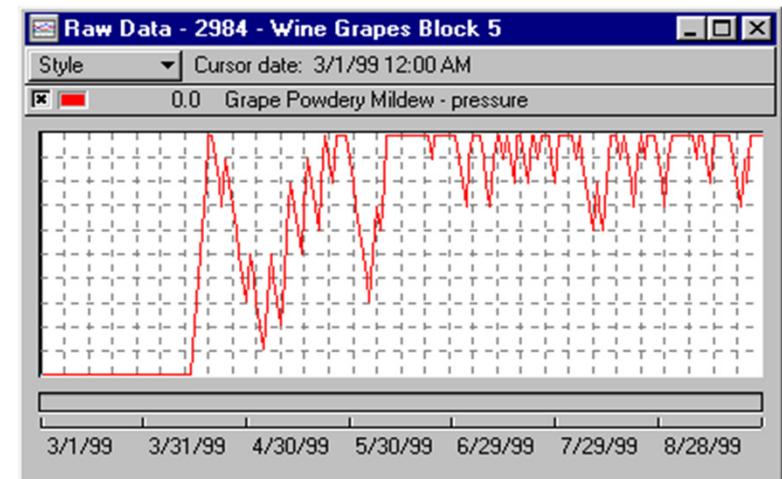
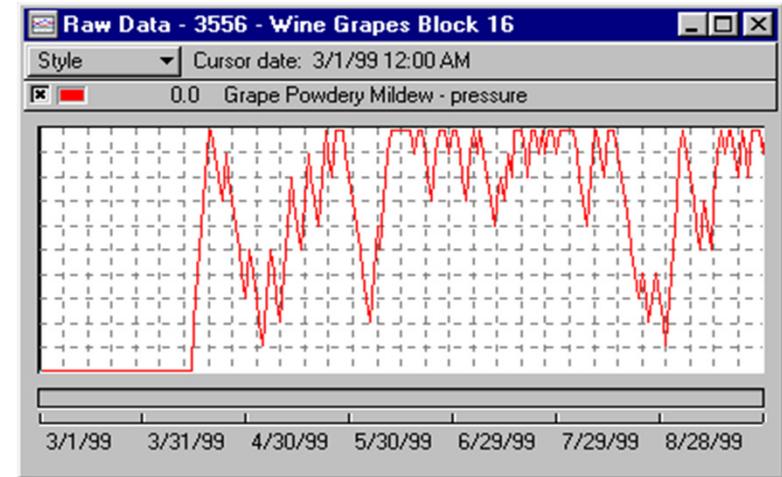


Map courtesy of Terra Spase
St. Helena, CA

» Local Weather Effects on Disease Models



- **Two sites**
- **Six miles apart**
- **Grape powdery mildew**
- **Nearly identical disease pressure in 1999**

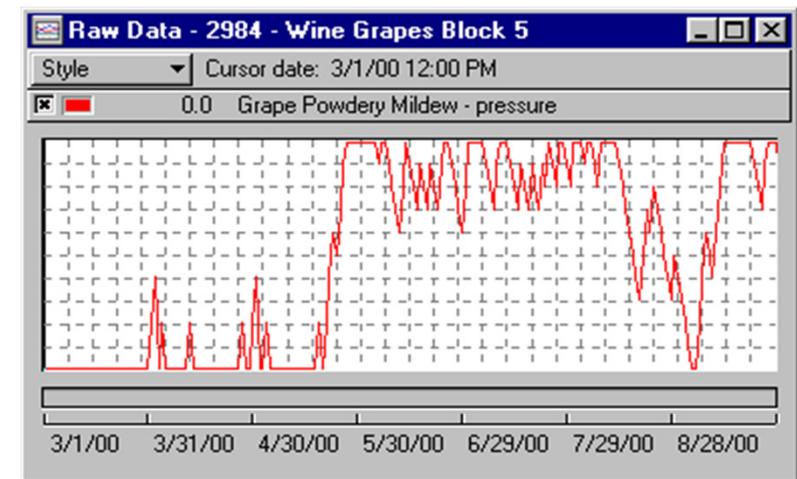
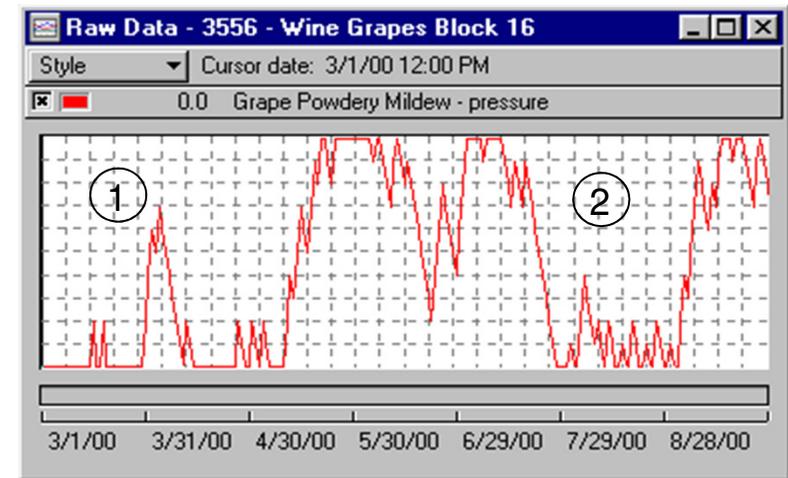


» Local Weather Effects on Disease Models



- **Two sites**
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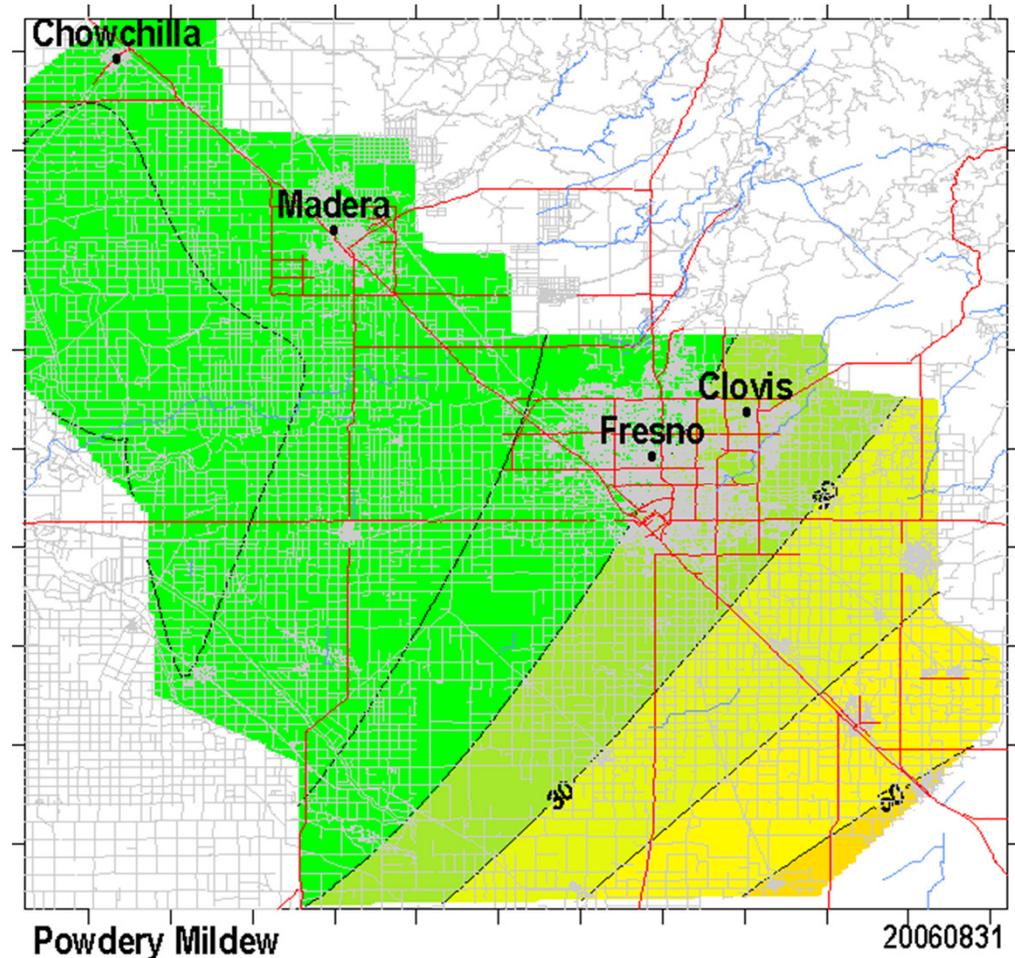
- **Different pressure in 2000**
- **High pressure in Block 1G earlier (1)**
 - Starting treatment late - risks infection
- **Low pressure mid season (2)**
 - in Block 1G allows spray interval to be “stretched”
 - opportunity for less treatments



» Effect on Disease Models Regionally



- Grape Powdery mildew
- Madera/Fresno area CA
- June through August 2006
- Early & late season pressure is very similar
- Mid-season pressures and treatment schedules should vary greatly

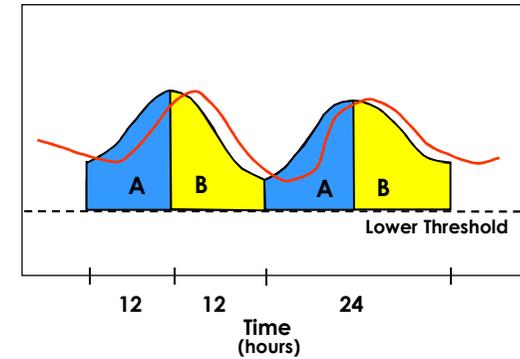


Maps courtesy of Western Farm Service
Madera, CA

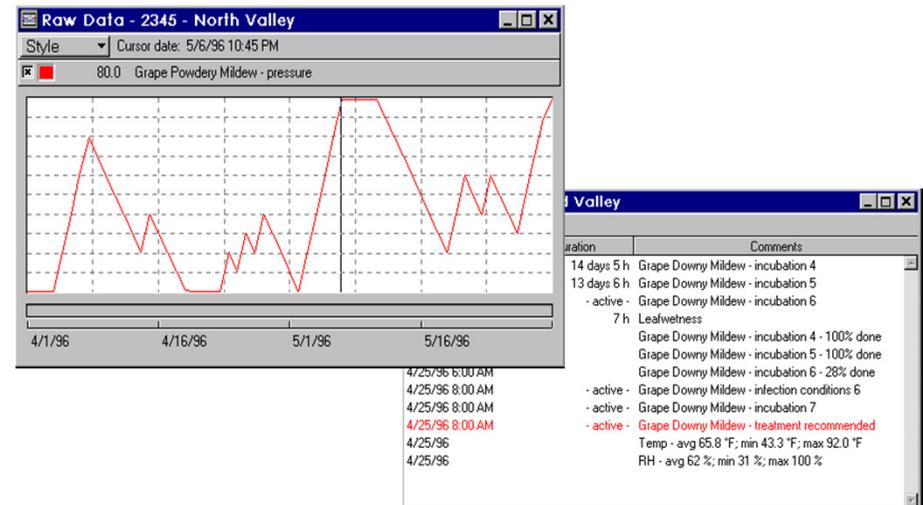
» General Methods of Modeling



- **Heat units**
 - Degree-Days
 - Degree-Hours
 - Growing Degree Days (GDD)
 - Chilling/heat hours



- **Disease Models**
 - Pressure models
 - Risk models



» Heatunits



Why measure heat unit accumulation?

- Many organisms grow based on the amount of heat received over time, **not** based on calendar time.

- Arthropods (Insects, mites. etc)



- Plants (growth stage, harvest, etc)



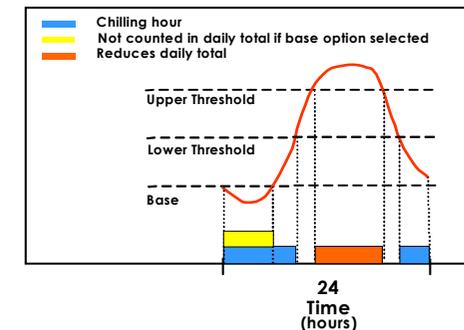
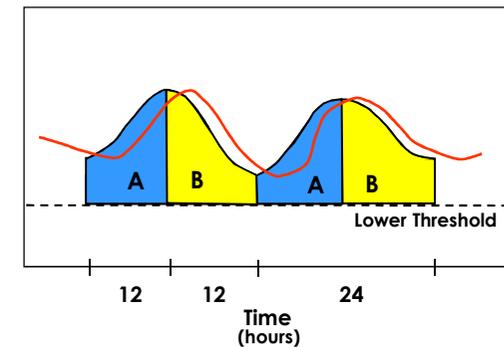
- Pathogens/Fungal life stages



» How are Heatunits calculated?



- **Temperature is used as measure of „heat“**
- **A number of standardized formulas exist**
 - Degree Days
 - Single or double sine
 - Single or double triangle
 - GDD
 - Averaging
 - Chilling Hours
 - Standard
 - Utah method
 - Heat Hours



» How are Heatunits used?



- **Critical thresholds are identified**
- **Growers can track upcoming thresholds and plan for action**

| Date | Duration | Comments |
|--------|----------|--|
| 8/1/96 | | Heatunit - Wine Grapes - cumulative value 2337.6 |
| 8/1/96 | | Heatunit - Wine Grapes - daily value 16.5 |
| 8/2/96 | | Heatunit - Wine Grapes - cumulative value 2352.5 |
| 8/2/96 | | Heatunit - Wine Grapes - daily value 14.8 |
| 8/3/96 | | Heatunit - Wine Grapes - cumulative value 2370.0 |
| 8/3/96 | | Heatunit - Wine Grapes - daily value 17.6 |
| 8/4/96 | | Heatunit - Wine Grapes - cumulative value 2389.8 |
| 8/4/96 | | Heatunit - Wine Grapes - daily value 19.7 |
| 8/5/96 | | Heatunit - Wine Grapes - cumulative value 2406.7 |
| 8/5/96 | | Heatunit - Wine Grapes - daily value 16.9 |
| 8/6/96 | | Heatunit - Wine Grapes - cumulative value 2425.1 |
| 8/6/96 | | Heatunit - Wine Grapes - daily value 18.3 |
| 8/7/96 | | Heatunit - Wine Grapes - cumulative value 2443.0 |
| 8/7/96 | | Heatunit - Wine Grapes - daily value 18.0 |

» Available Heatunit Models



- Researchers have used heatunit models for years (especially degree day models)
- Hundreds of validated models are available
- The addVANTAGE Pro 6 Heatunits extension is designed to allow the user to select the calculation method and enter thresholds and custom warning messages

http://207.212.70.27:8080 - Properties - Mozilla Firefox

General | **Extension** | Inputs | Security

Start Date: January 1, 2006

Degree Days Method: Averaging

Status: Enabled

Initial Accumulated Value (°DC): 100.0

Computation Method: Discrete

Cut Off Method: Horizontal

Adjust Min/Max to Low/High Thresholds: No

Low Threshold (°C): 15.0

High Threshold (°C): 100.0000

Alarms:

| Threshold | Message |
|-----------|------------------|
| 100.0 | 100 degress days |
| 500.0 | 500 degress days |
| 1000.0 | 1000 degree days |
| 2000.0 | 2000 degree days |
| 3000.0 | 3000 degree days |

OK Cancel Apply

Done

» Disease Risk Models



- **Typically attempt to track and/or predict the initiation or growth of a disease**
 - Models vary from very simple to complex
 - Some models focus on growing conditions for the disease
 - Some models focus on the risk of infection/outbreak
 - Some models are effective regionally while others function better with site specific information
 - Most models use temperature, rH, rainfall and/or leaf wetness as model inputs

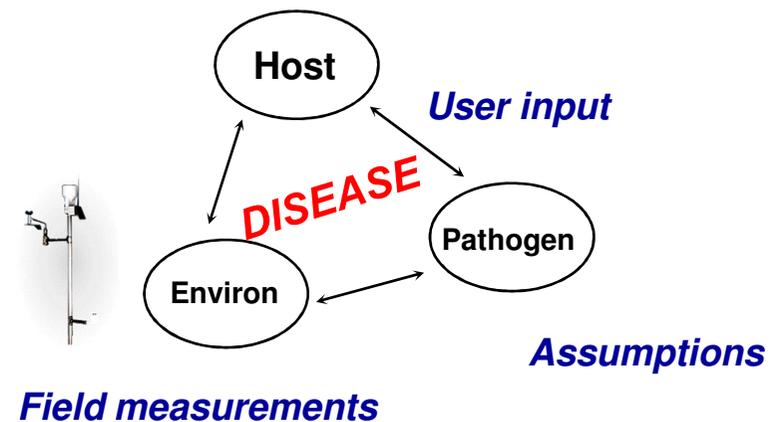


» Common Elements



- **Most disease models have common elements**

- analogous to the Disease Triangle
- infectable host, pathogen, and appropriate environmental conditions must exist for disease to be present
- user provides info on infectable tissue
- pathogens are always assumed to be present
- weather station provides data on environmental conditions



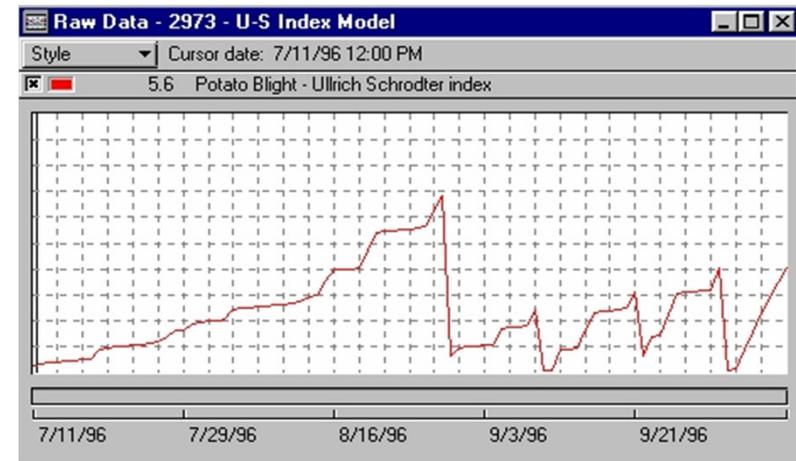
» Basic Types of Disease Models



Events model - Model output is typically binary in nature and in text format. Tracks various conditions and typically provides a warning when some condition(s) has been surpassed (qualitative).

| Date | Duration | Comments |
|-----------------|-------------|--|
| 8/4/96 9:00 PM | 12 h | Potato Blight - Infection conditions (Winstel A-event) |
| 8/5/96 6:00 AM | 6 days | Potato Blight - incubation |
| 8/5/96 6:00 AM | 2 h | Potato Blight - treatment recommended |
| 8/5/96 6:00 AM | | Potato Blight - incubation - 0% done |
| 8/5/96 6:00 AM | | Potato Blight - Winstel B-event reached |
| 8/5/96 8:00 AM | 8 days | Potato Blight - treated with Contact (8 day duration/8 mm washoff) |
| 8/5/96 10:00 PM | 10 h 30 min | Potato Blight - Infection conditions (Winstel A-event) |
| 8/6/96 6:00 AM | | Potato Blight - incubation - 17% done |
| 8/6/96 8:45 PM | 13 h | Potato Blight - Infection conditions (Winstel A-event) |
| 8/7/96 6:00 AM | | Potato Blight - incubation - 34% done |
| 8/7/96 8:30 PM | 13 h | Potato Blight - Infection conditions (Winstel A-event) |

Index model - The model generates a numeric value. The index typically models changes in disease pressure (quantitative). The model recommends treatments based upon combinations of index value, treatment thresholds, and other rules.

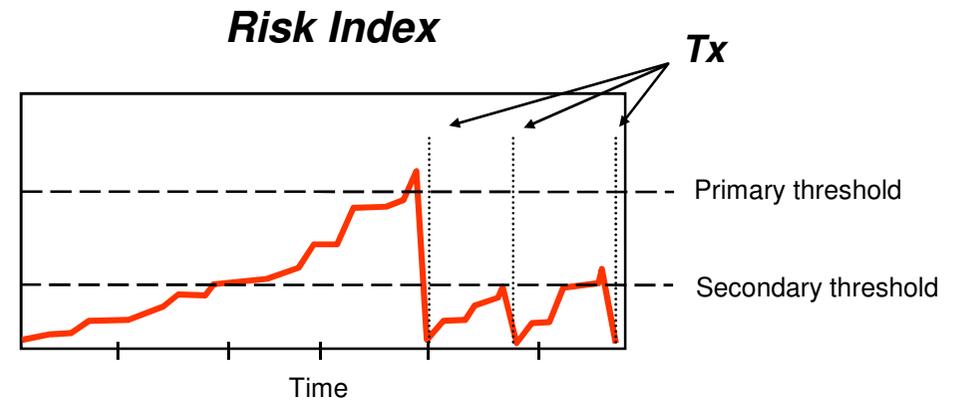


Events & Index - Combination of events & index models

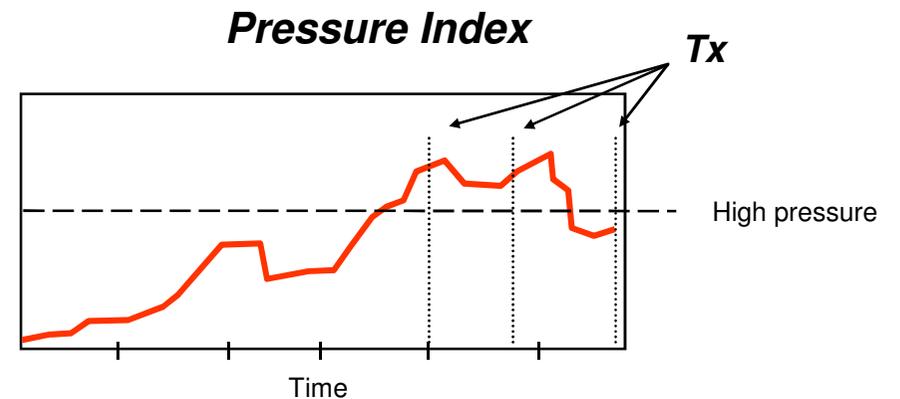
» Types of Index Models



Risk - Once a treatment is applied the index is reset to zero (0) and the index begins accumulating points again.



Pressure - These indexes generally model growth conditions for a disease. The index value does not reset to zero (0) after a treatment.



» Example of an Events Model



General Summary

- Events model for Bunch Rot of Grapes
- Regression to compute an index through leaf wetness periods
- Treatment warning is issued when the index exceeds a set threshold (0.50 in California)
- Model does not change in different phenological stages

| Events - 2000 - Standard Station | | |
|----------------------------------|-------------|--|
| Date | Duration | Comments |
| 4/7/98 5:30 PM | 15 h 15 min | Leafwetness |
| 4/8/98 12:45 AM | 15 min | Precipitation - 0.01 in. |
| 4/8/98 4:00 AM | 1 h 15 min | Precipitation - 0.15 in. |
| 4/8/98 7:15 AM | - active - | Bunch Rot of Grapes - treatment recommended |
| 4/8/98 7:15 AM | | Bunch Rot of Grapes - risk index 0.53 |
| 4/8/98 | | Temp - avg 63.7 °F; min 56.6 °F; max 73.6 °F |
| 4/8/98 | | RH - avg 87 %; min 56 %; max 100 % |
| 4/8/98 | | Precipitation - daily quantity - 0.16 in. |

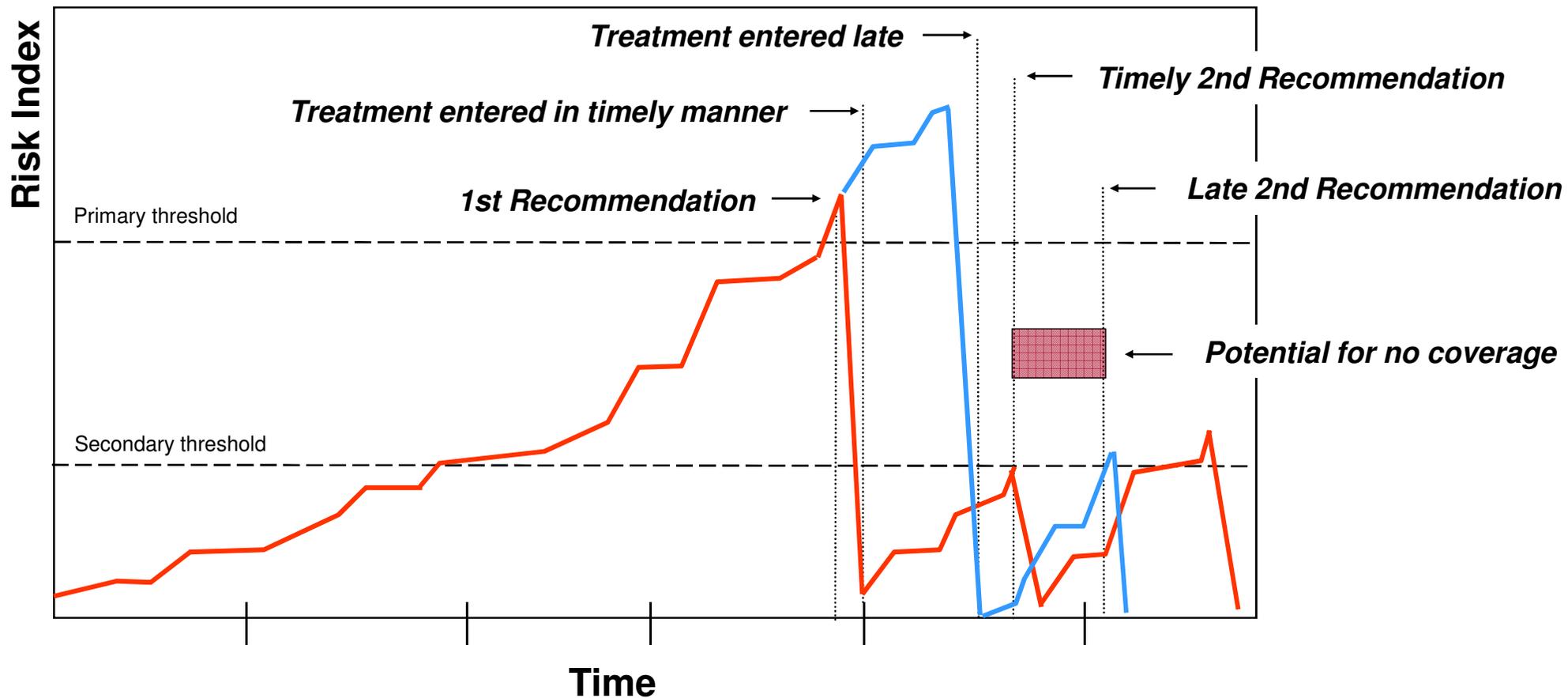
» Example of a Risk Model (Ullrich-Schrodter)



General Summary

- “Risk” type model for late blight of potato
- Model activates at phenological phase *Emergence*
- Ullrich-Schrodter index is computed daily based upon factors such as average temperature and the duration of high relative humidity
- Daily index values are accumulated until an initial threshold of 150 points is reached
- The first treatment warning is issued when the accumulated index > 150 pts and the daily index = 8 pts or greater
- Accumulated index is **reset** to zero (0) upon treatment
- Daily values accumulate until a secondary threshold of 40 pts is reached (for susceptible cultivars).
- All secondary treatment warnings are issued when the accumulated index > 40 pts and the daily index = 8 pts or greater

» Example of a Risk Model (Ullrich-Schrodter)



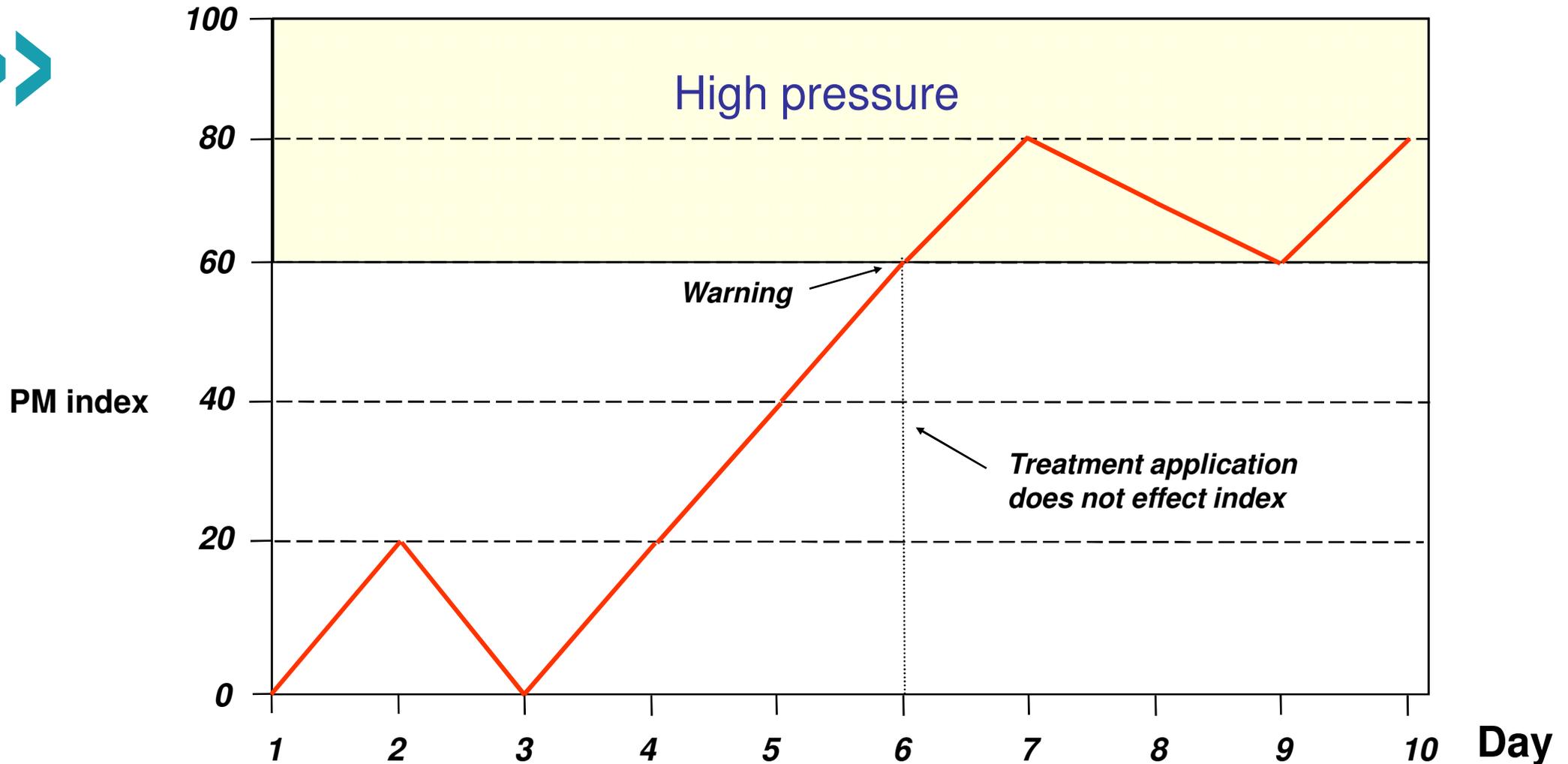
» Example of a Pressure Model (Gubler-Thomas)



General Summary

- Combination of events & index model for grape powdery mildew
- Model activates at phenological phase *Budbreak*
- Events portion predicts ascospore events based on 2/3 Mills table
- Index calculated daily based upon temperature
 - Add 20 pts if 6 or more consecutive hours $21 < T < 30$
 - Subtract 10 pts if less than 6 consecutive hours $21 < T < 30$
(except in early season until the first time 60 pts in accumulated)
 - Subtract 10 pts if $T > 35^{\circ}\text{C}$
- Daily values accumulated: Minimum index = 0
Maximum index = 100
- Treatment warnings issued when: Automatically at budbreak
Based upon index oriented intervals starting from budbreak
- Integrated treatment duration stretching algorithm

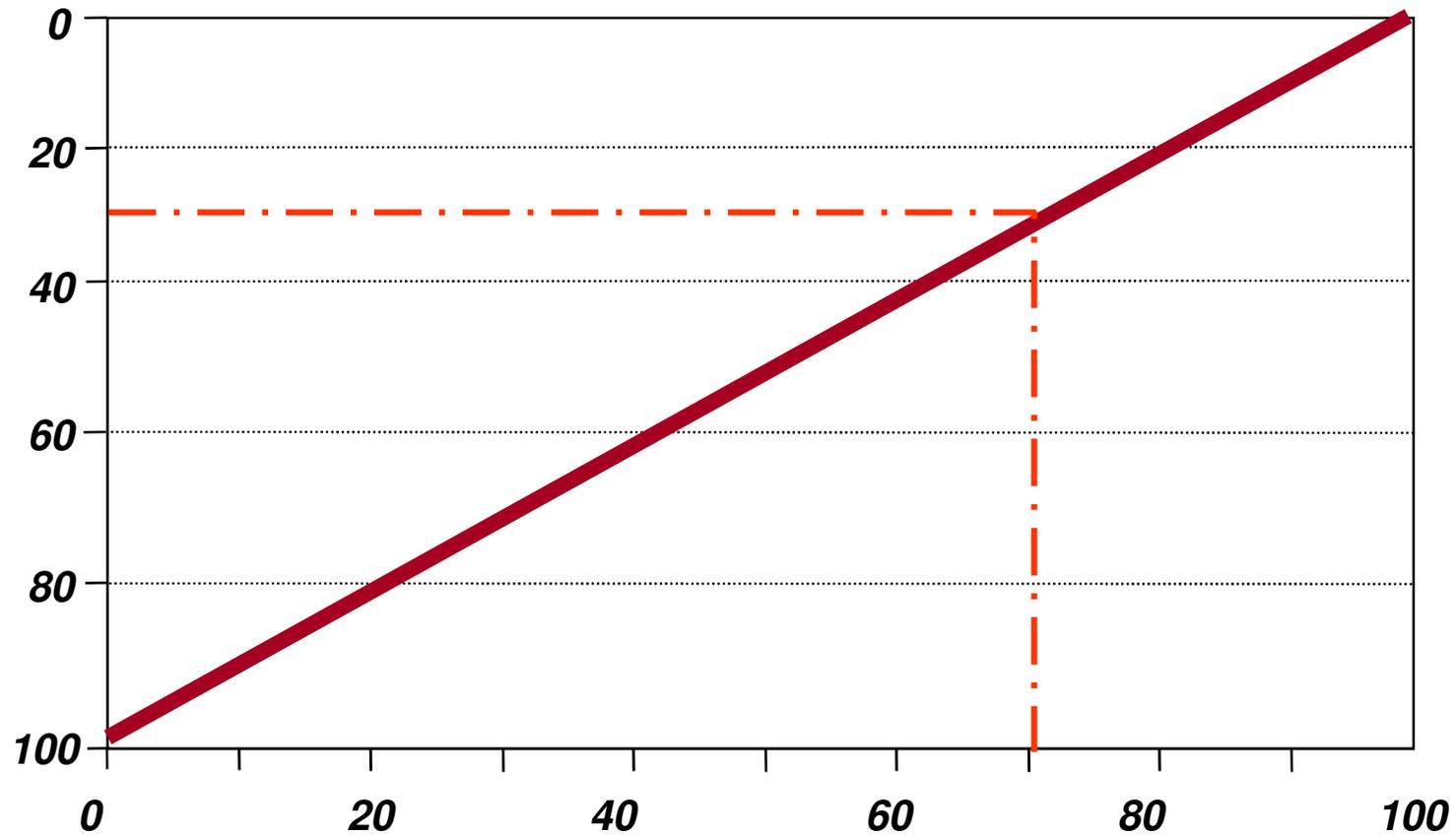
» Example of a Pressure Model (Gubler-Thomas)



» Example of a Pressure Model (Gubler-Thomas)



**% Stretch
(of control duration)**



**Average
PM Index**

» Alternative Ways to Use Models



- **Most models have multiple ways they can be used:**
 - Detailed PC/computer based options
 - As guidelines for pressure/outbreaks through the season
 - Identifying the initial onset of disease risk/growth conditions



» Models Use – Detailed PC Based Options



- **PC based options allow many details to be incorporated into the model outputs:**

- Site specific phenology
- Site specific treatment schedules/recommendations
- Treatment specific control durations / washoffs
- Sensitivity by crop / field
- Automated changes in model sensitivity by phenological stage
- Automated warnings for washoff conditions, etc.

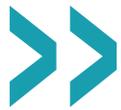
The screenshot displays two overlapping browser windows from the URL <http://nbaty.dyndns.org:8080>. The background window, titled 'Events1', shows a table of events with columns for '#', 'Begin Date', 'Duration', and 'Crop Service'. The foreground window, titled 'Treatments', shows a list of chemicals and a table of treatments.

| # | Begin Date | Duration | Crop Service |
|--------------------------|------------------|------------|----------------------|
| | 1/1/07 12:00 AM | | Crop Service |
| | 1/3/07 12:00 AM | | Crop Service |
| <input type="checkbox"/> | 1/3/07 12:00 AM | - active - | Grape Powdery Mildew |
| <input type="checkbox"/> | 1/4/07 6:00 AM | 24m | Grape Powdery Mildew |
| | 1/13/07 12:00 AM | | Crop Service |
| | 1/30/07 12:00 AM | | Crop Service |
| <input type="checkbox"/> | 2/8/07 10:00 AM | 2d 23h | Grape Powdery Mildew |

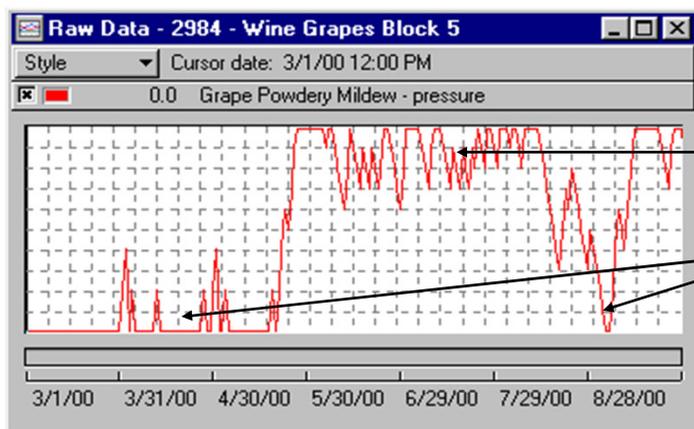
| Chemical | Application date |
|---------------------------------|------------------|
| Bayleton 25 (Triadimefon) 0,02% | 1/10/07 1:29 PM |

The 'Chemicals' list in the foreground window includes: Dorado (PyrifenoX) 0,01-0,02%, Dorado Duo (Mancozeb+PyrifenoX) 0,3%, Arcotan fl. (Dinocap) 0,1-0,12%, Prothane (Mycobutanil) 0,01-0,02%, Karanthane FN 57 (Dinocap) 0,1%, Warning ignored (Grape Powdery Mildew), Vigil (Diclobutrazol) 0,04-0,08%, and Sceda (Tebuconazole) 0,02-0,03%.

» Model Use – as Guidelines during the Season

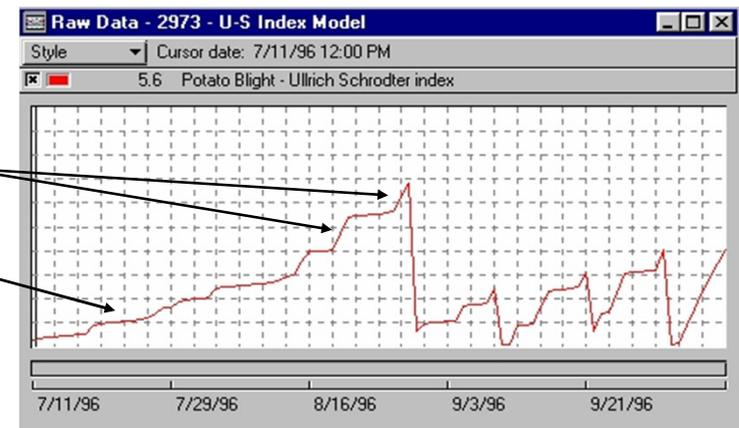


- **Many times logistics do not allow detailed use**
- **Following pressure / risk conditions:**
 - Helps keep spray intervals tight during risky periods
 - Identify periods when treatments can be stretched / skipped versus treatments called for using calendar methods



High Risk

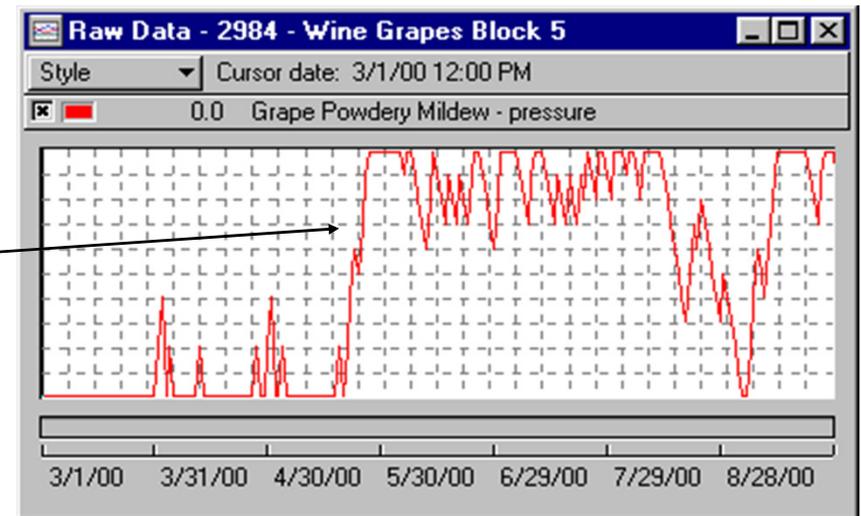
Low Risk



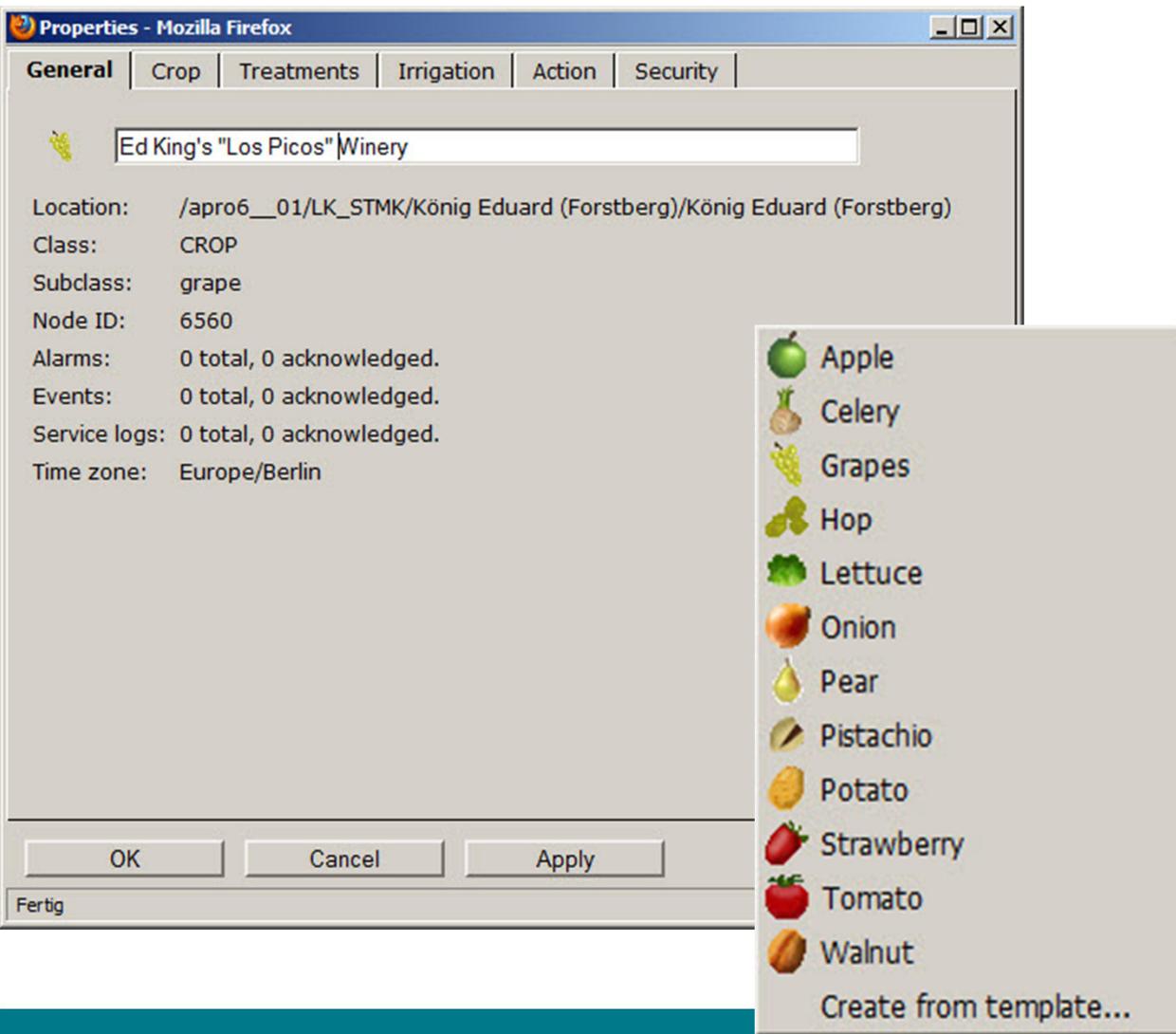
» Models Use – Identifying First Onset

- » » • **Simplest method is to identify the initiation of disease growth conditions**
 - Wait until conditions are ripe for disease growth
 - Start calendar schedule when first conditions are present
 - Minimally avoid wasting inputs until they are needed

Start calendar
treatment schedule



» New approach to disease models with addVANTAGE Pro 6



The Crop Node:

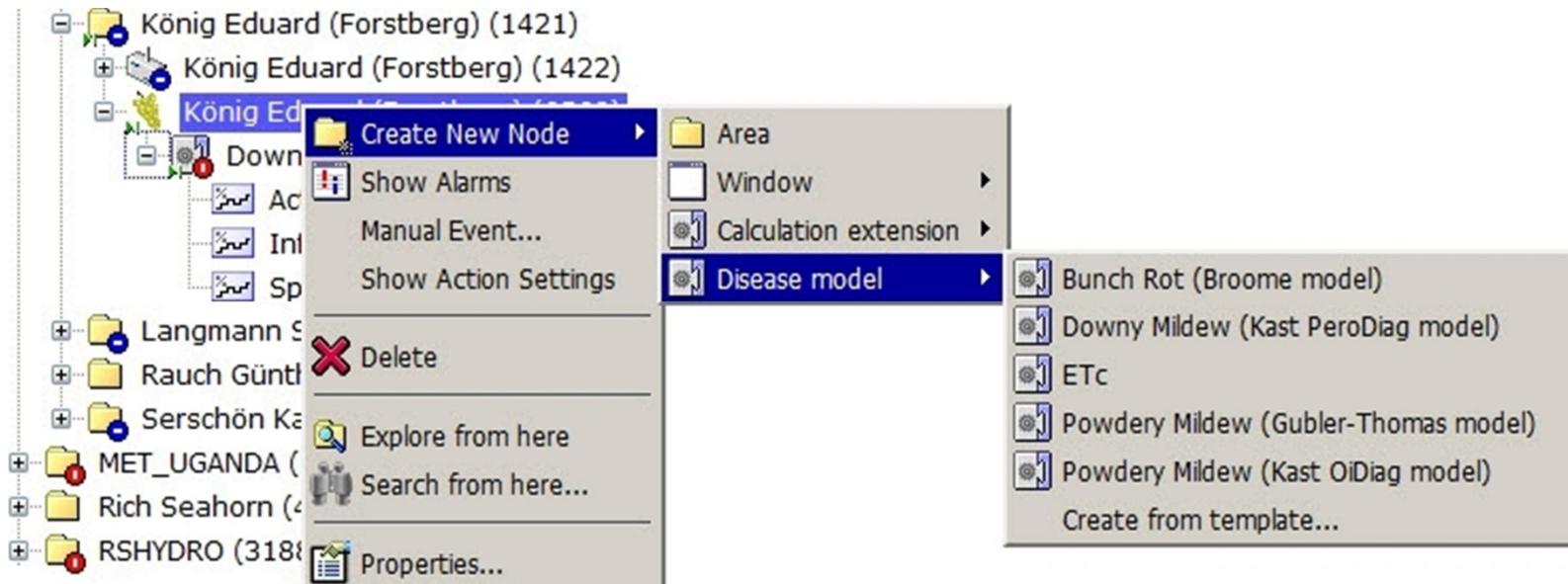
Separates the properties of the crop from the disease models.

Insert all information regarding a crop only once for all your disease models:

- Phenological phases
- Treatments
- Irrigations
- Actions

» THE CROP NODE

- » Connect as many disease models as you like –
- e.g. connect the same model 5 times with different settings - perfect for rapid model validation



» THE CROP NODE



Contains all info on phenological phases.

Automatic progress based on BBCH table.

Modify start dates as needed.

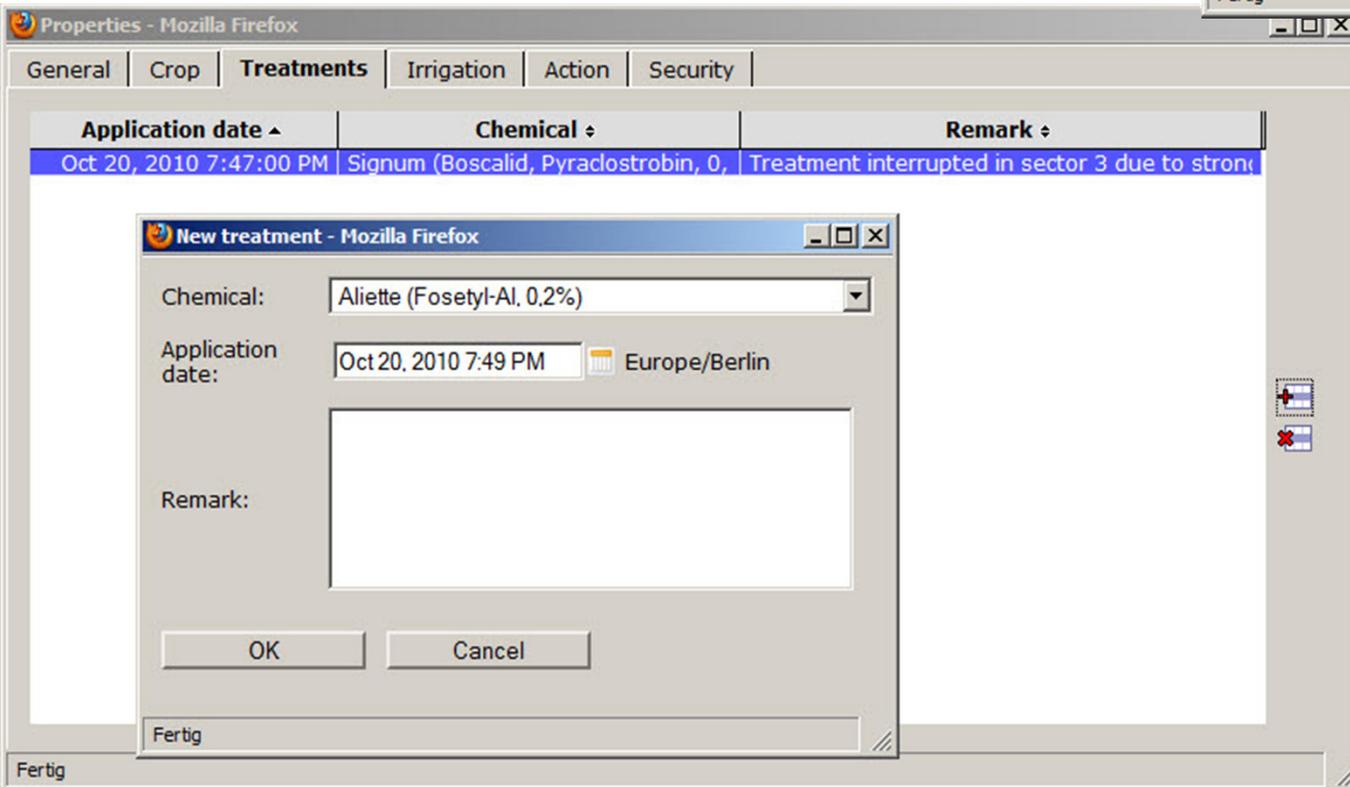
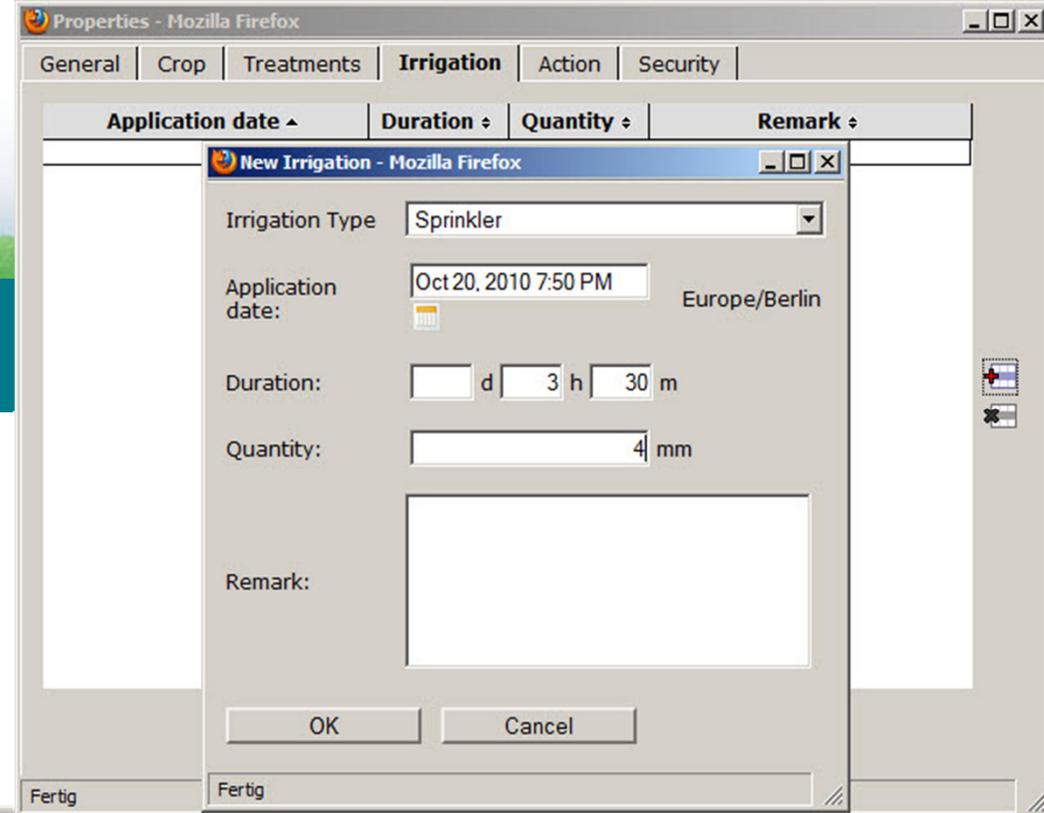
An image helps identify the crop stage.

| BBCH | Name | Date |
|------|--------------------------|--------------|
| 00 | Winter Dormancy | Jan 1, 2009 |
| 07 | Bud Burst | Apr 21, 2009 |
| 13 | 3 Leaves Unfolded | Jan 11, 2009 |
| 55 | Inflorescence Swelling | Jan 19, 2009 |
| 65 | Full Flowering | Jan 26, 2009 |
| 69 | End of Flowering | Jan 8, 2009 |
| 81 | Beginning of Ripening | Mar 7, 2009 |
| 89 | Berries Ripe for Harvest | Jan 31, 2009 |



» THE CROP NODE

» Insert treatments: select chemical from your own database, enter treatment date, add a remark.



Insert irrigations:

- Type of irrigation
- Date
- Duration
- Quantity
- Remark

» THE CROP NODE



Get information by email on many actions of the user and the model, e.g. when a user enters or deletes a treatment or irrigation, or when a pheno-phase changes.

New action - Mozilla Firefox

Node: König Eduard (Forstberg)

Event: Treatment added

Action: E-mail

Max. age of event: 1 d 12 h m

Recipients: Bernhard;Martin;james@plants.com

OK Cancel

- Treatment added
- Irrigation added
- Irrigation removed
- Manual event
- Phenophase changed
- Treatment added**
- Treatment removed

» The new, advanced disease extensions of Pro 6



Enter setup information required by the model and the model developer.

Properties - Mozilla Firefox

General | **Extension** | Advanced settings | Inputs | Action | Security

Variables for the preconditions

Method: ⓘ

Initial degree day value: °DC

Current degree day value: 0.0 °DC

Algorithm variables

Minimum Relative humidity for a sporulation: % RH

Minimum Temperature for a sporulation: °C

OK Cancel Apply

Fertig

» The new, advanced disease extensions of Pro 6



Advanced settings for research and model validation:

Modify every single parameter of the algorithm!

Properties - Mozilla Firefox

General | Extension | **Advanced settings** | Inputs | Action | Security

| Name | Type | Value | Unit |
|-------------------------------------|---------|--------------------------|------|
| initialDD | Unit | 0.0 | °DC |
| isIrrigable | Boolean | true | |
| isIrrigationCountForAlgorithm | Boolean | false | |
| isMultiplePrimaryPossible | Boolean | false | |
| isTreatable | Boolean | true | |
| isWashableByIrrigation | Boolean | false | |
| lwRhMinDuration | Float | 4 | |
| method | String | TEMPERATURE | |
| minGerminationSpan | Long | 50 | |
| muellerPrimaryIncubationTable | String | muellerPimaryIncubationT | |
| muellerSecondaryIncubationTable | String | muellerSecondaryIncubati | |
| pluviOosporesDurationMaxCountMillis | Long | 259200000 | |
| pluviOosporesRainPeriodDays | Long | 3 | |
| pluviOosporesRainThreshold | Unit | 10.0 | mm |
| pluviOosporesTempPeriodDays | Long | 1 | |
| pluviOosporesTempThreshold | Unit | 10.0 | °C |
| pluviOosporesTempUseMinAsThreshold | Boolean | false | |
| rainMethodBbchStart | Long | 7 | |
| rhMinSporulation | Unit | 96.0 | % RH |
| sporeLifeFactor | Float | 100 | |
| startBBCH | Long | 0 | |
| tempMinSporulation | Unit | 11.5 | °C |
| thresholdDegreeDays | Unit | 170.0 | °DC |

Reset to default

OK Cancel Apply

Fertig

» Disease Modeling with addVANTAGE Pro



- **Grapes**

- Powdery Mildew
 - Downy Mildew
 - Botrytis

- **Apples**

- Apple Scab
 - Powdery Mildew
 - Fire Blight

- **Potatoe**

- Phytophthora

- **Various Nuts**

- Pistacchio
 - Walnuts

- **Hops**

- Downy Mildew
 - Powdery Mildew

- **DSV Extension**

- TomCast &
Wisdom TomCast for
 - Tomatoes (late blight),
 - Potatoes (late blight),
 - Carots (Alternaria),
 - Celery (Septoria)

- **Strawberries**

- **Degree Days**, many methods

» REFERENCES – Who is Who of Adcon Users

»» **Austria: the Chambers of Agriculture network**

Since 1995 the Austrian Chambers of Agriculture as the National Extension Service has built a network of over 300 weather stations.

This network covers all major grape, apple, pear, and potatoe growing areas, from East to West, from North to South.

Purpose: disease advise

Since 2008: 25 stations added for FireBlight prediction in Apples

Adcon Market Share: ~ 90%

A photograph showing four men standing in a field of tall grass and sunflowers. In the background, there is a weather station on a tall pole, a green car, and a landscape of rolling hills under a clear blue sky. The men are dressed in casual to semi-formal attire. The text boxes are overlaid on the bottom of the image.

Prof. Samuel Ortega,
Univ. of Talca, Chile

Dipl.Eng. Weigl and
Dipl.Eng. Schmiedl, heads of
Lower Austrian Chamber of
Agriculture

» REFERENCES – Who is Who of Adcon Users



Austria: the Chambers of Agriculture network

Achievements:

Grapes: reduction of Sprays between 25 and 60%!

Apples: reduction of sprays on average 30%

Potatoes: reduction of sprays 30%;

» REFERENCES – Who is Who of Adcon Users



Honduras: the WWF for Nature

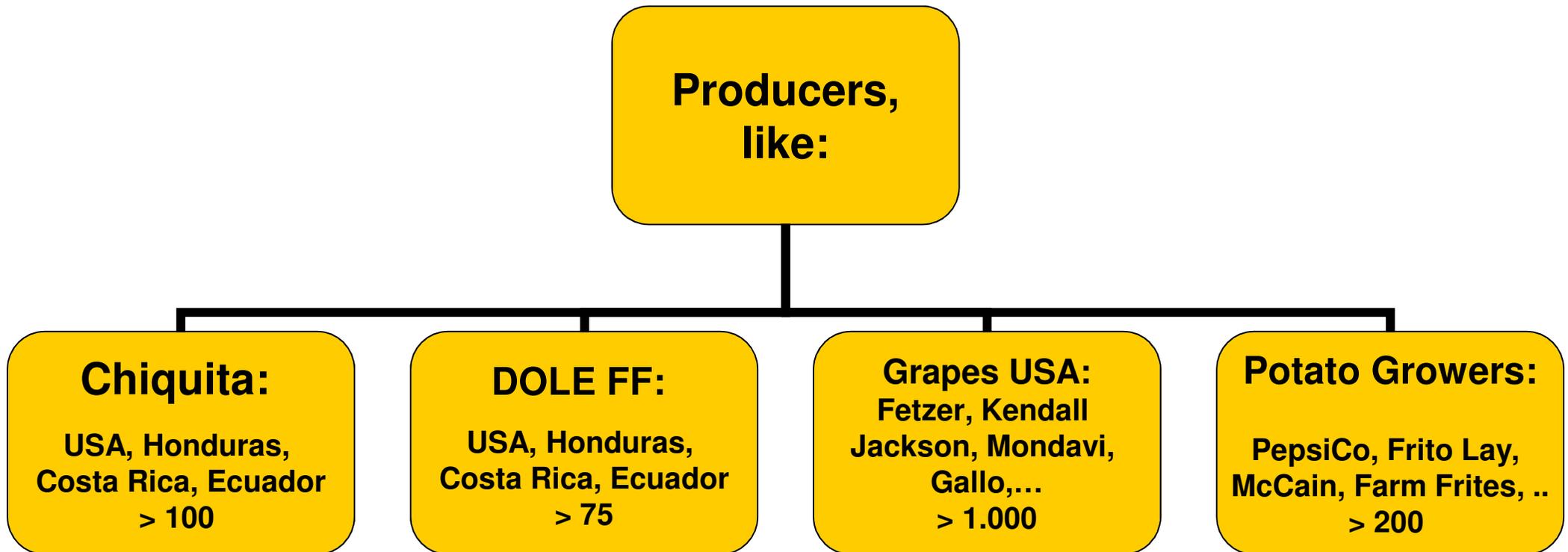
Since 2006 the WWF with its HQ in Honduras is building a network of weather stations in Central America.

- a) To monitor Climate Change
- b) To bring Kow How to the Farmers
- c) To improve sugar cane irrigation and reduce fertilizer runoff

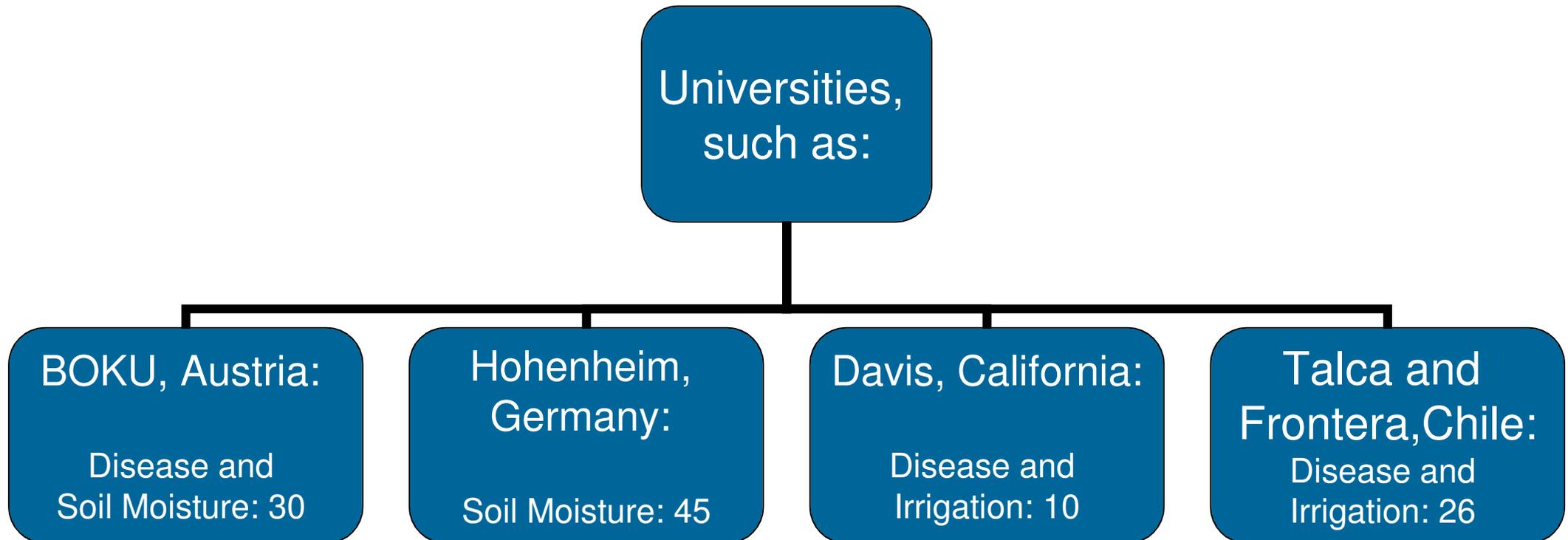
A central addVANTAGE Pro Server operated by agronomists will bring the chance to give many people access to data and agronomical know how.

<http://www.youtube.com/watch?v=TPe98r1kXhU>

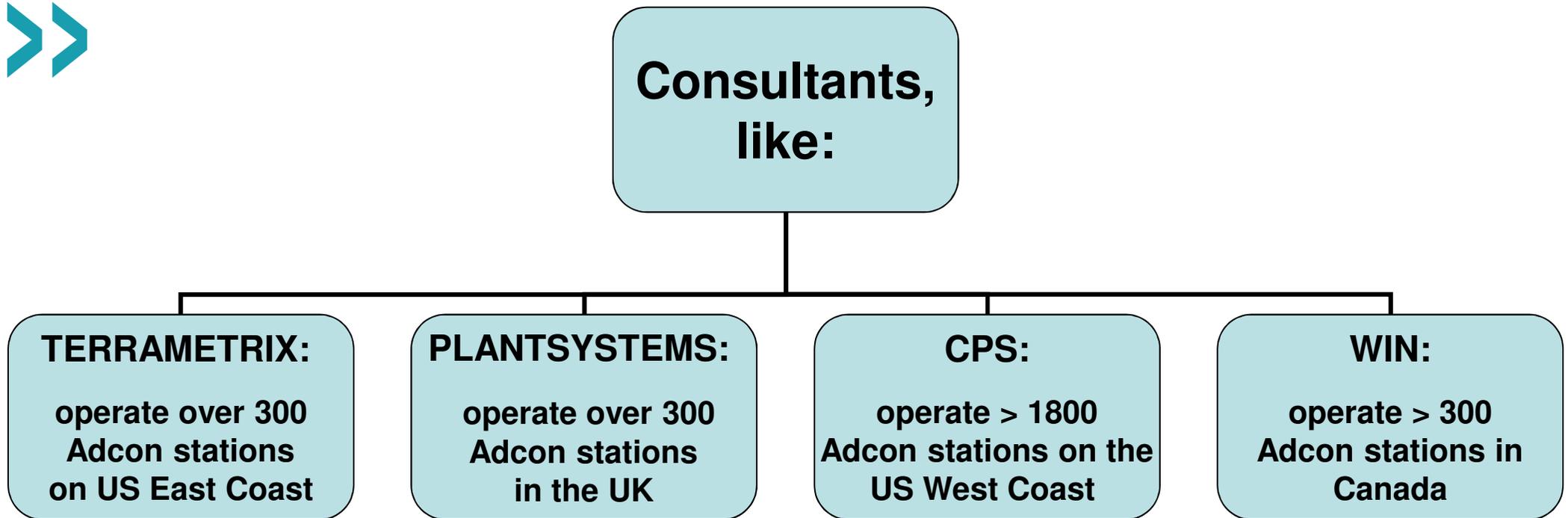
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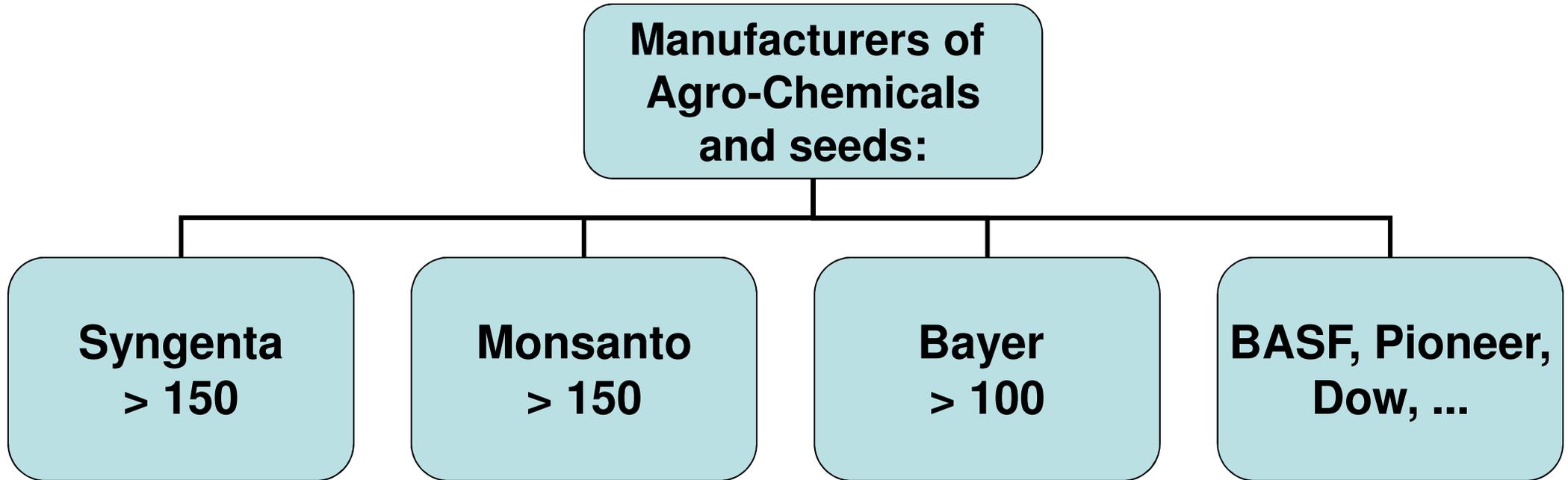
» REFERENCES – Who is Who of Adcon Users



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Thank you for your attention!

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