



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



UC Statewide IPM Project
© 2000 Regents, University of California

» Site Specific Weather

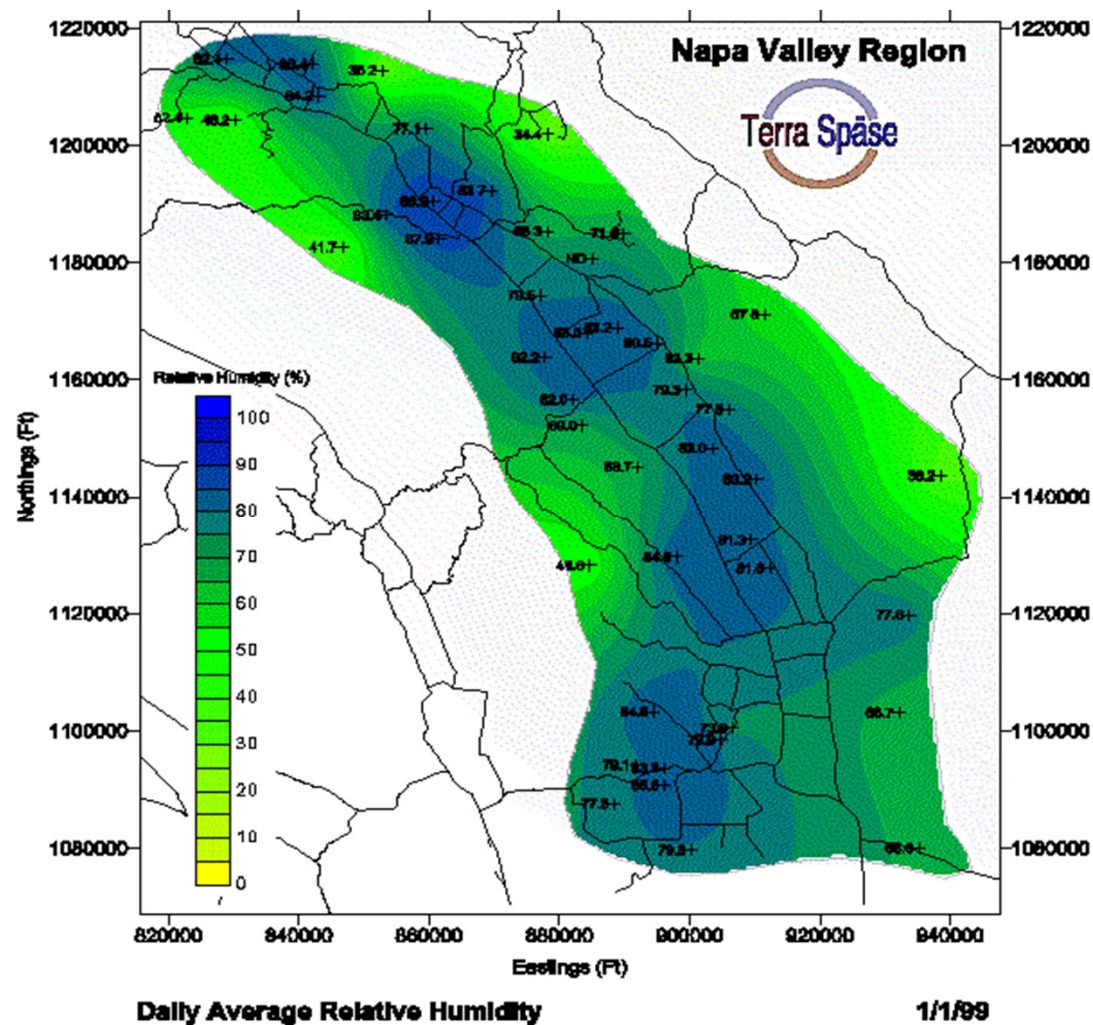


- **In the past weather data for agriculture was collected regionally**
 - Airports
 - Local extensions offices
 - Regional weather mesonets
- **Site specific data has been shown to be significant in the past 15 years relative to disease modeling**
 - Basic weather parameters change over short distances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

» Weather Variability



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

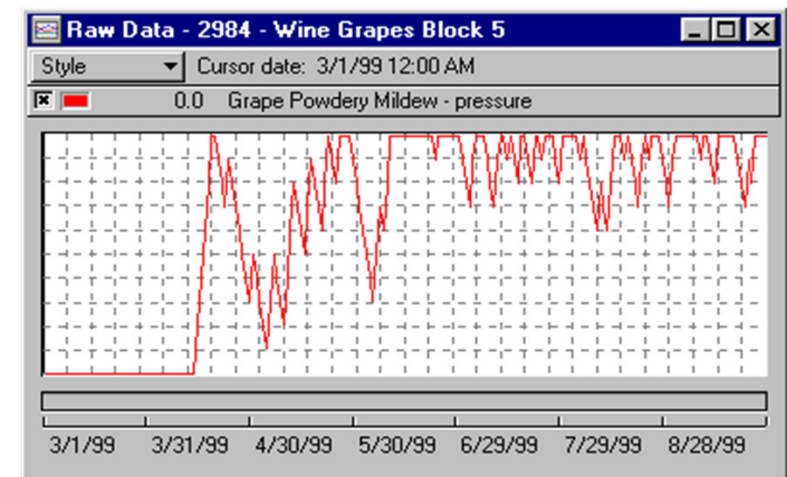
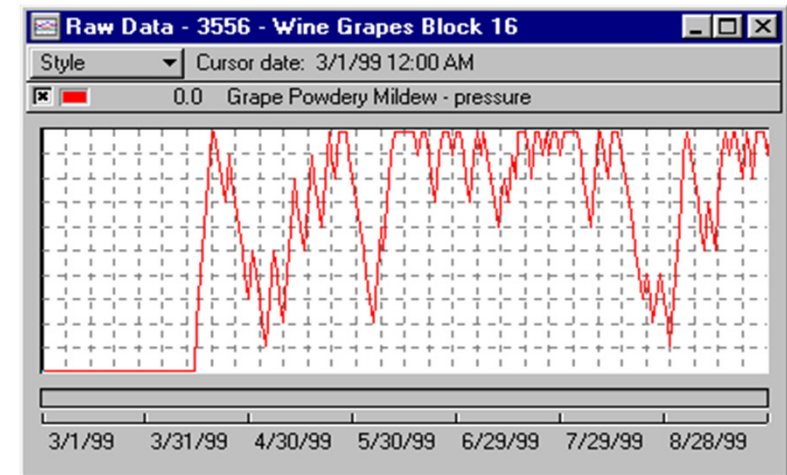


Map courtesy of Terra Spase
St. Helena, CA

» Local Weather Effects on Disease Models



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

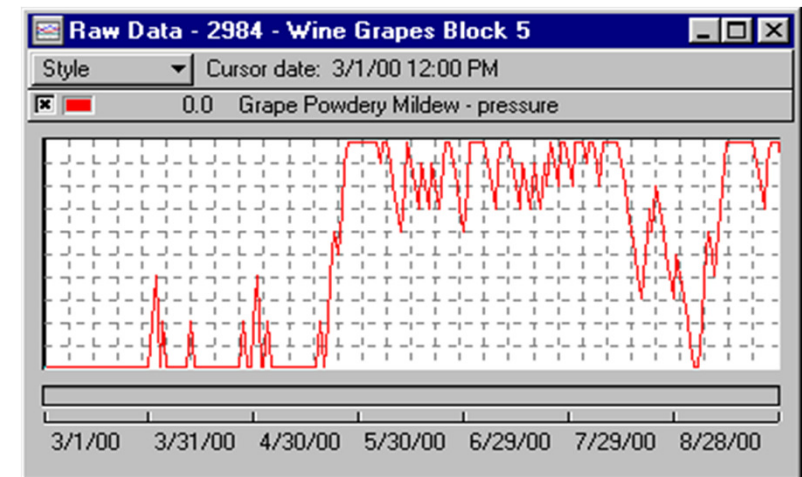
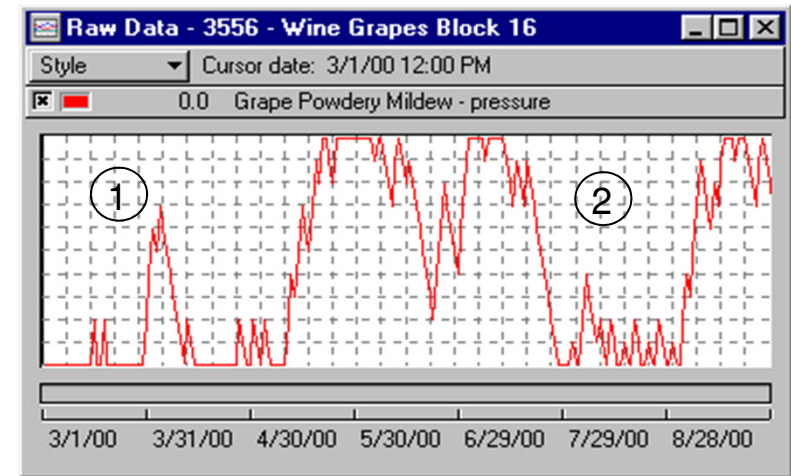


» Local Weather Effects on Disease Models



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

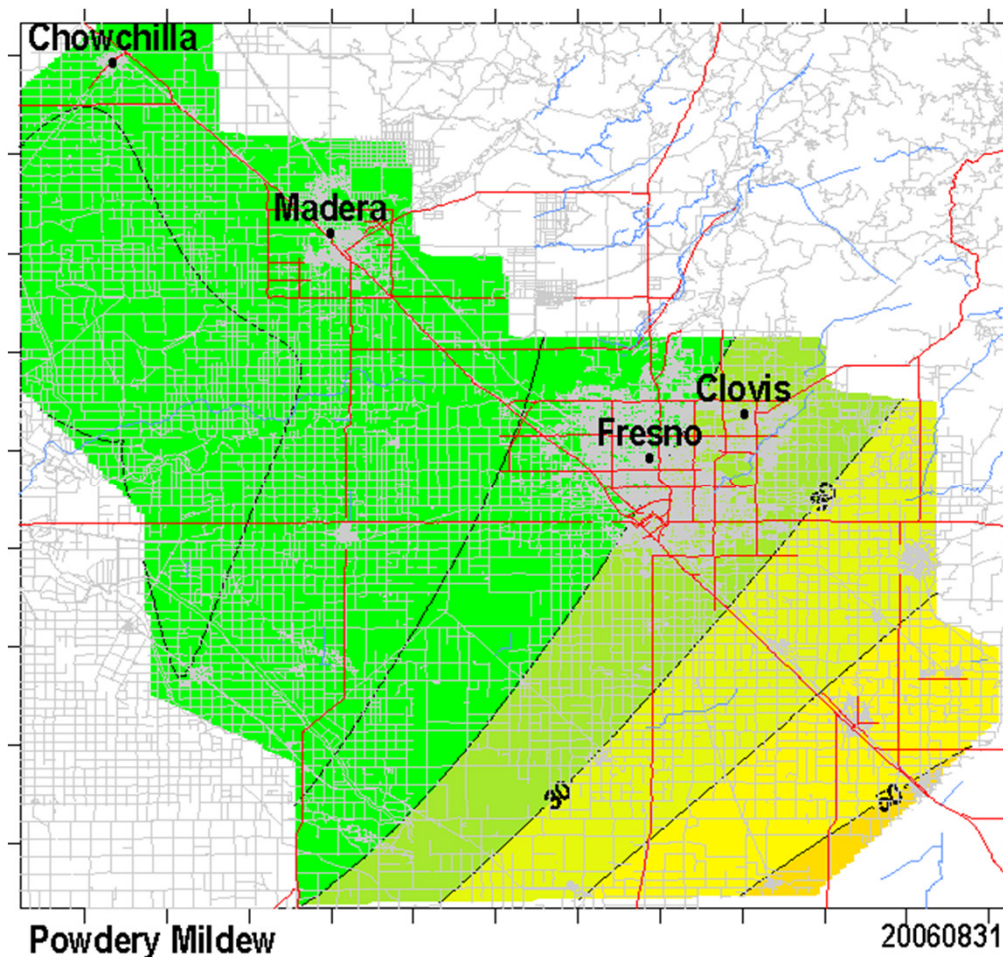
- **Different pressure in 2000**
- **High pressure in Block 1G earlier (1)**
 - Starting treatment late - risks infection
- **Low pressure mid season (2)**
 - in Block 1G allows spray interval to be “stretched”
 - opportunity for less treatments



» 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



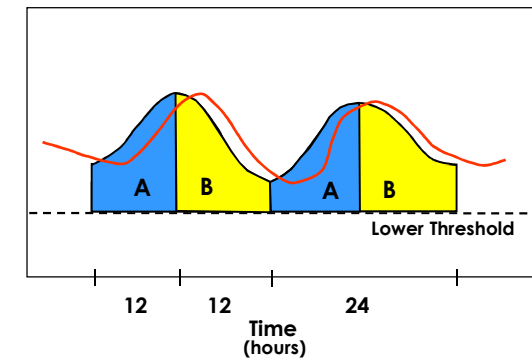
Maps courtesy of Western Farm Service
Madera, CA

» General Methods of Modeling



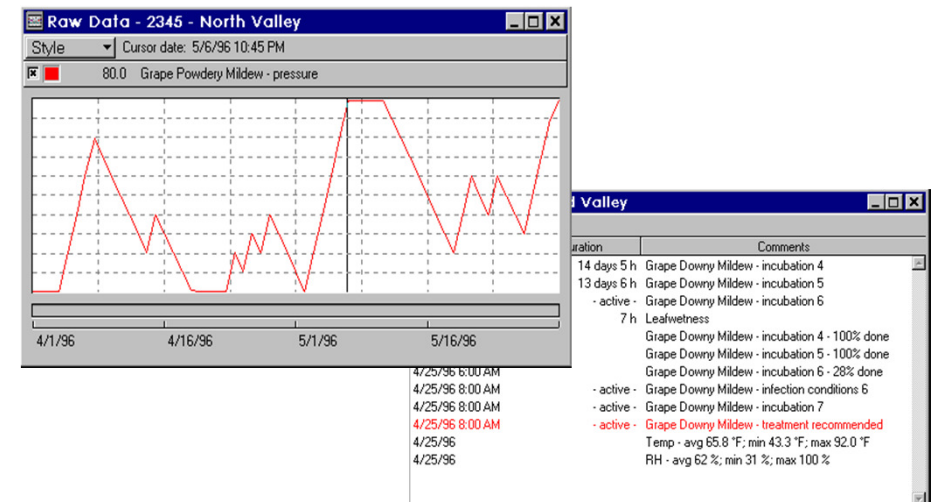
• Heat units

- 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)



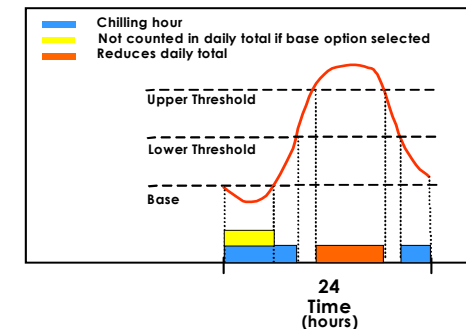
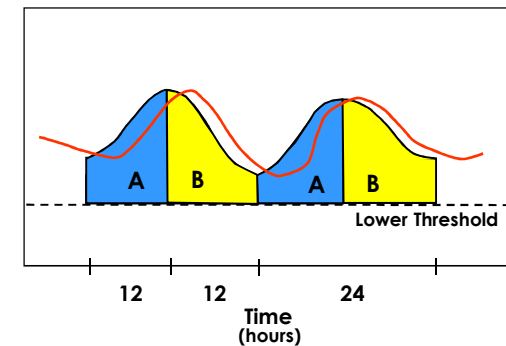
- Pathogens/Fungal life stages



» 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

Events - 3000 - Standard Station		
Style		
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 degree days
500.0	500 degree 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

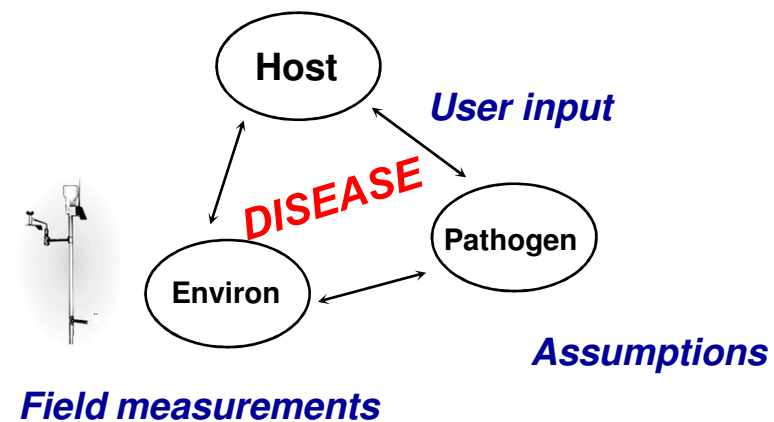


» Common Elements



- **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



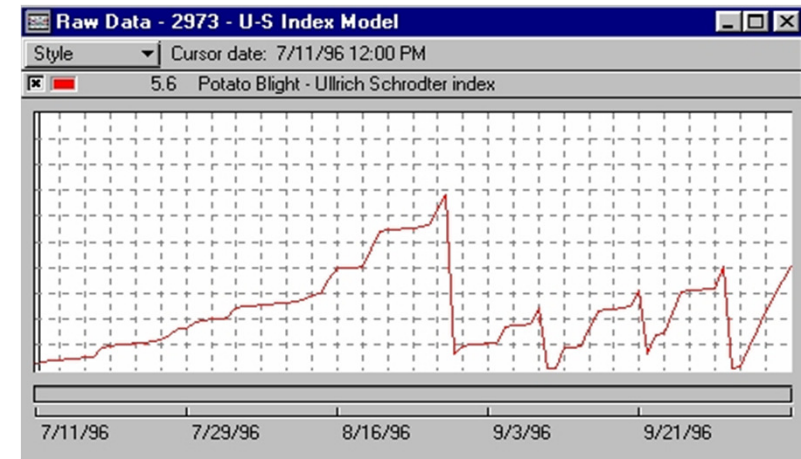
» Basic Types of Disease Models



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.

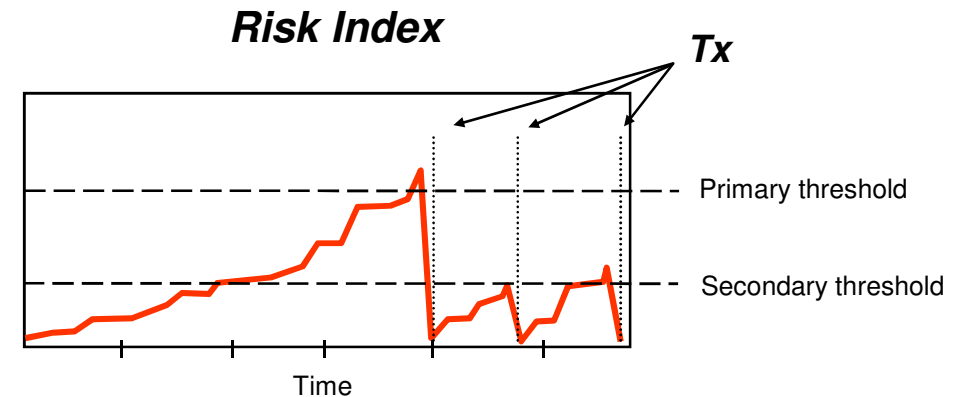


Events & Index - Combination of events & index models

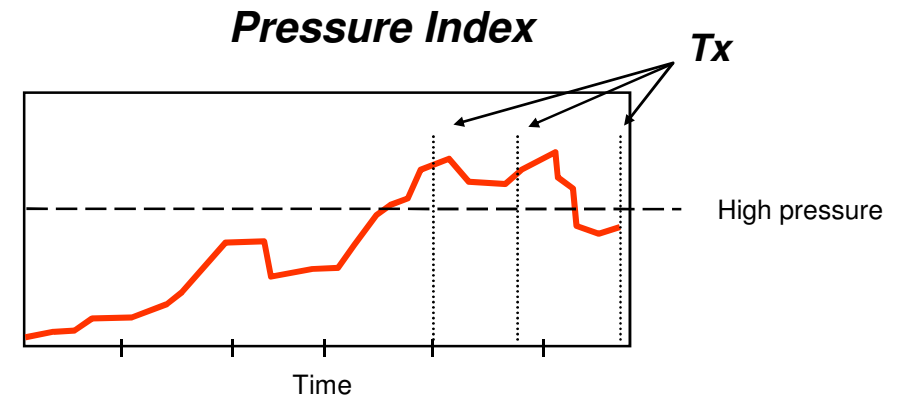
» Types of Index Models



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		
Style		
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.

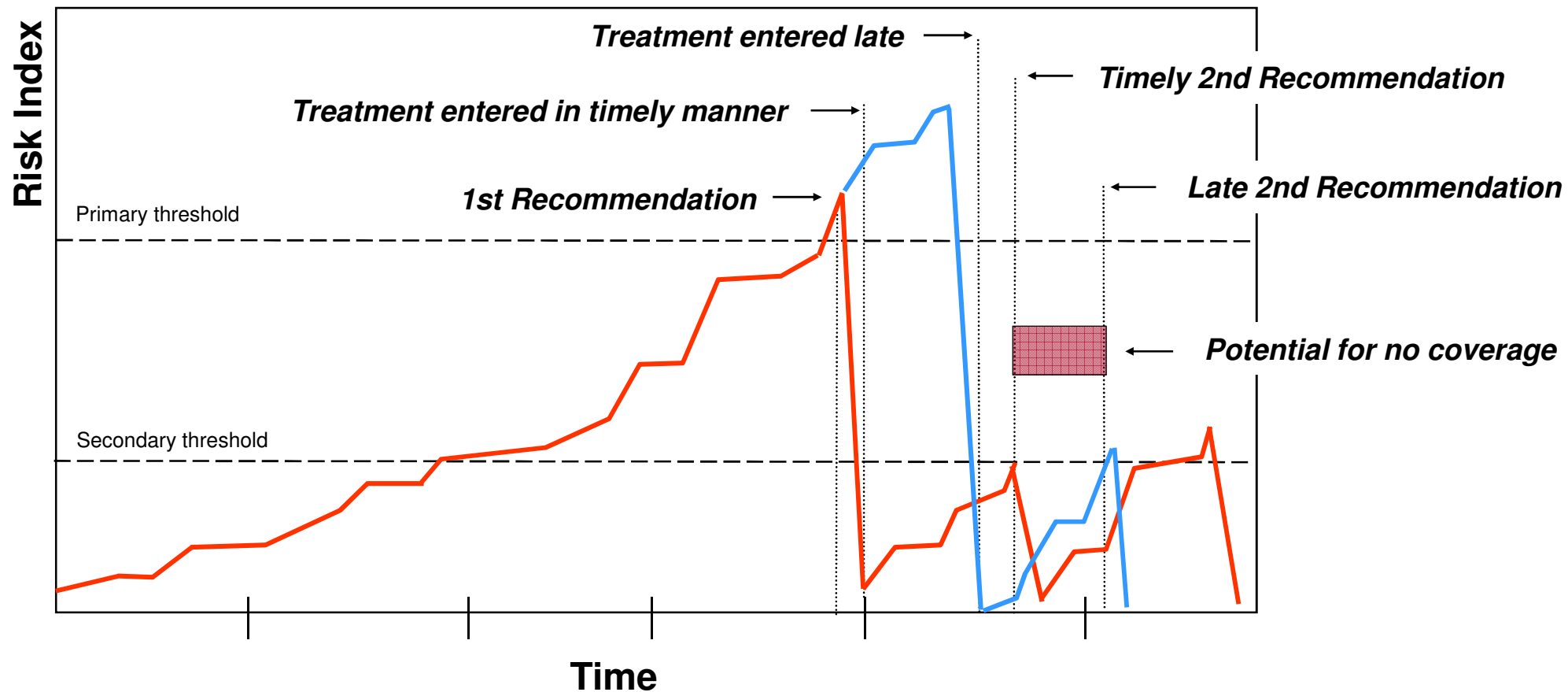
» Example of a Risk Model (Ullrich-Schrodter)



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)



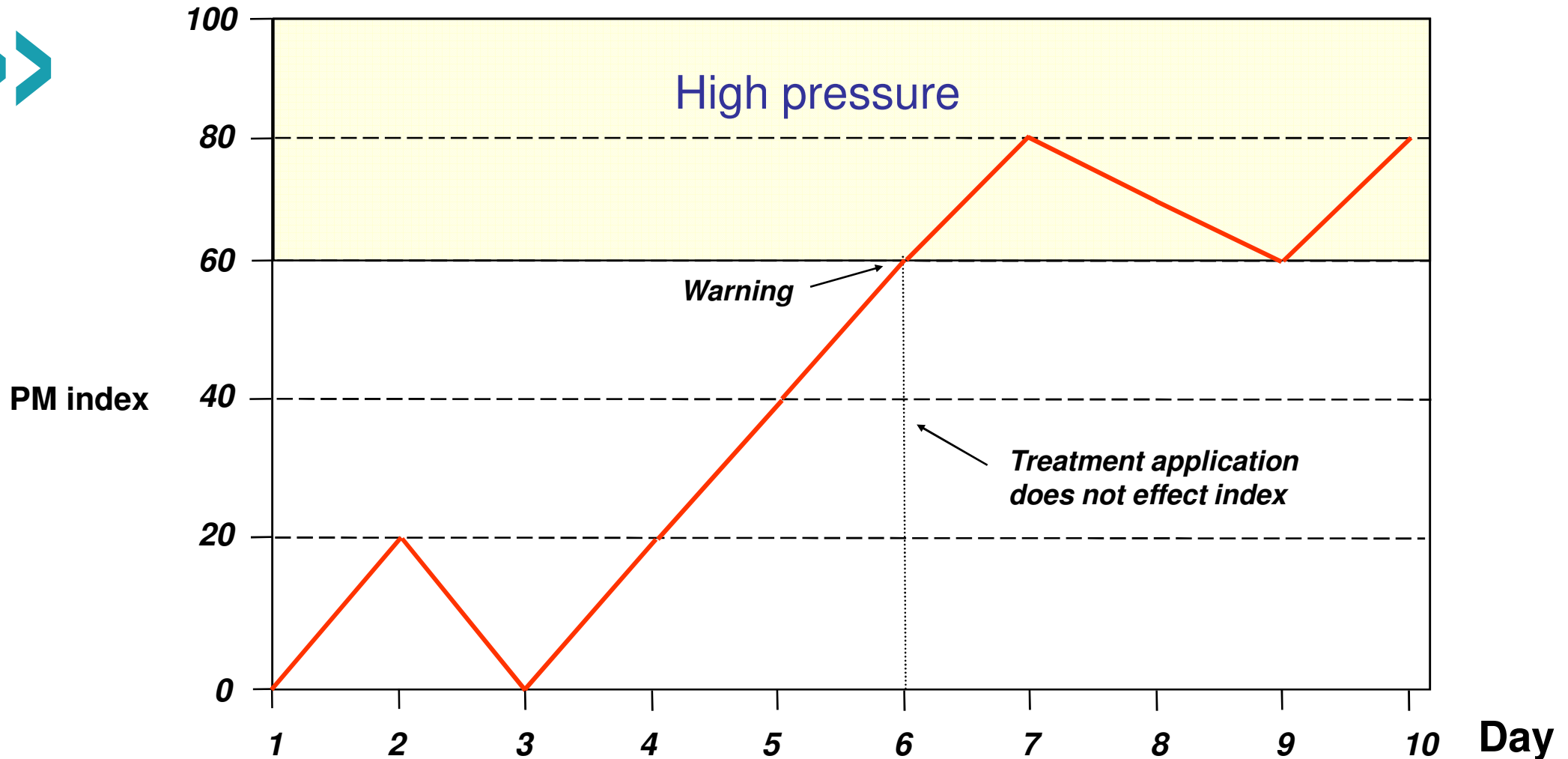
» Example of a Pressure Model (Gubler-Thomas)



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

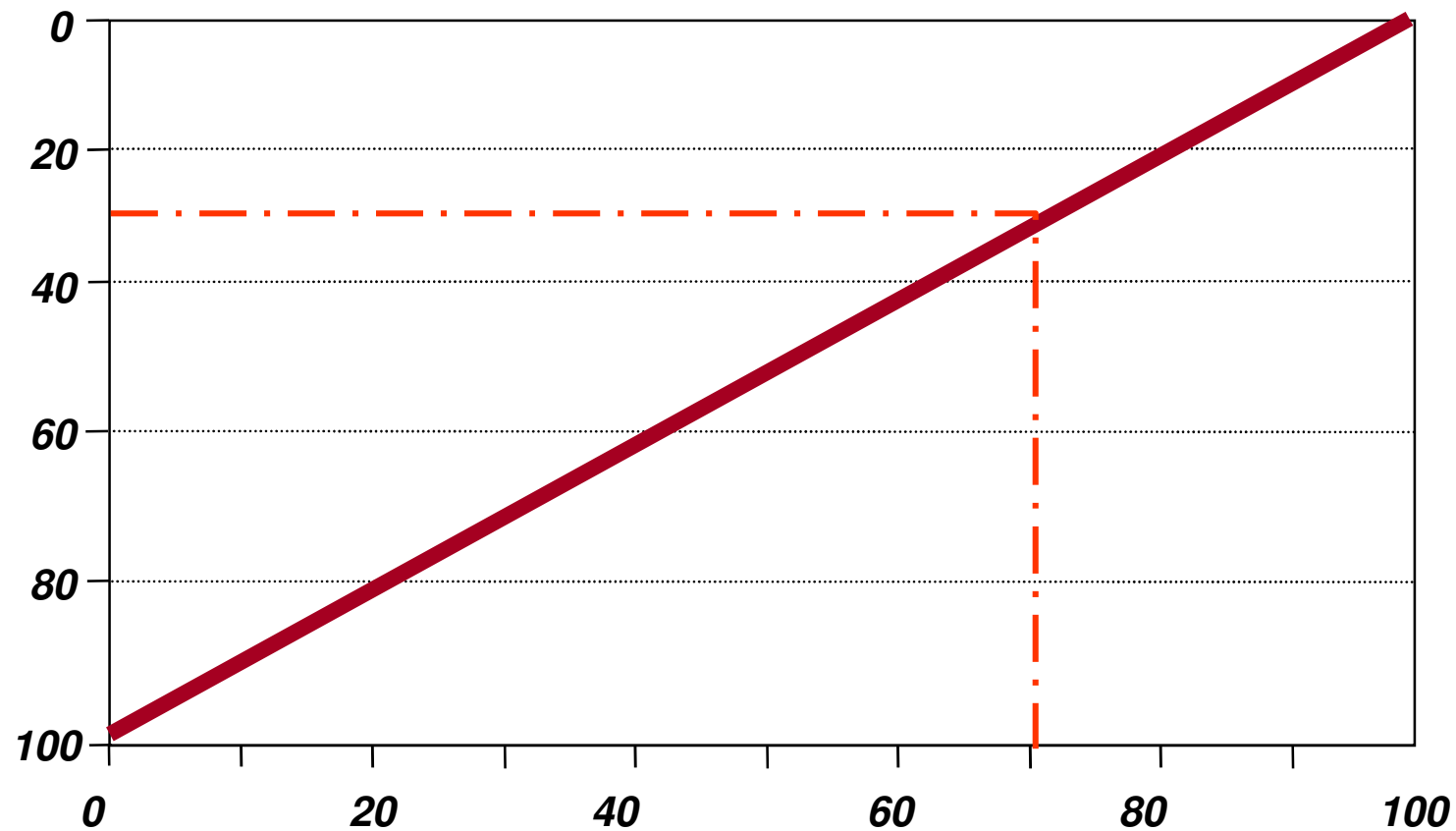
» Example of a Pressure Model (Gubler-Thomas)



» Example of a Pressure Model (Gubler-Thomas)



**% Stretch
(of control duration)**



**Average
PM Index**

» Alternative Ways to Use Models



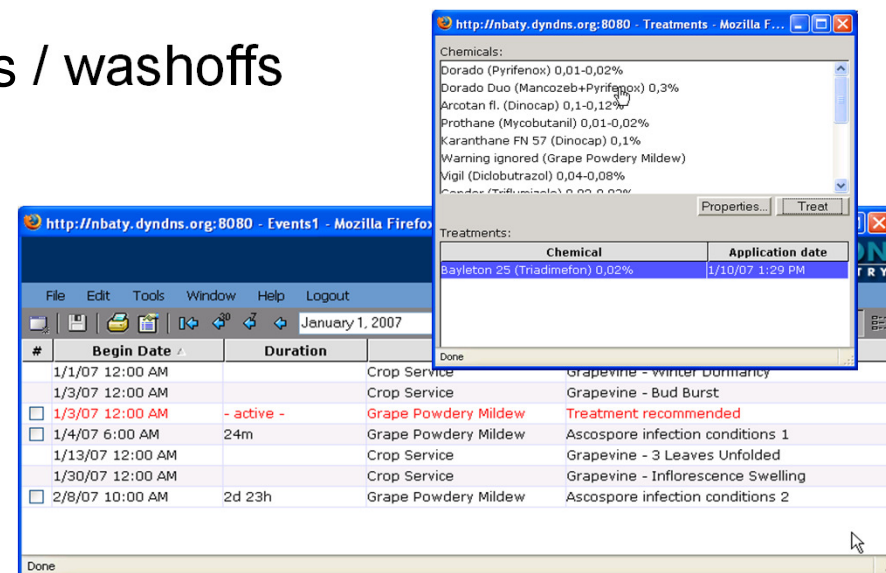
- **Most models have multiple ways they can be used:**
 - Detailed PC/computer based options
 - As guidelines for pressure/outbreaks through the season
 - Identifying the initial onset of disease risk/growth conditions



» Models Use – Detailed PC Based Options



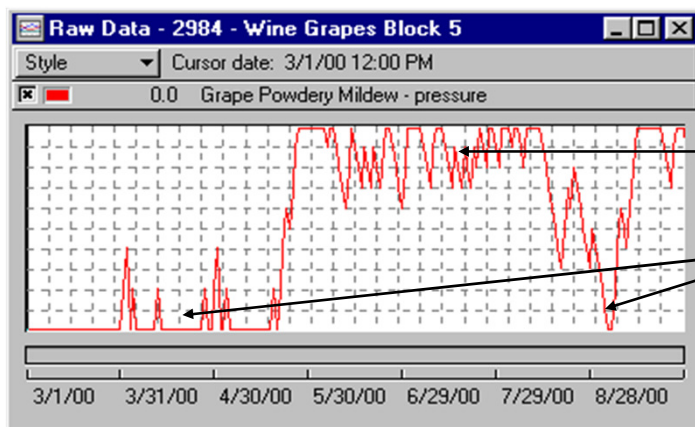
- **PC based options allow many details to be incorporated into the model outputs:**
 - Site specific phenology
 - Site specific treatment schedules/recommendations
 - Treatment specific control durations / washoffs
 - Sensitivity by crop / field
 - Automated changes in model sensitivity by phenological stage
 - Automated warnings for washoff conditions, etc.



» Model Use – as Guidelines during the Season

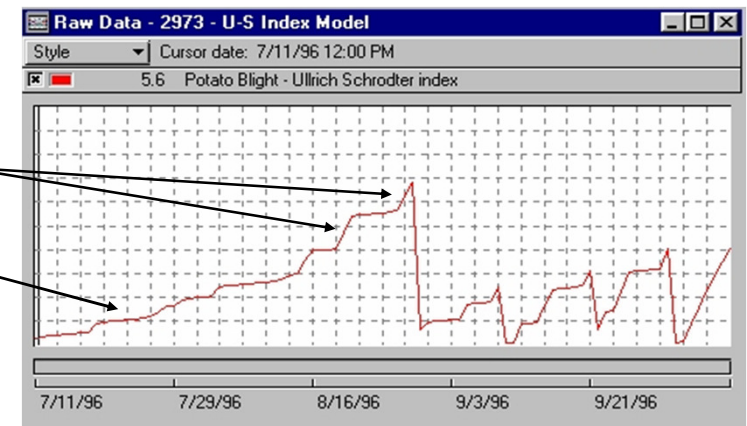


- **Many times logistics do not allow detailed use**
- **Following pressure / risk conditions:**
 - Helps keep spray intervals tight during risky periods
 - Identify periods when treatments can be stretched / skipped versus treatments called for using calendar methods



High Risk

Low Risk

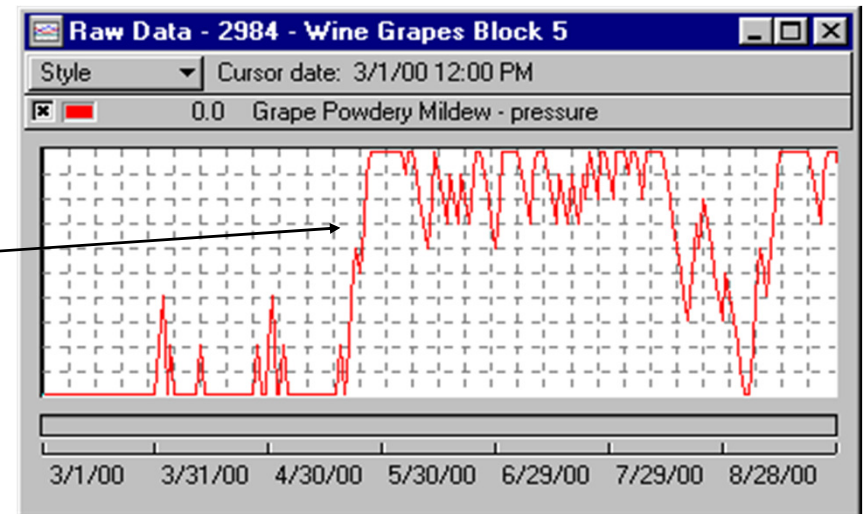


» Models Use – Identifying First Onset

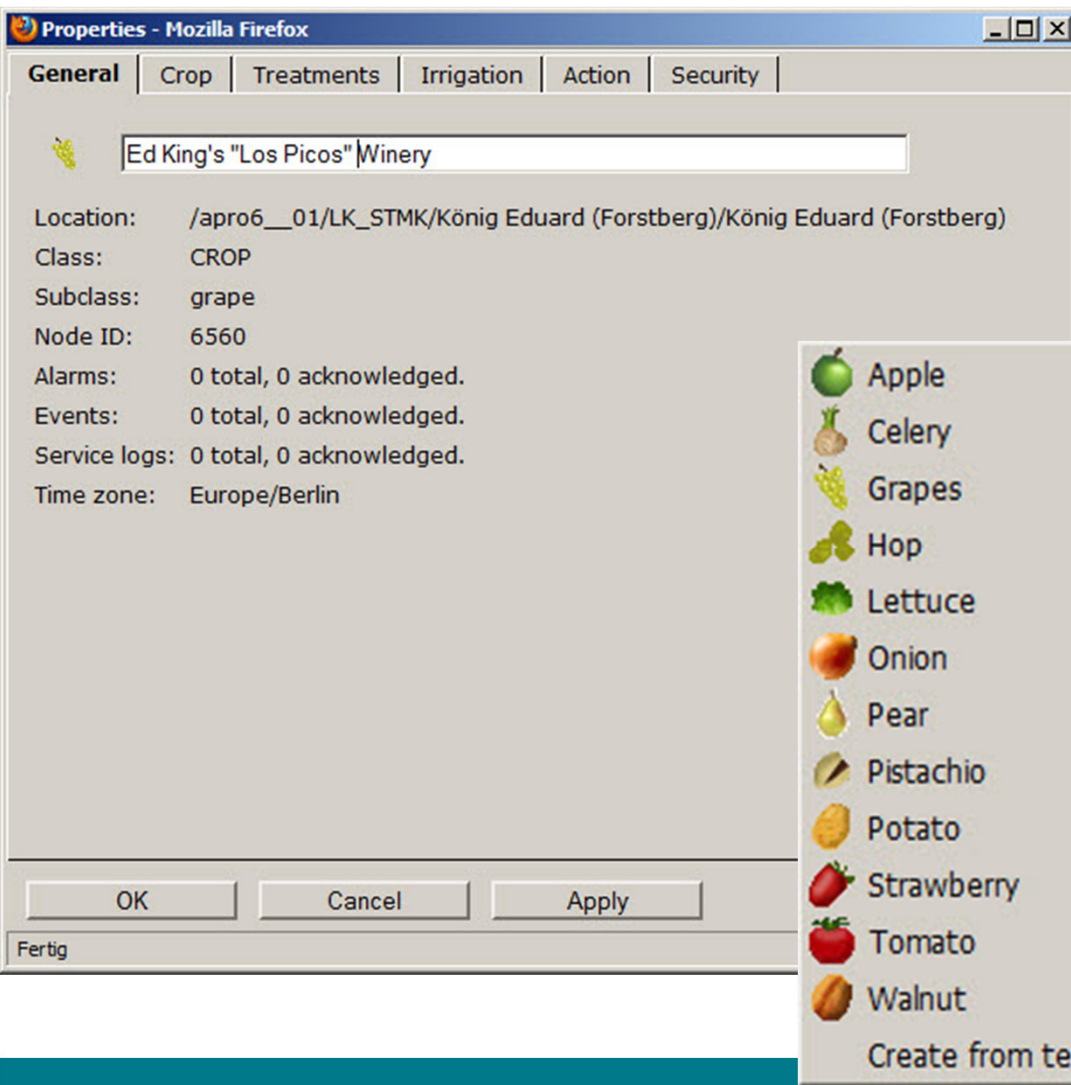


- **Simplest method is to identify the initiation of disease growth conditions**
 - Wait until conditions are ripe for disease growth
 - Start calendar schedule when first conditions are present
 - Minimally avoid wasting inputs until they are needed

Start calendar
treatment schedule



» New approach to disease models with addVANTAGE Pro 6



The Crop Node:

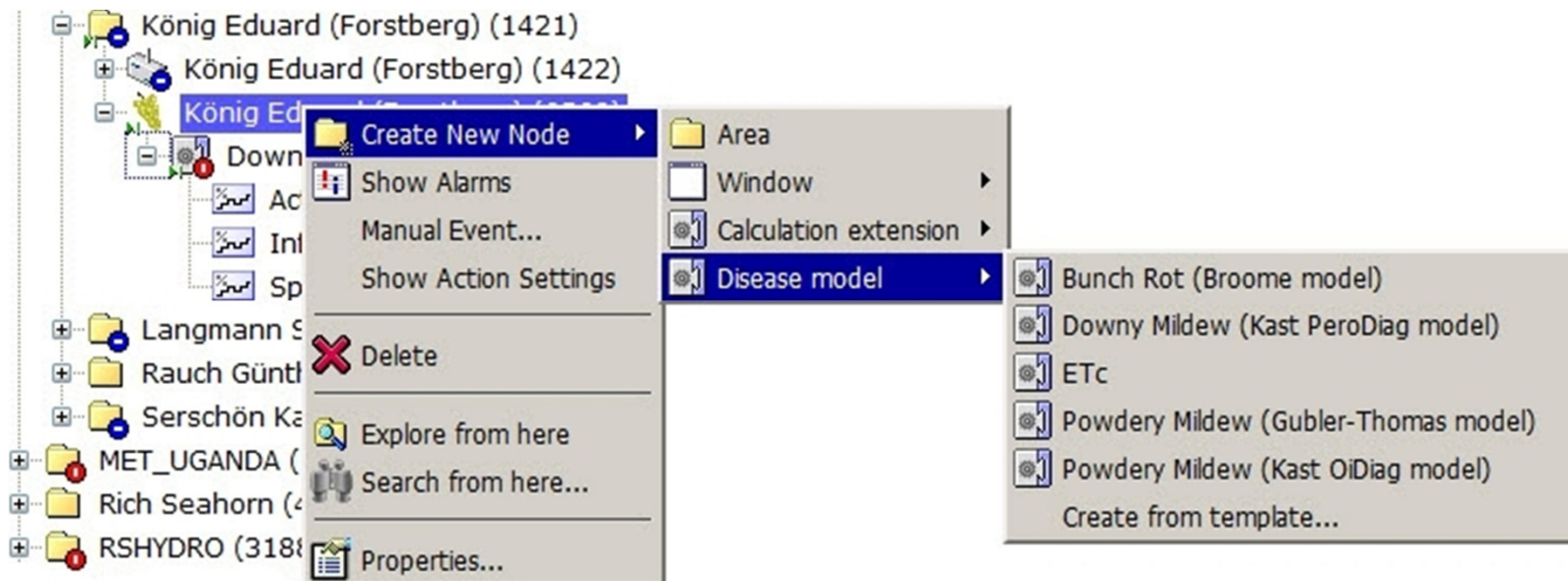
Separates the properties of the crop from the disease models.

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.


Properties - Mozilla Firefox

General | **Crop** | Treatments | Irrigation | Action | Security

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

OK Cancel Apply

Fertig



» THE CROP NODE

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

Properties - Mozilla Firefox

General | Crop | Treatments | **Irrigation** | Action | Security

Application date ▲ | Duration ▾ | Quantity ▾ | Remark ▾

New Irrigation - Mozilla Firefox

Irrigation Type: Sprinkler

Application date: Oct 20, 2010 7:50 PM Europe/Berlin

Duration: 3 d 3 h 30 m

Quantity: 4 mm

Remark:

OK Cancel

Fertig

Properties - Mozilla Firefox

General | Crop | **Treatments** | Irrigation | Action | Security

Application date ▲ | Chemical ▾ | Remark ▾

Oct 20, 2010 7:47:00 PM | Signum (Boscalid, Pyraclostrobin, 0, | Treatment interrupted in sector 3 due to stron

New treatment - Mozilla Firefox

Chemical: Aliette (Fosetyl-Al, 0.2%)

Application date: Oct 20, 2010 7:49 PM Europe/Berlin

Remark:

OK Cancel

Fertig

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

- **Hops**

Downy Mildew
Powdery Mildew

- **Apples**

Apple Scab
Powdery Mildew
Fire Blight

- **DSV Extension**

TomCast &
Wisdom TomCast for

- Tomatoes (late blight),
- Potatoes (late blight),
- Carrots (Alternaria),
- Celery (Septoria)

- **Potatoe**

Phytophthora

- **Various Nuts**

Pistacchio
Walnuts

- **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 of 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 small town in the distance under a clear blue sky.

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

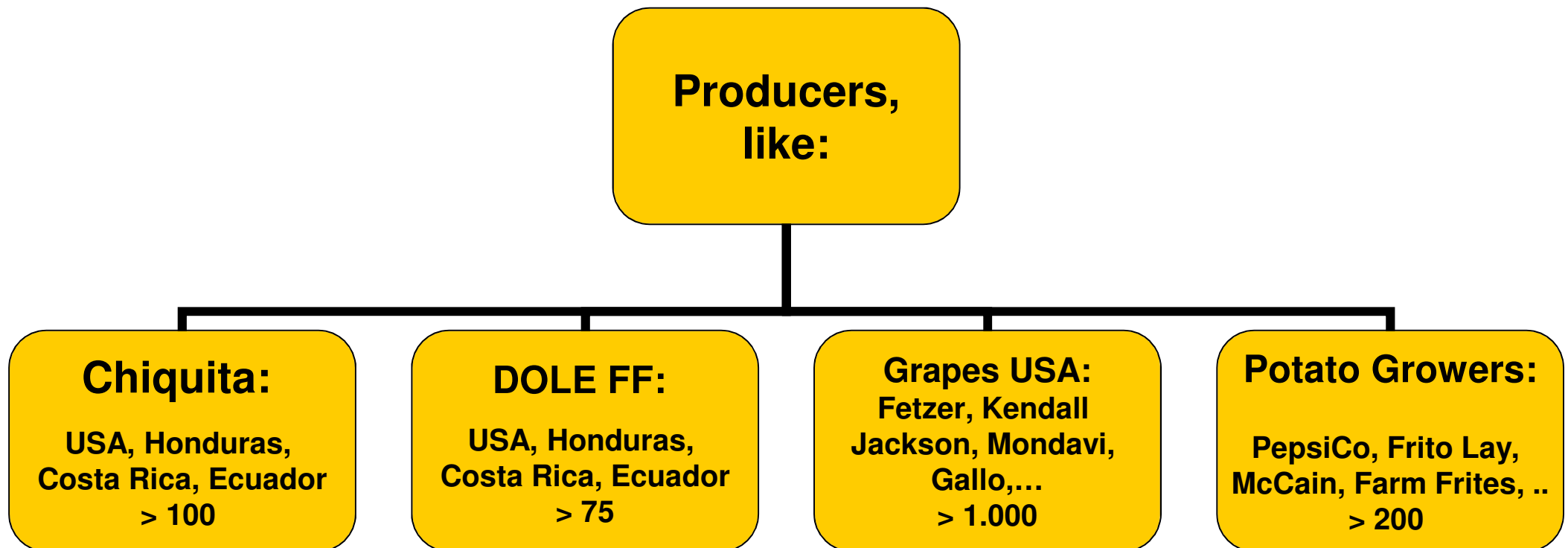
Since 2006 the WWF with its HQ in Honduras is building a network of weather stations in Central America.

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

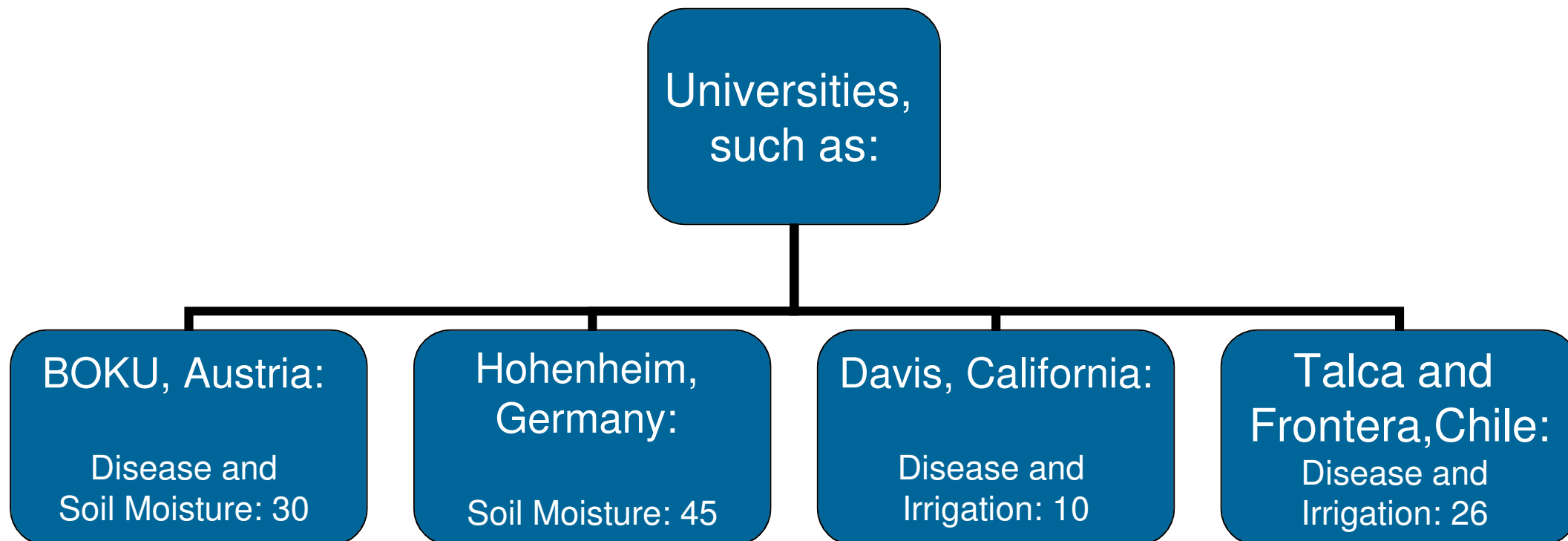
A central addVANTAGE Pro Server operated by agronomists will bring the chance to give many people access to data and agronomical know how.

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

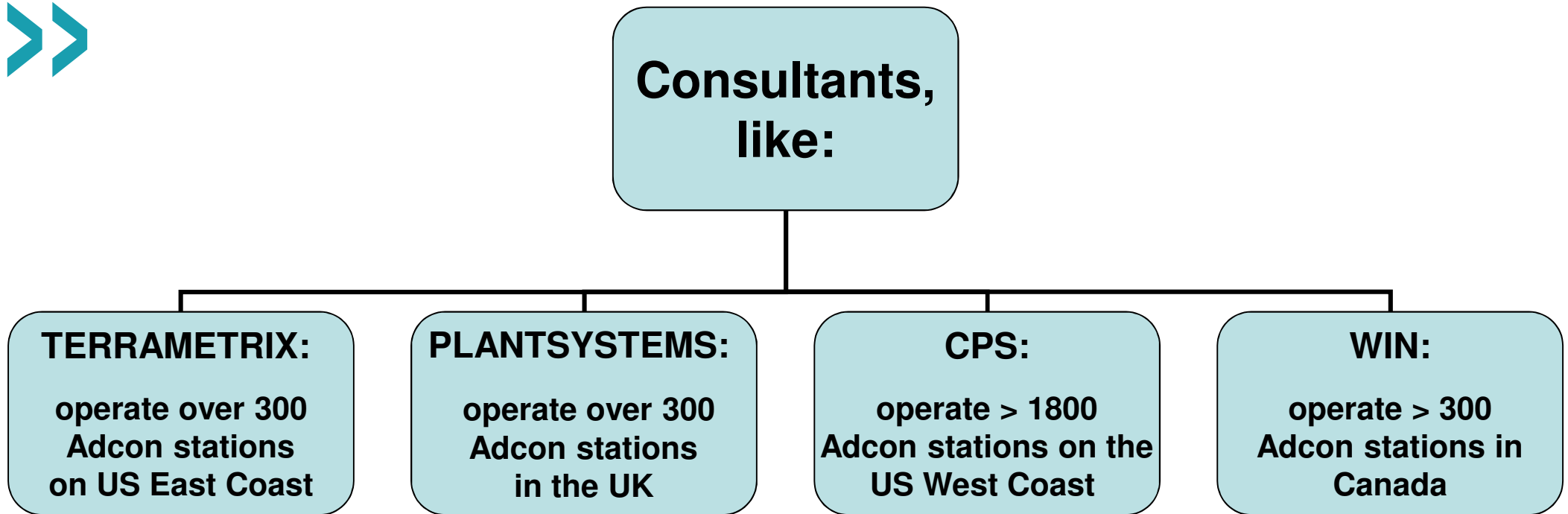
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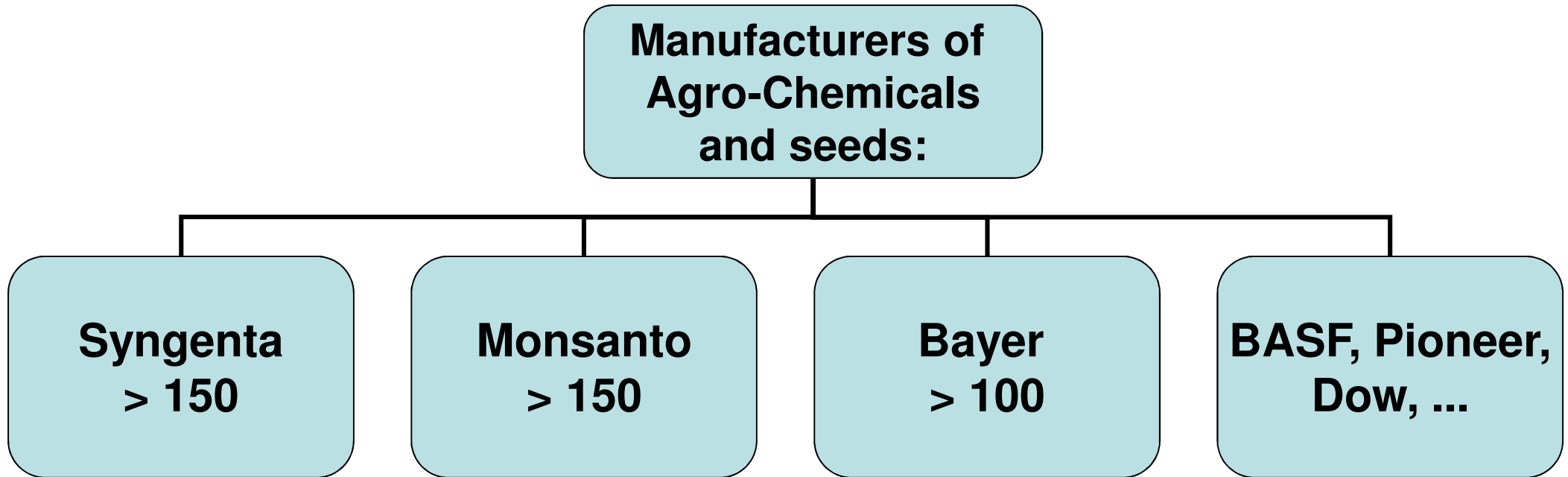
» REFERENCES – Who is Who of Adcon Users



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Thank you for your attention!

b.pacher@adcon.com