Predicting Pest Activity with Degree-Day Models

Outline

- Temperature effects on insect and plant biology
- Degree-days Models
- How forecasting helps crop management
- Where to find resources

Insect Biology

- Insects are cold-blooded
- Growth is controlled by temperature
- Minimum temperature for development
- Maximum temperature

Development rate of plants is also temperature dependent.

Temperature & Onion Thrips

- Survivorship
- Reproduction
- Generation Time
- Population Dynamics

Onion Thrips Survival, Fecundity and Generation Times (Days) at VariousTemperatures

	68^0 F	77^0 F	86^0 F
Adulthood	47 days	25 days	13 day
Eggs / Female	210	165	63
Generation Time	48 days	30 days	17 days

Murai (2000)

Onion Thrips Population Growth

	Number of Females		
Date	68^0 F		
June1	1		
June 8			
June 15			
June 22			
June 29			
July 6			
July 13			
July 20	210		
July 27			
August 3			
Number generations	1		

Onion Thrips Population Growth

	Number of Females		
Date	68^0 F	77^0 F	
June1	1	1	
June 8			
June 15			
June 22			
June 29		165	
July 6			
July 13			
July 20	210		
July 27			
August 3		27,225	
Number generations	1	2	

Onion Thrips Population Growth

	Number of Females		
Date	68^0 F	77^0 F	86^0 F
June1	1	1	1
June 8			
June 15			63
June 22			
June 29		165	3,969
July 6			
July 13			250,047
July 20	210		
July 27			15,752,961
August 3		27,225	
Number generations	1	2	4

How to Use Development Rates in Crop Management?

- Predict timing of pest populations
- Improve scouting
- Improve timing of pesticide applications

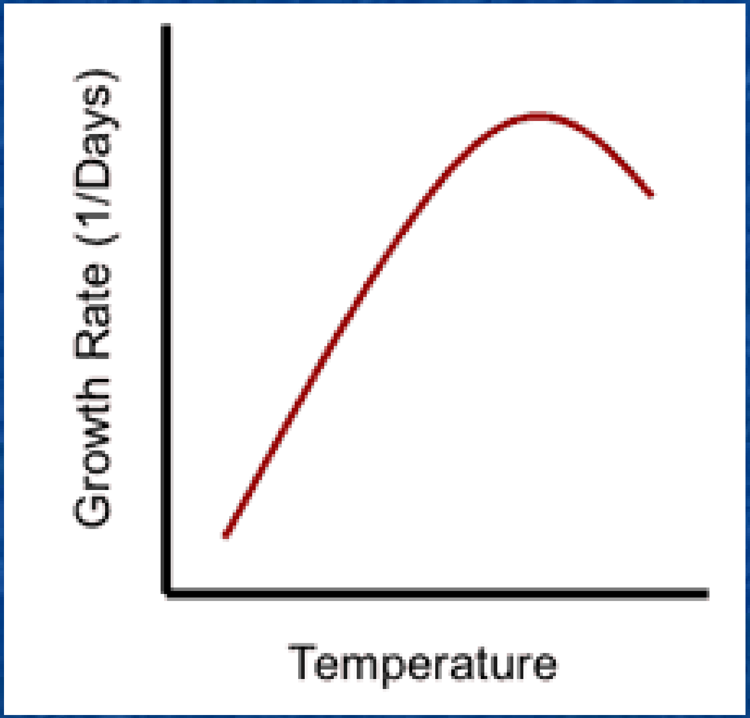
Quiz

- How long does it take a codling moth eggs to hatch?

a) 8 days
b) 11 days
c) 14 days
d) All of the above

Degree-Day Models as a Tool

- Use to predict when susceptible pest stages are present to maximize control



Degree – Days

- Degree-days (DD) are used in models because they allow a simple way of predicting development of cold-blooded organisms (insects, mites, bacteria, fungi, plants).

Degree - Day

- Degree-day: used to measure insect development
- Amount of heat accumulated over a specified base temperature during a 24 hour day.
- 1 degree-day (DD) – single degree of temperature above an insect's lower threshold maintained for 24 hours

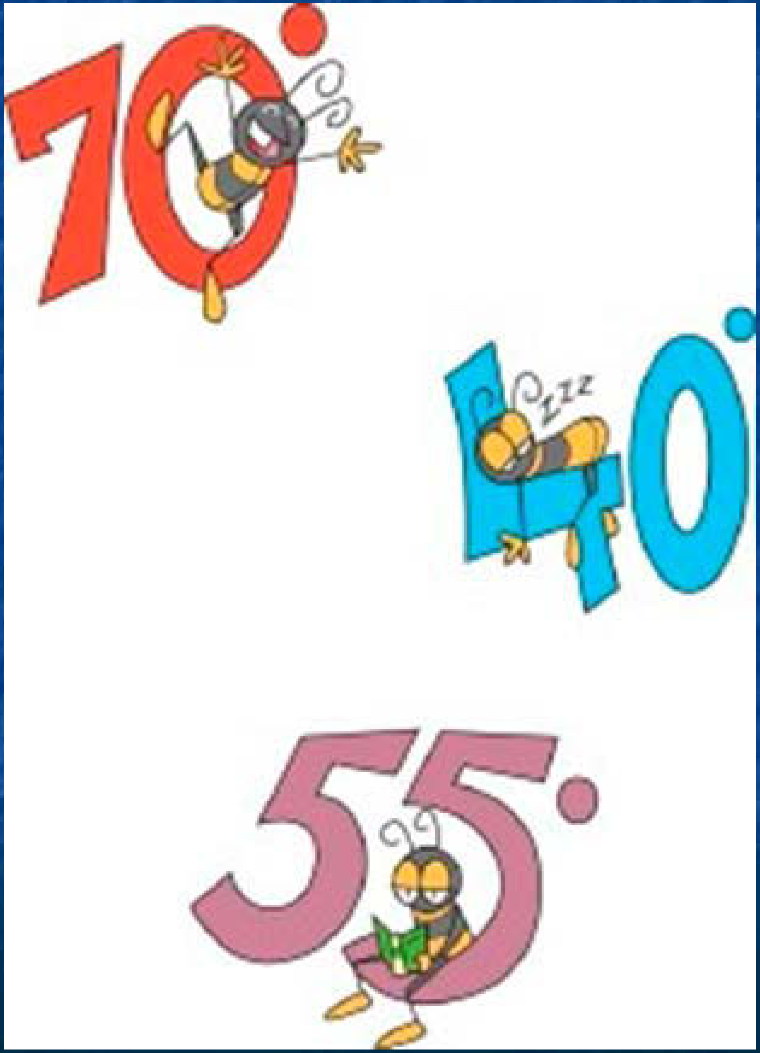
Daily temperature readings can be used to calculate growing degree-days, which is a measure of accumulated heat.

Base Temperature

- Temperature above which degree-day accumulation is calculated
- Ideally, the base temperature is the lower temperature threshold for development or activity

Lower Temperature Threshold

Temperature below which no growth or development occurs in the species of interest.



Cumulative Degree - Days

- Number of degree-days accumulated during a specified time interval (e.g since the beginning of the year).
- Calculated in reference to the starting date

Key Point

- Degree-days only have meaning if base temperature and starting date are specified.

Calculating Degree-Days

- Average method
- Modified average method
- Modified sine wave

Average Method

DD = Average Temp – Base Temp

Max = 70, Min = 40

Base = 50

$$\frac{70 + 40}{2} - 50 = 5 \text{ DD}$$

Average Method

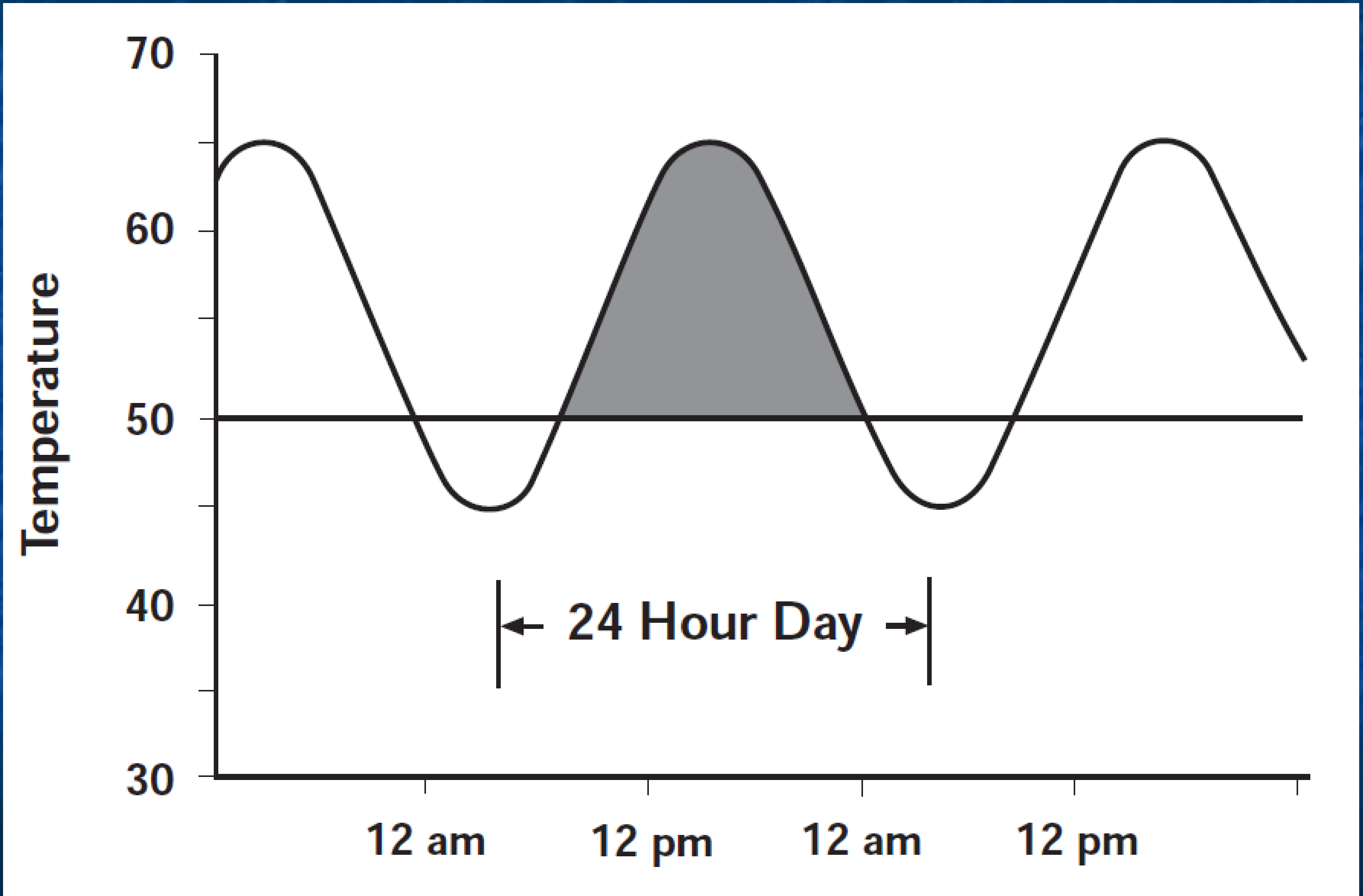
DD = Average Temp – Base Temp

Max = 80, Min = 50

Base = 50

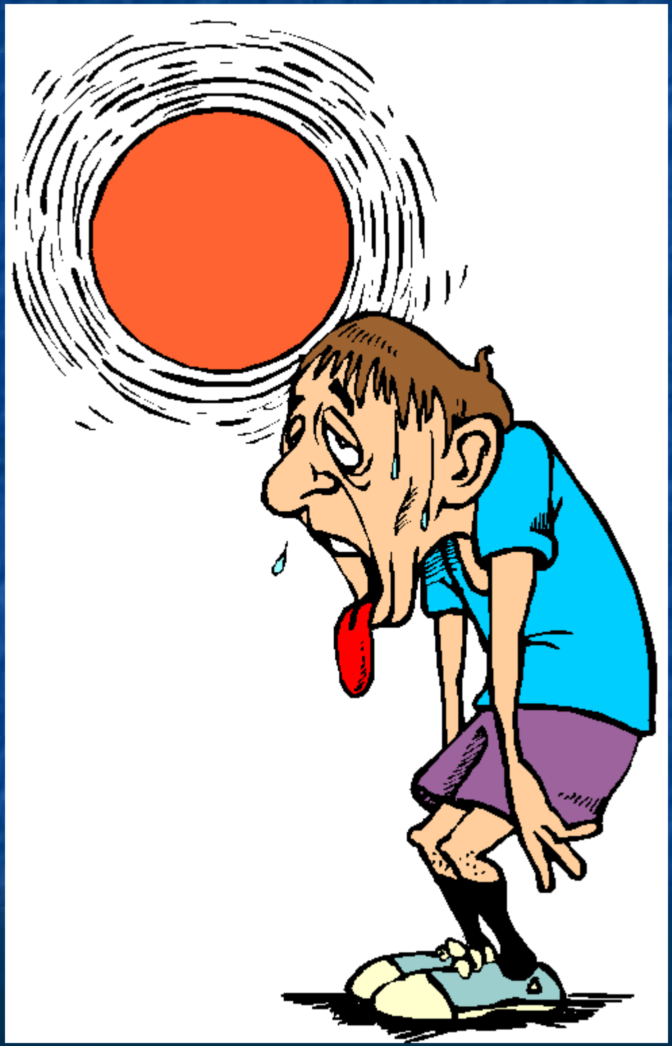
$$\frac{80 + 50}{2} - 50 = 15 \text{ DD}$$

Modified Sine Wave Method

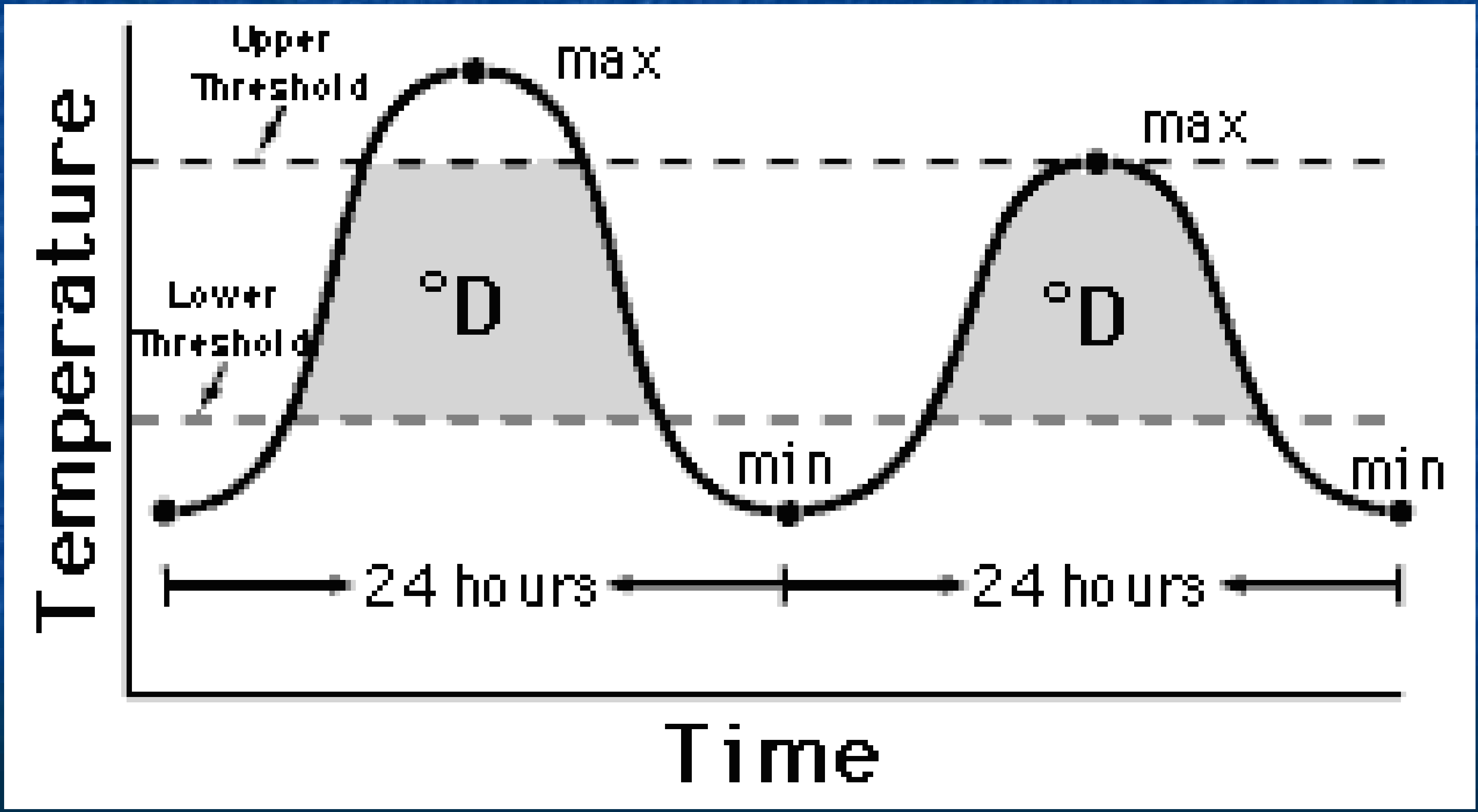


Upper Temperature Threshold

Temperature above which no growth or development occurs.



Upper Temperature Threshold



Limitations of Degree-Day Models

- Insect response to temperature is not linear
- Thresholds known for very few species.
- Measured temperatures not the same as those experienced by the pest.

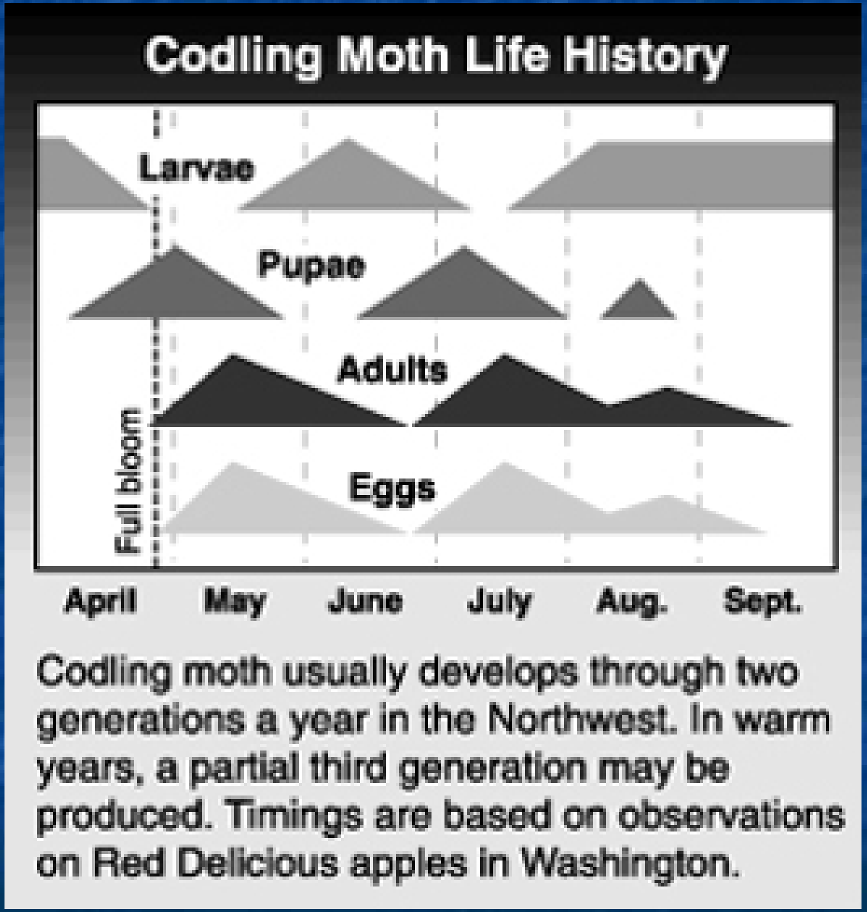
Degree-Day Models

- Predict timing of events
- Guidelines to help time scouting efforts
- Improve crop management

Codling Moth Development

Predicting Codling Moth

- Overwinter as mature larvae
- Adult flight begins around full bloom
- Larvae bore into fruit



Two Methods to Manage Larvae

Calendar Approach

- Treat 3 weeks after full bloom

Degree Day Model

- Monitor adult flight with pheromone traps
- Biofix = 1st consistent catch of moths in traps
- Treat at 250 DD after Biofix

Comparison of Spray Timing Methods for Codling Moth

Year	Full bloom	Biofix (1st moth)	Calendar method	Model method	Observed 1st entry	Model accuracy	Calendar accuracy	Days between biofix and 1st entry
79	Apr 28	Apr 29	May 19	May 22	May 22	0	3	23
80	Apr 26	Apr 27	May 17	May 21	May 21	0	4	24
81	Apr 23	Apr 22	May 14	May 29	May 27	-2	13	35
82	May 5	May 3	May 26	May 28	May 28	0	2	25
83	Apr 24	Apr 28	May 15	May 24	May 23	-1	8	25
84	Apr 30	May 6	May 27	June 8	June 8	0	18	33
85	Apr 30	Apr 29	May 21	May 23	May 22	-1	1	23
86	Apr 25	May 1	May 16	May 29	May 29	0	13	28
87	Apr 23	Apr 20	May 14	May 10	May 12	2	-2	22
93	May 6	May 5	May 26	May 20	May 20	0	6	15

Biofix: The first capture of male moths in pheromone traps.
Calendar method: Spray 21 days after full bloom.
Model method: Spray 250 degree days after biofix.
Accuracy: Difference, in days, between observed first larval entry in the field and predicted timing. Negative numbers indicate predicted timing was too late; positive numbers indicate predicted timing was too early.

Alfalfa Weevil

Alfalfa Weevil

- Short time between when the insect emerges from its overwintering site in leaf litter to depositing eggs into the terminal leaders and egg hatch.
- If treatments are timed on a calendar date alone, it may not be effective since insect development is related to temperature

Alfalfa Weevil

- Sampling fields can save money by avoiding unnecessary pesticide application

- Crop damage can be reduced by using an insecticide at the time of greatest effectiveness.

Alfalfa Weevil Development

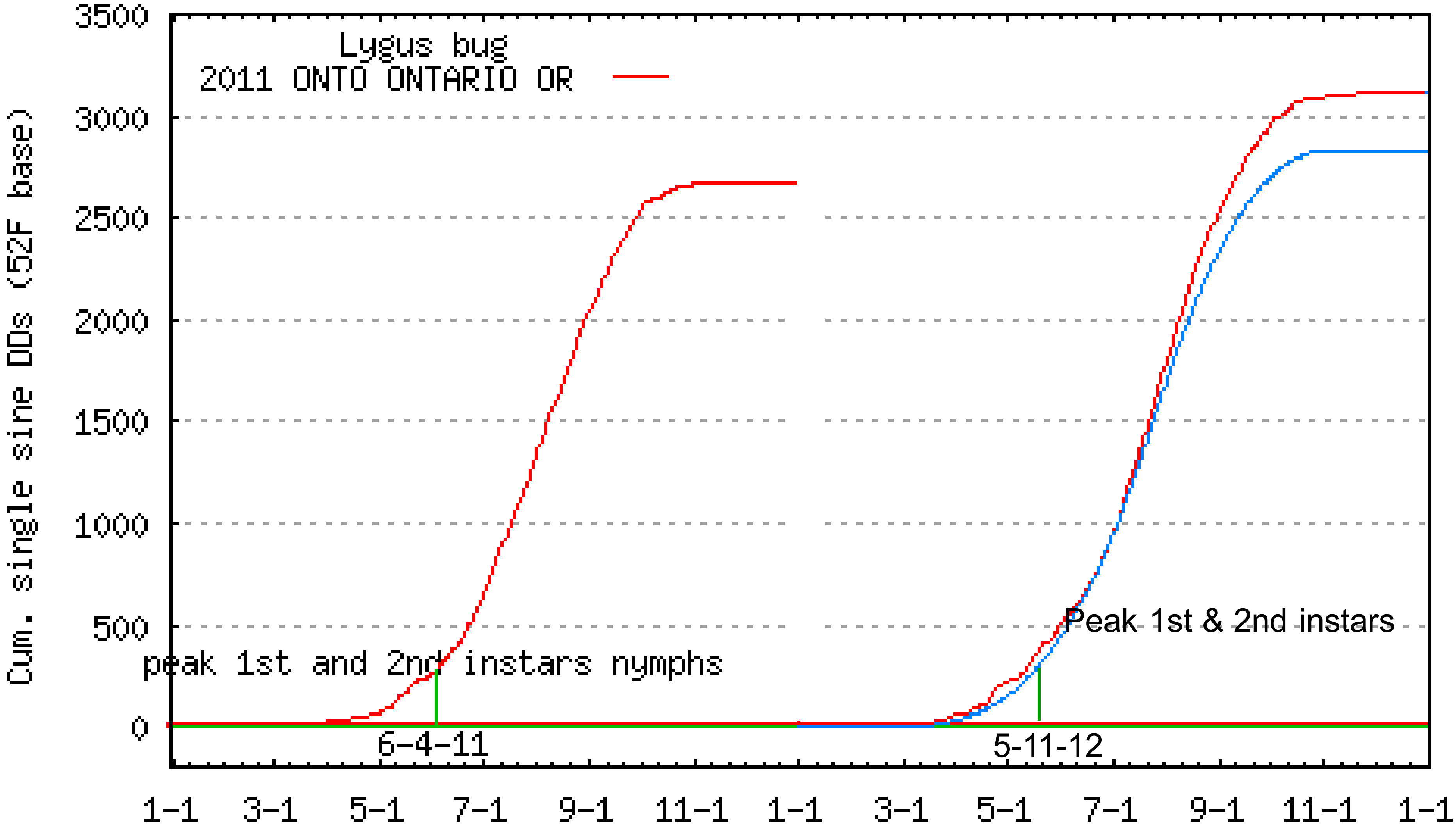
Stage of Development	Degree Days to Complete Life Stage	Accumulated Degree Days
egg	300	300
1st instar	71	371
2nd instar	67	438
3rd instar	66	504
4th instar	91	595
Pupa	219	814
Base = 48oF	Start = January 1	

Degree Days - Alfalfa Weevil Eggs

YEAR	Degree Days as of April 26
2008	304
2009	203
2010	353
2011	143
2012	460
Average of 5 years	292.5

(Central Michigan)

Lygus 2011 vs. 2012



Other Uses for Degree-Day Models

- Crop Maturity

- Disease Forecasting

Corn Maturity Relative to Degree-Days

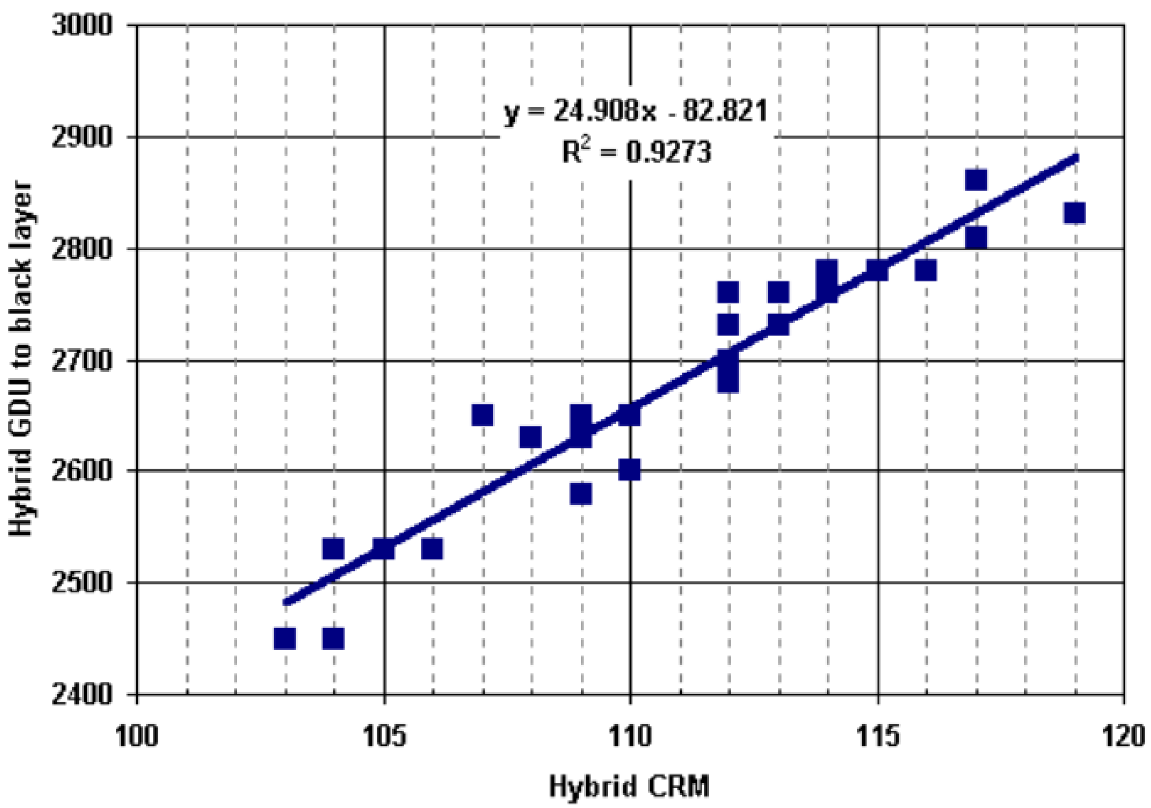


Figure 1. Relationship between hybrid comparative relative maturity (CRM) and hybrid growing degree units (GDU) from planting to kernel black layer for a group of Pioneer" brand corn hybrids(1). (Source of data: Pioneer Hi-Bred International sales literature, 2001.)

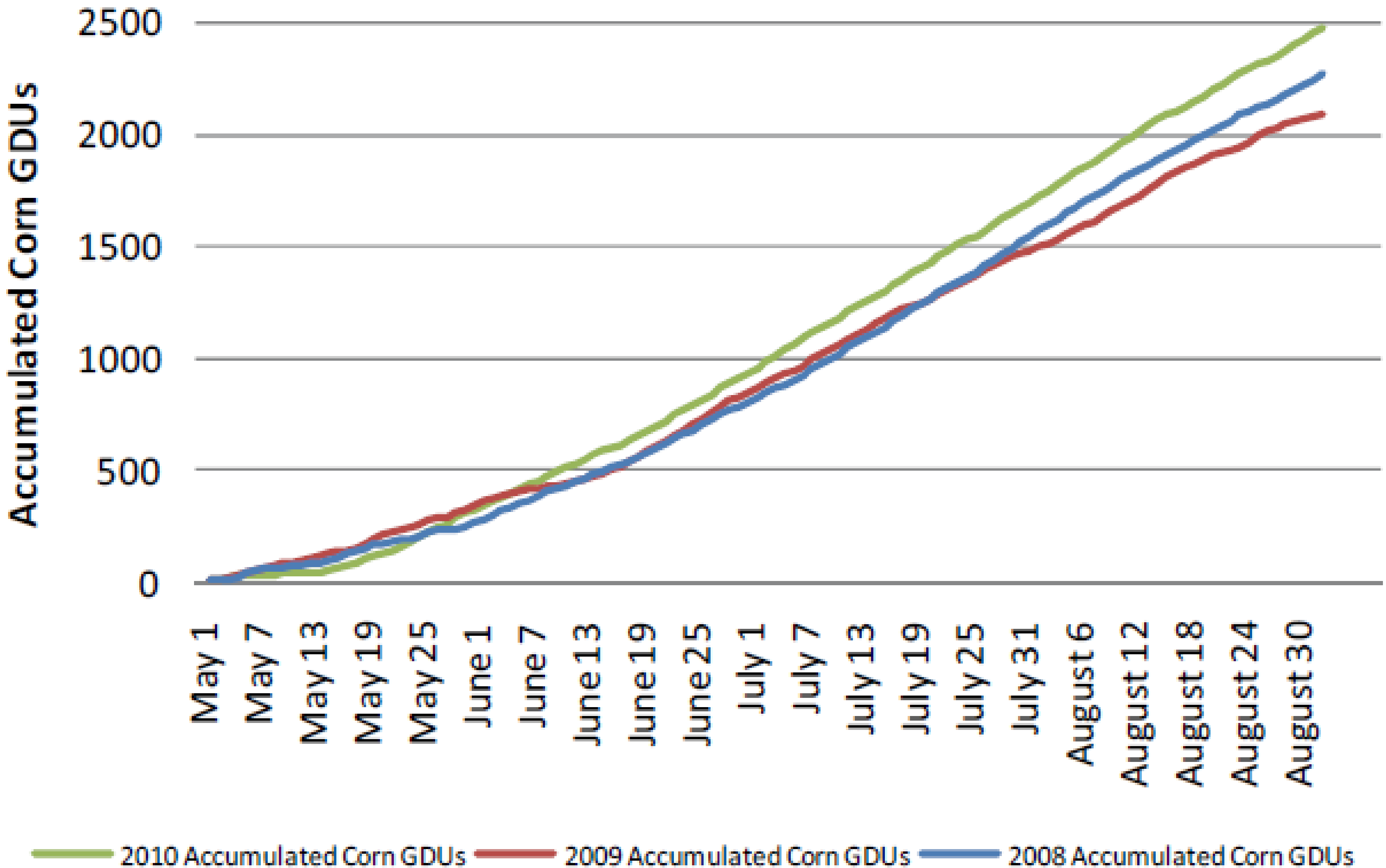


Figure 3. Accumulated corn GDUs during May 1 to August 31st in Parkston, SD for 2008, 2009 & 2010.

Disease Forecasting

- Temperature
- Leaf Wetness
- Calculate DSV – Disease Severity Values
- Requires monitors for temperature & moisture

Tom-Cast Model

Mean Daily Temp	**Hours of Leaf Wetness to Produce**				
55 – 63	0 – 6	7 -15	16 – 20	21+	
64 – 68	0 – 3	4 – 8	9 – 15	16 – 22	23+
70 – 77	0 – 2	3 – 5	6 – 12	13 – 20	21+
79 – 84	0 – 3	4 – 8	9 – 15	16 – 22	23+
DSV	**0**	**1**	**2**	**3**	**4**

Where to find resources?

Welcome to the USPEST.ORG/PNWPEST.ORG/IPPC2.ORST.EDU web server at the Integrated Plant Protection Center of Oregon State University

The following web sites/resources are hosted here:

1. http://uspest.org/wea - Online IPM Pest and Plant Disease Models and Forecasting - for agricultural, pest management, and plant biosecurity decision support in the US; including:
   - http://uspest.org/cgi-bin/ddmodel.pl Pacific NW interface to degree-day models and calculations.
   - Online daily degree-day maps / tables. GIS/mapping, degree-day and plant disease risk modeling system for:
     Main index to online tutorials, daily DD maps, models linked from weather stations (tables)
   - http://uspest.org/risk/models Online plant disease risk and phenology models and degree-day calculations.
   - http://uspest.org/cgi-bin/usmapmaker.pl Custom degree-day mapping calculator for 48 US states
2. Online publishing engine and decision support system for Pacific Northwest Pest Management Handbooks:
   - http://uspest.org/pnw/insects PNW Insect Management Handbook - since 2002, updated yearly
   - http://uspest.org/pnw/weeds PNW Weed Management Handbook - from 2001 - 2010, now this link forwards to a new site hosted by OSU EESC
   - http://plant-disease.ippc.orst.edu PNW Plant-Disease Management Handbook - from Jan 2003 - Jan 2007, now hosted by an IPPC server managed by Hans Luh
3. http://mint.ippc.orst.edu - IPMP 3.0 Insect Pest Management on Peppermint Decision Support System
4. http://uspest.org/potato Identification and Management of Major Pest and Beneficial Insects In Potato
5. http://uspest.org/ipm/mcalc.html Release calculator and guidelines to use a predator mite, *Neoseiulus fallacis* for biological control two-spotted spider mites in strawberry

integrated plant protection center IPPC OSU · PRISM GROUP · Western IPM Center · ipmPIPE · NPDN National Plant Diagnostic Network · NIFA

USPEST.ORG

Online Phenology and Degree-day Models

for agricultural and pest management decision making in the US

Degree-day Calculator

Select degree-day model list or calculator mode instructions:

Degree-Day Calculator calculator general introduction

(hint: select all form options, click here: ☐ and make a bookmark for later use)

For calculator mode, enter thresholds in °F (or celsius °C: ☐) and calculation method:

lower: ____ ° upper: ____ ° single sine

Select starting Jan 1 2013 and ending Dec 31 2013 dates

Starting date/BIOFIX instructions:

Select location: Only one column should display a location, otherwise "None"

Oregon, California, Alaska	Washington, Idaho	Montana, Wyoming
none	None	none

Or upload your own weather data file to calculate: (see format description or example file)

Choose File No file chosen

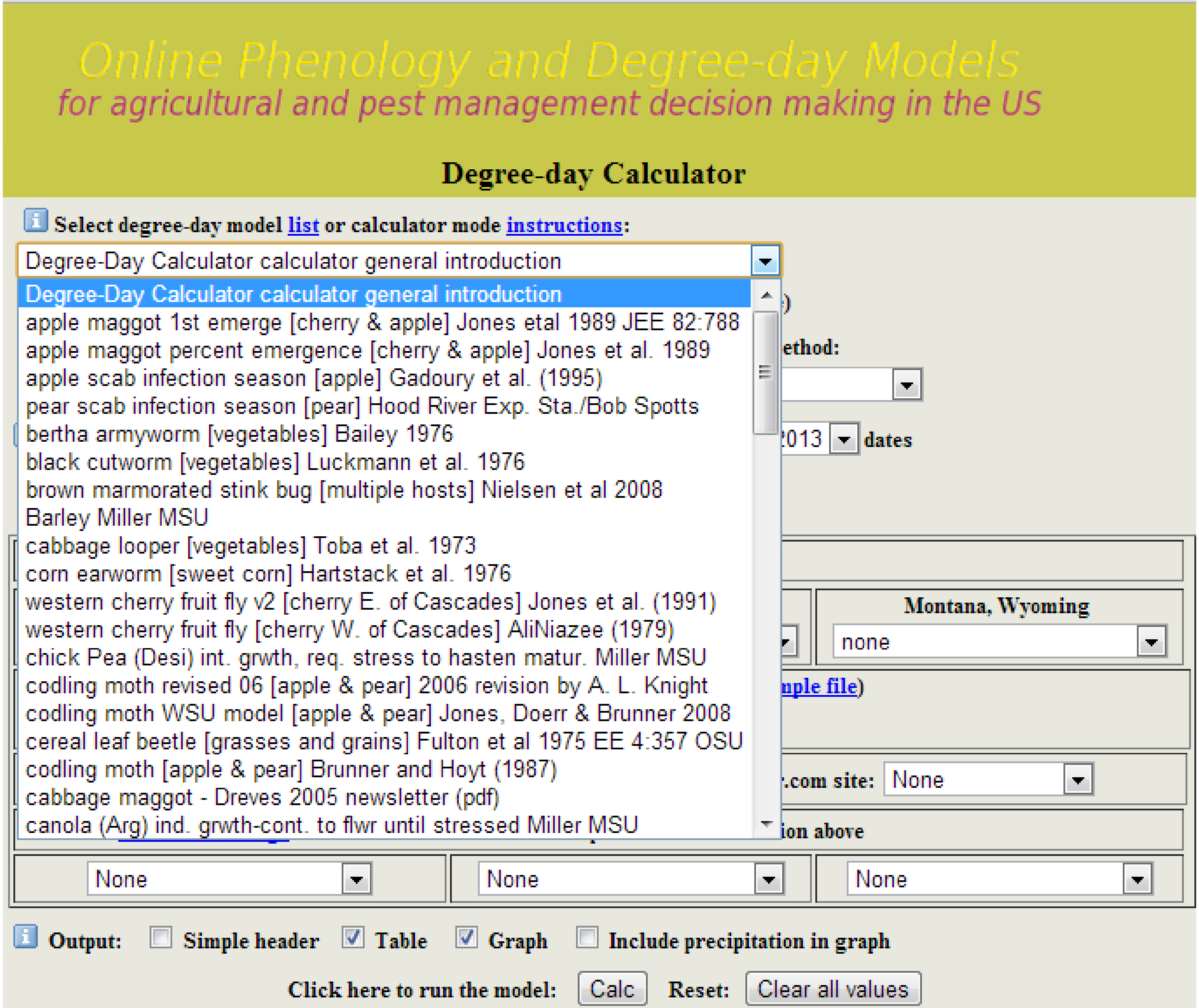
Forecasts: NWS zipcode/city, state: ____ or weather.com site: None

Select historical average forecast location: Should line up with selected location above

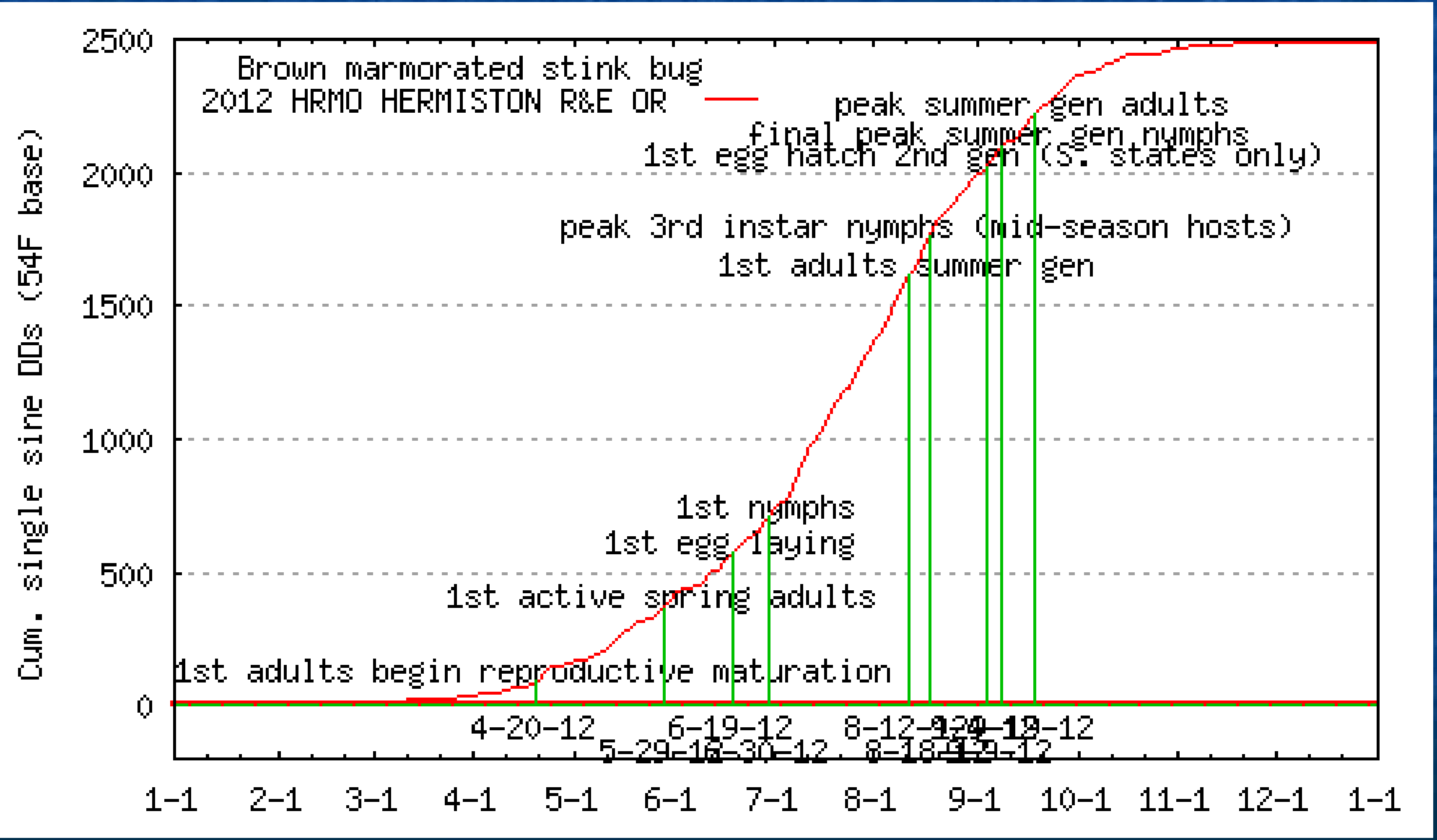
None	None	None

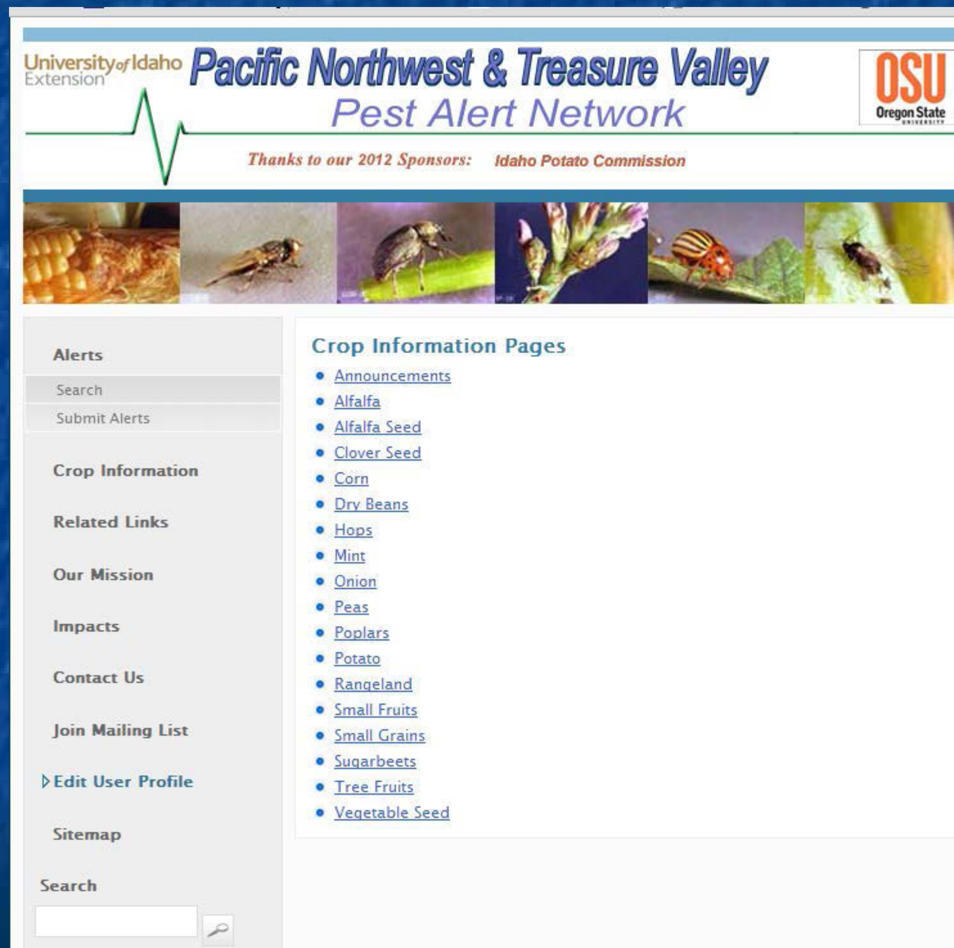
Output: ☐ Simple header ☑ Table ☑ Graph ☐ Include precipitation in graph

Click here to run the model: Calc Reset: Clear all values


Online Phenology and Degree-day Models
for agricultural and pest management decision making in the US
Degree-day Calculator
Select degree-day model list or calculator mode instructions:
Degree-Day Calculator calculator general introduction
Degree-Day Calculator calculator general introduction
apple maggot 1st emerge [cherry & apple] Jones etal 1989 JEE 82:788
apple maggot percent emergence [cherry & apple] Jones et al. 1989
apple scab infection season [apple] Gadoury et al. (1995)
pear scab infection season [pear] Hood River Exp. Sta./Bob Spotts
bertha armyworm [vegetables] Bailey 1976
black cutworm [vegetables] Luckmann et al. 1976
brown marmorated stink bug [multiple hosts] Nielsen et al 2008
Barley Miller MSU
cabbage looper [vegetables] Toba et al. 1973
corn earworm [sweet corn] Hartstack et al. 1976
western cherry fruit fly v2 [cherry E. of Cascades] Jones et al. (1991)
western cherry fruit fly [cherry W. of Cascades] AliNiazee (1979)
chick Pea (Desi) int. grwth, req. stress to hasten matur. Miller MSU
codling moth revised 06 [apple & pear] 2006 revision by A. L. Knight
codling moth WSU model [apple & pear] Jones, Doerr & Brunner 2008
cereal leaf beetle [grasses and grains] Fulton et al 1975 EE 4:357 OSU
codling moth [apple & pear] Brunner and Hoyt (1987)
cabbage maggot - Dreves 2005 newsletter (pdf)
canola (Arg) ind. grwth-cont. to flwr until stressed Miller MSU
ethod:
2013 dates
Montana, Wyoming
none
mple file)
.com site: None
ion above
None
None
None
Output: Simple header Table Graph Include precipitation in graph
Click here to run the model: Calc Reset: Clear all values

BMSB at Hermiston




University of Idaho Extension
Pacific Northwest & Treasure Valley
Pest Alert Network
OSU
Oregon State
Thanks to our 2012 Sponsors:
Idaho Potato Commission
Alerts
Search
Submit Alerts
Crop Information
Related Links
Our Mission
Impacts
Contact Us
Join Mailing List
Edit User Profile
Sitemap
Search
Crop Information Pages
Announcements
Alfalfa
Alfalfa Seed
Clover Seed
Corn
Dry Beans
Hops
Mint
Onion
Peas
Poplars
Potato
Rangeland
Small Fruits
Small Grains
Sugarbeets
Tree Fruits
Vegetable Seed

Washington State University
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Pacific Northwest Vegetable Extension Group

of Washington State University, Oregon State University, and University of Idaho

Vegetable Events Calendar

PNW-VEG Home
About the Team
Alert Archives
Diagnostic Labs
IPM Resources
Photo Gallery of Vegetable Problems
Publications
Team Newsletter Archive
Vegetable Resources

Lindsey du Toit
WSU Mount Vernon
NWREC
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Mount Vernon, WA 98273
USA
Tel. 360-848-6140
Fax 360-848-6159
E-mail: dutoit@wsu.edu

IPM Resources*

Disease Forecast Systems

Pesticide Information Centers/Services

Pest Identification and Management

General pest, disease, and other problems of vegetables; identification and management resources

Cucurbit resources
Legume resources
Onion resources
Potato resources
Tomato resources

The resources listed below are for informational purposes only, and do not imply recommendation or endorsement by the PNW VEG.

Disease Forecast Systems

2010 Potato Insect Pest Survey for the Columbia Basin of Washington, Washington State University

Onion Disease Forecast Models for the northeastern U.S., New York State Integrated IPM Program, and Network for Environment and Weather Applications (NEWA)

Potato Disease Forecast Models for the the northeastern U.S., New York State Integrated IPM Program, and Network for Environment and Weather Applications (NEWA)

How to Manage Pests

Degree-days: Codling Moth in Apples

Use this program to run a model of codling moth in apples, recommended by UC Cooperative Extension. In calculating degree-days, the program uses temperatures from the UC IPM weather database, a file you supply, or data you enter online.

How to use this model in: apples, pears, plums, prunes, walnuts, or landscape
| Sunset temperatures | Calculate any degree-days | Using this calculator | Reference degree-day tables | About degree-days |

Codling Moth in Apples

- Lower/upper threshold: 50/88°F
- Calculation/upper cutoff method: single sine/horizontal
- Biofix: The first biofix is the first date that moths are consistently found in traps and sunset temperatures have reached 62°F.
- Additional information on using this model: Pest Management Guideline

Specify source of temperature data

Select the source of temperatures to be used to calculate degree-days. You may also use your own maximum and minimum temperatures and look up approximate daily degree-day values in a reference degree-day table for codling moth, then total them yourself.

Weather station from UC IPM database

Select from stations in which California county?

Modoc
Mono
Monterey
Napa
Nevada

Include active stations only

Set time period for running model

Biofix (start date): March 15 2013

End date: February 16 2013

Biofix (start date): The first biofix is the first date that moths are consistently found in traps and sunset temperatures have reached 62°F.

Choose File No file chosen

Text file (comma or tab delimited) format

Questions?

"Harris, when I said 'any questions' I was using only a figure of speech."