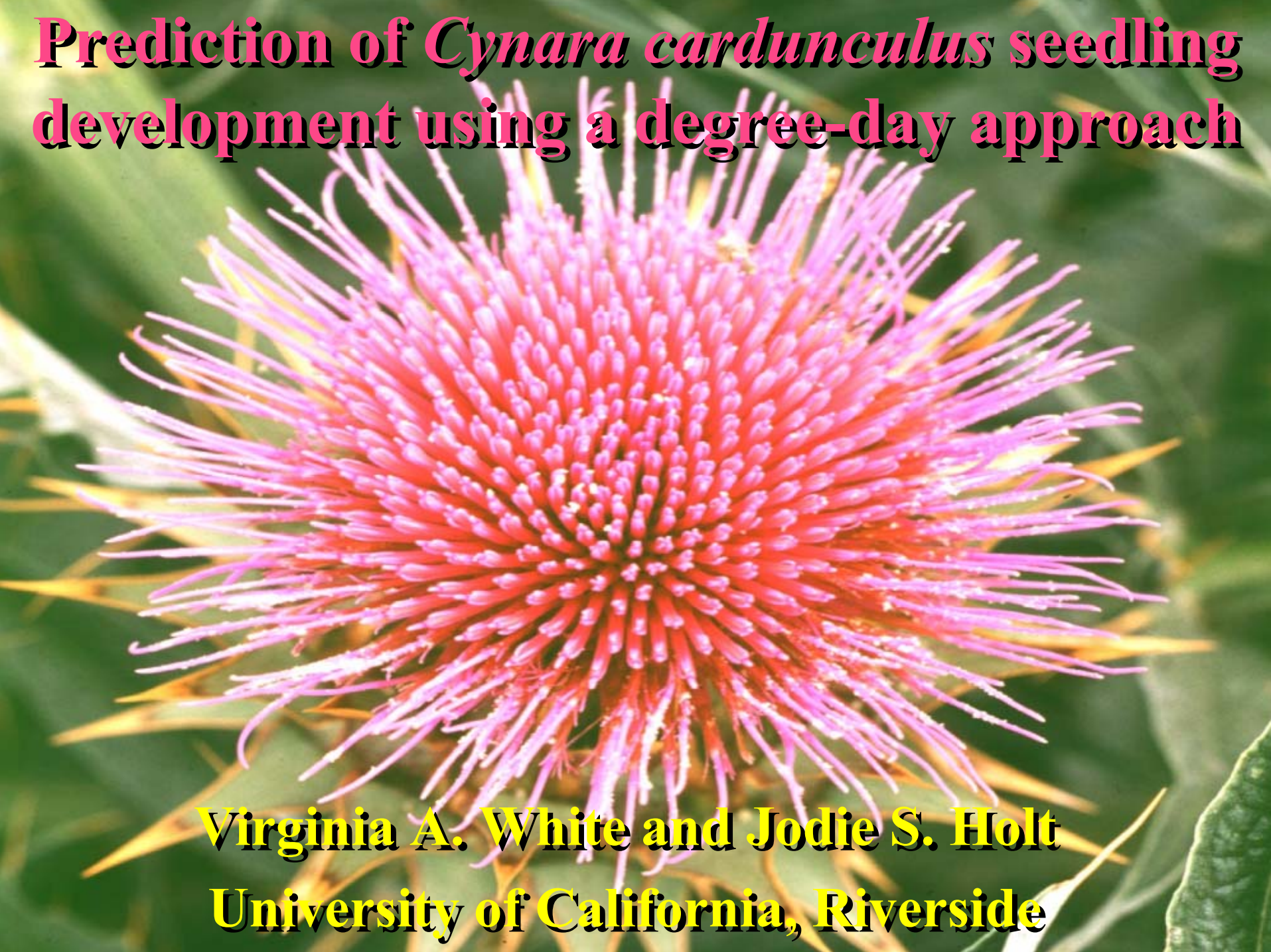
Prediction of *Cynara cardunculus* seedling development using a degree-day approach



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Objective and Procedure

- The objective of this project is to determine a degree-day model which accurately predicts *Cynara carcunculus* development.
- This project involves a phenology experiment, degree-day model construction, and model validation.
- Degree-day calculator available at: (http://www.ipm.ucdavis.edu)

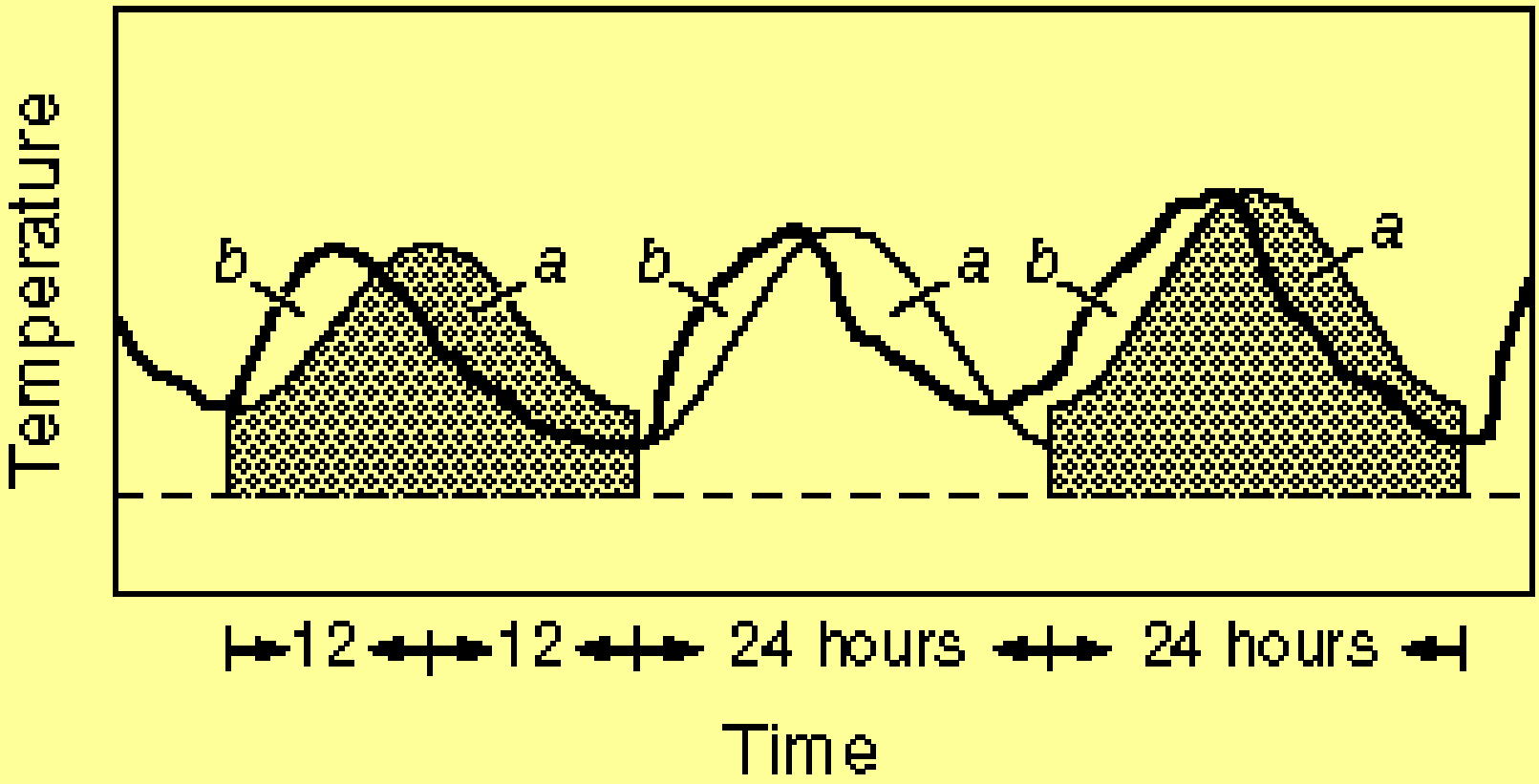
Degree-Day Explanation

- "One degree-day is equal to one degree above the lower developmental threshold over 24 hours."
  - (http://www.ipm.ucdavis.edu)
- Example:
  - Minimum temperature threshold: 7° C
  - Daily temperature of 8° C= 1 degree-day
  - Daily temperature of 9° C= 2 degree-days

Basic Criteria

- Biofix
  - Date when degree-days begin accumulating
- Temperature
  - Daily temperature readings (max, min)
- Method of Calculation
  - Single-sine calculation: uses daily max and min temperature to produce a sine curve
- Upper threshold cutoff method
  - Horizontal, intermediate, vertical

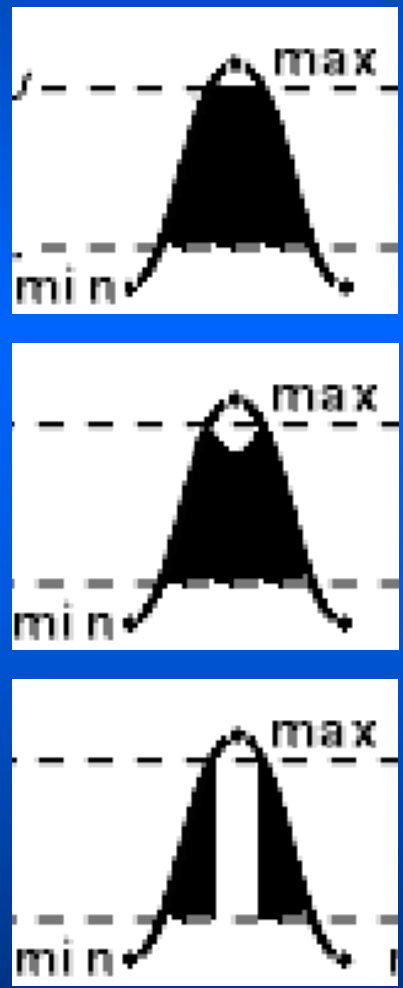
Single-Sine Calculation Method



http://www.ipm.ucdavis.edu/WEATHER/ddconcepts.html#Using

Upper Cutoff Methods

- Horizontal
  - Development continues at a constant rate above upper threshold
- Intermediate
  - Development slows (but does not stop) above upper cutoff
- Vertical
  - Development stops above upper threshold



Phenology Experiment

- Agricultural Experiment Station
- 12 plots per block
  - One plot seeded per month
- 16 planting locations per plot
  - Arranged in a 2 m x 2 m grid
  - Central 4 planting locations:
    5 seeds planted, thinned to one
- Randomized Complete Block Design, 4 replicates

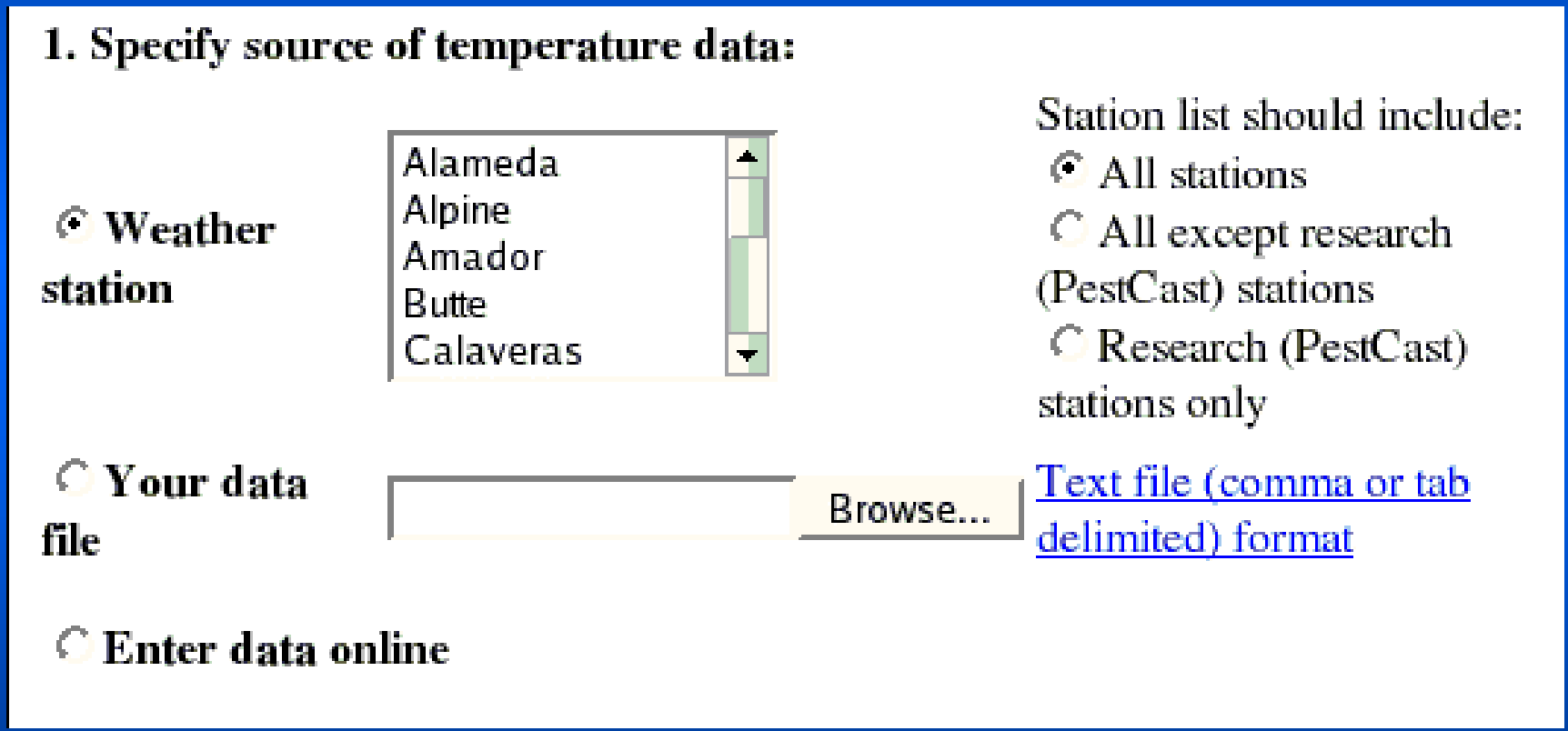
Phenology Experiment, cont.

- Data recorded twice weekly
- Recorded days after planting to developmental stages:
  - Emergence, 2-11 leaves, bolting, 1-11 flowers open, seed shed, re-sprouting

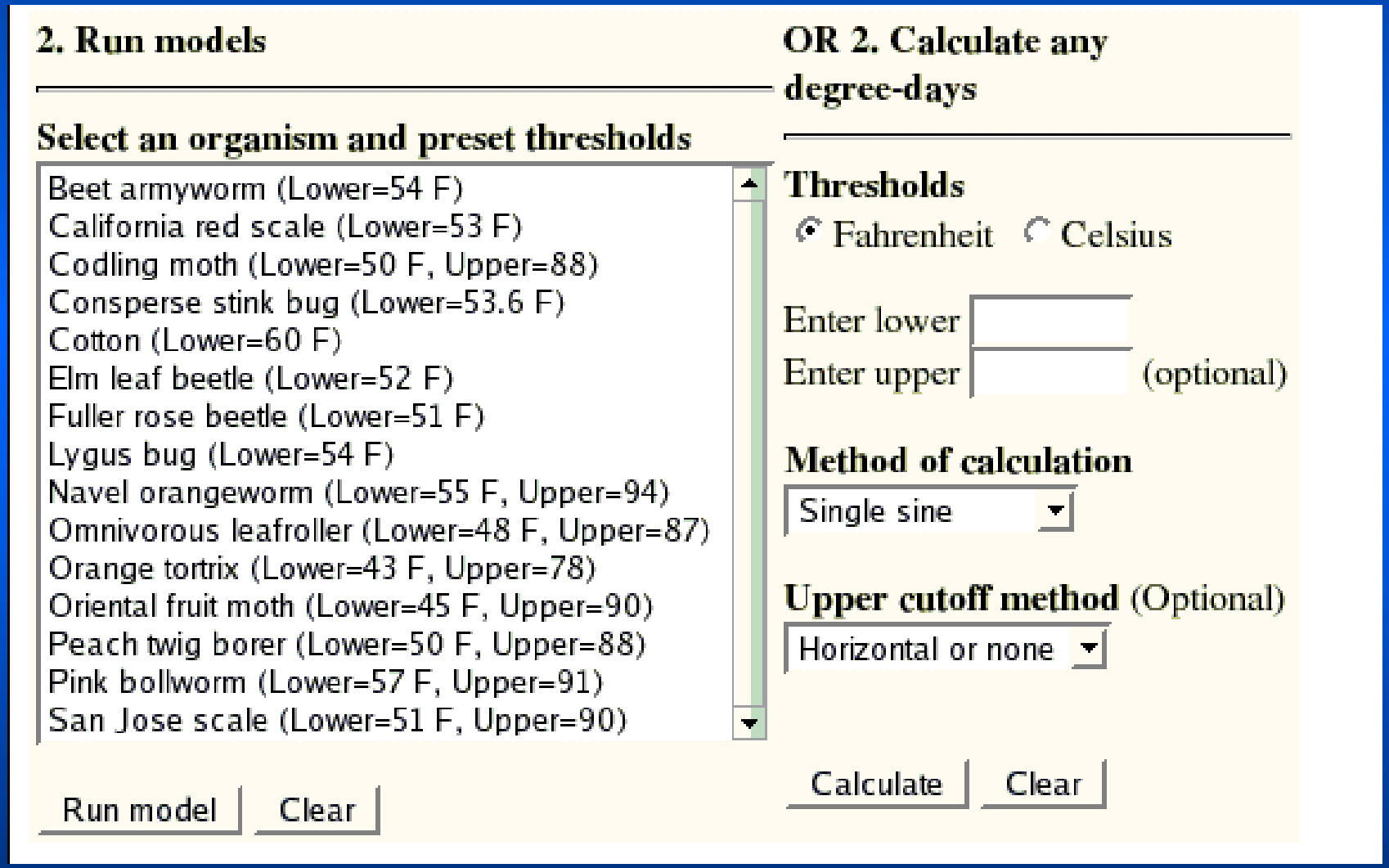
Phenology Data

- Determined median days to each developmental stage within each plot
- Averaged the four blocks for each treatment (month of planting)
- Determined mean number of degree-days accumulated for each stage of development and each treatment (used planting date as biofix)

Degree-Day Calculator



Degree-Day Calculator, cont.



Degree-Days Accumulated-Determination for Each Model

(January)

Day after Biofix	4H24	7V30	4I36	5V24	7V22
0	8.5	5.52	8.5	7.5	5.52
1	17.3	11.32	17.3	15.3	11.32
2	23.9	15.15	23.9	20.9	15.15
3	29.87	19.04	29.87	26.12	19.04
4	36.25	23.46	36.25	31.81	23.46
5	43.16	28.28	43.16	37.98	28.28
6	51.06	33.65	51.06	44.93	33.65
7	57.36	36.98	57.36	50.23	36.98
8	65.56	42.18	65.56	57.43	42.18
9	75.16	48.78	75.16	66.03	48.78
10	83.96	54.58	83.96	73.83	54.58

Model Selection Using Phenology Data

Emergence							
	Date						
Model	1/2/1998	2/3/1998	3/2/1998	4/1/1998	5/1/1998	Mean	CV
7V20	88.05	83.2	75.05	73.65	84.15	80.82	7.670570162
4V20	135.14	132.82	111.53	115.11	117.94	122.508	8.77273749
10V20	48.21	44.07	43.66	41.2	51.29	45.686	8.797432896
2V20	167.91	168.17	136.99	145.19	140.47	151.746	9.988145822
5V22	129.03	117.39	111.37	107.98	137.1	120.574	10.14129474
2V30	189.53	170.4	185.3	163	215.45	184.736	10.97619722
2V36	189.53	170.4	185.3	163	215.45	184.736	10.97619722
6V22	112.66	100.55	98.37	93.5	123.94	105.804	11.6733542
2V24	186.08	170.4	159.6	160.9	209.06	177.208	11.68678797
4V23	148.48	134.81	128.7	125.98	165.74	140.742	11.69065366
7V22	96.73	84.83	85.88	80.31	110.77	91.704	13.35282175

Validation Study

- Crystal Cove State Park
- 6 transects: each 50 m long
- 2 aspects:
  - 3 transects facing east
  - 3 transects facing west
- 10 plots/transect: 1 m x 0.5 m
- Flagged emerged seedlings
- Recorded stage of development weekly

Validation Procedure

- Determine biofix
  - Use significant rain events as biofix dates
- Calculate degree-days accumulated
  - Use field temp. data and degree-day calculator
- Predict each stage of development from best-fit model
- Determine actual number of days to each stage of development in validation study

Degree-Days Accumulated- Field Results

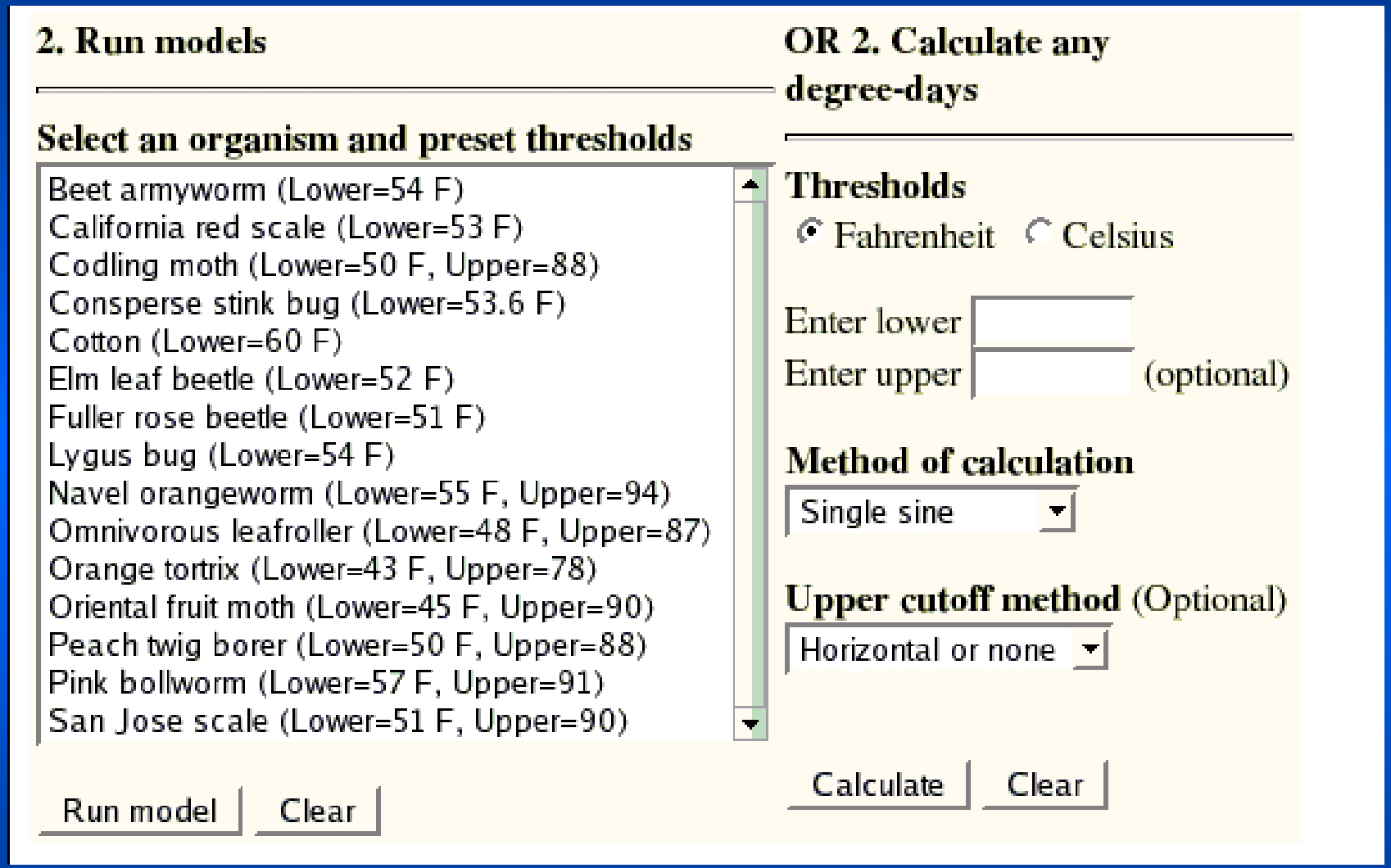
	11/8/2002							
Day	7v22	7v23	10v20	10v24	5v22	6v22	7v24	7v25
0	8.28	8.28	5.28	5.28	10.28	9.28	8.28	8.28
1	18.22	18.22	12.22	12.22	22.22	20.22	18.22	18.22
2	26.78	26.78	15.58	17.78	32.78	29.78	26.78	26.78
3	35.61	35.61	18.67	23.61	43.61	39.61	35.61	35.61
4	40.7	41.44	20.84	28.04	50.03	45.37	42.33	43.5
5	46.34	48.23	23.09	34.55	57.2	51.77	51.72	52.89
6	54.9	56.79	26.45	40.11	67.76	61.33	60.27	61.44
7	58.67	61.01	28.02	43.09	72.64	65.66	65	66.71
8	62.91	65.89	29.77	46.77	78.23	70.57	70.62	73.27
9	67.66	71.55	31.71	51.62	84.48	76.07	77.68	82.1
10	71.72	76.23	33.4	55.21	89.89	80.8	83.09	88.43

Validation Data

- Determined median days to each developmental stage for each transect
- Averaged all six transects= Actual ‘days to’
- Calculated Predicted – Actual ‘days to’ for each model, each stage of development

Prediction Success

	11/8/2002		11/29/2002		12/16/2002	
Stage	Models	Diff	Models	Diff	Models	Diff
Emergence	5v22	0.167	7v24	0	10v20	0.689
	6v22	0.167	10v24	-1	5v22	-2.311
	7v22	0.167	6v22	2	6v22	-2.311
	7v23	0.167	7v22	2	7v22	-2.311
	7v24	0.167	7v23	2		
	7v25	0.167	7v25	-2		
	10v20	0.167				
	10v24	0.167				
2 leaves	5v22	8.667	10v20	-1	10v20	-1.037
	6v22	8.667	5v22	-5	5v22	-4.037
	7v22	8.667	6v22	-5	6v22	-4.037
	7v23	8.667	7v22	-5		
	7v25	8.667				


2. Run models
Select an organism and preset thresholds
Beet armyworm (Lower=54 F)
California red scale (Lower=53 F)
Codling moth (Lower=50 F, Upper=88)
Consperse stink bug (Lower=53.6 F)
Cotton (Lower=60 F)
Elm leaf beetle (Lower=52 F)
Fuller rose beetle (Lower=51 F)
Lygus bug (Lower=54 F)
Navel orangeworm (Lower=55 F, Upper=94)
Omnivorous leafroller (Lower=48 F, Upper=87)
Orange tortrix (Lower=43 F, Upper=78)
Oriental fruit moth (Lower=45 F, Upper=90)
Peach twig borer (Lower=50 F, Upper=88)
Pink bollworm (Lower=57 F, Upper=91)
San Jose scale (Lower=51 F, Upper=90)
Run model
Clear
OR 2. Calculate any degree-days
Thresholds
Fahrenheit
Celsius
Enter lower
Enter upper
(optional)
Method of calculation
Single sine
Upper cutoff method (Optional)
Horizontal or none
Calculate
Clear

Implications and Future Work

- Land managers can use their own temperature data and rain events to predict *Cynara cardunculus* development
  - Improve timing of control efforts
  - Reduction of personnel time/effort
- Next up: predicting the re-sprouting and development of *Cynara cardunculus* adults

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