Phenology and Weed Management

John Cardina, Catherine Herms and Dan Herms

What do we want to predict to aid weed management?

When to look

When to get ready

When to treat

When it's too late

Growth stages of interest

Times of maximum susceptibility to control:

* Germination – annuals (preemergence control)
* Final emergence – annuals (post-emergence control)
* Low internal energy reserves – perennials

Goal of prediction

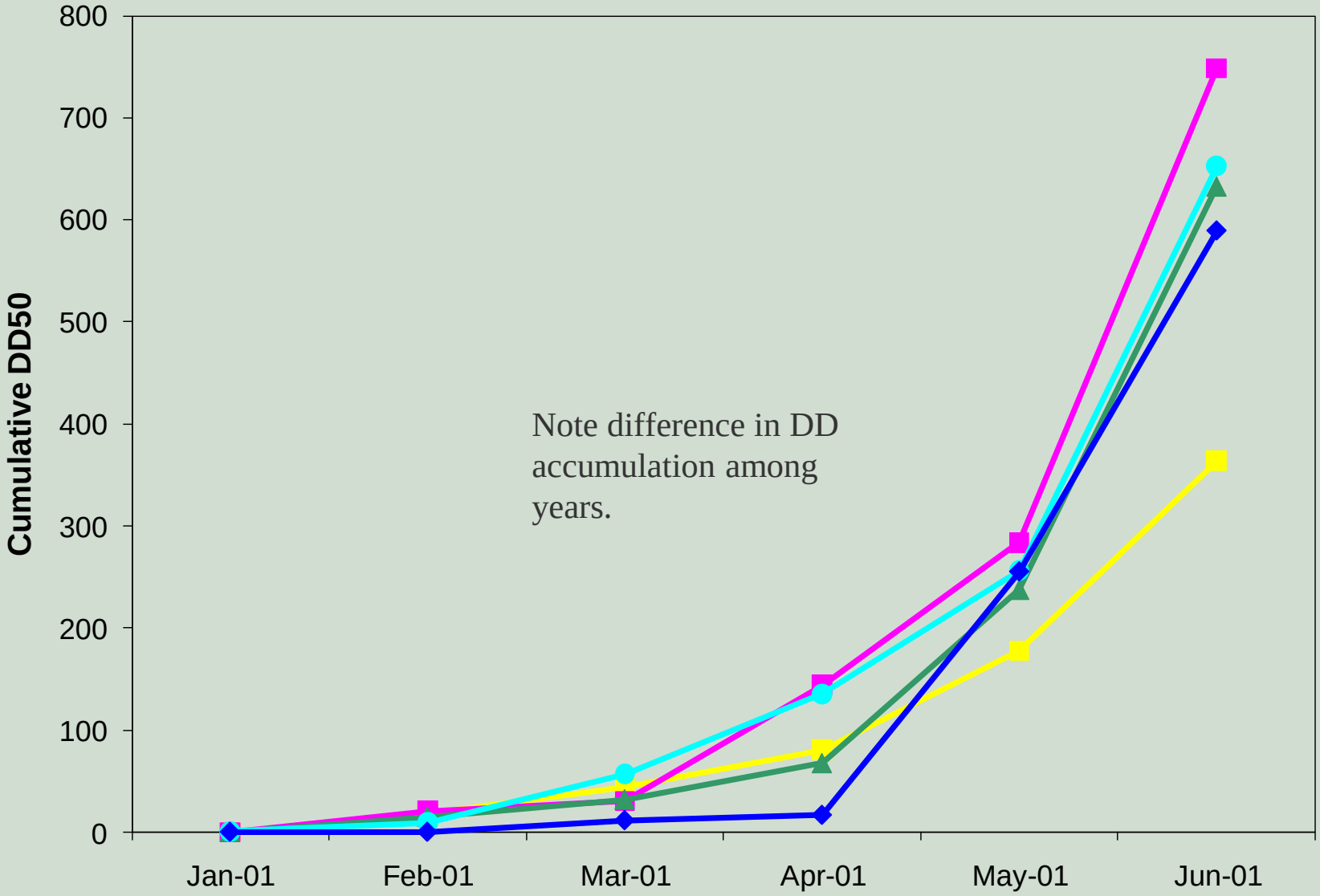
Optimum timing for effective management

Optimum timing might reduce inputs, cost etc

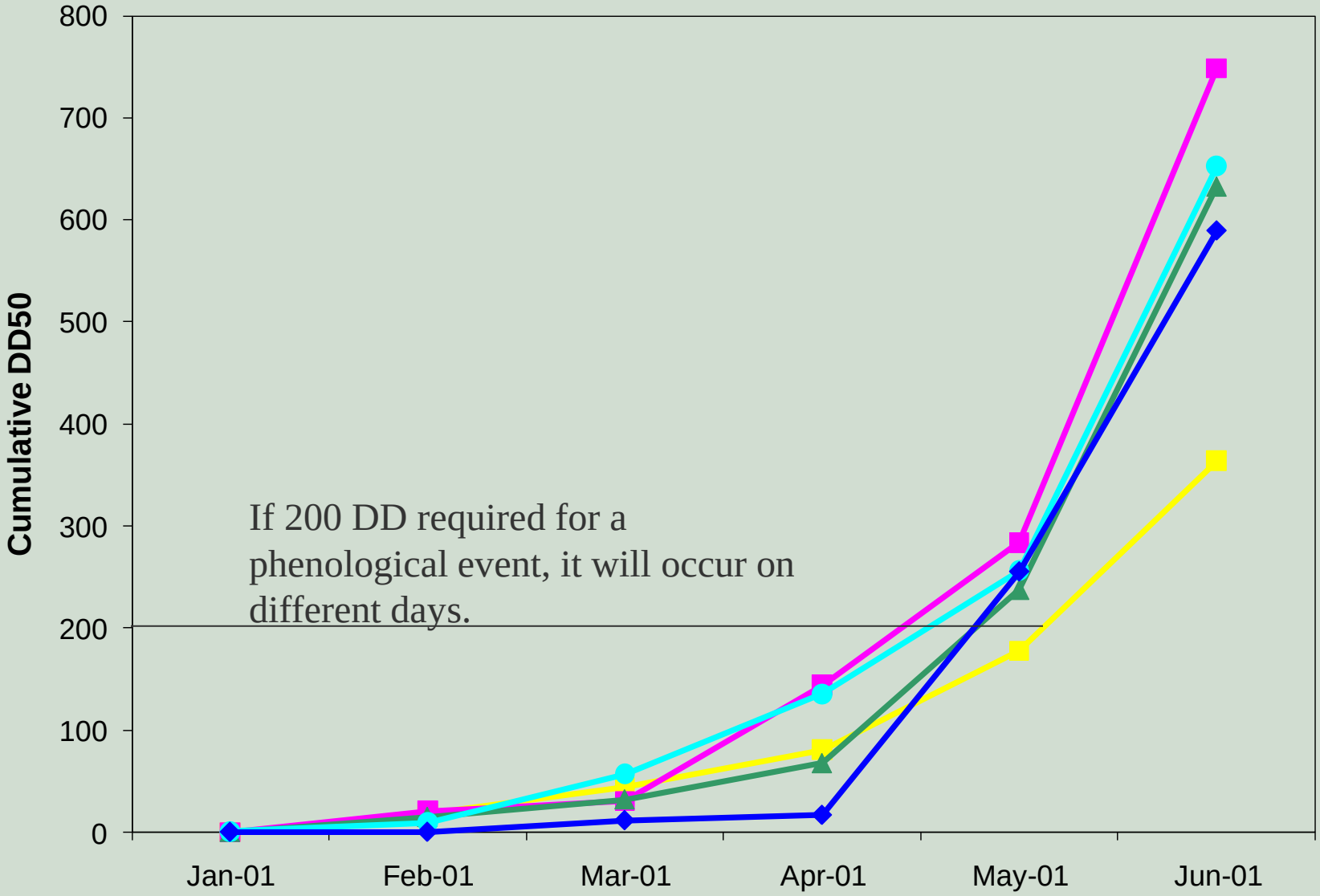
What we know about predicting weed development:

- Emergence and growth are temperature dependent.
- Degree-day accumulation varies over space & time.
- Degree-day and calendar date are poor predictors.
- Susceptible growth stages difficult to detect & monitor.

DD_{50} Accumulation by Year



DD_{50} Accumulation by Year



METHODS:

flowering phenology of >80 native and ornamental plant species and/or cultivars

4 individuals of each were monitored 3x weekly

* Date of First Bloom

* Date of Full Bloom

> 200 phenological events

These phenological events can be determined with precision. ⇨

First and Full Bloom

First flower bud opens, revealing pistils & stamens

95% of flower buds open (ie. 19 of 20 buds open)

Plant taxa include:

Acer

Aesculus

Amelanchier

Cercis

Crataegus

Forsythia

Lonicera

Magnolia

Malus

Prunus

Pyrus

Rhododendron

Spiraea

Syringa

Viburnum

Weigela

Weed emergence phenology methods-

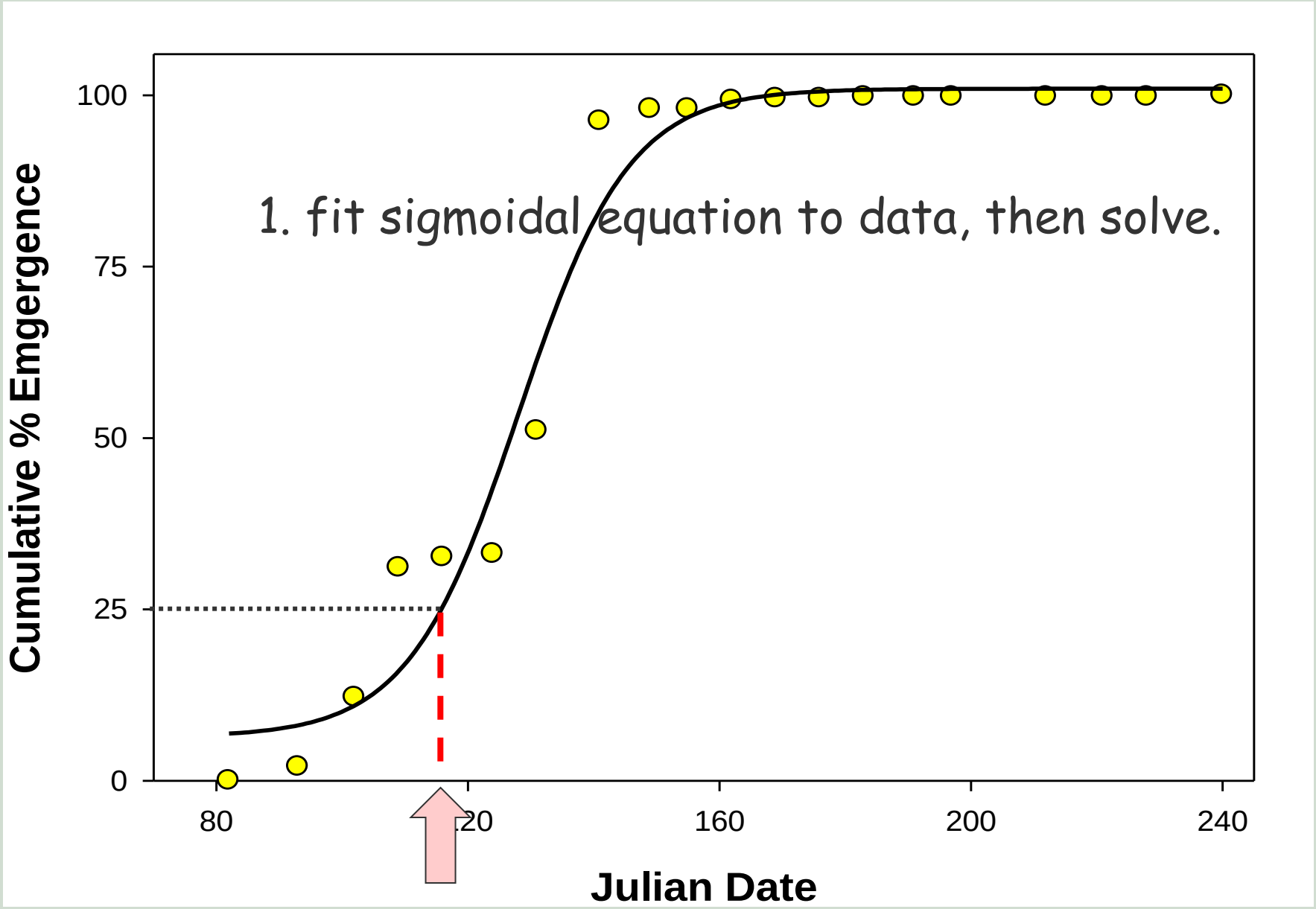
Monitored in crop field and lawn environments

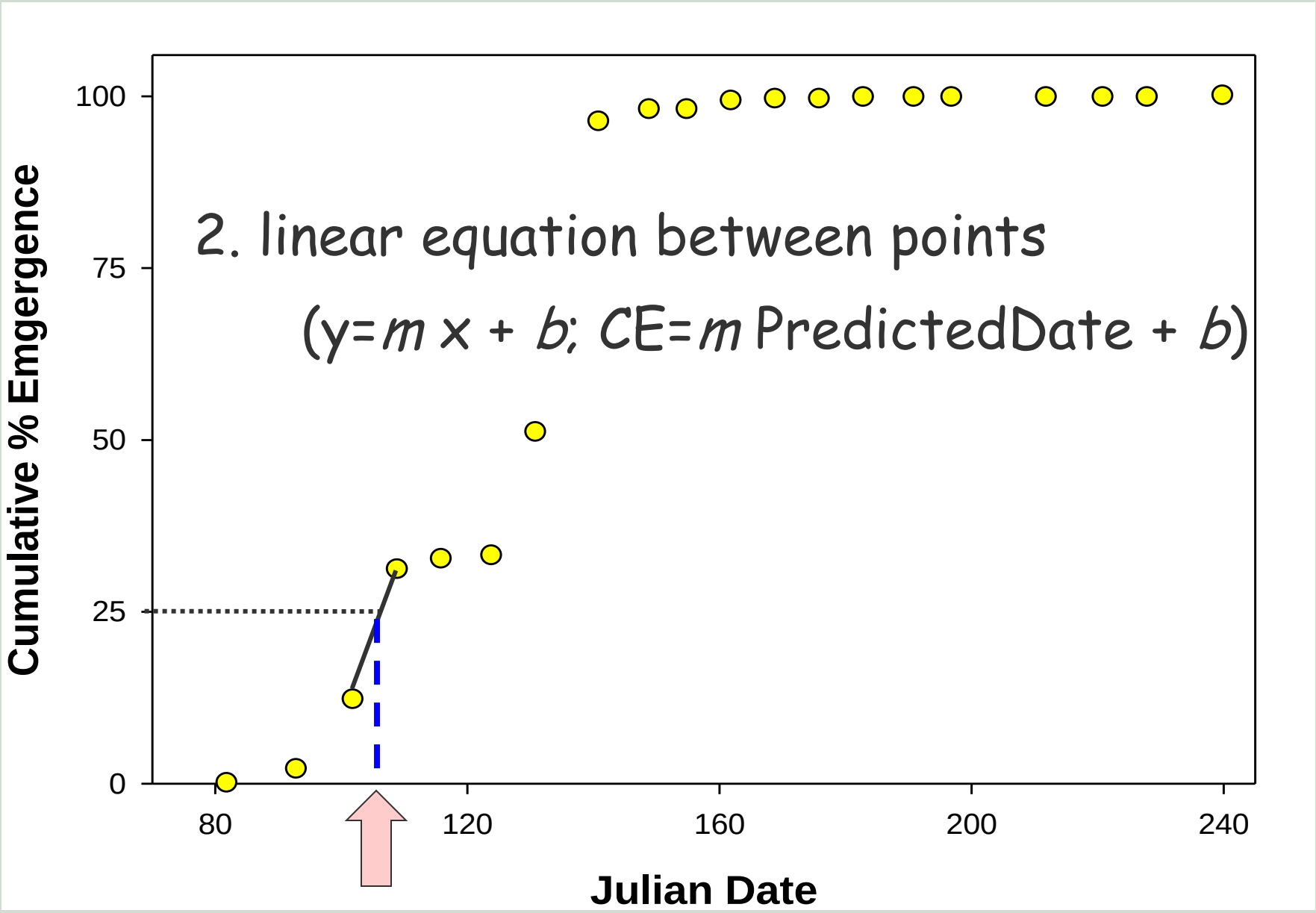
Weekly emergence counts - March to August

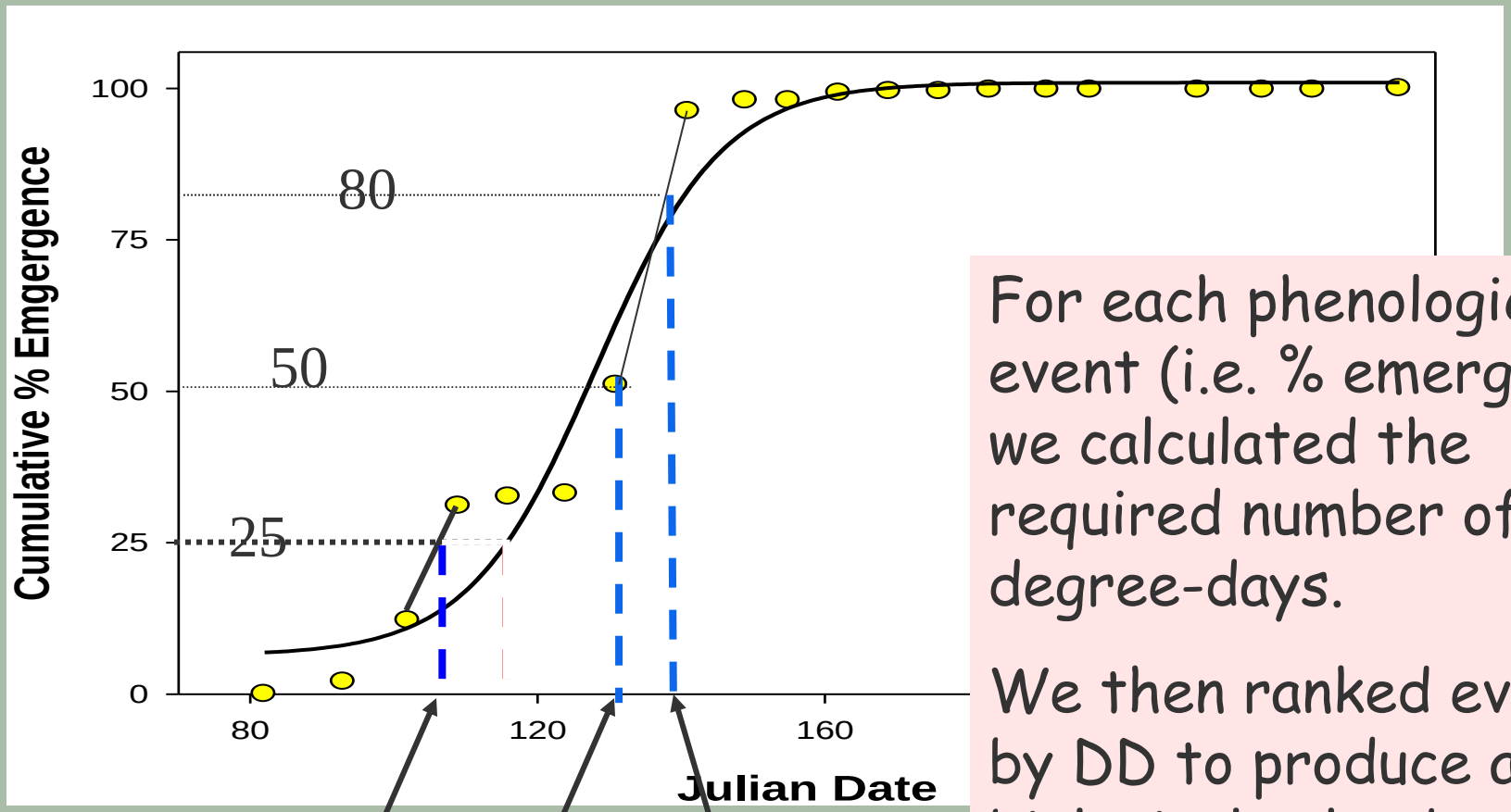
Cumulative emergence (%) for each date

Estimated date of 25, 50 and 80% emergence

two methods:


1. fit sigmoidal equation to data, then solve.
Cumulative % Emergence
100
75
50
25
0
80
120
160
200
240
Julian Date

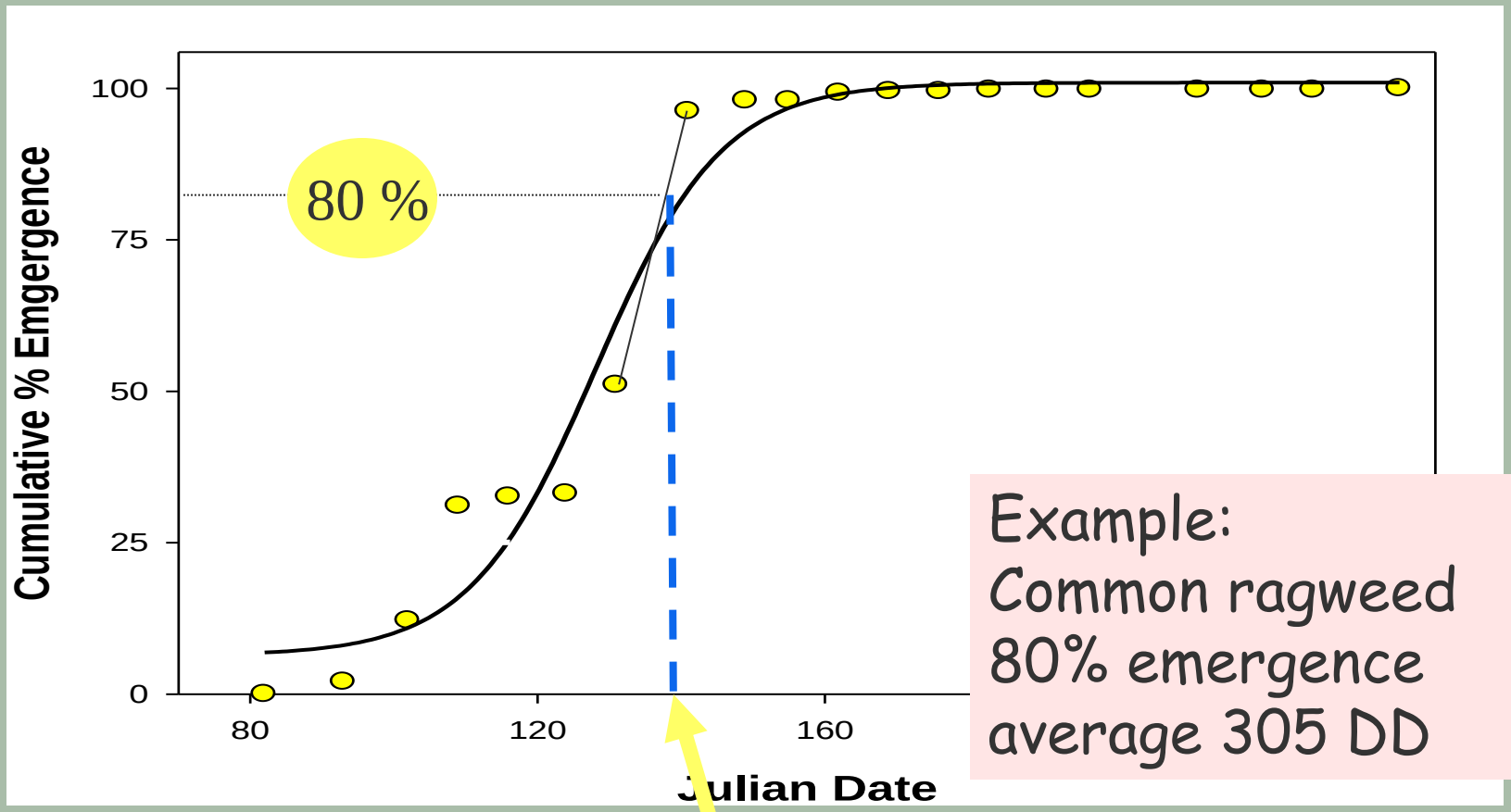

2. linear equation between points
(y=m x + b; CE=m PredictedDate + b)
Cumulative % Emergence
100
75
50
25
0
80
120
160
200
240
Julian Date



For each phenological event (i.e. % emergence) we calculated the required number of degree-days.

We then ranked events by DD to produce a biological calendar >>

DD_{50} : 160 248 305



Example:
Common ragweed
80% emergence
average 305 DD

DD_{50} : 305

Put weed emergence events into biological calendar:

Species	Event	DD50					Average	
		1997	1998	1999	2000	2001	Date	DD50
Silver Maple	first bloom	48	24	32	53	11	2-Mar	34
Corneliancherry Dogwood	first bloom	49	32	40	63	17	16-Mar	40
Silver Maple	full bloom	59	32	44	61	16	19-Mar	42
Red Maple	first bloom	59	36	48	66	18	24-Mar	45
Red Maple	full bloom	97	80	67	96	35	28-Mar	75
Star Magnolia	first bloom	97	80	77	112	51	31-Mar	83
Border Forsythia	first bloom	80	80	89	108	72	30-Mar	86
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
Sargent Crabapple	full bloom	261	292	301	329	308	7-May	298
Umbrella Magnolia	first bloom	308	312	301	309	289	9-May	304
Red Horsechestnut	first bloom	261	292	301	329	337	7-May	304
Common Ragweed	80%	268	312	229	309	407	8-May	305
Vanhoutte Spirea	first bloom	301	312	315	291	324	9-May	309
Common Lilac	full bloom	308	301	315	329	324	9-May	315

Weed Emergence in the Biological Calendar

Species	Event	DD50					Average	
		1997	1998	1999	2000	2001	Date	DD50
Norway Maple	first bloom	119	114	121	127	98	3-Apr	116
Compact Garland Spirea	first bloom	154	163	165	163	150	17-Apr	159
Common Ragweed	25%	.	.	188	.	131	17-Apr	160
Eastern Redbud	first bloom	201	192	199	199	162	23-Apr	191
Common Ragweed	50%	206	.	199	199	148	27-Apr	197
Common Horsechestnut	first bloom	230	257	247	291	232	4-May	251
Velvetleaf	25%	.	.	.	264	241	30-Apr	253
Japanese Flowering Crab	full bloom	273	238	247	256	255	3-May	254
Lambsquarter	25%	.	256	327	249	217	29-Apr	262
Red Buckeye	first bloom	245	274	271	279	255	5-May	265
Flowering Dogwood	first bloom	268	256	271	291	255	5-May	268
Eastern Black Nightshade	25%	343	.	284	291	210	8-May	282
Wayfaringtree Viburnum	full bloom	268	284	301	309	289	7-May	290
Giant Foxtail - T1	25%	315	251	271	279	352	7-May	294
Red Horsechestnut	first bloom	261	292	301	329	337	7-May	304
Common Ragweed	80%	268	312	229	309	407	8-May	305
Common Lilac	full bloom	308	301	315	329	324	9-May	315
Redosier Dogwood	first bloom	315	322	327	329	324	10-May	323
Eastern Black Nightshade	50%	380	.	344	353	217	11-May	324
Common Horsechestnut	full bloom	332	322	344	378	352	12-May	346
Lambsquarter	50%	.	257	484	291	415	8-May	362

CONTINUED…Weed Emergence in the Biological Calendar

Species	Event	DD50					Average	
		1997	1998	1999	2000	2001	Date	DD50
Giant Foxtail - T1	50%	398	284	374	353	407	13-May	363
Pagoda Dogwood	first bloom	343	348	357	405	364	13-May	363
Velvetleaf	50%	.	.	.	329	407	8-May	368
Black Cherry	first bloom	322	376	374	405	364	13-May	368
Ohio Buckeye	full bloom	353	362	374	418	364	14-May	374
Winter King Hawthorn	full bloom	409	397	390	418	423	17-May	407
Eastern Black Nightshade	80%	423	.	398	465	352	18-May	410
Smokebush	first bloom	516	539	500	494	478	24-May	505
Velvetleaf	80%	.	.	.	535	478	20-May	507
White Fringetree	full bloom	535	503	513	512	520	25-May	517
Giant Foxtail - T1	80%	560	503	513	545	478	25-May	520
Lambsquarter	80%	268	840	588	483	467	25-May	529
Black Locust	full bloom	549	579	537	535	538	27-May	548
Multiflora Rose	first bloom	549	519	549	597	538	28-May	550
Dandelion	25%	580	634	549	559	437	28-May	552
Mountain-laurel	first bloom	516	565	549	597	598	30-May	565
Smokebush	full bloom	599	588	633	617	618	2-Jun	611
Dandelion	50%	632	765	610	624	511	1-Jun	628
Multiflora Rose	full bloom	615	610	654	700	654	4-Jun	647
Dandelion	80%	793	935	678	718	560	9-Jun	737
Mountain-laurel	full bloom	793	802	899	809	809	14-Jun	822

Possible applications of the biological calendar:

- Web-based predictions of emergence
- Local verification with ornamentals
- When to scout….
- Optimum time of control….


Today's Feature:
Crabgrass !

Smooth

Digitaria ischaemum

Large

Digitaria sanguinalis

Smooth

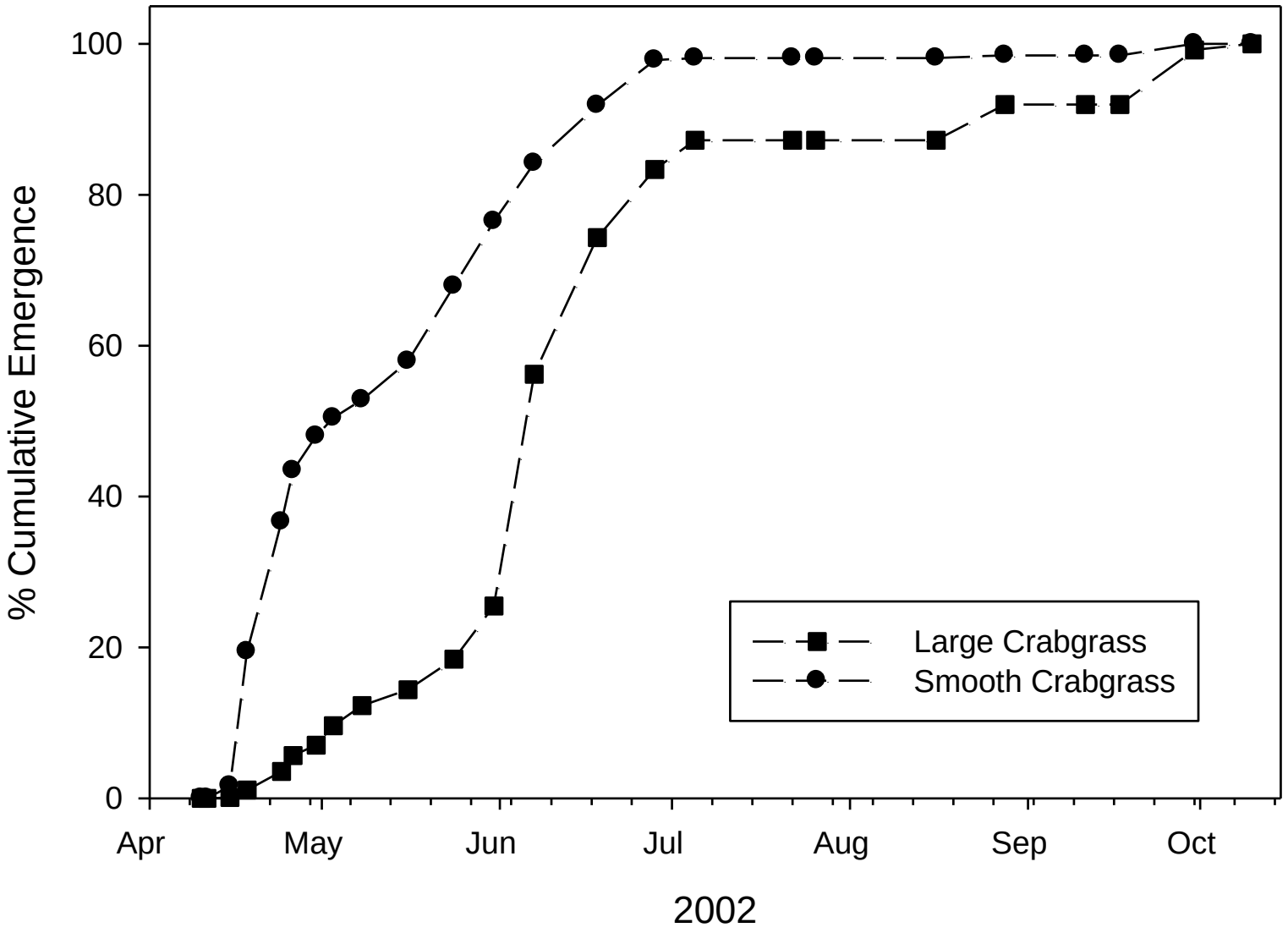
Digitaria ischaemum

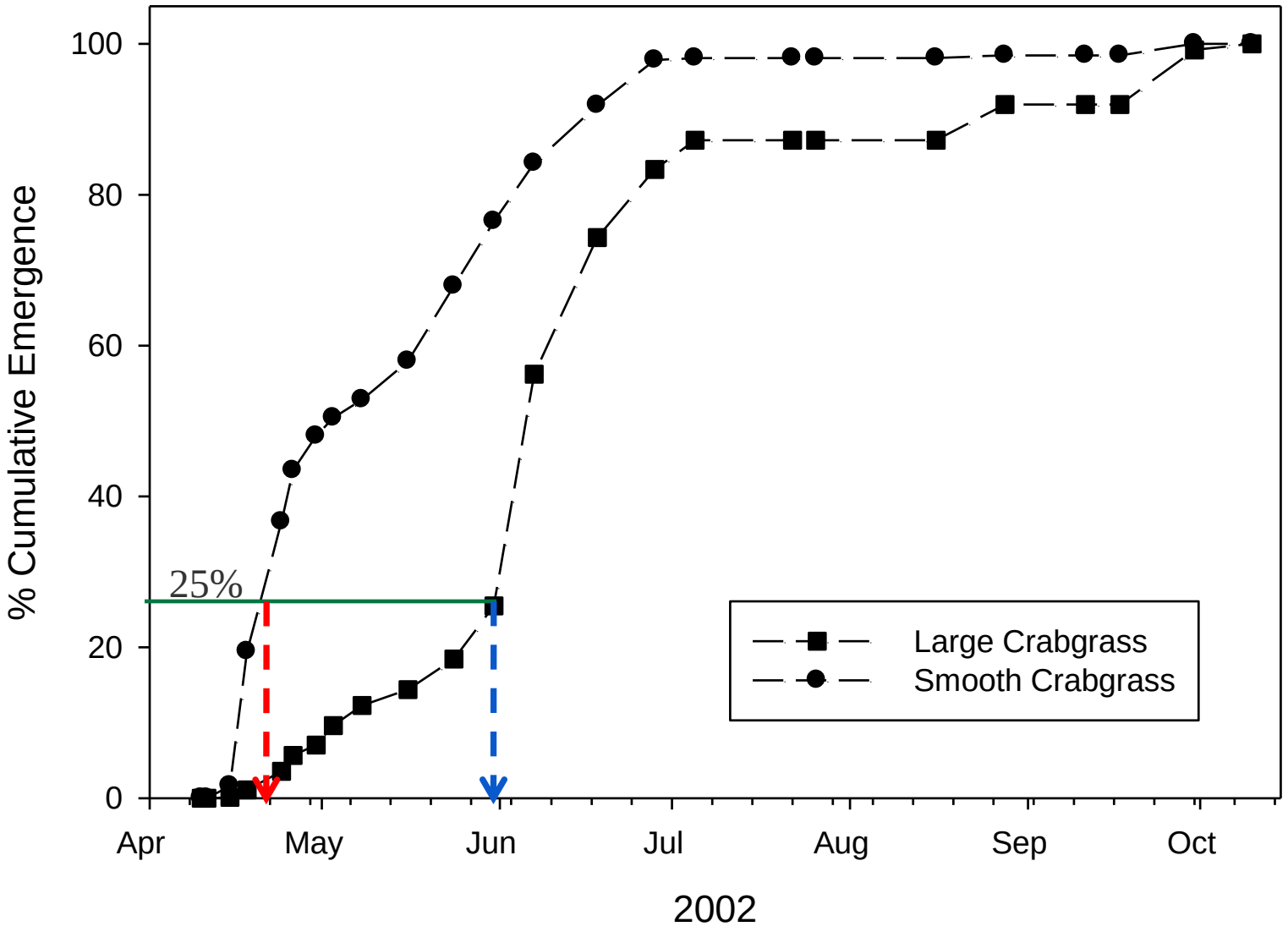
Large

Digitaria sanguinalis

Smooth
Digitaria ischaemum

Large
Digitaria sanguinalis


% Cumulative Emergence
100
80
60
40
20
0
Apr
May
Jun
Jul
Aug
Sep
Oct
2002
Large Crabgrass
Smooth Crabgrass


% Cumulative Emergence
100
80
60
40
20
0
25%
Apr
May
Jun
Jul
Aug
Sep
Oct
2002
Large Crabgrass
Smooth Crabgrass

Day of first and 80% emergence of large and smooth crabgrass in turf environments in 2002 – 2004.

Year	Species	First emergence		80% emergence	
		---------- Day of Year ----------			
2002	Large	111	b	183	a
	Smooth	107	c	166	b
2003	Large	124	a	189	a
	Smooth	106	b	134	c
2004	Large	119	b	164	b
	Smooth	115	c	150	b

Degree-day models used to predict emergence of large and smooth crabgrass in turf.

Percent Emergence	Crabgrass species	Air temperature models			Soil temperature models		
		Start Date	Base Temp (C)	Cumulative DD	Start Date	Base Temp (C)	Cumulative DD
First	Large	1-Nov	9	201	1-Nov	1	643
	Smooth	1-Nov	15	41	1-Mar	2	212
80%	Large	1-Nov	3	1495	1-Nov	0	2037
	Smooth	1-Mar	5	544	1-Mar	2	730

Chosen model parameters gave the lowest CV in cumulative growing DD for emergence data collected from 2002 to 2004. Air and soil (at 5 cm) temperatures were obtained from a weather station near the study site.

Biological calendar of ornamental plant bloom events and **first emergence** of large and smooth crabgrass at Wooster, Ohio from 2002 to 2004 (DD; 50°F base temperature, January 1 start date).

Common Name	Bloom or Emergence Event	Date	DD
Red Maple	first bloom	20-Mar	49
Star Magnolia	first bloom	4-Apr	89
Border Forsythia	first bloom	4-Apr	92
Border Forsythia	full bloom	13-Apr	105
Saucer Magnolia	first bloom	13-Apr	119
Bradford Callery Pear	first bloom	15-Apr	137
Star Magnolia	full bloom	16-Apr	149
Allegheny Serviceberry	first bloom	16-Apr	155
Smooth Crabgrass	**first emergence**	**16-Apr**	**155**
PJM Rhododendron	first bloom	16-Apr	155
Saucer Magnolia	full bloom	18-Apr	184
Allegheny Serviceberry	full bloom	18-Apr	187
Bradford Callery Pear	full bloom	19-Apr	189
Eastern Redbud	first bloom	20-Apr	192
PJM Rhododendron	full bloom	20-Apr	201
Large Crabgrass	**first emergence**	**24-Apr**	**211**
Snowdrift Crabapple	first bloom	21-Apr	213
Common Lilac	first bloom	24-Apr	231
Ohio Buckeye	first bloom	25-Apr	241

Biological calendar of ornamental plant bloom events and **80% emergence** of large and smooth crabgrass at Wooster, Ohio from 2002 to 2004 (DD; 50°F base temperature, January 1 start date).

Black Locust	first bloom	20-May	459
Sweet Mockorange	first bloom	23-May	500
Smooth Crabgrass	**80% emergence**	**24-May**	**548**
Arrowwood Viburnum	first bloom	27-May	564
Black Locust	full bloom	28-May	565
Multiflora Rose	first bloom	29-May	588
Washington Hawthorn	first bloom	2-Jun	641
Arrowwood Viburnum	full bloom	3-Jun	649
Multiflora Rose	full bloom	3-Jun	652
Northern Catalpa	first bloom	5-Jun	678
Large Crabgrass	**80% emergence**	**6-Jun**	**692**
American Elder	first bloom	7-Jun	713
Sweet Mockorange	full bloom	9-Jun	733
Washington Hawthorn	full bloom	10-Jun	775

Celebrating Our 25th Year of Publication

WEED TECHNOLOGY

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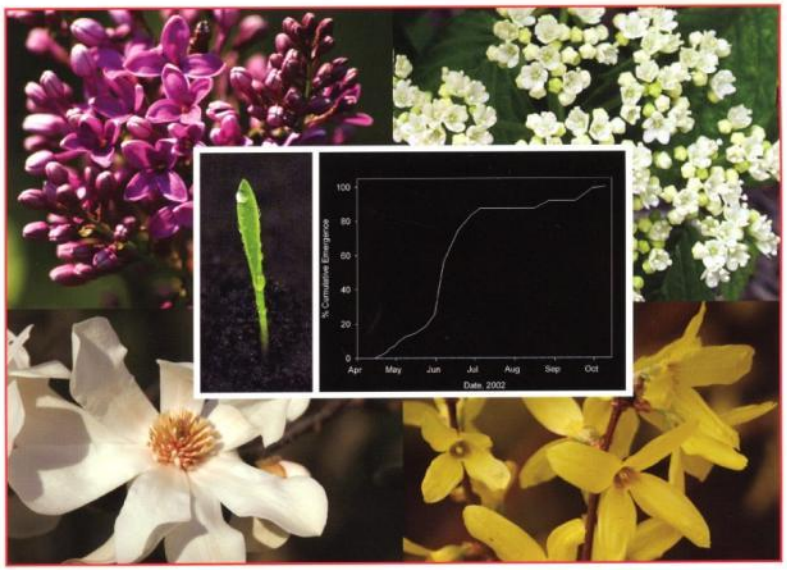

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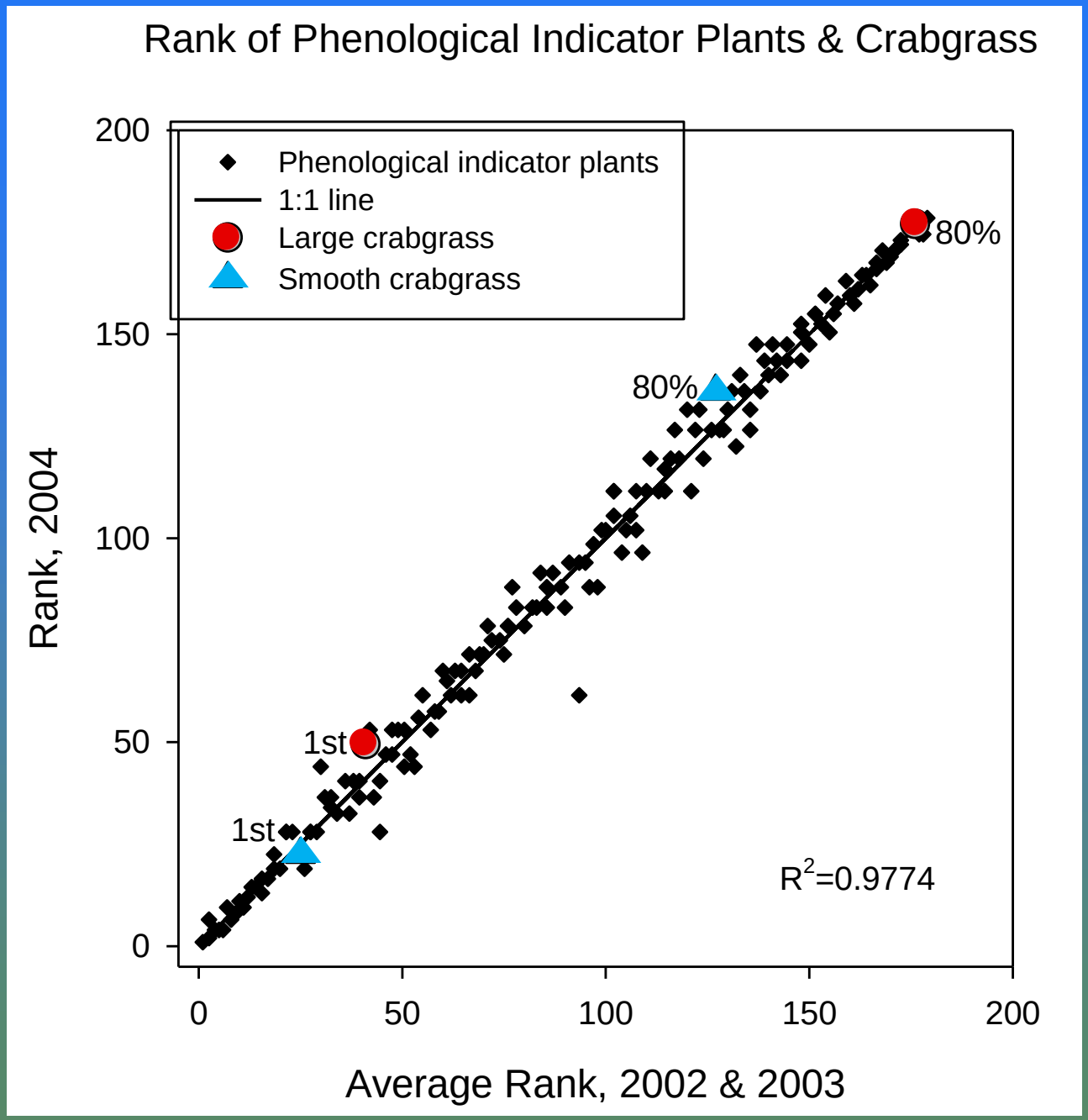
25% emerged

80% emerged

First emergence

Photo credits:
Janet Sternfeld,
Denise Ellsworth

How consistent is the order of weed emergence and flowering events over years for several species?


Rank of Phenological Indicator Plants & Crabgrass
Phenological indicator plants
1:1 line
Large crabgrass
Smooth crabgrass
80%
80%
1st
1st
R^2=0.9774
Rank, 2004
Average Rank, 2002 & 2003
0
50
100
150
200

Rules for crabgrass control:

Rules for crabgrass control:

- Apply preemergence herbicide when forsythia blooms
- Apply preemergence herbicide when forsythia starts to bloom
- Apply preemergence herbicide when forsythia blooms drop

Rules for crabgrass control:

Apply preemergence herbicide when forsythia blooms

Apply preemergence herbicide when forsythia starts to bloom

Apply preemergence herbicide when forsythia blooms drop

Apply preemergence herbicide when soil temp > 50 F

Days delay in crabgrass emergence relative to selected ornamental plant bloom events.

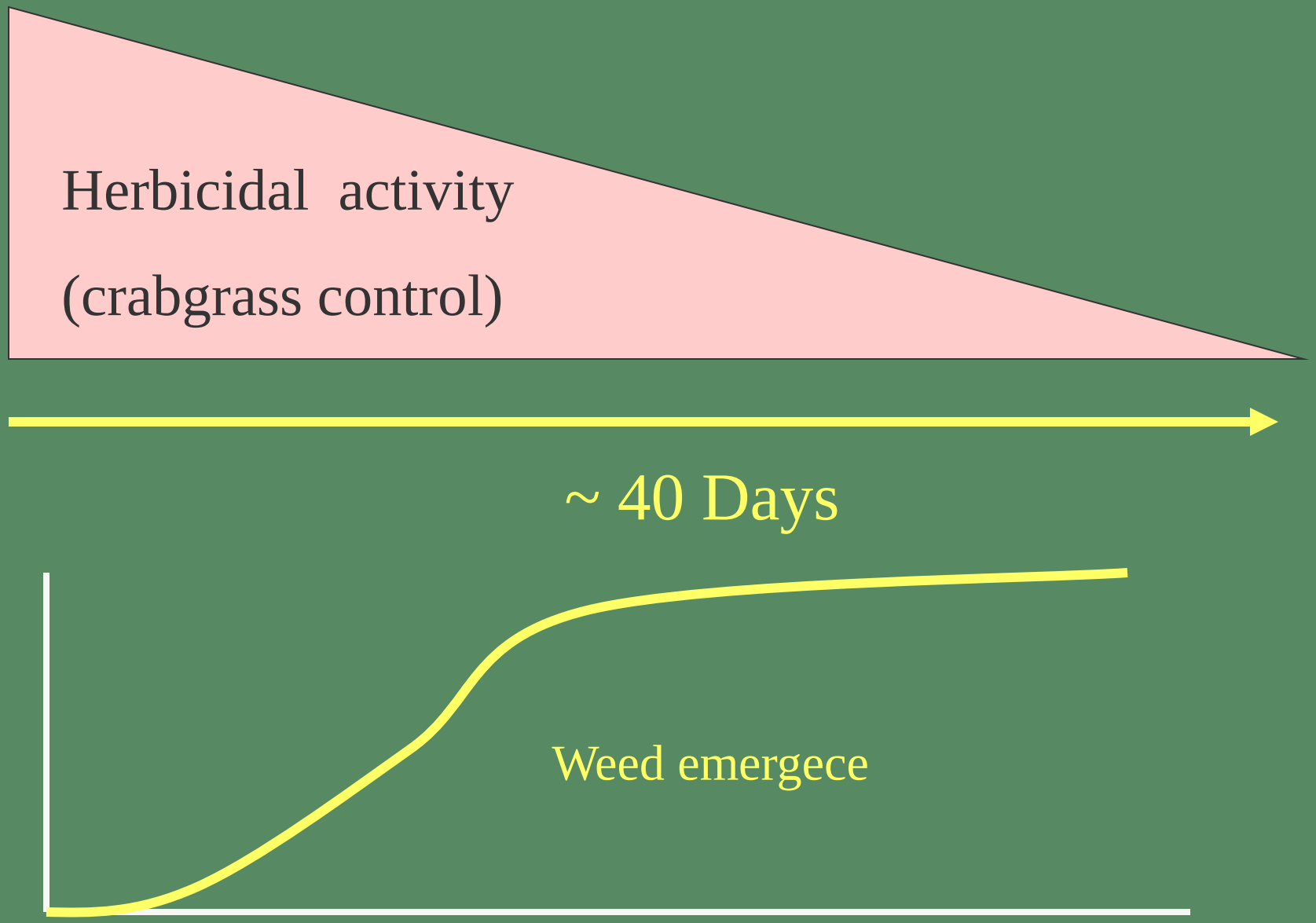
Crabgrass Species	Ornamental Plant	Bloom Event	Deviation in Days (emerged Day – bloom Day) 2002	2003	2004
Large	Forsythia	First	11	26	22
	Forsythia	Full	3	--	13
	Eastern redbud	First	-1	10	3
	Bradford pear	Full	0	8	5
Smooth	Forsythia	First	11	13	12
	Forsythia	Full	3	--	3
	Saucer magnolia	First	3	3	2
	Bradford pear	First	2	2	0

Forsythia blooms were frosted out in 2003.
Higher number => delay in emergence relative to blooming.

Delay in emergence of large and smooth crabgrass from dates predicted by rules for when to apply preemergence herbicides for crabgrass control.

Rule	Crabgrass Species	Delay in emergence (Observed first emergence - predicted PRE application)		
		2002	2003	2004
		days		
[1] apply when soil temperatures at 10-cm depth remain above 10 C for 24 consecutive hours.	Large	2	13	10
	Smooth	2	0	0
[2] apply when soil temperatures at 2.5- to 5.0-cm depth reach 10 to 12.8 C, or when forsythia is in full bloom.	Large	6	26	21
	Smooth	6	13	11

[1]McCarty et al. 2001; [2]Calhoun 2002


Herbicidal activity
(crabgrass control)
~ 40 Days
Weed emergece

IPM Approach to Crabgrass Management

Late spring	Summer	Fall ===> Late fall

Allow grass to grow as long as tolerable

Mow high to suppress crabgrass seedlings

If seed heads form, collect clippings

Over - seed weak spots

Fertilize only in fall; only if needed

Sources of Error in Weed Phenology Prediction

Determining first emergence

Determining 100% emergence

Moisture response of weeds vs ornamentals

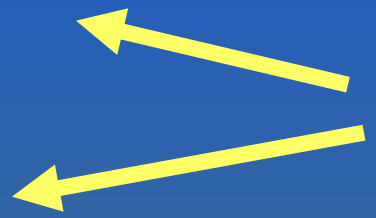
Weed biotypes?

Geographical variation?

Why it might be less consistent for weeds:

Emergence is final stage of complicated process

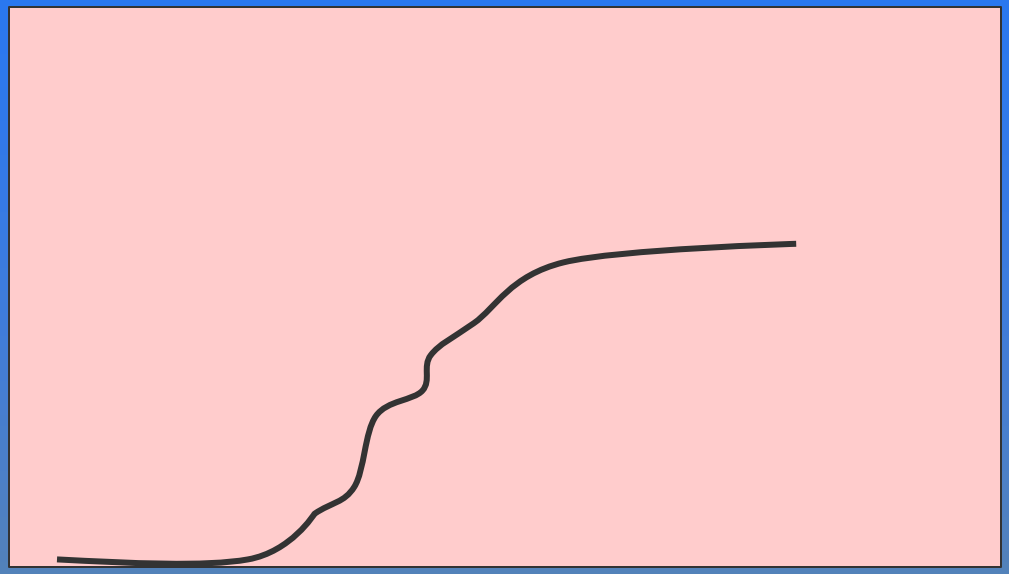
Loss of dormancy
Water absorption
Germination
Initial seedling growth
Emergence

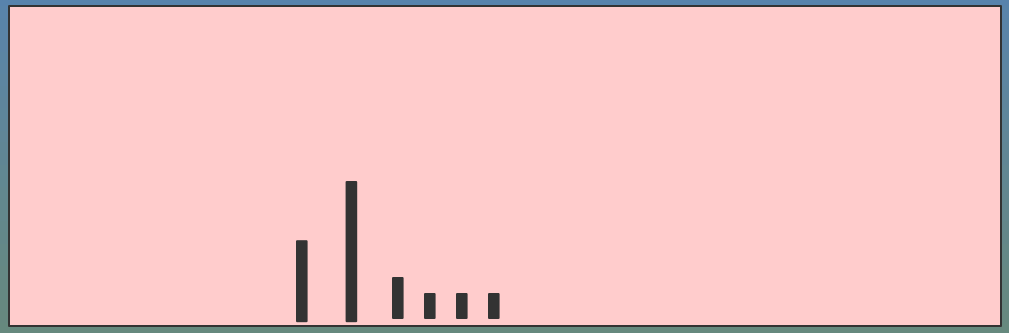


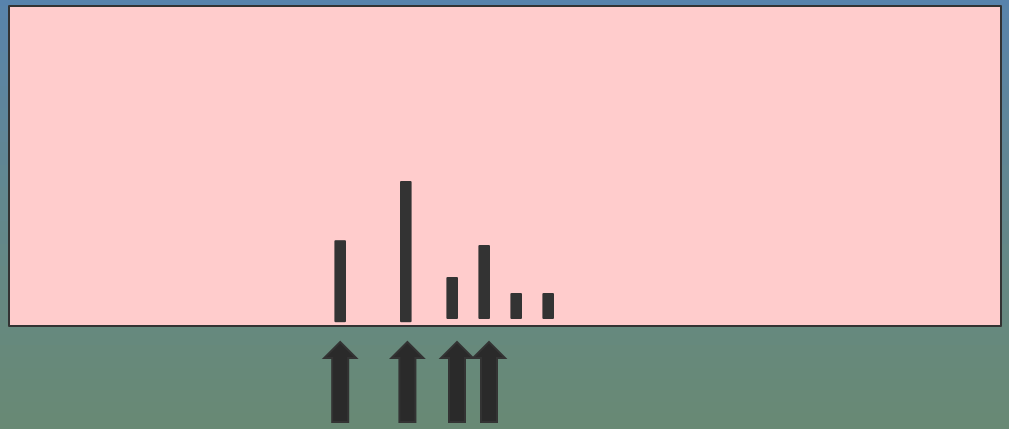
Environmental cues

Weed seeds & seedlings respond to small zone of soil temperature, not air temperature

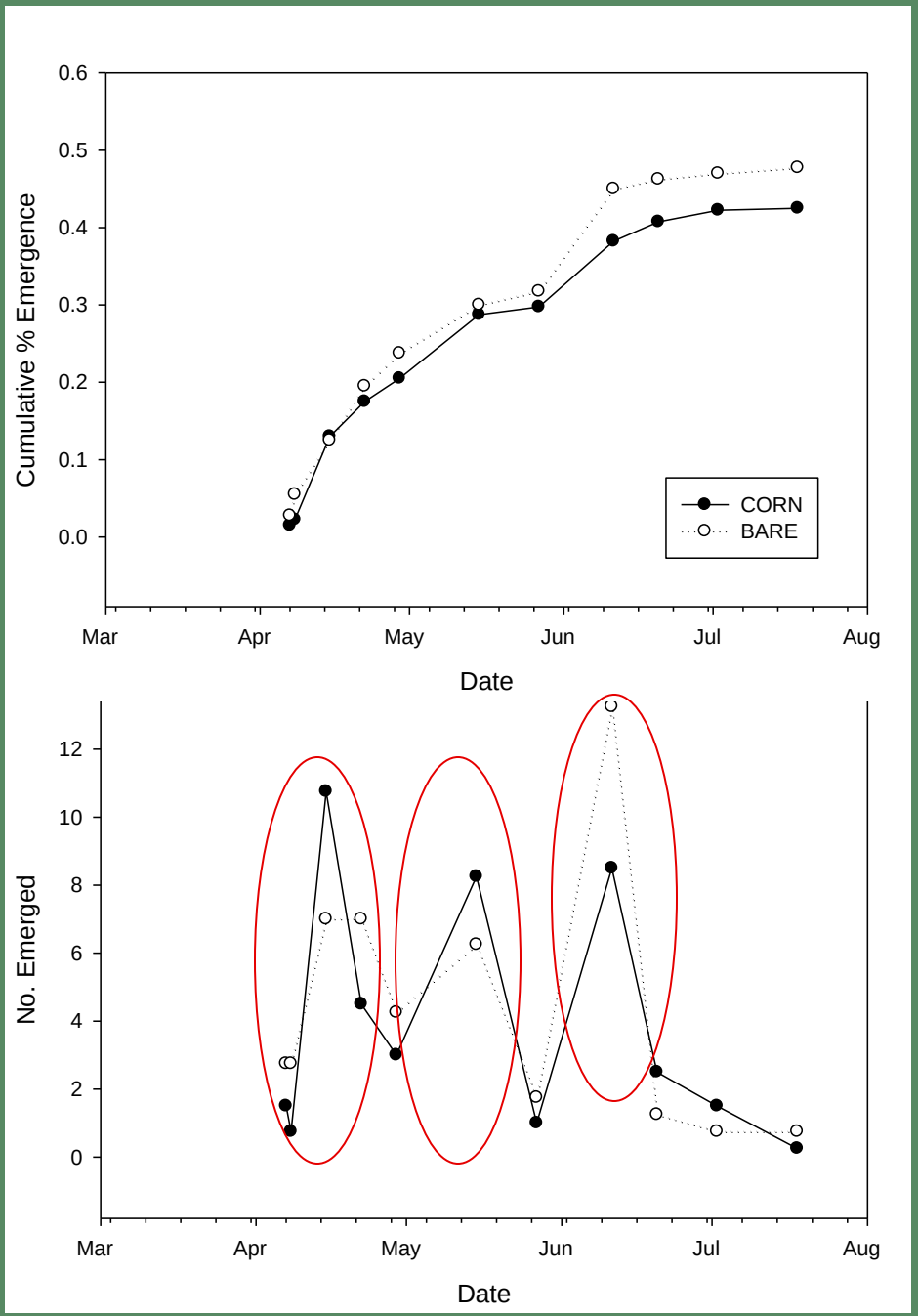
Seeds on top of soil vs deeply buried







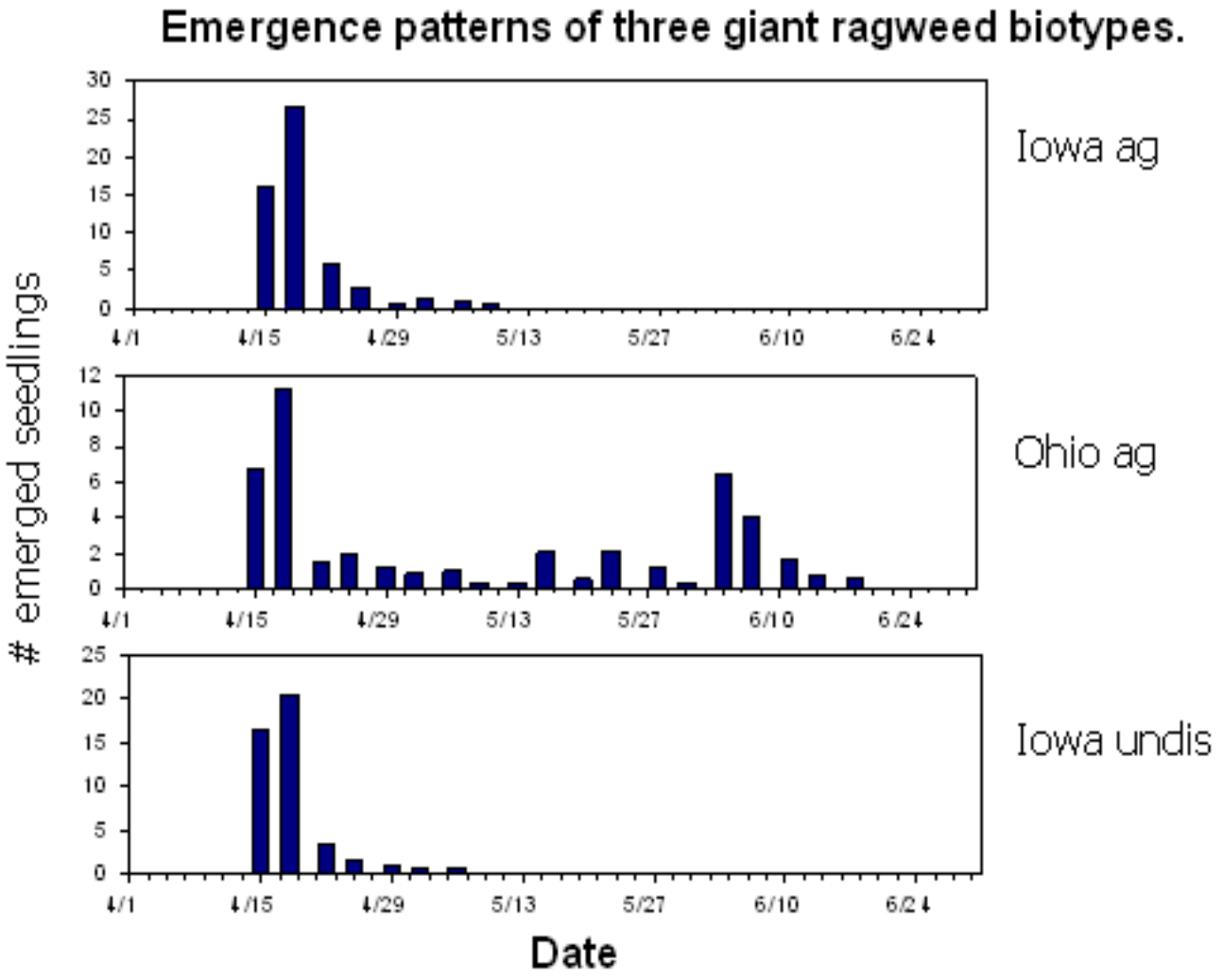
Multiple emergence cohorts
Genetically determined



2008 ragweed emergence

Three distinct emergence cohorts

Emergence pattern varies with plant origin.



Relative emergence of common weeds