IPM Planning Guide

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GCSAA

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Using threat temperatures for IPM Planning

Threat temperatures are rough guidelines that we have proposed to try to predict when pests are likely to first begin causing damage on golf course turf. Once a threat temperature is reached, some type of action is usually triggered. In the case of curatively controlled pests, that action is usually monitoring for symptoms (control procedures should take place only after evidence of the pest or its symptoms has been confirmed). In the case of preventively controlled pests, a preventive action such as pesticide application or cultural practice is usually called for. These threat temperatures were developed based on our knowledge of turf pest biology, as well as by mining the scientific literature for temperature data on insect, disease, weed and nematode pests of turf.

Threat temperatures for curative insect control

Insect	Threat * temperature		Monitoring (begin at threat temp. unless otherwise noted)	Control Measure
	F	C		
Annual bluegrass weevil	>55	>13	Monitor for adult weevils, starting at avg air temp >55F (13C). Peak activity @68F	If adult weevils detected, apply contact product against adults, 2 wks after adults 1st appear
Ants (nuisance)	>65	>18	Monitor for foraging ants.	If detected, apply labeled ant product at entrance to mounds
Armyworms	>60	>16	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Bermudagrass scale	>65	>18	Monitor for eggs & crawlers in damaged patches of turf.	If detected scale, fertilize and irrigate to promote recovery. No effective products are labeled
Billbugs (bluegrass)	>60	>16	Monitor for adults on paved areas, starting at avg. air temp>62F (17C)	If adult billbugs detected, apply contact product against adults, 2 wks after adults 1st appear
Cicada killers & tarantula hawk wasps	>65	>18	Monitor for flying wasps	Treat burrows with contact product, but only if completely necessary; these are usually beneficial insects!
Chinch bug, hairy (cool season turf)	>60	>16	Monitor for chinch bugs (all stages)	Apply contact product when numbers are high enough for concern
Chinch bug, southern (warm season turf)	>55	>13	Monitor for chinch bugs (all stages)	Spot treat w/contact product when numbers are high enough for concern
Crane flies	>45	>7	Monitor for larvae w/cup cutter	Apply contact product when larval numbers are high enough for concern
Cutworms	>55	>13	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Fall armyworms	>65	>18	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Fire ants	All year		Monitor for foraging ants, starting when average air temp>65F (18C)	When detected, broadcast a bait formulation Follow several days later with a contact insecticide applied broadcast (in heavily trafficked areas) or to individual mounds (in areas of lower use)
Ground pearls	All year		Monitor roots of damaged turf, starting when avg air temp>75F (24C)	If ground pearls detected, fertilize and irrigate to promote recovery.
Mole crickets	>75	>24	Monitor w/soap flush, starting when avg air temp >75F(24C)	If present, target small nymphs (<1/2" or <1.2 cm) w/contact product; or large nymphs & adults w/ beneficial nematodes
Sod webworms (cool season turf)	>70	>21	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Sod webworms (warm season turf)	>75	>24	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern

*average daily air temperature unless otherwise noted

NOTE: Most contact (curative) products require 1 or more follow-up applications, within 1-2 weeks of application

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Threat temperatures for preventive insect control

Timing of threat periods and management activities for key insect pests of turf. The threat temperature is a rough guideline that indicates when insects are likely to begin laying eggs or causing damage on golf course turf.

Insect	Threat temperature*		Monitoring (begin when threat temp is reached unless otherwise noted)	Control Measure
	F	C		
WHITE GRUBS	65-73	18-23	No monitoring. Control appropriate only if history of infestation.	Apply systemic product within 2-4 wks after reaching threat temperature. If multiple white grubs spp present, use insect w/lowest threat temperature to time application.
• Asiatic garden beetle	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Black turfgrass ataenius	>65	>18	"	Apply systemic product 2-4 wks after reaching threat temperature.
• European chafer	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Green June beetle	>73	>23	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Japanese beetle	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Masked chafers	>71	>22	"	Apply systemic product 2-4 wks after reaching threat temperature.
• May/June beetles	>71	>22	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Oriental beetle	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
OTHER PREVENTIVELY CONTROLLED INSECTS				
Annual bluegrass weevil	>55	>13	Monitor for adult weevils, starting at avg air temp >55F (13C) **OR**	Apply systemic product against grubs, 4 wks after adults appear
Annual bluegrass weevil	>55	>13	No monitoring. Appropriate only if history of infestation	Apply systemic product against grubs 2 wks after reaching threat temperatures
Billbugs	>60	>16	Monitor for adults on paved areas, starting at avg. air temp>60F (16C) **OR**	Apply systemic product against grubs, 4 wks after adults appear
Billbugs	>60	>16	No monitoring. Appropriate only if history of infestation)	Apply systemic product against grubs within 2 – 4 wks after reaching threat temperature.
Earthworms	>45	>7	Monitor for earthworm casts	Institute sand topdressing program on fairways at least 4X/year during periods of active turf growth only
Mole crickets	>60	>16	No monitoring; use this option only if history of infestation	Target hatching eggs w/imidacloprid or fipronil when avg air temps > 65 F(18C)

*average daily air temperature unless otherwise noted

NOTE: Most systemic products (imidacloprid, halofenozide) applied against soil pests are applied 1X/ season, & have 2-3 months residual activity. Follow-up applications are required only in warm locations with long (>3 months) periods of threat from damage

WEATHER REFERENCE

Timing disease control using threat temperatures

The average air temperatures below are rough guidelines that indicate when diseases are likely to begin causing damage on golf course turf. If you have a history of a preventively controlled disease, preventive control measures should begin when threat temperatures are reached. For curatively controlled diseases, begin monitoring at beginning of threat period; do not treat until symptoms are confirmed

DISEASE	THREAT TEMPERATURE
Anthracnose	≥ 65
Bacterial wilt	≥ 60
Bipolaris Leaf Spot	≥ 70
Brown Patch	≥ 60
Curvularia Blight	≥ 70
Cyanobacteria	≥ 55
Dollar Spot	≥ 65
Fairy Ring	≥ 65
Gray Leaf Spot	≥ 68

DISEASE	THREAT TEMPERATURE
Bermuda/ kikuyu decline	≥ 75
Pythium Blight	≥ 70
Rapid Blight	>55
Red thread	≥ 65
Snow Mold	≤ 62
Southern Blight	≥ 70
Spring Dead Spot	≥ 65 and < 80
Summer Patch	≥ 65
Take-all Patch	≥ 65

Timing herbicide applications and weed threat temperatures

Common Name	Scientific name	Activity	Timing/Threat temperature*
Barnyardgrass	*Echinocloa*	Pre-emerge herbicides	When air temperatures reach >60F (16C) for 3 days in a row
Crabgrass	*Digitaria*	Pre-emerge herbicide	When air temperatures reach >50F (10C) for 3 days in a row
Foxtails	*Setaria*	Pre-emerge herbicide	When air temperatures reach >65F (18C) for 3 days in a row
Goosegrass	*Eleusine*	Pre-emerge herbicide	When air temperatures reach >60F (16C) for 3 days in a row
Annual bluegrass	*Poa annua*	Pre-emerge herbicide	Fall/winter, when air temperatures drop to <75F (24C) (and >50F/10C) for 3 days in a row
Weeds controlled post-emergence		Begin weekly monitoring, mapping, record keeping	When air temperatures reach >50F (10C)

***average daily air temperatures.** NOTE: Most pre-emerge products have 2-3 months of residual activity. Split applications, spaced 2-3 months apart, can be used to extend the period of control.

Growth potentials

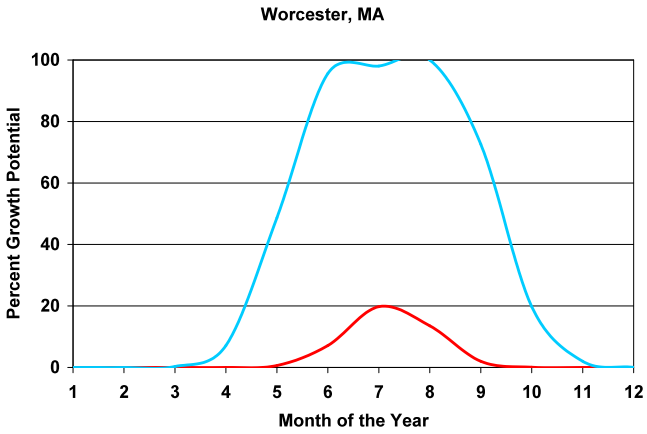
The concept of growth potential was developed to explain the myriad of ways in which weather impacts turf growth. The basic assumptions are that:

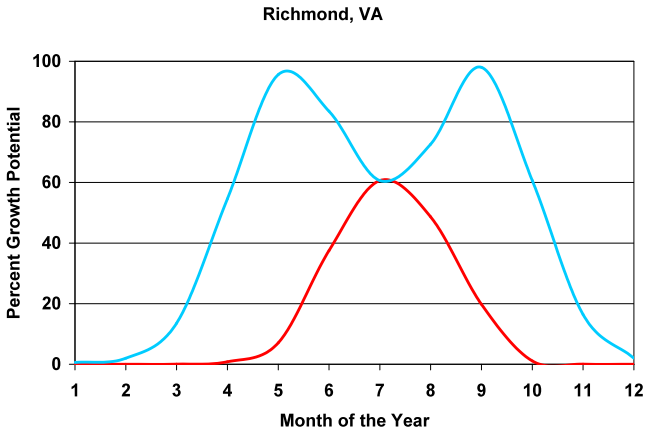
- turf growth is good when the growth potential (GP) is between 50% and 100%
- the best possible growth occurs at a GP of 100%.
- when weather conditions are either too hot or too cold for optimal turf growth, the GP falls below 50%, and turf becomes progressively more stressed. When the GP falls to 10% or lower, growth is extremely limited.
- Based on the scientific literature, cool-season turf grows best between average air temperatures of 60° and 75°F (with optimum growth at about 68F), while warm-season turf grows best at average air temperatures between 80° and 95°F (with optimum growth at about 88F).

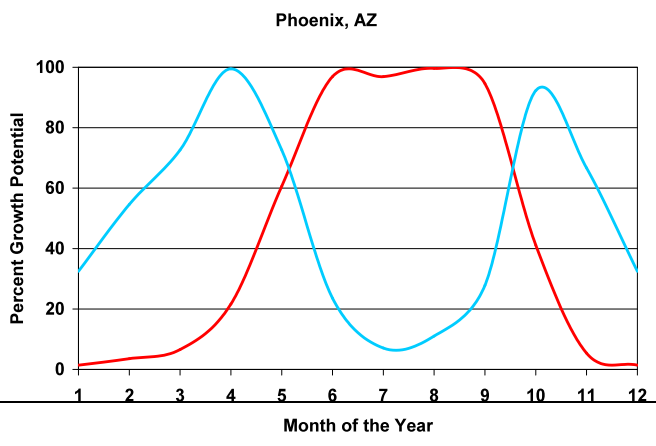
Using the growth potential concept

Growth potential data can be used to educate golfers and managers, to provide a scientific basis for decisions, to predict the performance of different turf types when exposed to different climates, and to forecast the effects of different overseeding and transition practices. Specific examples include:

- Timing application for chemical transition accelerators (Kerb, Revolver, Monument, Manor, Blade, TranXit): Warm-season turf GP should be 50% or higher at the time of application in order to ensure that sufficient warm-season turf cover is present.
- Scheduling aggressive management practices (aerification) or stressful events (tournaments): Turf growth potential should be as high as possible (greater than 50%) and on the rise when stressful events are scheduled. This allows for the greatest recovery potential of the turf.
- Explaining why cool- or warm-season turf is performing poorly (or well): Use growth potential to illustrate how your current weather conditions are affecting turf performance.







WEATHER REFERENCE

Percent growth potential (GP) of cool-season and warm-season turf at different average air temperatures

Air Temp (F)	%Warm GP	%Cool GP
38	0	1
39	0	2
40	0	2
41	0	3
42	0	4
43	0	5
44	0	6
45	0	8
46	0	10
47	0	12
48	0	15
49	1	18
50	1	22
51	1	26
52	1	30
53	2	35
54	2	40
55	3	46
56	3	52
57	4	58
58	5	64
59	6	70

Air Temp (F)	%Warm GP	%Cool GP
60	7	75
61	9	81
62	10	86
63	12	90
64	15	94
65	17	97
66	20	99
67	23	100
68	27	100
69	30	99
70	35	97
71	39	94
72	43	90
73	48	86
74	53	81
75	58	75
76	63	70
77	68	64
78	73	58
79	78	52
80	82	46
81	86	40

Air Temp (F)	%Warm GP	%Cool GP
82	90	35
83	93	30
84	96	26
85	98	22
86	99	18
87	100	15
88	100	12
89	99	10
90	98	8
91	96	6
92	93	5
93	90	4
94	86	3
95	82	2
96	78	2
97	73	1
98	68	1
99	63	1
100	58	1
101	53	0
102	48	0
103	43	0

Air Temp (F)	%Warm GP	%Cool GP
104	39	0
105	35	0
106	30	0
107	27	0
108	23	0
109	20	0
110	17	0
111	15	0
112	12	0
113	10	0
114	9	0
115	7	0
116	6	0
117	5	0
118	4	0
119	3	0
120	3	0
121	2	0
122	2	0
123	1	0

GROWTH POTENTIAL MODEL EQUATION

The growth potential values above were calculated using the equation below:

GP = growth potential

obsT = observed temperature (F)

optT = optimum turf growth temperature (F)

sd = standard deviation of the distribution

(sd warm = 12; sd cool = 10)

e = natural logarithm base **2.718282…**

$$GP := 100 \cdot \left[\frac{1}{e^{\left[\frac{1}{2} \left[\frac{(obsT - optT)}{sd} \right]^2 \right]}} \right]$$

WEATHER REFERENCE: Using growth potentials

Percent warm season and cool season turfgrass growth potential (GP) in selected U.S. locations. Months with 50% or more warm season turf growth potential are highlighted in red, while months with 50% or more cool season turf growth potential are highlighted in blue. Values are based on 30-year normal average monthly air temperatures from the National Oceanic and Atmospheric Administration.

	PERCENT WARM SEASON TURFGRASS GP												PERCENT COOL SEASON TURFGRASS GP											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PHOENIX, AZ	2	5	11	34	77	100	88	95	99	56	10	2	38	62	87	97	53	12	3	6	19	78	85	41
LITTLE ROCK, AR	0	0	2	11	35	75	90	85	54	12	1	0	2	6	35	86	96	55	35	42	80	90	31	5
FRESNO, CA	0	1	3	9	30	66	90	84	56	18	2	0	9	26	46	82	99	66	35	44	78	97	38	9
LOS ANGELES AP, CA	5	7	8	13	19	33	55	59	52	33	12	5	56	61	64	76	89	98	99	96	97	100	84	57
PALM SPRINGS, CA	3	7	13	31	65	97	94	98	97	58	12	3	46	73	91	99	67	24	5	8	23	75	90	50
RIVERSIDE, CA	2	3	4	8	18	39	69	68	53	22	5	2	34	46	56	78	98	94	62	64	81	100	65	36
DENVER, CO	0	0	0	0	4	23	51	41	11	1	0	0	0	0	2	16	59	100	84	93	87	27	2	0
JACKSONVILLE, FL	1	3	9	23	50	78	89	87	74	34	10	3	32	47	81	100	84	51	37	39	57	97	85	46
TAMPA, FL	7	10	22	40	70	88	91	91	86	57	25	11	75	84	100	93	61	39	33	33	41	77	100	87
ATLANTA, GA	0	0	2	10	31	63	77	74	47	11	2	0	3	8	38	84	99	70	53	57	87	87	35	7
MACON, GA	0	1	4	15	43	75	87	84	60	17	3	1	9	17	57	95	91	55	39	44	74	96	52	17
HONOLULU,HI	48	48	55	62	71	80	84	88	86	81	69	54	86	86	79	71	61	49	43	38	40	48	62	80
CHICAGO,IL	0	0	0	1	6	29	49	42	16	2	0	0	0	0	1	17	69	99	85	92	95	34	2	0
INDIANAPOLIS, IN	0	0	0	1	12	43	60	49	22	2	0	0	0	0	3	32	90	91	73	85	100	44	5	0
DES MOINES, IA	0	0	0	1	11	42	66	53	18	2	0	0	0	0	1	25	87	91	66	81	97	38	2	0
WICHITA, KS	0	0	0	3	19	62	88	79	36	6	0	0	0	0	9	54	98	71	38	50	96	67	7	0
SHREVEPORT, LA	0	1	4	19	46	80	92	91	67	22	4	0	8	19	61	98	88	49	31	34	65	100	56	15
BOSTON, MA	0	0	0	0	5	26	51	43	17	2	0	0	0	0	2	15	65	100	84	91	96	45	9	0
DETROIT, MI	0	0	0	0	5	25	45	37	13	1	0	0	0	0	1	13	66	100	89	96	91	26	2	0
MINNEAPOLIS, MN	0	0	0	0	5	27	51	37	8	1	0	0	0	0	0	11	67	100	83	96	78	17	0	0
JACKSON, MS	0	0	4	16	43	77	88	86	63	16	3	0	6	15	56	96	90	53	38	41	70	96	50	14
ST. LOUIS, MO	0	0	0	4	20	60	81	71	35	5	0	0	0	0	8	56	99	73	47	60	96	66	10	0
LAS VEGAS, NV	0	1	3	15	53	98	96	100	84	28	3	0	9	26	53	94	81	22	6	11	43	100	46	9
RENO, NV	0	0	0	1	4	18	42	33	8	1	0	0	0	1	5	17	55	97	92	98	78	25	2	0
NEW YORK (JFK AP), NY	0	0	0	1	7	32	61	57	25	4	0	0	0	0	3	24	75	98	73	77	100	58	13	1
RALEIGH, NC	0	0	1	6	23	55	74	69	39	7	1	0	2	4	23	70	100	79	57	63	94	76	26	5
AKRON, OH	0	0	0	1	6	26	43	36	14	1	0	0	0	0	1	16	70	100	91	96	93	32	4	0
OKLAHOMA CITY, OK	0	0	1	8	28	67	90	87	48	10	1	0	1	3	23	78	100	65	35	40	86	86	20	2
GUAM, PC	70	69	72	78	81	82	80	78	79	78	79	75	62	62	59	52	48	46	49	51	50	51	50	55
PITTSBURGH, PA	0	0	0	1	7	26	44	37	14	1	0	0	0	0	2	20	73	100	90	96	94	32	4	0
CHARLESTON AP,SC	0	1	5	17	47	75	88	85	65	23	5	1	14	24	64	97	87	56	38	42	67	100	66	26
KNOXVILLE, TN	0	0	1	4	18	49	66	63	35	5	1	0	1	2	18	61	98	85	66	70	97	66	17	2
AUSTIN, TX	1	2	10	33	61	88	97	98	83	39	9	1	17	34	84	98	72	39	24	22	45	94	80	28
CORPUS CHRISTI, TX	3	5	19	46	73	90	96	96	86	53	19	5	46	67	98	88	58	35	25	25	40	81	98	65
HOUSTON, TX	1	2	8	28	56	84	92	91	74	33	9	2	23	40	79	100	78	44	32	33	56	98	81	38
SAN ANTONIO, TX	1	2	10	32	61	91	98	98	79	35	8	1	19	38	85	98	73	34	22	22	50	96	78	31
RICHMOND, VA	0	0	0	4	20	53	73	67	35	6	1	0	1	2	15	59	99	81	58	65	97	67	20	2