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# Using Growing Degree-Days for Insect Pest Management

When pest management is based on calendar timings, daily temperature is not taken into account. This can result in misleading information regarding current insect activity. Depending on weather conditions, insect development may vary from year to year by a few weeks, consequently predicting the proper time for control measures is difficult.

Insects, like plants and many other organisms, are dependent on temperature to develop. These organisms begin developing when the temperature exceeds the lower developmental threshold or base temperature. The rate of development increases as the temperature exceeds the base temperature and decreases as the temperature drops. Thus, insect development is accelerated during warm years and delayed during cooler years. Upper developmental thresholds, temperatures above which growth slows or ceases, are seldom used for insects since these thresholds are either not known, or they live in habitats where the upper threshold is seldom exceeded. Growing Degree-Days (GDD) takes into account the average daily temperature by calculating the number of heat units received. Thus, this system can be more accurate than the calendar method for estimating insect development and timing management strategies.

Several mathematical equations, can be used for calculating GDD based on minimum and maximum temperature. The easiest method is to average the daily maximum and minimum temperatures and subtract from-it the base temperature as follows:

$$\frac{\text{Max Temperature + Minimum Temperature}}{2} \quad \textbf{minus} \quad \textbf{Base Temperature} \quad = \quad \textbf{Daily GDD}$$

For each day that the average temperature is one degree above the base temperature, one degree-day accumulates. Depending on the species, the base temperature can vary. Cool weather organisms will have lower base temperatures while other types of organisms will have higher ones. For most situations though, a base temperature of 50°F: is satisfactory. If a development prediction for a particular insect varies more than expected, using a lower base temperature could be necessary for that organism.

Biophenometers are instruments, which record the temperature every few minutes and accumulate the GDD as that portion of a 24-hour period. This is the most accurate way of calculating GDD but it does not retain minimum and maximum temperature data which would be important to calculate the most appropriate base temperature to use. When using GDD from other sources it is important to determine the method and 'base temperature used for calculations.

Ideally, taking temperature readings from the property or general area where the pest problem exists would be most accurate. When doing so several things should be considered. Minimum/maximum thermometers or any other devices used to detect temperature should be placed in a well ventilated, white weather shelter. The thermometer should not be exposed to direct sunlight. Shelters should be placed in the full sun, ideally in areas free from excessive radiant heat from driveways, sidewalks, buildings, etc. The accumulated GDD for various locations in Nassau and Suffolk Counties as well as New York City can be accessed from the Cornell Cooperative Extension – Suffolk County web site at the following web address http://ccesuffolk.org/agriculture/growing-degree-days-gdd

Each day between March 1 and September 30 the daily GDD are calculated (using the above mentioned formula) and totaled to determine the accumulated GDD (**Table 1**). If the average temperature is below the base temperature, which would return a negative daily GDD number, just enter zero - 0 - for the day. For the system to work you must collect the maximum and minimum temperature every day. Early in the season the numbers will accumulate slowly but as the average daily temperature increases the GDD will accumulate faster.

**Table 1. Example calculating growing degree-days (GDD) and accumulated growing degree-days (AGDD)**

| Date | Min | Max | Avg. | GDD | AGDD |
|---|---|---|---|---|---|
| March 1 | 30 | 40 | 35 | 0[1] | 0 |
| March 2 | 40 | 65 | 52.5 | 2.5 | 2.5 |
| March 3 | 50 | 65 | 57.5 | 7.5 | 10 |

[1]Negative numbers are never added, enter zero.

The GDD for many insects are listed in (**Table 2**.) The time for pest control is expressed in a range of numbers beginning with first perceptible feeding injury and continuing until approximately the end of the insects' plant injury cycle. In other cases, ranges indicate optimum control periods. If more than one range of numbers appears, this is indicative of multiple generations and/or control- periods in an insect's life cycle. For example, Cooley spruce gall adelgid GDD (on spruce) are 22 - 81 and 1850 - 1950. This means the insect

is active starting around 22 GDD and control measures can be implemented until approximately 81 GDD. Cooley spruce gall adelgid also has another period during the growing season when controls may be effective and necessary. This period is between 1850 and 1950 GDD.

GDD should be used as a guide as to determine when pest control actions should be utilized. Monitoring should be employed at some point before the GDD number is reached to determine if a pest problem exists and if some type of control is warranted. Decisions as to whether or not to use control measures will be dependent upon such things as the level of damage or potential damage and the life stage of the insect. Treatment, if decided upon, would be timed to correspond with some point within the GDD range.

**Table 2. A partial list of common insects found on woody trees and shrubs along with the stage of development and the coordinating growing degree-day (GDD) range of the particular insect pest. This information was provided by Dr. Warren T. Johnson, Department of Entomology, Cornell University and the *2006 PMG for Commercial Production and Maintenance of Trees and Shrubs*. Unless specified otherwise (i.e. Soil Treatment) the GDD ranges pertain to foliar applications.**

| Common Name | Scientific Name | Dormant[2] | Stage[3] | GDD Min[1] | GDD Max[1] |
|---|---|---|---|---|---|
| American plum borer | Euzophera semifuneralis | | A | 245 | 440 |
| Aphids | Leaf and twig forms | * | E | 7 | 120 |
| | | | N,A | 100 | 200 |
| | | | N,A | 100 | 250 |
| | | | N,A | 250 | 2800 |
| Arborvitae leafminers | *Argyresthia spp.* | | A | 533 | 700 |
| | | | L | 150 | 260 |
| | | | L | 1800 | 2200 |
| | **Soil Treatment** | | L | 1700 | 2100 |
| Azalea leafminer | *Caloptilia azaleela* | | L | 450 | 800 |
| | | | L | 1260 | 1500 |
| Azalea whitefly | *Pealius azaleae* | | N,A | 448 | 700 |
| | | | N,A | 1250 | 1500 |
| | | | N,A | 2032 | 2150 |
| Bagworm | *Thyridopteryx ephemeraeformis* | | L | 600 | 900 |
| Balsam gall midge | *Paradiplosis tumifex* | | L | 120 | 299 |
| Balsam twig aphid | *Mindarus abietinus* | | N | 30 | 100 |
| Birch leafminer | *Fenusa pusilla* | | L | 190 | 290 |
| | | | L | 530 | 700 |
| Black Vine Weevil | *Otiorhynchus sulcatus* | | A | 148 | 400 |
| Boxwood leafminer | *Monarthropalpus buxi* | | A | 350 | 600 |
| | | | L | 1200 | 2400 |
| Boxwood mite | *Eurytetranychus buxi* | | N,A | 245 | 600 |
| Boxwood psyllid | *Psylla buxi* | | N | 290 | 440 |
| Bronze birch borer | *Agrilus anxius* | | A | 440 | 800 |
| Cankerworms (inch worms) | | | L | 148 | 290 |
| Cooley spruce gall adelgid | *Adelges cooleyi* – on Douglas Fir | | N,A | 1500 | 1775 |
| | | | N,A | 120 | 190 |
| Cooley spruce gall adelgid | *Adelges cooleyi* - on Spruce | | N,A | 1850 | 1950 |
| | | | N,A | 22 | 81 |
| Cottony maple scale | *Pulvinaria innumerabilis* | * | C | 802 | 1265 |
| Cottony maple leaf scale | *Pulvinaria acericola* | * | C | 802 | 1265 |
| Cottony taxus scale | *Pulvinaria floccifera* | | C | 802 | 1388 |
| | | * | N | 7 | 91 |
| Dogwood borer | *Synanthedon scitula* | | A | 148 | 700 |
| Eastern spruce gall adelgid | *Adelges abietis* | | N | 22 | 170 |
| Eastern tent caterpillar | *Malacosma americanum* | | L | 90 | 190 |
| Elongate hemlock scale | *Fiorinia externa* | | C | 360 | 700 |
| | | * | A | 7 | 120 |
| Euonymus scale | *Unaspis euonymi* | | C | 533 | 820 |
| | | | C | 1150 | 1388 |
| | | * | N | 35 | 120 |
| European fruit lecanium | *Parthenolecanium corni* | | C | 1266 | 1645 |
| | | * | N | 35 | 145 |
| European Pine Sawfly | *Neodiprion sertifer* | | L | 78 | 220 |
| European pine shoot moth | *Rhyacionia buoliana* | | L | 34 | 121 |

| | | | L | 480 | 710 |
|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **Dormant[2]** | **Stage[3]** | **Min[1]** | **Max[1]** |
| European red mite | *Panonychus ulmi* | | E,L,N | 240 | 810 |
| | | * | E | 7 | 58 |
| Fall webworm | *Hyphantria cunea* | | L | 1266 | 1795 |
| Fletcher scale | *Parthenolecanium fletcheri* | | C | 1029 | 1388 |
| | | | C | 2515 | 2800 |
| | | | N | 38 | 148 |
| Fruitree leafroller | *Archips argyrospilus* | | L | 300 | 618 |
| Gypsy moth | *Lymantria dispar* | | L | 90 | 448 |
| Hemlock eriophyid (rust) mite | *Nalepella tsugifolia* | * | N,A | 7 | 450 |
| Hemlock scale | *Abgrallaspis ithacae* | | C | 1388 | 2154 |
| | | * | N | 35 | 121 |
| Hickory leaf stem gall phylloxera | *Phylloxera carvaecaulis* | | N | 91 | 246 |
| Holly leafminer | *Phytomyza ilicis* | | L,A | 246 | 448 |
| | **Soil Treatment** | | L | 192 | 290 |
| Honeylocust spider mite | *Eotetranychus multidigituli* | | E,L,N,A | 912 | 1514 |
| Honeylocust plant bug | *Diaphnocoris chlorionis* | | N,A | 58 | 246 |
| Honeylocust pod gall midge | *Dasineura gleditschiae* | | L | 192 | 229 |
| Honeylocust spider mite | *Platytetranychus multidigituli* | | N,A | 912 | 1514 |
| Japanese beetle | *Popillia japonica* | | A | 1029 | 2154 |
| Juniper scale | *Carulaspis juniperi* | | C | 707 | 1260 |
| | | * | N | 22 | 148 |
| Juniper webworm | *Dichomeris marginella* | | L | 1645 | 1917 |
| Lace bugs | *Corythuca spp* | | N,A | 239 | 363 |
| | | | N,A | 1266 | 1544 |
| | *Stephanitis spp.* | | N,A | 120+ | |
| Leafhoppers | Several species | | N,A | 618 | 802 |
| | | | N,A | 1266 | 1514 |
| | | | N,A | 1917 | 2155 |
| Lilac borer | *Podosesia syringae* | | A | 200 | 299 |
| | | | A | 400+ | |
| Locust borer | *Magacyllene robiniae* | | L,A | 2271 | 2805 |
| Magnolia scale | *Neolecanium cornuparvum* | * | N | 7 | 35 |
| Mountain ash sawfly | *Pristiphora geniculata* | | L | 448 | 707 |
| Nantucket pine tip moth | *Rhyacionia frustrana* | | L | 121 | 448 |
| | | | L | 1514 | 1917 |
| Native holly leafminer | *Phytomyza iliciola* | | L | 192 | 298 |
| | | | L | 1029 | 1266 |
| Oak blotch leafminers | *Cameraria spp., Tischeria spp.* | | L | 533 | 912 |
| Oak leaftier | *Croesia semipurpurana* | | L | 7 | 35 |
| Oak skeletonizer | *Bucculatrix ainsliella* | | L | 448 | 707 |
| | | | L | 1798 | 2155 |
| Oak spider mite | *Oligonychus bicolor* | | L,N | 802 | 1266 |
| Oystershell scale | *Lepidosaphes ulmi* | | C | 363 | 707 |
| | | * | E | 7 | 91 |
| Peachtree borer | *Synanthedon exitiosa* | | L | 1500 | 1800 |
| Pine bark adelgid | *Pineus strobi* | | C | 58 | 618 |
| | | * | C | 22 | 58 |
| Pine eriophyid mites | *Eriophyidae* | | N,A | 298 | 533 |
| Pine needle miner | *Exoteleia pinifoliella* | | L,A | 448 | 802 |
| Pine needle scale | *Chionaspis pinifoliae* | | C | 1290 | 1917 |
| | | | C | 298 | 448 |
| | | * | E | 98 | 248 |
| Pine sawflies | *Diprion spp., Neodiprion spp.* | | L | 246 | 1388 |
| Pine spittlebugs | *Aphrophora cribrata* | | N | 148 | 298 |
| | *A. saratogensis* | | N | 148 | 298 |
| Pine webworm | *Tetralopha robustella* | | L | 802 | 2000 |
| Pitch twig moth | *Petrova comstockiana* | | L | 298 | 707 |
| Privet rust mite | *Aculus ligustri* | | L,N,A | 1266 | 1515 |

| | | | L,N,A | 298 | 802 |
|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **Dormant[2]** | **Stage[3]** | **Min[1]** | **Max[1]** |
| Privet thrips | *Dendrothrips ornatus* | | L,A | 192 | 618 |
| | | | L,A | 1029 | 1266 |
| Rhododendron borer | *Synanthedon rhododendri* | | A | 533 | 707 |
| | | | A | 192 | 298 |
| Rhododendron gall midge | *Clinodiplosis rhododendri* | | L | 192 | 363 |
| Rhododendron stem borer | *Oberea myops* | | A | 298 | 802 |
| Rose chafer | *Macrodactylus subspinosus* | | A | 448 | 802 |
| Roundheaded apple tree borer | *Saperda candida* | | A | 802 | 1029 |
| | | | A | 1514 | 1798 |
| Rust mites | *Eriophyidae* | | L,N,A | 1644 | 2033 |
| | | | L,N,A | 533 | 802 |
| Southern red mite | *Oligonychus ilicis* | | N,A | 246 | 363 |
| | | | N,A | 618 | 802 |
| | | | N,A | 2500 | 2700 |
| | | * | E | 7 | 91 |
| Spruce needle miner | *Endothenia albolineane* | | L | 448 | 802 |
| Spruce spider mite | *Oligonychus ununguis* | * | E | 7 | 121 |
| | | | N,A | 192 | 363 |
| | | | N,A | 2375 | 2806 |
| Taxus bud mite | *Cedidophyopsis psilaspis* | | N,A | 148 | 448 |
| | | | N,A | 707 | 912 |
| Taxus mealybug | *Dysmicoccus wistariae* | | N | 246 | 618 |
| | | * | N | 7 | 91 |
| Tuliptree aphid | *Macrosiphum liriodendri* | | N,A | 1151 | 1514 |
| | | | N,A | 1917 | 2033 |
| Tuliptree scale | *Toumeyella liriodendri* | | C | 2032 | 2629 |
| | | * | N | 12 | 121 |
| Tussock moth | *Orgyia leucostigma* | | L | 192 | 298 |
| | | | L | 2145 | 2516 |
| Twobanded Japanese weevil | *Callirhopalus bifasciatus* | | A | 1644 | 2271 |
| Twospotted spider mite | *Tetranychus urticae* | | N,A | 363 | 618 |
| | | | A | 1300 | 2000 |
| White pine aphid | *Cinara strobi* | | A | 1917 | 2271 |
| | | | N | 121 | 246 |
| | | * | E | 7 | 121 |
| White pine weevil | *Pissodes strobi* | | A | 7 | 58 |
| White prunicola scale | *Pseudaulacaspis prinicola* | | C | 707 | 1151 |
| | | | E | 35 | 145 |
| Woolly beech aphids | *Grylloprociphilus imbricator* | | N,A | 363 | 707 |
| | *Phyllaphis fagi* | | N,A | 363 | 707 |
| Woolly elm aphid | *Erisoma americanum* | | N | 121 | 246 |
| Zimmerman pine moth | *Dioryctria zimmermani* | | L | 121 | 246 |
| | | | A | 1917 | 2154 |

[1]If more than one range of numbers appears this is indicative of multiple generations and/or control periods in an insect's life cycle.

[2]If an asterisk (*) appears in this column, then a treatment with an appropriate insecticide may be warranted during the dormant season (before bud break) providing a pest problem is present. For specific guidelines homeowners may refer to the current version of *Part II Guide to Pest Management around the Home – Pesticide Guidelines*, Cornell Misc. Bulletin S74II and commercial pesticide applicators can refer to the current version of *Pest Management Guidelines for Commercial Production and Maintenance of Trees and Shrubs.*

[3]A = adult; C = crawler; E = egg; L = larvae; N = nymph.

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